

# **Jharkhand University of Technology**

## **Ranchi, 834010**



### **SYLLABUS**

**For Diploma Program in**  
**Electrical Engineering/ Electrical & Electronics Engineering**  
**(Effective from 2024-25)**

**DEPARTMENT OF ELECTRICAL ENGINEERING/  
ELECTRICAL & ELECTRONICS ENGINEERING**

**(3<sup>rd</sup> – SEMESTER)**

# **BASICS OF ELECTRICAL POWER SYSTEM**

Subject code -EEE301

## **1. RATIONALE**

A power system comprises of the various subsystems that include generation, transmission, and distribution and Load. Basic knowledge of Electrical Power System **is essential for student of diploma in electrical Engineering** to work in Generation, transmission and distribution field. An electrical engineering diploma student must be knowledgeable about various sources of energy, construction and operation of conventional and non-conventional power plants, economics of power generation and techniques of transmission and distribution. The study of basic concepts of electrical power generation will help the student to understand various issues associated with Generation, transmission and Distribution.

## **2. COURSE SKILL SET**

The aim of the course is to help the student to attain the following industry identified competency through various teaching –learning experiences

- **Select the site** for Hydroelectric, Thermal, Nuclear, Wind and Solar power plants.
- **Construction and operation** of conventional and non-conventional power plants.

## **3. COURSE OUT COMES**

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

<b>CO1</b>	Describe the Non-renewable energy methods of Generation.
<b>CO2</b>	Describe the Renewable energy methods of Generation.
<b>CO3</b>	Analyze the economic operation of power generation.
<b>CO4</b>	Describe basic elements of the electric transmission and distribution systems.

#### 4. DETAILS OF COURSE CONTENT

*The following topics/sub topics is to be taught and assessed in order to develop Unit Skill sets for achieving CO to attain identified skill sets*

Session No.	Contents
<b>Unit-I</b>	<b>Hydroelectric and Thermal power plants</b>
1	Power sector scenario including generation, transmission, and distribution scenario of India
2	<b>Introduction</b> -Importance of electrical power generation. Sources of energy available in nature. Conventional and non-conventional sources.
3	<b>Hydro power plant</b> -Factors to be considered for selection of site and Classify hydroelectric power plants based on the available head of water, plant capacity, load and construction.
4	General layout of hydro power plant and explain of its components. Meaning of water hammer and its effect.
5	Advantages and Disadvantages of Hydroelectric power plant. Environmental Impact of Hydel power plant
6	<b>Thermal power plant</b> - Factors to be considered for selection of site. General layout of thermal (steam) power plant.
7	Working of thermal power plant. Advantages and disadvantages of Thermal power plant. Environmental Impact of Thermal power plants
8	<b>Activity based Learning</b> on Hydroelectric and Thermal power plant
<b>Unit-II</b>	<b>Nuclear, Diesel and Gas turbine power plants</b>
9	<b>Nuclear power plant</b> -Factors to be considered for selection of site and Schematic diagram of nuclear power plant.

Session No.	Contents
10	Construction and working of Nuclear power plant.
11	Nuclear power plant impacts such as Health physics, nuclear wastes and nuclear waste disposal. Comparison between thermal power plant with nuclear power plant.
12	<b>Diesel power plant</b> -Schematic diagram of a Diesel generator unit and main components. Advantages and Disadvantages of Diesel power plant
13	<b>Gas turbine power plant</b> - Schematic diagram of a Gas turbine power plant. Advantages and Disadvantages of Gas turbine plant
14	<b>Activity based Learning</b> on Nuclear, Diesel and Gas turbine power plants
<b>Unit-III</b>	<b>Solar photovoltaic system and Wind Power plant</b>
15	Photovoltaic effect, solar power, Construction of solar cell, solar photovoltaic module with block diagrams.
16	Construction of photovoltaic panel and PV array with block diagrams. Materials used in solar cells and Solar cells Applications.
17	Classification of solar photovoltaic systems.
18	Stand-alone and grid interactive solar PV system with block diagram
19	Advantages and disadvantages of PV systems and environmental impacts of solar PV system on environment.
20	Importance of Wind Energy. Explain the origin of Global and local winds.
21	Factors affecting distribution of wind energy on surface of the earth. Factors to be considered for site selection.
22	Nature of winds with neat sketches.
23	Classification of wind turbine generator, Comparison between horizontal axis and vertical axis wind turbine generator Environmental Impact of wind plants.
24	<b>Activity based Learning</b> on Solar PV system and Wind Power plant
<b>Unit-IV</b>	<b>Biomass Power, Fuel cell and Hybrid PV systems</b>
25	<b>Urban waste to energy conversion</b> - Block diagram municipal solid waste (MSW) to energy incineration plant.
26	<b>Bio Energy</b> -Describe biomass and sources, conversion process. Importance of biomass energy and its scope. Factors to be considered for site selection. Line diagram of biomass power plant. Benefits of biomass. Biomass briquetting

Session No.	Contents
27	Bio fuels, electricity generation using biomass. Biogas plants, mention types of biogas plants.
28	<b>Chemical Energy source:</b> fuel cells, working of fuel cells, classification, applications
29	Hybrid PV systems-Types of hybrid PV systems.
30	Block diagram PV-Wind hybrid system and, PV-fuel cell hybrid system.
31	<b>Activity based Learning</b> on Biomass Power, Fuel cell and Hybrid PV systems
<b>Unit-V</b>	<b>Economics of Power Generation</b>
32	Related terms: connected load, firm power, cold reserve, hot reserve, spinning reserve.
33	Base load and peak load plants; Load curve, load duration curve, integrated duration curve
34	Cost of generation: Average demand, maximum demand, demand factor, plant capacity factor, plant use factor, diversity factor, load factor and plantload factor.
35	Simple problems on Cost of generation
36	Choice of size and number of generator units, combined operation of power station.
37	<b>Activity based Learning</b> on Economics of Power Generation
<b>Unit-VI</b>	<b>Basics of Transmission and Distribution</b>
38	<b>Transmission:</b> AC transmission and distribution system with typical Single line diagrams with components of the electric supply transmission and distribution systems.
39	Classification of transmission lines: Primary and secondary transmission; standard voltage level used in India
40	Classification of transmission lines: based on type of voltage, voltage level, length and others, Characteristics of high voltage for power transmission.
41	HVDC transmission lines-block diagram, list and explain the functions of main components of HVDC transmission system
42	<b>AC Distribution:</b> Components classification, requirements of an ideal distribution system, primary and secondary distribution system.
43	Connection schemes of distribution system- radial, ring main and interconnected systems. Distinguish between Feeder, distributor and service main.
44	Substation and receiving station and their functions, Classification of substations.
45	Single Line diagram (layout) of 66/11KV Substation, Symbols and functions of their components.
46	Single Line diagram (layout) of 11KV/400V Sub-Station Symbols and functions of their components.

Session No.	Contents
47	Causes and Impact and reasons of Grid system fault: State grid, national grid, brownout and black out, Sample blackouts at national and international level
48	Explain Black start Restoration
49	Explain Demand side Management
50	Functions of Load Dispatch Centre
51	Functions of Power Generation and Distribution Companies Different electric distribution companies and their functions (BESCOM, MSCOM, HESCOM etc.)
52	<b>Activity based Learning</b> on Basics of Transmission and Distribution
	<b>TOTAL</b>

## SUGGESTED LEARNING RESOURCES

### Reference Books:

Principles of power system by V.K.Mehta and Rohit Mehta S.CHAND
Generation of Electrical Energy, by B.R.Gupta, publisher S.chand& company LTD, New Delhi
Electrical Power Generation, Transmission and Distribution. - S.N.Singh. PHI Publications.
Elements of power station design-M V Deshpande-PHI Publications
Power Plant Engineering - A. K. Raja, New Age International Publisher
Generation Distribution and Utilisation of electric energy by C.L. Wadwa, -New-Age International Publisher
Non-conventional Energy Resources - G.S.Sawhney, PHI publications, second Printing- 2014, Delhi-110092.
Non-conventional Energy Resources-B.H.Khan 2 <sup>nd</sup> Edition Tata McGraw hill PVT, New-Delhi.
Solar photovoltaic Technology and systems, - Chetan Singh Solanki, PHI, Delhi-110092.
Generation of Electrical Energy, by B.R.Gupta, publisher S.chand& company LTD, New Delhi
Transmission, distribution and utilization – vol 3 B.L Thereja and A.K.Theraja.
Transmission and Distribution of Electric Power by J.B Gupta Katsons Publications.
Energy Management by Dr. Umesh Rathod, Katson publications

## E-resources:

1. [https://en.wikipedia.org/wiki/Electricity\\_generation](https://en.wikipedia.org/wiki/Electricity_generation).
2. <https://www.google.com/phindia.com//solarphotovoltaics>.
3. <https://www.schandgroup.com>.
4. <https://www.tatamcgrawhill.com>
5. <https://www.youtube.com/watch?v=daeyoS-PCUA> (Generation, distribution and transmission of electrical power)
6. <https://www.youtube.com/watch?v=IdPTuwKEfmA> (Thermal power plant)
7. <https://www.youtube.com/watch?v=zcWkEKNvqCA> (Gas turbine power plant)
8. <https://www.youtube.com/watch?v=-hooifWJ1jY> (Hydroelectric power plant)
9. <https://www.youtube.com/watch?v=bQ23kCvokAc> (Nuclear power plant)
10. [https://www.youtube.com/watch?v=eAX\\_fK\\_c8Mc](https://www.youtube.com/watch?v=eAX_fK_c8Mc) (Diesel power plant)
11. <https://www.youtube.com/watch?v=ZLgOoMSIS3Y> (Solar)
12. [https://www.youtube.com/watch?v=qSWm\\_nprfqE](https://www.youtube.com/watch?v=qSWm_nprfqE) (wind)
13. <https://www.youtube.com/watch?v=VkTRcTyDSyk> (Tidal)
14. <https://www.youtube.com/watch?v=sZuc4LMtHoY> (Wave)
15. <https://www.youtube.com/watch?v=OL26yYFmDHU> (Ocean thermal)
16. <https://www.youtube.com/watch?v=3UafRz3QeO8> (Biogas)
17. [https://www.youtube.com/watch?v=nV117JLn\\_u0](https://www.youtube.com/watch?v=nV117JLn_u0) (Biomass)
18. <https://www.youtube.com/watch?v=bXHwnKMchkk> (Fuel cell)
19. <https://www.youtube.com/watch?v=qjY31x0m3d8> (Transmission lines)
20. <https://www.youtube.com/watch?v=WUHcVXjfsxs> (Transmission and distribution)
21. [https://www.youtube.com/watch?v=R\\_HGnc63QKU](https://www.youtube.com/watch?v=R_HGnc63QKU) (Power blackout)
22. <https://www.pbs.org/wgbh/nova/labs/lab/energy/1/1/> ( Alternative energy )
23. We have to create interest among the students through Activity-Based Learning (ABL)
24. Classroom activities will give simultaneous benefits to both students as well as for teachers (students can overcome the difficulty in learning typical course, teachers can deliver a topic in a variety of approaches effectively).
25. Collaborative learning among students will create a healthy learning environment and also emphasize student's performance, teamwork.
26. Any student tries to identify a solution for a given problem but, through collaborative learning with a group of people will give an **optimized** solution to the same **problem**.



## ACTIVITY BASED LEARNING:

In order to develop **higher order thinking skills**, it is important to conduct lessons using **activity- based teaching**.

<b>Activity Based Learning Suggested Activities in Class</b>	
<b>1. Identification of Topic (IOT):</b>	<ul style="list-style-type: none"><li>• The objective of this activity is to identify, recollect the technical words.</li><li>• Identification of topic names /part name, parts of an apparatus, a mistake in the content in given image.</li></ul>
<b>2. Word search:</b>	place technical words, components names of in the 12 x 12 table in various directions (left to right, right to left, top to bottom, bottom to top, diagonally from top to bottom and diagonally bottom to top from both sides (left, right)). The objective of this activity is to search technical words in the course.
<b>3. Mind map:</b>	Students have to draw a variety of mind maps by interfacing power system topics with aspects of societal, environment, etc. By these mind maps students elevated power system concepts in a different approach, so that they can remember the concepts for a long time. <ul style="list-style-type: none"><li>• <a href="https://creately.com/diagram/example/i08rf3b52/Mind%20Map%20of%20Hydroelectric%20Dam">https://creately.com/diagram/example/i08rf3b52/Mind%20Map%20of%20Hydroelectric%20Dam</a>.</li><li>• <a href="https://durofy.com/mind-map-energy-resources">https://durofy.com/mind-map-energy-resources</a></li><li>• <a href="https://www.brighthubengineering.com/power-plants/17353-electricity-generation-in-power-plants/">https://www.brighthubengineering.com/power-plants/17353-electricity-generation-in-power-plants/</a></li></ul>
<b>4. Mapping/Scratch Cards:</b>	Prepare various quiz questions cards, answers cards, and scratchcards. Separate, question cards on the left side, answer cards on the right side and asked batch- wise to map question cards with answer cards. <a href="https://www.essentialenergy.com.au/ext/electricity-and-safety-unit/assets/documents/Lesson%204%20-%20Practical%20-%20Generation%20and%20movement%2011.pdf">https://www.essentialenergy.com.au/ext/electricity-and-safety-unit/assets/documents/Lesson%204%20-%20Practical%20-%20Generation%20and%20movement%2011.pdf</a>
<b>5. Crossword:</b>	create a cross on any of the topics of the course using online resources : <a href="https://wordmint.com/public_puzzles/182138">https://wordmint.com/public_puzzles/182138</a> Students have to draw various types of power plants that are exploring their creativity
<b>6. Preparing Posters/ chart:</b>	students have to prepare posters/ charts on various topics of power system and present in the class.

## **7. Energy games**

### **Energy Island game**

<http://siemens.zincmediadev.com/energy/island/index.html> Game

**on wind and Solar Power Generation**

<https://climatekids.nasa.gov/power-up/>

**Game on Solar Power Generation**

<https://wonderville.org/asset/solarenergydefenders>

**Game on wind , Solar Power, Hydel and Geothermal Generation**

<https://wonderville.org/asset/save-the-world>

**Game on Generation, Transmission and Distribution**

<http://www.hydroquebec.com/games/network/flash.html> Mange

**Virtual power Plant and prevent blackout**

<https://www.next-kraftwerke.com/virtual-power-plant-vpp-simulation/?lang=en> Game on

**Power GRID**

<https://gamejolt.com/games/powerthegrid/306616> Game on

**Design Renewable future**

<https://www.pbs.org/wgbh/nova/labs//lab/energy/research> Game on

**Energy City**

[https://assets.jason.org/resource assets/8239/3733/popup.html](https://assets.jason.org/resource/assets/8239/3733/popup.html)

**8. Case Studies:** Through this activity, students will get to know about problems/issues which are happening/happened in the Power System sector.

# Transmission and Distribution

Subject code -EEE302

## 1. Rationale:

Electric power transmission is the bulk movement of electrical energy from a power plant, to an electrical substation. Transmission network is the interconnected lines which facilitate this movement. Efficient transmission involves reducing the currents by stepping up the voltage prior to transmission, and stepping it down at a substation at the far end. Electric power distribution is the final stage in the delivery of electric power, it carries electricity from the transmission system to individual consumers through distribution substation. An Electrical Technician shall have the knowledge of the various T&D systems, components of the T&D systems and constructional features, simulate its performance, losses, distribution line maintenance and substations and shall prepare an estimation using estimation software.

**2. Course Outcomes/Skill Sets:** On successful completion of the course, the students will be able to

CO-01	Conduct performance analysis of a given transmission and distribution lines in a real/ simulated environment
CO-02	Describe the procedure to install, test and maintain transmission & distribution lines.
CO-03	Prepare the list of equipment/materials with specifications to install a given transmission and distribution system.

## 3. Course Content

Week	CO	PO*	Lecture (Knowledge Criteria)	Tutorial (Activity Criteria)	Practice (Performance Criteria)
1	1	1,4	1. Vectorial representation of AC quantities. Represent vectors in Rectangular, Trigonometric and Polar forms, Convert Rectangular form into Polar form and vice-versa and problems on R to P and P to R. Arithmetic operations on vectors, problems	Refer Table 1	1. Measure active power, reactive power, apparent power and power factor in a single-phase/ three- phase circuit using appropriate measuring instruments. Ensure improvement of PF by use of capacitor in single-phase/three phase circuit.
			2. Concept of active power, reactive power, apparent power and power factor in AC circuit.		Introduction to simulation software

			calculate active, reactive, apparent power and power factor in a given single/ 3phase phase AC circuit.		1. Verify KCL and KVL using simulation software.
			3a. Explain KCL and KVL 3b. Explain Thevenin's and Superposition theorem, application of theorems.		
2	1	1,4	1. Various systems for power transmission and distribution: 2 wire AC, 3 wire AC and 3 phase 4 wire AC systems. -Simple Problems -Compare HVAC and HVDC system.	Refer Table 1	1. Simulate a given short transmission line-1
			<b>2. Line Constants and Performance:</b> -Classification of transmission lines based on distance. - Line constants -resistance, inductance and capacitance. -Short transmission line-equivalent circuit		2. Simulate a given short transmission line-2. Find i. Sending end active and reactive power ii. Receiving end active and reactive power. iii. Voltage regulation and Transmission efficiency. compare simulation results with calculated values. <b>Ref.7(6)</b>
			3. Vector diagram of a short transmission line. -Equations for receiving end voltage, efficiency, voltage regulation and power factor. - simple problems		
3	1	4	1. Skin effect, Ferranti effect transposition of conductor and its necessity.	Refer Table 1	1. Simulation of Ferranti effect. <b>Ref.7(7)</b>
			2. Corona: Phenomena, disruptive and visual critical voltages, corona loss. Advantages and disadvantages of corona. Methods of reducing corona.		2. Solve problems on Transmission and Distribution losses. <b>Ref.7(8)</b>
			3. Explain Transmission and Distribution losses. <b>Ref.7(9,10,11)</b>		
4	1	4	1. Main components of overhead transmission lines (Supports, Cross arms and Clamps. Insulators, Conductors., Guys and Stays., Fuses and Isolating Switches, Continuous Earth Wire etc.).	Refer Table 1	1a. Identify Different components of Overhead Transmission lines. 1b. Identify various conductors viz., All aluminium conductor (AAC), AAAC, ACSR conductor.
			2. Characteristics and applications of ACSR, AAC, AAAC conductors, types of ACSR and		2. Identify HT/LT line insulators • Install the shackle type insulator on HT overhead line • Install the pin type insulator on the LT overhead line.

			<p>their applications, compare ACSR, AAC, AAAC conductors. Insulators-suspension, Pin Type, Shackle Type, Disc Type, Guy Strain, Pins for Insulators.</p> <p>3. Guy Assembly, G.I. Wire, GO Switches, 11kV Cross-arms, L.T. Line Spacers, spacing between conductor, concept of length of span, sag on overhead line, Guarding, Types of Guarding.</p>		<ul style="list-style-type: none"> <li>• fasten jumper in cross-arm of pole with pin insulator</li> <li>• fasten the jumper in shackle type insulator</li> <li>• fasten the jumper in the suspension type insulator.</li> </ul>
5	1	4	<p><b>1. UNDERGROUND TRANSMISSION LINES:</b> -</p> <p>Classification of UG cables</p> <p>-General construction of a single core UG cable</p> <p>-Need of HT cables, advantages and disadvantages</p> <p>-Selection of HT and LT underground cable.</p> <p>2. Construction of PVC, Construction of 3 core XLPE cables</p> <p>-Advantages and Disadvantages of Underground Power Cable System.</p> <p>3. Scope of IS 7098-1 and IEC standards for various cables (IEC 60502-1, IEC 60502-2).</p>	Refer Table 1	<p>Comply with safety &amp; IE rules while working on LT/ HT cables.</p> <p>1a. Identify different types of HT/LT cables.</p> <p>b. Identify different parts of various underground cables.</p> <p>c. Select appropriate cable for given application.</p> <p>2a. Practice preparation of cables for termination and joining.</p> <p>b. Demonstrate termination kits and practice on terminations of LT/HT cables.</p> <p><b>Ref.7(21)</b></p>
6	1,2	2,4	<p>1. Methods of laying UG cables. Faults in UG cable. <b>Cable gland-</b> different types of cable gland, lug, types.</p> <p>2. Underground Cable Testing</p> <p>3. Bonding and grounding</p>	Refer Table 1	<p>1a. Identify various cable single and double glands. and lugs.</p> <p>b. Test the underground cables for open, short circuit &amp; ground fault and also check insulation resistance</p> <p>2. Demonstrate bonding and grounding of raceways, cable assembly and panels.</p>
7	1	4	<p><b>1.Substation:</b> Meaning of substation, Necessity of substation, classification, comparison between outdoor and indoor substation.</p>	Refer Table 1	<p><b>In grid map of Karnataka</b></p> <p>1a. Locate 765kV, 400kV, 220kV, 110kV &amp; 66kV Substations</p> <p>b. Locate 400kV, 220kV, 110kV &amp; 66kV transmission lines.</p> <p>c. Locate 400kV HVDC station and Transmission line.</p>

			<p>2. Code of practice related to substation. List the materials required for 66/11 KV substation with their specifications <b>Ref.7(23,24)</b></p>		<p>2a. Read and Interpret Single line/ Layout drawings with Equipment and Protection codes as per ANSI. 2b. Read and Interpret Layout drawings of 220kV, 110kV &amp; 66kV outdoor substations. Interpret various panel wiring drawings of substation equipment</p>
			<p>3.Capacitor banks, specifications and calculation. <b>Ref.7(17,18, 19)</b> selection of capacitor bank.</p>		
8	1	4	<p><b>Substation Energy meters:</b> - 1a. Error, precision, accuracy, sensitivity, resolution and tolerance. Types of errors- gross error, random error, systematic error environmental, observation error and instrumental error. 1b. Trivector energy meter Ref.7(12) -Common Meter Reading Instrument (CMRI) <b>Ref.7(14,15)</b> -Class of accuracy of energy meters.</p>	Refer Table 1	<p>1a. Demonstrate working of Trivector energy meter, Identify the class of accuracy of given energy meter. Ref.7(12)  1b. Practice on using MRI (Meter reading instrument)</p>
			<p>2. -Standards for electricity metering -Scope of <b>IS 15707</b> -Scope of <b>IEC 62052-11</b> -Distributed Digital Fault Recorder (DDFR). <b>Ref.7(16,17)</b></p>		<p>2a. Take meter reading by using USB / Optical cable.  2b. Operation of SBM (Spot billing machine).</p>
			<p>3.Maintenance and up keeping of daily Log Sheet at various Substation and energy accounting.</p>		
9	1	2,4	<p><b>1. Distribution System:</b> Single line diagram of AC distribution system, Classification of AC distribution system, connection schemes of distribution system- radial, ring main and interconnected systems.</p>	Refer Table 1	<p>Observe the various components of the <b>Distribution System</b> by visiting the MUSS and prepare report Obtain:</p>
			<p>2. Feeder, distributor and service main, characteristics of Feeder, distributor and service main.</p>		<p>1. Number of feeders connected 2. Energy consumption of each feeder 3. Number of DTC meters connected 4. Percentage of distribution losses 5. 11kV Feeders Interruption Details 6. Operation of 11 kV feeders supplying power to IP sets in open delta</p>
			<p>3.Concept of voltage drop in feeders/distributors - simple problem on DC distributor fed at one end.</p>		

10	1,2	2,4	<b>1. OPERATION OF 11KV/440V DISTRIBUTION SYSTEM-</b> -List Various components of the 11 kV power system (Components: e.g. transformers, Isolators, CTs, PTs, Circuit breakers, LA's, etc.) -List Various types of Panels & Substation protection systems	Refer Table 1	Observe the various components of the power system by visiting the 11 kV substation and prepare report 1. List the job requirements as per the government policies and regulations 2. Observe the various components of the power system by visiting the 11 kV substation (Identify various substation equipment viz., isolators, over current relays, earth fault relay, differential relay, REF relay, lightning arresters, Surge counter, wave trap, Reactor, Capacitor bank, Circuit breakers – ACB, SF-6 and VCB etc.) 3. List the materials required for the 11 kV installation 4. Observe the substation erection and installation work 5. Observe the operation of distribution transformer 6. Check the poles set to proper depth, and are properly aligned 7. Observe the erection of channel on the pole 8. Observe the fixing of lightning arrester 9. Check the installation of earth connection as per standard procedure 10. Observe the lifting Observe the lifting of the transformer, to put it on the transformer bed in a safe and efficient manner 11. Observe the connection of low voltage cables" 12. Identify Aerial bundled cables for LT and HT
			2a. Transformer parts and their function.		
			2b. Specific health and safety precautions which must be taken when carrying out substation installation processes		
			3. Construction of Aerial Bundled (AB) Cables, - advantages and disadvantages, - AB Cables for LT Lines. -, AB Cables for HT Lines		

11	2	2,4	<b>1.Maintenance schedule for distribution Transformer</b> a. Explain the terms inspection, preventive maintenance and overhaul. b. Explain recommended schedule for inspection of Distribution transformers. c. Explain recommended schedule for preventive maintenance of Distribution transformers. d. Explain recommended schedule for overhaul of Distribution transformers. <b>Ref 7(22)</b>	Refer Table 1	Visit the nearby substation prepare report on 1. Maintenance schedule for distribution Transformer 2. Maintenance schedule for 11kV overhead lines 3. Maintenance schedule for 11kV UG system as per standard format
			<b>2.Maintenance schedule for 11kV overhead lines</b> a. Explain recommended schedule for inspection of 11kV overhead lines b. Explain recommended schedule for preventive maintenance of 11kV overhead lines c. Explain recommended schedule for overhaul of 11kV overhead lines. <b>Ref 7(22)</b>		
			<b>3.Maintenance schedule for 11kV UG system</b> a. Explain recommended schedule for inspection of 11kV UG system b. Explain recommended schedule for preventive maintenance of 11kV UG system c. Explain recommended schedule for overhaul of 11kV UG system <b>Ref 7(22)</b>		
12	3	2,3	1. Prepare schedule of materials for providing single-phase OH and UG service connection for electrification of a residential building.	Ref table 1	Prepare estimation manually/ using estimation simulation software
			2.List the materials used in transmission lines with their specifications. Classify the types of towers. Prepare a table showing voltage level, ACSR conductor used,		



			number of discs insulators in suspension string and tension string		
			3. Prepare the schedule of materials for the 11 KV single circuit HT line for Rural Electrification."		
13	3	2,3	<p>Estimate for Electrification of newly formed Residential Layout to an extent of 1045 KW including street light, water supply and STP installations.</p> <p>1. Tapping and Extension 11KV line of (F-11) feeder of 66/11KV MUSS upto the Proposed Layout using Rabbit ACSR Conductor and 3*95 Sqmm XLPE HTUG Cable</p> <p>2. Extension 11KV line Inside the Proposed Layout using Rabbit ACSR Conductor</p> <p>3. Providing 11Mtrs Spun Pole Transformer Structure with allied Materials for erection of 3x250KVA and 1x100KVA 5 Star Rated Distribution Transformers on Concrete Bed.</p> <p>4. Extension of LT Overhead line (3 Phase, 5Wire) inside the layout Premises and Providing Street Light Metering.</p> <p>5. Calculate HT VR (voltage regulation) and LT VR.</p>		Prepare estimation manually/ using estimation simulation software
<b>Total in hours</b>			<b>39</b>	<b>13</b>	<b>52</b>

**Reference:**

Sl. No.	Description
1	Transmission, distribution and utilization – vol 3 B.L Thereja and A.K.Theraja.
2	Principles of Power System” by V. K. Mehta, Rohit Mehta S. Chand Publishers, 4th Revised edition 2008
3	Electrical Power Generation Transmission and Distribution by S.N.Singh, PHI Publication
4	Transmission and Distribution of Electric Power by J.B Gupta Katsons Publications.
5	Electric Power Distribution Automation by M.K Khedkar, University Science Press (Laxmi Publications)

6	<a href="https://www.youtube.com/watch?v=Knpt6zcK CU">https://www.youtube.com/watch?v=Knpt6zcK CU</a>
7	<a href="http://vp-dei.vlabs.ac.in/Dreamweaver/objective9.html">http://vp-dei.vlabs.ac.in/Dreamweaver/objective9.html</a>
8	<a href="https://www.easycalculation.com/physics/electromagnetism/electrical-power-transmission-line-power-loss.php">https://www.easycalculation.com/physics/electromagnetism/electrical-power-transmission-line-power-loss.php</a>
9	<a href="https://electricalnotes.wordpress.com/2014/03/01/calculate-technical-losses-of-distribution-line/">https://electricalnotes.wordpress.com/2014/03/01/calculate-technical-losses-of-distribution-line/</a>
10	<a href="https://blog.se.com/energy-management-energy-efficiency/2013/03/25/how-big-are-power-line-losses/">https://blog.se.com/energy-management-energy-efficiency/2013/03/25/how-big-are-power-line-losses/</a>
11	<a href="https://blog.se.com/access-to-energy/2018/06/29/effective-power-distribution-and-asset-monitoring-can-shelve-off-losses-in-transformer-services/">https://blog.se.com/access-to-energy/2018/06/29/effective-power-distribution-and-asset-monitoring-can-shelve-off-losses-in-transformer-services/</a>
12	<a href="https://instrumentationforum.com/t/working-principle-of-trivector-meter/6996">https://instrumentationforum.com/t/working-principle-of-trivector-meter/6996</a>
13	<a href="https://www.youtube.com/watch?v=ZP-Gv ERN7k">https://www.youtube.com/watch?v=ZP-Gv ERN7k</a> , <a href="https://www.youtube.com/watch?v=SgMhJQdVONQ">https://www.youtube.com/watch?v=SgMhJQdVONQ</a>
14	<a href="https://dhbvn.org.in/staticContent/tender/mm/specification/spec-cmri-453.pdf">https://dhbvn.org.in/staticContent/tender/mm/specification/spec-cmri-453.pdf</a>
15	<a href="https://www.youtube.com/watch?v=SgMhJQdVONQ">https://www.youtube.com/watch?v=SgMhJQdVONQ</a>
16	<a href="https://www.aimil.com/products/digital-fault-recording-systems">https://www.aimil.com/products/digital-fault-recording-systems</a>
17	<a href="https://www.gegridsolutions.com/multilin/catalog/ddfr.htm">https://www.gegridsolutions.com/multilin/catalog/ddfr.htm</a>
18	<a href="https://www.watelectrical.com/what-is-a-capacitor-bank-working-and-its-calculation/">https://www.watelectrical.com/what-is-a-capacitor-bank-working-and-its-calculation/</a>
19	<a href="https://www.gegridsolutions.com/hvmv-equipment/catalog/high-volt-capacitor.htm#Ov7">https://www.gegridsolutions.com/hvmv-equipment/catalog/high-volt-capacitor.htm#Ov7</a>
20	<a href="https://www.metartec.com/DataEditorUploads/R8%20-%20Capacitor%20banks%20and%20accessories.pdf">https://www.metartec.com/DataEditorUploads/R8%20-%20Capacitor%20banks%20and%20accessories.pdf</a>
21	<a href="https://www.youtube.com/watch?v=oKhKFALKDAE">https://www.youtube.com/watch?v=oKhKFALKDAE</a>
22	<a href="https://kptcl.karnataka.gov.in/storage/pdf-files/epra/mmdsystem.pdf">https://kptcl.karnataka.gov.in/storage/pdf-files/epra/mmdsystem.pdf</a>
23	<a href="https://kptcl.karnataka.gov.in/storage/pdf-files/epra/Maintenance%20Schedule.pdf">https://kptcl.karnataka.gov.in/storage/pdf-files/epra/Maintenance%20Schedule.pdf</a>
24	<a href="https://kptcl.karnataka.gov.in/storage/pdf-files/epra/HAND%20Book%20Of%20manintenance%20Schedule%20For%20Staions%20&amp;Transsion%20Lines.pdf">https://kptcl.karnataka.gov.in/storage/pdf-files/epra/HAND%20Book%20Of%20manintenance%20Schedule%20For%20Staions%20&amp;Transsion%20Lines.pdf</a>
25	Electrical Design Estimating and Costing. K.B.Raina & K.Battacharya. Khanna Publications
26	Electrical Installation Estimating and Costing. J.B.Gupta, S.K.Kataria and Sons

**9. Equipment/software list**

Sl. No.	Particulars	Specification	Quantity
1	Trivector energy meter		
2	Common Meter Reading Instrument (CMRI)		
3	Distributed Digital Fault Recorder (DDFR)		
4	SBM (Spot billing machine)		
5	Capacitor Banks		
6	GNU Octave/ SCI LAB /PSCAD /MATLAB software		
7	Electrical Estimation software		

## Switchgear and Protection

Subject code -EEE303

### 1. Rationale:

Electrical switch gears and protective devices are the main components of power systems in any type of industry like power sector, manufacturing, process industry, hospitals, hotels, commercial buildings etc. An electrical and electronics diploma graduate should be capable of testing, commissioning, troubleshooting and maintenance of the electrical switchgears and protection devices.

**2. Course Outcomes/Skill Sets:** On successful completion of the course, the students will be able to

CO-01	Demonstrate the operation and testing of a given switchgear.
CO-02	Select a switchgear for a given application and list the procedures for preventive maintenance of such a switchgear to ensure it performs optimally.
CO-03	Demonstrate the testing of a protection scheme for a given power system including all its elements (alternators, transformers, bus bars and feeders).
CO-04	Identify accessories of a control panel and demonstrate the testing procedure of a given LV control panel.

### 3. Course Content:

Week No.	CO	PO*	Lecture (Knowledge Criteria)	Tutorial (Activity Criteria)	Practice (Performance Criteria)
1	1	1,4	1. Meaning of Switch gear, Types-Indoor type and Outdoor type, Essential features of Switchgear, List most commonly used Switchgear equipment and Protective Devices for switching and interruption of current. Importance of power system protection and Necessity of Protective Devices.	Refer table 1	1. Identify various fuse sets viz., HRC, DO, 33KV fuse set, etc.
			2. Sources of Faults, Types of faults, Harmful Effects of short circuit current, Symmetrical and unsymmetrical faults on three-phase systems.		2a. Measure and select the appropriate size of fuse wire. 2b. Test the HRC fuse by performing a Load test.
			3. <b>Fuse</b> - Meaning, List the types of fuses with applications, Fuse Element Materials, Desirable features of Fuse elements, Characteristics of fuse. Important Terms: Current Rating of Fuse element, fusing current, fusing factor, Prospective current, cut off current, Pre-Arcing Time, Arcing Time,		

			<p>Breaking Capacity, Total Operating Time.</p> <p>HRC fuses –list the types and applications, general construction and working, Merits and demerits.</p>		
2	1	1,2,4	<p><b>1.Circuit Breaker</b> – Meaning, Classification of Circuit Breakers, list the types -LV, HV types with applications. Explain the terminologies – Circuit Breaker Rating, Arc-Voltage, Arching Time, Pre – Arcing Time, Prospective Current, TRV, Recovery Voltage, RRRV, Total Break Time, Making current, Breaking current, Short circuit rating and Short-time current rating.</p>	Refer table 1	<p>1a. Identify the various types of CB- MCB, ELCB, RCCB, MPCB and MCCB. Trace and locate MCBs used in your institution and note down their specifications.</p> <p>1b. Dismantle MCCB/ELCB and identify various parts.</p> <p>1c. Test the MCB and plot its inverse time characteristic curve.</p>
			<p>2.Construction, working principle and applications of ELCB, RCCB, MCCB and MPCB.</p> <p>Concept of <b>ACCL</b> (automatic changeover with current limiter).</p>		
			<p>3.MCB- Types, Classification based on trip curves and their application, General construction and working, Characteristics of MCB.</p>		<p>2a. Troubleshooting and servicing of LT circuit breaker.</p> <p>2b. Test any commercially available <b>ACCL</b>.</p>
3	1,2	1,2,4	<p>1.HV Circuit Breaker- working concept. ACB- Working principle, Construction, Merits, Demerits &amp; Applications.</p>	Refer table 1	<p>Visit to Substation.</p> <p>1a. Identify the parts of circuit breaker and check its operation.</p> <p>1b. Demonstrate test tripping characteristic of circuit breaker for over current and short circuit current.</p>
			<p>2.VACUUM CB- Working principle, Construction, Merits, Demerits &amp; Applications.</p>		<p>2a. Demonstrate Installation operation and maintenance of SF6 circuit breaker, Vacuum circuit breaker.</p>
			<p>3.SF6 CB- Working principle, Construction, Merits, Demerits &amp; Applications.</p> <p>Concept of RMU (Ring main unit) and LBS (Load Break Switch)</p>		<p>2b. Carry out timer test on circuit breakers.</p> <p>2c. Demo on RMU</p>
4	1	1,4	<p><b>1.Protective Relay</b>- Definition, Types of relays, Classification of protective relaying with applications, Meaning of Primary and Back up protections, Desired qualities of Protective Relaying, General Features of protective relays.</p> <p>Important Terms: pick up VA, Hold-on VA, drop out VA and Burden</p> <p>Pickup current, current setting, PSM, TSM, Time -PSM Curve.</p>	Refer table 1	<p>1a. Demonstrate various parts of the relay and ascertain the operation.</p> <p>1b. Demonstrate setting of pick-up current/ time setting multiplier for relay operation. Ref.7(7)</p>
			<p>2.Construction. Working principle and application of Earth Leakage relay.</p> <p>Meaning of ZCT (Zero-Phase Current</p>		<p>2a. Test the Earth Leakage Relay. (Anyone type).</p> <p>2b. Test the</p>

			Transformers), <b>CBCT</b> (Core balance CT) - construction, working and application.		Electromechanical over current OR <b>over</b> voltage relay.
			3. Construction. Working principle and application of Induction type Electro-mechanical Over Current and Overvoltage Relays. Merits and Demerits of Electro-Mechanical relays. List and explain different Testing Methods for Relays		
5	1	1,4	1a. Block diagram and working of Microprocessor/ Microcontroller based Overcurrent Relay. 1b. Causes of over voltages and under voltages, Effects of OV/UV.	Refer table 1	1. Test the Static Over Voltage and Under Voltage Relay and Plot its inverse time – Voltage Characteristics. OR 1. Test static Over Current Relay (Any type of static relay).
			2a. Construction, working and application of Static relays- OV/UV relay and OCR relay. 2b. Lightning arresters & surge absorbers - Construction and principle of operation.		2a. Program and test the Numerical Over Current/ Earth Fault Relay for Normal inverse curve for various PSM and TMS and for definite Time operations. 2b. Demonstrate multifunction numerical relays.
			3a. Construction, working and applications of Numerical Relays. Comparison of Static Relays with Electro-Magnetic Relays and microprocessor/microcontroller-based relays. 3b. Concept of Multifunction Protection numerical Relays.		
6	3	1,4	<b>Transformer protection:</b> 1a. Explain Abnormalities & List different types of Faults. 1b. Construction and working of Circulating Current Scheme for Transformers Protection. Ref.7(10)	Refer table 1	1. Test the operation of Buchholz Relay.
			2a. Construction and working of Earth Fault or Leakage Protection Systems for Transformer. 2b. Construction and working Stator Inter Turn Protection for transformers.		2a. Conduct BDVT on Transformer oil. 2b. Demo on Restricted earth fault protection of Transformer.
			3a. Construction and working of Buchholz Relay. 3b. Transformer oil – Electrical properties, desired properties and applications of Transformer oil , BDVT.		
7	3	1,4	1. Alternator Protection-Types of Protection, Explain Abnormalities and List different types of Faults.	Refer table 1	Simulate/Test Alternator protection scheme.
			2. Construction and working of Differential protection for Alternators.		

			3.Construction and working of Balanced Earth Fault Protection for Alternators.		
8	3	1,4	<b>Feeder Protection:</b> 1a. Explain abnormalities and list different types of Faults. 1b. Time Graded Over Current Protection on transmission line.	Refer table 1	1.Simulate/Test the operation Distance Relay.
			2a. Construction and working of Differential Pilot – Wire Protection. 2b. Discuss Basic principle of Distance Protection.		2.Simulate/Test the operation of Differential Relay.
			<b>Bus–Bar Protection:</b> 3a. Explain Abnormalities & List different types of Faults. 3b. Construction and working of Differential Protection of Bus -Bars.		
9	1,3		1.List Testing methods of Circuit Breaker, Explain type test and routine test & maintenance.	Refer table 1	1.Test the operation of the LV circuit breaker.
			2.List & Explain Testing methods of CT's & PT's and Maintenance of Relays.		2. Demonstrate Substation earthing.
			3.Explain Substation Earthing (Solid, Resistance and Reactance Earthing), - Neutral Earthing-Importance and types -Explain Principle and applications Peterson coil.		
10	4	2,3,4	1.Control Panel –Meaning, Types/various forms, construction of typical control panel. <b>Power gears-</b> Isolators, SFU (switch fuse unit), change over switch, selector switch.	Refer table 1	Typical low voltage power distribution panel- Identify and study the types of contactors- Power contactors and auxiliary contactors. Dis-assemble, perform preventive maintenance, service, assemble and test the contactors. Testing of control panel a. Visual test b. Insulation test c. Testing of control circuit. d. Testing of power circuit e. Conduct Logic tests
			2.Contactors – types, configuration and their specifications, various control accessories like PB switches, Indicators.		
			3.Explain various sections of control panel- Incoming section, outgoing section, busbar section.		
11	4	4	1. <b>Metering section</b> – Energy meter, Trivector meter, multi-function meter.		1.Install and test Multifunction meter.
			2. <b>Various auxiliary relays:</b> lockout, DC failure relay, TCS (trip circuit supervision relay), contact multiplier relay. -Safety interlocks.		2a. Identify and test various Auxiliary relays 2b. Demonstrate(video) Interlocking operation.
			3.Significance and importance of: IEC 61439 standards ANSI Device numbers		

12	1,4	4	1.Motor Control Centre (MCC): working, typical specification and application: Motor protection relay		1.Test the Motor Protection Relay.
			2a. Working, typical specification and application: Thermal Overload Relays 2b. Working, typical specification and application: Bimetal Relays -Direct / CT operated.		2.Test the operation of Thermal OLR
			3.Scope of IEC standard IEC 60947-4-1		
13	4	4	1.APFC (Automatic power Factor Control panel) - construction and working.		1.Test the operation of APFC.
			2.AMF (Automatic mains failure) panel - Construction and working.	2.Test the operation of AMF panel.	
			3.STP (Standard Temperature Pressure Control) panel- Construction and working.		
Total in hours			39	13	52

#### Reference:

Sl. No.	Description
1	Principles of Power System" by V. K. Mehta, Rohit Mehta S. Chand, 4th revised edition 2008
2	Power System Protection and Switchgear by Buvanesh A Oza, Nirmalkumar C Nair, Rases P Mehta and Vijay H Makwana, McGraw HILL Education (India Pvt. Ltd) Newdelhi
3	J.B.Gupta "Switchgear & Protection", (edition), Katson Publisher,2008
4	MadhavaRao T.S., 'Power System Protection - Static Relays', McGraw Hill, New Delhi,2nd Edition, 21st reprinted, 2008.
5	Handbook of Switchgears by BHEL
6	Testing, commissioning, operation and maintenance of electrical equipment by Sunil S Rao, Khanna Publications
7	<a href="#">Protection relay: Power system protection - YouTube</a>
8	<a href="#">Transmission Line Protection (21) - YouTube</a>
9	<a href="#">Restricted Earth Fault Protection REF relay working principle - YouTube</a>
10	<a href="#">TRANSFORMER PROTECTION ELECTRICAL TECHNOLOGY AND INDUSTRIAL PRACTICE - YouTube</a>
11	<a href="#">MOTOR PROTECTION PROTECTION OF INDUCTION MOTOR ELECTRICAL TECHNOLOGY AND INDUSTRIAL PRACTICE - YouTube</a>
12	<a href="#">Bus Bar Protection Busbar Differential Protection How busbar is protected - YouTube</a>
13	<a href="#">Directional Over current relay Protection of parallel lines Directional over current protection - YouTube</a>
14	<a href="#">Distance Protection Transmission Line Protection Impedance protection Protection of line - YouTube</a>
15	<a href="#">Differential protection in power transformer - YouTube</a>
16	<a href="#">Protection of transformer - YouTube</a>
17	<a href="#">Differential protection - YouTube</a>
18	<a href="#">Transformer Differential Protection: Challenges and Solutions - YouTube</a>
19	<a href="#">GENERATOR PROTECTION PART 1 GENERATOR CONNECTION GENERATOR EARTHING GENERATOR FAULTS - YouTube</a>
20	<a href="#">Earth Leakage Relay - ELR / How to Wire ELR &amp; CBCT with MCCB / Working Principle of ELR - YouTube</a>
21	<a href="#">Over current relay CDG 31 - YouTube</a>



22	Smart WiFi Circuit Breaker Automatic Remote-Control Protection for Solar and any other appliances <a href="https://www.youtube.com/watch?v=m1r-78m51ds">https://www.youtube.com/watch?v=m1r-78m51ds</a>
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### Equipment/software list

Sl. No.	Particulars	Specification	Quantity
1	Different types of fuses (kit-kat fuse, cartridge fuse, glass fuse etc.) (For identification experiment)		
2	Single pole MCB	6 A ,220 V	
3	Single-phase ELCB	6A ,220 V 30 mA	
4	MCCB (for study / identification experiment only)	125 A 415V	
5	MPCB (Motor Protection Circuit Breaker) of any low current rating (for study / identification experiment only)	3 Phase 415 V	
6	Automatic changeover with current limiter (ACCL)		
	Air circuit breaker		
8	DPST and SPST knife switches or 2 pole, 3way, 6A selector switch		
9	DPST and SPST knife switches or 2 pole, 3way, 6A selector switch	10A or 16 A or 32 A, 415 V	
10	3 phase auxiliary contactor - any model with 2NO + 2 NC.	10 A , 415 V	
11	Single-phase Auto transformer	Single-phase Auto transformer	
12	Transformer (for voltage injection purpose)	240V/500V	
13	Transformer (for current injection purpose)	240V/24V, 20A	
14	Rheostats	45ohms 8.5 A, 100 ohms 5 A, 300 ohms 2.5 A	
15	Thermal Overload Relay	3 Phase 415 V, 0-4.5 or 0-6 A or 0-10 A	
16	Motor Protection Relay	3 HP, 3 Ph Induction Motor.	
17	Digital Time Interval Meter (Digital stop watch may also be used as alternative)	0-999 ms, 0-99.9 sec, 0-99.9 min	
18	Single-phase preventer (phase failure relay)		
19	Lock out relay with 2 NO and 2 NC (any low rating model).		
20	Electro-mechanical Relay Trainer Kit or module with 4 mm banana pin sockets and patch cords. (TYPE - Over Load Relay or Over Voltage Relay or Under Voltage Relay or Earth Fault Relay)		
21	Static Relay (OLR or OVR or UVR or EFR – ANY ONE) Trainer Kit or module with 4 mm banana pin sockets and patch cords.		
22	Numerical relay or Digital relay (OLR or OVR or UVR or EFR – ANY ONE)-Trainer Kit or module with 4 mm banana pin sockets and patch cords.		
23	Buchholz Relay		
24	AUX. Current source / current injection kit suitable for the above trainer kits with 4 mm banana pin sockets and patch cords.	15A	

25	AUX Voltage source / voltage injection kit suitable for the above trainer kits with 4 mm banana pin sockets and patch cords.	220 V AC /110 V DC	
26	Fuse and MCB testing- trainer kit		
27	P-spice/ GNU-Octave/MatLab		
27	Multifunction meter		
28	Trivector meter	3- phase	
29	TCS(trip circuit supervision relay 24/30/48 V DC 110-125/220-250 V DC/AC		
30	Lock out Relay		

## Analog and Digital Electronics

Subject code -EEE304

### 1. Rationale:

Analog Electronic circuits are used to amplify, process and filter analog signals which are continuously variable, using amplifiers, Oscillators, switching circuits, operational amplifiers etc. Digital electronic circuits are usually made from large assemblies of logic gates. This digital logic circuitry is based on a binary system which has only two voltage levels, Low and High viz., Digital computers. Any intelligent electronic system is built by a combination of analog and digital circuits hence, it is imperative for any aspiring Technician to acquaint with the concepts of analog and digital electronics.

### 2. Course Outcomes/Skill Sets: *On successful completion of the course, the students will be able to*

CO-01	Identify the components of a given electronic circuit, list the uses and characteristics of the components and test the components to ensure they are in working condition.
CO-02	Use datasheets to list the alternative electronic components for a given electronic circuit ensuring the results/output remains the same.
CO-03	Build an electronic circuit for a given application and demonstrate its working either in real or a simulated environment.
CO-04	Test a given circuit for desired result/outcome, identify the problem and troubleshoot to obtain the desired result/output.

### 3. Course Content

Week	CO	PO*	Lecture (Knowledge Criteria)	Tutorial (Activity Criteria)	Practice (Performance Criteria)
1	1	1,4	<b>ANALOG ELECTRONICS</b> 1.Passive components (Resistor, Inductors and capacitors): Introduction, symbols, units, types/classification, identification, selection and applications.	Refer Table 1	1a. Identify the different types of resistors. 1b. Measure the resistor values using colour code and verify the reading by measuring in the multimeter. 1c. Identify the power rating of carbon resistors by their size 1d. Identify different inductors and measure the values using LCR meter. 1e. Identify the different capacitors and measure capacitance of various capacitors using LCR meter.

			<p>2.Semiconductors: Meaning, list semiconductor materials (Si, Ge,GaAs). -list characteristics of semiconductors. -Draw covalent bond diagram: Si, Ge, GaAs -Intrinsic Semiconductors-Two types of flow (free electrons &amp; holes) Ref 7(1)</p>		<p>2a. Preparation of components, use of soldering iron and lead and flux. 2b. Standard Soldering practice to connect the components on base-board /PCB/assembly board (follow soldering standard).</p>
			<p>3.Doping a Semiconductor- Explain two types of Extrinsic Semiconductors (n-type and p-type). -concept of majority carrier and minority carriers. -Diode- formation, depletion region. Ref7(1)</p>		
2	2,3	1,4	<p>1. Diode-VI Characteristics, types, ratings and applications. Zener diode- reverse bias characteristics, voltage Regulation, shunt voltage regulator and their applications.</p>	Refer Table 1	<p>1a. Study and interpret data sheets of diodes and Zener diodes. 1b. Execute testing of given diode using multimeter and determine forward to reverse resistance ratio. 1c. Construct and test Zener based voltage regulator circuit.</p>
			<p>2.Bipolar Junction Transistors (BJT): Structure, Types, symbols, Construction, operation of (NPN/PNP) transistors. BJT Configurations, Transistor currents, alpha, beta and relationship between alpha and beta.</p>		<p>2a. Identify different transistors with respect to different package type, B-E-C pins, power, switching transistor, heat sinks etc b. Obtain output characteristics of BJT in CE configuration in physical mode. <b>OR</b> Simulate output characteristics of BJT in CE configuration <b>Ref.7(6)</b></p>
			<p>3. CE input and output characteristics- cut off, saturation, and active regions. -Transistor biasing- definition, importance, list types. - Explain Voltage divider bias. Transistor as a switch in CE mode. -Stabilisation, thermal runaway, heat sink. <b>Ref.7(7).</b></p>		
3	1,3	1,4	<p>1. FET- types. MOSFET- definition, types, symbols, N type enhancement mode- construction, working, MOSFET characteristics</p>	Refer Table 1	<p>1a. Identify terminals of a MOSFET and test. b. Obtain output characteristics of MOSFET in physical mode. <b>OR</b> Simulate output characteristics of MOSFET.</p>
			<p>2. MOSFET as switch, ratings.</p>		<p>2.Construct and test MOSFET application circuit (MOSFET as a switch)</p>

			3. List applications of MOSFET, Differentiate between BJT and MOSFET		
4	3,4	1,4	1. Rectifiers- half wave, centre tapped FWR, efficiency, ripple factor, PIV. Filters- definition, necessity, C and PI filters.	Refer Table 1	1a. Identify the different types of fixed +ve and –ve regulator ICs and the different current ratings (78/79 series) 1b. Build +5V 1A DC Power Supply. <b>OR</b> Build +12V 1A DC Power Supply <b>Ref.7(8,9,10)</b>
			2. Regulated power supply- block diagram and applications. Regulator- working of 7805, mention operating voltages of 7809, 7812, 7905, 7912 Op-amp regulator, 723 regulators (Transistorized & IC based).		2a. Identify different heat sinks for IC based regulators b. Identify the parts, trace the connection and test the DC regulated power supply with safety. c. Troubleshoot and service a DC regulated power supply.
			3. Testing and Troubleshooting of Regulated Power Supply. <b>Ref.7(11,12)</b>		
5	1,3	1,4	1. Working of LED, IR LEDs, Photodiode, photo transistor and their characteristics and applications. Opto-couplers, circuits with Opto-Isolators. LASER diodes-characteristics and applications.	Refer Table 1	1a. Identify the different types of LEDs and IR LEDs. 1b. Identify optocoupler input/output terminals and measure the quantum of isolation between the terminals 1c. Construct a circuit to switch lamp load using phototransistor
			2. Amplifier- faithful amplification, classification based on configuration, power, and frequency		2. Construct and test a common emitter amplifier with and without bypass capacitors. <b>Ref.7(13)</b>
			3. Transistor CE amplifier with biasing, Working of Push pull amplifier.		
6	1,3	1,4	1. OPAMP– block diagram, operation, Characteristics, applications, $\mu A$ 741 pin diagram.	Refer Table 1	1. Construct and test OP AMP as a Summer. Use an Analog IC tester to test the Analog ICs.
			2. OPAMP applications– inverting, differentiator. Integrator, summer, voltage follower, and comparator.		2. Construct and test Astable timer circuit using IC 555. Construct and test mono stable timer circuit using IC 555. <b>Ref.7(14)</b> Use an Analog IC tester to test the Analog ICs
			3. Timer– block diagram, pin diagram of IC 555, duty cycle, time-delay, Applications, A stable and Monostable multi-vibrators using IC 555.		
7	3	1,2	<b>DIGITAL ELECTRONICS</b> 1. Definitions- bit, nibble, byte, word, and parity bit. Number system- definition, types, radix, decimal, BCD, binary and hexadecimal.	Refer Table 1	1. Solve problems on number system

			<p>2. Binary number system, Binary arithmetic: addition, subtraction, multiplication and division Complements: 1's, 2's.</p> <p>3. Hexadecimal- addition, subtraction, Conversion- decimal to binary, decimal to hexadecimal</p>		2. Solve problems on conversion.
8	3	1,2,4	<p>1. Boolean variable, complement, Boolean function, expression, truth table. Boolean Algebra- rules and laws. <b>Ref.7(15)</b></p> <p>2. Logic gates NOT, AND, OR- definition, symbol, Boolean equation, truth table and working. Logic gates NAND, NOR, EX-OR- definition, symbol, Boolean equation, truth table and working. De Morgan's theorems- statement and equations</p> <p>3. Karnaugh's map up to three variables- Simplification and drawing logic diagrams.</p>	Refer Table 1	<p>1. An electronic telephone exchange is being powered by a normal power supply. However, looking at the criticality of the exchange, a power backup generator is also installed, which can supply power in case of power failure. An alarm circuit is to be designed. There will be two LEDs (one green and the other red) on the front panel of the exchange, such that the green LED glows when power supply is available. In case of failure of power supply, the exchange draws its power from a generator, and in this case, the green LED goes OFF and the RED LED glows. In case, the generator also goes down, both green LED and red LED go OFF and a buzzer starts ringing indicating that there is a major failure. Design and implement this control circuit for both the LEDs and the buzzer.</p> <p>2. Akshay's Automated Cafeteria orders a machine to dispense coffee, tea, and milk. Design the machine so that it has a button (input line) for each choice and so that a customer can have at most one of the three choices. Diagram the circuit to ensure that the "at most one" condition is met. Implement the Circuit</p>
9	1,3	1,4	<p>1. COMBINATIONAL LOGIC CIRCUITS- Half adder- block diagram, logic diagram using AND and XOR, truth table and working.</p> <p>2. Full adder- block diagram, logic diagram using AND, OR and XOR, truth table and working.</p> <p>3. Multiplexer and Demultiplexer, 4:1 MUX, 1: 4 DEMUX List real life applications of MUX and DEMUX</p>	Refer Table 1	<p>1a. Construct Half Adder circuit using ICs and verify the truth table 1b. Construct Full adder with two Half adder circuits using ICs and verify the truth table. Use a digital IC tester to test the digital ICs</p> <p>2. Construct a circuit to verify the truth table of 4:1 multiplexer using IC 74153 and 1:4 Demultiplexer using IC 74139.  Use a digital IC tester to test the digital ICs</p>

10	1,3	1,4	1. Encoders and Decoders- definition, applications. Seven segment display- working	Refer Table 1	1. Construct a circuit to display 0-9 digits using standard Seven segment display with the help of decoder/ driver IC 7446/ or 7447. Use a digital IC tester to test the digital ICs.
			2. FLIP-FLOPS: S-R flip-flops, Clocked RS flip flop- block diagram, truth table, logic diagram.		2a. Identify different Flip-Flop (ICs) by the number printed on them 2b. Verify the truth tables of Flip-Flop ICs (RS, D, T, JK, MSJK) by connecting switches and LEDs.
			3. D flip- flop, JK flip-flop and T Flip-flop and Master JK flip-flop - block diagram, truth table, logic diagram.		
11	1,3	1,4	1. Shift Registers- definition, types and applications. Four-bit SISO using D Flip flops- block diagram, truth table and operation		1. Construct and test a four-bit SIPO register.
			2. Four-bit SIPO, PISO and PIPO shift registers using D flip flops- block diagram, truth table and operation.		2. Construct and test four-bit PIPO register.
			3. Counters- definition, modulus concept, timing diagram, types and applications		
12	3,4	1,4	1. Four-bit binary asynchronous counter- block diagram using JK flip flops, truth table, timing diagram and working	Refer Table 1	1. construct and test 4-bit Asynchronous binary up /down counter (IC <b>74LS193</b> )
			2. Four-bit decade asynchronous counter- block diagram using JK flip flops, truth table, timing diagram and working.		2. Rig up and test the truth table of Decade Asynchronous Counter (IC 74LS90)
			3. Three-bit synchronous up counter- block diagram, truth table, timing diagram and working.		
13	1,3	1,4	1. Digital to Analog converters: Binary weighted Resistor, DAC- block diagram and operation.		1. Construct and test (Binary weighted Resistor) Digital to Analog converter circuit.
			2. D/A converter specifications: resolution, accuracy and conversion speed. -Selection criteria for DAC		2. Construct and test the Analog to Digital

			3. Analog to Digital converters: Successive Approximation ADC- block diagram and operation. -Selection criteria for ADC		converter circuit. <b>Ref.7(16,17)</b>
<b>Total in hours</b>			<b>39</b>	<b>13</b>	<b>52</b>

**Reference:**

Sl. No.	Description
1	Electronic Devices and Circuits theory by Robert L. Boylestad Louis Nashelsky
2	Electronics Principles by Malvino, Mc. Graw Hill, Third edition. 2000.
3	Electronics Devices and Circuits by Allen Mottershead, PHI Learning Pvt. Ltd., First Edition
4	Electronics Principles and applications by Charles A Schuler and Roger L Tokhiem, Sixth Edition, Mc. Graw Hill, 2008. 2. 3.. 4.. 5.
5	Electronics Analog and Digital by I. J. Nagrath, PHI Learning Pvt. Ltd., 2013 Edition
6	Linear Integrated Circuits by Ramakant A. Gayakwad, PHI Learning Pvt. Ltd., Fourth Edition.
7	<a href="https://www.youtube.com/watch?v=nCqQhqLTmxw">https://www.youtube.com/watch?v=nCqQhqLTmxw</a>
8	<a href="https://bestengineeringprojects.com/automatic-cut-off-power-supply/">https://bestengineeringprojects.com/automatic-cut-off-power-supply/</a>
9	<a href="https://www.circuitstoday.com/5v-power-supply-using-7805">https://www.circuitstoday.com/5v-power-supply-using-7805</a>
10	<a href="http://www.ide.iitkgp.ac.in/Pedagogy/view/example.jsp?USER_ID=70">http://www.ide.iitkgp.ac.in/Pedagogy/view/example.jsp?USER_ID=70</a>
11	<a href="https://bestengineeringprojects.com/noise-free-dual-polarity-12v-power-supply-circuit/">https://bestengineeringprojects.com/noise-free-dual-polarity-12v-power-supply-circuit/</a>
12	<a href="https://bestengineeringprojects.com/problem-and-troubleshooting-of-power-supply/">https://bestengineeringprojects.com/problem-and-troubleshooting-of-power-supply/</a>
13	<a href="https://bestengineeringprojects.com/regulated-power-supply-troubleshooting/">https://bestengineeringprojects.com/regulated-power-supply-troubleshooting/</a>
14	<a href="http://ee.cet.ac.in/downloads/Notes/ECLab/04-CE%20Amplifier.pdf">http://ee.cet.ac.in/downloads/Notes/ECLab/04-CE%20Amplifier.pdf</a>
15	<a href="https://bestengineeringprojects.com/adjustable-dual-timer-circuit-using-555-timer-ic/">https://bestengineeringprojects.com/adjustable-dual-timer-circuit-using-555-timer-ic/</a>



16	<a href="https://www.iitg.ac.in/cseweb/vlab/Digital-System-Lab/experiments.php">https://www.iitg.ac.in/cseweb/vlab/Digital-System-Lab/experiments.php</a>
17	<a href="https://www.ti.com/lit/ds/symlink/dac0808.pdf?ts=1613370064634&amp;ref_url=https%253A%252F%252Fwww.google.com%252F">https://www.ti.com/lit/ds/symlink/dac0808.pdf?ts=1613370064634&amp;ref_url=https%253A%252F%252Fwww.google.com%252F</a>
18	<a href="https://www.mepits.com/project/336/diy-projects/diy-project-digital-thermometer">https://www.mepits.com/project/336/diy-projects/diy-project-digital-thermometer</a>
19	Work sheets digital 1. <a href="https://www.liveworksheets.com/un1107740kg">https://www.liveworksheets.com/un1107740kg</a> 2. <a href="https://nohoacsl.weebly.com/uploads/1/1/2/2/112297219/digital_electronics_worksheet.pdf">https://nohoacsl.weebly.com/uploads/1/1/2/2/112297219/digital_electronics_worksheet.pdf</a>
20	<a href="https://inst.eecs.berkeley.edu/~ee100/su07/handouts/EE100-MultiSim-Tutorial.pdf">https://inst.eecs.berkeley.edu/~ee100/su07/handouts/EE100-MultiSim-Tutorial.pdf</a>
21	<a href="http://eceweb1.rutgers.edu/~psannuti/ece223/Manual-for-multisim.pdf">http://eceweb1.rutgers.edu/~psannuti/ece223/Manual-for-multisim.pdf</a>

#### Equipment/software list

Sl. No.	Particulars	Specification	Quantity
1	DC Regulated power supply	(0-30V, 2A)	
2	DC Regulated Dual power supply	(+/- 15V, 2A)	
3	DC Regulated Dual power supply	(+/- 5, 1A)	
4	Cathode Ray Oscilloscope	Dual trace, 25 MHz.	
5	Signal Generator / Function generator	(5V P-P, 200mA)	
6	DC Voltmeter	(0-1V)	
7	DC Voltmeter	(0-10V)	
8	DC Voltmeter	(0-30V)	
9	DC Ammeter	(0 -100mA)	
10	DC Ammeter	(0 -10mA)	
11	DC Ammeter	(0 -100mA)	
12	Digital Multimeter-	3 1/2" 06	
13	Analog Multimeter		
14	LCR meter		
15	Decade resistance box	(4 Dial)	
16	Decade capacitor box	(4 Dial)	
17	Analog IC Trainer Kit		
18	Digital Trainer kit		
19	Digital IC Tester.		
20.	Electronic Circuit Simulation Software (Multi sim/P spice/ LT spice/GNU-Octave/ Mat Lab- Simulink)		