Course Title	Switchgear and Protection	Semester	VII
Course Code	MVJ19EE71	CIE	50
Total No. of Contact Hours	50	SEE	50
No. of Contact Hours/week	5, 3:1:1 (L: T:P)	Total	100
Credits	4	Exam. Duration	3 Hours

Course objective is to: This course will enable students to

- Discuss performance of protective relays, components of protection scheme and relay terminology.
- Explain Overcurrent protection using electromagnetic relays and Overcurrent protective schemes.
- Explain construction, operating principles of various distance relays for distance protection.
- Discuss protection of generators, motors, Transformer and Bus Zone Protection.
- Discuss construction, operating principles of static and numerical relays for Numerical protection.
- Explain the principle of circuit interruption and different types of circuit breakers.

Module-1	L1, L2	10Hrs

Protective Relays: Introduction, Need for power system protection, evolution of protective relays, zones of protection, primary and backup protection, essential qualities of protection, classification of protective relays and schemes, basic relay terminology.

Operating Principles and Relay Construction: Electromagnetic relays, thermal relays, static relays.

Laboratory Sessions/ Experimental learning: Field visit to show placing and operation of relays in substation.

Applications: Selection of relays for protection of system components.

Web Link and Video Lectures:

1. https://nptel.ac.in/courses/108/101/108101039/
2. https://youtu.be/NEXWcOgqZOI

Module-2	L1, L2, L3	10Hrs

Over-Current Protection: Time-current characteristics, current setting, over current protective schemes, directional relay, Protection of parallel feeders, protection of ring mains, Phase fault and earth fault protection, Combined earth fault and phase fault protective scheme.

Distance Protection: Impedance relay, reactance relay, MHO relay, Effect of arc resistance, Effect of power swings, effect of line length and source impedance on the performance of distance relays, selection of distance relays.

Laboratory Sessions/ Experimental learning: Design of protection system for distribution system.

Applications: Protection of transmission line and selection of distance relays.

Web Link and Video Lectures:

1. https://nptel.ac.in/courses/108/101/108101039/
2. https://youtu.be/XdE149Hk_h0

Module-3	L1, L2, L3	10Hrs

Differential protection–Introduction, differential relays, differential protection scheme, Wire Pilot protection (Transley scheme), Carrier current protection.

AC Machines and Bus Zone Protection: Protection of Generators, Protection of transformers, Protection of induction motors, Protection of Bus zone protection

Laboratory Sessions/ Experimental learning: Study the gas actuated Buchholz relay for oil filled transformer (virtual lab).

Application: Protection of machines from internal and external faults.

Web Link and Video Lectures:

1. https://nptel.ac.in/courses/108/101/108101039/
2. https://youtu.be/ZXyq-xxRLnQ

Module-4	L1, L2, L3	10Hrs

Numerical Protection Static Relays: Amplitude and Phase comparators, Static amplitude comparator, static over current relays, static directional relay, and static distance relays.

Microprocessor Based Relays: Over current relays, directional relays, distance relays.

Laboratory Sessions/ Experimental learning: Industrial visit

Application: Numerical protection is used in smart grid.

Web Link and Video Lectures:

1. https://nptel.ac.in/courses/108/101/108101039/
2. https://youtu.be/NEXWcOgqZOI

Module-5	L1, L2, L3	10Hrs

FUSES: Introduction, fuse characteristics, types of fuses, application of HRC fuses, discrimination

Circuit Breakers: Introduction, arcing in circuit breakers, arc interruption theories, re-striking and recovery voltage, resistance switching, current chopping, interruption of capacitive current, oil circuit breaker, air blast Circuit breakers, SF6 circuit breaker, operating mechanism, selection of circuit breakers, ratings of circuit breakers, testing of circuit breakers.

Laboratory Sessions/ Experimental learning:

1. Circuit Breaker Status Indication from field input(virtual lab)
2. Substation Visit

Application: MCB & Fuses are used for protection of all electrical machines.

Web Link and Video Lectures:

1. https://nptel.ac.in/courses/108/101/108101039/
2. https://youtu.be/JRv2RVyYMtM

Course outcomes:

C401.1	Compare and contrast electromagnetic, static and microprocessor-based relays.
C401.2	Select relay settings of over current and distance relays.
C401.3	Analyze different protective schemes for bus-bars, generators, induction motors and transformers
C401.4	Apply technology to protect power system components.
C401.5	Analyze quenching mechanisms used in air, oil and vacuum circuit breakers

Text Books:

1	Badriram and D.N. Vishwakarma, Power System Protection and Switchgear, TMH 2001
2	J B Gupta, Fundamentals of Switchgear and Protection, Technical Publications, 2001.

Reference Books:

1	Y.G.Paithankar and S.R.Bhide ,Fundamentals of Power system protection, PHI private limited,NewDelhi,2010
2	Sunil S Rao, Switch Gear and Protection, Khanna Publication, 1999.

CIE Assessment:

CIE is based on quizzes, tests, assignments/seminars and any other form of evaluation. Generally, there will be: Three Internal Assessment (IA) tests during the semester (30 marks each), the final IA marks to be awarded will be the average of three tests

- Quizzes/mini tests (4 marks)
- Mini Project / Case Studies (8 Marks)
- Activities/Experimentations related to courses (8 Marks)

SEE Assessment:

i. Question paper for the SEE consists two parts i.e. Part A and Part B. Part A is compulsory and consists of objective type or short answer type questions of 1 or 2 marks each for total of 20 marks covering the whole syllabus.
ii. Part B also covers the entire syllabus consisting of five questions having choices and may contain sub-divisions, each carrying 16 marks. Students have to answer five full questions.
iii. One question must be set from each unit. The duration of examination is 3 hours.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
C401.1	3	3	2	2	3	1	2	1	2	3	1	2
C401.2	3	3	2	2	3	1	2	1	2	3	1	2
C401.3	3	3	2	2	3	1	2	1	2	3	1	2
C401.4	3	3	2	2	3	1	2	1	2	3	1	2
C401.5	3	3	2	2	3	1	2	1	2	3	1	2

High-3, Medium-2, Low-1

Course Title	Power Quality	Semester	VII
Course Code	MVJ19EE72	CIE	50
Total No. of Contact Hours	50	SEE	50
No. of Contact Hours/week	5, 3:1:1 (L: T:P)	Total	100
Credits	4	Exam. Duration	3 Hours

Course objective is to: This course will enable students to

- Understand power quality related terms
- Illustrate power quality issues for short and long interruptions
- Construct study of characterization of voltage sag magnitude.
- Understand the fundamentals and effect of harmonics.

Module-1	L1, L2	10Hrs.

Introduction: Introduction of the Power Quality (PQ) issues, Voltage Sag, Swell, Surges, Harmonics, over voltages, spikes, Voltage fluctuations, Transients, Interruption, Characteristics and Causes of various power quality problem, overview of power quality phenomenon, power quality monitoring, IEEE guidelines, standards and recommended practices.

Laboratory Sessions/ Experimental learning: Study of effect of nonlinear loads on power quality by using MATLAB simulation

Applications: Identification and classification of power quality issues.

Video link: https://nptel.ac.in/courses/108/107/108107157

Module-2	L1, L2, L3, L4	10Hrs.

Voltage sags – Sources of Sags and Interruptions, Estimating Voltage Sag Performance, Fundamental Principles of Protection, Solutions at the End-User Level, Evaluating the Economics of Different Ride-Through Alternatives, Motor-Starting Sags, Utility System Fault-Clearing Issues **Mitigation of voltage sag** – Introduction to mitigation of voltage sags, DVR, Static transfer switches and fast transfer switches.

Laboratory Sessions/ Experimental learning: Design of dynamic voltage restorer using MATLAB

Applications: Mitigation of voltage sag

Video link :https://nptel.ac.in/content/storage2/108/107/108107157/MP4/mod02lec06.mp4

Module-3	L1, L2, L3	10Hrs.

Transient over Voltages: Sources of Transient Overvoltage, Principles of Overvoltage protection, devices for Overvoltage protection, Utility Capacitor-Switching Transients, Utility System Lightning Protection. , Ferro resonance phenomenon, , Switching Transient Problems with Loads, Computer Tools for Transients Analysis **Laboratory Sessions/ Experimental learning**: Simulation for generation of transients **Applications**: Selection of equipment rating. **Video link:** https://nptel.ac.in/content/storage2/108/107/108107157/MP4/mod02lec07.mp4		
Module-4	**L1, L2, L3**	**10Hrs.**
Fundamentals of Harmonics: IEEE guide lines, standards and recommended practices, Harmonic Distortion, Voltage versus Current Distortion, Harmonics versus Transients, Harmonic Indexes, Harmonic Sources from Commercial Loads, Harmonic Sources from Industrial Loads, Locating Harmonic Sources, Effects of Harmonic distortion, Inter harmonics, Harmonic distortion Evaluations, Principles for compensating Harmonics **Laboratory Sessions/ Experimental learning**: Study of current harmonics by using MATLAB simulation. **Applications**: Identification of harmonics for designing harmonic filters. **Video link:** https://www.youtube.com/watch?v=FiGjNyX6h8c		
Module-5	**L1, L2, L3, L4**	**10Hrs.**
Effects of Harmonics Distortion: Introduction, Resonances, Effects of Harmonics on Rotating Machines, Effect of Harmonics on Static Power Plant, Power Assessment with Distorted Waveforms, Harmonic Interference with Power System Protection, Effect of Harmonics on Consumer Equipment. **Power Quality Monitoring**: Monitoring considerations, Power Quality Measurement Equipment, Assessment of Power Quality Measurement Data, Application of intelligent Systems, Power Quality Monitoring Standards, Monitoring considerations **Laboratory Sessions/ Experimental learning**: Design of active shunt compensator for harmonics compensation **Applications**: Active filters **Video link:** https://www.youtube.com/watch?v=FiGjNyX6h8c		

Course outcomes:

C402.1	Discuss the various power quality phenomenon
C402.2	Interpret and evaluate the voltage sags and interruptions
C402.3	Interpret and evaluate the Transient over voltages

C402.4	Discuss the fundamental, effects of harmonics.
C402.5	Understand the power quality problems in distribution system

Text Books:

1	Dugan, Roger C, Santoso, Surya, McGranaghan, Mark F Beaty, "Electric Power Quality," H. Wayne McGraw-Hill professional publication 2003.
2	Math H. J.Bollen, "Understanding power quality problems voltage sags and interruptions"-. IEEE Press, 2000.

Reference Books:

1	Power System Harmonics, J. Arrillaga, N.R. Watson, John Wiley & Sons Ltd, Second Edition, 2003.
2	Power Quality: Problems and Mitigation Techniques, Bhim Singh, Ambrish Chandra, Kamal AlHaddad, Wiley, 2014.

CIE Assessment:

CIE is based on quizzes, tests, assignments/seminars and any other form of evaluation. Generally, there will be: Three Internal Assessment (IA) tests during the semester (30 marks each), the final IA marks to be awarded will be the average of three tests

- Quizzes/mini tests (4 marks)
- Mini Project / Case Studies (8 Marks)
- Activities/Experimentations related to courses (8 Marks)

SEE Assessment:

i. Question paper for the SEE consists two parts i.e. Part A and Part B. Part A is compulsory and consists of objective type or short answer type questions of 1 or 2 marks each for total of 20 marks covering the whole syllabus.

ii. Part B also covers the entire syllabus consisting of five questions having choices and may contain sub-divisions, each carrying 16 marks. Students have to answer five full questions.

iii. One question must be set from each unit. The duration of examination is 3 hours.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
C402.1	3	3	3	2	3	2	2	-	2	1	-	2
C402.2	3	3	3	2	3	2	2	-	2	1	-	2
C402.3	3	3	3	3	3	2	2	-	2	1	-	2
C402.4	3	3	3	3	3	2	2	-	2	1	-	2
C402.5	3	3	3	3	3	2	2	-	2	1	-	2

High-3, Medium-2, Low-1

Course Title	Smart Grid	Semester	VII
Course Code	MVJ19EE731	CIE	50
Total No. of Contact Hours	40	SEE	50
No. of Contact Hours/week	4, 2:1:1 (L:T:P)	Total	100
Credits	3	Exam. Duration	3 Hours

Course objective is to: This course will enable students to

- Understand the basics of power system and renewable generation integration.
- Understand concept of smart grid and communications in smart grid.
- Understand the demand side management
- Understand the wide area measurement, security and privacy.
- Understand the economics of power system.

Module-1	L1, L2, L3	8Hrs.

Smart Grid: Introduction to Smart Grid: Evolution of Electric Grid, Concept of Smart Grid, Definitions, Need of Smart Grid, Functions of Smart Grid, Opportunities & Barriers of Smart Grid, Difference between conventional & smart grid, Present development & International policies in Smart Grid.

Renewable Generation: Renewable Resources: Wind and Solar, Micro-grid Architecture, Distributed Storage and Reserves, dealing with short term variations, stochastic models of solar and wind generation, forecasting of renewable power generation.

Laboratory Sessions/ Experimental learning: Forecasting of wind power generation

Applications: Renewable generation integration and microgrid formation

Video link :https://nptel.ac.in/courses/108/107/108107113/

Module-2	L1, L2, L3	8Hrs.

Smart Grid Communications: Two-way Digital Communications Paradigm, Network Architectures, IP-based Systems Power Line Communications, Advanced Metering Infrastructure.

Laboratory Sessions/ Experimental learning: Design any network architecture using suitable software

Applications: Design of smart grid: A case study

Video link : https://nptel.ac.in/courses/108/107/108107113/

Module-3	L1, L2, L3	8Hrs.

Demand Side Management: Definition, Applications, Load characteristics, load curve and load duration curve, Energy Consumption Scheduling, Controllable Load Models, Dynamics, and Challenges, Plug-in-hybrid Vehicles and smart appliances. **Laboratory Sessions/ Experimental learning**: Apply demand side management to your house **Applications**: System unloading **Video link** : https://nptel.ac.in/courses/108/107/108107113/		
Module-4	**L1, L2, L3**	**8Hrs.**
Wide Area Measurement: Sensor Networks, Phasor Measurement Units, Communications Infrastructure, Fault Detection and Self-Healing Systems, Applications and Challenges. **Security and Privacy**: Cyber Security Challenges in Smart Grid, Load Altering Attacks, False Data Injection Attacks, Defence Mechanisms, Privacy Challenges. **Laboratory Sessions/ Experimental learning**: A case study of cyber-attack on the power grid. **Applications**: Strengthening the smart grid security. **Video link** : https://nptel.ac.in/courses/108/107/108107113/		
Module-5	**L1, L2, L3**	**8Hrs.**
Economics and Market Operations: Power system generation economics, Modelling of Consumers and producers, Electricity market structures, types of markets, Location Marginal price, financial transmission rights price forecasting models **Laboratory Sessions/ Experimental learning**: A case study on Indian electricity market. **Applications**: Analysis of energy market **Video link**: https://nptel.ac.in/courses/108/107/108107113/		

Course outcomes:	
C403.1.1	Analyze the complexities in integration of renewable energy sources.
C403.1.2	Design the communication systems in the smart grid.
C403.1.3	Implement the demand side management techniques.
C403.1.4	Analyze the security issues in the smart grid.
C403.1.5	Analyse the pricing mechanism and electricity market.
Text Books:	
1	D.S. Kirshen, Fundamental of Power System Economics, John Wiley & Sons

2	A. J. Wood, B. F. Wollenberg, Power Generation Operation and Control, John Wiley & Sons
Reference Books:	
1	G. M. Masters, Renewable and Efficient Electric Power Systems, John Wiley & Sons
2	S. Stoft, Power System Economics: Designing Markets for Electricity, Wiley-Interscience

CIE Assessment:

CIE is based on quizzes, tests, assignments/seminars and any other form of evaluation. Generally, there will be: Three Internal Assessment (IA) tests during the semester (30 marks each), the final IA marks to be awarded will be the average of three tests

- Quizzes/mini tests (4 marks)
- Mini Project / Case Studies (8 Marks)
- Activities/Experimentations related to courses (8 Marks)

SEE Assessment:

i. Question paper for the SEE consists two parts i.e. Part A and Part B. Part A is compulsory and consists of objective type or short answer type questions of 1 or 2 marks each for total of 20 marks covering the whole syllabus.

ii. Part B also covers the entire syllabus consisting of five questions having choices and may contain sub-divisions, each carrying 16 marks. Students have to answer five full questions.

iii. One question must be set from each unit. The duration of examination is 3 hours.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
C403.1.1	3	3	2	2	2	2	1	-	-	1	-	2
C403.1.2	3	3	2	2	3	2	1	-	-	1	-	2
C403.1.3	3	3	3	3	3	2	1	-	-	1	1	2
C403.1.4	3	3	3	3	3	2	1	-	-	2	1	2
C403.1.5	3	3	3	3	3	2	1	-	-	2	1	2

High-3, Medium-2, Low-1

Course Title	AI Techniques to Power Systems	Semester	VII
Course Code	MVJ19EE732	CIE	50
Total No. of Contact Hours	40	SEE	50
No. of Contact Hours/week	4, 2:1:1 (L: T:P)	Total	100
Credits	3	Exam. Duration	3 Hours

Course objective is to: This course will enable students to

- Provide insight into fundamentals of Artificial Intelligence Techniques to the students.
- Understanding of fuzzy theory and its applications
- Concept of neural networks
- Use of genetic algorithm and evolutionary programming
- Convey application of Artificial Intelligence techniques in power system.

Module-1	L1, L2	8 Hrs.

Artificial Intelligence: Definition, History and Evolution, Intelligence, Communication, Learning, Artificial Intelligence, AI Applications, Problem Solving methods of ANN, ES and GA, Searching Techniques. Knowledge representation, predicate logic, predicate calculus, multi valued logic

Laboratory Sessions/ Experimental learning: Case study on AI evolution.

Applications: Learning and problem solving by machines.

Video link: https://youtu.be/fV2k2ivttL0?list=PLCD819D1E1C4F91C3

Module-2	L1,L2,L3,L4	8 Hrs.

Fuzzy logic: Introduction, Representing Fuzzy Elements, Basic Terms and Operations, Properties of Fuzzy Sets, Fuzzification, Arithmetic operations of Fuzzy Numbers, Fuzzy linguistic Descriptions, Fuzzy Relation Inferences, Defuzzification methods

Laboratory Sessions/ Experimental learning: Design fuzzy logic controller for speed control of a fan.

Applications: Handling of uncertainty.

Video link: https://youtu.be/H9SikB7HbSU

Module-3	L1,L2,L3	8 Hrs.

Artificial Neural Network: Definition and Fundamental concepts, Biological neural network, Artificial neuron, concept of perceptron, ADALINE, Neural network architectures, feedback in neural network, Application of neural network in power system.

Laboratory Sessions/ Experimental learning: State Estimations using Neural Network **Applications**: Classification, pattern recognition, estimation **Video link**: https://youtu.be/_l58zd2OFwg		
Module-4	L1,L2,L3	8 Hrs.
Genetic Algorithms and Evolutionary Programming: Introduction, Genetic algorithms and representations, Initialization and Selection, Genetic Operators, Mutations, Evolutionary Programming and working. **Laboratory Sessions/ Experimental learning**: Optimal placement of capacitor in the distribution system. **Applications: Solving** optimization problems in power systems **Video link**: https://youtu.be/Z_8MpZeMdD4		
Module-5	L1,L2,L3	8 Hrs.
Applications of AI Techniques: Load forecasting, Load flow studies, Economic Load dispatch, Load frequency control, Reactive power control, Speed control of DC and AC motors **Laboratory Sessions/ Experimental learning**: Load Flow analysis using Neural Network **Applications**: state estimation, load and power flow **Video link**: https://youtu.be/Y46zXHvUB1s		

Course outcomes:	
C403.2.1	Understand concepts of Artificial Intelligence
C403.2.2	Design Fuzzy logic of controllers
C403.2.3	Understand the concept of Neural Network
C403.2.4	Optimize problems in power system
C403.2.5	Analyze how AI techniques used in power system.

Text Books:	
1	Artificial Intelligence and Intelligent Systems, OXFORD University Press, Nev Delhi, 2005- N. P. Padhy
2	Understanding Neural Networks and Fuzzy Logic: Basic concepts and Applications, Prentice Hall India Private Limited, New Delhi,2002- Stamations V. Kartalopoulos

Reference Books:	
1	Artificial Intelligence Techniques in Power Systems, IEE Power Engineering Series, UK, 1997- Kevin Warwick, Arthur Ekwue and Raj Aggarwal
2	Intelligent Systems and Signal Processing in Power Engineering, Springer Berlin Heidelberg, New York- AbhisekUkil

CIE Assessment:

CIE is based on quizzes, tests, assignments/seminars and any other form of evaluation. Generally, there will be: Three Internal Assessment (IA) tests during the semester (30 marks each), the final IA marks to be awarded will be the average of three tests

- Quizzes/mini tests (4 marks)
- Mini Project / Case Studies (8 Marks)
- Activities/Experimentations related to courses (8 Marks)

SEE Assessment:

i. Question paper for the SEE consists two parts i.e. Part A and Part B. Part A is compulsory and consists of objective type or short answer type questions of 1 or 2 marks each for total of 20 marks covering the whole syllabus.
ii. Part B also covers the entire syllabus consisting of five questions having choices and may contain sub-divisions, each carrying 16 marks. Students have to answer five full questions.
iii. One question must be set from each unit. The duration of examination is 3 hours.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
C403.2.1	3	3	2	1	3	-	-	-	2	2	2	3
C403.2.2	3	3	2	1	3	-	-	-	2	2	2	3
C403.2.3	3	3	2	1	3	-	-	-	2	2	2	3
C403.2.4	3	3	2	1	3	-	-	-	2	2	2	3
C403.2.5	3	3	2	1	3	-	-	-	2	2	2	3

High-3, Medium-2, Low-1

Course Title	System On Chip	Semester	VII
Course Code	MVJ19EE733	CIE	50
Total No. of Contact Hours	40	SEE	50
No. of Contact Hours/week	4, 2:1:1(L: T:P)	Total	100
Credits	3	Exam. Duration	3 Hours

Course objective is to: This course will enable students to

- Understand the components of system, hardware and software
- Know the basic concepts of processor architecture and instructions
- Describe external and internal memory of SOC
- Get knowledge of bus models of SOC
- Understand SOC customization and reconfiguration technologies

Module-1	L1, L2	8 Hrs.

Introduction to the System Approach: System Architecture, Components of the system, Hardware & Software, Processor Architectures, Memory and Addressing. System level interconnection.

Laboratory Sessions/ Experimental learning: Write-up on Microprocessors, 8086 Functional block diagram, Pin diagram and description.

Applications: Understand different microprocessor architectures (ARM, Intel etc)

Video link: https://www.youtube.com/watch?v=3KLOXUYGo9s

Module-2	L1, L2	8 Hrs.

Processors: Introduction, Processor Selection for SOC, Basic concepts in Processor Architecture, Basic concepts in Processor Micro Architecture, Basic elements in Instruction handling. Buffers: minimizing Pipeline Delays, Branches, More Robust Processors, and Vector Processors.

Laboratory Sessions/ Experimental learning: Design and develop an assembly language program to search a key element "X" in a list of 'n' 16-bit numbers. Adopt Binary search algorithm in your program for searching.

Applications: Consumer device, Networking, and communication.

Video link: https://nptel.ac.in/courses/108/107/108107029/

Module-3	L1, L2	8 Hrs.

Memory Design for SOC: Overview of SOC external memory, Internal Memory, Size, Scratchpads and Cache memory, Cache Organization, Cache data, Write Policies, Strategies for line replacement at miss time, Types of Cache, Split – I, and D – Caches, Multilevel Caches, Virtual to real translation, SOC Memory System, Models of Simple Processor – memory interaction. **Laboratory Sessions/ Experimental learning**: Design and develop an assembly program to sort a given set of 'n' 16-bit numbers in ascending order. Adopt Bubble Sort algorithm to sort given elements. **Applications**: Biomedical devices, Media processors, GPS controllers. **Video link**: https://nptel.ac.in/courses/108/107/108107029/		
Module-4	L1, L2	8 Hrs.
Interconnect Customization and Configuration: Interconnect Architectures, Bus: Basic Architectures, SOC Standard Buses, Analytic Bus Models, Using the Bus model, Effects of Bus transactions and contention time. **Laboratory Sessions/ Experimental learning**: Develop an assembly language program to reverse a given string and verify whether it is a palindrome or not. Display the appropriate message. **Applications**: ASICs, PC-on-a-chip etc. **Video link**: https://nptel.ac.in/courses/108/107/108107029/		
Module-5	L1, L2, L3	8 Hrs.
SOC Customization: An overview, Customizing Instruction Processor, Reconfiguration Technologies, Mapping design onto Reconfigurable devices, Instance- Specific design, Customizable Soft Processor, Reconfiguration - overhead analysis and trade-off analysis on reconfigurable Parallelism. **Application Studies / Case Studies**: SOC Design approach, AES algorithms, Design and evaluation, Image compression – JPEG compression. **Laboratory Sessions/ Experimental learning**: To write and simulate ARM assembly language programs for data transfer, arithmetic, and logical operations (Demonstrate with the help of a suitable program). **Applications**: Image processing, AI, and ML. **Video link**: https://nptel.ac.in/courses/108/107/108107029/		
Course outcomes:		

C403.3.1	Memorize the system architecture, components of system hardware and software
C403.3.2	Know the basic concepts of processor architecture and instructions and delays
C403.3.3	Describe external and internal memory of SOC and organization
C403.3.4	Explain bus architectures and models of SOC
C403.3.5	Apply the knowledge of SOC design in real time applications
Text Books:	
1	Design of System on a Chip: Devices and Components – Ricardo Reis, 1st Ed., 2004, Springer
2	Co-Verification of Hardware and Software for ARM System on Chip Design (Embedded Technology) – Jason Andrews – Newness, BK and CDROM.
Reference Books:	
1	System on Chip Verification – Methodologies and Techniques –Prakash Rashinkar, Peter Paterson and Leena Singh L, 2001, Kluwer Academic Publishers.
2	C.Rowen, Engineering the Complex SOC: Fast,Flexible design with configurable processors, Prentice Hall, 2004

CIE Assessment:

CIE is based on quizzes, tests, assignments/seminars and any other form of evaluation. Generally, there will be: Three Internal Assessment (IA) tests during the semester (30 marks each), the final IA marks to be awarded will be the average of three tests

- Quizzes/mini tests (4 marks)
- Mini Project / Case Studies (8 Marks)
- Activities/Experimentations related to courses (8 Marks)

SEE Assessment:

i. Question paper for the SEE consists two parts i.e. Part A and Part B. Part A is compulsory and consists of objective type or short answer type questions of 1 or 2 marks each for total of 20 marks covering the whole syllabus.

ii. Part B also covers the entire syllabus consisting of five questions having choices and may contain sub-divisions, each carrying 16 marks. Students have to answer five full questions.

iii. One question must be set from each unit. The duration of examination is 3 hours.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12

C403.3.1	2	2	2	1	2	-	-	-	-	-	-	-
C403.3.2	2	2	2	2	3	-	-	-	-	-	-	-
C403.3.3	2	2	2	2	3	-	-	-	-	-	-	-
C403.3.4	2	3	3	2	3	-	-	-	-	-	-	-
C403.3.5	2	2	3	2	3	-	-	-	-	-	-	-

High-3, Medium-2, Low-1

Course Title	Power system operation and control	Semester	VII
Course Code	MVJ19EE741	CIE	50
Total No. of Contact Hours	40	SEE	50
No. of Contact Hours/week	4, 2:1:1 (L: T:P)	Total	100
Credits	3	Exam. Duration	3 Hours

Course objective is to: This course will enable students to

- Understand the significance of power system operation and control.
- Understand the reactive power-voltage interaction and to learn the control actions to be implemented for maintaining the voltage profile against varying system load.
- Understand the basics of speed governing system, various methods to control frequency.
- Understand the significance economic operation of power system.
- Understand the SCADA and its application for real time operation and control of power systems

Module-1	L1,L2	08Hrs.

Preliminaries on power system operation and control: Power scenario in Indian grid – National and Regional load dispatching centres – requirements of good power system - necessity of voltage and frequency regulation - real power vs frequency and reactive power vs voltage control loops - system load variation, basic concepts of load dispatching - load forecasting.

Experimental learning: Visiting national and regional load dispatch centre websites.

Applications: Power system operation.

Web Link and Video Lectures:

1.https://engmag.in/power-scenario-india-now-insight/

2.https://www.eeeguide.com/requirements-of-a-distribution-system/

Module-2	L1,L2	08Hrs.

Reactive power and Voltage control: Generation and absorption of reactive power, basics of reactive power control, Automatic Voltage Regulator (AVR), block diagram representation of AVR loop, static and dynamic analysis, stability compensation, voltage drop in transmission

line, methods of reactive power injection, tap changing transformer, SVC (TCR + TSC) and STATCOM for voltage control.

Experimental learning: Design of Simulink model for AVR

Applications: Reactive power control

Web Link and Video Lectures:

1.https://www.electricalindia.in/reactive-power-management-voltage-control-to-avoid-blackouts/

2.https://electrical-engineering-portal.com/how-reactive-power-is-helpful-to-maintain-a-system-healthy

Module-3	L1,L2	08Hrs.

Load –Frequency Control: Basics of speed governing mechanism and modelling – speed load characteristics – load sharing between two synchronous machines in parallel. Control area concept LFC control of a single-area system. Static and dynamic analysis of uncontrolled and controlled cases. Integration of economic dispatch control with LFC. Two area system – modelling - static analysis of uncontrolled case - tie line with frequency bias control of two-area system - state variable model.

Experimental learning: Two area LFC control.

Applications: Frequency control.

Web Link and Video Lectures:

1.https://jntua.ac.in/gate-online-classes/registration/downloads/material/a159041328312.pdf

2.https://www.allumiax.com/blog/top-5-advantages-of-parallel-operation-of-generators-or-alternators

Module-4	L1,L2	08Hrs.

Economic operation of power system :Statement of economic dispatch problem - input and output characteristics of thermal plant - incremental cost curve - optimal operation of thermal units without and with transmission losses (no derivation of transmission loss coefficients) - base point and participation factors method - statement of unit commitment (UC) problem - constraints on UC problem - solution of UC problem using priority list – special aspects of short term and long term hydrothermal problems.

Experimental learning: Solving unit commitment problem using software.

Applications: Solving unit commitment problems

Web Link and Video Lectures:

1.https://nptel.ac.in/content/storage2/courses/108107028/module1/lecture1/lecture1.pdf

2.https://www.power-technology.com/features/feature-the-top-10-biggest-thermal-power-plants-in-india/		
Module-5	L1,L2	08Hrs.
Computer Control of Power Systems: Need of computer control of power systems. Concept of energy control centre (or) load dispatch centre and the functions - system monitoring - data acquisition and control. System hardware configuration – SCADA and EMS functions. Network topology – Importance of Load Forecasting and simple techniques of forecasting. **Experimental learning:** Visiting substation equipped with SCADA. **Applications:** Automation. **Web Link and Video Lectures:** 1.https://www.inductiveautomation.com/resources/article/what-is-scada 2.https://www.youtube.com/watch?v=nlFM1q9QPJw		

Course outcomes:	
C404.1.1	Describe the day-to-day operation of electric power system.
C404.1.2	Understand the reactive power-voltage interaction.
C404.1.3	Acquire knowledge on real power-frequency interaction.
C404.1.4	Describe the significance of power system operation and control
C404.1.5	Design SCADA and its application for real time operation.

Text Books:	
1	Kothari D.P. and Nagrath I.J., 'Power System Engineering', Tata McGraw-Hi Education, Second Edition, 2008.
2	Hadi Saadat, 'Power System Analysis', McGraw Hill Education Pvt. Ltd., New Delhi, 21st reprint, 2010.

Reference Books:	
1	Kundur P., 'Power System Stability and Control, McGraw Hill Education Pvt. Ltd., New Delhi, 10th reprint, 2010.
2	Allen. J. Wood and Bruce F. Wollen berg, 'Power Generation, Operation and Control', John Wiley & Sons, Inc., 2016.

CIE Assessment:

CIE is based on quizzes, tests, assignments/seminars and any other form of evaluation. Generally, there will be: Three Internal Assessment (IA) tests during the semester (30 marks each), the final IA marks to be awarded will be the average of three tests

- Quizzes/mini tests (4 marks)
- Mini Project / Case Studies (8 Marks)
- Activities/Experimentations related to courses (8 Marks)

SEE Assessment:

i. Question paper for the SEE consists two parts i.e. Part A and Part B. Part A is compulsory and consists of objective type or short answer type questions of 1 or 2 marks each for total of 20 marks covering the whole syllabus.

ii. Part B also covers the entire syllabus consisting of five questions having choices and may contain sub-divisions, each carrying 16 marks. Students have to answer five full questions.

iii. One question must be set from each unit. The duration of examination is 3 hours.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
C404.1.1	3	3	-	3	-	-	-	-	-	-	2	1
C404.1.2	3	3	-	3	-	-	-	-	-	-	3	1
C404.1.3	3	3	1	3	-	-	-	-	-	-	2	-
C404.1.4	3	3	-	3	-	-	-	-	-	-	3	1
C404.1.5	3	3	-	3	-	-	-	-	-	-	2	1

High-3, Medium-2, Low-1

Course Title	Electric Vehicle Technologies	Semester	VII
Course Code	MVJ19EE742	CIE	50
Total No. of Contact Hours	40	SEE	50
No. of Contact Hours/week	4, 2:1:1 (L:T:P)	Total	100
Credits	3	Exam. Duration	3 Hours

Course objective is to: This course will enable students to

- Understand fundamental laws and vehicle mechanics.
- Understand upcoming technology of hybrid electric vehicles.
- Ability to develop the electric propulsion unit for EVs.
- Understand about drives and control of EVs.
- Ability to analyze different power converter topologies used for EVs application

Module-1	L1,L2	8Hrs.

Vehicle Mechanics: Roadway Fundamentals, Laws of Motion, Vehicle Kinetics, Dynamics of Vehicle Motion, Propulsion Power, Force-Velocity Characteristics, Maximum Gradeability, Velocity and Acceleration, Constant FTR, Level Road, Velocity Profile, Distance Traversed, Tractive Power, Energy Required, Non-constant FTR, General Acceleration, Propulsion System Design.

Laboratory Sessions/ Experimental learning: Simulation of a vehicle to understand the different forces acting on vehicle.

Applications: Stability check and mechanical design of EVs.

Video link:

1. https://youtu.be/wypbLRe9xUg
2. https://nptel.ac.in/courses/108/102/108102121/

Module-2	L1,L2,L3	8Hrs.

Introduction to Electric Vehicles: Introduction, conventional vehicles, and Electric vehicles, vehicle fundamentals, Types, performance and configuration of EVs, Traction motor characteristics.

Hybrid Electric Vehicles: Energy consumption concept of Hybrid Electric Drive Trains, Architecture of Hybrid Electric Drive Trains, Series Hybrid Electric Drive Trains, Parallel Hybrid Electric Drive Trains.

Laboratory Sessions/ Experimental learning: Case study on different EVs

Applications: Electric vehicles **Video link:** https://youtu.be/T5P9b0_Fv6w		
Module-3	**L1,L2,L3**	**8Hrs.**
Electric Propulsion System: Electric propulsion unit, EV consideration, Configuration and speed control : DC motor drives, Induction motor drives, Permanent Magnet Motor Drives, Switch Reluctance Motor Drive for Electric Vehicles, Sizing of Electric Machine for EVs and HEVs, Drive System Efficiency **Laboratory Sessions/ Experimental learning:** Analysis of Speed control of different types of motor in EVs using Simulink **Applications:** Electric vehicles **Video link:** https://nptel.ac.in/courses/108/102/108102121/		
Module-4	**L1,L2,L3**	**8Hrs.**
Design of Electric and Hybrid Electric Vehicles: **Series Hybrid Electric Drive Train Design:** Operating patterns, control strategies, Sizing of major components, power rating of traction motor, power rating of engine/generator, design of PPS **Parallel Hybrid Electric Drive Train Design:** Control strategies of parallel hybrid drive train, design of engine power capacity, design of electric motor drive capacity, transmission design, energy storage design. **Laboratory Sessions/ Experimental learning:** Case study on different energy management strategies. **Applications:** Electric vehicles **Video link:** https://nptel.ac.in/courses/108/102/108102121/		
Module-5	**L1,L2,L3,L4**	**8Hrs.**
Power Electronic Converter for Battery Charging: Charging methods for battery, Termination methods, charging from grid, The Z-converter, Isolated bidirectional DC-DC converter, High-frequency transformer based isolated charger topology, Transformer less topology. E-mobility Indian Roadmap Perspective. Policy: EVs in infrastructure system, integration of EVs in smart grid, social dimensions of EVs. **Laboratory Sessions/ Experimental learning:** Modeling of Electric Vehicles using MATLAB & Simulink. **Applications:** Electric vehicles **Video link:** https://youtu.be/yCjtiCFTFbk		

Course outcomes:	
C404.2.1	Explain roadway fundamental, laws of motion and vehicle mechanics
C404.2.2	Acquire fundamental concepts and principles of hybrid electric vehicles (HEV)
C404.2.3	Develop the electric propulsion unit for application of EVs.
C404.2.4	Analyze and apply electric drives in vehicles / traction
C404.2.5	Design converters for battery charging and explain transformer less topologies.
Text Books:	
1	Modern Electric, Hybrid Electric, andFuel Cell Vehicles: Fundamentals,Theory and Design, M. Ehsani, Y. Gao, S.Gay and Ali Emadi, CRC Press, 2005
2	Modern Electric Vehicle Technology C.C. Chan and K.T.Chau, OxfordUniversity 2001
Reference Books:	
1	Husain, I. "Electric and Hybrid Vehicles" Boca Raton, CRC Press, 2010
2	Larminie, James, and John Lowry, "Electric Vehicle Technology Explained" John Wiley and Sons, 2012

CIE Assessment:

CIE is based on quizzes, tests, assignments/seminars and any other form of evaluation. Generally, there will be: Three Internal Assessment (IA) tests during the semester (30 marks each), the final IA marks to be awarded will be the average of three tests

- Quizzes/mini tests (4 marks)
- Mini Project / Case Studies (8 Marks)
- Activities/Experimentations related to courses (8 Marks)

SEE Assessment:

i. Question paper for the SEE consists two parts i.e. Part A and Part B. Part A is compulsory and consists of objective type or short answer type questions of 1 or 2 marks each for total of 20 marks covering the whole syllabus.

ii. Part B also covers the entire syllabus consisting of five questions having choices and may contain sub-divisions, each carrying 16 marks. Students have to answer five full questions.

iii. One question must be set from each unit. The duration of examination is 3 hours.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12

C404.2.1	2	3	1	1	-	-	-	-	-	-	-	-
C404.2.2	2	3	1	2	-	-	-	-	-	-	-	-
C404.2.3	2	3	1	2	-	-	-	-	-	-	-	-
C404.2.4	2	3	1	2	-	-	-	-	-	-	-	-
C404.2.5	2	3	1	3	-	-	-	-	-	-	-	-

High-3, Medium-2, Low-1

Course Title	Advanced Power Electronics	Semester	VII
Course Code	MVJ19EE743	CIE	50
Total No. of Contact Hours	40	SEE	50
No. of Contact Hours/week	4, 2:1:1 (L:T:P)	Total	100
Credits	3	Exam. Duration	3 Hours

Course objective is to: This course will enable students to

- Determine the operation and characteristics of DC-DC switched mode converters
- Understand the various topologies of multilevel inverters.
- Study the basic topologies of resonant converters.
- Estimate various power supplies involves in the power electronics circuit.
- Apply the concept of power converters in various electrical applications

Module-1	L1, L2, L3	8Hrs.

DC-DC SWITCHED MODE CONVERTERS: Buck Converter, Boost Converter, Buck-Boost Converter, Cuk converters, SEPIC.

Laboratory Sessions/ Experimental learning: To study Cuk converter and SEPIC converter along with simulation

Applications: Portable electronic devices

Web Link and Video Lectures:

1. https://nptel.ac.in/courses/108/108/108108036/#
2. https://youtu.be/SOHXMx-8F5g
3. https://youtu.be/J6Sewi4WvNY

Module-2	L1, L2, L3	8Hrs.

Multilevel Inverter: Introduction, multilevel concept, types of multilevel inverters, Diode clamped multilevel inverter, flying capacitor multilevel inverter, cascaded multilevel inverter: principle of operation and features, Applications.

Laboratory Sessions/ Experimental learning: To study Diode clamped multilevel inverter along with simulation.

Applications: UPS, High voltage DC transmission, Variable Frequency Drives

Web Link and Video Lectures:

1. https://nptel.ac.in/content/storage2/108/102/108102157/MP4/mod03lec11.mp4
2. https://nptel.ac.in/content/storage2/108/102/108102157/MP4/mod03lec12.mp4

3. https://www.youtube.com/watch?v=vKKO7uPe6fI		
Module-3	**L1, L2, L3**	**8Hrs.**
RESONANT CONVERTERS: Introduction, need of resonant converters, Classification of resonant converters, load resonant converters, Resonant switch converters, zero voltage switching dc-dc converters, zero current switching dc-dc converters, clamped voltage topologies **Laboratory Sessions/ Experimental learning**:To study MOSFET/IGBT based single-phase series-resonant inverter with simulation. **Applications**:induction cookers, portable power supplies, network connection of renewable energy mains, hybrid and electric vehicles **Web Link and Video Lectures:** 1.https://nptel.ac.in/courses/108/107/108107128/ 2. https://www.youtube.com/watch?v=53avTO3BYnI		
Module-4	**L1, L2, L3**	**8Hrs.**
POWER SUPPLIES: Introduction, DC power supplies: flyback converter, forward converter, push-pull converter, half bridge converter, full bridge converter. **AC power supplies**: Switched mode AC power supplies, resonant AC power supplies, bidirectional AC power supplies. **Laboratory Sessions/ Experimental learning:** To study various design of power supplies through simulation **Applications**: Battery charging, automotive **Web Link and Video Lectures:** 1.https://nptel.ac.in/content/storage2/108/107/108107128/MP4/mod05lec23.mp4 2. https://nptel.ac.in/content/storage2/108/107/108107128/MP4/mod05lec24.mp4		
Module-5	**L1, L2, L3**	**8Hrs.**
APPLICATIONS: Uninterrupted power supplies, High voltage DC transmission, static switches, Static circuit breakers, solid state relays, Induction heating **Laboratory Sessions/ Experimental learning:** To study single phase AC switch using two thyristors along with waveforms using simulation. **Web Link and Video Lectures:** 1. https://nptel.ac.in/courses/108/108/108108034/ 2.https://youtu.be/lKRW4fEB6bE		
Course outcomes:		
C404.3.1	Analyze the operation and characteristics of DC-DC switched mode	

	converters
C404.3.2	Understanding various topologies of multilevel inverters
C404.3.3	Develop the basic topologies of resonant converters
C404.3.4	Estimation of various power supplies involves in the power electronics circuitry
C404.3.5	Apply the concepts of power converters in various electrical applications
Text Books:	
1	Power Electronics-circuits, devices an application, Muhammad H Rashid, Prentice-hall of India,3rd edition
2	Power Electronics, Dr. P S Bimbhra, Khanna Publishers, 5th edition, 2012
Reference Books:	
1	Power Electronics - converters, application & design, Mohan N, Undeland T.M., Robins, W.P,John Wiley ,3rd Edition 2008
2	Power Electronics Daniel W Hart McGraw Hill 1 st Edition, 2011

CIE Assessment:

CIE is based on quizzes, tests, assignments/seminars and any other form of evaluation. Generally, there will be: Three Internal Assessment (IA) tests during the semester (30 marks each), the final IA marks to be awarded will be the average of three tests

- Quizzes/mini tests (4 marks)
- Mini Project / Case Studies (8 Marks)
- Activities/Experimentations related to courses (8 Marks)

SEE Assessment:

i. Question paper for the SEE consists two parts i.e. Part A and Part B. Part A is compulsory and consists of objective type or short answer type questions of 1 or 2 marks each for total of 20 marks covering the whole syllabus.

ii. Part B also covers the entire syllabus consisting of five questions having choices and may contain sub-divisions, each carrying 16 marks. Students have to answer five full questions.

iii. One question must be set from each unit. The duration of examination is 3 hours.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
C404.3.1	3	2	2	1	-	-	-	-	-	-	-	3
C404.3.2	3	2	2	1	-	-	-	-	-	-	-	3
C404.3.3	3	2	2	1	-	-	-	-	-	-	-	3

C404.3.4	3	2	2	1	-	-	-	-	-	-	-	3
C404.3.5	3	2	2	1	-	-	-	-	-	-	-	3

High-3, Medium-2, Low-1

Course Title	Special Electrical Machines	Semester	VII
Course Code	MVJ19EE751	CIE	50
Total No. of Contact Hours	40	SEE	50
No. of Contact Hours/week	4, 2:1:1 (L:T:P)	Total	100
Credits	3	Exam. Duration	3 Hours

Course objective is to: This course will enable students to

- Understand the construction, operation and performance of Permanent magnet synchronous motor.
- Learn the operation and applications of Synchronous Reluctance Motors.
- Understand and compare the performance of different Single phase special electric machines
- Discuss operation, control and characteristics of servo motors and brushless D.C. motors.
- Evaluate the operation, control and performance of stepper motors and linear electric machines.

Module-1	L1,L2	8Hrs.
Permanent Magnet Synchronous Motor (PMSM): Construction, Principle of Operation, EMF Equation of PMSM, Control of PMSM, Comparison of Conventional and PM Synchronous Motors, Applications of PMSM-Study of application of PMSM as traction motor for electric vehicles. **Laboratory Sessions/ Experimental learning:** MATLAB simulation of speed control of PMSM. **Applications:** Robotics, machine tools, actuators. **Video link:** https://nptel.ac.in/courses/108/102/108102156/		
Module-2	**L1,L2,L3**	**8Hrs.**
Synchronous Reluctance Motors: Constructional features, operating principles, Types, Axial and Radial flux motors, Voltage equation, Characteristics, Advantages, disadvantages and application: SRM for automotive applications. **Laboratory Sessions/ Experimental learning:** Industrial Visit **Applications:** Conveyor belts, rice mills, paper mills **Video link:** https://nptel.ac.in/courses/108/102/108102156/		
Module-3	**L1,L2,L3**	**8Hrs.**

Single phase Special Electric machines: AC Series Motor – Construction, Principle of Working, EMF equation, Torque-Speed Characteristics. Repulsion Motor- Construction and Working, Types of Repulsion motors & characteristics. Hysteresis Motor, Universal Motor – Construction and Types, principle of operation, Applications.

Laboratory Sessions/ Experimental learning: Speed control of universal motor (Hardware/simulation)

Applications: Domestic appliances, High-speed lifts, Air compressors, Mining tools, Devices with noiseless operation

Video link:

1. https://nptel.ac.in/courses/108/102/108102156
2. https://www.youtube.com/watch?v=aMYGv0MM6UQ

Module-4	L1,L2,L3	8Hrs.

Servo Motors: DC Servo Motors – Construction, Principle of Operation, AC Servo Motors – Construction & Working, Analysis of Two-phase AC Servo Motor, Torque speed characteristics, Transfer Function.

Brushless D.C. Motors: Principle of Operation, Types, Magnetic circuit analysis, EMF equation, Commutation, Motor characteristics and control, Torque/speed characteristics

Laboratory Sessions/ Experimental learning: Speed torque characteristics of AC & DC servo motor.

Applications: Robotics, Solar Tracking System, Metal Cutting Metal Forming Machines, Industrial robots, CNC machine tools.

Video link:

1. https://www.youtube.com/watch?v=UmHtWX2XYSM
2. https://www.youtube.com/watch?v=EQzm51BK6UE&list=PLA5CA7D35114BA425&index=23

Module-5	L1,L2,L3	8Hrs.

Stepper Motor: Introduction, Variable Reluctance Stepper Motor, Permanent Magnet Stepper Motor, Hybrid Stepper Motor, Windings in Stepper Motors, Characteristics of Stepper Motor, Open – loop Control of Stepper Motor, Closed – loop Control of Stepper Motor, Microprocessor – Based Control of Stepper Motor, Applications of Stepper Motor.

Linear Electric Machines: Linear Induction motor, DC Linear Motor, Linear Reluctance and Levitation Machines.

Laboratory Sessions/ Experimental learning: Demonstration with an experiment, microprocessor-based control of stepper motor.

Applications: 3D printing equipment, Textile machines, CNC milling machines, Welding equipment, overhead traveling cranes and beltless conveyors, , maglev (magnetic levitation) trains

Video link:
1.https://www.youtube.com/watch?v=UmHtWX2XYSM
2.https://www.youtube.com/watch?v=Tp724MqrosA

Course outcomes:	
C405.1.1	Explain the operation and control of permanent magnet synchronous motors.
C405.1.2	Use the concept of operation and control of synchronous reluctance motor for choosing such motors in a wide range of applications.
C405.1.3	Distinguish the different single phase special electric machines.
C405.1.4	Explain Servo motors and brushless DC motors.
C405.1.5	Analyse the performance of stepper motors and linear electric machines.

Text Books:	
1	E.G. Janardanan, "Special Electrical Machines" PHI, 1 st Edition 2014.
2	T J E Miller, "Brushless Permanent Magnet and Reluctance Motor Drives" Clerendon Press, Oxford 1989.

Reference Books:	
1	Kenjo T and Nagamori S, "Permanent Magnet and Brushless DC Motors", Clerendon Press, Oxford,1985.
2	Kenjo, "Stepping Motors and their Microprocessor Control", Clerendon Press Oxford,1984.

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- Quizzes/mini tests (4 marks)
- Mini Project / Case Studies (8 Marks)
- Activities/Experimentations related to courses (8 Marks)

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iii. One question must be set from each unit. The duration of examination is 3 hours.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
C405.1.1	3	3	1	3	-	-	-	-	-	-	2	-
C405.1.2	3	3	-	3	-	-	-	-	-	-	2	-
C405.1.3	3	3	-	3	-	-	-	-	-	-	1	2
C405.1.4	3	3	-	3	-	--	-	-	-	-	1	-
C405.1.5	3	3	-	3	-	--	-	-	-	-	2	-

High-3, Medium-2, Low-1

Course Title	Energy Storage Systems	Semester	VII
Course Code	MVJ19EE752	CIE	50
Total No. of Contact Hours	40	SEE	50
No. of Contact Hours/week	4,2:1:1 (L:T:P)	Total	100
Credits	3	Exam. Duration	3 Hours

Course objective is to: This course will enable students to

- Understand the needs for energy storage.
- Understand the types of electrical energy storage Systems.
- Understand the various technologies available and their applications.
- Explain various devices used for the energy storage systems.

Module-1	L1,L2	8Hrs.

Needs for Electrical Energy Storage: Emerging needs for EES, Smart Grid uses, The roles of electrical energy storage technologies, The roles from the viewpoint of a utility, consumers and generators of renewable energy, Classification of EES systems.

Laboratory Sessions/ Experimental learning: Case study on the need of energy storage.

Applications: Uninterrupted power supply.

Web Link and Video Lectures: https://www.youtube.com/watch?v=EakRe6ICM-Q

Module-2	L1,L2,L3	8Hrs.

Mechanical Energy Storage Systems: Mechanical storage systems, Pumped hydro storage (PHS), Compressed air energy storage (CAES), Flywheel energy storage (FES).

Electrical Energy Storage Systems: Electrical Energy storage-super-capacitors, Magnetic Energy Storage-Superconducting systems,

Laboratory Sessions/ Experimental learning: Demonstration of energy storage using capacitor.

Applications: Power grids

Web Link and Video Lectures: https://nptel.ac.in/courses/108/106/108106182/

Module-3	L1,L2,L3	8Hrs.

Chemical Energy Storage Systems: Chemical-Hydrogen production and storage, Principle of direct energy conversion using fuel cells, thermodynamics of fuel cells, Types of fuel cells, AFC, PEMFC, MCFC, SOFC, Microbial fuel cell, Fuel cell performance,

Laboratory Sessions/ Experimental learning: Demonstration of Fuel cell

Application: Domestic, commercial and transport **Web Link and Video Lectures:** https://nptel.ac.in/courses/108/106/108106182/		
Module-4	**L1,L2,L3**	**8Hrs.**
Electrochemical Energy Storage: Battery, primary, secondary and flow batteries. **Thermal Energy Storage systems:** Thermal Energy storage, sensible and latent heat, phase change materials, Energy and energy analysis of thermal energy storage. **Laboratory Sessions/ Experimental learning:** Demonstration of Battery. **Application:** Electrical vehicles and RES **Web Link and Video Lectures:** https://www.youtube.com/watch?v=HUlQ09x6Tmo		
Module-5	**L1,L2,L3**	**8Hrs.**
Design and Applications of Energy Storage: Renewable energy storage-Battery sizing and stand-alone applications, stationary (Power Grid application), Small scale application-Portable storage systems and medical devices, Mobile storage Applications- Electric vehicles (EVs), types of EVs, batteries and fuel cells, future technologies, hybrid systems for energy storage. **Laboratory Sessions/ Experimental learning:** Battery energy management in electric vehicles **Application:** RES, Smart grid. **Web Link and Video Lectures:** https://nptel.ac.in/courses/108/106/108106182/		

Course outcomes:	
C405.2.1	Explain needs for Electrical Energy Storage.
C405.2.2	Analyse the characteristics of energy from various sources.
C405.2.3	Classify various types of energy storage systems and various devices used for the purpose
C405.2.4	Understand the types of electrical energy storage Systems.
C405.2.5	Identify various real time applications.
Text Books:	
1	"James M. Eyer, Joseph J. Iannucci and Garth P. Corey ", "Energy Storage Benefits and Market Analysis", Sandia National Laboratories, 2004
2	"Jim Eyer, Garth Corey", Energy Storage for the Electricity Grid: Benefits and Market Potential Assessment Guide, Report, Sandia National Laboratories, Feb 2010.
Reference Books:	
1	Pillai.S.K A First Course on Electric Drives, Wiley Eastern Limited, 2012
2	Singh. M.D., K.B.Khanchandani, Power Electronics, Tata McGraw-Hill, 2006.

CIE Assessment:

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SEE Assessment:

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ii. Part B also covers the entire syllabus consisting of five questions having choices and may contain sub-divisions, each carrying 16 marks. Students have to answer five full questions.

iii. One question must be set from each unit. The duration of examination is 3 hours.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
C405.2.1	1	1	1	-	2	2	2	-	3	1	1	3
C405.2.2	1	1	1	-	2	2	2	-	2	2	1	3
C405.2.3	1	1	1	-	2	2	1	-	3	1	1	1
C405.2.4	1	1	1	-	1	2	2	-	2	1	1	2
C405.2.5	1	1	1	-	3	2	1	-	2	1	1	2

High-3, Medium-2, Low-1

Course Title	Reliability of Engineering Systems	Semester	VII
Course Code	MVJ19EE753	CIE	50
Total No. of Contact Hours	40	SEE	50
No. of Contact Hours/week	4, 2:1:1 (L:T:P)	Total	100
Credits	3	Exam. Duration	3 Hours

Course objective is to: This course will enable students to

- Familiarize with reliability evaluation
- Understand the probability theory for reliability evaluation
- Familiarize with different probability distribution functions.
- Assess the reliability of simple and complex system.
- Understand the Monte Carlo simulation and its applications.

Module-1	L1, L2	8Hrs.

Basic Probability Theory: Elements of probability, probability distributions, Random variables, Density and Distribution functions, Binomial distribution, Poisson distribution, normal distribution, exponential distribution, Weibull distribution, Expected value and standard deviation.

Laboratory Sessions/ Experimental learning: Probability distribution function fitting in MATLAB for a random variable.

Applications: Estimation of failure and repair time by using probability distribution functions.

Video link:

1. https://nptel.ac.in/courses/114/106/114106041/
2. https://nptel.ac.in/courses/105/108/105108128/

Module-2	L1, L2, L3	8Hrs.

Concept of Reliability: Definition of terms used in reliability, Component reliability, Hazard rate, derivation of the reliability function in terms of the hazard rate. Hazard models – Bath tub curve, Effect of preventive maintenance. Measures of reliability: Mean Time to Failure and Mean Time Between Failures.

Laboratory Sessions/ Experimental learning: Evaluation of MTF and MTBF for a component.

Applications: Estimation of failure and repair times for reliability evaluation.

Video link: 1. https://nptel.ac.in/courses/114/106/114106041/ 2. https://nptel.ac.in/courses/105/108/105108128/		
Module-3	L1, L2, L3	8Hrs.
Network Modelling and Evaluation Of Simple Systems: Basic concepts- Evaluation of network Reliability / Unreliability – Series systems, Parallel systems- Series-Parallel systems Partially redundant systems- Examples. **Evaluation of Complex systems:** Conditional probability method, tie set, Cutset approach- Event tree and reduced event tree methods- Relationships between tie and cutsets- Examples. Fault tree, Quantitative assessment of a top event, Duplicated basic events, Minimal cut sets **Laboratory Sessions/ Experimental learning**: Develop a fault tree for transformer failure assessment. **Applications**: Reliability evaluation of simple and complex systems using analytical methods **Video link:** 1. https://nptel.ac.in/courses/114/106/114106041/ 2. https://nptel.ac.in/courses/105/108/105108128/		
Module-4	L1, L2, L3	8Hrs.
Time Dependent Probability: Basic concepts- Reliability function f(t). F(t), R(t) and h(t) – Relationship between these functions. Network Reliability Evaluation Using Probability Distributions: Reliability Evaluation of Series systems, Parallel systems – Partially redundant systems- determination of reliability measure- MTTF for series and parallel systems – Examples. **Laboratory Sessions/ Experimental learning**: Evaluation of reliability for series and parallel system. **Applications**: Evaluation of time dependent reliability **Video link**: 1.https://nptel.ac.in/courses/114/106/114106041/ 2.https://nptel.ac.in/courses/105/108/105108128/		
Module-5	L1, L2, L3,L4	8Hrs.

Monte Carlo Simulation: Introduction, Concepts of simulation, Random variants, Simulation output, Application of MCS techniques, Number of simulations: Stopping rules, Variance reduction techniques

Laboratory Sessions/ Experimental learning: Calculate the failure probability of any equipment in your discipline.

Applications: Assessment of reliability considering the uncertainty in the failures.

Video link:

1. https://nptel.ac.in/courses/114/106/114106041/
2. https://nptel.ac.in/courses/105/108/105108128/

Course outcomes:

C405.3.1	Application of probability theory for reliability evaluation.
C405.3.2	Understanding of basic reliability concepts.
C405.3.3	Reliability evaluation of simple and complex system.
C405.3.4	Application of time dependent probability theory
C405.3.5	Reliability evaluation using Monte Carlo Technique

Text Books:

1	Roy Billinton and Ronald N Allan, Reliability Evaluation of Engineerin Systems, Plenum Press, 1983.
2	E. Balagurusamy, Reliability Engineering, Tata McGraw-Hill Publishing Company Limited, 2002.

Reference Books:

1	K. K. Agarwal, Reliability Engineering-Kluwer Academic Publishers, 1993
2	Charles E. Ebeling, An Introduction to Reliability and Maintainability Engineering, Tata McGraw-Hill Publishing Company Limited,

CIE Assessment:

CIE is based on quizzes, tests, assignments/seminars and any other form of evaluation. Generally, there will be: Three Internal Assessment (IA) tests during the semester (30 marks each), the final IA marks to be awarded will be the average of three tests

- Quizzes/mini tests (4 marks)
- Mini Project / Case Studies (8 Marks)
- Activities/Experimentations related to courses (8 Marks)

SEE Assessment:

i. Question paper for the SEE consists two parts i.e. Part A and Part B. Part A is compulsory and consists of objective type or short answer type questions of 1 or 2 marks each for total of 20 marks covering the whole syllabus.

ii. Part B also covers the entire syllabus consisting of five questions having choices and may contain sub-divisions, each carrying 16 marks. Students have to answer five full questions.

iii. One question must be set from each unit. The duration of examination is 3 hours.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
C405.3.1	1	1	1	-	2	2	2	-	3	1	1	3
C405.3.2	1	1	1	-	2	2	2	-	2	2	1	3
C405.3.3	1	1	1	-	2	2	1	-	3	1	1	1
C405.3.4	1	1	1	-	1	2	2	-	2	1	1	2
C405.3.5	1	1	1	-	3	2	1	-	2	1	1	2

High-3, Medium-2, Low-1

Course Title	Simulation of Power Electronic Converters	Semester	VII
Course Code	MVJ19EEL76	CIE	50
Total No. of Contact Hours	20	SEE	50
No. of Contact Hours/week	4,0:2:2(L:T:P)	Total	100
Credits	2	Exam. Duration	3 Hours

Course objective is to: This course will enable the students to

- Design three phase converters with different loads.
- Design ZVS and ZCS resonant converters.
- Design DC-DC converters
- Design a solar system for DC Loads

Sl No	Experiment Name	RBT Level	Hours
1	Simulation of three phase-controlled rectifiers with R and RL load	L3	2
2	Simulation of three phase inverter with PWM controller.	L3	2
3	Simulation of zero current switching resonant converter	L3	2
4	Simulation of zero voltage switching resonant converter.	L3	2
5	Simulation of Buck and Boost converter	L3	2
6	Simulation Buck-Boost converter	L3	2
7	Simulation of single phase two stage photovoltaic system.	L3	2
8	Simulation of Multilevel converter	L3	2
Along with mandatory experiments students are advised to complete two open ended experiments. The following are some suggestions for open ended experiments.			
1	Simulation of a bidirectional converter	L3	2
2	Simulation of Power Quality mitigation devices	L3	2
3	Linear control of power electronics converter	L3	2

Course outcomes:

C406.1	Design switching technique of three phase rectifier and inverter for practical applications.
C406.2	Design switching techniques of ZVS and ACS resonant converters.
C406.3	Design of Buck-Boost converter for real time applications.

C406.4	Design a solar system with boost converter for dc loads.

Scheme of Evaluation

SEE :

Examinations will be conducted for 100 marks and scaled-down to 50. The weight age shall be,

Write-up : 20 marks

Conduction : 40 marks

Analysis of results : 20 marks

Viva : 20

CIE :

Regular Lab work :20

Record writing :5

Lab Tests(Minimum 2 tests shall be conducted for 15 marks and average of two will be taken)

Viva 10 marks

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
C406.1	3	3	2	2	3	1	-	-	3	-	-	3
C406.2	3	3	2	2	3	1	-	-	3	-	-	3
C406.3	3	3	2	2	3	1	-	-	3	-	-	3
C406.4	3	3	2	2	3	1	-	-	3	-	-	3

High-3, Medium-2, Low-1

Course Title	Power System Protection Lab	Semester	VII
Course Code	MVJ19EEL77	CIE	50
Total No. of Contact Hours	20	SEE	50
No. of Contact Hours/week	4, 0:2:2(L: T:P)	Total	100
Credits	2	Exam. Duration	3 Hours

Course objective is to: This course will enable students to

- Understand the operation of over current relays.
- Understand the operation of under voltage and over voltage relays.
- Analyze the lightning impulse voltage.
- Measure the HVDC and HVAC using Standard Spheres.
- Explain the various protection schemes.

Sl No	Experiment Name	RBT Level	Hours
1	IDMT non-directional characteristics and calculation of error in operating time for Over current Relay (Electro mechanical type)	L3	2
2	Operating characteristics of Over voltage & Under voltage Relay (Electro mechanical type)	L3	2
3	Operating characteristics of Microprocessor – based (numeric) Over / Under voltage Relay.	L3	2
4	Operating Characteristics of Microprocessor Based (Numeric) Over Current Relay.	L3	2
5	Motor protection scheme Studies.	L3	2
6	Spark over characteristics of air insulation subjected to High Voltage AC – with Spark over voltage corrected to STP.	L3	2
7	Breakdown strength of transformer oil using oil test kit.	L3	2
8	Generator Protection Scheme	L3	2
Along with mandatory experiments students are advised to complete two open ended experiments. The following are some suggestions for open ended experiments.			
1	Field mapping using electrolytic tank for capacitor model	L3	2
2	Generation of standard lightning impulse voltage.	L3	2
3	Spark over characteristics of air insulation subjected to High Voltage DC.	L3	2

Course outcomes:

C407.1	Understand the IDMT characteristics of Electro – mechanical relays.
C407.2	Interpret the breakdown strength of transformer oil using oil test kit.
C407.3	Show the operating characteristics of microprocessor based relay
C407.4	Summarize the generator and motor protection schemes
C407.5	Obtain the spark over characteristics of air insulation subjected to HVDC and HVAC.

Scheme of Evaluation

SEE :

Examinations will be conducted for 100 marks and scaled-down to 50. The weight age shall be,

Write-up : 20 marks

Conduction : 40 marks

Analysis of results : 20 marks

Viva : 20

CIE :

Regular Lab work :20

Record writing :5

Lab Tests(Minimum 2 tests shall be conducted for 15 marks and average of two will be taken)

Viva 10 marks

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
C407.1	3	1	2	2	1	-	-	-	-	-	-	1
C407.2	3	2	2	3	1	-	-	-	-	-	-	1
C407.3	3	1	2	2	1	-	-	-	-	-	-	1
C407.4	3	2	2	2	1	-	-	-	-	-	-	1
C407.5	3	2	2	2	1	-	-	-	-	-	-	1

High-3, Medium-2, Low-1

Course Title	PROJECT PHASE – 1	Semester	VII
Course Code	MVJ19EEP78	CIE	100
Total No. of Contact Hours	L : T : P :: 0 : 0 : 4	SEE	
No. of Contact Hours/week	-	Total	100
Credits	02	Exam. Duration	3 Hours

Course Objective: This course will enable the students to

- Develop interactive, communication, organization, time management, and presentation skills.
- Impart flexibility and adaptability.
- Inspire independent and team working.
- Expand intellectual capacity, credibility, judgment, intuition.
- Adhere to punctuality, setting and meeting deadlines.
- Instill responsibilities to oneself and others.
- Train students to present the topic of project work in a seminar without any fear, face audience confidently, enhance communication skill, involve in group discussion to present and exchange ideas.

Project Work Phase - I: Each student of the project batch shall involve in carrying out the project work jointly in constant consultation with internal guide, co-guide, and external guide and prepare the project report as per the norms avoiding plagiarism.

Course outcomes: At the end of the course the student will be able to:

C408.1	Describe the project and be able to defend it. Develop critical thinking and problem-solving skills.
C408.2	Learn to use modern tools and techniques. Communicate effectively and to present ideas clearly and coherently both in written and oral forms.
C408.3	Develop skills to work in a team to achieve common goal. Develop skills of project management and finance.

C408.4	Develop skills of self-learning, evaluate their learning and take appropriate actions to improve it.
C408.5	Prepare them for life-long learning to face the challenges and support the technological changes to meet the societal needs.

Scheme of Evaluation:

Continuous Internal Evaluation: The CIE (100 marks) evaluation shall be based on Phase wise completion of the project work, Project report, Presentation and Demonstration of the actual/model/prototype of the project.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
C408.1	2	2	2	3	3	2	1	1	2	1	1	2
C408.2	2	2	2	3	3	2	1	1	2	1	2	2
C408.3	2	2	2	3	3	2	1	1	2	1	2	2
C408.4	2	2	2	3	3	2	1	1	2	1	2	2
C408.5	2	2	2	3	3	2	1	1	2	1	2	2