POWER ELECTRONIC CONVERTERS			
Course Code	22LPE12	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:2:0	SEE Marks	50
Total Hours of Pedagogy	40 hours Theory + 11 Lab slots	Total Marks	100
Credits	04	Exam Hours	03

Course objectives:

1. To understand and acquire knowledge about various types of DC-DC Converters.
2. To understand and acquire knowledge about principles and characteristics of various control modules, Inverters.
3. To familiarize students to the principle of operation, design and synthesis of different power conversion circuits and their applications.

MODULE-1

Review of DC-DC converters: Buck,Boost, Buck-boost, Cuk, SEPIC converters, half bridge and full bridge converters

DC/DC Converters with galvanic isolation: Forward Converters - Analysis of the Basic Circuit, continuous and Discontinuous Modes, Power Losses, need of tertiary winding. Flyback converters, analysis, nature of isolation transformer. Push – Pull (Symmetric) Converters - Analysis of Idealized Circuit in Continuous Mode, Output Characteristics, Selection of Components, DC Pre-magnetization of the Core, Half-Bridge and Full-Bridge Converters with isolation, Hamilton Circuit, Ćuk Converters with Galvanic Isolation.

Control Modules: Basic Principles and Characteristics of PWM Control Modules - Circuit Analysis, Simple PWM, Voltage-Controlled PWM, Current-Controlled PWM-Compensated PWM, IC Control Modules - ControlModuleTL494, ControlModuleSG1524/2524/3524, ControlModuleTDA1060.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

MODULE-2

DC/AC Converters–Inverters: Single-Phase Voltage Inverters-Pulse-Controlled Output Voltage, Pulse-Width Modulated Inverters - Unipolar and bipolar PWM, Three-Phase Inverters-Over modulation, Asynchronous PWM,Space Vector Modulation - Space Vector Modulation: Basic Principles, Application of Space Vector Modulation Technique, Direct and Inverse Sequencing.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

MODULE-3

AC-DC Converters – Rectifiers : Review of single phase and three phase controlled rectifiers in continuous and discontinuous modes with R, RL and RLE loads.

PFC rectifiers: Rectifiers with Circuit for Power Factor Correction, Active Rectifier - Active Rectifier with Hysteresis Current Controller, PWM Rectifiers - Advanced Control Techniques of PWM Rectifiers , PWM Rectifier with current Output, PWM Rectifiers in Active Filters, Some Topologies of PWM Rectifiers, Applications of PWM Rectifiers.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

MODULE-4

Resonant Converters: Resonant Circuits - Resonant Converters of Class D, Series Resonant Converters, ParallelResonantConverters,Series–ParallelResonantConverter,SeriesResonantConvertersBasedonGTOThyristors,Class E Resonant Converters, DC/DC Converters Based on Resonant Switches - ZCS Quasi-resonant Converters,ZVS Quasi-resonant Converters, Multi-resonant Converters, ZVS Resonant DC/AC Converters, Soft SwitchingPWMDC/DCConverters-PhaseShiftBridgeConverters,ResonantTransitionsPWMConverters,ControlCircuitsofResonantConverters-IntegratedCrircuitFamilyUCx861-8,IntegratedCircuitsforControl ofSoft,Switching PWMConverters.	
Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos
MODULE 5	
Matrix converters: Introduction to AC/AC Matrix Converters –Direct and indirect matrix converters, Basic Characteristics, Bidirectional Switches, Realization of Input Filter, Current Commutation, Protection of Matrix Converter, Application of Matrix Converter. **Introduction to Multilevel Converters:** Basic Characteristics-Multilevel DC/DC Converters, Multilevel Inverters - Cascaded H-Bridge Inverters, Diode-Clamped Multilevel Inverters, Flying Capacitor Multilevel Inverter, Other Multilevel Inverter Topologies, Control of Multilevel Inverters- Multilevel SPWM, Space Vector Modulation, Space Vector Control, Selective Harmonic Elimination.	
Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos
Sl.NO	Experiments
P-Spice Simulation of following	
1	Comparison of basic power electronic circuit with analog circuit.
2	Buck and Boost converter
3	Flyback converter
4	Single-phase inverter
5	Three-phase inverter
6	Single- and three-phase diode rectifier
Hardware Experiments	
7	Design and analysis of single-phase DC-DC converter (buck, boost and buck-boost).
8	Design and analysis AC-DC half-controlled and fully-controlled rectifiers.
9	Development of mathematical model for Solar cell.
10	EMI filter design for DC-DC converters using bode plots.
11	Development of mathematical model for separately excited DC motor.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

CIE for the theory component of IPCC

1. Two Tests each of **20 Marks**

2. Two assignments each of **10 Marks/One Skill Development Activity of 20 marks**
3. Total Marks of two tests and two assignments/one Skill Development Activity added will be CIE for 60 marks, marks scored will be proportionally scaled down to **30 marks**.

CIE for the practical component of IPCC

- On completion of every experiment/program in the laboratory, the students shall be evaluated and marks shall be awarded on the same day. The**15 marks** are for conducting the experiment and preparation of the laboratory record, the other **05 marks shall be for the test** conducted at the end of the semester.
- The CIE marks awarded in the case of the Practical component shall be based on the continuous evaluation of the laboratory report. Each experiment report can be evaluated for 10 marks. Marks of all experiments' write-ups are added and scaled down to 15 marks.
- The laboratory test at the end /after completion of all the experimentsshall be conducted for 50 marks and scaled down to 05 marks**.**

Scaled-down marks of write-up evaluations and tests added will be CIE marks for the laboratory component of IPCC for **20 marks**.

SEE for IPCC

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (duration 03 hours)

1. The question paper will be set for 100 marks and marks scored will be scaled down proportionately to 50 marks.
2. The question paper will have ten questions. Each question is set for 20 marks.
3. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
4. The students have to answer 5 full questions, selecting one full question from each module.

The theory portion of the IPCC shall be for both CIE and SEE, whereas the practical portion will have a CIE component only. Questions mentioned in the SEE paper shall include questions from the practical component).

- The minimum marks to be secured in CIE to appear for SEE shall be the 15 (50% of maximum marks-30) in the theory component and 10 (50% of maximum marks -20) in the practical component. The laboratory component of the IPCC shall be for CIE only. However, in SEE, the questions from the laboratory component shall be included**.** The maximum of 04/05 questions to be set from the practical component of IPCC, the total marks of all questions should not be more than the 20 marks.
- SEE will be conducted for 100 marks and students shall secure 40% of the maximum marks to qualify in the SEE. Marks secured will be scaled down to 50. (Student has to secure an aggregate of 50% of maximum marks of the course(CIE+SEE)

Suggested Learning Resources:

Text/Reference Books

1. Power Electronics Converters and Regulators, Branko L. Doki ć Branko Blanu š a, Springer (International Publishing, Switzerland), 3rd Edition, 2015.
2. Power Electronics Converters, Applications, and Design, Ned Mohan at el, Wiley, 3rd Edition, 2014.

Web links and Video Lectures (e-Resources):

- www.nptel.ac.in

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- Seminars
- Quizes
- Assignments

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Use the knowledge of PWM techniques in controlling different power electronic converters.	L3
CO2	Apply the knowledge of power electronics in design and analysis of DC–DC PWM converters.	L3
CO3	Design and analyze DC –AC and AC – DC converters and control their operation using PWM techniques.	L3
CO4	Design and analyze different resonant converters and their control circuits.	L3
CO5	Analyze AC – AC converters and multilevel converters.	L3

POWERSEMICONDUCTORDEVICESANDHIGH FREQUENCY MAGNETICS			
Course Code	22LPE13	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:2	SEE Marks	50
Total Hours of Pedagogy	50 Hours	Total Marks	100
Credits	04	Exam Hours	03

Course Learning objectives:

1. To understand and acquire knowledge of emerging new devices.
2. To understand the snubber circuits, gate and base drive circuits, component temperature control.
3. To understand the magnetic, various laws governing the magnetics, electrical equivalent circuits.
4. To understand winding resistance components, skin effect, leakage inductance and paracitic capacitance and their effects.
5. To acquire knowledge of designing inductor, transformer for converters.

Module-1

Basic Semiconductor Physics: Introduction, Conduction Processes in Semiconductors pn Junctions, Charge Control Description of pn-Junction Operation, Avalanche Breakdown.

Review of power diodes, BJTs, Thyristors, GTOs, Power Mosfets, IGBTs

Emerging Devices and Circuits: Introduction, Power Junction Field Effect Transistors, Field-Controlled Thyristor, JFET-Based Devices versus Other Power Devices, MOS-Controlled Thyristors, Power Integrated

Circuits, New Semiconductor Materials for Power Devices.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-2

Snubber Circuits: Function and Types of Snubber Circuits, Diode Snubbers, Snubber Circuits for Thyristors, Need for Snubbers with Transistors, Turn-Off Snubber, Overvoltage Snubber, Turn-On Snubber, Snubbers for Bridge Circuit Configurations, GTO Snubber Considerations.

Gate and Base Drive Circuits: Preliminary Design Considerations, dc-Coupled Drive Circuits, Electrically Isolated Drive Circuits, Cascode-Connected Drive Circuits, Thyristor Drive Circuits, Power Device Protection in Drive Circuits. circuit Layout Considerations.

Component Temperature Control and Heat Sinks: Control of Semiconductor Device Temperatures, Heat Transfer by Conduction, Heat sinks, Heat Transfer by Radiation and Convection.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-3

Basics of magnetics : Basics of magnetics, fields, magnetic relationships, B-H curve, magnetic energy, energy density, eddy currents, inductance, air gap effects, Inductance of coaxial cables, Faradays', Lenz's and Ampere's laws, magnetic circuits and electrical equivalent circuits, B-H curve, magnetic energy, energy density, eddy currents, inductance, air gap effects, Inductance of coaxial cables, self-resonant frequency, Quality Factor of Inductors, multi-winding magnetics, non-inductive coils, Ferrites, powdered cores, amorphous cores.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-4	
Winding ac resistance : skin and proximity effects, Dowell's equation, conduction losses with PWM waveforms, resistance matrix, Litz wire – basic principle and design, air-gap fringing and its effects on AC resistance, Power Loss Density in Round Conductor, Skin Effect in Single Rectangular Plate, Skin Effect in Rectangular Foil Conductor Placed Over Ideal Core, proximity effects. **Leakage inductance** : Analytical estimation of leakage inductance, interleaving to reduce leakage and ac resistance in transformers and its limitations. **Parasitic Capacitances:** Inter and intra-winding capacitances – genesis and their impacts on circuit operation, techniques to reduce them, analytical estimation, self capacitances of different circuit configurations. Hysteresis and Eddy current losses- origin, Steinmetz equation and improvements, core loss measurement techniques, choice of core material.	
Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos
Module-5	
Transformer and Inductor Design: Area Product Method, Optimum Flux Density, Transformer Design for flyback Converter in CCM and DCM, Geometrical Coefficient Kg Method. **Planar inductors and transformers**: Construction, advantages over bobbin wound devices.	
Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs
3. The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Text Books/ Reference Books

1.PowerElectronics,Daniel W Hart,McGrawHill.
2.Power ElectronicsConverters,Applications,andDesign,NedMohanetal,Wiley,3rd Edition,2014.
3.SemiconductorDeviceModelingwith Spice,G. Massobrio, P.Antognetti, McGraw-Hill, 2nd Edition, 2010.
4.PowerSemiconductorDevices,B.JayantBaliga,Springer,2008.
5.PowerElectronicsPrinciplesandApplications,JosephVithayathil,McGraw-Hill,2011.

Web links and Video Lectures (e-Resources):

- www.nptel.com

Skill Development Activities Suggested

1. **Study of Pspice**: Simulation using PSPICE, Capture and schematics, Analog behavioral models, power computations using PSPICE.
2. Simulation of various device characteristics.
3. Calculating various losses theoretically and verifying the same using simulation.
4. Designing inductors for specific applications.
5. Seminars

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Analyse and explain emerging new Power Electronic devices and circuits.	L3
CO2	Analyse and explain the function and types ofSnubber Circuits, gate and base drive circuits for various power electronics devices, the function of heat sink.	L3
CO3	Explain B-H curve, magnetic energy applied for converters, materials used for inductors.	L3
CO4	Explain winding resistance, leakage inductor and parasitic capacitance of transformer.	L3
CO5	Design and analyse inductor and transformer.	L3

MODELLINGANDDESIGNOFCONTROLLERS			
Course Code	22LPE14	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	40 Hours	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

1. To understand and acquire knowledge about Computer Simulation of Power Electronic Converters and Systems and modelling of systems.
2. To understand control system essentials, representation of system in digital Domain, control principles.
3. To understand the design of digital controller, techniques involved.
4. To understand optimal and robust controller design principles and design robust controller.
5. To understand and acquire knowledge about DiscreteComputation essentials.

Module-1

Computer Simulation of Power Electronic Converters and Systems: Introduction, Challenges in ComputerSimulation, Simulation Process, Mechanics of Simulation, SolutionTechniquesforTime-DomainAnalysis,WidelyUsed, Circuit-OrientedSimulators,EquationSolvers.
ModellingofSystems: Input-Outputrelations,DifferentialEquationsandLinearization,StateSpaceRepresentation,TransferFunctionRepresentation,BlockDiagrams,Lagrangemethod,CircuitAveraging,Bond Graphs,SpaceVectorModelling.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-2

Control System Essentials: Representation of system in digital Domain, The Z – Transform, Digital Filter,Mappingbetweens–planeandz–plane,EffectofSampling,ContinuoustoDiscreteDomainConversion,ControlSystemBasics, ControlPrinciples, State -

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-3

Digital Controller Design: Controller Design Techniques, Bode Diagram Method, PID Controller, Root LocusMethod, State Space Method, Full State Feedback, Regulator Design by Pole Placement, Estimation Design,Tracker:Controller Design.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-4

Digital Controller Design (continued): Controlling Voltage, Controlling Current, Control of Induction motor,OutputFeedback, InductionmotorControlwithOutputFeedback.
Optimal and Robust Controller Design: Least Squares Principle, Quadratic Forms, Minimum Energy Principle,Least Square Solution, Weighted Least Squares, Recursive Least Squares, Optimal Control: Linear Quadratic,Induction motor example,RobustController Design.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-5	
DiscreteComputationEssentials: NumericFormats,TrackingtheBasePointintheFixedPointSystem,Normalization AndScaling, ArithmeticAlgorithms.	
Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs
3. The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Text Books/Reference Books

1.Power ElectronicsConverters,Applications,andDesign,NedMohan,ToreM.Undeland,WilliamP.Robbins, Wiley,3rd Edition,2014.
2.PowerElectronicsEssentialsand Applications,L. Umanand,Wiley,1stEdition,2014.

Web links and Video Lectures (e-Resources):

- www.nptel.ac.in

Skill Development Activities Suggested

1) Interact with industry (small, medium, and large.
2) Involve in research/testing/projects to understand their problems and help creative and innovative methods to solve the problem.
3) Involve in case studies and field visits/ fieldwork.
4) Accustom to the use of standards/codes etc., to narrow the gap between academia and industry.
5) Handle advanced instruments to enhance technical talent.
6) Gain confidence in modelling of systems and algorithms for transient and steady-state operations, thermal study, etc.
7) Work on different software/s (tools) to simulate, analyze and authenticate the output to interpret and conclude.

Course outcome (Course Skill Set)
At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Simulation of Power Electronic Converters and Systems and model the systems.	L3
CO2	Explain control system essentials and control principles, represent the system in digital Domain.	L3
CO3	Design the digital controller and explain the techniques involved.	L4
CO4	Apply optimal and robust controller design principles and design robust controller.	L4
CO5	Apply discretecomputation essentials.	L4

ADVANCED CONTROL SYSTEMS			
Course Code	22LPE15	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	40 Hours	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

1. To understand and acquire knowledge of basics of digital control, signal conversion and stability criterion.
2. To understand digital control devices and systems, implementation of digital controllers.
3. To understand state variable analysis of digital control systems, stability improvement, pole placement.
4. To understand the concepts of quadratic optimal control, control configurations.
5. To understand the concepts of nonlinear systems, system behaviour, stability analysis.

Module-1

DigitalControl: ControlSystemTerminology,NeedofDigitalcontrol,ConfigurationsoftheBasicDigitalControlScheme, PrincipleofSignalConversion,BasicDiscrete–TimeSignals,TimeDomainModelsforDiscrete –TimeSystems,Thez–Transform,TransferFunctionModels,FrequencyResponse,Stabilityonthez–PlaneandJuryStability Criterion,SampleandHoldSystems,SampledSpectraandAliasing,Reconstruction ofAnalog Signals,PracticalAspectsofthechoiceofSamplingRate, PrincipleofDiscretization.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-2

ModelsofDigital Control Devices and Systems: Introduction, z–DomainDescriptionof SampledContinuous –timePlants,z–DomainDescriptionofSampleswithDead–Time,ImplementationofDigitalControllers,TunablePIDControllers,DigitalTemperatureandPositionControlSystem

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-3

State Variable Analysis of Digital Control Systems: Introduction, State Description of Digital Processors, StateDescriptionofSampledcontinuous–TimePlants,StateDescriptionofSystemswithDeadTime,SolutionofStateDifferenceEquations,ControllabilityandObservability,Multivariable Systems.

PolePlacementDesignandStateObservers: Introduction,StabilityImprovementbyStateFeedback,Necessaryand sufficient Conditions for Arbitrary Pole – Placement, State Regulator Design, Design of State Observers,CompensatorDesignbytheSeparationPrinciple,ServoDesign–IntroductionofthereferenceInputbyFeedforwardControl,StateFeedbackwithIntegralControl,DigitalControlSystemswithStateFeedback,DeadbeatcontrolbyState FeedbackandDeadbeatObservers.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-4

Quadratic Optimal Control: Introduction, The Concept of Lyapunov Stability, Lyapunov Functions for LinearSystems,ParameterOptimizationandOptimalControlProblems,QuadraticPerformanceIndex,ControlConfigurations,OptimalStateRegulator,OptimalDigitalControlSystems,ConstrainedStateFeedbackControl.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-5
Nonlinear System Analysis: Introduction, Common nonlinear System Behaviours, Common nonlinearities inControl Systems, Describing Function Fundamentals, Describing Function of Common nonlinearities, StabilityAnalysis by the Describing Function Method, Concept of Phase PlaneAnalysis, Construction of Phase Portraits,SystemAnalysisonthePhasePlane,SimpleVariableStructureSystems,LyapunovStabilityDefinitions,LyapunovStabilityTheorems,LyapunovFunctionsfor Nonlinear Systems.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs
3. The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Text Books/Reference Books

1.DigitalControlandStateVariableMethods(ConventionalandIntelligentControlSystems),MGopal,MGH
2.Discrete–TimeControlSystems,KatsuhikoOgata,Pearson,2nd Edition,2015.
3.DigitalControlSystems,BenjaminCKuo,Oxford UniversityPress,2nd Edition,2007.
4.ControlSystemEngineering,I.J.Nagrath,M.Gopal,NewAgeInternational,5th Edition, 2007.

Web links and Video Lectures (e-Resources):

- www.nptel.ac.in

Skill Development Activities Suggested

1) Interact with industry (small, medium, and large.
2) Involve in research/testing/projects to understand their problems and help creative and innovative methods to solve the problem.
3) Involve in case studies and field visits/ fieldwork.
4) Accustom to the use of standards/codes etc., to narrow the gap between academia and industry.
5) Handle advanced instruments to enhance technical talent.
6) Gain confidence in modelling of systems and algorithms for transient and steady-state operations, thermal study, etc.
7) Work on different software/s (tools) to simulate, analyze and authenticate the output to interpret and conclude.

Course outcome (Course Skill Set)
At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Explain the basics of digital control, signal conversion and stability criterion.	L3
CO2	Analyse the digital control devices and systems, design and implement the digital controllers.	L3
CO3	Use the state variable analysis of digital control systems and explain the stability improvement, pole placement.	L4
CO4	Employ the concepts of quadratic optimal control, control configurations.	L4
CO5	Analyse nonlinear systems.	L4

POWERELECTRONICSLABORATORY-1			
Course Code	22LPEL17	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	1:2:0	SEE Marks	50
Credits	02	Exam Hours	03

Course objectives:

- To analyze and apply the knowledge of theory.
- Assess and Verify the results.

Sl.NO	Experiments
1	Analysisofstaticand dynamiccharacteristicofMOSFETandIGBT.
2	Performanceofsinglephasefullycontrolledandsemi-controlledconverterforRLloadforcontinuous currentmode.
3	Performanceofsinglephasefullycontrolledandsemi-controlledconverterforRLloadfordiscontinuous currentmode.
4	Studyofeffectofsourceinductanceontheperformanceofsinglephasefullycontrolledconverter.
5	Performanceanalysisofthreephasefullycontrolledandsemi-controlledconverterforRLloadfor continuouscurrentmode.
6	Performanceanalysisofthreephasefullycontrolledandsemi-controlledconverterforRLloadfor discontinuouscurrentmode.
7	Performance analysisofsinglephase bridgeinverterfor RLloadandvoltagecontrol bysingle pulsewidth modulation.
8	Performanceanalysisoftwoquadrantchopper.
9	Diodeclampedmultilevelinverter.
10	ZVSoperationofaSynchronousbuckconverter.

Course outcomes (Course Skill Set):

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

Courseoutcomes:

Attheend ofthecoursethestudent willbeableto:

- Analyzethe staticanddynamiccharacteristics ofvarioussemiconductordevices.
- Applytheknowledgeofconvertersinassessingtheperformanceofsinglephaseand threephasefullycontrolled and semicontrolled convertersforRLload for continuouscurrentmodes.
- Applytheknowledgeofconvertersin assessingtheperformanceofsinglephaseand threephasefullycontrolled and semicontrolled convertersforRLload for discontinuouscurrentmodes.
- Assesstheperformanceofsinglephasebridgeinverterfor RLloadandcontrolthevoltagebypulsewidthmodulat ion.
- Applytheknowledgeofpowerelectronicsinperformanceanalysisofchopperandsynchronousbuck converter.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each course. The student has to secure not less than 40%of maximum marks in the semester-end examination(SEE). In total of CIE and SEE student has to secure 50% maximum marks of the course.

Continuous Internal Evaluation (CIE):

CIE marks for the practical course is **50 Marks**.

The split-up of CIE marks for record/ journal and test are in the ratio **60:40**.

- Each experiment to be evaluated for conduction with observation sheet and record write-up. Rubrics for the evaluation of the journal/write-up for hardware/software experiments designed by the faculty who is handling the laboratory session and is made known to students at the beginning of the practical session.
- Record should contain all the specified experiments in the syllabus and each experiment write-up will be evaluated for 10 marks.
- Total marks scored by the students are scaled downed to 30 marks (60% of maximum marks).
- Weightage to be given for neatness and submission of record/write-up on time.
- Department shall conduct 02 tests for 100 marks, the first test shall be conducted after the 8th week of the semester and the second test shall be conducted after the 14th week of the semester.
- In each test, test write-up, conduction of experiment, acceptable result, and procedural knowledge will carry a weightage of 60% and the rest 40% for viva-voce.
- The suitable rubrics can be designed to evaluate each student's performance and learning ability.
- The average of 02 tests is scaled down to **20 marks** (40% of the maximum marks).

The Sum of **scaled-down** marks scored in the report write-up/journal and average marks of two tests is the total CIE marks scored by the student.

Semester End Evaluation (SEE):

SEE marks for the practical course is 50 Marks.

SEE shall be conducted jointly by the two examiners of the same institute, examiners are appointed by the University.

All laboratory experiments are to be included for practical examination.
(Rubrics) Breakup of marks and the instructions printed on the cover page of the answer script to be strictly adhered to by the examiners. **OR** based on the course requirement evaluation rubrics shall be decided jointly by examiners.
Students can pick one question (experiment) from the questions lot prepared by the internal /external examiners jointly.
Evaluation of test write-up/ conduction procedure and result/viva will be conducted jointly by examiners.
General rubrics suggested for SEE are mentioned here, writeup-20%, Conduction procedure and result in -60%, Viva-voce 20% of maximum marks. SEE for practical shall be evaluated for 100 marks and scored marks shall be scaled down to 50 marks (however, based on course type, rubrics shall be decided by the examiners)
Change of experiment is allowed only once and 10% Marks allotted to the procedure part to be made zero.
The duration of SEE is 03 hours

Semester- II

SWITCHEDMODEPOWERSUPPLIES			
Course Code	22LPE21	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	40 Hours	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

1. To explainaSMPS,itscharacteristics,newtechnologies, basicprinciplesandcontrolmodes and suggestasuitableDC/DCconverter foranSMPS.
2. To understandthemethodofselectingkeyperipheralcomponents ofSMPS.
3. To designthepowerfactorcorrectioncircuitfor SMPS and understand the designingofhigh-frequencytransformer.
4. To understand and acquire knowledge ofdesigningdifferentSMPS.
5. To understand thetestingtechnologyofSMPS and protectionandmonitoringcircuit forSMPS.

Module-1

Switching-ModePowerSupply(SMPS): Overview,Classification of IntegratedRegulatedPowerSupply,Characteristics of SMPS, New Development Trend of SMPS, Basic Principles of SMPS, Control Mode Type ofSMPS,WorkingMode ofSMPS,FeedbackType ofSMPS,LoadCharacteristicsofSMPS.
Topologies of the DC/DC Converter: Topologies of the DC/DC Converter, Basic Principle of Buck Converter,Basic Principle of- Boost Converter, Buck-Boost Converter, Charge Pump Converter, (Single-ended primaryinductorconverter)SEPIC,FlybackConverter,ForwardConverter,Push-PullConverter,Half/FullBridgeConverter,SoftSwitchingConverter,Half-BridgeLLCResonant Converter,2-SwitchForwardConverter.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-2

MethodforSelectingKeyPeripheralComponentsofSMPS: SelectionMethodfor-FixedResistor,Capacitors,InductorCharacteristicsandSelectionMethodforMagneticBeads,SelectionMethodforEMI Filter-InputBridgeRectifier,OutputRectifier,TransientVoltageSuppressor(TVS),PowerSwitchingTube,OpticalCoupler,Ad

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-3

Power Factor Correction Circuit Design of SMPS: Brief Introduction to Power Factor Correction (PFC), BasicPrincipleofPassivePFCCircuit,DesignExamplesofPassivePFCCircuit,BasicPrincipleofActivePFCCircuit,Design ExamplesofActivePFCCircuit,PrincipleandApplicationofHigh-PowerPFC,MeasurestoSuppressPFCElectromagneticInterference,PFCConfigurationScheme.
Design of High-Frequency Transformer: Selection Method for Magnetic Cores by the Empirical Formula orOutput Power Table, Waveform Parameters of the High-Frequency Transformer Circuit, Formula Derivation ofSelecting High-Frequency Transformer Magnetic Core Based on AP Method, Design of Flyback High-FrequencyTransformer,DesignofForward High-FrequencyTransformer,LossofHigh-FrequencyTransformer.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-4

Key Design Points of SMPS: SMPS Design Requirements, Design of High-Efficiency SMPS, Methods ofReducingNo-LoadandStandbyPowerConsumptionofSMPS,StabilityDesignofOptocouplerFeedbackControlLoop SMPS Layout and Wiring, Design of Constant Voltage/Current SMPS, Design of Precision ConstantVoltage/Current SMPS, Design of Remote Turn-Off Circuit for SMPS, Typical Application and Printed CircuitDesign of New Single-Chip SMPS, Electromagnetic Interference Waveform Analysis and Safety Code Design ofSMPS, Radiator Design of Single-Chip SMPS, Radiator Design of Power Switching Tube (MOSFET),

CommonTroubleshootingMethodsofSMPS.	
Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-5

SMPS Testing Technology: Parameter Testing of SMPS, Performance Testing of SMPS, SMPS MeasurementSkills,AccurateMeasurementMethodofDutyRatio,MethodtoDetecttheMagneticSaturationofHigh-FrequencyTransformerwithOscilloscope,DigitalOnlineCurrent/ResistanceMeter,ElectromagneticCompatibilityMeasurementofSMPS, WaveformTestandAnalysisofSMPS.

Protection and Monitoring Circuit Design of SMPS: Design of Drain Clamp Protection Circuit, OvervoltageProtection Circuit Constituted by Discrete Components, Application of Integrated Overvoltage Protector, DesignofUndervoltageProtectionCircuit,DesignofOvercurrentandOverpowerProtectionCircuit,DesignofSoft-StartCircuit, Mains Voltage Monitor, Transient Interference and Audio Noise Suppression Technology of SMPS,DesignofOverheatingProtectionComponentandCoolingControlSystem.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs
3. The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Text Books/Reference Books

1. Switching Power Supply Design, Abraham I. Pressman, Keith Billings, Taylor Morey 3rd Ed. 2009, MGH
2. Switchmode Power Supply Handbook, Keith Billings, Taylor Morey 3/E, 2011, MGH
3. S.Manikantla, Switching Power Supply Design and Optimization, McGrawHill Indian Edition

Web links and Video Lectures (e-Resources):

- www.nptel.ac.in

Skill Development Activities Suggested

1) Interact with industry (small, medium, and large.
2) Involve in research/testing/projects to understand their problems and help creative and innovative methods to solve the problem.
3) Involve in case studies and field visits/ fieldwork.
4) Accustom to the use of standards/codes etc., to narrow the gap between academia and industry.
5) Handle advanced instruments to enhance technical talent.
6) Gain confidence in modelling of systems and algorithms for transient and steady-state operations, thermal study, etc.
7) Work on different software/s (tools) to simulate, analyze and authenticate the output to interpret and conclude.

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	ExplainaSMPS,itscharacteristics,newtechnologies, basicprinciplesandcontrolmodes and suggestasuitableDC/DCconverter foranSMPS.	L3
CO2	Explainthemethodofselectingkeyperipheralcomponents ofSMPS.	L3
CO3	DesignthepowerfactorcorrectioncircuitofSMPS anddesigningofhigh-frequencytransformer.	L4
CO4	Explaindesigning procedure ofdifferentSMPS.	L3
CO5	ExplaintestingtechnologyofSMPS and Design aprotectionandmonitoringcircuit forSMPS	L4

ELECTRICDRIVES			
Course Code	22LPE22	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:2:0	SEE Marks	50
Total Hours of Pedagogy	40 hours Theory + 11 Lab slots	Total Marks	100
Credits	04	Exam Hours	03

Course objectives:

1. To understand and analyzecharacteristicsofDCmotors,inductionmotorsandsynchronousmotors.
2. To classifyelectricdrives and discuss dynamic conditions of drive system.
3. To explain and discuss thespeedcontrol aspects ofelectricdrives.
4. To discussadriveforaspecificapplication.
5. To discuss applications of microprocessorinthecontrolofanelectricdrive.

MODULE-1

Characteristics ofElectricmotors: Introduction,CharacteristicsofDCmotors,ThreephaseInductionMotorsandSynchronousMotors, BrakingofElectric Motors.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

MODULE-2

DynamicsofElectricDrives: Introduction,ClassificationofElectricDrives,BasicElementsofanElectricDrive,Dynamic ConditionsofDriveSystem,StabilityConsiderationsofElectric Drive.
ControlofElectricMotors: InductionMotorDrives.

Teaching-Learning Process	1. . Chalk & Talk 2. PPT / Animations 3. Videos

MODULE-3

ControlofElectricMotors(continued): SynchronousMotorDrives,DCDrives.PermanentMagnetSynchronousMotor ,ClassificationofPermanentMagnetSynchronousMotor,Cycloconverters fedSynchronousMotor.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

MODULE-4

ControlofElectricMotors(continued): PermanentMagnetSynchronousMotor,ClassificationofPermanentMagnetSynchronousMotor,CycloconvertersfedSynchronousMotor.
Applications: DriveConsiderationsfoeTextileMills,SteelRollingMills,CranesandHoistDrives,CementMills,SugarMills,MachineTools,PaperMills,CoalMines, CentrifugalPumps,Turbo-compressors.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

MODULE 5

Microprocessors and Control of Electrical Drives: Introduction, Dedicated Hardware Systems versus Microprocessor Control, Applications Area and Functions of Microprocessors in Drive Technology, Control of Electric Drives using Microprocessors, Control System Design of Microprocessors based Variable Speed Drives, Stepper motors.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos
Sl.NO	Experiments
1	PWM inverter fed three phase induction motor control using PSPICE/MATLAB/PSIM software
2	VSI fed induction motor drive analysis using MATLAB/PSPIC/PSIM software
3	Study of V/f control operation of three phase induction motor
4	Study of vector controlled three phase induction motor drive.
5	Study of permanent magnet synchronous motor drive fed by PWM inverter using simulation software.
6	Study of BLDC motor drive fed by PWM inverter using simulation software.
7	Study of SRM motor drive fed by PWM inverter using simulation software.
8	Regenerative/ Dynamic breaking operation for AC motor using simulation software
9	To study speed control of single phase induction motor using micro controller.
10	To perform speed control of separately excited dc motor using chopper.
11	Speed control of dc motor using closed loop and open loop.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

CIE for the theory component of IPCC

1. Two Tests each of **20 Marks**
2. Two assignments each of **10 Marks/One Skill Development Activity of 20 marks**
3. Total Marks of two tests and two assignments/one Skill Development Activity added will be CIE for 60 marks, marks scored will be proportionally scaled down to **30 marks**.

CIE for the practical component of IPCC

- On completion of every experiment/program in the laboratory, the students shall be evaluated and marks shall be awarded on the same day. The**15 marks** are for conducting the experiment and preparation of the laboratory record, the other **05 marks shall be for the test** conducted at the end of the semester.
- The CIE marks awarded in the case of the Practical component shall be based on the continuous evaluation of the laboratory report. Each experiment report can be evaluated for 10 marks. Marks of all experiments' write-ups are added and scaled down to 15 marks.

- The laboratory test at the end /after completion of all the experimentsshall be conducted for 50 marks and scaled down to 05 marks**.**

Scaled-down marks of write-up evaluations and tests added will be CIE marks for the laboratory component of IPCC for **20 marks**.

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SEE for IPCC

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (duration 03 hours)

1. The question paper will be set for 100 marks and marks scored will be scaled down proportionately to 50 marks.
2. The question paper will have ten questions. Each question is set for 20 marks.
3. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
4. The students have to answer 5 full questions, selecting one full question from each module.

The theory portion of the IPCC shall be for both CIE and SEE, whereas the practical portion will have a CIE component only. Questions mentioned in the SEE paper shall include questions from the practical component).

- The minimum marks to be secured in CIE to appear for SEE shall be the 15 (50% of maximum marks-30) in the theory component and 10 (50% of maximum marks -20) in the practical component. The laboratory component of the IPCC shall be for CIE only. However, in SEE, the questions from the laboratory component shall be included**.** The maximum of 04/05 questions to be set from the practical component of IPCC, the total marks of all questions should not be more than the 20 marks.
- SEE will be conducted for 100 marks and students shall secure 40% of the maximum marks to qualify in the SEE. Marks secured will be scaled down to 50. (Student has to secure an aggregate of 50% of maximum marks of the course(CIE+SEE)

Suggested Learning Resources:

Text/Reference Books

1. ElectricDrivesConceptsand Applications,VedamSubrahmanyam,McGrawHill,2nd Edition,2016.
2. FundamentalsofIndustrialDrives,B.N.Sarkar,PHI,2012.
3. FundamentalsofElectricalDrives,GopalKDubey,NarosaBookDistributors,2010.
4. ElectricDrives,NisitK. De,PrasantaKSen,PHI,1st Edition,2014.
5. Bose B.K., Modern Power Electronics & AC Drives, PHI Pvt. Ltd.

Web links and Video Lectures (e-Resources):

- www.nptel.ac.in

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- Seminars
- Quizes
- Assignments

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Analyze thecharacteristicsofDCmotors,inductionmotorsandsynchronousmotors.	L3
CO2	Discuss and classify the electricdrives, dynamic conditions of drive system.	L4
CO3	Explain and discuss thespeedcontrol aspects ofelectricdrives.	L4
CO4	Discuss and suggest adriveforaspecificapplication.	L4
CO5	Discuss applications of microprocessorinthecontrolofanelectricdrive.	L4

EMCINPOWERELECTRONICS			
Course Code	22LPE231	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	40 Hors	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

1. To recognize the sources of conducted and radiated EMI in Power Electronic converters and consumer appliances and to know EMI measuring instruments.
2. To learn measuring of high frequency characteristics of EMI filter elements.
3. To learn the methods of noise suppression and application of snubbers.
4. To Design EMI filters, common-mode chokes measures to keep the interference within tolerable limits.
5. To learn various EMC tests as per IEC specifications and other methods of testing and provide solutions for reducing EMI.

Module-1

Electromagnetic Disturbances: Introduction, Classification of disturbances by frequency content, by characterand transmissionmode.
Conducted EMI Measurement: Introduction, EMI measuring instruments, Basic terms and conducted EMIreferences, Measuring the interference voltage and current, Spectrum analysers, EMI measurements for consumerapplications,Measuringimpulse like EMI.
EMIinPowerElectronicEquipment:EMIfrompowersemiconductors,controlledrectifiercircuits,EMI calculationforsemiconductorequipment.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-2

EMIFilterElements: MeasuringHighFrequencyCharacteristicsofEMIFilterElements,Capacitors,Choke Coils,Resistors.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-3

Noise Suppression: Noise Suppression in Relay Systems, Application of AC Switching Relays, Application ofRC–SnubberstoPowerSemiconductors,ShieldedTransformers,CapacitorFilters,EMIGenerationandReductionat itsSource,Influence ofLayoutandControlof Parasitics.
EMI Filter Circuit selection and measurement: Definition of EMI Filter Parameters, ENI Filter Circuits,Insertion LossTestMethods.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-4

EMI Filter Design:EMI Filter Design for Insertion Loss, Calculation of Worst – case Insertion Loss, DesignMethodforMismatchedImpedanceCondition,DesignMethodforEMIFilterswithCommon–ModeChokeCoils,Damped EMI Filters and Lossy Filter Elements, HF Characteristics of Noise Filter Circuit Elements, EMI FilterLayout.	
Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos
Module-5	
TestingforSusceptibilitytoPowerLineDisturbances: SurgeVoltagesinACPowerMains,EMCTests as perIECSpecifications,OtherEMS TestMethods. **ReductionTechniquesforinternalEMI:**ConductiveNoiseCoupling,ElectromagneticCoupling,Electromagnetic Coupling Reduction Methods, Wiring Layout Methods to Reduce EMI Coupling, PCB DesignConsiderations.	
Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs
3. The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Text Books

1.ElectromagneticCompatibilityinPowerElectronics,LaszloTihanyi,Newnes,1stEdition,1995.

Web links and Video Lectures (e-Resources):

- www.nptel.ac.in

Skill Development Activities Suggested

1) Interact with industry (small, medium, and large.
2) Involve in research/testing/projects to understand their problems and help creative and innovative methods to solve the problem.
3) Involve in case studies and field visits/ fieldwork.
4) Accustom to the use of standards/codes etc., to narrow the gap between academia and industry.
5) Handle advanced instruments to enhance technical talent.
6) Gain confidence in modelling of systems and algorithms for transient and steady-state operations, thermal study, etc.
7) Work on different software/s (tools) to simulate, analyze and authenticate the output to interpret and conclude.

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Recognize the sources of conducted and radiated EMI in Power Electronic converters and consumer appliances and to know EMI measuring instruments.	L3
CO2	Explain and discuss the measurement of high frequency characteristics of EMI filter elements.	L4
CO3	Discuss the methods of noise suppression and application of snubbers.	L4
CO4	Design the EMI filters, explain common-mode chokes and measures to keep the interference within tolerable limits.	L5
CO5	Explain various EMC tests as per IEC specifications and other methods of testing and provide solutions for reducing EMI.	L3

Semester- II

CONVERTERSFORSOLARANDWINDPOWERSYSTEMS			
Course Code	22LPE232	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	40 Hours	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

1. To learnsdevelopmentsinthePVandWTpenetrationsinthe worldwidepowersystems.
2. To discussthevarioushigh-efficiencytopologies forPVinvertersandgenericcontrolstructures.
3. To understandthegridrequirementsforPVinstallations,anddifferentquadraturesignal generatormethods,
4. To learngridsynchronizationtechniquesforsinglephasepowerconverters.
5. To understandislandingdetectionmethodsandtypicalWT gridconvertertopologies, controlstructures,thegrid requirementsforWT grid connectionandthegridcodes.
6. To learngridsynchronizationofthreephasepowerconvertersandnewrobust synchronizationstructuresto cope withtheunbalance anddistortedgrid conditions.
7. To understandthegridconvertercontrolstructuresforWTandthecontrolissueforthecaseofgridfaults.
8. To designgridinterface filtersusedtodamptheresonance forLCLfiltersand methodsforcontrollingthegrid current.

Module-1

Introduction: Wind Power Development, Photovoltaic Power Development, The Grid Converter – The KeyElementinGridIntegrationofWTandPV Systems.
Photovoltaic Inverter Structures: Introduction, Inverter Structures Derived from H-Bridge Topology, InverterStructures Derived from NPC Topology, Typical PV Inverter Structures, Three-Phase PV Inverters, ControlStructures,ConclusionsandFuture Trends.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-2

Grid Synchronization in Single-Phase Power Converters: Introduction, Grid Synchronization Techniques forSingle-Phase Systems, Phase Detection Based on In-Quadrature Signals, Some PLLs Based on In-QuadratureSignalGeneration,SomePLLsBasedonAdaptiveFiltering,TheSOGIFrequency-LockedLoop.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-3

Islanding Detection: Introduction, Non-detection Zone,Overview of Islanding Detection Methods, PassiveIslandingDetectionMethods, Active IslandingDetectionMethods. **Grid Converter Structures for Wind Turbine Systems:** Introduction, WTS Power Configurations, Grid PowerConverter Topologies, WTSControl. **Grid Requirements for WT Systems:** Introduction, Grid Code Evolution (Germany),Frequency and VoltageDeviationunderNormalOperation,ActivePowerControlinNormalOperation,ReactivePowerControlinNormalOperation(Germany),BehaviourunderGridDisturbances(Germany),DiscussionofHarmonizationofGridCodes.	
Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos
Module-4	
GridSynchronizationinThree-PhasePowerConverters: Introduction,TheThree-PhaseVoltageVectorunderGrid Faults, The Synchronous Reference Frame PLL under Unbalanced and Distorted Grid Conditions, TheDecoupled Double Synchronous Reference Frame PLL (DDSRF-PLL), The Double Second-Order GeneralizedIntegratorFLL(DSOGI-FLL).	
Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos
Module-5	
Control of Grid Converters under Grid Faults: Introduction, Overview of Control Techniques for Grid-Connected Converters under Unbalanced Grid Voltage Conditions, Control Structures for Unbalanced CurrentInjection,PowerControlunderUnbalancedGridConditions,FlexiblePowerControlwithCurrentLimitation. **GridFilterDesign:**Introduction,FilterTopologies,DesignConsiderations,PracticalExamplesofLCLFiltersandGrid Interactions,ResonanceProblemand DampingSolutions, NonlinearBehaviouroftheFilter.	
Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks**

to attain the COs and POs

3. The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Text Books

1.GridConvertersforPhotovoltaicandWindPowerSystems, RemusTeodorescuatal,Wiley,2011.

Web links and Video Lectures (e-Resources):

- www.nptel.ac.in

Skill Development Activities Suggested

1) Interact with industry (small, medium, and large.
2) Involve in research/testing/projects to understand their problems and help creative and innovative methods to solve the problem.
3) Involve in case studies and field visits/ fieldwork.
4) Accustom to the use of standards/codes etc., to narrow the gap between academia and industry.
5) Handle advanced instruments to enhance technical talent.
6) Gain confidence in modelling of systems and algorithms for transient and steady-state operations, thermal study, etc.
7) Work on different software/s (tools) to simulate, analyze and authenticate the output to interpret and conclude.

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	ExplaindevelopmentsinthePVandWTpenetrationsinthe worldwidepowersystems and discussthevarioushigh-efficiencytopologies forPVinvertersandgenericcontrolstructures.	L3
CO2	Explaingridsynchronizationtechniquesforsinglephasepowerconverters.	L3
CO3	ExplainislandingdetectionmethodsandtypicalWT gridconvertertopologies,controlstructures,thegrid requirementsforWT grid connectionandthegridcodes.	L3
CO4	Explaingridsynchronizationofthreephasepowerconvertersandnewrobust synchronizationstructuresto cope withtheunbalance anddistortedgrid conditions.	L3
CO5	ExplainthegridconvertercontrolstructuresforWTandthecontrolissueforthecaseofgrid faults and to designgridinterface filters.	L3

Semester- II

UNINTERRUPTIBLEPOWERSUPPLY			
Course Code	22LPE233	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	50 Hours	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

1. To understandclassificationofUPS,batteriesforUPS,paralleloperationand rerformanceevaluationandcontrolofUPSsystems.
2. Acquire knowledge aboutsourcesofharmonicsandtheirmitigationusingactive filters.
3. To understandsteady-stateoperationand controlofunified powerqualityconditioners andtheconceptofreducedparts converter.
4. To understandanon-lineupssystem basedonnovelAC/DCrectifier.
5. To understand the reduced parts activefilters,theirmodelingand control.

Module-1

UninterruptiblePowerSupplies: Classification,BatteriesforUPSApplications,FlywheelsforUPSApplications,ComparativeAnalysis of Flywheels andElectrochemicalBatteries, Applications ofUPS Systems,ParallelOperation,PerformanceEvaluationofUPSSystems,PowerFactorCorrectioninUPSSystems,ControlofUPS Systems,Converters forUPSSystems,BatteryCharger/Discharger.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-2

Active Filters: Harmonic Definition, Harmonic Sources in Electrical Systems, Effects of Harmonics, HarmonicMitigationMethods,ClassificationofActiveFilters,ActiveFiltersforDC/DCConverters,ModellingandAnalysis,ControlStrategies, StabilityAssessment.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-3

UnifiedPowerQualityConditioners: Series–ParallelConfiguration,CurrentControl,VoltageControl,PowerFlowandCharacteristic Power. **Reduced-PartsUninterruptiblePowerSupplies:**ConceptofReduced-PartsConvertersappliedtoSingle- PhaseOn-LineUPSSystems,New On-LineUPSSystemsBased onHalf-BridgeConverters.	
Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos
Module-4	
NewOn-LineUPSSystemsBasedonaNovelAC/DCRectifier: NewThree-PhaseOn-LineUPSSystemwithReducedNumberofSwitches,New Single-PhasetoThree-PhaseHybridLine-Interactive/On-LineUPSSystem.	
Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos
Module-5	
Reduced-Parts Active Filters: Reduced-Parts Single-Phase and Three-Phase Active Filters,Reduced-PartsSingle-Phase Unified Power Quality Conditioners,Reduced-Parts Single-Phase Series–Parallel Configurations,Reduced-PartsThree-PhaseSeries–Parallel Configurations..	
Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs
3. The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module.

Suggested Learning Resources:

Text Books/Reference Books

1.UninterruptiblePowerSuppliesand ActiveFilters, AliEmadietal,CRCPress,2005.
2.UninterruptiblePowerSuppliesandStandbyPowerSystems, AlexanderCKing,WilliamKnight,McGraw-Hill, 2003.

Web links and Video Lectures (e-Resources):

- www.nptel.ac.in

Skill Development Activities Suggested

1) Interact with industry (small, medium, and large.
2) Involve in research/testing/projects to understand their problems and help creative and innovative methods to solve the problem.
3) Involve in case studies and field visits/ fieldwork.
4) Accustom to the use of standards/codes etc., to narrow the gap between academia and industry.
5) Handle advanced instruments to enhance technical talent.
6) Gain confidence in modelling of systems and algorithms for transient and steady-state operations, thermal study, etc.
7) Work on different software/s (tools) to simulate, analyze and authenticate the output to interpret and conclude.

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	ExplainclassificationofUPS,batteriesforUPS,paralleloperationandperformance evaluationandcontrolofUPSsystems.	L3
CO2	Discusssourcesofharmonicsandtheirmitigationusingactive filters.	L3
CO3	Explainsteady-stateoperationand controlofunified powerqualityconditioners andtheconceptofreducedparts converter.	L2
CO4	Explainanon-lineupssystem basedonnovelAC/DCrectifier.	L2
CO5	Discuss the reduced parts activefilters,theirmodelingand control	L3

Semester II

HYBRIDELECTRICVEHICLES			
Course Code	22LPE234	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	40 Hours	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

1. To understandthebasicsofelectricandhybridelectricvehicles,theirarchitecture,technologiesandfundamentals.
2. To acquire knowledge about plug–inhybridelectricvehiclearchitectureandcomponentsizing.
3. To understandtheuseofdifferentpowerelectronicsdevicesinhybridelectricvehicles.
4. To acquire knowledge aboutasuitableelectricdriveforaspecifictypeofhybridelectricvehicle.
5. To understandtheuseofdifferentenergystoragedevices usedforhybridelectricvehicles,theirtechnologiesand control.
6. To learn Simulation ofelectrichybridvehiclesbydifferenttechniquesfor theperformanceanalysis.

Module-1

Introduction: SustainableTransportation,ABriefHistoryofHEVs,WhyEVsEmergedandFailed,Architecturesof HEVs, Interdisciplinary Nature of HEVs, State of the Art of HEVs, Challenges and Key Technology of HEVs.**HybridizationoftheAutomobile:**VehicleBasics,BasicsoftheEV,BasicsoftheHEV,BasicsofPlug-InHybridElectricVehicle (PHEV), BasicsofFuel CellVehicles(FCVs).
HEVFundamentals: Introduction,VehicleModel,VehiclePerformance,EVPower-trainComponentSizing, SeriesHybridVehicle,ParallelHybridVehicle,WheelSlipDynamics.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-2

Plug-in Hybrid Electric Vehicles: Introduction to PHEVs, PHEV Architectures, Equivalent Electric Range ofBlendedPHEVs,FuelEconomyofPHEVs,PowerManagementofPHEVs,PHEVDesignandComponentSizing,Compon ent Sizing of EREVs, Component Sizing of Blended PHEVs, HEV to PHEV Conversions, Other TopicsonPHEVs, Vehicle-to-GridTechnology. **Power Electronics in HEVs:** Introduction, Principle of Power Electronics, Rectifiers Used in HEVs, BuckConverter Used in HEVs, Non-isolated Bidirectional DC–DC Converter, Voltage Source Inverter, Current SourceInverter, Isolated Bidirectional DC–DC Converter, PWM Rectifier in HEVs, EV and PHEV Battery Chargers,Modelling and Simulation of HEV Power Electronics, Emerging Power Electronics Devices, Circuit Packaging,ThermalManagementofHEVPowerElectronics.	
Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos
Module-3	
ElectricMachinesandDrivesinHEVs: Introduction,InductionMotorDrives,PermanentMagnetMotorDrives,Switche dReluctanceMotors,DoublySalientPermanentMagnetMachines,DesignandSizingofTractionMotors, Thermal AnalysisandModellingofTractionMotors.	
Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos
Module-4	
Batteries, Ultracapacitors, Fuel Cells, and Controls: Introduction, Battery Characterization, Comparison ofDifferent Energy Storage Technologies for HEVs, Modelling Based on Equivalent Electric Circuits, BatteryChargingControl,ChargeManagementofStorageDevices,FlywheelEnergyStorageSystem,HydraulicEnergy StorageSystem,FuelCellsandHybridFuelCellEnergyStorageSystem.	
Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos
Module-5	
Modelling and Simulation of Electric and Hybrid Vehicles: Introduction, Fundamentals of Vehicle SystemModelling, HEV Modelling Using ADVISOR, HEV Modelling Using PSAT, Physics-Based Modelling, BondGraphand Other ModellingTechniques,ConsiderationofNumericalIntegrationMethods,Conclusion. **HEV Component Sizing and Design Optimization**: Introduction, Global Optimization Algorithms for HEVDesign, Model-in-the-Loop Design Optimization Process, Parallel HEV Design Optimization Example, SeriesHEVDesignOptimizationExample, Conclusion.	
Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs .
3. The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Text Books

1. Hybrid Electric Vehicles principles and Applications with Practical Perspectives, Chris Mi,M. Abul asrur, David Wenzhong Gao, Wiley, 2011.

Web links and Video Lectures (e-Resources):

- www.nptel.ac.in

Skill Development Activities Suggested

1) Interact with industry (small, medium, and large.
2) Involve in research/testing/projects to understand their problems and help creative and innovative methods to solve the problem.
3) Involve in case studies and field visits/ fieldwork.
4) Accustom to the use of standards/codes etc., to narrow the gap between academia and industry.
5) Handle advanced instruments to enhance technical talent.
6) Gain confidence in modelling of systems and algorithms for transient and steady-state operations, thermal study, etc.
7) Work on different software/s (tools) to simulate, analyze and authenticate the output to interpret and conclude.

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Explain thebasicsofelectricandhybridelectricvehicles, theirarchitecture,technologiesand fundamental, architectureandcomponentsizing.	L3
CO2	Discusstheuseofdifferentpowerelectronicsdevicesinhybridelectricvehicles.	L3
CO3	Suggestasuitableelectricdriveforaspecifictypeofhybridelectricvehicle.	L3
CO4	Discussuseofdifferentenergystoragedevices usedforhybridelectricvehicles,theirtechnologiesand control.	L3
CO5	Simulate electrichybridvehiclesbydifferenttechniquesfor theperformanceanalysis.	L4

Semester- II

NEURALANDFUZZY LOGICCONTROLOFDRIVES			
Course Code	22LPE235	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	40 Hours	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

1. To understandcontrolstrategiesfor electricdrives/powersystems.
2. To understandANN architecture, its implementation and complexity analysis.
3. To understand fuzzy logic, VHDL fundamentals and advancedfeaturesinVHDL.
4. To learn currentcontrolalgorithm, newsensor lessmotor controlstrategy for induction motor.
5. To understand the design of VHDL and FPGA controller for induction motor.

Module-1

ModerncontrolsystemsdesignusingCADtechniques: Introduction,ControlsystemsforACdrives,Electronicdesign automation (EDA), Application specific integrated circuit (ASIC) basics, Field programmable gate arrays(FPGAs),ASICsfor power systemsanddrives,Electricmotors.
Electricmotors: Motors,Pulsewidthmodulation,Thespacevectorinelectricalsystems,Inductionmotorcontrol.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-2

Elementsofneuralcontrol: Neuronetypes,Artificialneuralnetworksarchitectures,Trainingalgorithms,ControlapplicationsofANNs, Neuralnetworkimplementation.
NeuralFPGAimplementation:Neuralnetworksdesignandimplementationstrategy,UniversalprogramsFFANN,hardware implementation,Hardware implementationcomplexityanalysis.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-3

Fuzzylogicfundamentals: Introduction,Fuzzy setsandfuzzy logic,Typesofmembershipfunctions,Linguisticvariables,Fuzzylogicoperators,Fuzzycontrolsystems,Fuzzylogic inpower and control,Applications.
VHDLfundamentals:Introduction,VHDLdesignunits,Libraries,visibilityandstatesysteminVHDL,Sequentialstatements, Concurrentstatements,Functionsandprocedures,AdvancedfeaturesinVHDL.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-4

Neuralcurrentandspeedcontrolofinductionmotors: Theinductionmotorequivalent circuit,Thecurrentcontrolalgorithm, The newsensor lessmotor controlStrategy.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-5

Neuralcurrentandspeedcontrolofinductionmotors(continued): InductionmotorcontrollerVHDL Design, FPGAcontrollerexperimental results.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs
3. The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Text Books

1.Neuraland FuzzyLogicControlofDrivesandPower Systems,M.N.Cirstea, etal,Newnes,2002.

Web links and Video Lectures (e-Resources):

- www.nptel.ac.in

Skill Development Activities Suggested

1) Interact with industry (small, medium, and large.
2) Involve in research/testing/projects to understand their problems and help creative and innovative methods to solve the problem.
3) Involve in case studies and field visits/ fieldwork.
4) Accustom to the use of standards/codes etc., to narrow the gap between academia and industry.
5) Handle advanced instruments to enhance technical talent.
6) Gain confidence in modelling of systems and algorithms for transient and steady-state operations, thermal study, etc.
7) Work on different software/s (tools) to simulate, analyze and authenticate the output to interpret and conclude.

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Discusscontrolstrategiesfor electricdrives/powersystems.	L3
CO2	ExplainANN architecture, its implementation and analyse complexity.	L3
CO3	Explain fundamentals of fuzzy logic, VHDL and advancedfeaturesinVHDL.	L3
CO4	Discuss currentcontrolalgorithm, newsensor lessmotor controlstrategy for induction motor.	L4
CO5	Design the controller for induction motor using VHDL and FPGA.	L4

Semester- II

FACTSCONTROLLERS			
Course Code	22LPE241	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
kiiiujujmTotal Hours of Pedagogy	40 Hours	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

1. To understandthegrowthofelectrical transmission networks and its complexity,thelackof controllabilityoftheactive andreactive-power flowsinenergizednetworks.
2. To understandtheconventionalcontrolledsystemsandthebasicoperatingprinciplesofFACTS.
3. To understandthevariouscomponentsofageneralSVC,itscontrolsystem,control characteristicsandthe design of the SVCvoltage regulator.
4. To learn theuseofSVCinstabilityenhancement,dampingsub synchronousoscillations,improvementofHVDClinkperformance.
5. To understandtheconceptsofseriescompensation,TCSCcontrolleranditsoperation, characteristics,modelingandapplications.
6. To understandtheoperationofvoltagesourceconverterbased FACTS.

Module-1

ControlMechanismofTransmissionSystem: Background,ElectricalTransmissionNetworks,ConventionalControl Mechanisms,FlexibleacTransmissionSystems(FACTS), EmergingTransmission Networks.
Reactive-PowerControlinElectricalPowerTransmissionSystems: ReactivePower,UncompensatedTransmission Lines, Passive Compensation.
Concept of reactive power compensation, Review of Power Flow methods and series shunt compensation, Review of voltage and current sourced converters, Concepts of transient stability and voltage stability, Power system oscillations. Need for FACTS controllers- types of FACTS controllers.
PrinciplesofConventionalReactive-PowerCompensators: Introduction,SynchronousCondensers,The SaturatedReactor(SR),TheThyristor-ControlledReactor(TCR),TheThyristor-ControlledTransformer(TCT).

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-2

PrinciplesofConventionalReactive-PowerCompensators(continued): TheFixedCapacitor–Thyristor-ControlledReactor(FC–TCR),TheMechanicallySwitchedCapacitor–Thyristor-ControlledReactor(MSC–TCR),TheThyristor-SwitchedCapacitor(TSC),TheThyristor-SwitchedCapacitor–Thyristor-ControlledReactor(TSC–TCR),AComparisonofDifferentSVCs.
SVCVoltageControl: IntroductionVoltageControl.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-3

SVCVoltageControl(continued): EffectofNetworkResonancesontheControllerResponse,The2ndHarmonicInteraction between the SVC and ac Network, Application of the SVC to Series-Compensated ac Systems, 3rdHarmonicDistortion, Voltage-Controller DesignStudies.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-4

SVC Applications: Introduction, Increase in Steady-State Power-Transfer Capacity, Enhancement of TransientStability,AugmentationofPower-SystemDamping-PrincipleoftheSVC,AuxiliaryControl,TorqueContributionsofSVCControllers,EffectofthePowerSystem,EffectoftheSVC,SVCMitigationofSubsynchronous Resonance (SSR) - Principle of SVC Control, Configuration and Design of the SVC Controller,RatingofanSVC,PreventionofVoltageInstability-PrinciplesofSVCControl-ACaseStudy,ConfigurationandDesignofthe SVCController, RatingofanSVC.

TheThyristor-ControlledSeriesCapacitor(TCSC): SeriesCompensation,TheTCSCController,OperationoftheTCSC,TheTSSC,AnalysisoftheTCSC,CapabilityCharacteristics,HarmonicPerformance,Losses,Response oftheTCSC,ModellingoftheTCSC.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-5

TCSCApplications: Introduction, Open-Loop Control, Closed-Loop Control, Improvement of the System-StabilityLimit,EnhancementofSystemDamping,SubsynchronousResonance(SSR)Mitigation,Voltage-CollapsePrevention.

VSCbasedFACTSControllers:

Introduction,TheSTATCOM,TheSSSC,TheUPFC,ComparativeEvaluationofDifferentFACTSControllers.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Assessment Details (both CIE and SEE)

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Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs
3. The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Text Books/Reference Books

1. Thyristor-Based FACTs Controllers for Electrical Transmission Systems, R. Mohan Mathur Rajiv K. Varma, Wiley, 2002.
2. Understanding FACTS: concepts and technology of flexible AC Transmission systems, Narain G. Hingorani Laszlo Gyugyi., Wiley, 2000.

3. Facts Controllers in Power Transmission and Distribution, K. R. Padiyar, New Age International, 2007.

Web links and Video Lectures (e-Resources):

- www.nptel.ac.in

Skill Development Activities Suggested

1) Interact with industry (small, medium, and large.
2) Involve in research/testing/projects to understand their problems and help creative and innovative methods to solve the problem.
3) Involve in case studies and field visits/ fieldwork.
4) Accustom to the use of standards/codes etc., to narrow the gap between academia and industry.
5) Handle advanced instruments to enhance technical talent.
6) Gain confidence in modelling of systems and algorithms for transient and steady-state operations, thermal study, etc.
7) Work on different software/s (tools) to simulate, analyze and authenticate the output to interpret and conclude.

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Discuss thegrowthofelectrical transmission networks and its complexity,thelackof controllabilityoftheactive andreactive-power flowsinenergizednetworks andthebasicoperatingprinciplesofFACTS.	L3
CO2	Explain the principles of conventional reactive power compensators.	L3
CO3	Explain the effectofNetworkResonancesonthecontrollerresponse, Interaction between the SVC and ac Network.	L3
CO4	Discuss the Increase in Steady-State Power-Transfer Capacity, Enhancement of TransientStability, ConfigurationandDesignofthe SVCController, RatingofanSVC.	L3
CO5	Discuss the concepts of series compensation, TCSC controller and its operation, characteristics, modelling and applications and VSC based FACTS controller.	L3

Semester II

DIGITALPOWERELECTRONICS			
Course Code	22LPE242	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	40 Hours	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

1. To understand thetraditionalparameterscomputation,multiplequadrantoperationandchoppers.
2. To understand the disadvantages of analog power electronics and conversion technology, energy factor andsub-sequentialparameters.
3. To understandbasic mathematicsofdigitalcontrolsystemsandmathematical modelingofdigitallycontrolledpower electronic devicessuchasrectifiers,invertersand converters.
4. To learn the mathematicalmodelingofAC/DCrectifiers,DC/ACinverters,DC/DCconvertersand AC/AC(AC/DC/AC)convertersareworkinginthediscrete-time state.
5. To understand DC/AC pulse-width-modulation (PWM) inverters and AC /AC converters modeled as a first-order-hold (FOH) elementindigitalcontrolsystems.
6. To understandDC/DCconvertermodeledasasecondorder-hold(SOH)elementindigitalcontrolsystems.
7. To understand openloop and closedloopcontrolofpower electronicdevicesand energyfactorapplicationofACandDCmotor drives.

Module-1

Introduction: Historicalreview,Traditionalparameters,Multiple-quadrantoperationsandchoppers,Digitalpowerelectronics: pump circuits and conversion Technology, Shortage of analog power electronics and conversiontechnology,Powersemiconductordevicesappliedindigitalpower electronics.
EnergyFactor(EF)andSub-sequentialParameters: Introduction,Pumpingenergy(PE),Stored energy(SE),Energyfactor(EF),Variationenergyfactor(EFV),Timeconstant,τ,anddampingtimeconstant,τd, Examplesofapplications,Smallsignalanalysis.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-2

Mathematical Modelling of Digital Power Electronics: Introduction, A zero-order hold (ZOH) for AC/DCcontrolledrectifiers,Afirst-ordertransferfunctionforDC/ACpulse-width-modulationInverters,Asecond-order transferfunctionforDC/DCconverters,Afirst-ordertransferfunctionforAC/AC(AC/DC/AC)converters.
Self Study: BasicMathematicsofDigitalControlSystems

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-3

Digitally Controlled DC/AC Inverters: Introduction, Mathematical modelling for DC/AC PWM inverters,Single-phasehalf-waveVSI,Single-phasefull-bridgePWMVSI,Three-phasefull-bridgePWMVSI,Three-phasefull-bridgePWM CSI, Multistage PWMinverter, MultilevelPWMinverter.
Digitally Controlled DC/DC Converters: Introduction, Mathematical Modelling for power DC/DC converters,FundamentalDC/DCconverter,DevelopedDC/DCconverters,Soft-switchingconverters,Multi-elementresonant
powerconverters.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-4

DigitallyControlledAC/ACConverters: Introduction,TraditionalmodellingforAC/AC(AC/DC/AC)converters, Single-phase AC/AC converter, Three-phase AC/AC voltage controllers, SISO cycloconverters, TISOcycloconverters,TITOcycloconverters,AC/DC/ACPWMconverters,Matrixconverters. **Open-loopControlforDigitalPowerElectronics:**Introduction,Stabilityanalysis,Unit-stepfunctionresponses, Impulseresponses.	
Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos
Module-5	
Closed-LoopControlforDigitalPowerElectronics: Introduction,PIcontrolforAC/DCrectifiers,PIcontrolforDC/ACinverters andAC/AC(AC/DC/AC) converters,PIDcontrolforDC/DCconverters. **EnergyFactorApplicationinACandDCMotorDrives:**Introduction,Energystorageinmotors, ADC/AC voltagesource,AnAC/DCcurrentsource,ACmotordrives,DCmotordrives.	
Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs
3. The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Text Books/Reference Books

1. Digital Power Electronics and Applications, Fang Lin Luo, Hong Ye, Muhammad Rashid, Elsevier, 2005.

Web links and Video Lectures (e-Resources):

- www.nptel.ac.in

Skill Development Activities Suggested

1) Interact with industry (small, medium, and large.
2) Involve in research/testing/projects to understand their problems and help creative and innovative methods to solve the problem.
3) Involve in case studies and field visits/ fieldwork.
4) Accustom to the use of standards/codes etc., to narrow the gap between academia and industry.
5) Handle advanced instruments to enhance technical talent.
6) Gain confidence in modelling of systems and algorithms for transient and steady-state operations, thermal study, etc.
7) Work on different software/s (tools) to simulate, analyze and authenticate the output to interpret and conclude.

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Explaintraditionalparameters of computation,multiplequadrantoperationandchoppers.	L2
CO2	Discuss the disadvantages of analog power electronics and conversion technology, energy factor andsub-sequentialparameters.	L3
CO3	Explainbasic mathematicsofdigitalcontrolsystemsandmathematical modelingofdigitallycontrolledpower electronic devicessuchasrectifiers,invertersand converters.	L2
CO4	Describe mathematicalmodelingofAC/DCrectifiers,DC/ACinverters,DC/DCconvertersand AC/AC(AC/DC/AC)convertersareworkinginthediscrete-time state.	L3
CO5	Discuss DC/AC pulse-width-modulation (PWM) inverters and AC /AC converters modeled as a first-order-hold (FOH) elementindigitalcontrolsystems.	L3
CO6	DiscussDC/DCconvertermodeledasasecondorder-hold(SOH)elementindigitalcontrolsystems.	L3
CO7	Explainopenloop and closedloopcontrolofpower electronicdevicesand energyfactorapplicationofACandDCmotor drives.	L2

Semester- II

EMBEDDEDSYSTEMS			
Course Code	22LPE243	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	40 Hours	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

1. To understand thedesignprocessinembeddedsystemandformulationofsystemdesign.
2. To understand theprocessorarchitectureandmemoryorganization.
3. To understand the the devices; serial port, parallel port devices, timing devices, devices for synchronous andasynchronouscommunication.
4. To understand thedevicedriversandinterruptmechanisms.
5. To understand theprogrammingconceptsandsourcecodeengineeringtoolsforembeddedprogramming.
6. To understand the real time programming and program modeling concepts during single and multi-processorsystemsoftware developmentprocess.
7. To understand therealtimeoperatingsystemsconcepts.

Module-1

IntroductiontoEmbeddedSystems: EmbeddedSystems,ProcessorEmbeddedintoaSystem,EmbeddedHardware Units and Devices in a System, Embedded Software in a System, Examples of Embedded Systems,Embedded Systems – on –chip (Soc) and Use of VLSI Circuit Design Technology, Complex Systems Design andProcessors,DesignofProcessinEmbeddedSystem,FormulationofSystemDesign,DesignProcessandDesign Examples,ClassificationofEmbedded Systems,SkillrequiredforanEmbedded SystemDesigner.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-2

Processor Architecture and Memory Organisation: 8051 Architecture, Real world Interfacing, Introduction toAdvancedArchitecture,ProcessorandMemoryOrganization,InstructionLevelParallelism,PerformanceMetrics,Memory– Types, Memory –MapsandAddresses,ProcessorSelection, MemorySelection.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-3

Devices and Communication Buses, InterruptServices:IO Types andExamples,Serial CommunicationDevices, Parallel Device Ports, Sophisticated Interfacing Features in Device Ports, Wireless Devices, Timer andCountingDevices,WatchdogTimer,RealTimeClock,NetworkedEmbeddedSystems,SerialBusDeviceProtocols–ParallelCommunicationNetworkUsingISA,PCI,PCI–Xand Advanced Protocols.
DeviceDriversandInterruptsServiceMechanisms: Programmed–I/OBusy–waitApproachwithoutInterruptServiceMechanism,ISRConcept,InterruptSources,InterruptServicingMechanism,DirectMemoryAccess.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-4

Program Modelling concepts: Program Models, DFG Models, State Machine Programming Models for Event – controlled ProgramFlow,ModellingofMultiprocessorSystems, UMLModelling. **InterprocessCommunicationandSynchronizationofProcesses,ThreadsandTasks:**MultipleProcessesinanApplication,MultipleThreadsinanApplication,Tasks,TaskStatus,TaskandData,Clear–cutDistentionBetweenFunctions,ISRSandTasksbytheirCharacteristics,ConceptofSemaphores,SharedData,InterprocessCommunication, Signal Function, Semaphore Functions, Message Queue Functions, Mailbox Functions, PipeFunctions,Socket Functions,RPCFunctions.	
Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos
Module-5	
Real-TimeOperatingSystems:OSServices,ProcessManagement,TimerFunctions,EventFunctions,Memorymanagement, Device, File and IO Subsystems Management , Interrupt Routines in RTOS Environment andHandlingofInterruptSourceCalls,Real–timeOperatingSystems,BasicDesignUsinganRTOS,RtosTask SchedulingModels,Interrupt LatencyandResponseofthetaskasperformanceMetrics,OSSecurityIssues.	
Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs
3. The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Text Books

1.EmbeddedSystems: Architecture,ProgrammingandDesign,Raj Kamal,McGrawHill, 2nd Edition,2014.

Web links and Video Lectures (e-Resources):

- www.nptel.ac.in

Skill Development Activities Suggested

1) Interact with industry (small, medium, and large.
2) Involve in research/testing/projects to understand their problems and help creative and innovative methods to solve the problem.
3) Involve in case studies and field visits/ fieldwork.
4) Accustom to the use of standards/codes etc., to narrow the gap between academia and industry.
5) Handle advanced instruments to enhance technical talent.
6) Gain confidence in modelling of systems and algorithms for transient and steady-state operations, thermal study, etc.
7) Work on different software/s (tools) to simulate, analyze and authenticate the output to interpret and conclude.

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Explaindesignprocessinembeddedsystemandformulationofsystemdesign,	L2
CO2	Describeprocessorarchitectureandmemoryorganization.	L3
CO3	Describe the devices, serial port, parallel port devices, timing devices, SerialBusDeviceProtocols and advanced protocols.	L3
CO4	Discuss theprogram modeling concepts, interprocess communication and synchronization process.	L3
CO5	Describerealtimeoperatingsystemsconcepts	L3

Semester- II

Sensor Less AC Drives			
Course Code	22LPE244	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	40 Hours	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

1. To understand therequirementsforInternet-basedcontrolsystemsandtobuildingafunctionalmodel,traditionalTele-operationsystemsandWeb-baseduserinterfacedesign.
2. To understand theReal-timeDataTransferovertheInternetdealingwithInternetTransmissionDelayandDataLossfromthe NetworkViewandControlperspective.
3. To learndesignofMulti-rateSISOandMIMOInternet-basedControlSystemsandSafetyandSecurityChecking.
4. To understand thebasicconceptsandgeneralguidelinesofcontrolsystemperformancemonitoring,remotelydesigning,testing, and updatingreal-time controlsoftware throughtheInternet.
5. To understand the PerformanceMonitoring,PerformanceMonitoringofControlSystems,RemoteControlPerformanceMaintenance, Real-time Control SystemLife Cycle, Implementation of the General Integrated Environment.

Module-1

Introduction: NetworkedControlSystems(NCS),Internet-basedControlSystems(ICS),ChallengesofNCS/ICS.**Requirements Specification for Internet-based Control Systems:** Introduction, Requirements Specification,Functional Modelling of Internet-based Control Systems, Information Hierarchy, Possible Implementation ofInformation Architecture.
Internet-basedControlSystemArchitectureDesign: Introduction,TraditionalBilateralTele-operationSystems,RemoteControlovertheInternet,Canonical Internet-basedControlSystemStructures.
Web-basedUserInterfaceDesign: FeaturesofWeb-basedUserInterface,MultimediaUserInterfaceDesign, CaseStudy.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-2

Real-time Data Transfer over the Internet: Real-time Data Processing, Data Wrapped with XML, Real-timeDataTransferMechanism, Case Study.
DealingwithInternetTransmissionDelayandDataLossfromtheNetworkView: RequirementsofNetworkInfrastructure for Internet-based Control, Features of Internet Communication, Comparison of TCP and UDP,NetworkInfrastructureforInternet-based Control,TypicalImplementation forInternet-basedControl.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-3

Dealing with Internet Transmission Delay and Data Loss from the Control Perspective: Overcoming theInternet Transmission Delay, Control Structure with the Operator Located Remotely, Internet-based Control witha Variable Sampling Time, Multi-rate Control, Time Delay Compensator Design, Simulation Studies, ExperimentalStudies.
DesignofMulti-rateSISOInternet-basedControlSystems: Introduction,Discrete-timeMulti-rateControl Scheme,DesignMethod,StabilityAnalysis,SimulationStudies,Real-timeImplementation.

Teaching-Learning	1. Chalk & Talk 2. PPT / Animations

Process	3. Videos

Module-4

DesignofMulti-rateMIMOInternet-basedControlSystems: Introduction,SystemModeling,ControllerDesign,StabilityAnalysis,DesignProcedure, Model-basedTimeDelayCompensation,SimulationStudy.
SafetyandSecurityChecking: Introduction,SimilarityofSafetyandSecurity,FrameworkofSecurityChecking,ControlCommandTransmissionSecurity, SafetyChecking, Case Study.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-5

Remote Control Performance Monitoring and Maintenance over the Internet: Introduction, PerformanceMonitoring,PerformanceMonitoringofControlSystems,RemoteControlPerformanceMaintenance,CaseStudy.**Remote Control System Design and Implementation over the Internet:**Introduction, Real-time Control SystemLife Cycle, Integrated Environments, A Typical Implementation of the General Integrated Environment, CaseStudy.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs
3. The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Text Books

1.Internet-based ControlSystems:Designand Applications,Shuang-HuaYang,Springer-Verlag,2011.

Web links and Video Lectures (e-Resources):

- www.nptel.ac.in

Skill Development Activities Suggested

1) Interact with industry (small, medium, and large.
2) Involve in research/testing/projects to understand their problems and help creative and innovative methods to solve the problem.
3) Involve in case studies and field visits/ fieldwork.
4) Accustom to the use of standards/codes etc., to narrow the gap between academia and industry.
5) Handle advanced instruments to enhance technical talent.
6) Gain confidence in modelling of systems and algorithms for transient and steady-state operations, thermal study, etc.
7) Work on different software/s (tools) to simulate, analyze and authenticate the output to interpret and conclude.

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	DiscussrequirementsforInternet-basedcontrolsystemsandtobuildingafunctionalmodel,traditionalTele-operationsystemsandWeb-baseduserinterfacedesign.	L3
CO2	DiscussReal-timeDataTransferovertheInternetdealingwithInternetTransmissiondelayandDataLossfromthe NetworkViewandControlperspective.	L3
CO3	DiscussdesignofMulti-rateSISOandMIMOInternet-basedControlSystemsandSafetyandSecurityChecking.	L4
CO4	Explainthebasicconceptsandgeneralguidelinesofcontrolsystemperformancemonitoring,remotelydesigning,testing, and updatingreal-time controlsoftware throughtheInternet	L3
CO5	Discuss PerformanceMonitoring,PerformanceMonitoringofControlSystems,RemoteControlPerformanceMaintenance, Real-time Control SystemLife Cycle Implementation of the	L3

Semester II

MEMS TECHNOLOGY			
Course Code	22LPE245	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	40 Hours	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

1. To introduce the basic concepts of micro systems and advantages of miniaturization.
2. To study the various materials and their properties used for micromachining techniques.
3. To teach the fundamentals of micromachining and micro fabrication techniques.
4. To impart knowledge of the basic concept of electromechanical effects, thermal effects Micro fluidics and Integrated fluidic systems.
5. To teach the fundamentals of pressure sensors and accelerometer sensors through design and modeling
6. To give exposure to different MEMS devices.

Module-1

Properties of silicon: Crystal structure – Orientation effects – crystal defects – Impurities in Silicon – Properties of Silicon and Gallium Arsenide - Starting materials – Bridgeman techniques for crystal growth.
Bulk MicroMachining: wet etching of silicon-Isotropic etching-anisotropic etching-alkali hydroxide etchants-ammonium hydroxide-tetra methyl ammonium hydroxide (TMAH)-ethylene diamine pyrochatechol (EDP)-ultrasonic agitation in wet etching- stop layers for dopant elective etchants. Porous-silicon formation – anistrophic wet etching of porous aluminum-anistrophic wet etching - quartzvapour phase etches. RLE-laser driven bulk processing.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-2

Surface Micromachining: Thin film processes-nonmetallic thin film for micromachining –silicon dioxide – silicon nitride - silicon carbide - polycrystalline diamond - polysilicon and other semiconductors and thin film transition – wet etching of non-metallic thin film-metallic thin film for micromachining - Resistive evaporation – E - beam evaporation-sputter deposition-comparison of evaporation and sputtering - CVD of metals - adhesion layer for metals - electro deposition (E plating) - Electrodeposition mechanism: - DC electroplating-pulsed electroplatingAgitation for electroplating-black metal film-electro less plating

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-3

Bonding Processes: Anodic Bonding-Anodic bonding using deposited glasssilicon fusion bonding-other bonding and techniques-compound processes using bonding. Sacrificial Processes and Other Techniques: Sticking problem during wet releasing-prevention of sticking-phase change release methods-geometry-examples of sacrificial processes - Sacrificial LIGA process.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-4

Advanced MEMS for Sensing and Actuation: Electromechanical effects: Piezoresistance - Piezoelectricity - Shape memory alloy-Thermal effects: Temperature coefficient of resistance - Thermo-electricity – Thermocouples – Micro fluidics: - Squeeze film damping - Surface tension and bubbles -Devices: pumps, valves, mixers -Integrated fluidic systems: BioMEMS.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-5

Design of Pressure Sensors: Piezoreistive Pressure Sensor: Sensing Pressure, Piezoresistance- Analytic Formulation in Cubic Materials-Longitudinal and Transverse Piezoresistance -Piezoresistive Coefficients of Silicon- Structural Examples- Signal Conditioning and Calibration.

Design of Capacitive Accelerometer: Fundamentals of Quasi-Static Accelerometers, Position Measurement with Capacitance- Circuits for Capacitance Measurement Demodulation Methods- Case Study- Specifications- Sensor Design and Modeling Fabrication and Packaging.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs
3. The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Reference Books

1. G.K. Ananthasuresh, K.J. Vinoy, S. Gopalakrishnan, K.N. Bhat, V.K. Aatre, Micro and Smart Systems, Wiley India, First Edition, 2010.

2. Chang Liu, Foundations of MEMS, (ILLINOIS ECE Series), Pearson Education International, 2006.

3. Gregory TA Kovacs, Micro machined Transducers Source Book, WCB McGraw Hill, Singapore, 1998.

4. Tai-Ran-Hsu, MEMS & Microsystems Design and Manufacture, TATA McGraw-Hill, New Delhi, 2002.

5. Sorab. K.Ghandhi, VLSI Fabrication Principles, Wiley Inter Science Publication, New York, 1994.

6. M.H.Bao "Micromechanical transducers :Pressure sensors, accelerometers and gyroscopes", Elsevier, NewYork, 2000.

Web links and Video Lectures (e-Resources):

- www.nptel.ac.in

Skill Development Activities Suggested

1) Interact with industry (small, medium, and large.
2) Involve in research/testing/projects to understand their problems and help creative and innovative methods to solve the problem.
3) Involve in case studies and field visits/ fieldwork.
4) Accustom to the use of standards/codes etc., to narrow the gap between academia and industry.
5) Handle advanced instruments to enhance technical talent.
6) Gain confidence in modelling of systems and algorithms for transient and steady-state operations, thermal study, etc.
7) Work on different software/s (tools) to simulate, analyze and authenticate the output to interpret and conclude.

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Explain the materials used for micromachining techniques53	L3
CO2	Discuss the process of Bulk Micro Machining techniques.	L4
CO3	Discuss the Electromechanical effects, Thermal effects, Micro fluidics, Devices such as pumps, valves, mixers, Integrated fluidic systems and BioMEMS.	L4
CO4	Analyze and develop models for different types of Pressure Sensors and acclereometers	L4
CO5	Explain the design of sensors for any practical applications.	L3

POWERELECTRONICSLABORATORY-2			
Course Code	22LPEL26	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	1:2:0	SEE Marks	50
Credits	02	Exam Hours	03

Course objectives:

- To analyze and apply the knowledge of theory.
- Assess and Verify the results.

Sl.NO	Experiments
1	Studyandperformanceanalysisofsinglephase fullycontrolledconverterfed separatelyexcitedDCMotor forcontinuouscurrentmode.
2	Studyandperformanceanalysisofsinglephase fullycontrolledconverterfed separatelyexcitedDCMotor fordiscontinuouscurrentmode.
3	StudyandperformanceanalysisofthreephasefullycontrolledconverterfedseparatelyexcitedDCMotor forcontinuouscurrentmode.
4	StudyandperformanceanalysisofthreephasefullycontrolledconverterfedseparatelyexcitedDCMotor fordiscontinuouscurrentmode.
5	PerformanceanalysisofapracticalchopperfedDCDrivessystemforclass-Aandclass-Ccommutationand analysisofwave formsincontinuous mode.
6	Simulationstudyofbuck,boostandbuck-boostconverter(basictopologies)andanalysisofwaveformsforcontinuouscurrentmode (CCM).
7	Simulationstudyofbuck,boostandbuck-boostconverter(basictopologies)andanalysisofwaveformsfor discontinuouscurrentmode(DCM).
8	Simulationstudyofforwardconverterandflybackconverterandperformanceanalysisofvariouswaveforms.
9	Resonantconvertersimulationstudyandanalysis.
10	Closedloopoperationofabuckandboostconverter.

Course outcomes (Course Skill Set):

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

- Conductexperimentsonsinglephase/threephasefullycontrolledconverterfedseparatelyexcitedDCmotor to assesstheperformanceincontinuousand discontinuouscurrentmodes.
- Conductexperiments toassesstheperformanceofChopperfedDCdrivesforclass AandclassCcommutationincontinuouscurrentmode.
- Simulatedifferentconvertersforanalyzingthewaveformincontinuousanddiscontinuouscurrentmod es.
- Simulateforwardconverter,flybackconverterandresonantconvertertostudytheirperformance

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each course. The student has to secure not less than 40%of maximum marks in the semester-end examination(SEE). In total of CIE and SEE student has to secure 50% maximum marks of the course.

Continuous Internal Evaluation (CIE):

CIE marks for the practical course is **50 Marks**.

The split-up of CIE marks for record/ journal and test are in the ratio **60:40**.

- Each experiment to be evaluated for conduction with observation sheet and record write-up. Rubrics for the evaluation of the journal/write-up for hardware/software experiments designed by the faculty who is handling the laboratory session and is made known to students at the beginning of the practical session.
- Record should contain all the specified experiments in the syllabus and each experiment write-up will be evaluated for 10 marks.
- Total marks scored by the students are scaled downed to 30 marks (60% of maximum marks).
- Weightage to be given for neatness and submission of record/write-up on time.
- Department shall conduct 02 tests for 100 marks, the first test shall be conducted after the 8th week of the semester and the second test shall be conducted after the 14th week of the semester.
- In each test, test write-up, conduction of experiment, acceptable result, and procedural knowledge will carry a weightage of 60% and the rest 40% for viva-voce.
- The suitable rubrics can be designed to evaluate each student's performance and learning ability.
- The average of 02 tests is scaled down to **20 marks** (40% of the maximum marks).

The Sum of **scaled-down** marks scored in the report write-up/journal and average marks of two tests is the total CIE marks scored by the student.

Semester End Evaluation (SEE):

SEE marks for the practical course is 50 Marks.

SEE shall be conducted jointly by the two examiners of the same institute, examiners are appointed by the University.

All laboratory experiments are to be included for practical examination.
(Rubrics) Breakup of marks and the instructions printed on the cover page of the answer script to be strictly adhered to by the examiners. **OR** based on the course requirement evaluation rubrics shall be decided jointly by examiners.
Students can pick one question (experiment) from the questions lot prepared by the internal /external examiners jointly.
Evaluation of test write-up/ conduction procedure and result/viva will be conducted jointly by examiners.
General rubrics suggested for SEE are mentioned here, writeup-20%, Conduction procedure and result in -60%, Viva-voce 20% of maximum marks. SEE for practical shall be evaluated for 100 marks and scored marks shall be scaled down to 50 marks (however, based on course type, rubrics shall be decided by the examiners)
Change of experiment is allowed only once and 10% Marks allotted to the procedure part to be made zero.
The duration of SEE is 03 hours

III Semester

MODELLING AND ANALYSIS OF ELECTRICAL MACHINES			
Course Code	22LPE31	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:2	SEE Marks	50
Total Hours of Pedagogy	50 Hours	Total Marks	100
Credits	04	Exam Hours	03

Course Learning objectives:

1. To understand the concepts of modelling of DC Machines.
2. To understand the dynamic modelling of 3 phase Induction Machine.
3. To understand the modelling of Transformer.
4. To understand the modelling of synchronous machines.
5. To understand the performance and dynamic analysis of Synchronous Machines.

Module-1

BasicConceptsofModelling: Basictwopolemachinerepresentationofcommutatormachines,3-phasesynchronous machine with and without damper bar and 3-phase induction machine, Kron's primitive machine-voltage, currentandtorque equations.
DC Machine Modelling: Mathematical model of separately excited DC motor-steady state and transient stateanalysis,suddenapplicationofinertiaload,transferfunctionofseparatelyexcitedDCmotor,mathematicalmodelo fdcseries motor,shunt motor,linearizationtechniques forsmallperturbations.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-2

Reference Frame Theory: Real time model of a two phase induction machine, transformation to obtain constantmatrices,three phasetotwophasetransformation, powerequivalence.
DynamicModellingofThreePhaseInductionMachine: Generalizedmodelinarbitraryframe,electromagnetictorq ue,deviationofcommonlyusedinductionmotormodels-statorreferenceframesmodel,rotorreferenceframesmodel, synchronously rotating reference frames model, equations in flux linkages, per unit model, dynamicsimulation.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-3

Small Signal Equations of the Induction Machine: Derivation of small signal equations of induction machine,spacephasormodel,DQfluxlinkagesmodelderivation,controlprinciple oftheinduction motor.
Transformer Modelling: Introduction, single phase transformer model, three phase transformer connections, perphase analysis, normal systems, per unit normalization, per unit three phase quantities, change of base, per unitanalysis ofnormalsystem,regulating transformersforvoltageandphaseanglecontrol,autotransformers,transmissionline andtransformers.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-4

Modelling of Synchronous Machines: Introduction, voltage equations and torque equation in machine variables,stator voltage equations in arbitraryand rotor reference frame variables, Park'sequations, torque equations insubstitute variables,rotorangleandanglebetweenrotors,per unit system,analysisofsteadystateoperation.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-5

Dynamic Analysis of Synchronous Machines: Dynamic performance during sudden change in input torque andduringa 3-phase fault at the machine terminals, approximate transient torque versus rotor angle characteristics,comparisonofactualandapproximatetransienttorque-anglecharacteristicsduringasuddenchangeininputtorque;first swing transient stability limit, comparison of actual and approximate transient torque-angle characteristicsduringa3-phasefaultatthemachineterminals,criticalclearingtime,equalareacriterion,computersimulation.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs
3. The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Text Books:

1. GeneralizedTheoryofElectricalMachines,P.S.Bimbra, KhannaPublications,5thEdition,1995.
2. ElectricMotorDrives -Modelling, Analysis&Control,R.Krishnan,PHILearningPrivateLtd,IndianEdition,
3. AnalysisofElectricalMachineryand DriveSystems,P.C.Krause,etal,Wiley,2ndEdition,2010.

Reference Books:

1. PowerSystemAnalysis, ArthurRBergenandVijayVittal, Pearson,2nd Edition,2009.
2. PowerSystemStabilityandControl,PrabhaKundur,Mc GrawHill,1st Edition,1994.
3. DynamicSimulationofElectricMachineryusingMatlab /Simulink,Chee-MunOng,PrenticeHall,1998.

Web links and Video Lectures (e-Resources):

- www.nptel.ac.in

Skill Development Activities Suggested

1) Interact with industry (small, medium, and large.
2) Involve in research/testing/projects to understand their problems and help creative and innovative methods to solve the problem.
3) Involve in case studies and field visits/ fieldwork.
4) Accustom to the use of standards/codes etc., to narrow the gap between academia and industry.
5) Handle advanced instruments to enhance technical talent.
6) Gain confidence in modelling of systems and algorithms for transient and steady-state operations, thermal study, etc.
7) Work on different software/s (tools) to simulate, analyze and authenticate the output to interpret and conclude.

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Explain and model the DC Machines.	L4
CO2	Explain and model the 3 phase Induction Machine.	L4
CO3	Explain and model the Transformer.	L4
CO4	Explain and model thesynchronous machines.	L4
CO5	Discuss the performance and dynamic analysis of Synchronous Machines.	L3

III Semester

HVDC POWER TRANSMISSION			
Course Code	22LPE321	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	40 Hours	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

1. To understand the concepts of HVDC Technology, organization of HVDC systems and various power converters.
2. To understand the harmonics in HVDC and removal, Control of converters.
3. To understand the InteractionbetweenHVDCandACPower System.
4. To understand the concept of converter circuit design, design of cooling system, HVDC noise and vibration.
5. To understand the behaviour, protection and other configurations of HVDC converters.

Module-1	
HVDCTechnology: Introduction,AdvantagesofHVDCSystems,HVDCSystemCosts,OverviewandOrganization of HVDC Systems, Review of the HVDC System Reliability, HVDC Characteristics and EconomicAspects. **PowerConversion:** Thyristor,3-PhaseConverter,3-PhaseFullBridgeConverter,12-PulseConverter.	
Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos
Module-2	
HarmonicsofHVDCandRemoval: Introduction,DeterminationofResultingHarmonicImpedance,ActivePower Filter. **ControlofHVDCConverterandSystem:**ConverterControlforanHVDCSystem,CommutationFailure,HVDCControlandDesign.	
Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos
Module-3	
ControlofHVDCConverterandSystem(continued):HVDCControlFunctions,ReactivePowerandVoltageStability. **InteractionsbetweenACandDCSystems**:DefinitionofShortCircuitRatioandEffectiveShortCircuitRatio,InteractionbetweenHVDCandACPower System.	
Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos
Module-4	
MainCircuitDesign: ConverterCircuitandComponents,ConverterTransformer,CoolingSystem, HVDC OverheadLine,HVDC Earth Electrodes,HVDCCable,HVDC TelecommunicationsCurrent Sensors,HVDCNoise andVibration.	
Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos
Module-5	
Fault BehaviourandProtectionofHVDCSystem: ValveProtection Functions, ProtectiveActionof anHVDCSystem,ProtectionbyControlActions, FaultAnalysis. **OtherConverterConfigurationsforHVDCTransmission**:Introduction,VoltageSourceConverter(VSC),CCCand CSCCHVDCSystem, 10.4 Multi-Terminal DCTransmission. **TrendsforHVDCApplications:**WindFarmTechnology,ModernVoltageSourceConverter(VSC)HVDCSystems,800kV HVDCSystem.	

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs
3. The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Text Books:

1. HVDCTransmission:PowerConversionApplicationsinPowerSystems, Chan-KiKim etal,Wiley,2009.
2. DirectCurrentTransmission,E.W.Kimbark,Wiley,1971.
3. HVDCPowerTransmissionSystems,K.R.Padiyar,NewAgeInternational,2012.

Reference Books:

1. HighVoltageDirectCurrentTransmission,Arrilaga, IET,2nd Edition,1998.
2. HVDCTransmission,S.Kamakshaiahetal,McGrawHill,2011.

Web links and Video Lectures (e-Resources):

- www.nptel.ac.in

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Explain the concepts of HVDC Technology, organization of HVDC systems and various power converters.	L2
CO2	Discuss the harmonics in HVDC and removal, Control of converters.	L3
CO3	Explain the InteractionbetweenHVDCandACPower System.	L2
CO4	Discuss the concept of converter circuit design, design of cooling system, HVDC noise and vibration.	L3
CO5	Explain the behaviour, protection and other configurations of HVDC converters.	L2

III Semester

MULTILEVELCONVERTERSFORINDUSTRIALAPPLICATIONS			
Course Code	22LPE322	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	40 Hours	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

1. To understandthe workingofmedium-voltagepowerconvertersandtheirapplications.
2. To understandmultilevel,symmetricandasymmetrictopologies.
3. To understandthestructureandoperationofthediode-clampedmultilevelconverter,anda multilevelspacevectormodulation.
4. To characterize thebalancingboundaryofthepassivefront-endconverter.
5. To understandtheoperationandanalysisoftheflyingcapacitormultilevelconverter.
6. To understandthecharacteristicstopologiesoftheCascade AsymmetricMultilevelController.
7. To understandtheworkingofadistributionstaticcompensator(DSTATCOM)builtwithCAMCforreactivepow er andharmonic compensation.
8. To understandtheperformanceof back-to-backconverter inaninductionmotordrive forseveralworkingconditions

Module-1

Converters: Introduction,Medium-VoltagePowerConverters,MultilevelConverters,Applications.
MultilevelTopologies: Introduction,GeneralizedTopologywithaCommonDCBus,ConvertersDerivedfromtheGener alizedTopology,SymmetricTopologieswithoutaCommonDCLink,SummaryofSymmetric Topologies,AsymmetricTopologies.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-2

Diode-ClampedMultilevelConverter: Introduction,ConverterStructureandFunctionalDescription,ModulationofMultile vel Converters,VoltageBalanceControl,EffectivenessBoundaryofVoltageBalancingin

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-3

FlyingCapacitorMultilevelConverter: Introduction,FlyingCapacitorTopology,ModulationSchemefortheFCMC,Dy namic Voltage Balance ofthe FCMC.
CascadeAsymmetricMultilevelConverter(CAMC): Introduction,GeneralCharacteristicsoftheCAMC,CAMCThree -Phase Inverter, ComparisonoftheFive-LevelTopologies.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-4

CaseStudy1:DSTATCOMBuiltwithaCascadeAsymmetricMultilevelConverter: Introduction,CompensationPri nciples,CAMCModel,ReactivePowerand HarmonicsCompensation.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-5

CaseStudy2:Medium-VoltageMotorDriveBuiltwithDCMC: Introduction,Back-to-BackDCMCConverter, Unified Predictive Controller of the Back-to-Back DCMC in an IM Drive Application, PerformanceEvaluation.	
Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs
3. The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Text Books:

1. MultilevelConvertersforIndustrialApplications,SergioAlbertoGonzález,SantiagoAndrésVerne,MaríaInésValla, CRCPress, 2014.

Web links and Video Lectures (e-Resources):

- www.nptel.ac.in

Skill Development Activities Suggested

1) Interact with industry (small, medium, and large.
2) Involve in research/testing/projects to understand their problems and help creative and innovative methods to solve the problem.
3) Involve in case studies and field visits/ fieldwork.
4) Accustom to the use of standards/codes etc., to narrow the gap between academia and industry.
5) Handle advanced instruments to enhance technical talent.
6) Gain confidence in modelling of systems and algorithms for transient and steady-state operations, thermal study, etc.
7) Work on different software/s (tools) to simulate, analyze and authenticate the output to interpret and conclude.

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Explain the working of medium-voltage power converters and their applications, multilevel, symmetric and asymmetric topologies.	L2
CO2	Explain the structure and operation of the diode-clamped multilevel converter, and a multilevel space vector modulation.	L2
CO3	Describe the operation and analysis of the flying capacitor multilevel converter.	L2
CO4	Explaintheworkingofadistributionstaticcompensator(DSTATCOM)builtwithCAM Cforreactivepower andharmonic compensation.	L2
CO5	Evaluatetheperformanceof back-to-backconverter inaninductionmotordrive forseveralworkingconditions	L3

III Semester

MULTI-TERMINALDCGRIDS			
Course Code	22LPE323	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	40 Hours	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

1. To understandthefundamentalsofMTDCgrids,theirnetworkarchitectures,componentsandcontrolmodes
2. To understandidealandpracticalvoltagesourcedconverters.
3. To acquire the knowledge of Simulating AC-MTDCgridsfortheanalysis.
4. To understandtheconceptofpowersharinginMTDCgrid,load flowsolutionandpostcontingencyoperation.
5. To understandfrequencysupportfromwindfarms.
6. To understandprotectionissuesofMTDCgrids,includingtheDCcircuitbreakersandfaultblockingVSCsystemsandprotectionstrategies.

Module-1

Fundamentals: Introduction, Rationale behind MTDC Grids, Network Architectures of MTDC Grids, EnablingTechnologies and Components of MTDC Grids, Control Modes in MTDC Grid, Challenges for MTDC Grids,ConfigurationsofMTDCConverterStations, ResearchInitiativesonMTDCGrids.
Voltage-Sourced Converter (VSC): Introduction, Ideal Voltage-Sourced Converter, Practical Voltage-SourcedConverter.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-2

Voltage-SourcedConverter(continued): Control,Simulation.
Modelling,Analysis,andSimulationofAC–MTDCGrids: Introduction,MTDCGridModel.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-3

Modelling,Analysis,andSimulationofAC–MTDCGrids(continued):ACGridModel,AC–MTDCLoadflowAnalysis, AC–MTDC Grid Model for Nonlinear Dynamic Simulation, Small-signal Stability Analysis of AC–MTDCGrid,TransientStabilityAnalysisofAC–MTDCGrid.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-4

Modelling,Analysis,andSimulationofAC–MTDCGrids(continued): CaseStudy1:TheNorthSeaBenchmarkSystem,CaseStudy2:MTDC GridConnectedtoEquivalent ACSystems,CaseStudy3:MTDCGridConnected toMulti-machineACSystem.
Autonomous Power Sharing: Introduction, Steady-state Operating Characteristics, Concept of Power Sharing,Power Sharing in MTDC Grid, AC–MTDC Grid Load flow Solution, Post-contingency Operation, Linear Model,CaseStudy.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-5

Frequency Support: Introduction, Fundamentals of Frequency Control, Inertial and Primary Frequency Supportfrom Wind Farms, Wind Farms in Secondary Frequency Control (AGC), Modified Droop Control for FrequencySupport,AC–MTDCLoad FlowSolution,Post-ContingencyOperation, CaseStudy.
ProtectionofMTDCGrids: Introduction,ConverterStationProtection,DCCableFaultResponse,Fault-blockingConverters,DCCircuitBreakers, ProtectionStrategies.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs
3. The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Text Books:

1. Multi-TerminalDirect-CurrentGridsModelling,Analysis,andControl,NilanjanRayChaudhurietal,Wiley,2014.

Web links and Video Lectures (e-Resources):

- www.nptel.ac.in

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	ExplainthefundamentalsofMTDCgrids,theirnetworkarchitectures,componentsandcontrolmodes and differentiateidealandpracticalvoltagesourcedconverters.	L2
CO2	Simulate AC-MTDCgridsand analyze.	L2
CO3	ExplaintheconceptofpowersharinginMTDCgrid,load flowsolutionandpostcontingencyoperation.	L2
CO4	Explainfrequencysupportfromwindfarms.	L2
CO5	ExplainprotectionissuesofMTDCgrids,includingtheDCcircuitbreakersandfaultblockingVSCsystemsandprotectionstrategies	L3

III Semester

MPPT IN SOLAR SYSTEMS			
Course Code	22LPE324	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	40 Hours	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

1. To understandthePVcell,itscharacteristicsanditsmodels,equivalentcircuitsandcircuitparametercalculations.
2. To understand thedifferent methodsoftrackingmaximumpowerpoint.
3. To understandthesourcesofnoise, effectofnoiseonMPPT andreductionofnoise.
4. To understand thedistributedMaximumPowerPointTrackingofPVarrays.
5. To understandDCanalysisofPVarraywithDMPPT.
6. To understand ACanalysisofPVarraywithDMPPT.
7. To understandtheuseof highenergy efficiencypower converters forPVMPPTapplication.

Module-1	
PVModelling: FromthePhotovoltaicCelltotheField,TheElectricalCharacteristicofaPVModule,TheDouble-Diode and Single-Diode Models, From Data Sheet Values to Model Parameters, Example: PV Module EquivalentCircuitParametersCalculation,The LambertWFunctionfor Modellinga PVField, Example. **Maximum Power Point Tracking:** The Dynamic Optimization Problem, Fractional Open-Circuit Voltage andShort-CircuitCurrent,SoftComputingMethods,The Perturb and Observe Approach.	
Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-2	
MaximumPowerPointTracking(continued): ImprovementsoftheP&OAlgorithm,EvolutionofthePerturbativeMethod, PVMPPTviaOutputParameters, MPPTEfficiency. **MPPTEfficiency:NoiseSourcesandMethodsforReducingtheirEffects:**Low-FrequencyDisturbancesinSingle-PhaseApplications,InstabilityoftheCurrent-BasedMPPTAlgorithms,SlidingModeinPVSystem, AnalysisoftheMPPTPerformancesinaNoisyEnvironment, NumericalExample.	
Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-3	
Distributed Maximum Power Point Tracking of Photovoltaic Arrays: Limitations of Standard MPPT, A NewApproach: Distributed MPPT, DC Analysis of a PV Array with DMPPT, Optimal Operating Range of the DCInverter InputVoltage.	
Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-4	
DistributedMaximumPowerPointTrackingofPhotovoltaicArrays(continued):ACAnalysisofaPVArraywithDMPPT.	
Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-5
DesignofHigh-Energy-EfficiencyPowerConvertersforPVMPPTApplications: Introduction,Power,Energy,Efficiency,EnergyHarvesting

inPVPlantUsingDMPPTPowerConverters,LossesinPowerConverters,Lossesinthe SynchronousFETSwitchingCells,ConductionLosses,SwitchingLosses.**TrendsforHVDCApplications:**WindFarmTechnology,ModernVoltageSourceConverter(VSC)HVDCSystems,800kV HVDCSystem.	
Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs
3. The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Text Books:

PowerelectronicsandControlTechniquesforMaximumenergyharvestinginPhotovoltaicsystems,Nicola

Web links and Video Lectures (e-Resources):

- www.nptel.ac.in

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	ExplainthePVcell,itscharacteristicsanditsmodels,equivalentcircuitsandcircuitparametercalculations anddifferent methodsoftrackingmaximumpowerpoint.	L2
CO2	Explainthesourcesofnoise, effectofnoiseonMPPT andreductionofnoise.	L2
CO3	ExplainDistributedMaximumPowerPointTrackingofPVarrays.	L2
CO4	Conduct and discuss ACanalysisofPVarraywithDMPPT.	L3
CO5	Explaintheuseof highenergy efficiencypower converters forPVMPPTapplication.	L2

III Semester

POWER SYSTEM HORMONICS			
Course Code	22LPE325	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	40 Hours	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

1. To understand thefundamentalissuesofharmonics.
2. To understandthecauses forgenerationofharmonics.
3. To understand theeffectsofharmonicsdistortiononpowersystemequipmentandloadsandsuppressionofharmonicsinpowersystems.
4. To understand the standardlimitsofharmonicdistortionandmodelingofpowersystemcomponentsforharmonicanalysis study.
5. To understandtransmissionlinesand cablesforharmonicanalysis.
6. To understand theimplementationofharmonic studies.

Module-1

Fundamentals of Harmonics: Introduction, Examples of harmonic waveforms, characteristics of harmonics inpower systems, measurement of harmonic distortion, power in passive elements, calculation of passive elements,resonance, capacitor banks and reactive power supply, capacitor banks and power factor correction, bus voltageriseandresonance, harmonicsintransformers.
Harmonics in Power system: Introduction, sources of harmonics, transformers, rotating machines, fluorescentlights,staticvarcompensators,cyclo-converters.Singlephasecontrolledrectifiers,threephaseconverters.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-2

Effects of Harmonic Distortion on Power System: Introduction, thermal losses in a harmonic environment,harmoniceffects on powersystem equipment,capacitorbanks,transformers,rotatingmachines,protection,communicationandelectronicequipment.
Mitigation of Power system Harmonics: Introduction, harmonic filters, power converters, transformers, rotatingmachines,capacitor banks,harmonicfilter design,active filters.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-3

Limits of Harmonic Distortion: Introduction, voltage harmonic distortion limits, current harmonic distortionlimits.
Harmonic studies – Modelling ofSystem Components: Introduction, impedance in the presence of harmonics,skin effect, modelling of the high voltage grid, generator modelling, modelling of shunt capacitor banks, seriescapacitorbanks, loadmodels,inductionmotormodelling.
Transformer Modelling: Introduction,modelling of twowinding transformers, phase sequence admittancematrices, transmission of voltage and current across two winding transformers, transmission matrices and phaseadmittancematrix,modellingofthree andfourwindingtransformers.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-4

Modelling of Transmission lines/Cables: Introduction, skin effect, modelling of power lines, Line's seriesimpedance,mutualcouplingbetweenconductors,mutuallycoupledlines,line'sshuntcapacitance,surgeimpedance and velocity of propagation, line's series impedance and shunt capacitance – single phase equivalents,the transmission (ABCD) matrix, the admittance matrix, conversion between the transmission and admittancematrices, the nominal pi model – single phase equivalent, the equivalent pi model – voltage and current the line,line losses, the equivalent pi model – single phase equivalent, variations in the network's short circuit capacity,examples–the nominal andequivalentmodels.	
Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos
Module-5	
PowerSystemHarmonicStudies: Introduction,harmonicanalysisusingacomputerprogram,harmonicanalysisusingspreadsheet,harmonicdistortionlimits,harmonicfilterrating,andpracticalconsiderations.Harmonicstudyofsimplesystem, 300-22kV power systemandlowvoltagesystem.	
Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs
3. The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Text Books:

1. Power Systems Harmonics: Fundamentals, Analysis and Filter Design, George J. Wakileh, Springer, 2007.
2. Power System Harmonics, Jos Arrillaga, Neville R. Watson, John Wiley & Sons, Ltd, Second Edition, 2003.

Web links and Video Lectures (e-Resources):

- www.nptel.ac.in

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Explainthefundamentalsthatfacilitatethe understandingoftheissuesofharmonics andthecauses forgenerationofharmonics.	L2
CO2	Explaintheeffectsofharmonicsdistortiononpowersystemequipmentandloadsan dsuppressionofharmonicsinpowersystems.	L2
CO3	Discussstandardlimitsofharmonicdistortionandmodelingofpowersystemcompon entsforharmonicanalysis study.	L3
CO4	Modeltransmissionlinesand cablesforharmonicanalysis.	L4
CO5	Discussimplementationofharmonic studies	L3

III Semester

OPTIMIZATION TECHNIQUES			
Course Code	22LPE331	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	40 Hours	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

1. To understandEngineering Optimization, classification.
2. To understandthe formulating the models using linear programming.
3. To understandClassical optimization methods using non linear programming.
4. To understandthedifferent methods of optimization search.
5. To understandtheprinciples of Dynamic programming and Integer linear programming.

Module-1

Introduction to Optimization: Engineering application of Optimization – Statement of an Optimization problem – Optimal Problem formulation – Classification of Optimization problem. Optimum design concepts: Definition of Global and Local optima – Optimality criteria – Review of basic calculus concepts – Global optimality

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-2

Linear Programming: Introduction and formulation of models - Convexity - simplex method - Big-M method - two-phase method - degeneracy - non-existent and unbounded solutions - duality in LPP - dual simplex method - sensitivity analysis - revised simplex method - transportation and assignment problems - travelling salesman problem.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-3

Nonlinear Programming: Classical optimization methods - equality and inequality constraints - Lagrange multipliers and Kuhn-Tucker conditions - quadratic forms - quadratic programming problem and Wolfes' method.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-4

Search Methods: One dimensional optimization - sequential search - fibonacci search - multidimensional search methods - univariate search - gradient methods - steepest descent/ascent methods - conjugate gradient method - Fletcher-Reeves method - penalty function approach.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-5

Dynamic Programming: Principle of optimality - recursive relations - solution of LPP - simple examples. **Integer Linear Programming:** Gomory's cutting plane method - Branch and bound algorithm - Knapsack problem - linear 0-1 problem.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs
3. The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Text Books:

1. Deb K. – 'Optimization for Engineering Design Algorithms and Examples' – PHI – 2000
2. J.C. Pant : Introduction to Optimization, Jain Brothers,2004
3. S.S. Rao :Optimization Theory and applications, Wiley Eastern Ltd. 2009
4. K.V.Mittal: Optimization Methods, Wiley Eastern Ltd. 2005

Web links and Video Lectures (e-Resources):

- www.nptel.ac.in

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	ExplaintheEngineering Optimization and its classification.	L3
CO2	Discussthe formulation of optimization models using linear programming.	L3
CO3	ExplaintheClassical optimization methods using non linear programming.	L3
CO4	Discussthedifferent methods of optimization search.	L3
CO5	Apply theprinciples of Dynamic programming and Integer linear programming.	L4

III Semester

MODELLING AND SIMULATION OF POWER ELECTRONIC SYSTEMS			
Course Code	22LPE332	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	40 Hours	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

1 To understand the challenges in simulation process and issues in modelling power electronic systems.
2 To solve linear, non – linear systems and ODE
3 To model the system to evaluate the dynamic performance of the power electronic devices, circuits and machines
4 To simulate steady state and transient studies on converters and Drives

Module-1

Computer Simulation of Power Electronic Converters and Systems Challenges in computer simulation, simulation process, Types of analysis, mechanics of simulation, circuitoriented simulators, equation solvers, comparison of circuit oriented simulators and equation solvers.
Modelling of Systems: Input-Output relationship, differential equation representation, linearization, state space and transfer function representations.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-2

MNA and ST approaches: Nodal analysis, Modified Nodal analysis, sparse tableau approach. Nonlinearcircuits,Newton-Raphson Method, computation time, convergence issues, Practical limitations.
Introduction to transient simulation: Discretization of time, transient analysis, Accuracy and stability, Explicit and Implicit Schemes.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-3

Method of Transient Simulation: Introduction, Numerical methods for solving ODEs, Stability of numerical methods. Stiff equations, Adaptive step size, Transient analysis in circuit simulation, Equivalent circuit approach, and practical aspects.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-4

Dynamic performance of switched mode power converters: Introduction, PWM converter, Average model of the converter, Circuit Average model of the converter. Introduction toClosed loop control of switching converters, closed loop performance functions.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-5

Advanced topics in Switching converters: Current control of DC to DC converters, Soft switching converters.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Assessment Details (both CIE and SEE)

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Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs
3. The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Text Books:

1. Ned Mohan, Tore M. Undeland, William P. Robbins, "Power Electronics Converters, Applications, and Design", 3rdEdition. Wiley India Pvt Ltd, 2011, ISBN : 978-81- 265-1090-0
2. L.Umanand,"Power Electronics Essentials and Applications",1stEdition, John Wiley & Sons, 2009, ISBN: 978-81-265-1945-3
3. M.B.Patil, V.Ramanarayanan, V.T.Ranganathan, "Simulation of Power Electronic Circuits", Narosa Publishing House, 2013, ISBN: 978-81-7319-989-9

Web links and Video Lectures (e-Resources):

- www.nptel.ac.in

Skill Development Activities Suggested

1) Interact with industry (small, medium, and large.
2) Involve in research/testing/projects to understand their problems and help creative and innovative methods to solve the problem.
3) Involve in case studies and field visits/ fieldwork.
4) Accustom to the use of standards/codes etc., to narrow the gap between academia and industry.
5) Handle advanced instruments to enhance technical talent.
6) Gain confidence in modelling of systems and algorithms for transient and steady-state operations, thermal study, etc.
7) Work on different software/s (tools) to simulate, analyze and authenticate the output to interpret and conclude.

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Analyze performance parameters of various circuits, Power electronic converters and Drives by modelling and simulating with appropriate time steps	L3
CO2	Solve steady state and transient problems of Power electronic systems	L3
CO3	Apply numerical techniques to solve ODE.	L4
CO4	Design, Analyse and Implement open loop and closed loop systems	L3

III Semester

MODERN CONTROL THEORY			
Course Code	22LPE333	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	40 Hours	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

1. To understand the concepts of basic and modern control system for the real time analysis and design of control systems.
2. To understand concepts of state variables analysis.
3. To study and analyze non linear systems.
4. To understand the concept of stability of nonlinear systems and categorization.
5. To understand the comprehensive knowledge of optimal theory for Control Systems.

Module-1

Mathematical Preliminaries and State Variable Analysis: Fields, Vectors and Vector Spaces – Linear combinations and Bases – Linear Transformations and Matrices – Scalar Product and Norms – Eigen values, Eigen Vectors and a Canonical form representation of Linear systems – The concept of state – State space model of Dynamic systems – Time invariance and Linearity – Non uniqueness of state model – State diagrams for Continuous-Time State models – Existence and Uniqueness of Solutions to Continuous-Time State Equations – Solutions of Linear Time Invariant Continuous-Time State Equations – State transition matrix and it's properties. Complete solution of state space model due to zero input and due to zero state.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-2

Controllability and Observability: General concept of controllability – Controllability tests, different state transformations such as diagnolization, Jordon canonical forms and Controllability canonical forms for Continuous-Time Invariant Systems – General concept of Observability – Observability tests for Continuous-Time Invariant Systems – Observability of different State transformation forms.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-3

State Feedback Controllers and Observers: State feedback controller design through Pole Assignment, using Ackkermans formula– State observers: Full order and Reduced order observers.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-4

Non-Linear Systems: Introduction – Non Linear Systems – Types of Non-Linearities – Saturation – Dead-Zone – Backlash – Jump Phenomenon etc; Linearization of nonlinear systems, Singular Points and its types– Describing function–describing function of different types of nonlinear elements, – Stability analysis of Non-Linear systems through describing functions. Introduction to phase-plane analysis, Method of Isoclines for Constructing Trajectories, Stability analysis of nonlinear systems based on phase-plane method.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-5

Stability Analysis: Stability in the sense of Lyapunov, Lyapunov's stability, and Lypanov's instability theorems – Stability Analysis of the Linear continuous time invariant systems by Lyapunov second method – Generation of Lyapunov functions – Variable gradient method – Krasooviski's method.	
Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Assessment Details (both CIE and SEE)

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Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs
3. The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Text Books:

1. M. Gopal, Modern Control System Theory by – New Age International – 1984
2. Ogata. K, Modern Control Engineering by– Prentice Hall – 1997
3. N K Sinha, Control Systems– New Age International – 3rd edition.

Reference Books:

1. Donald E. Kirk, Optimal Control Theory an Introduction, Prentice – Hall Network series – First edition.

Web links and Video Lectures (e-Resources):

- www.nptel.ac.in

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Explain the concepts of basic and modern control system for the real time analysis and design of control systems.	L3
CO2	Explain and apply concepts of state variables analysis.	L4
CO3	Analyze non linear systems.	L3
CO4	Analyze the concept of stability of nonlinear systems and categorization.	L3
CO5	Apply the comprehensive knowledge of optimal theory for Control Systems.	L4

III Semester

DESIGN OF CONTROLLERS			
Course Code	22LPE334	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	40 Hours	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

1. To understand the structure of PID controllers and the various controllers' performance specifications.
2. To understand the practical problem in implementation of PID controllers.
3. To understand the design of a control system with conventional tuning of PID controllers.
4. To acquire the knowledge on the application of advance tuning methods for a system.

Module-1

INTRODUCTION TO PID CONTROL

Introduction of controllers – feedback, feed forward and cascade controllers - PID control- modification of PID algorithm - Parallel PID Controllers, Conversion to Time constant PID Forms, Series PID Controllers, Simple PID Tuning.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-2

PID CONTROLLER IMPLEMENTATION ISSUES

Bandwidth-Limited Derivative Control – Proportional Kick – Derivative Kick – Integral Anti-Windup Circuits – **Reverse Acting Controller:** Digital Implementation – Operational aspects – Commercial controllers.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-3

CONTROLLER DESIGN

Control structures - Time and frequency domain performance measures - Ziegler-Nichols' and Related Methods - Loop Shaping - Optimization Methods - Pole Placement - Dominant Pole Design - Design for Disturbance Rejection.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-4

CONVENTIONAL TUNING METHODS OF PID CONTROLLER

A spectrum of Tools – Step Response methods – Frequency response methods – Phase locked loop methods - Complete process knowledge – Assessment of Performance.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-5

FUZZY LOGIC AND GENETIC ALGORITHM METHODS IN PID TUNING

Fuzzy PID Supervision for an Automotive Application: Design and Implementation, Multi-Objective Optimised Genetic Algorithm based Fuzzy PID Control, Application of Fuzzy PID Control in Robotics.

Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Assessment Details (both CIE and SEE)

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Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
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Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
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4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Reference Books:

1. Johnson and H. Moradi, "PID Control: New Identifications and Design Methods" Springer - Verlag, 2005.
2. Karl J. Astrom & Tore Hagglun. "PID Controllers: Theory, Design and Tuning" International Society for Measurement and Control, 1995.
3. Cheng-Ching Yu, "Auto tuning of PID Controllers; A Relay Feedback Approach" Springer, 2nd Edition, 2006.
4. Antonio Visioli, "Practical PID Control" Springer-Verlag London Limited, 2006.
5. Guillermo J. Silva, Aniruddha Datta & S.R Bhattacharyya, "PID Controllers for Time-Delay Systems" Printed in the United States of America, 2005.

Web links and Video Lectures (e-Resources):

- www.nptel.ac.in

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Implement the concept of PID Controller Structures and performance specifications.	L4
CO2	Identify and resolve the practical implementation issues of PID controller.	L3
CO3	Design of controller using different methods.	L4
CO4	Design a control system with conventional tuning methods of PID controllers.	L4
CO5	Design and apply the advanced PID tuning technology.	L4

III Semester

RELIABILITY ENGINEERING			
Course Code	22LPE335	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	40 Hours	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

1. To understand major concepts of reliability prediction.
2. To apply reliability theory to assessment of reliability in engineering design.
3. To apply the analytical skills in solving real life problems of engineering and science.
4. To understand the possible causes of poor reliability and suggest appropriate reliability tests and the associated failure analysis methods.
5. To use modern simulation tools aiding in reliability analysis

Module-1	
Reliability definition, requirement, methods of enhancement. Reliability importance and allocation, concept of random variable, distribution functions. Distribution functions of function of a single random variable.	
Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-2	
Failure density function e.g. Exponential, Weibull, Normal, Hypoexponential, Hyper exponential etc. Hazard function, Reliability function and inter relationship, safety and reliability. Effect of Wear-in-period on reliability. Effect of preventive maintenance. Reliability evaluation with component replacement.	
Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-3	
Network methods of reliability evaluation. Event-space method, Decomposition method, Tieset method and cut set method. Random number generators, Generation of random variants from failure distributions e.g. Exponential, Normal, Rayleigh etc. Montecarlo simulation based network reliability evaluation. Convergence using coefficient of variation and confidence intervals. Standby systems and load sharing systems. Multistate models.	
Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-4	
Markov modeling, state equations, MTTF calculations. Steady state and time dependent state probabilities. System availability and unavailability. Concept of frequency and durations. State enumeration method for frequency, MUT, MDT calculations.	
Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Module-5	
Load, capacity and reliability evaluation. Normal distribution of load and capacity. Estimation of parameters of failure laws e.g. exponential and normal.	
Teaching-Learning Process	1. Chalk & Talk 2. PPT / Animations 3. Videos

Assessment Details (both CIE and SEE)

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Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
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4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Text Books:

1. R. Billinton, R. N. Allan, "Reliability evaluation of engineering system: concept and techniques", second edition Springer US 1992.
2. C. E. Ebeling, "Reliability and Maintainability Engineering", Tata McGraw Hill 2004.
3. E. E. Lewis, "Introduction to Reliability Engineering", second edition Wiley 1995.

Reference Books:

1. David J. Smith, "Reliability, Maintainability and risk", fourth edition Elsevier 2013.
2. Joel A. Nachlas, "Reliability Engineering: Probability Model and maintenance methods", Taylor and Francis 2005.

Web links and Video Lectures (e-Resources):

- www.nptel.ac.in

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Demonstrate an understanding of the concepts of reliability engineering and various failure mechanisms.	L3
CO2	Identify importance of statistical distributions for modelling failure data and the physical meanings of different parameters.	L3
CO3	Evolve the efficacy to develop reliability models of complicated systems and be able to analyse and interpret the data to infer reliability indices from the data.	L4
CO4	Estimate model mean time to failure and demonstrate an understanding of steady state and time-dependent probabilities.	L3
CO5	Estimate reliability and parameters for failure laws from the test data.	L3