Semester -

Power Electronic Converters -II			
Course Code	**MEPS201**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)		SEE Marks	50
Total Hours of Pedagogy	40 hours Theory + 10-12 Lab slots	Total Marks	100
Credits	04	Exam Hours	03

Course objectives:

1. To discuss the concept switched mode inverters, PWM scheme, modulation scheme.
2. To design voltage control schemes for inverters.
3. To discuss operation of three phase inverters for various modes of operation.
4. To discuss various topologies of multi level inverters.
5. To analyze the operation of cycloconvertes.

MODULE-1

Single Phase inverters:

Basic concept of switch –mode inverters, Pulse width modulation switching scheme, Linear modulation and over modulation- Single phase half bridge inverter- Single phase full bridge inverter- Unipolar and bipolar switching's- voltage cancellation control- Ripple in the single phase inverter - Push pull inverter switch utilization.

MODULE-2

Voltage control of Single phase inverter:

Single pulse width modulation, Multiple-pulse width modulation, modified sinusoidal pulse-width modulation, phase-displacement control. Trapezoidal modulation, staircase modulation, Harmonic injection modulation, Delta modulation.

MODULE-3

Three Phase Inverters:

180- Degree Conduction, 120 – Degree Conduction, Harmonic analysis – Delta connected and star connected load. Sinusoidal PWM, Third harmonic PWM, 60 degree PWM, Space vector modulation, Effect of blanking time on voltage in PWM inverters. Current source inverters.

MODULE-4

Multi level inverter:

Diode-clamped multilevel inverter, Flying capacitor multilevel inverter, Cascade multilevel inverter. Operation and control. Hybridization of Fundamental frequency switching (FFS) and PWM switching inverters.

MODULE-5

Cycloconverters:

Single phase to single phase cycloconverter, Three phase to three phase cycloconverter, single phase to three phase cycloconverters, Three phase to three phase bridge cycloconverter. Operation in blocked mode and current circulating mode. Load commuted cycloconverters. Matrix converter.

PRACTICAL COMPONENT OF IPCC*(May cover all / major modules)*

Sl.NO	Experiments
1	Design of current commutation circuit for SCRs used in forced commutated inverters and choppers. Trace the waveforms of voltage and currents of main and auxiliary SCR, inductor current etc.
2	Study and performance analysis of single phase fully controlled converter fed separately excited DC Motor for continuous current mode.
3	Study and performance analysis of three phase fully controlled converter fed separately excited DC Motor for continuous current mode.
4	Design of Single-phase Half bridge inverter with R and RL loads. Trace the waveforms of device voltage, load voltage, load current and device currents.
5	Study and performance analysis of three phase fully controlled converter fed separately excited DC Motor for discontinuous current mode.

6	Simulation study of buck, boost and buck-boost converter (basic topologies) and analysis of waveforms for continuous current mode (CCM).
7	Simulation study of buck, boost and buck-boost converter (basic topologies) and analysis of waveforms for discontinuous current mode (DCM).
8	Analysis of Multi-Level converter
9	Analysis of Three phase AC voltage control with PWM control.
10	Analysis of Three phase Cycloconverter
11	Design a compensator for a given systems for required specifications
12	Simulation of Three phase inverter with PWM controller.

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 **25 Marks**
2. Two assignments each of **25 Marks/One Skill Development Activity of 50 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 the 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:

Books

1. Power Electronics Converters, Application And Design – Ned Mohan, T M Undeland, William P Robbins, John Wiley & Sons 2003
2. Power Electronics – M D Singh, Khanchandani, 2nd Edition, Tata Mcgraw Hill
3. Fundamentals of Power Electronics, Second Edition, Robert W Erickson, Dragan Maksimovic, Kluwer Academic Publishers.
4. Power Electronics Principles And Applications – Joseph Vithayathil – Tata Mcgraw Hill
5. Power Electronics – Cyril W Lander – Tata Mcgraw Hill

Web links and Video Lectures (e-Resources):

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

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Discuss the concept switched mode inverters, PWM scheme, modulation scheme.	L3
CO2	Design voltage control schemes for inverters.	L4
CO3	Discuss operation of three phase inverters for various modes of operation.	L3
CO4	Discuss various topologies of multi level inverters.	L3
CO5	Analyze the operation of cycloconvertes.	L3

Program Outcome of this course

Sl. No.	Description	POs

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1										
CO2										
CO3										
CO4										
CO5										

Semester- II

Advanced Control Systems			
Course Code	**MEPS202**	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 physical systems, motion control systems.
2. To discuss perspective on state-space design, state variables.
3. To develop discrete-time systems.
4. To design feedback control systems.
5. To analyze non linear systems.

Module-1

Review of Modeling and Analysis of LTI Systems:

Modeling of physical Systems. Design specifications and performance indices, Motion control systems, Transportation lags. Approximation of time-delay functions., Sensitivity of control systems to parameter variations. Effects of disturbance of signals. Disturbance rejection.

Module-2

Analysis in state-space:

A perspective on state-space design. State variables. State models for physical systems. SISO and MIMO systems. Solution of state equations. Transfer function. Eigen values and eigenvectors. Jacobian linearization technique. State transformations and diagonalisation. Transformation to phase-variable canonical form. Controllability and observability. Duality property. Stability.

Module-3

Introduction to Discrete-time Systems:

Basic elements of discrete-time control system. Z-transform and properties. Inverse Z-transform. Difference equation and its solution by Z-transform method. Z-transfer function. State diagram of digital systems. Time delay. Direct, cascade and parallel decomposition of Z-transfer functions.

Module-4

Feedback control design:

Continuous control design. Proportional, derivative and integral control action. PID controller tuning rules. Ziegler-Nichols method. Two degree of freedom control systems. Compensator design using Bode diagram in frequency response approach. Lag, Lead, Lag-lead compensator. Control law design for full state feedback by pole placement. Full order observer system. Observer based state feedback. Separation principal.

Module-5

Non linear system:

Classification and types of non-linearity. Phenomena peculiar to non-linear systems. Methods of analysis. Linearization based on Taylor's series expansion. Jacobian Linearization. Phase trajectory and its construction. Phase-plane analysis of linear and non-linear sustems. Existence of limit cycles. Describing function of typical non-linearities. Stability analysis by DF method. Introduction to DIDF. Popov's circle criterion. Stability analysis by Lyapunov's indirect and direct methods, Lypunov's theorem.

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. Two Unit Tests each of **25 Marks**
2. Two assignments each of **25 Marks**or **oneSkill Development Activity of 50 marks** to attain the COs and POs

The sum of two 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:

Books

1. Ogata, K – Modern Control Engineering, PHI Learning
2. Kuo, B.C. – Automation Control Systems, Prentice Hall
3. Roy Choudhury, D – Modern Control Engineering, Prentice Hall
4. Nagrath, J. J. Gopal, M – Control System Engineering, New Age Pub.
5. Schulz, D.G. and Melsa, . L. – State Functions and Linear Control Systems, McGraw-Hill.
6. Stepheni, Shahian, Savant, Hostetler – Design of feedback control systems, Oxford University Press.
7. Vidyasagar- Nonlinear system analysis, Prentice-Hall.
8. Gibson, J.E.- Non linear system , Mc. Grawhill.
9. Gopal. M, Digital Control and State Variable Methods, TMH

Web links and Video Lectures (e-Resources):

- .

Skill Development Activities Suggested

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Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Develop physical systems, motion control systems.	L4
CO2	Discuss perspective on state-space design, state variables.	L3
CO3	Develop discrete-time systems.	L4
CO4	Design feedback control systems.	L4
CO5	Analyze non linear systems.	L4

Program Outcome of this course

Sl. No.	Description	POs

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1										
CO2										
CO3										
CO4										
CO5										

Semester- II

Electric Drives			
Course Code	**MEPS202**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

1. To understand and analyze dynamics of Electric Drives.
2. To design and analyze drives for DC motors
3. To design and analyze drives for induction motors
4. To design and analyze drives for synchronous motors
5. To discuss applications of microprocessor in the control of an electric drive.

Module-1

Introduction to Electric Drives – advantages – parts of electric drives - dynamics of electric drive - torque equation – four quadrant operation - equivalent values of drive parameters- classification of load torques - steady state stability - load equalization - Classes of motor duty- determination of motor rating.

Module-2

DC motor drives – starting – regenerative braking, dynamic braking, plugging – Transient analysis of separately excited motor – speed control – controlled rectifier fed DC drives – single phase fully controlled & half controlled rectifier control of separately excited DC motor – discontinuous and continuous conduction - three-phase fully controlled & half controlled rectifier control separately excited DC motor

Module-3

Induction motor drives – 3-phase induction motor - torque equation – analysis with unbalanced source voltages and single-phasing – analysis of induction motor fed from non-sinusoidal voltage supply – regenerative braking, pugging, dynamic braking – speed control – pole changing – stator voltage control – static rotor resistance control - stator frequency control below and above base speed.

Module-4

Synchronous motor drives – cylindrical rotor and salient pole types – torque equation – power factor control – operation with non-sinusoidal supply - speed control of synchronous motors – true synchronous mode and self-controlled mode – rotor position encoder – load commutated synchronous motor drive – closed loop speed control – line commutated cycloconverter fed synchronous motor drive.

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.

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. Two Unit Tests each of **25 Marks**
2. Two assignments each of **25 Marks**or **oneSkill Development Activity of 50 marks** to attain the COs and POs

The sum of two 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:

Books

1. Fundamentals of Industrial Drives, B. N. Sarkar, PHI,2012.
2. Fundamentals of Electrical Drives, Gopal K Dubey, Narosa Book Distributors, 2010.
3. Electric Drives, Nisit K.De, Prasanta K Sen, PHI, 1st Edition, 2014.
4. Bose B. K., Modern Power Electronics & AC Drives, PHI Pvt. Ltd.
5. P.C Sen "Thyristor DC Drives", John wiley and sons, New York, 2001.
6. Vedam Subrahmanyam, " Thyristor Control of Electric Drives", Mc Graw Hill, 2017
7. R.Krishnan, 'Electric Motor Drives - Modeling, Analysis and Control', Pearson., 2015

Web links and Video Lectures (e-Resources):

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Skill Development Activities Suggested

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Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Develop capability to choose a suitable Motor and Power Electronic Converter package from a description of drive requirement – involving load estimation, load cycle considerations, thermal aspects and motor-converter matching	L3
CO2	Design and analyse drives for DC motors	L4
CO3	Design and analyse drives for induction motors	L4
CO4	Design and analyse drives for synchronous motors	L4
CO5	Discuss applications of microprocessor in the control of an electric drive.	L3

Program Outcome of this course

Sl. No.	Description	POs

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1										
CO2										
CO3										
CO4										
CO5										

Semester- II

Switched Mode Power Converters			
Course Code	**MEPS204**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

- To understand the design constrains of reactive elements in power electronic system.
- To analyse and dynamic modelling of higher order switched mode power converters.
- Have a foundation on soft switching and pulse width modulated rectifiers.

Module-1

Design constraints of reactive elements in Power Electronic Systems. Design of inductor, transformer for power electronic applications.
Basic concepts of Switched Mode power converters.

Module-2

Steady-state analysis of second order Switched Mode power converters: PWM DC - DC Converters(buck, boost, buck- boost) (CCM and DCM)
DC-DC converters- operating principles, constituent elements.

Module-3

Dynamic Modelling and control of second and higher order switched Mode power converters Converter transfer functions, current programmed and critical conduction mode control.

Module-4

Soft-switching DC - DC Converters: zero-voltage-switching converters, zero-current switching resonant converters.
z- source converters and quasi resonant converters.

Module-5

Pulse Width Modulated Rectifiers: Properties of ideal rectifier, realization of near ideal rectifier, control of the current waveform
Single phase and three-phase converter systems incorporating ideal rectifiers.

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. Two Unit Tests each of **25 Marks**
2. Two assignments each of **25 Marks**or **oneSkill Development Activity of 50 marks** to attain the COs and POs

The sum of two 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:

Books

1. Robert W Ericson and DarganMaksimovic ,"Fundamental of power electronics ", Springer, 2nd edition , 2001.
2. Power Electronics Conveters , Application and design – Ned Mohan, T M Undeland, William P Robbins, John Wiley & sons 2003
3. Marian K. Kazimierczk, " Pulse- width Modulated DC-DC power converters" John Wiley & Sons Ltd., 1st Edition,2008

Web links and Video Lectures (e-Resources):

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Skill Development Activities Suggested

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Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Discuss the constraints of Power Electronic Systems	L3
CO2	Analyse the second order Switched Mode power converters	L3
CO3	Model and control the second and higher order switched Mode power converters.	L3
CO4	Design and analyse resonant converters.	L4
CO5	Discuss the properties of ideal rectifier	L3

Program Outcome of this course

Sl. No.	Description	POs

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1										
CO2										
CO3										
CO4										
CO5										

Semester- II

Converters For Solar And Wind Power Systems			
Course Code	**MEPS215A**	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 developments in the PV and WT penetrations in the world wide power systems.
2. To discuss the various high-efficiency topologies for PV inverters and generic control structures.
3. To understand the grid requirements for PV installations, and different quadrature signal generator methods,
4. To analyze grid synchronization techniques for single phase power converters.
5. To discuss islanding detection methods and typical WT grid converter topologies, control structures, the grid requirements for WT grid connection and the grid codes.
6. To discuss grid synchronization of three phase power converters and new robust synchronization structures to cope with the unbalance and distorted grid conditions.
7. To analyze the grid converter control structures for WT and the control issue for the case of grid faults.
8. To design grid interface filters used to damp the resonance for LCL filters and methods for controlling the grid current.

Module-1

Introduction:
Wind Power Development, Photovoltaic Power Development, The Grid Converter–The Key Element in Grid Integration of WT and PV Systems.

Photovoltaic Inverter Structures:
Introduction, Inverter Structures Derived from H-Bridge Topology, Inverter Structures Derived from NPC Topology, Typical PV Inverter Structures, Three-Phase PV Inverters, Control Structures, Conclusions and Future Trends.

Module-2

Grid Synchronization in Single-Phase Power Converters:
Introduction, Grid Synchronization Techniques
For Single-Phase Systems, Phase Detection Based on In-Quadrature Signals, Some PLLs Based on In-Quadrature Signal Generation, Some PLLs Based on Adaptive Filtering, The SOGI Frequency-Locked Loop.

Module-3

Islanding Detection:
Introduction, Non-detection Zone, Overview of Islanding Detection Methods, Passive Islanding Detection Methods, Active Islanding Detection Methods.

Grid Converter Structures for Wind Turbine Systems:
Introduction, WTS Power Configurations, Grid Power Converter Topologies, WTS Control.

Grid Requirements for WT Systems:
Introduction, Grid Code Evolution (Germany), Frequency and Voltage Deviation under Normal Operation, Active Power Control in Normal Operation, Reactive Power Control in Normal
Operation (Germany), Behavior under Grid Disturbances (Germany), Discussion of Harmonization of Grid Codes.

Module-4

Grid Synchronization in Three-Phase Power Converters: Introduction, The Three-Phase Voltage Vector under Grid Faults, The Synchronous Reference Frame PLL under Unbalanced and Distorted Grid Conditions, The Decoupled Double Synchronous Reference Frame PLL (DDSRF-PLL), The Double Second-Order Generalized Integrator FLL (DSOGI-FLL).

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 Current Injection, Power Control under Unbalanced Grid Conditions, Flexible Power Control with Current Limitation.

Grid Filter Design:
Introduction, Filter Topologies, Design Considerations, Practical Examples of LCL Filters and Grid Interactions, Resonance Problem and Damping Solutions, Nonlinear Behavior of the Filter.

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. Two Unit Tests each of **25 Marks**
2. Two assignments each of **25 Marks**or **oneSkill Development Activity of 50 marks** to attain the COs and POs

The sum of two 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:

Books

1. Grid Converters for Photo voltaic and Wind Power Systems, Remus Teodorescuatal, Wiley, 2011.

Web links and Video Lectures (e-Resources):

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Skill Development Activities Suggested

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Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Explain developments in the PV and WT penetrations in the world wide power systems and discuss the various high-efficiency topologies for PV inverters and generic control structures.	L3
CO2	Explain grid synchronization techniques for single phase power converters.	L3
CO3	Explain islanding detection methods and typical WT grid converter topologies, control structures, the grid requirements for WT grid connection and the grid codes.	L3
CO4	Explain grid synchronization of three phase power converters and new robust synchronization structures to cope with the unbalance and distorted grid conditions.	L3
CO5	Explain the grid converter control structures for WT and the control issue for the case of grid faults and to design grid interface filters.	L3

Program Outcome of this course

Sl. No.	Description	POs

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1										
CO2										
CO3										
CO4										
CO5										

ವಿಶ್ವೇಶ್ವರಯ್ಯ ತಾಂತ್ರಿಕ ವಿಶ್ವವಿದ್ಯಾಲಯ

'ಬಿ ಟಿ ಯು ಅಧಿನಿಯಮ ೧೯೯೪' ರ ಅಡಿಯಲ್ಲಿ ಕರ್ನಾಟಕ ಸರ್ಕಾರದಿಂದ ಸ್ಥಾಪಿತವಾದ ರಾಜ್ಯ ವಿಶ್ವವಿದ್ಯಾಲಯ

Visvesvaraya Technological University

(State University of Government of Karnataka Established as per the VTU Act, 1994)

"Jnana Sangama" Belagavi-590018, Karnataka, India

Prof. B.E. Rangaswamy, Ph.D.
Registrar

Phone No: (0831) – 2405468
Fax No. : (0831) – 2405467

Ref. No.: VTU/BOS/A12/2025-26/767

Date: 16 MAY 2025

Circular

Sub: **MEPS215B Uninterruptible Power Supply** in M.Tech. Power Electronics Programme (2024 Scheme) – Updating the syllabus content

Ref: Chairperson, BOS in EEE, VTU, Belagavi email dated 13-05-2025

With reference to the above, it is observed that the syllabus content for the subject **"MEPS215B Uninterruptible Power Supply"** is repeated as that of "MEPS215A Converters For Solar And Wind Power Systems" syllabus in M.Tech. Power Electronics Programme (2024 Scheme. The Chairperson, BOS in EEE, VTU, Belagavi has submitted the correct syllabus for the subject **MEPS215B Uninterruptible Power Supply** and the same is enclosed herewith for your information.

You are hereby requested to bring the contents of this Circular to the notice of all the concerned faculty members / students of your college and follow the same.

Encl: syllabus

16/05/25 BE
Registrar

To

1) The Principals of constituent and all affiliated engineering colleges under VTU.
2) The Chairpersons/Programme Coordinators of all VTU PG Centres at Muddenhalli, Belagavi, Mysuru and Kalaburagi Regions.

Copy to:

1) The Secretary to VC, VTU, Belagavi.
2) The Registrar (Eval.), VTU, Belagavi.
3) The Regional Director (I/c), VTU Regional Offices at Bengaluru, Belagavi, Kalaburagi & Mysuru for information and circulation.
4) The Director, ITISMU, VTU, Belagavi to upload the Circular in the University website.
5) The Special Officer, Examination Section, VTU, Belagavi.
6) PS to Registrar, VTU, Belagavi.

Semester- II

Uninterruptible Power Supply			
Course Code	**MEPS215B**	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 classification of UPS, batteries for UPS, parallel operation and performance evaluation and control of UPS systems.
2. Acquire knowledge about sources of harmonics and their mitigation using active filters.
3. To understand steady-state operation and control of unified power quality conditioners and the concept of reduced parts converter.
4. To understand an on-line ups system based on novel AC/DC rectifier.
5. To understand the reduced parts active filters, their modeling and control.

Module-1

Uninterruptible Power Supplies: Classification, Batteries for UPS Applications, Flywheels for UPS Applications, Comparative Analysis of Flywheels and Electrochemical Batteries, Applications of UPS Systems, Parallel Operation, Performance Evaluation of UPS Systems, Power Factor Correction in UPS Systems, Control of UPS Systems, Converters for UPS Systems, Battery Charger/Discharger.

Module-2

Active Filters: Harmonic Definition, Harmonic Sources in Electrical Systems, Effects of Harmonics, Harmonic Mitigation Methods, Classification of Active Filters, Active Filters for DC/DC Converters, Modelling and Analysis, Control Strategies, Stability Assessment.

Module-3

Unified Power Quality Conditioners: Series–Parallel Configuration, Current Control, Voltage Control, Power Flow and Characteristic Power.
Reduced-Parts Uninterruptible Power Supplies: Concept of Reduced-Parts Converters Applied to Single-Phase On-Line UPS Systems, New On-Line UPS Systems Based on Half-Bridge Converters.

Module-4

New On-Line UPS Systems Based on a Novel AC/DC Rectifier: New Three-Phase On-Line UPS System with Reduced Number of Switches, New Single-Phase to Three-Phase Hybrid Line-Interactive/On-Line UPS System.

Module-5

Reduced-Parts Active Filters: Reduced-Parts Single-Phase and Three-Phase Active Filters, Reduced-Parts Single-Phase Unified Power Quality Conditioners, Reduced-Parts Single-Phase Series–Parallel Configurations, Reduced-Parts Three-Phase Series–Parallel Configurations.

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. Two Unit Tests each of **25 Marks**
2. Two assignments each of **25 Marks**or **one Skill Development Activity of 50 marks** to attain the COs and POs

The sum of two 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:

Books

1. Uninterruptible Power Supplies and Active Filters, Ali Emadi et al, CRC Press, 2005.
2. Uninterruptible Power Supplies and Standby Power Systems, Alexander C King, William Knight, McGraw-Hill, 2003.

Web links and Video Lectures (e-Resources):

-

Skill Development Activities Suggested

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Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Discuss classification of UPS, batteries for UPS, parallel operation and performance evaluation and control of UPS systems.	L3
CO2	Discuss the sources of harmonics and their mitigation using active filters.	L3
CO3	Discuss the steady-state operation and control of unified power quality conditioners and the concept of reduced parts converter.	L3
CO4	Discuss the on-line ups system based on novel AC/DC rectifier.	L3
CO5	Discuss the reduced-Parts Single-Phase and Three-Phase Active Filters.	L3

Program Outcome of this course

Sl. No.	Description	POs

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1										
CO2										
CO3										
CO4										
CO5										

Semester- II

Electromagnetic Interference and Compatibility			
Course Code	**MEPS215C**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

1. To study the Principles of Electromagnetic Interference mechanisms of EMI generation.
2. To analyse the transients in power supply lines, EMI-conduction, radiation coupling.
3. To describe the Conducted Interference measurements and analyse the effect of power supply components on Conducted emissions.
4. To describe the Grounding, Cabling, Shielding, Bonding mechanisms for EMCand the mechanism of EMI emission/coupling in cables.
5. To understand various EMI/EMC standards and design various EMI filters.

Module-1

INTRODUCTION :

Introduction to EMI and EMC, Sources of EMI, Conducted and Radiated EMI emission and susceptibility, Radiation hazards to humans, EMC Testing categories, Practical experiences and concerns, frequency spectrum conservations, Mechanisms of EMI generation, EMI Testing and Measurement, Methods of mitigation of EMI and Biological effects of EMI.

Module-2

EMI FROM APPARATUS / CIRCUITS:

Introduction, Electromagnetic Emissions, Noise from relays and Switches, Nonlinearities in Circuits, Passive Inter modulation, Cross-Talk in Transmission lines, Transients in Power Supply Lines calculation of induced Voltages and Currents, Surges on Mains Power Supply, EMI- Radiation coupling, Conduction coupling, Combination of both Radiation and Conduction coupling.

Module-3

CONDUCTED INTERFERENCE MEASUREMENTS:

Introduction, Characterization of Currents / Voltages, Common-Mode and Differential-Mode Interferences-examples, Conducted EMI Noise on Power Supply Lines-Transients on power Supply Lines, Propagation of surges in Low Voltage AC lines, Conducted EMI from equipment and Apparatus-Instrumentation for Measuring the Conducted EMI, Experimental setup, Measurement of CM and DM Interferences, Immunity to Conducted EMI. Power Supplies - Linear Power Supplies - Switched-Mode Power Supplies (SMPS)- Effect of Power Supply Components on Conducted Emissions- Power Supply and Filter Placement Conducted Susceptibility.

Module-4

GROUNDING, CABLING, SHIELDING AND BONDING:

Safety and signal grounds, low and high frequency grounding methods, grounding of amplifiers and cable shields, isolation, neutralizing transformers, shield grounding at high frequencies, digital grounding. Types of cables, Mechanism of EMI emission / Coupling in cables. Shielding Effectiveness, near and far fields / impedances sources, methods of analysis, total loss due to absorption and reflection effects, composite absorption and reflection losses for electric fields / magnetic fields, Low frequency magnetic shielding, Effect of Apertures. Electrical Bonding, Shape and Material for Bond straps, General Characteristics of good bonds.

Module-5

EMI FILTERS AND EMI/EMC STANDARDS:

Introduction, Characteristics of various filters – Impedance Mismatch Effects-Lumped Element Low-Pass Filters, High-Pass Filters, Band-Pass Filters, Band-reject Filters, Power Line Filter design-Common-Mode Filter, Differential-Mode filter, Combined CM and DM filter. Components for EMC and EMC Standards - Choice of capacitors, inductors, transformers and resistors, EMC design components, National / International EMC standards, military and civilian standards.

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. Two Unit Tests each of **25 Marks**
2. Two assignments each of **25 Marks**or **oneSkill Development Activity of 50 marks** to attain the COs and POs

The sum of two 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:

Books

1. Dr. V.P. Kodali, Engineering Electromagnetic Compatibility, IEEE Printed in India by S. Chand & Co. Ltd., New Delhi, 2000. Publication,
2. Henry W. Ott, Electromagnetic Compatibility Engineering, John Wiley & Sons Inc, New York, 2009
3. Clayton R.Paul, Introduction to electromagnetic compatibility, John Wiley and Sons, Inc. 1991.
4. Daryl Gerke and William Kimmel, EDN's Designer's Guide to Electromagnetic Compatibility, Elsevier Science & Technology Books, 2002.
5. Dr Kenneth L Kaiser, The Electromagnetic Compatibility Handbook, CRC Press 2005.

Web links and Video Lectures (e-Resources):

- .

Skill Development Activities Suggested

-

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Descuss EMI Environment, Coupling principles, Different sources Mitigation Techniques.	L3
CO2	Discuss Electromagnetic emissions and distinguish EMI radiation and conduction coupling..	L3
CO3	Distinguish Measurement Techniques for Conducted Interference and the effect of power supply components on Conducted Emissions.	L3
CO4	Describe the Grounding, Cabling, Shielding, Bonding mechanisms for EMC.	L3
CO5	Describe the Characteristics of EMI filters and components for EMI/EMC standards	L3

Program Outcome of this course

Sl. No.	Description	POs

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1										
CO2										
CO3										
CO4										
CO5										

VISVESVARAYA TECHNOLOGICAL UNIVERSITY

BELAGAVI

Scheme of Teaching and Examinations

M.Tech. in Electrical & Electronics Engineering

(Power Electronics)

Choice Based Credit System (CBCS) and Outcome Based Education (OBE)

Specialization in –(Power Electronics)

II SEMESTER

Sl. No	Course	Course Code	Course Title	Teaching Hours /Week			Examination				Credits
				Theory	Practical/ Seminar	Tutorial/ Skill Development Activities	Duration in hours	CIE Marks	SEE Marks	Total Marks	
				L	P	T/SDA					
1	PCC/PEC/ MDC/PCC(PB) /IPCC	MPE201	Power Electronic Converters -II	3	2	0	03	50	50	100	4
2		MPE202	Advanced Control Systems	3	0	0	03	50	50	100	3
2		MPE203	Electric Drives	3	0	0	03	50	50	100	3
3		MPE204	Switched Mode Power Converters	3	0	0	03	50	50	100	3
4		MPE205	ELECTIVE -III	3	0	0	03	50	50	100	3
5		MPE206	ELECTIVE -IV	3	0	0	03	50	50	100	3
6	PCCL	MPEL207	Control and Drives Lab	0	2	2	03	50	50	100	2
7	AEC/SEC	PE258x	Ability/Skill Enhancement Course (Offline/Online)	00 01	02 00	--- ----	02 01	50	50	100	1
TOTAL								**400**	**400**	**800**	**22**

Note: **PCC**: Professional core. **IPCC**-Integrated Professional Core Courses, **PCC(PB):** Professional Core Courses (Project Based), **PCCL**-Professional Core Course lab**, PEC-** Professional Elective Courses, **MDC-** Multi-Disciplinary Courses
, **L-Lecture, P-Practical, T/SDA-Tutorial / Skill Development Activities** (Hours are for Interaction between faculty and students)
L-Lecture, P-Practical, T/SDA-Tutorial / Skill Development Activities (Hours are for Interaction between faculty and students) **PBLC**: Project Based Learning Course,
Note: **xxx** means specialization code for example **MDE- Design** Engineering, **LDN-** Digital Communication and Networking, **SCE**- Computer Engineering, **CCT**- Construction Technology, **AUD**- Urban Design, **MBA**- Master of Business Administration, **MCA**-Master of Computer Application, etc

Ability / Skill Enhancement Courses					
Course Code	**Course title**	L	T/SDA	P	
PE258A	Refer www.online.vtu.ac.in				
PE258B	Refer www.online.vtu.ac.in				
PE258C	Refer www.online.vtu.ac.in				
PE258D	Refer www.online.vtu.ac.in				

Ability Enhancement Courses (AEC):.These courses are designed to help students enhance their skills in communication, language, and personality development. They also promote a deeper understanding of subjects like social sciences and ethics, culture and human behaviour, human rights, and the law.**Skill Enhancement Course (SEC):**Skill Enhancement Course means a coursedesigned toprovide value-based or skill-based knowledge and should contain both theoryand lab/hands-on/training/fieldwork. The main purpose of these courses is to providestudents with life skills in the hands-on mode to increase their employability.

If AEC/SEC courses are ONLINE (MOOCs) courses suggested by the concerned board of studies. These courses will be made available on **www.online.vtu.ac.in**, however online courses are not considered forvertical progression, but qualifying in online courses is mandatory for the award of the degree.

Specialization		**Specialization**	
Course Code	**Course Title**	**Course Code**	**Course Title**
MPE205A	Converters for Solar and Wind Power Systems	MPE206A	Power Electronics Application to Power Systems
MPE205B	Uninterruptible Power Supply	MPE206B	Digital Power Electronics
MPE205C	Electromagnetic Interference and Compatibility	MPE206C	Embedded Systems
MPE205D	Neural and Fuzzy Logic Control of Drives	MPE206D	Internet-based Control Systems

Semester- II

Power Electronics Application to Power Systems			
Course Code	**MEPS216A**	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 basics of formation of bus admittance matrix, modeling of transmission line, and analyze the load flow.
2. To analyze the sensitivity of power system security.
3. To explain the voltage stability, proximity indicators and participation factors.
4. To familiarize with FACT systems for controlling the power and configuration of various FACT devices.
5. To discuss the thyristor controlled series capacitor, its analysis, different modes of operation and various models.

Module-1

Power System components models formation of bus admittance matrix, algorithm for formation of bus impedance matrix, Reactive power capability of an alternator, transmission line model and loadability, Reactive power transmission and associated difficulties, Regulated shunt compensation, Models of OLTC and Phase shifting transformer, load flow study.

Module-2

Sensitivity analysis: Generation shift distribution factors, line outage distribution factors, Compensated shift factors. Power system security levels, contingency selection and evaluation, security constrained economic dispatch. Pre-contingency corrective rescheduling.

Module-3

Voltage stability: Proximity indicators e.g. slope of PV-curve, Minimum Eigen value of reduced load flow Jacobian, participation factors based on modal analysis and application.

Module-4

Flexible ac transmission systems, Reactive power control, Brief description and definition of FACT's controllers, Shunt compensators, Configuration and operating characteristics of TCR, FC-TCR, TSC, Comparison of SVCs.

Module-5

The Thyristor-controlled series capacitor (TCSC), Advantages of the TCSC, Basic principle and different mode of operation, Analysis, Variable-reactance model and transient stability model of TCSC.

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. Two Unit Tests each of **25 Marks**
2. Two assignments each of **25 Marks**or **oneSkill Development Activity of 50 marks** to attain the COs and POs

The sum of two 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:

Books

1. D. P. Kothari and I. J. Nagrath, "Modern Power System Analysis", Tata McGraw Hill 2011.
2. A. J. Wood and B. F. Wollenberg, "Power generation, operation and control", second edition John Wiley and Sons 1996.
3. N. G. Hingorani and L. Gyugyi, "Understanding facts: Concepts and Technology of flexible AC transmission systems", Wiley Press 2000.

Web links and Video Lectures (e-Resources):

- .

Skill Development Activities Suggested

-

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Create the bus admittance matrx, describe the reactive power of transmission line, model the transmission line, define the model of OLTC and analyse the load flow of lines.	L4
CO2	Analyze the sensitivity of different distribution factors, explain the power system security, and select and evaluate the contingency.	L3
CO3	Determine the voltage stability, proximity indicators and participation factor based on model analysis.	L3
CO4	Describe the FACT's controllers for power system and configure various FACT devices.	L3

Program Outcome of this course

Sl. No.	Description	POs

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1										
CO2										
CO3										
CO4										
CO5										

Semester- II

Digital Power Electronics			
Course Code	**MEPS216B**	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 traditional parameters computation, multiple quadrant operation and choppers.
2. To understand the disadvantages of analog power electronics and conversion technology, energy factor and sub-sequential parameters.
3. To understand basic mathematics of digital control systems and mathematical modeling of digitally controlled power electronic devices such as rectifiers, inverters and converters.
4. To learn the mathematical modeling of AC/DC rectifiers, DC/AC inverters, DC/DC converters and AC/AC (AC/DC/AC) converters are working in the discrete-time state.
5. To understand DC/AC pulse-width-modulation (PWM) inverters and AC/AC converters modeled as a first-order-hold (FOH) element in digital control systems.
6. To understand DC/DC converter modeled as a second order-hold (SOH) element in digital control systems.
7. To understand open loop and closed loop control of power electronic devices and energy factor application of AC and DC motor drives.

Module-1

Introduction: Historical review, Traditional parameters, Multiple-quadrant operations and choppers, Digital power electronics: pump circuits and conversion Technology, Shortage of analog power electronics and conversion technology, Power semiconductor devices applied in digital power electronics.

Energy Factor (EF) and Sub-sequential Parameters: Introduction, Pumping energy(PE), Stored Energy (SE), Energy factor(EF), Variation energy factor(EFV), Time constant, τ, and damping time constant, τd, Examples of applications, Small signal analysis.

Module-2

Mathematical Modelling of Digital Power Electronics: Introduction, A zero-order hold (ZOH) for AC/DC controlled rectifiers, A first-order transfer function for DC/AC pulse-width-modulation Inverters, A second-order transfer function for DC/DC converters, A first-order transfer function for AC/AC(AC/DC/AC) converters.

Self Study: Basic Mathematics of Digital Control Systems

Module-3

Digitally Controlled DC/AC Inverters: Introduction, Mathematical modeling for DC/AC PWM inverters, Single-phase half-wave VSI, Single-phase full-bridge PWM VSI, Three-phase full-bridge PWM VSI, Three-phase full-bridge PWM CSI, Multi stage PWM inverter, Multi level PWM inverter.

Digitally Controlled DC/DC Converters: Introduction, Mathematical Modelling for power DC/DC converters, Fundamental DC/DC converter, Developed DC/DC converters, Soft-switching converters, Multi-element resonant power converters.

Module-4

Digitally Controlled AC/AC Converters: Introduction, Traditional modeling for AC/AC (AC/DC/AC) converters, Single-phase AC/AC converter, Three-phase AC/AC voltage controllers, SISO cycloconverters, TISO cycloconverters, TITO cycloconverters, AC/DC/AC PWM converters, Matrix converters.

Open-loop Control for Digital Power Electronics: Introduction, Stability analysis, Unit-step function responses, Impulse responses.

Module-5

Closed- Loop Control for Digital Power Electronics: Introduction, PI control for AC/DC rectifiers, PI control for DC/AC inverters and AC/AC (AC/DC/AC) converters, PID control for DC/DC converters.

Energy Factor Application in AC and DC Motor Drives: Introduction, Energy storage in motors, ADC/AC voltage source, An AC/DC current source, AC motor drives, DC motor drives.

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. Two Unit Tests each of **25 Marks**
2. Two assignments each of **25 Marks**or **oneSkill Development Activity of 50 marks** to attain the COs and POs

The sum of two 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:

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

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Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Explain traditional parameters of computation, multiple quadrant operation and choppers.	L2
CO2	Discuss the disadvantages of analog power electronics and conversion technology, energy factor and sub-sequential parameters.	L3
CO3	Discuss basic mathematics of digital control systems and mathematical modeling of digitally controlled power electronic devices such as rectifiers, inverters and converters.	L3
CO4	Describe mathematical modeling of AC/DC rectifiers, DC/AC inverters, DC/DC converters and AC/AC (AC/DC/AC) converters are working in the discrete-time state.	L3
CO5	Discuss DC/AC pulse-width-modulation (PWM) inverters and AC/AC converters modeled as a first-order-hold (FOH)element in digital control systems.	L3
CO6	Discuss DC/DC converter modeled as a second order-Hold (SOH) element in digital control systems.	L3
CO7	Explain open loop and closed loop control of power electronic devices and energy factor application of AC and DC motor drives.	L2

Program Outcome of this course

Sl. No.	Description	POs

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1										
CO2										
CO3										
CO4										
CO5										

Semester- II

Power Quality Enhancement using Custom Power Devices			
Course Code	**MEPS216C**	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 analyze the Power quality issues and concerns of the country.
2. To identify the type of Power quality problems with reference to IEEE/IET standards.
3. To analyze, evaluate and realize the control techniques for power quality problems.
4. To decide on choosing the necessary monitoring equipment and mitigation techniques.

Module-1

Introduction and Characterization of Electric Power Quality:
Electric Power Quality, Power Electronic applications in Power Transmission Systems, Power Electronic applications in Power Distribution Systems. Power Quality terms and Definitions, Power Quality Problems.

Analysis and Conventional Mitigation Methods:
Analysis of Power Outages, Analysis of Unbalance, Analysis of Distortion, Analysis of Voltage Sag, Analysis of Voltage Flicker, Reduced Duration and Customer impact of Outages, Classical Load Balancing Problem, Harmonic Reduction, Voltage Sag or Dip Reduction.

Module-2

Custom Power Devices:
Introduction, Utility-Customer Interface, Custom Power Devices, Custom Power Park, Status of Application of CP Devices, Closed-Loop Switching Control, Second and higher order Systems.

Module-3

Solid State Limiting, Breaking and Transferring Devices:
Solid State Current Limiter, Solid State Breaker, Issues in Limiting and Switching operations, Solid State Transfer Switch, Sag/Swell Detection Algorithms.

Module-4

Generation of Reference Parameter :
Generating Reference Currents Using Instantaneous PQ Theory, Generating reference currents using instantaneous Symmetrical Components, General Algorithm for generating reference currents, Generating Reference currents when the Source is Unbalanced.

Module-5

Active Power Filters:
Series Active Filter, Shunt Active Filter, UPQC Configurations, RightShunt UPQC Characteristics, Left-Shunt UPQC Characteristics, Structure and Control of Right-Shunt UPQC, Structure and Control of Left-Shunt UPQC.

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. Two Unit Tests each of **25 Marks**
2. Two assignments each of **25 Marks**or **oneSkill Development Activity of 50 marks** to attain the COs and POs

The sum of two 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:

Books

1. Arindam Ghosh et.al, Power Quality Enhancement Using Custom Power Devices, Kluwer Academic Publishers, 2002.
2. Math H J Bollen, "Understanding Power Quality Problems; Voltage Sags and Interruptions", Wiley India, 2011.
3. Roger C Dugan, et.al, "Electrical Power Systems Quality", 3rd Edition, TMH, 2012.
4. G T Heydt, "Electric Power Quality", Stars in Circle Publications, 1991.
5. Ewald F Fuchs, et. el, "Power Quality in Power System and Electrical Machines", Academic Press, Elsevier, 2009.
6. C. Shankaran "Power Quality", CRC Press, 2013.
7. Ewald F Fuchs, et. el, "Power Quality in Power System and Electrical Machines", Academic Press, Elsevier, 2009.

Web links and Video Lectures (e-Resources):

- www.nptel.ac.in

Skill Development Activities Suggested

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Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Analyze the Power quality issues and concerns of the country.	L4
CO2	Identify the type of Power quality problems with reference to IEEE/IET standards.	L3
CO3	Analyze, evaluate and realize the control techniques for power quality problems.	L4
CO4	Decide on choosing the necessary monitoring equipment and mitigation techniques.	L4

Program Outcome of this course

Sl. No.	Description	POs

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1										
CO2										
CO3										
CO4										
CO5										

Semester- II

Internet-based Control Systems			
Course Code	**MEPS216D**	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 requirements for Internet-based control systems and to building a functional model, traditional Tele-operation systems and Web-based user interface design.
2. To understand the Real-time Data Transfer over the Internet dealing with Internet Transmission Delay and Data Loss from the Network View and Control perspective.
3. To learn design of Multi-rate SISO and MIMO Internet-based Control Systems and Safety and Security Checking.
4. To understand the basic concepts and general guidelines of control system performance monitoring, remotely designing, testing, and updating real-time control software through the Internet.
5. To understand the Performance Monitoring, Performance Monitoring of Control Systems, Remote Control Performance Maintenance, Real-time Control System Life Cycle, Implementation of the General Integrated Environment

Module-1

Introduction: Networked Control Systems (NCS),Internet-based Control Systems (ICS), Challenges of NCS/ICS. **Requirements Specification for Internet-based Control Systems:** Introduction, Requirements Specification, Functional Modelling of Internet-based Control Systems, Information Hierarchy, Possible Implementation of Information Architecture.

Internet-based Control System Architecture Design: Introduction, Traditional Bilateral Tele-operation Systems, Remote Control over the Internet, Canonical Internet-based Control System Structures.

Web-based User Interface Design: Features of Web-based User Interface, Multimedia User Interface Design, Case Study.

Module-2

Real-time Data Transfer over the Internet: Real-time Data Processing, Data Wrapped with XML, Real-time Data Transfer Mechanism, Case Study.

Dealing with Internet Transmission Delay and Data Loss from the Network View: Requirements of Network Infrastructure for Internet-based Control, Features of Internet Communication, Comparison of TCP and UDP, Network Infrastructure for Internet-based Control, Typical Implementation for Internet-based Control.

Module-3

Dealing with Internet Transmission Delay and Data Loss from the Control Perspective: Overcoming the Internet Transmission Delay, Control Structure with the Operator Located Remotely, Internet-based Control with a Variable Sampling Time, Multi-rate Control, Time Delay Compensator Design, Simulation Studies, Experimental Studies.

Design of Multi-rate SISO Internet-based Control Systems: Introduction, Discrete-time Multi-rate Control Scheme, Design Method, Stability Analysis, Simulation Studies, Real-time Implementation.

Module-4

Design of Multi-rate MIMO Internet-based Control Systems: Introduction, System Modeling, Controller Design, Stability Analysis, Design Procedure, Model-based Time Delay Compensation, Simulation Study.

Safety and Security Checking: Introduction, Similarity of Safety and Security, Framework of Security Checking, Control Command Transmission Security, Safety Checking, Case Study.

Module-5

Remote Control Performance Monitoring and Maintenance over the Internet: Introduction, Performance Monitoring, Performance Monitoring of Control Systems, Remote Control Performance Maintenance, Case Study.

Remote Control System Design and Implementation over the Internet: Introduction, Real-time Control System Life Cycle, Integrated Environments, A typical Implementation of the General Integrated Environment, Case Study.

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. Two Unit Tests each of **25 Marks**
2. Two assignments each of **25 Marks**or **oneSkill Development Activity of 50 marks** to attain the COs and POs

The sum of two 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:

Books

1. Internet-based Control Systems: Design and Applications, Shuang- Hua Yang, Springer-Verlag, 2011.

Web links and Video Lectures (e-Resources):

- www.nptel.ac.in

Skill Development Activities Suggested

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Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Discuss requirements for Internet-Based control systems and to building a functional model, traditional Tele-operation systems and Web-based user interface design.	L3
CO2	Discuss Real-time Data Transfer over the Internet dealing with Internet Transmission delay and Data Loss from the Network View and Control perspective.	L3
CO3	Discuss design of Multi-rate SISO and MIMO Internet-based Control Systems and Safety and Security Checking.	L4
CO4	Explain the basic concepts and general guidelines of control system performance monitoring, remotely designing, testing, and updating real-time control software through the Internet	L3
CO5	Discuss Performance Monitoring, Performance Monitoring of Control Systems, Remote Control Performance Maintenance, Real-time Control System Life Cycle, Implementation of the	L3

Program Outcome of this course

Sl. No.	Description	POs

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1										
CO2										
CO3										
CO4										
CO5										

Control and Drives Lab			
Course Code	**MEPSL207**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	0:2:2	SEE Marks	50
Credits	02	Exam Hours	03

Course objectives:

- To design and develop power electronic drives and control.

Sl.NO	Experiments
1	Open loop and closed loop speed control of DC Shunt Motor with constant torque /variable torque load using suitable Intelligent Power Module.
2	Speed control of DC-DC converter based DC motor drive
3	. Performance analysis of open loop Speed control of Permanent Magnet Brushless DC Motor (PMBLDC) using suitable Intelligent Power Module.
4	V/f control of three phase induction motors
5	Performance analysis of closed loop speed control of Permanent Magnet Brushless DC Motor (PMBLDC) using suitable Intelligent Power Module.
6	Speed control of SRM motor drive
7	Vector control of three phase induction motors
8	Speed control of three phase synchronous motors
	Demonstration Experiments (For CIE) if any
9	Analysis of Three phase AC voltage control with PWM control.
10	To study the operation of solar power generation and its uses a. Draw the Voltage-Current (V-I) and Power-Voltage (P-V) characteristics of solar panel. b. To study the operation of solar panel based battery charger and understand the principle of charge controller.
11	Analysis of Multi-Level converter
12	Analysis of Resonant converters

Course outcomes (Course Skill Set):

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

- Design and analyse the power electronic drives and control.

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 an 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 down to 30 marks** (60% of maximum marks).
- Weightage to be given for neatness and submission of record/write-up on time.
- Department shall conduct 01 tests for 100 marks, test shall be conducted after the 14th week of the semester.
- In 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 test marksis scaled down to 20 marks** (40% of the maximum marks).

The Sum of **scaled-down** marks scored in the report write-up/journal and marks of test 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

Suggested Learning Resources:

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