SRI SIDDHARTHA INSTITUTE OF TECHNOLOGY- TUMAKURU
(A constituent College of Siddhartha Academy of Higher Education, Tumakuru)

Syllabus for the Academic Year 2020 - 2021

Department: Electrical & Electronics Engineering

Semester: VI

Subject Name: POWER SYSTEM ANALYSIS & STABILITY

Subject Code: PC-18EE601 **L-T-P-C: 3-1-0-4**

Course Objectives:

1. To understand the concepts of single line diagram, per unit system, types of faults, symmetrical components and stability studies for a given power system network with all its complex components present.
2. To apply the basic concepts to solve power system problems under normal and abnormal conditions
3. To analyze the given power system for symmetrical and unsymmetrical faults.
4. To evaluate the current and voltage in a power system during normal and abnormal conditions.

UNIT	Description	Hours
I	**Representation of Power system Components**: Circuit models of Transmission line, Synchronous machines, Transformer and load, one line diagram, Assumptions made to draw impedance and reactance diagram. Per unit system, Per unit impedance diagram, Illustrative examples.	**10**
II	**Symmetrical three phase faults:** Transients on an unloaded transmission line for a fault, Short - Circuit currents and the reactance of synchronous machine on No load & On load, Selection of circuit breakers, Illustrative examples. **Symmetrical components:** Analysis of unbalanced load against balanced three phase supply, Resolution of unbalanced phasors into their symmetrical components, Illustrative examples.	**11**
III	**Symmetrical components:** Phase shift of symmetrical components in star-delta transformer bank, Power in terms of symmetrical components, Analysis of balanced and unbalanced loads against unbalanced three phase supply, Sequence impedances and sequence networks, Sequence impedance of power system elements (alternator, transformer and transmission line), positive, negative and zero sequence networks of power system elements, Illustrative examples.	**11**

IV	**Unsymmetrical faults:** L-G, L-L, L-L-G faults on an unloaded alternator with and without fault impedance, Unsymmetrical faults on a power system with and without fault impedance, Open conductor faults in power systems, Illustrative examples.	**10**
V	**Stability studies:** Steady state and transient stability, Rotor dynamics and the swing equation, Power angle equation, Equal-area criterion of stability and its application.	**10**

Course Outcomes:

At the end of course, student will be able to:

1. Understand the concepts of single line diagram, per unit system, types of faults, symmetrical components and stability studies for a given power system network with all its complex components present.
2. Apply the basic concepts to solve power system problems under normal and abnormal conditions
3. Analyze the given power system for symmetrical and unsymmetrical faults.
4. Evaluate the current and voltage in a power system during normal and abnormal conditions.

Text Books:

1. Elements of Power System Analysis, W D Stevenson, First edition, 1994, Mc Graw Hill
2. Modern Power System Analysis, I J Nagrath and D P Kothari, Fourth edition, 2011, TMH.

Reference Books:

1. Power system analysis, HadiSaadat, Second edition, 2002,TMH
2. Power system analysis, Bergen Arthur, Second edition, Pearson Education

Syllabus for the Academic Year – 2020 – 2021

Department: Electrical & Electronics Engineering

Semester: VI

Subject Name: Digital Signal Processing

Subject Code: PC-18EEI602 **L-T-P-C: 3-0-2-4**

Course Objectives:

1. To understand the concept of Discrete Fourier Transforms, Fast Fourier Transforms and digital filters.
2. To apply DFT and inverse DFT to find the convolution of the given sequence.
3. To analyze different methods of realizing a digital IIR and FIR filter.
4. To design digital filters using impulse invariant ,bilinear transformation and window techniques

UNIT	Description	Hours
1.	**Discrete Fourier transforms:** Definitions, properties-Periodicity, linearity, Circular time and frequency shift, symmetry for real sequences. Circular convolution and linear convolution, Overlap odd and save method.	**08**
2.	**Fast Fourier transforms algorithms:** Introduction, decimation in time algorithm, decimation in frequency algorithm, number of computations, Inverse DIT and DIF (Illustrative examples only). Convolutions, decomposition for 'N' a composite number (N = 6)	**08**
3.	**Realization of digital systems:** Introduction, realization of IIR systems-direct form, cascade form, parallel form, realization of FIR systems-direct form, cascade form, linear phase realizations.	**08**
4.	**Design of IIR Digital filters:** Introduction, Impulse Invariant & Bilinear Transformations, design of digital Butterworth & Chebyshev filters.	**08**
5.	**Design of FIR Digital filters:** Introduction, windowing, rectangular, Hamming, frequency sampling technique	**07**

LABORATORY EXPERIMENTS

1	Verification of Sampling Theorem.
2	Circular and Linear convolution of two given sequences.
3	Computation of N-point DFT of a given sequence and to plot magnitude & phase spectrum

4	Design and implementation of IIR filter to meet given specifications.
5	Design and implementation of FIR filter to meet given specifications

Course Outcomes:

After completion of course, student will be able to:

1. Understand the concept of Discrete Fourier Transforms, Fast Fourier Transforms and digital filters.
2. Apply DFT and inverse DFT to find the convolution of the given sequence.
3. Analyze different methods of realizing a digital IIR and FIR filter.
4. Design digital filters using impulse invariant, bilinear transformation and window techniques

Text Book:

Digital signal processing Principle, Algorithms and Applications, John D Proakis, 3rd edition, PHI, 2004.

Reference Books:

1. Introduction to digital signal processing, Johnny R Johnson, 3rd edition, PHI, 2003.
2. Digital signal processing, Sanjith K. Mithra, 3rd edition, TMH, 2005

Syllabus for the Academic Year 2020 - 2021

Semester: VI

Subject Name: SWITCHGEAR AND HIGH VOLTAGE ENGINEERING

Subject Code: PC-18EE603 **L-T-P-C: 3-1-0-4**

Course Objectives:

1. To understand the basic Protection schemes in power systems and need for High voltage study
2. To apply the knowledge of circuit breakers and protective relays in their operation.
3. To analyze the generation of high voltages AC and DC
4. To evaluate the techniques for measurement of high voltages.

UNIT	Description	Hours
I	**Circuit breakers:** Arcing phenomenon and arc interruption, DC and AC circuit breaking, Re-striking voltage and Recovery voltage, Rate of rise of re-striking voltage, Resistance switching, Current chopping, Interruption of capacitive current, Types of circuit breaker: Air blast, Air break, SF_6 and Vacuum circuit breakers.	**10**
II	**Relays:** Introduction, types, essential qualities of relay: sensitivity, selectivity, speed and time, reliability & dependability, principles of power system protection, zones of protection. Thermal relay, Over current relays, Impedance relay, Differential protection: Percentage differential relay, earth leakage protection, Bus bar protection.	**10**
III	**INTRODUCTION:** Introduction to HV technology, advantages of transmitting electrical power at high voltages, need for generating high voltages in laboratory. Important applications of high voltage. **BREAKDOWN PHENOMENA:** Classification of HV insulating media. Properties of important HV insulating media under each category. Gaseous dielectrics: Ionizations: primary and secondary ionization processes. Criteria for gaseous insulation breakdown based on Townsend's theory. Limitations of Townsend's theory. Streamer's theory breakdown in non-uniform fields. Corona discharges. Breakdown in electro negative gasses. Paschen's law and its significance. Time lags of Breakdown. Breakdown in solid dielectrics: Intrinsic, avalanche, thermal, and electro mechanic breakdown. Breakdown of liquids dielectric dielectrics: Suspended particle theory, electronic, cavity (bubble's theory) and electro convection breakdown.	**12**

IV	**GENERATION OF HVAC AND HVDC VOLTAGE:** HVAC-High Voltage transformer; Need for cascade connection and working of transformers units connected in cascade. Series resonant circuit- principle of operation and advantages. Tesla coil. HVDC- voltage doubler circuit, Cock croft- Walton type high voltage DC set. Calculation of high voltage regulation, ripple and optimum number of stages for minimum voltage drop	**10**
V	**MEASUREMENT OF HIGH VOLTAGES:** Electrostatic voltmeter- principle, construction and limitation. Chubb and Fortescue method for HVAC measurement. Generating voltmeter- Principle, construction. Series resistance micro ammeter for HVDC measurements. Standard sphere gap measurements of HVAC, HVDC, and impulse voltages; Factors affecting the measurements.	**10**

Course Outcomes:

At the end of course, student will be able to:

1. Understand the basic Protection schemes in power systems and need for High voltage study
2. Apply the knowledge of circuit breakers and protective relays in their operation.
3. Analyze the generation of high voltages AC and DC
4. Evaluate the techniques for measurement of high voltages.

Text Books:

1. Switchgear & Protection, Sunil S. Rao, Khanna Publication. 11th Edition, 1998
2. High Voltage Engineering-M.S.Naidu and Kamaraju, 3rd Edition, THM, 2007.

Reference Books:

1. Power System Protection & Switchgear, Badriram&Vishwa Karma, 2nd Edition, TMH, 2011
2. Power System Protection & Switchgear, Ravindranath&Chander, New Age Publications, 1st Edition, 2018.
3. High Voltage Engineering, C.L.Wadhwa, New Age International Private limited 1995.
4. High Voltage Engineering Fundamentals, E. Kuffel and W.S. Zaengl, 2nd edition, Elsevier, press, 2005.

SRI SIDDHARTHA INSTITUTE OF TECHNOLOGY- TUMAKURU
(A constituent College of Siddhartha Academy of Higher Education, Tumakuru)

Syllabus for the Academic Year – 2020 - 2021

Department: Electrical & Electronics Engineering

Semester: VI

Subject Name: ADVANCED POWER ELECTRONICS

Subject Code: PE-18EE6PE41 **L-T-P-C: 3-0-0-3**

Course Objectives:

1. To understand the design and working of Switch mode power supplies and UPS.
2. To apply the concept of design procedure of high frequency inductor and transformers for SMPS.
3. To analyze the operation of switched mode DC-DC converter, multilevel inverters
4. To designesonant converters, SMPS, Multilevel invertersfor various applications.

UNIT	Description	Hours
I	D.C-D.C Switched mode converter topologies: Buck, boost, buck-boost, Cuk D.C-D.C converter-Detail theory and working principles. (Operation of the above converters is CCM-mode only).	**08**
II	Derived converters: Forward, flyback, push-pull converters, full bridge and half-bridge DC-DC converter.	**08**
III	Classification of resonant converters, Series and parallel loaded resonant converters, Zero voltage and Zero current resonant switch converters-Detail theory and working principle.	**08**
IV	High frequency Inductor and transformers, on line, off line UPS, reliability of UPS and batteries for UPS.	**07**
V	Multilevel Inverters: Introduction, types, diode clamped multi-level inverters, cascaded H-bridge inverter, flying capacitor clamped inverter and applications.	**08**

Course Outcomes:

After completion of course, student will be able to:

1. Understand the design and working of DC-DC converter and UPS.
2. Apply the concept of design procedure for high frequency inductor and transformers for SMPS.
3. Analyze the operation of switched mode DC-DC converter, multilevel inverters
4. Design and analyze resonant converters, DC-DC converters and applications

Department of Electrical & Electronics Engineering.

Text Books:

1. Power Electronics, M H Rashid, 3rdEdition, PHI publishers
2. Power Electronics, M D Singh, K B, Khanchandani, TMH.

Reference Books:

1. Power Electronics Converters, Application & Design, Mohan N Undeboud, T M, Robins, W P, John Wiley 1989
2. Power Electronics Control in A C Motors, Murplhy JM D Turnnbull, F.G. Pergamon 1988

SRI SIDDHARTHA INSTITUTE OF TECHNOLOGY- TUMAKURU
(A constituent College of Siddhartha Academy of Higher Education, Tumakuru)

Syllabus for the Academic Year – 2020 - 2021

Department: Electrical & Electronics Engineering

Semester: VI

Subject Name: Solar and Wind Energy Systems

Subject Code: PE-18EE6PE42 **L-T-P-C: 3-0-0-3**

Course Objectives:

1. To understand the importance of Wind and Solar Power Generations and the concept of Battery Storage System
2. To apply the concept of Maximum Power Point Tracking
3. To analyze Stand-Alone & Grid-Connected System
4. To design the control and conversion system components of Wind Energy systems

UNIT	Description	Hours
I	**Introduction to PV** Need for sustainable energy sources, Importance of wind and solar power generations, solar radiations and its measurements, Construction and operation of PV cell, Operational characteristics, Single diode modeling ,series and parallel resistances, Efficiency limits, factors affecting performance, PV modules.	**08**
II	**MPPT-Converter-Battery Selection** Maximum Power Point Tracking. The Dynamic Optimization Problem, Fractional Open-Circuit Voltage and Short-Circuit Current, Soft Computing Methods, the Perturb and Observe Approach Improvements of the P&O Algorithm, Evolution of the Perturbative Method, PV MPPT via Output Parameters, MPPT Efficiency	**08**
III	**Wind Energy:** Basics & Power Analysis, Wind resource assessment, Power Conversion Technologies and applications. **Wind Turbine Generators:** Induction, Synchronous machine, constant V & F and variable V & F generations, Reactive power compensation.	**07**
IV	**Stand-Alone Systems:** PV Stand-Alone, Wind Stand-Alone. **Grid-Connected System:** Interface Requirements, Synchronizing with Grid, Inrush Current, Synchronous Operation, Load Transient, Safety, Operating Limit, Voltage Regulation, Stability Limit -Grid connection Issues -Grid Integrated PMSG and SCIG Based WECS.	**08**
V	**Battery Storage System:** Basic concepts, components of cells and batteries, Classification of cells and batteries, Operation of a cell, Specifications, free energy, theoretical cell voltage, specific capacity, specific energy, energy density, memory effect, cycle life, shelf life, state of charge (SOC) and depth of discharge (DOD), internal resistance and coulombic efficiency. lithium batteries, lead-acid batteries (Components, Chemistry and Performance characteristics)	**08**

Course Outcomes:

After completion of course, student will be able to:

1. Understand the importance of Wind and Solar Power Generations and the concept of Battery Storage System
2. Apply the concept of Maximum Power Point Tracking
3. Analyze Stand-Alone & Grid-Connected System
4. Design the control and conversion system components of Wind Energy systems

Text Books:

1. Solar Photovoltaics: Fundamentals, Technologies and Applications, Chetan Singh Solanki, 2nd Edition, PHI publishers
2. Wind and Solar Power System, Mukund R. Patel, CRC Press; 1 edition (March 30, 1999)

Reference Books:

1. ENERGY HARVESTING, Solar, Wind, and Ocean, Energy Conversion Systems,
2. Energy, Power Electronics, and Machines Series, AlirezaKhaligh and Omer C.Onar
3. CRC Press Publications
4. Renewable Energy Sources and Emerging Technologies, D.P Kothari, K.C. Singal
5. and Rakesh Ranjan, 2nd Edition, PHI Learning Pvt Ltd.

Syllabus for the Academic Year – 2020 - 2021

Department: Electrical & Electronics Engineering

Semester: VI

Subject Name: DIGITAL SYTEM DESIGN USING VERILOG

Subject Code: PE-18EE6PE43 **L-T-P-C: 3-0-0-3**

Course Objectives:

1. To understand the concept of Verilog HDL in designing digital circuits
2. To apply digital principles in modeling of behavioral and RTL models
3. To analyze various models and synthesizing RTL models to standard cell libraries and FPGAs
4. To verify behavioral and RTL models

UNIT	Description	Hours
1	**Introduction to Verilog HDL:** Verilog as HDL, Levels of Design Description, Concurrency, Simulation and Synthesis, Function Verification, System Tasks, Programming Language Interface, Module, Simulation and Synthesis Tools **Language Constructs and Conventions:** Introduction, Keywords, Identifiers, White Space, Characters, Comments, Numbers, Strings, Logic Values, Strengths, Data Types, Scalars and Vectors, Parameters, Operators.	8
2	**Gate Level Modeling:** Introduction, AND Gate Primitive, Module Structure, Other Gate Primitives, Illustrative Examples, Tristate Gates, Array of Instances of Primitives, Design of Flip-Flops with Gate Primitives, Delay, Strengths and Construction Resolution, Net Types, Design of Basic Circuit. **Modeling at Dataflow Level:** Introduction, Continuous Assignment Structure, Delays and Continuous Assignments, Assignment to Vector, Operators.	8
3	**Behavioral Modeling:** Introduction, Operations and Assignments, Functional Bifurcation, Initial Construct, Always Construct, Assignments with Delays, Wait construct, Multiple Always Blocks, Designs at Behavioral Level, Blocking and Non-Blocking Assignments, The case statement, Simulation Flow if and if-else constructs, Assign-De-Assign construct, Repeat construct, for loop, the Disable construct, While loop, Forever loop, Parallel Blocks, Force-Release construct, Event.	7
4	**Switch Level Modeling:** Basic Transistor Switches, CMOS Switches, Bi-Directional Gates, Time Delays with Switch Primitives, Instantiation with 'Strengths' and 'Delays' Strength Contention with Trireg Nets. **System Tasks, Functions and Compiler Directives:** Parameters, Path Delays, Module Parameters. System Tasks and Functions, File Based Tasks and Functions, Computer Directives, Hierarchical Access, User Defined Primitives.	8

5	**Sequential Circuit Description**: Sequential Models –Feedback Model, Capacitive Model, Implicit Model, Basic Memory Components, Functional Register, Static Machine Coding, Sequential Synthesis. **Components Test and Verification:** Test Bench-Combinational Circuit Testing, Sequential Circuit Testing, Test bench techniques, Design Verification, Assertion Verification.	8

Course Outcomes:

At the end of course, student will be able to:

1. Understand the importance and concept of Verilog HDL in digital system design.
2. Apply the knowledge of digital principles and Verilog HDL in design and development of digital system.
3. Analyze various models and synthesize RTL models to standard cell libraries and FPGAs.
4. Verify behavioral and RTL models.

Text Books:

1. Design through Verilog HDL, T.R. Padmanabhan, B. Bala Tripura Sundari Wiley, 2009
2. Verilog Digital System Design, ZainalabdienNavabi, TMH, 2nd Edition

Reference Books:

1. Fundamentals of Logic Design with Verilog Design, Stephen. Brown and ZvonkoVranesic
2. TMH, 2nd Edition
3. Verilog HDL, Samir Palnitkar, **Pearson,** 2nd Edition
4. Advanced Digital Design with Verilog HDL, Michael D. Ciletti, **PHI** 2009

Self Study: NPTEL: “Hardware Design Using Verilog”, Prof. IndranilSengupta, IIT Kharagpur

Syllabus for the Academic Year – 2020 - 2021

Department: Electrical & Electronics Engineering

Semester: VI

Subject Name:Programmable Logic Controllers

Subject Code: OE-18EE6OE51 L-T-P-C: 3-0-0 -3

Course Objectives:

1. To understand PLC system, advantages and disadvantages, hardware components, ladder diagram and its programming.
2. To apply identification of common operating modes found in PLCs, writing and entering the ladder logic programs using FBD, SFC and ST.
3. To analyze the functions of Relays, Motor Starters, Switches, Sensors, Output devices, Timer and counters
4. To design PLC systems using ladder logic and programs for different industrial process

UNIT	Description	Hours
1.	**Introduction:** Introduction to Programmable Logic Controller (PLC), role in automation, advantages and disadvantages, hardware, internal architecture, sourcing and sinking, characteristics of I/O devices, input and output devices, signal conditioning, remote connections, networks.	**08**
2.	**Programming:** Ladder programming- ladder diagrams, logic functions, latching, multiple outputs, entering programs, functional blocks, programme on location of fail safe and limit switches.	**08**
3.	**Programming Statement:** Instruction list, sequential functions charts & structured text, jump and call subroutines.	**08**
4.	**Internal Relays:** Battery- backed relays, one - shot operation, set-reset, master control relay.	**07**
5.	**Timers and Counters:** ON and OFF- delay timers, pulse timers, up, down, up-down counting, timers with counters, sequencer.	**08**

Course Outcomes:

After completion of course, student will be able to:

1. Understand history of PLC, its sequence of operation, advantages and disadvantages, main parts and their functions
2. Apply ladder logic, FBD, SFC and ST concept for the systems
3. Analyze Relays, Motor Starters, Switches, Sensors, Output devices, timer and counters
4. Design PLC systems using ladder logic and programs for different industrial process

Text Book:

Programmable Logic controllers, W Bolton, Elsevier- Newness, 4thedition, 2006

Reference Books:

1. Programmable Logic Controllers - principles and applications, John W Webb, Ronald A, 2nd impression, Pearson education, 2007, 5th edition.
2. Programmable Controller Theory and Applications, L. A Bryan, E. A Bryan An industrial text company publication, 1997, 2nd edition.

Syllabus for the Academic Year – 2020 - 2021

Department: Electrical & Electronics Engineering

Semester: VI

Subject Name:Fundamental of Renewable Energy Sources

Subject Code: OE-18EE6OE52 L-T-P-C: 3-0-0-3

Course Objectives:

1.To understand the processing and limitations of fossil fuels. (coal, petroleum and natural gas.)
2.To demonstrate the concept of energy conversion techniques in Non-Conventional Energy Sources.
3.To analyze the effective utilization techniques in Non-Conventional Energy Sources.
4. To acquire the knowledge of modern energy conversion techniques

UNIT	Description	Hours
1.	**Introduction to Energy Sources:** Energy consumption as a measure of prosperity, World energy futures- brief discussion of conventional energy sources and their availability, Non-conventional energy sources.	**8**
2.	**Solar Energy:** Solar radiation, Beam and Diffuse radiation, types of collectors, advantages and disadvantages, solar electric power generation. **Application of Solar Energy:** Solar water heating, solar distillation, solar cooking, solar green house, solar furnace.	**8**
3.	**Wind Energy:** Principle of wind energy conversion system (WECS), components of WECS, classification of WECS, Types of wind energy collectors, site selection, advantages and disadvantages of WECS.	**8**
4.	**Energy from Biomass:** Different types of biomass fuels, biomass conversion technologies, classification of biogas plants, KVIC digester.	**8**
5.	**Energy from Oceans:** Principle of ocean thermal energy conversion (OTEC), open cycle, closed cycle & hybrid cycle, OTEC. **Energy from Tides:** Tidal power, components of tidal power plants, single basin arrangement, double basin arrangement, advantages and limitation of tidal power.	**7**

Course Outcomes:

After completion of course, student will be able to:

1. Understand the processing and limitations of fossil fuels. (Coal, petroleum and natural gas.)
2. Demonstrate the concept of energy conversion techniques in Non-Conventional Energy Sources.
3 To analyze the effective utilization techniques in Non-Conventional Energy Sources.
4 To acquire the knowledge of modern energy conversion techniques

Text book:

G. D. Rai, "Non conventional energy sources", , Khanna Publication, 1st Edition, 2011

Reference books:

1. Sukhatme, "solar energy", TMH Publication, 2nd Edition
1. William C Dikkinson , "Solar Energy Hand Book".
2. Twiddleelbs, Renewable Energy Sources

* **Visit to Power Plant is mandatory and subsequent submission of report carries 10% of the CIE marks.**

Syllabus for the Academic Year – 2020 - 2021

Department: Electrical & Electronics Engineering

Semester: VI

Subject Name:COMPUTER AIDED ELECTRICAL DRAWING

Subject Code: PC-18EE607 **L-T-P-C: 0-0-2-1**

Course Objectives:

1. To understand the concept of single line diagram and Electrical machines
2. To apply winding concept and assembly of DC and AC machines
3. To analyze and design the assembly of AC and DC machines.

	SYLLABUS CONTENT
	PART – A
	Single line diagrams of generating stations and substations.
	PART –**B**
	Winding Diagrams: **(a) Developed winding diagrams of D.C. machines** (i) Simplex double layer Lap and Wave windings. (ii) Duplex double layer Lap and Wave windings. **(b) Developed winding diagrams of A.C. machines** (i) Integral and Fractional slot double layer Lap and Wave windings. (ii) Integral and Fractional slot single layer Lap and Wave windings.
	PART -C
	Electrical machine assembly drawing. (a) Transformers - sectional views of single and three phase core and shell type transformers. (b) D.C. machine - sectional views of yoke, field system, armature and commutator dealt Separately. (c) Induction motor and synchronous generator – sectional views of stator and rotor dealt separately.

Course Outcomes:

At the end of course, student will be able to:

1. Understand the concept of single line diagram and Electrical machines
2. Apply winding concept and assembly of DC and AC machines
3. Analyze and design the assembly of AC and DC machines.

Department of Electrical & Electronics Engineering.

Syllabus for the Academic Year – 2020 - 2021

Department: Electrical & Electronics Engineering

Semester: VI

Subject Name: Relay and High Voltage lab

Subject Code: PC-18EE608 **L-T-P-C: 0-0-2-1**

Course Objectives:

1. To understand the concept of field mapping and operating characteristics of solid state and Numerical Relays
2. To analyze the sparkover characteristics of Air insulation subjected to HVAC/HVDC and breakdown strength for different electrodes.
3. To evaluate breakdown strength of air and oil.

UNIT	Description
1.	I-T Characteristics of Inverse over current relay.
2.	IDMT Characteristics of Over / Under Voltage Relay.
3.	Operating Characteristics of Over Voltage / Under Voltage Relay.
4.	Operation of Negative Sequence Relay.
5.	Current-Time Characteristics of Fuse.
6.	Operating Characteristics of Microprocessor Based (Numeric) Over Current Relay.
7.	Operating Characteristics of Microprocessor Based (Numeric) Over/Under Voltage Relay.
8.	Spark over Characteristics of Air Insulation Subjected to High Voltage AC/DC with Spark Over Voltage Corrected to STP.
9.	Measurement of High Voltage AC/DC using Sphere gap arrangements.
10	Breakdown Strength of Transformer Oil Using Oil-Testing Unit.
11.	Field Mapping Using Electrolytic Tank for parallel or coaxial geometry.

DEMONSTRATION EXPERIMENTS

1.	Generation of Impulse Voltage
2.	Motor Protection Scheme – Fault studies

Course Outcomes:

At the end of course, student will be able to:

1. Understand the concept of field mapping and operating characteristics of solid state and Numerical Relays
2. Analyze the sparkover characteristics of Air insulation subjected to HVAC/HVDC and breakdown strength for different electrodes.
3. Evaluate breakdown strength of air and oil.