# Approved Syllabus of courses offered by EED
## as per new Course Structure
## of
## 3rd B. Tech. (Electrical Engineering) - Semester VI


**Department of Electrical Engineering**

**School of Engineering**

**Harcourt Butler Technical University**

**Kanpur-208 002**

## Existing

**SEMESTER VI**

| Sr. No. | Course Type | Subject Code | Course Title | Credits | Sessional Marks | | | | ESE | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | MSE | TA | Lab | Total | | |
| 1. | PCC | EEE-302 | Power System-II | 5 (3-1-3) | 15 | 20 | 15 | 50 | 50 | 100 |
| 2. | PCC | EEE-304 | Power Electronics | 6 (3-2-2) | 15 | 20 | 15 | 50 | 50 | 100 |
| 3. | PCC | EEE-306 | Power Station Practice | 4 (3-1-0) | 30 | 20 | - | 50 | 50 | 100 |
| 4. | PCC | EET-310 | Electromagnetic Field Theory | 4 (3-1-0) | 30 | 20 | - | 50 | 50 | 100 |
| 5. | OEC (Humanities) | HHS-342 | Entrepreneurship Development | 3 (3-0-0) | 30 | 20 | - | 50 | 50 | 100 |
| Total Credit | | | | 22 | | | | | | |

## Proposed only for subject EEE - 302 Power System - II

| EEE - 302 | Power System - II | 3L: 2T: 0P | 5 Credits | Course Type: PCC |
|---|---|---|---|---|


| EEE - 302 | Power System - II | 3L: 2T: 0P | 5 Credits | Course Type: PCC |
|---|---|---|---|---|


**Preamble:**

This course will provide a good understanding and hold to the students in the area of power system. The course includes concepts, modelling, components, calculations, simple designing and analysis of power system.

**Prerequisites:**

Basic Electrical Engineering, Power System - I

**Course Outcomes:**

On the successful completion of this course, students will be able to:

| COs | Course Outcomes | Bloom's Level |
|---|---|---|
| **CO1** | Understanding basics and needs of representation of power system components | Remembering, Understanding |
| **CO2** | Able to solve problems of faults analyses, stability analyses of power system | Applying, Analysing |
| **CO3** | Understanding basic concepts of load flow | Understanding, Analysing, Evaluating |
| **CO4** | Understanding and analyse the basic components of power system stability | Understanding, Analysing, Evaluating |
| **CO5** | Handling problems of fault analysis using computer | Understanding, Analysing, Evaluating |
| **CO6** | Able to learn power system and its concepts for life long | Remembering, Understanding, Analysing, Creating |

**Mapping with Programme Outcomes:**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 3 | - | - | - | 2 | - | - | 1 | - | - | 2 |
| **CO2** | 3 | 3 | 1 | 1 | 1 | 3 | 1 | - | 2 | - | - | 2 |
| **CO3** | 3 | 3 | 1 | 2 | 1 | 3 | 1 | - | 2 | - | - | 2 |
| **CO4** | 3 | 3 | 1 | 1 | 1 | 3 | 1 | - | 2 | - | - | 2 |
| **CO5** | 3 | 3 | 1 | 2 | 1 | 3 | 1 | - | 2 | - | - | 2 |
| **CO6** | 3 | 3 | 2 | 2 | 2 | 3 | 1 | - | 3 | - | 1 | 3 |
| **Avg.** | 3.0 | 3.0 | 1.0 | 1.3 | 1.0 | 2.8 | 0.8 | 0.0 | 2.0 | - | 0.2 | 2.7 |

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) if there is no correlation, put "-"

**Course Level Assessment Questions**

**Course Outcome 1:**

1. Define load flow analyses and classify the buses.
2. Explain the need of symmetrical component.

**Course Outcome 2:**

1. Derive the relation to calculate line-to-ground fault current in three phase alternator.
2. Derive the swing equation.

**Course Outcome 3:**

1. Obtain the load flow equation for Gauss-Siedel Method.
2. Compare the performance of Gauss-Siedel Method and Neuton-Raphson Method.

**Course Outcome 4:**

1. Differentiate steady-state and transient stability.
2. Explain equal area criterion and apply it on the three phase alternator when its mechanical input is suddenly raised.

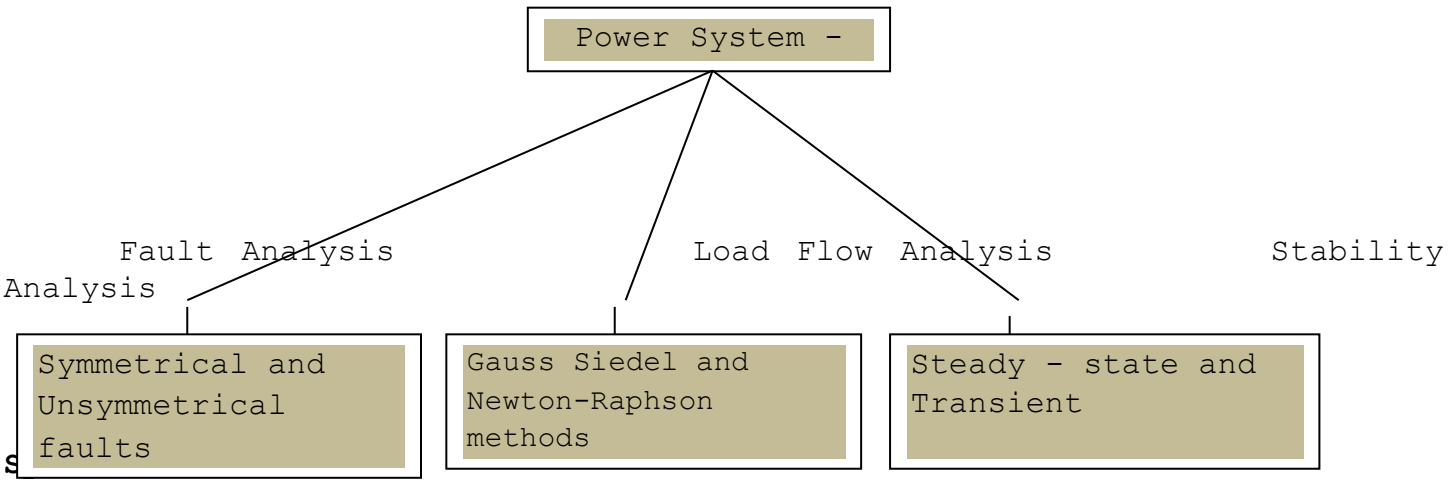
**Course Outcome 5:**

1. Explain nodal admittance matrix (Ybus).
2. Do all necesssray derivations for electrical variables in the case of Line to ground fault on an unloaded generators and power system network with and without fault impedance.

**Course Outcome 6:**

1. Show all needed calculations of 3-phase short circuit current and reactance of synchronous machine.
2. What are various factors affecting steady state and transient stability and also explain methods of its improvement?

**Concept Map**




**Module 1: Representation of Power System Components and Symmetrical fault analysis (10 Lectures):**

Representation of Power System Components:
Synchronous machines, Transformers, Transmission lines, One line diagram, Impedance and reactance diagram, per unit System
Symmetrical fault analysis:
Transient in R-L series circuit, calculation of 3-phase short circuit current and reactance of synchronous machine, internal voltage of loaded machines under transient conditions

**Module 2: Symmetrical components and Unsymmetrical faults (10 Lectures):**

Symmetrical components:

Symmetrical Components of unbalanced phasors, power in terms of symmetrical components, sequence impedances and sequence networks
Unsymmetrical faults:
Analysis of single line to ground fault, line-to-line fault and Double Line to ground fault on an unloaded generators and power system network with and without fault impedance

**Module 3: Building of $Z_{bus}$ and introduction to computer method for fault analysis (10 Lectures):**

Formation of $Z_{bus}$ using singular transformation and $Z_{bus}$ building algorithm, Introduction to computer method for short circuit calculations

**Module 4: Load Flow (10 Lectures):**

Introduction, bus classifications, nodal admittance matrix ($Y_{bus}$), Development of load flow equations, Load flow solution using Gauss Siedel and Newton-Raphson method

**Module 5: Power System Stability (10 Lectures):**

Stability and Stability limit, Steady state stability study, Derivation of Swing equation, Transient stability studies by equal area criterion and step-by-step method, Factors affecting steady state and transient stability and methods of improvement

**Text Books:**

1. W. D. Stevenson, Jr. "Elements of Power System Analysis", Mc Graw Hill
2. C. L. Wadhwa, "Electrical Power System", New Age International
3. I. J. Nagrath and D. P. Kothari, "Power System Enginerring", TMH

**Reference Books:**

1. Chakraborthy, Soni,Gupta & Bhatnagar, "Power System Engineering", Dhanpat Rai & Co.
2. T.K Nagsarkar & M.S. Sukhija, "Power System Analysis" Oxford University Press,2007.

**Course Contents and Lecture Schedule**

| Module No. | Topic(s) | No. of Lectures |
|---|---|---|
| 1 | Synchronous machines, Transformers, Transmission lines, One line diagram, Impedance and reactance diagram, per unit System | 5 |
| 1 | Transient in R-L series circuit, calculation of 3-phase short circuit current and reactance of synchronous machine, internal voltage of loaded machines under transient conditions | 5 |
| 2 | Symmetrical Components of unbalanced phasors, power in terms of symmetrical components, sequence impedances and sequence networks | 4 |
| 2 | Analysis of single line to ground fault, line-to-line fault and Double Line to ground fault on an unloaded generators and power system network with and without fault impedance | 6 |
| 3 | Formation of $Z_{bus}$ using singular transformation and $Z_{bus}$ building algorithm, | 5 |

| | | |
|---|---|---|
| 3 | Introduction to computer method for short circuit calculations | 5 |
| 4 | Introduction, bus classifications, nodal admittance matrix ($Y_{bus}$), Development of load flow equations | 4 |
| 4 | Load flow solution using Gauss Siedel and Newton-Raphson method | 6 |
| 5 | Stability and Stability limit, Steady state stability study, Derivation of Swing equation | 4 |
| 5 | Transient stability studies by equal area criterion and step-by-step method | 4 |
| 5 | Factors affecting steady state and transient stability and methods of improvement | 2 |

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| EEE- 304 | Power Electronics | 3L:2T:2P | 6 credits |
|---|---|---|---|

**Preamble:**

This course will provide a good understanding and hold to the students in the area of Power Electronics. The course includes: Fundamentals and basic Concepts of Power Electronics, DC-DC converters, AC-DC Converters, Inverters, Modulation Techniques. At the end of this course students will demonstrate the ability to Understand the differences between signal level and power level devices. Analyze controlled rectifier circuits. Analyze the operation of DC-DC choppers. Analyze the operation of voltage source inverters and AC regulators.

**Prerequisites:**

Electrical Circuit Analysis EEE-203, Solid State Devices and Circuits EET-201, Digital Electronics EET-203.

**Course Outcomes:** On the successful completion of this course, students will be able to:

| COs | Course Outcomes | Bloom's Level |
|---|---|---|
| CO1 | Demonstrate the ability to Understand the differences between signal level and power level devices. | Knowledge (1)<br>Comprehension (2) |
| CO2 | Describe basic operation and compare performance of various power semiconductor devices, passive components and switching circuits | Knowledge (1)<br>Comprehension (2) |
| CO3 | Design and Analyze power converter circuits and learn to select suitable power electronic devices by assessing the requirements of application fields. | Knowledge (1)<br>Analysis (4)<br>Application (3) |
| CO4 | Formulate and analyze a power electronic design at the system level and assess the performance. | Knowledge (1)<br>Analysis (4) |
| CO5 | Identify the critical areas in application levels and derive typical alternative solutions, select suitable power converters to control Electrical Motors and other industry grade apparatus. | Synthesis (5)<br>Evaluation (6) |

**Mapping with Programme Outcomes:**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO1O | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 1 | 1 | 1 | - | - | - | - | - | - | - | - |
| **CO2** | 2 | 2 | 3 | 1 | - | - | - | - | - | - | - | - |
| **CO3** | 3 | 3 | 3 | 2 | 2 | - | - | - | - | - | - | 1 |
| **CO4** | 3 | 3 | 3 | 2 | 2 | 1 | - | - | - | - | - | 1 |
| **CO5** | 3 | 3 | 3 | 3 | 3 | 2 | 1 | - | - | - | - | 1 |
| **Avg.** | 2.6 | 2.4 | 2.6 | 0.18 | 0.14 | 0.6 | 0.2 | - | - | - | - | 0.6 |

**1: Slight** (Low) 2: Moderate (Medium) 3: Substantial (High) if there is no correlation, put "-'

**Course Level Assessment Questions**

**Course Outcome 1:**

1. Compare Power MOSFET, IGBT and BJT.

2. What is the need of triggering circuit?

**Course Outcome 2:**

1. Explain class-A commutation.

2. What is the impact of switching frequency in selection of device for particular application?

3. Why we do series and parallel operation?

**Course Outcome 3:**

1. Explain operation of single phase rectifier with resistive load.

2. Explain operation of buck chopper.

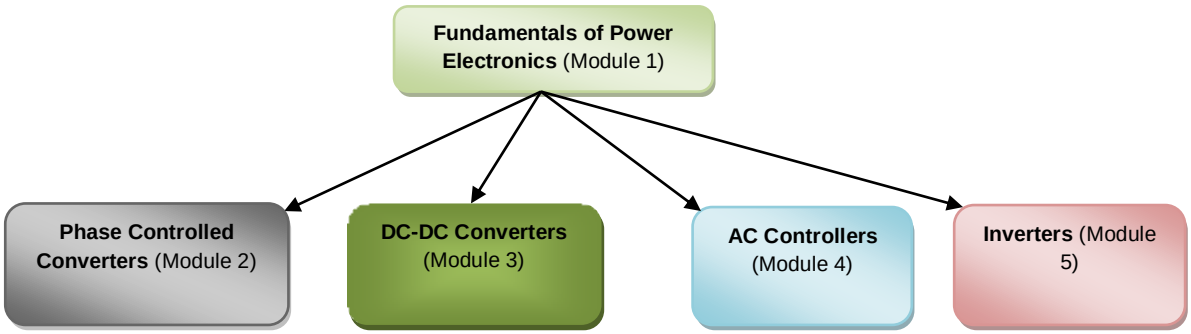
**Course Outcome 4:**

1. Explain various PWM techniques used to control inverter output voltage.
2. Advantage of MLI over square wave inverter.

**Course Outcome 5:**

1. How AC regulator can be used to control the temperature.
2. Derive the average output voltage for 3-phase bridge rectifier.

## Concept Map




**Module 1: Fundamentals of Power Electronics and Power Semiconductor Devices : (10 Hours)**

Concept of power electronics, application of power electronics, types of power electronic circuits and devices, Thyristor V- I characteristics, two transistor model and methods of turn-on, Operation and steady state characteristics of Power MOSFET, IGBT, GTO, MCT and TRIAC, Protection of thyristor, series and parallel operation of thyristors, commutation techniques of thyristor.

**Module 2 : Phase Controlled Converters: (10 Hours)**

Single phase half wave controlled rectifier with resistive, inductive and RLE loads, Single phase fully controlled and half controlled converters, effect of freewheeling diode and source inductance on the performance of converters. Three phase half wave converters, Three phase fully controlled and half controlled bridge converters, input current harmonics and power factors, techniques of power factor improvement and input harmonic spectrum, dual converters.

**Module3: DC-DC Converters: (8 Hours)**

Principle of operation, Power circuit of step down and step up choppers, relation between duty ratio and average output voltage, control strategies, types of choppers circuits based on quadrant of operation, performance parameters.

**Module 4: AC Controllers: (8 Hours)**

Principle of on-off and phase control, single phase AC voltage controllers with R and R-L loads, sequential controller, three phase AC voltage controllers, principle of operation of cycloconverters, single phase to single

phase step up and step down cycloconverters, three phase to single phase cycloconverters, three phase to three phase cycloconverters.

**Module 5: Inverters: (10 Hours)**

Principle of operation of single-phase voltage source inverter with R and R-L loads, switch states, pole voltage and instantaneous output voltage, square wave operation of the inverter, power circuit of a three-phase voltage source inverter, switch states, pole voltage and instantaneous output voltages, average output voltages over a sub-cycle, methods of voltage control and harmonic reduction of inverters, three-phase sinusoidal modulation, brief idea of multi level inverters, current source inverters.

**Text Books:**

1. M.H. Rashid,"Power Electronics: Circuits, Devices & Applications", Prentice Hall of India Ltd. 3rd Edition,2004.
2. M.D. Singh and K.B.Khanchandani, "Power Electronics"Tata MC Graw Hill, 2005.
3. V.R. Moorthy, " Power Electronics : Devices, Circuits and Industrial Applications" Oxford University Press,2007.
4. P.S. Bimbhra, "Power Electronics" Khanna Publishers Delhi, 2010.

**Reference Books:**

1. Chakrabarti & Rai, "Fundamentals of Power Electronics &Drives" Dhanpat Rai & Sons.
2. Ned Mohan, T.M.Undeland and W.P.Robbins, "Power Electronics:Converters, Applications and Design", Wiley India Ltd,2008
3. S.N.Singh, "A Text Book of Power Electronics" Dhanpat Rai & Sons.
4. M.S. Jamil Asghar, "Power Electronics" Prentice Hall of India Ltd., 2004
5. R. W. Erickson and D. Maksimovic, "Fundamentals of Power Electronics", Springer Science & Business Media, 2007.
6. L. Umanand, "Power Electronics: Essentials and Applications", Wiley India, 2009.

**Web Reference:**

1. Video/Web contents on NPTEL

**List of Experiments:**

1. To study V-I characteristics of SCR and measure latching and holding currents.
2. To study characteristics of MOSFET, IGBT, TRIAC
3. To study characteristics of IGBT
4. To study characteristics of TRIAC
5. To study single-phase half wave controlled rectified with (i) resistive load (ii) inductive load with and without freewheeling diode.
6. To study single phase (i) fully controlled (ii) half controlled bridge rectifiers with resistive and inductive loads.
7. To study single-phase ac voltage regulator with resistive and inductive loads
8. To study operation of IGBT/MOSFET chopper circuit

9. To study MOSFET/IGBT based single-phase bridge inverter.
10. To study MOSFET/IGBT based single-phase series-resonant inverter.

**Software based experiments (MATLAB)**

11. To obtain simulation of single phase half controlled rectifier and draw load voltage and load current waveform for inductive load.
12. To obtain simulation of single phase fully controlled bridge rectifier and draw load voltage and load current waveform for inductive load.
13. To obtain simulation of single phase full wave ac voltage controller and draw load voltage and load current waveforms for inductive load.
14. To obtain simulation of step down dc chopper with L-C output filter for inductive load and determine steady-state values of output voltage ripples in output voltage and load current.
15. To obtain simulation of single phase square wave bridge inverter with R and RL loads

| Module No. | Topic(s) | No. of Lectures |
|---|---|---|
| 1 | Concept of power electronics, application of power electronics, types of power electronic circuits and devices, | 2 |
| | Thyristor V- I characteristics, two transistor model and methods of turn-on, Operation and steady state characteristics of Power MOSFET, IGBT, GTO, MCT and TRIAC, | 4 |
| | Protection of thyristor, series and parallel operation of thyristors, commutation techniques of thyristor. | 4 |
| 2 | Single phase half wave controlled rectifier with resistive, inductive and RLE loads, | 2 |
| | Single phase fully controlled and half controlled converters, effect of freewheeling diode and source inductance on the performance of converters. | 2 |
| | Three phase half wave converters, Three phase fully controlled and half controlled bridge converters, input current harmonics and power factors, | 3 |
| | techniques of power factor improvement and input harmonic spectrum, dual converters. | 3 |
| 3 | Principle of operation, Power circuit of step down and step up choppers, | 3 |
| | relation between duty ratio and average output voltage, control strategies, | 2 |
| | types of choppers circuits based on quadrant of operation, performance parameters. | 3 |
| 4 | Principle of on-off and phase control, single phase AC voltage controllers with R and R-L loads, | 2 |
| | sequential controller, three phase AC voltage controllers, | 3 |
| | principle of operation of cycloconverters, single phase to single phase step up and step down cycloconverters, three phase to single phase cycloconverters, three phase to three phase cycloconverters | 3 |
| 5 | Principle of operation of single-phase voltage source inverter with R and R-L loads, switch states, pole voltage and instantaneous output voltage, | 2 |

| | | |
|---|---|---|
| | square wave operation of the inverter, power circuit of a three-phase voltage source inverter, switch states, pole voltage and instantaneous output voltages, average output voltages over a sub-cycle, | 2 |
| | methods of voltage control and harmonic reduction of inverters, three-phase sinusoidal modulation, | 3 |
| | brief idea of multi level inverters, current source inverters. | 3 |

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| | | | | |
|---|---|---|---|---|
| **EEE - 306** | **Power Station Practice** | **3L: 1T: 0P** | **4 Credits** | **Course Type: PCC** |

**Preamble:**

This course will provide a good understanding and hold to the students in the area of power stations. The course includes calculations of capital costs, operation costs, various factors, tariffs, power factor corrections and power plant economics. This course also gives an insight into various types of conventional and non-conventional power plants.

**Prerequisites:**

Engineering Mathematics, Engineering Physics and Basic Electrical Engineering

**Course Outcomes:**

On the successful completion of this course, students will be able to:

| COs | Course Outcomes | Bloom's Level |
|---|---|---|
| **CO1** | Able to know about various components of power plants | Remembering, Understanding |
| **CO2** | Able to calculate capital costs, operation costs, various factors, tariffs, power factor corrections, power output and power plant economics | Understanding, Applying, Analysing |
| **CO3** | Evaluating various aspects of power plants , sub-stations, power factor corrections and power plant economics | Analysing, Evaluating |
| **CO4** | Understand various aspects of power plant economics and their affects on power plant performance | Understanding, Analysing, |
| **CO5** | Able to do basic mechanical and electrical design calculations of some devices of power plants | Understanding, Analysing, Applying |
| **CO6** | Able to identify various aspects of non-conventional energy resources | Remembering, Understanding |

**Mapping with Programme Outcomes:**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 1 | - | - | - | 2 | 1 | - | - | - | - | 3 |
| **CO2** | 3 | 1 | 2 | 1 | 1 | 2 | 1 | - | 1 | - | 1 | 2 |
| **CO3** | 3 | 1 | 1 | - | 1 | 2 | 1 | - | 1 | - | 2 | 2 |
| **CO4** | 3 | 2 | 1 | 1 | 1 | 2 | 1 | - | 2 | - | 1 | 3 |
| **CO5** | 3 | 2 | 2 | 1 | 1 | 2 | 1 | - | 2 | - | 2 | 3 |
| **CO6** | 3 | 1 | 1 | 1 | 1 | 1 | 1 | - | 1 | - | 1 | 2 |
| **Avg.** | 3.0 | 1.3 | 1.2 | 0.7 | 0.8 | 1.8 | 1.0 | 0.0 | 1.2 | 0.0 | 1.2 | 2.5 |

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) if there is no correlation, put "-"

**Course Outcome 1:**

1. What do you understand by energy? What are its different types?
2. Briefly describe sub-station in electrical power system.
3. Explain Principle of OTEC.

**Course Outcome 2:**

1. Find the power density at the blades and speed required to generate power by the Wind Turbine with 30% efficiency, if required Wind Turbine

output is 120 Watts/$m^2$. Assume other standard values if any, as required in calculation.
2. An industrial load consists of (i) a synchronous motor of 100 metric h.p. (ii) induction motors aggregating 200 metric h.p. , 0.707 p.f. lagging and 82% efficiency and (iii) lighting load aggregating 30 kW. The tariff is Rs.100 per annum per kVA maximum demand plus 6 paise per kWh. Find the annual saving in cost if the synchronous motor operates at 0.8 p.f. leading, 93% efficiency instead of 0.8 lagging at 93% efficiency.
3. Derive expression for sinking fund method of depreciation.
4. A transformer costing Rs 90,000/- has a useful life of 20 years. Determine the annual depreciation charge using straight line method. Assume the salvage value of the equipment to be Rs 10,000/-.

**Course Outcome 3:**

1. What are various methods of power factor correction?
2. Discuss general layout of a nuclear power plant.
3. A generating station has an installed capacity of 50,000 kW and delivers 220 $\times 10^6$ units per annum. If the annual fixed charges are Rs 160/- per kW installed capacity and running charges are 4 paise per kWh, determine the cost per unit generated.

**Course Outcome 4:**

1. What is effect of low power factor on cost of energy generation in the case of conventional power plants?
2. The annual working cost of a power station is represented by the formula Rs (a + b kW + c kWh) where the various terms have their usual meaning. Determine the values of a, b and c for a 60 MW station operating at annual load factor of 50% from the following data :
(i) capital cost of building and equipment is Rs 5 $\times 10^6$
(ii) the annual cost of fuel, oil, taxation and wages of operating staff is Rs 9,00,000/-
(iii) the interest and depreciation on building and equipment are 10% per annum
(iv) annual cost of organisation and interest on cost of site etc. is Rs 5,00,000/-.
3. What are different types of tariff systems?

**Course Outcome 5:**

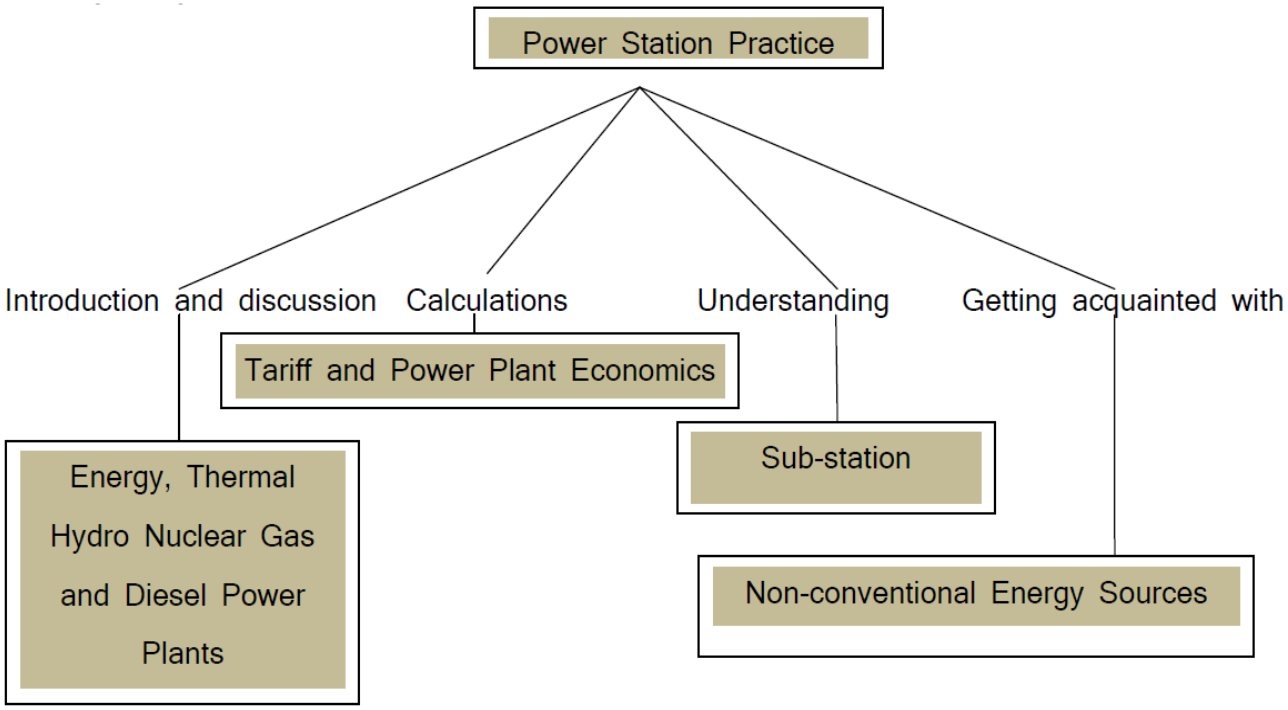
1. Derive expressions for power output calculations in the case of a hydroelectric power plant.
2. Differentiate different types of turbines on the basis of their working principle, mechanical designs and construction.
3.What are roles of air pre-heater and economisers in the case of thermal power plants?

**Course Outcome 6:**

1. Find the power density at the blades and speed required to generate power by the Wind Turbine with 30% efficiency, if required Turbine output

is 120 Watts/m2. Assume other standard values if any, as required in this calculation.
2. With the help of neat sketches, explain "Seeded Inert Gas MHD System.
3. Explain MPPT in the case of solar and wind energy power plants.

**Concept Map**




**Syllabus:**

**Module 1: Introduction, Thermal Power Plant and Hydro Electric Plants (8 Lectures):**

Introduction, Electric energy demand and growth in India, Electric energy sources
Thermal Power Plant: Site selection, general layout and operation of plant, detailed description and use of different parts
Hydro Electric Plants: Classifications, location and site selection, detailed description of various components, general layout and operation of Plants, brief description of impulse, reaction, Kaplan and Francis turbines, advantages & disadvantages, hydro-potential in India

**Module 2: Nuclear Power Plant, Gas Turbine Plant and Diesel Power Plant (7 Lectures):**

Nuclear Power Plant: Location, site selection, general layout and operation of plant. Brief description of different types of reactors Moderator material, fissile materials, control of nuclear reactors, disposal of nuclear waste material, shielding
Gas Turbine Plant: Operational principle of gas turbine plant & its efficiency, fuels, open and closed-cycle plants, regeneration, intercooling and reheating, role and applications

Diesel Plants: Diesel plant layout, components & their functions, its performance, role and applications

**Module 3: Power Plant Economics and Tariffs (7 Lectures):**

Power Plant Economics and Tariffs: Load curve, load duration curve, different factors related to plants and consumers, Cost of electrical energy, depreciation, generation cost, effect of Load factor on unit cost. Fixed and operating cost of different plants, role of load diversity in power system economy.
Objectives and forms of Tariff; Causes and effects of low power factor, advantages of power factor improvement, different methods for power factor improvements.

**Module 4: Sub-stations Layout and Economic Operation of Power Systems (4 Lectures):**

Types of substations, bus-bar arrangements, typical layout of substation.
Economic Operation of Power Systems: Characteristics of steam and hydro-plants, Constraints in operation, Economic load scheduling of thermal plants, Penalty factor, loss coefficients

**Module 5: Non Conventional Energy Sources (14 Lectures):**

Power Crisis, future energy demand, role of Private sectors in energy management
MHD generation: Working principle, open and closed cycles, MHD systems, advantages, parameters governing power output
Solar power plant: Conversion of solar heat to electricity, Solar energy collectors, Photovoltaic cell, power generation, future prospects of solar energy use
Wind Energy: Windmills, power output with combined operation of wind turbine generation and isolated generating system, technical choices& economic size
Geothermal Energy: Earth energy, heat extraction, vapor turbine cycle, difficulties & disadvantages
Tidal energy: Tidal phenomenon, tidal barrage, tidal power Schemes
Ocean Thermal Energy: Introduction, energy conversion, problems

**Text Books**

1. B.R. Gupta,"Generation of Electrical Energy", S. Chand Publication
2. Soni, Gupta & Bhatnagar, "A text book on Power System Engg.", Dhanpat Rai & Co.
3. P.S.R. Murthy, "Operation and control of Power System" BS Publications, Hyderabad

**Reference Books**

1. W. D. Stevenson, "Elements of Power System Analysis", McGraw Hill
2. S. L. Uppal, "Electrical Power", Khanna Publishers

**Course Contents and Lecture Schedule**

| Module No. | Topic(s) | No. of Lectures |
|---|---|---|
| 1 | Introduction, Electric energy demand and growth in India, Electric energy sources | 2 |
| 1 | Thermal Power Plant: Site selection, general layout and operation of plant, detailed description and use of different parts | 3 |
| 1 | Hydro Electric Plants: Classifications, location and site selection, detailed description of various components, general layout and operation of Plants, brief description of impulse, reaction, Kaplan and Francis turbines, advantages & disadvantages, hydro-potential in India | 3 |
| 2 | Nuclear Power Plant: Location, site selection, general layout and operation of plant. Brief description of different types of reactors Moderator material, fissile materials, control of nuclear reactors, disposal of nuclear waste material, shielding | 3 |
| 2 | Gas Turbine Plant: Operational principle of gas turbine plant & its efficiency, fuels, open and closed-cycle plants, regeneration, intercooling and reheating, role and applications | 2 |
| 2 | Diesel Plants: Diesel plant layout, components & their functions, its performance, role and applications | 2 |
| 3 | Power Plant Economics and Tariffs: Load curve, load duration curve, different factors related to plants and consumers, Cost of electrical energy, depreciation, generation cost, effect of Load factor on unit cost. | 3 |
| 3 | Fixed and operating cost of different plants, role of load diversity in power system economy.<br>Objectives and forms of Tariff; Causes and effects of low power factor, advantages of power factor improvement, different methods for power factor improvements. | 4 |
| 4 | Types of substations, bus-bar arrangements, typical layout of substation. | 2 |
| 4 | Economic Operation of Power Systems: Characteristics of steam and hydro-plants, Constraints in operation, Economic load scheduling of thermal plants, Penalty factor, loss coefficients | 2 |
| 5 | Power Crisis, future energy demand, role of Private sectors in energy management | 1 |
| 5 | MHD generation: Working principle, open and closed cycles, MHD systems, advantages, parameters governing power output | 3 |
| 5 | Solar power plant: Conversion of solar heat to electricity, Solar energy collectors, Photovoltaic cell, power generation, future prospects of solar energy use | 3 |

| | | |
|---|---|---|
| 5 | Wind Energy: Windmills, power output with combined operation of wind turbine generation and isolated generating system, technical choices& economic size | 3 |
| 5 | Geothermal Energy: Earth energy, heat extraction, vapor turbine cycle, difficulties & disadvantages<br>Tidal energy: Tidal phenomenon, tidal barrage, tidal power Schemes<br>Ocean Thermal Energy: Introduction, energy conversion, problems | 4 |

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