VISVESVARAYA TECHNOLOGICAL UNIVERSITY
BELAGAVI

Scheme of Teaching and Examinations and Syllabus

M.TECH COMPUTER APPLICATIONS TO INDUSTRIAL DRIVES (ECD)

(Effective from Academic year 2020 - 21)

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI
Scheme of Teaching and Examinations – 2020 - 21
M.Tech COMPUTER APPLICATIONS TO INDUSTRIAL DRIVES (ECD)
Choice Based Credit System (CBCS) and Outcome Based Education(OBE)

I SEMESTER

Sl. No	Course	Course Code	Course Title	Teaching Hours per Week			Examination				Credits
				Theory	Practical	Skill Development Activities	Duration in hours	CIE Marks	SEE Marks	Total Marks	
				L	P	SDA					
1	PCC	20EEE11	Mathematical Methods in Control	03	--	02	03	40	60	100	4
2	PCC	20ECD12	Advanced Control Systems	03	--	02	03	40	60	100	4
3	PCC	20ECD13	Power Electronic Converters	03	--	02	03	40	60	100	4
4	PCC	20ECD14	AC and DC Drives - 1	03	--	02	03	40	60	100	4
5	PCC	20ECD15	Modelling and Analysis of Electrical Machines	03	--	02	03	40	60	100	4
6	PCC	20ECDL16	Drives Laboratory-1	--	04	--	03	40	60	100	2
7	PCC	20RMI17	Research Methodology and IPR	01	--	02	03	40	60	100	2
			TOTAL	**17**	**04**	**12**	**21**	**280**	**420**	**700**	**24**

Note: PCC: Professional core.

Skill development activities:

Students and course instructor/s to involve either individually or in groups to interact together to enhance the learning and application skills.

The students should interact with industry (small, medium and large), understand their problems or foresee what can be undertaken for study in the form of research/ testing / projects, and for creative and innovative methods to solve the identified problem.

The students shall

(1) Gain confidence in modelling of systems and algorithms.

(2) Work on different software/s (tools) to Simulate, analyse and authenticate the output to interpret and conclude. Operate the simulated system under changed parameter conditions to study the system with respect to thermal study, transient and steady state operations, etc.

(3) Handle advanced instruments to enhance technical talent.

(4) Involve in case studies and field visits/ field work.

(5) Accustom with the use of standards/codes etc., to narrow the gap between academia and industry.

All activities should enhance student's abilities to employment and/or self-employment opportunities, management skills, Statistical analysis, fiscal expertise, etc.

Internship: All the students have to undergo mandatory internship of 6 weeks during the vacation of I and II semesters and /or II and III semesters. A University examination shall be conducted during III semester and the prescribed internship credit shall be counted for the same semester. Internship shall be considered as a head of passing and shall be considered for the award of degree. Those, who do not take-up/complete the internship shall be declared as fail in internship course and have to complete the same during the subsequent University examination after satisfying the internship requirements.

Note: (i) Four credit courses are designed for 50 hours Teaching – Learning process.
(ii) Three credit courses are designed for 40 hours Teaching – Learning process.
(iii) Two credit courses are designed for 25 hours Teaching – Learning process.

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI

Scheme of Teaching and Examinations – 2020 - 21

M.Tech COMPUTER APPLICATIONS TO INDUSTRIAL DRIVES (ECD)

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

II SEMESTER

Sl. No	Course	Course Code	Course Title	Teaching Hours /Week			Examination				Credits
				Theory	Practical/ seminar	Skill Development Activities	Duration in hours	CIE Marks	SEE Marks	Total Marks	
				L	P	SDA					
1	PCC	20ECD21	AC and DC Drives - 2	03	--	02	03	40	60	100	4
2	PCC	20ECD22	DSP Applications to Drives	03	--	02	03	40	60	100	4
3	PCC	20ECD23	Modelling and Design Of Controllers	03	--	02	03	40	60	100	4
4	PEC	20ECD24X	Professional elective 1	04	--	--	03	40	60	100	4
5	PEC	20ECD25X	Professional elective 2	04	--	--	03	40	60	100	4
6	PCC	20ECDL26	Drives Laboratory-2	--	04	--	03	40	60	100	2
7	PCC	20ECD27	Technical Seminar	--	02	--	--	100	--	100	2
TOTAL				**17**	**06**	**06**	**18**	**340**	**360**	**700**	**24**

Note: PCC: Professional core, PEC: Professional Elective.

Professional Elective 1		**Professional Elective 2**	
Course Code under 20ECD24X	**Course title**	**Course Code under 20ECD25X**	**Course title**
20ECD241	Special Electrical Machines	20ECD251	Predictive Control of Drives
20ECD242	Process Control and Instrumentation	20ECD252	Electric Drive Design
20ECD243	EMC in Power Electronics	20ECD253	Hybrid Electric Vehicles
20ECD244	Neural and Fuzzy Logic Control of Drives	20ECD254	Internet-Based Control Systems

Note:

1. Technical Seminar: CIE marks shall be awarded by a committee comprising of HoD as Chairman, Guide/co-guide, if any, and a senior faculty of the department. Participation in the seminar by all postgraduate students of the programme shall be mandatory.

The CIE marks awarded for Technical Seminar, shall be based on the evaluation of Seminar Report, Presentation skill and performance in Question and Answer session in the ratio 50:25:25.

2. Internship: All the students shall have to undergo mandatory internship of 6 weeks during the vacation of I and II semesters and /or II and III semesters. A University examination shall be conducted during III semester and the prescribed internship credit shall be counted in the same semester. Internship shall be considered as a head of passing and shall be considered for the award of degree. Those, who do not take-up/complete the internship shall be declared as fail in internship course and have to complete the same during the subsequent University examination after satisfying the internship requirements.

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI
Scheme of Teaching and Examinations – 2020 - 21
M.Tech COMPUTER APPLICATIONS TO INDUSTRIAL DRIVES (ECD)
Choice Based Credit System (CBCS) and Outcome Based Education(OBE)

III SEMESTER

Sl. No	Course	Course Code	Course Title	Teaching Hours /Week			Examination				Credits
				Theory	Practical/ Mini –Project/ Internship	Skill Development activities	Duration in hours	CIE Marks	SEE Marks	Total Marks	
				L	P	SDA					
1	PCC	20ECD31	Digital Power Electronics	03	--	02	03	40	60	100	4
2	PEC	20ECD32X	Professional elective 3	03	--	--	03	40	60	100	3
3	PEC	20ECD33X	Professional elective 4	03	--	--	03	40	60	100	3
4	Project	20ECD34	Project Work phase -1	--	02	--	--	100	--	100	2
5	PCC	20ECD35	Mini-Project	--	02	--	--	100	--	100	2
6	Internship	20ECDI36	Internship	(Completed during the intervening vacation of I and II semesters and /or II and III semesters.)			03	40	60	100	6
TOTAL				**09**	**04**	**02**	**12**	**360**	**240**	**600**	**20**

Note: PCC: Professional core, PEC: Professional Elective.

Professional elective 3		Professional elective 4	
Course Code under 20ECD32X	**Course title**	**Course Code under 20ECD33X**	**Course title**
20ECD321	Power Quality Problems and Mitigation	20ECD331	PLC Applications in Electric Drives
20ECD322	FPGA and Programmable Logic	20ECD332	AC drives with inverter Output Filters
20ECD323	Sensorless AC Motor Control	20ECD333	Sneak Circuits in Converters
20ECD324	Data Analytics for the Smart Grid	20ECD334	Cybersecurity in the Electricity Sector

Note:

1. Project Work Phase-1: Students in consultation with the guide/co-guide if any, shall pursue literature survey and complete the preliminary requirements of selected Project work. Each student shall prepare relevant introductory project document, and present a seminar.

CIE marks shall be awarded by a committee comprising of HoD as Chairman, Guide/co-guide if any, and a senior faculty of the department. The CIE marks awarded for project work phase -1, shall be based on the evaluation of Project Report, Project Presentation skill and performance in Question and Answer session in the ratio 50:25:25.

SEE (University examination) shall be as per the University norms.

2. Internship: Those, who have not pursued /completed the internship shall be declared as fail in internship course and have to complete the same during subsequent University examinations after satisfying the internship requirements. Internship SEE (University examination) shall be as per the University norms.

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI
Scheme of Teaching and Examinations – 2020 - 21
M.Tech COMPUTER APPLICATIONS TO INDUSTRIAL DRIVES (ECD)
Choice Based Credit System (CBCS) and Outcome Based Education(OBE)

IV SEMESTER

Sl. No	Course	Course Code	Course Title	Teaching Hours /Week		Examination				Credits
				Theory	Practical/ Field work	Duration in hours	CIE Marks	SEE Marks Viva voce	Total Marks	
				L	P					
1	Project	20ECD41	Project work phase -2	--	04	03	40	60	100	20
			TOTAL	--	**04**	**03**	**40**	**60**	**100**	**20**

Note:
1. Project Work Phase-2:
CIE marks shall be awarded by a committee comprising of HoD as Chairman, Guide/co-guide, if any, and a Senior faculty of the department. The CIE marks awarded for project work phase -2, shall be based on the evaluation of Project Report subjected to plagiarism check, Project Presentation skill and performance in Question and Answer session in the ratio 50:25:25.
SEE shall be at the end of IV semester. Project work evaluation and Viva-Voce examination (SEE), after satisfying the plagiarism check, shall be as per the University norms.

MATHEMATICAL METHODS IN CONTROL			
Course Code	20EEE11	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	3:0:2	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

Introduction to vector spaces and sub-spaces, definitions, illustrative example. Linearly independent and dependent vectors- Basis-definition and problems. Linear transformations-definitions. Matrix form of linear transformations-Illustrative examples.■

Module-2

Solution of Systems of Linear Equations: Direct methods-Relaxation method, Partition method, Croute's Triangularisation method. Eigen values and Eigen vectors. Bounds on Eigen Values. Jacobi method & Givens method for symmetric matrices.■

Module-3

Orthogonal vectors and orthogonal bases. Gram-Schmidt orthogonalization process. SVD and Applications.■

Module-4

Probability: Random variables, Probability distributions: Binomial, Poisson, Normal distributions, Joint probability distribution (discrete and continuous)-Illustrative examples. ■

Module-5

Moments, central moments, characteristic functions, probability generating and moment generating functions-illustrations. Poisson, Gaussian and Erlang distributions-examples. ■

Course outcomes:

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

1. Understand the fundamentals of vector space and bases in reference to transformations.
2. Solve system of linear equations using direct and iterative methods.
3. Use the idea of Eigen values and Eigen vectors for the application of SVD.
4. Describe the basic notions of discrete and continuous probability distributions.
5. Find out responses of linear systems using statistical and probability tools.■

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Textbooks

1. Linear Algebra and its Applications, David C.Lay et al, Pearson, 5th Edition, 2015.

2. Numerical Methods for Scientific and Engineering Computation, M. K. Jain et al, New Age International, 9th

Reference Books

1. Signals, Systems, and Inference, Alan V. Oppenheim and George C. Verghese, Pearson, 2012.

2. Numerical methods for Engineers, Steven C Chapra and Raymond P Canale, McGraw-Hill 7th Edition, 2015.

3. Higher Engineering Mathematics, B.S. Grewal, Khanna Publishers, 44th Edition, 2017.

ADVANCED CONTROL SYSTEMS			
Course Code	20ECD12	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	3:0:2	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

Digital Control: Control System Terminology, Need of Digital control, Configurations of the Basic Digital Control Scheme, Principle of Signal Conversion, Basic Discrete – Time Signals, Time Domain Models for Discrete – Time Systems, The z – Transform, Transfer Function Models, Frequency Response, Stability on the z – Plane and Jury Stability Criterion, Sample and Hold Systems, Sampled Spectra and Aliasing, Reconstruction of Analog Signals, Practical Aspects of the choice of Sampling Rate, Principle of Discretization. ■

Module-2

Models of Digital Control Devices and Systems: Introduction, z – Domain Description of Sampled Continuous – time Plants, z – Domain Description of Samples with Dead – Time, Implementation of Digital Controllers, Tunable PID Controllers, Digital Temperature and Position Control Systems, Stepping Motors and their Control. ■

Module-3

State Variable Analysis of Digital Control Systems: Introduction, State Description of Digital Processors, State Description of Sampled continuous – Time Plants, State Description of Systems with Dead Time, Solution of State Difference Equations, Controllability and Observability, Multivariable Systems.

Pole Placement Design and State Observers: Introduction, Stability Improvement by State Feedback, Necessary and sufficient Conditions for Arbitrary Pole – Placement, State Regulator Design, Design of State Observers, Compensator Design by the Separation Principle, Servo Design – Introduction of the reference Input by Feedforward Control, State Feedback with Integral Control, Digital Control Systems with State Feedback, Deadbeat control by State Feedback and Deadbeat Observers. ■

Module-4

Quadratic Optimal Control: Introduction, The Concept of Lyapunov Stability, Lyapunov Functions for Linear Systems, Parameter Optimization and Optimal Control Problems, Quadratic Performance Index, Control Configurations, Optimal State Regulator, Optimal Digital Control Systems, Constrained State Feedback Control. ■

Module-5

Nonlinear System Analysis: Introduction, Common nonlinear System Behaviours, Common nonlinearities in Control Systems, Describing Function Fundamentals, Describing Function of Common nonlinearities, Stability Analysis by the Describing Function Method, Concept of Phase Plane Analysis, Construction of Phase Portraits, System Analysis on the Phase Plane, Simple Variable Structure Systems, Lyapunov Stability Definitions, Lyapunov Stability Theorems, Lyapunov Functions for Nonlinear Systems. ■

Course outcomes:

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

- Evaluate Z transform of a continuous time signal.
- Assess the stability of a system in Z domain.
- Explain the process of reconstructing the analog signal from a digital signal.
- Model the digital systems to analyze them in the digital domain.
- Use state variable representation to design control law and observers for a system in both continuous and discrete time domains.
- Solve optimal control problems.
- Construct Lyapunov functions to evaluate the stability of a system.
- Use describing function, phase plane methods and Lyapunov method to assess the stability of the nonlinear system. ■

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module. ■

Text/Reference Books

1. Digital Control and State Variable Methods (Conventional and Intelligent Control Systems), M Gopal, Mc Graw Hill, 3rd Edition, 2008.
2. Discrete – Time Control Systems, Katsuhiko Ogata, Pearson, 2nd Edition, 2015.
3. Digital Control Systems, Benjamin C Kuo, Oxford University Press, 2nd Edition, 2007.
4. Control System Engineering, I.J. Nagrath, M.Gopal, New Age International, 5th Edition, 2007.

POWER ELECTRONIC CONVERTERS			
Course Code	20ECD13	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	3:0:2	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

DC/DC Converters: Forward Converters - Analysis of the Basic Circuit,
Galvanically Isolated Forward Converter, Boost Converter - Analysis of the Basic Scheme, Variation of the Output Voltage, Boundary Between the Continuous and the Discontinuous Mode , Discontinuous Mode Power Losses, Indirect Converter - Boundary Between the Continuous and the Discontinuous Mode, Discontinuous Mode, Indirect Converter with Galvanic Separation, Push – Pull (Symmetric) Converters - Analysis of Idealized Circuit in Continuous Mode, Output Characteristics, Selection of Components, DC Premagnetization of the Core, Half-Bridge Converter, Bridge Converter, Hamilton Circuit, Ćuk Converters - Elimination of the Current Ripple, Ćuk Converters with Galvanic Isolation. ■

Module-2

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 - Control Module TL494, Control Module SG1524/2524/3524, Control Module TDA 1060.
DC/AC Converters – Inverters: Single-Phase Voltage Inverters - Pulse-Controlled Output Voltage, Pulse-Width Modulated Inverters - Unipolar PWM, Three-Phase Inverters -Overmodulation ($m_a > 1$), Asynchronous PWM, Space Vector Modulation - Space Vector Modulation: Basic Principles, Application of Space Vector Modulation Technique, Direct and Inverse Sequencing, Real Drive Influence. ■

Module-3

AC/DC Converters – Rectifiers: Half-Wave Single-Phase Rectifiers , Full-Wave Rectifiers - Commutation of Current, Output Filters - Capacitive Filter, L Filter,
Voltage Doublers, Three-Phase Rectifiers, Phase Controlled Rectifiers - Full-Wave Thyristor Rectifiers, Three-Phase Thyristor Bridge Rectifiers, Twelve-Pulse 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.■

Module-4

Resonant Converters: Resonant Circuits - Resonant Converters of Class D, Series Resonant Converters, Parallel Resonant Converters, Series – Parallel Resonant Converter, Series Resonant Converters Based on GTO Thyristors, Class E Resonant Converters, DC/DC Converters Based on.
Resonant Converters (continued): Resonant Switches - ZCS Quasi-resonant Converters, ZVS Quasi-resonant Converters, Multiresonant Converters, ZVS Resonant DC/AC Converters, Soft Switching PWM DC/DC Converters -Phase Shift Bridge Converters, Resonant Transitions PWM Converters, Control Circuits of Resonant Converters - Integrated Circuit Family UCx861-8, Integrated Circuits for Control of Soft, Switching PWM Converters.■

Module-5

AC/AC Converters: Single-Phase AC/AC Voltage Converters - Time Proportional Control
Three-Phase Converters, Frequency Converters, Direct Frequency Converters, Introduction to AC/AC 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, Time Interval: $nT < t < nT + DT$, $n = 0, 1, 2$,Time Interval: $nT + DT < t < (n + 1)T$, 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. ■

Course outcomes:
At the end of the course the student will be able to:
- Use the knowledge of PWM techniques in controlling different power electronic converters.
- Apply the knowledge of power electronics in design and analysis of DC –DC PWM converters.
- Design and analyze DC –AC and AC – DC converters and control their operation using PWM techniques.
- Design and analyze different resonant converters and their control circuits.
- Analyze AC – AC converters and multilevel converters. ■

Question paper pattern: The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60. • The question paper will have ten full questions carrying equal marks. • Each full question is for 20 marks. • There will be two full questions (with a maximum of four sub questions) from each module. • Each full question will have sub question covering all the topics under a module. • The students will have to answer five full questions, selecting one full question from each module. ■
Text/Reference Books
1. Power Electronics Converters and Regulators, Branko L. Dokić, Branko Blanuša, Springer (International Publishing, Switzerland), 3rd Edition, 2015.
2. Power Electronics Converters, Applications, and Design, Ned Mohan et al, Wiley, 3rd Edition, 2014.

AC and DC DRIVES - 1			
Course Code	20ECD14	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	3:0:2	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

Power electronics Devices and Drives: Introduction, Power Devices and Switching, Motor Drives.
Modelling of DC Machines: Theory of Operation, Induced emf, Equivalent Circuit and Electromagnetic Torque, Electromechanical Modelling, Block Diagram and Transfer Functions, Field Excitation, Measurement of Motor Constants, Flow chart for Computation.
Phase – Controlled DC Motor Drives: Introduction, Principles of DC motor Speed Control, Phase Controlled Converters, Steady - State Analysis of the Three Phase Controlled DC Motor Drives. ■

Module-2

Phase – Controlled DC Motor Drives (continued): Two – Quadrant Three Phase Controlled DC Motor Drive, Transfer Functions of the Subsystems, Design of Controllers, Two – Quadrant DC Motor Drive with Field Weakening, Four – Quadrant DC Motor Drive, Converter Selection and Characteristics, Simulation of the One – Quadrant DC Motor Drive, Harmonics and Associated Problems, Sixth Harmonic Torque, Application Considerations, Applications, Parameter Sensitivity.
Chopper – Controlled DC Motor Drive: Introduction, Principle of operation of Chopper, Four – Quadrant Chopper Circuit, Chopper for Inversion, Chopper with Other Power Devices, Model of the Chopper, Input to the Chopper, Other Chopper Circuits, Steady – State Analysis of Chopper – Controlled DC Motor Drive, Rating of the Devices. ■

Module-3

Chopper – Controlled DC Motor Drive (continued): Pulsating Torques, Closed – Loop Operation, Dynamic Simulation, Applications.
PolyPhase Induction Machines: Introduction, Construction and Principle of Operation, Induction Motor Equivalent Circuit, Steady - State Performance Equations of the Induction Motor, Steady - State Performance, Measurement of Motor of Induction Motor, Dynamic Modelling of Induction Motor.■

Module-4

PolyPhase Induction Machines (continued): Dynamic Simulation, Small – Signal Equations of the Induction Machine, Evaluation of Control Characteristics of the Induction Machine, Space – Phasor Model, Control Principle of the Induction Motor.
Phase – Controlled Induction Motor Drives: Introduction, Stator – Voltage Conrtaol, Slip – Energy Recovery Scheme. ■

Module-5

Frequency – Controlled Induction Motor Drives: Introduction, Static Frequency Changers, Voltage Source Inverter – Driven Induction Motor. ■

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

- Discuss the motor –drive applications, the status of power devices, classes of electrical machines, power converters, controller s and mechanical systems.
- Discuss the principle of operation, steady state and dynamic modeling, block diagram development and measurement of dc motor parameters.
- Describe phase controlled dc motor for variable –speed operation.
- Describe chopper controlled dc motor for variable –speed operation.
- Discuss the principle of operation, steady state and dynamic modeling, block diagram development of induction motor.
- Explain the concepts of space – phasor modeling.
- Discuss two methods of speed control of induction motor; stator –phase control and slip –energy – recovery control.
- Discuss variable – frequency control of induction machines with both variable voltage and variable current. ■

Question paper pattern: The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60. • The question paper will have ten full questions carrying equal marks. • Each full question is for 20 marks. • There will be two full questions (with a maximum of four sub questions) from each module. • Each full question will have sub question covering all the topics under a module. • The students will have to answer five full questions, selecting one full question from each module. ■
Textbook
1. Electric Motor Drives: Modelling, Analysis, and Control, R. Krishnan, Pearson, 2016.

MODELLING AND ANALYSIS OF ELECTRICAL MACHINES			
Course Code	20ECD15	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	3:0:2	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

Basic Concepts of Modelling: Basic two pole machine representation of commutator machines, 3-phase synchronous machine with and without damper bar and 3-phase induction machine, Kron's primitive machine-voltage, current and torque equations.

DC Machine Modelling: Mathematical model of separately excited DC motor-steady state and transient state analysis, sudden application of inertia load, transfer function of separately excited DC motor, mathematical model of dc series motor, shunt motor, linearization techniques for small perturbations. ■

Module-2

Reference Frame Theory: Real time model of a two phase induction machine, transformation to obtain constant matrices, three phase to two phase transformation, power equivalence.

Dynamic Modelling of Three Phase Induction Machine: Generalized model in arbitrary frame, electromagnetic torque, deviation of commonly used induction motor models-stator reference frames model, rotor reference frames model, synchronously rotating reference frames model, equations in flux linkages, per unit model, dynamic simulation. ■

Module-3

Small Signal Equations of the Induction Machine: Derivation of small signal equations of induction machine, space phasor model, DQ flux linkages model derivation, control principle of the induction motor.

Transformer Modelling: Introduction, single phase transformer model, three phase transformer connections, per phase analysis, normal systems, per unit normalization, per unit three phase quantities, change of base, per unit analysis of normal system, regulating transformers for voltage and phase angle control, auto transformers, transmission line and transformers. ■

Module-4

Modelling of Synchronous Machines: Introduction, voltage equations and torque equation in machine variables, stator voltage equations in arbitrary and rotor reference frame variables, Park's equations, torque equations in substitute variables, rotor angle and angle between rotors, per unit system, analysis of steady state operation. ■

Module-5

Dynamic Analysis of Synchronous Machines: Dynamic performance during sudden change in input torque and during a 3-phase fault at the machine terminals, approximate transient torque versus rotor angle characteristics, comparison of actual and approximate transient torque-angle characteristics during a sudden change in input torque; first swing transient stability limit, comparison of actual and approximate transient torque-angle characteristics during a 3-phase fault at the machine terminals, critical clearing time, equal area criterion, computer simulation. ■

Course outcomes:

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

- Explain the basic concepts of modeling.
- Develop mathematical models for DC motors for transient state analysis.
- Use reference frame theory to transform three phase to two phase.
- Develop dynamic model for three phase induction motor in stator ad rotor reference frames.
- Develop mathematical model of single phase transformers.
- Model synchronous machine using Park's transformation for the analysis of steady state operation.
- Model synchronous machine to perform dynamic analysis under different conditions. ■

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module. ■

Text/Reference Books

1. Generalized Theory of Electrical Machines, P.S.Bimbra, Khanna Publications, 5th Edition, 1995.
2. Electric Motor Drives - Modelling, Analysis & Control, R. Krishnan, PHI Learning Private Ltd, Indian Edition,
3. Analysis of Electrical Machinery and Drive Systems, P.C.Krause, et al, Wiley, 2nd Edition, 2010.

4. Power System Analysis, Arthur R Bergen and Vijay Vittal, Pearson, 2nd Edition, 2009.
5. Power System Stability and Control, Prabha Kundur, Mc Graw Hill, 1st Edition, 1994.
6. Dynamic Simulation of Electric Machinery using Matlab / Simulink, Chee-Mun Ong, Prentice Hall, 1998.

DRIVES LABORATORY -1			
Course Code	20ECDL16	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	0:4:0	SEE Marks	60
Credits	02	Exam Hours	03

Sl. NO	Experiments
1	Analysis of static and dynamic characteristic of SCR, TRIAC.
2	Analysis of static and dynamic characteristic of MOSFET and IGBT.
3	Performance of single phase fully controlled and semi-controlled converter for RL load for continuous current mode.
4	Performance of single phase fully controlled and semi-controlled converter for RL load for discontinuous current mode.
5	Study of effect of source inductance on the performance of single phase fully controlled converter.
6	Performance analysis of three phase fully controlled and semi-controlled converter for RL load for continuous current mode.
7	Performance analysis of three phase fully controlled and semi-controlled converter for RL load for discontinuous current mode.
8	Performance analysis of single phase bridge inverter for RL load and voltage control by single pulse width modulation.
9	Performance analysis of two quadrant chopper.
10	ZVS operation of a Synchronous buck converter.

Course outcomes:

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

- Analyze the static and dynamic characteristics of various semiconductor devices.
- Apply the knowledge of converters in assessing the performance of single phase and three phase fully controlled and semi controlled converters for RL load for continuous current modes.
- Apply the knowledge of converters in assessing the performance of single phase and three phase fully controlled and semi controlled converters for RL load for discontinuous current modes.
- Assess the performance of single phase bridge inverter for RL load and control the voltage by pulse width modulation.
- Apply the knowledge of power electronics in performance analysis of chopper and synchronous buck converter. ■

RESEARCH METHODOLOGY AND IPR			
Course Code	20RMI17	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	1:0:2	SEE Marks	60
Credits	02	Exam Hours	03

Module-1

Research Methodology: Introduction, Meaning of Research, Objectives of Research, Motivation in Research, Types of Research, Research Approaches, Significance of Research, Research Methods versus Methodology, Research and Scientific Method, Importance of Knowing How Research is Done, Research Process, Criteria of Good Research, and Problems Encountered by Researchers in India.

Defining the Research Problem: Research Problem, Selecting the Problem, Necessity of Defining the Problem, Technique Involved in Defining a Problem, An Illustration. ■

Module-2

Reviewing the literature: Place of the literature review in research, Bringing clarity and focus to your research problem, Improving research methodology, Broadening knowledge base in research area, Enabling contextual findings, How to review the literature, searching the existing literature, reviewing the selected literature, Developing a theoretical framework, Developing a conceptual framework, Writing about the literature reviewed.

Research Design: Meaning of Research Design, Need for Research Design, Features of a Good Design, Important Concepts Relating to Research Design, Different Research Designs, Basic Principles of Experimental Designs, Important Experimental Designs. ■

Module-3

Design of Sampling: Introduction, Sample Design, Sampling and Non-sampling Errors, Sample Survey versus Census Survey, Types of Sampling Designs.

Measurement and Scaling: Qualitative and Quantitative Data, Classifications of Measurement Scales, Goodness of Measurement Scales, Sources of Error in Measurement Tools, Scaling, Scale Classification Bases, Scaling Technics, Multidimensional Scaling, Deciding the Scale.

Data Collection: Experimental and Surveys, Collection of Primary Data, Collection of Secondary Data, Selection of Appropriate Method for Data Collection, Case Study Method. ■

Module-4

Testing of Hypotheses: Hypothesis, Basic Concepts Concerning Testing of Hypotheses, Testing of Hypothesis, Test Statistics and Critical Region, Critical Value and Decision Rule, Procedure for Hypothesis Testing, Hypothesis Testing for Mean, Proportion, Variance, for Difference of Two Mean, for Difference of Two Proportions, for Difference of Two Variances, P-Value approach, Power of Test, Limitations of the Tests of Hypothesis.

Chi-square Test: Test of Difference of more than Two Proportions, Test of Independence of Attributes, Test of Goodness of Fit, Cautions in Using Chi Square Tests. ■

Module-5

Interpretation and Report Writing: Meaning of Interpretation, Technique of Interpretation, Precaution in Interpretation, Significance of Report Writing, Different Steps in Writing Report, Layout of the Research Report, Types of Reports, Oral Presentation, Mechanics of Writing a Research Report, Precautions for Writing Research Reports.

Intellectual Property: The Concept, Intellectual Property System in India, Development of TRIPS Complied Regime in India, Patents Act, 1970, Trade Mark Act, 1999,The Designs Act, 2000, The Geographical Indications of Goods (Registration and Protection) Act1999, Copyright Act,1957,The Protection of Plant Varieties and Farmers' Rights Act, 2001,The Semi-Conductor Integrated Circuits Layout Design Act, 2000, Trade Secrets, Utility Models, IPR and Biodiversity, The Convention on Biological Diversity (CBD) 1992, Competing Rationales for Protection of IPRs, Leading International Instruments Concerning IPR, World Intellectual Property Organisation (WIPO),WIPO and WTO, Paris Convention for the Protection of Industrial Property, National Treatment, Right of Priority, Common Rules, Patents, Marks, Industrial Designs, Trade Names, Indications of Source, Unfair Competition, Patent Cooperation Treaty (PCT), Advantages of PCT Filing Berne Convention for the Protection of Literary and Artistic Works, Basic Principles, Duration of Protection, Trade Related Aspects of Intellectual Property Rights(TRIPS) Agreement, Covered under TRIPS Agreement, Features of the Agreement, Protection of Intellectual Property under TRIPS, Copyright and Related Rights, Trademarks, Geographical indications, Industrial Designs, Patents, Patentable Subject Matter, Rights Conferred, Exceptions, Term of protection, Conditions on Patent Applicants, Process Patents, Other Use without Authorization of the Right Holder, Layout-Designs of Integrated Circuits, Protection of Undisclosed Information, Enforcement of Intellectual Property Rights, UNSECO. ■

Course outcomes: At the end of the course the student will be able to: • Discuss research methodology and the technique of defining a research problem • Explain the functions of the literature review in research, carrying out a literature search, developing theoretical and conceptual frameworks and writing a review. • Explain various research designs, sampling designs, measurement and scaling techniques and also different methods of data collections. • Explain several parametric tests of hypotheses, Chi-square test, art of interpretation and writing research reports • Discuss various forms of the intellectual property, its relevance and business impact in the changing global business environment and leading International Instruments concerning IPR.
Question paper pattern: • The question paper will have ten questions. • Each full question is for 20 marks. • There will be 2 full questions (with a maximum of four sub questions in one full question) from each module. • Each full question with sub questions will cover the contents under a module. • Students will have to answer 5 full questions, selecting one full question from each module.
Textbooks
1. Research Methodology: Methods and Techniques, C.R. Kothari, Gaurav Garg, New Age International, 4th Edition, 2018.
2. Research Methodology a step-by-step guide for beginners, Ranjit Kumar, SAGE Publications, 3rd Edition, 2011. (For the topic Reviewing the literature under module 2).
3. Study Material (For the topic Intellectual Property under module 5), Professional Programme Intellectual Property Rights, Law and Practice, The Institute of Company Secretaries of India, Statutory Body Under an Act of Parliament, September 2013.
Reference Books
1. Research Methods: the concise knowledge base, Trochim, Atomic Dog Publishing, 2005.
2. Conducting Research Literature Reviews: From the Internet to Paper, Fink A, Sage Publications , 2009.

*** END ***

AC AND DC DRIVES - 2			
Course Code	20ECD21	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	3:0:2	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

Frequency – Controlled Induction Motor Drives: Current Source Induction Motor Drives, Applications.
Vector Controlled Motor Drives: Introduction,Principal of Vector Control, Direct Vector Control, Derivation of Indirect Vector Control Scheme, Indirect Vector - Control Scheme, Implimentation of an Indirect Vector Control Scheme, Tunig of the Vector Controller, Flow Chart for Dynamic Computation, Dynamic Simulation Results. ■

Module-2

Vector Controlled Motor Drives (continued): Parameter Sensitivity of the Indirect Vector – Controlled Induction Motor Drive, Parameter Sensitivity Compensation, Flux Weaking Operation, Speed – controller Design for an Indirect Vector – Controlled Induction Motor Drive, Performance and Applications.
Permanent – Magnet Synchronous Motor: Introduction, Permanent Magnet (PM) and Characteristics, Synchronous Machines with PMs, Vector Control of PM Synchronous Motor. ■

Module-3

Permanent – Magnet Synchronous Motor (continued): Control Strategies, Flux Weakening Operation, Speed Controller Design, Sensorless Control, Parameter Sensitivity.
PM Brushless DC Motor (PMBDCM) – Modelling of PMBDCM, Drive scheme, Dynamic Simulation.■

Module-4

Switched Reluctance Drive Systems: Basic Machine Concepts, Operating Principles, Multi-Phase Machines, Control of Switched Reluctance Drives, Switched Reluctance Demonstration Machine. ■

Module-5

Expert System, Fuzzy Logic, and Neural networks for Drives: Introduction, Expert System, Fuzzy Logic, Neural Network. ■

Course outcomes:

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

- Explain the design and operational aspects of current source induction motor drives; vector controlled motor drives, their control schemes and their implementation and tuning of controllers.
- Explain controlling techniques for the induction motor.
- Design speed controllers for indirect vector controlled induction motor drive.
- Assess the performance of the drive and its parameter sensitivity.
- Explain the operation of permanent magnet synchronous motor, its control strategies and design of speed controller for it.
- Model, permanent magnet brushless DC motor for its analysis.
- Explain the basic concepts, operating principles and control of switched reluctance drives.
- Apply artificial intelligence techniques; expert system, fuzzy logic and neural networks for the control of drives. ■

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module. ■

Text/Reference Books

1. Electric Motor Drives: Modelling: Analysis, and Control, R. Krishnan, Pearson, 2016.

2. Advanced Electrical Drives Analysis, Modelling, Control, Rik De Doncker Duco, W.J. Pulle André Veltman, Springer, 2011.

3. Power Electronics and Variable Frequency Drives Technology and Applications, Bimal K. Bose, Wiley, Reprint 2013.

DSP APPLICATIONS TO DRIVES			
Course Code	20ECD22	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	3:0:2	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

Introduction to the TMSLF2407 DSP Controller: Introduction, Brief Introduction to Peripherals, Types of Physical Memory, Software Tools.
C2xx DSP CPU and Instruction Set: Introduction to the C2xx DSP Core and Code Generation, The Components of the C2xx DSP Core, Mapping External Devices to the C2xx Core and the Peripheral Interface, System Configuration Registers, Memory, Memory Addressing Modes, Assembly Programming Using the C2xx DSP Instruction Set. ■

Module-2

General Purpose Input /Output (GPIO) Functionality: Pin Multiplexing (MUX) and General Purpose I/O Overview, Multiplexing and General Purpose I/O Control Registers, Using the General Purpose I/O Ports, General Purpose I/O Exercise.
Interrupts on the TMS320LF2407: Introduction to Interrupts, Interrupt Hierarchy, Interrupt Control Registers, Initializing and Servicing Interrupts in Software, Interrupt Usage Exercise.
The Analog-to-Digital Converter (ADC): ADC Overview, Operation of the ADC, Analog to Digital Converter Usage Exercise. ■

Module-3

The Event Managers (EVA, EVB): Overview of the Event Manager (EV), Event Manager Interrupts, General Purpose (GP) Timers, Compare Units, Capture Units and Quadrature Encoded Pulse (QEP) Circuitry, General Event Manager Information, Exercise: PWM Signal Generation. ■

Module-4

DSP-Based Implementation of DC-DC Buck-Boost Converters: Introduction, Converter Structure, Continuous Conduction Mode, Discontinuous Conduction Mode, Connecting the DSP to the Buck-Boost Converter, Controlling the Buck-Boost Converter, Main Assembly Section Code Description, Interrupt Service Routine, The Regulation Code Sequences, Results.
DSP-Based Control of Stepper Motors: Introduction, The Principle of Hybrid Stepper Motor, The Basic Operation, The Stepper Motor Drive System, The Implementation of Stepper Motor Control System Using the LF2407 DSP, The Subroutine of Speed Control Module.
DSP-Based Control of Permanent Magnet Brushless DC Machines: Introduction, Principles of the BLDC Motor, Torque Generation, BLDC Motor Control System, Implementation of the BLDC Motor Control System Using the LF2407.
Clarke's and Park's Transformations: Introduction, Clarke's Transformation, Park's Transformation, Transformations between Reference Frames, Field Oriented Control (FOC) Transformations, Implementing Clarke's and Park's Transformations on the LF240X. ■

Module-5

Space Vector Pulse Width Modulation: Introduction, Principle of Constant V/Hz Control for Induction Motors, Space Vector PWM Technique, DSP Implementation.
DSP-Based Control of Permanent Magnet Synchronous Machines: Introduction, The Principle of the PMSM, PMSM Control System, Implementation of the PMSM System Using the LF2407.
DSP-Based Vector Control of Induction Motors: Introduction, Three-Phase Induction Motor Basic Theory, Model of the Three-Phase Induction Motor in Simulink, Reference Frame Theory, Induction Motor Model in the Arbitrary q-d-0 Reference Frame, Field Oriented Control, DC Machine Torque Control, Field Oriented Control, Direct and Indirect Approaches, Simulation Results for the Induction Motor Control System, Induction Motor Speed Control System, System Components, Implementation of Field-Oriented Speed Control of Induction Motor, Experimental Results. ■

Course outcomes:
At the end of the course the student will be able to: • Explain the architectural features of TMSLF2407 DSP processor, its peripherals. • Explain C2xxDSP CPU, its components and instruction set, and the peripheral interface. • Explain General Purpose Input /Output (GPIO) Functionality, interrupts on TMS320LF2407 and the analog to digital conversion (ADC). • Describe the capability of event managers of DSP. • Model DC – DC converters. • Perform mathematical modeling and control of different motors using DSP processor. • Explain space vector pulse width modulation technique used for the control of motors. ■
Question paper pattern: The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60. • The question paper will have ten full questions carrying equal marks. • Each full question is for 20 marks. • There will be two full questions (with a maximum of four sub questions) from each module. • Each full question will have sub question covering all the topics under a module. • The students will have to answer five full questions, selecting one full question from each module ■.
Textbook
1. DSP-Based Electromechanical Motion Control, Hamid A. Toliyat, CRC Press, 2004.

MODELLING AND DESIGN OF CONTROLLERS			
Course Code	20ECD23	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	3:0:2	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

Computer Simulation of Power Electronic Converters and Systems: Introduction, Challenges in Computer Simulation, Simulation Process, Mechanics of Simulation, Solution Techniques for Time-Domain Analysis, Widely Used, Circuit-Oriented Simulators, Equation Solvers.

Modelling of Systems: Input-Output relations, Differential Equations and Linearization, State Space Representation, Transfer Function Representation, Block Diagrams, Lagrange method, Circuit Averaging, Bond Graphs, Space Vector Modelling.■

Module-2

Control System Essentials: Representation of system in digital Domain, The Z – Transform, Digital Filter, Mapping between s – plane and z – plane, Effect of Sampling, Continuous to Discrete Domain Conversion, Control System Basics, Control Principles, State - Space Method. ■

Module-3

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

Module-4

Digital Controller Design (continued): Controlling Voltage, Controlling Current, Control of Induction motor, Output Feedback, Induction motor Control with Output Feedback.

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, Robust Controller Design. ■

Module-5

Discrete Computation Essentials: Numeric Formats, Tracking the Base Point in the Fixed Point System, Normalization And Scaling, Arithmetic Algorithms. ■

Course outcomes:

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

- Describe the role of computer simulations in the analysis and design of power electronics systems.
- Understand the functional modeling of static systems.
- Use sampling technique to determine a digital equivalent to a continuous time system.
- Understand the control basics of digital systems.
- Design digital controllers in discrete time and frequency domain.
- Design optimal and robust controllers by different methods.
- Explain essentials of discrete computation.■

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.■

Text/Reference Books

1. Power Electronics Converters, Applications, and Design, Ned Mohan, Tore M. Undeland, William P. Robbins, Wiley, 3rd Edition, 2014.
2. Power Electronics Essentials and Applications, L. Umanand, Wiley, 1st Edition, 2014.

SPECIAL ELECTRICAL MACHINES			
Course Code	20ECD241	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	4:0:0	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

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

Module-2

Switched Reluctance Motor (SRM): Construction, Principle of Working, Basics of SRM Analysis, Constraints on Pole Arc and Tooth Arc, Torque Equation and Characteristics, Power Converter Circuits, Control of SRM, Rotor Position Sensors, Current Regulators, Microprocessor – Based Control of SRM, Sensorless Control of SRM.
Permanent Magnet DC Motor and Brushless Permanent Magnet DC Motor: Permanent Magnet DC (PMDC) motor, Brushless Permanent Magnet DC (BLDC) Motors. ■

Module-3

Permanent Magnet Synchronous Motor (PMSM): Construction, Principle of Operation, EMF Equation, Torque Equation, Phasor Diagram, Circle Diagram, Comparison of Conventional and PMSM, Control of PMSM, Applications.
Synchronous Reluctance Motor (SyRM): Constructional of SyRM, Working, Phasor Diagram and Torque Equation, Control of SyRM, Advantages and Applications. ■

Module-4

Single Phase Special Electrical Machines: AC series Motor, Repulsion Motor, Hysteresis Motor, Single Phase Reluctance Motor, Universal Motor.
Servo Motors: DC Servo Motors, AC Servo Motors. ■

Module-5

Linear Electric Machines: Linear Induction Motor, Linear Synchronous Motor, DC Linear Motor, Linear Reluctance Motor, Linear Levitation Machines.
Permanent Magnet Axial Flux (PMAF) Machines: Comparison of Permanent Radial and Axial Flux Machines, Construction of PMAF Machines, Armature Windings, torque and EMF Equations of PMAF, Phasor Diagram, Output Equation, Pulsating Torque And its Minimisation, Control and Applications of PMAF. ■

Course outcomes:

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

- Discuss stepper motors, their construction, working and excitation, control schemes and their applications.
- Discuss the construction, working and applications of permanent magnet DC motors and permanent magnet synchronous motors and switched reluctance motor.
- Discuss the control schemes permanent magnet DC motors and permanent magnet synchronous motors
- Discuss the constructional features, principle of operation and control schemes of synchronous reluctance motor.
- Explain the construction, working and applications of special single phase motors.
- Discuss the constructional features and analysis of DC and AC servomotors.
- Describe the construction and working of linear electric motors; linear induction motor, linear synchronous motor, linear DC motor and linear reluctance motor.
- Explain the structure, analysis, control and applications of permanent magnet axial flux machines. ■

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module. ■

Text/Reference Books

1. Special Electrical Machines, E.G. Janardanan, PHI, 1st Edition, 2014.

2. Special Electrical Machines, K Venkataratham, University Press, 2009.
3. Brushless Permanent Magnet and Reluctance Motor Drives, T J E Miller, Clerendon Press, Oxford, 1989.
4. Permanent Magnet and Brushless DC Motors, Kenjo T and Nagamori S, Clerendon Press, Oxford, 1985.
5. Stepping Motors and their Microprocessor Control, KenjoT, Clerendon Press Oxford, 1984.
6. Switched Reluctance Motor Drives Modelling, Simulation Design and Applications, Krishan R, CRC, 2001.

PROCESS CONTROL AND INSTRUMENTATION			
Course Code	20ECD242	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	4:0:0	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

Introduction to Process Control: Process control principles, servo mechanism, discrete state control system, process control block diagram, control system evaluation, analog and digital processing, sensor time response. ■

Module-2

Analog and Digital Signal Conditioning: Principle of analog signal conditioning, Op-amp circuit in instrumentation, converters, data acquisition systems. ■

Module-3

Sensors: Resistance-Temperature Detectors, Thermistor, Thermocouple, Capacitive and Inductive sensors, Variable –Reluctance sensors, Level sensors, Strain sensors. ■

Module-4

Discrete State Process Control: Definition, characteristic of the system, relay controllers and ladder diagrams and PLC’s. ■

Module-5

Digital Control: computers in process control, process control networks, characteristic of digital data. ■

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

- Explain process control loop, digital process control and measurement time response.
- Define the purpose and techniques of analog and digital signal conditioning.
- Describe different types of sensors.
- Apply digital control implementation strategies for process control.
- Explain controllers principle and characteristics.
- Apply the process control principles to distributed control application. ■

Question paper pattern:
The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module. ■

Text/Reference Books

1. Process Control Instrumentation Technology, Curtis D.Johnson, PHI.

2. Instrumentation Device and Systems, Rangan, Sharma and Mani, TMH Publication.

EMC IN POWER ELECTRONICS			
Course Code	20ECD243	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	4:0:0	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

Electromagnetic Disturbances: Introduction, Classification of disturbances by frequency content, by character and transmission mode.
Conducted EMI Measurement: Introduction, EMI measuring instruments, Basic terms and conducted EMI references, Measuring the interference voltage and current, Spectrum analysers, EMI measurements for consumer applications, Measuring impulse like EMI.
EMI in Power Electronic Equipment: EMI from power semiconductors, controlled rectifier circuits, EMI calculation for semiconductor equipment. ■

Module-2

EMI Filter Elements: Measuring High Frequency Characteristics OF EMI Filter Elements, Capacitors, Choke Coils, Resistors. ■

Module-3

Noise Suppression: Noise Suppression in Relay Systems, Application of AC Switching Relays, Application of RC – Snubbers to Power Semiconductors, Shielded Transformers, Capacitor Filters, EMI Generation and Reduction at its Source, Influence of Layout and Control of Parasitics.
EMI Filter Circuit selection and measurement: Definition of EMI Filter Parameters, ENI Filter Circuits, Insertion Loss Test Methods. ■

Module-4

EMI Filter Design: EMI Filter Design for Insertion Loss, Calculation of Worst – case Insertion Loss, Design Method for Mismatched Impedance Condition, Design Method for EMI Filters with Common – Mode Choke Coils, Damped EMI Filters and Lossy Filter Elements, HF Characteristics of Noise Filter Circuit Elements, EMI Filter Layout. ■

Module-5

Testing for Susceptibility to Power Line Disturbances: Surge Voltages in AC Power Mains, EMC Tests per IEC Specifications, Other EMS Test Methods.
Reduction Techniques for internal EMI: Conductive Noise Coupling, Electromagnetic Coupling, Electromagnetic Coupling Reduction Methods, Wiring Layout Methods to Reduce EMI Coupling, PCB Design Considerations. ■

Course outcomes:

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

- Describe Electromagnetic interference and its classification and measurement of conducted high frequency disturbance.
- Survey electromagnetic interference specific to power electronic equipment.
- Explain the characteristics of circuit elements used for noise suppression.
- Explain EMI suppression methods used in semiconductor and electromechanical devices.
- Explain design of EMI filter circuits and filtering methods.
- Explain susceptibility and noise withstand capability test.
- Explain EMS reduction techniques for power electronic equipment.
- Conduct test as per IEC specifications and explain the process of reducing internal EMI. ■

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module. ■

Textbook

1. Electromagnetic Compatibility in Power Electronics, Laszlo Tihanyi, Newnes, 1st Edition, 1995.

NEURAL AND FUZZY LOGIC CONTROL OF DRIVES			
Course Code	20ECD244	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	4:0:0	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

Modern control systems design using CAD techniques: Introduction, Control systems for AC drives, Electronic design automation (EDA), Application specific integrated circuit (ASIC) basics, Field programmable gate arrays (FPGAs), ASICs for power systems and drives, Electric motors.
Electric motors: Motors, Pulse width modulation, The space vector in electrical systems, Induction motor control. ■

Module-2

Elements of neural control: Neurone types, Artificial neural networks architectures, Training algorithms, Control applications of ANNs, Neural network implementation.
Neural FPGA implementation: Neural networks design and implementation strategy, Universal programs FFANN, hardware implementation, Hardware implementation complexity analysis. ■

Module-3

Fuzzy logic fundamentals: Introduction, Fuzzy sets and fuzzy logic, Types of membership functions, Linguistic variables, Fuzzy logic operators, Fuzzy control systems, Fuzzy logic in power and control, Applications.
VHDL fundamentals: Introduction, VHDL design units, Libraries, visibility and state system in VHDL, Sequential statements, Concurrent statements, Functions and procedures, Advanced features in VHDL. ■

Module-4

Neural current and speed control of induction motors: The induction motor equivalent circuit, The current control algorithm, The new sensorless motor control Strategy. .■

Module-5

Neural current and speed control of induction motors (continued): Induction motor controller VHDLDesign, FPGA controller experimental results.■

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

- Discuss control strategies for electric drives/power systems.
- Understand the complex features of control strategies, EDA, neural networks, fuzzy logic, electric machines and drives, power systems and VHDL. ■

Question paper pattern:
The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module. .■

Textbook

1. Neural and Fuzzy Logic Control of Drives and Power Systems, M.N. Cirstea, et al, Newnes, 2002.

PREDICTIVE CONTROL OF DRIVES			
Course Code	20ECD251	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	4:0:0	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

Modelling of AC Drives and Power Converter: Space Phasor Representation, Model of Surface Mounted PMSM, Model of Interior Magnets PMSM, Per Unit Model and PMSM Parameters, Modelling of Induction Motor, Modelling of Power Converter.

Control of Semiconductor Switches via PWM Technologies: Topology of IGBT Inverter, Six-step Operating Mode, Carrier Based PWM, Space Vector PWM, Simulation Study of the Effect of PWM. ■

Module-2

PID Control System Design for Electrical Drives and Power Converters: Overview of PID Control Systems Using Pole-assignment Design Techniques, Overview of PID Control of PMSM, PI Controller Design for Torque Control of PMSM, Velocity Control of PMSM, PID Controller Design for Position Control of PMSM, Overview of PID Control of Induction Motor, PID Controller Design for Induction Motor, Overview of PID Control of Power Converter, PI Current and Voltage Controller Design for Power Converter.

PID Control System Implementation: P and PI Controller Implementation in Current Control Systems, Implementation of Current Controllers for PMSM, Implementation of Current Controllers for Induction Motors, Current Controller Implementation for Power Converter, Implementation of Outer-loop PI Control System, MATLAB Tutorial on Implementation of PI Controller. ■

Module-3

Tuning PID Control Systems with Experimental Validations: Sensitivity Functions in Feedback Control Systems, Tuning Current-loop q-axis Proportional Controller (PMSM), Tuning Current-loop PI Controller (PMSM), Performance Robustness in Outer-loop Controllers, Analysis of Time-delay Effects, Tuning Cascade PI Control Systems for Induction Motor, Tuning PI Control Systems for Power Converter, Tuning P Plus PI Controllers for Power Converter, Robustness of Power Converter Control System Using PI Current Controllers, Summary. ■

Module-4

FCS Predictive Control in $\mathbf{d-q}$ Reference Frame: States of IGBT Inverter and the Operational Constraints, FCS Predictive Control of PMSM, MATLAB Tutorial on Real-time Implementation of FCS-MPC, Analysis of FCS-MPC System, Overview of FCS-MPC with Integral Action, Derivation of I-FCS Predictive Control Algorithm, MATLAB Tutorial on Implementation of I-FCS Predictive Controller, I-FCS Predictive Control of Induction Motor, I-FCS Predictive Control of Power Converter, Evaluation of Robustness of I-FCS-MPC via Monte-Carlo Simulations, Velocity and Position Control of PMSM Using I-FCS-MPC,Velocity and Position Control of Induction Motor Using I-FCS-MPC, Summary. ■

Module-5

FCS Predictive Control in $\boldsymbol{\alpha-\beta}$ Reference Frame: FCS Predictive Current Control of PMSM, Resonant FCS Predictive Current Control, Resonant FCS Current Control of Induction Motor, Resonant FCS Predictive Power Converter Control.

Discrete-time Model Predictive Control (DMPC) of Electrical Drives and Power Converter: Linear Discrete-time Model for PMSM, Discrete-time MPC Design with Constraints, Experimental Evaluation of DMPC of PMSM, Power Converter Control Using DMPC with Experimental Validation.

Continuous-time Model Predictive Control (CMPC) of Electrical Drives and Power Converter: Continuous-time MPC Design, CMPC with Nonlinear Constraints, Simulation and Experimental Evaluation of CMPC of Induction Motor, Continuous-time Model Predictive Control of Power Converter, Gain Scheduled Predictive Controller, Experimental Results of Gain Scheduled Predictive Control of Induction Motor. ■

Course outcomes:

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

- Develop mathematical models of machine drives and power converter using space vector description of physical variables.
- Explain control of semiconductor switches in the implementation of control systems and the PWM implementation of control systems.
- Explain design and control of PI and PID controller using pole placement design techniques for the position, velocity and torque control of PSSM and induction motors.
- Explain Implementation of P and PI controllers for current control as inner-loop controllers,
- Explain Implementation of P and PI controllers for velocity and voltage control as outer-loop controllers.
- Explain tuning of P and PI controllers.
- Assess the performance robustness of the controllers. ■

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module. ■

Textbook

1. PID And Predictive Control of Electrical Drives and Power Converters Using Matlab®/Simulink®, Liuping Wang et al, Wiley, 2015.

ELECTRIC DRIVE DESIGN			
Course Code	20ECD252	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	4:0:0	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

Electric Drive Components: Definition, Electric drive components.
Driven Bodies: Function of the driven body, Reference or rated running, Transient behaviour, Specifications.
Transmission: Transmission types and characterization, Resolution, Speed adaptation, Dynamic behaviour, Oscillatory torque, Position transfer. ■

Module-2

Motors: Characterization, Rotating and linear motors, Induction motors, DC motors, Synchronous motors, Variable reluctance motors, Linear motors, Piezoelectric motors and actuators, BLDC motor characteristics. ■

Module-3

Motors - Characterization: Characteristics, Scaling laws, Parametric expression.
Global Design of an Electric Drive: Introduction, Dynamic equations, Example. ■

Module-4

Heating and Thermal Limits: Heating importance, Thermal equations, Energy dissipated at start-up, Cooling modes.
Electrical Peripherals: Adaptation, Sources, Voltage adjustment, Current adjustment devices.
Electronic Peripherals: Power electronic, Simple switch, H bridge, Element bridge. ■

Module-5

Sensors: Functions and types, Optical position sensors, Hall sensors, Inductive position sensors, Resolver-type rotating, inductive, contactless sensors, Other position sensors, The motor as a position sensor, Sensor position, Current sensors, Protection sensors.
Direct Drives: Performance limits, Motor with external rotor, Example.
Integrated Drives: Principle, Realization. ■

Course outcomes:

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

- Explain the function and specifications of driven body, its transient behavior and transmission types and characterization of transmission system.
- Suggest a motor for a drive, its characteristics.
- Develop dynamic equations for the design of the drive.
- Develop thermal equations for the analysis of the transient behavior of electrical machine.
- Explain the necessity of the electrical and electromagnetic peripherals and devices used for starting the electrical motors.
- Explain power electronics devices to control the operation of the motor.
- Explain the speed and position sensors, performance limits of direct drives and motors with external rotors.
- Explain realization of power electronics and control systems associated with a drive. ■

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module. ■

Textbook

1. Electric Drives, Marcel Jufer, Wiley, 2010.

HYBRID ELECTRIC VEHICLES			
Course Code	20ECD253	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	4:0:0	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

Introduction: Sustainable Transportation, A Brief History of HEVs, Why EVs Emerged and Failed, Architectures of HEVs, Interdisciplinary Nature of HEVs, State of the Art of HEVs, Challenges and Key Technology of HEVs.
Hybridization of the Automobile: Vehicle Basics, Basics of the EV, Basics of the HEV, Basics of Plug-In Hybrid Electric Vehicle (PHEV), Basics of Fuel Cell Vehicles (FCVs).
HEV Fundamentals: Introduction, Vehicle Model, Vehicle Performance, EV Powertrain Component Sizing, Series Hybrid Vehicle, Parallel Hybrid Vehicle, Wheel Slip Dynamics. ■

Module-2

Plug-in Hybrid Electric Vehicles: Introduction to PHEVs, PHEV Architectures, Equivalent Electric Range of Blended PHEVs, Fuel Economy of PHEVs, Power Management of PHEVs, PHEV Design and Component Sizing, Component Sizing of EREVs, Component Sizing of Blended PHEVs, HEV to PHEV Conversions, Other Topics on PHEVs, Vehicle-to-Grid Technology.
Power Electronics in HEVs: Introduction, Principle of Power Electronics, Rectifiers Used in HEVs, Buck Converter Used in HEVs, Non-isolated Bidirectional DC–DC Converter, Voltage Source Inverter, Current Source Inverter, 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, Thermal Management of HEV Power Electronics. ■

Module-3

Electric Machines and Drives in HEVs: Introduction, Induction Motor Drives, Permanent Magnet Motor Drives, Switched Reluctance Motors, Doubly Salient Permanent Magnet Machines, Design and Sizing of Traction Motors, Thermal Analysis and Modelling of Traction Motors. ■

Module-4

Batteries, Ultracapacitors, Fuel Cells, and Controls: Introduction, Battery Characterization, Comparison of Different Energy Storage Technologies for HEVs, Modelling Based on Equivalent Electric Circuits, Battery Charging Control, Charge Management of Storage Devices, Flywheel Energy Storage System, Hydraulic Energy Storage System, Fuel Cells and Hybrid Fuel Cell Energy Storage System. ■

Module-5

Modelling and Simulation of Electric and Hybrid Vehicles: Introduction, Fundamentals of Vehicle System Modelling, HEV Modelling Using ADVISOR, HEV Modelling Using PSAT, Physics-Based Modelling, Bond Graph and Other Modelling Techniques, Consideration of Numerical Integration Methods.
HEV Component Sizing and Design Optimization: Introduction, Global Optimization Algorithms for HEV Design, Model-in-the-Loop Design Optimization Process, Parallel HEV Design Optimization Example, Series HEV Design Optimization Example.
Vehicular Power Control Strategy and Energy Management: A Generic Framework, Definition, and Needs, Methodology to Implement, Benefits of Energy Management. ■

Course outcomes:

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

- Explain the basics of electric and hybrid electric vehicles, their architecture, technologies and fundamentals.
- Explain plug – in hybrid electric vehicle architecture, design and component sizing.
- Explain the use of different power electronics devices in hybrid electric vehicles.
- Suggest a suitable electric drive for a specific type of hybrid electric vehicle.
- Explain the use of different energy storage devices used for hybrid electric vehicles, their technologies and control.
- Simulate electric hybrid vehicles by different techniques for the performance analysis.■

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module. ■

Textbook

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

INTERNET-BASED CONTROL SYSTEMS			
Course Code	20ECD254	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	4:0:0	SEE Marks	60
Credits	04	Exam Hours	03

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. ■

Course outcomes:
At the end of the course the student will be able to:
- Discuss requirements for Internet-based control systems and to building a functional model, traditional tele-operation systems and Web-based user interface design.
- Discuss Real-time Data Transfer over the Internet dealing with Internet Transmission Delay and Data Loss from the Network View and Control perspective.
- Discuss design of Multi-rate SISO and MIMO Internet-based Control Systems and Safety and Security Checking.
- Explain the basic concepts and general guidelines of control system performance monitoring, remotely designing, testing, and updating real-time control software through the Internet. ■

Question paper pattern:
The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.
- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module. ■

Textbook

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

DRIVES LABORATORY - 2			
Course Code	20ECDL26	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	0:4:0	SEE Marks	60
Credits	02	Exam Hours	03

Sl. NO	Experiments
1	Modelling and validation of a separately excited DC motor. (i)To verify the performance under open loop for different input voltages of Step, Ramp and Step-ramp.
2	Closed loop operation of a separately excited DC motor. (i)To study the closed loop operation using P & PI gain speed controller and PI current controller.
3	Operation of two pulse converter (a)Simulation of operation of a single phase fully controlled converter and generation of firing pulses (b)Validate the output voltage of the converter for various control voltages
4	Operation of six pulse converter simulation of a three phase controlled converter and generation of firing pulses.
5	Implementation of two quadrant chopper DC drive.
6	Study of thyristor converter based DC drive.
7	Study and evaluation of the performance of a cycloconverters.
8	Study of AC motor drive (a) V/f Open loop control (b) Closed loop speed control with slip compensation.
9	Study of space vector PWM (VSI) based Induction Motor drive.
10	Testing of motor drive under various load conditions (mechanical coupling of 2 motor drives).

Course outcomes:

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

- Model separately excited DC motor to evaluate its performance under open loop for different types of voltages and closed loop condition with speed and current controllers.
- Model separately excited DC motor to evaluate its performance under closed loop condition with speed and current controllers.
- Conduct experiments on two pulse single phase fully controlled converter to validate the output voltage for different input voltages.
- Simulate a six pulse converter to generate firing pulses.
- Verify the performance of two quadrant choppers, cycloconverters, thyristor converter based dc drive, open loop and closed loop control of AC drive.
- Model VSI based induction motor drive to and test under different loading conditions. ■

TECHHNICAL SEMINAR			
Course Code	20ECD27	CIE Marks	100
Number of contact Hours/week	2	SEE Marks	--
Credits	02	Exam Hours	--

Course objectives:

The objective of the seminar is to inculcate self-learning, face audience confidently, enhance communication skill, involve in group discussion and present and exchange ideas.

Each student, under the guidance of a Faculty, is required to

- Choose, preferably through peer reviewed journals, a recent topic of his/her interest relevant to the Course of Specialization.
- Carryout literature survey, organize the Course topics in a systematic order.
- Prepare the report with own sentences.
- Type the matter to acquaint with the use of Micro-soft equation and drawing tools or any such facilities.
- Present the seminar topic orally and/or through power point slides.
- Answer the queries and involve in debate/discussion.
- Submit two copies of the typed report with a list of references.

The participants shall take part in discussion to foster friendly and stimulating environment in which the students are motivated to reach high standards and become self-confident.

The CIE marks for the seminar shall be awarded (based on the relevance of the topic, presentation skill, participation in the question and answer session and quality of report) by the committee constituted for the purpose by the Head of the Department. The committee shall consist of three faculties from the department with the senior most acting as the Chairperson. ■

Marks distribution for CIE of the course 20ECD27 seminar:

Seminar Report: 30 marks

Presentation skill:50 marks

Question and Answer:20 marks

*** END ***

DIGITAL POWER ELECTRONICS			
Course Code	20ECD31	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	3:0:2	SEE Marks	60
Credits	04	Exam Hours	03

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

Basic Mathematics of Digital Control Systems: Introduction, Digital Signals and Coding, Shannon's sampling theorem, Sample-and-hold devices, Analog-to-digital conversion, Digital-to-analog conversion, Energy quantization, Introduction to reconstruction of sampled signals, Data conversion: the zero-order hold, The first-order hold, The second-order hold, The Laplace transform (the s-domain), The z-transform (the z-domain),

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 forAC/AC (AC/DC/AC) converters.

Digitally Controlled AC/DC Rectifiers: Introduction, Mathematical modelling for AC/DC rectifiers, Single-phase half-wave controlled AC/DC rectifier, Single-phase full-wave AC/DC rectifier,Three-phase half-wave controlled AC/DC rectifier, Three-phase full-wave controlled AC/DC rectifier, Three-phase double-anti-star with interphase-transformer controlled AC/DC rectifier, Six-phase half-wave controlled AC/DC rectifier, Six-phase full-wave controlled AC/DC rectifier. ■

Module-3

Digitally Controlled DC/AC Inverters: Introduction, Mathematical modelling 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, Multistage PWM inverter, Multilevel 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 modelling 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, A DC/AC voltage source, An AC/DC current source, AC motor drives, DC motor drives. ■

Course outcomes:

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

- Explain traditional parameters computation, multiple quadrant operation and choppers.
- Explain the disadvantages of analog power electronics and conversion technology, energy factor and sub-sequential parameters.
- Explain basic mathematics of digital control systems and mathematical modeling of digitally controlled power electronic devices such as rectifiers, inverters and converters.
- 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.
- Discuss DC/AC pulse-width-modulation (PWM) inverters and AC /AC converters modeled as a first-order-hold (FOH) element in digital control systems.
- Discuss DC/DC converter modeled as a second order-hold (SOH) element in digital control systems.
- To explain open loop and closed loop control of power electronic devices and energy factor application of AC and DC motor drives.■

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module. ■

Textbook

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

POWER QUALITY PROBLEMS AND MITIGATION			
Course Code	20ECD321	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Module-1

Power Quality: Introduction, State of the Art on Power Quality, Classification of Power Quality Problems, Causes of Power Quality Problems, Effects of Power Quality Problems on Users, Classification of Mitigation Techniques for Power Quality Problems.

Power Quality Standards and Monitoring: Introduction, State of the Art on Power Quality Standards and Monitoring, Power Quality Terminologies, Power Quality Definitions, Power Quality Standards, Power Quality Monitoring, Numerical Examples.

Passive Shunt and Series Compensation: Introduction, State of the Art on Passive Shunt and Series Compensators, Classification of Passive Shunt and Series Compensators, Principle of Operation of Passive Shunt and Series Compensators, Analysis and Design of Passive Shunt Compensators, Modelling, Simulation, and Performance of Passive Shunt and Series Compensators, Numerical Examples. ■

Module-2

Active Shunt Compensation: Introduction, State of the Art on DSTATCOMs, Classification of DSTATCOMs, Principle of Operation and Control of DSTATCOMs, Analysis and Design of DSTATCOMs, Modelling, Simulation, and Performance of DSTATCOMs, Numerical Examples. ■

Module-3

Active Series Compensation: Introduction, State of the Art on Active Series Compensators, Classification of Active Series Compensators, Principle of Operation and Control of Active Series Compensators, Analysis and Design of Active Series Compensators, Modelling, Simulation, and Performance of Active Series Compensators, Numerical Examples. ■

Module-4

Unified Power Quality Compensators: Introduction, State of the Art on Unified Power Quality Compensators, Classification of Unified Power Quality Compensators, Principle of Operation and Control of Unified Power Quality Compensators, Analysis and Design of Unified Power Quality Compensators, Modelling, Simulation, and Performance of UPQCs, Numerical Examples (from 6.01 to 6.10). ■

Module-5

Unified Power Quality Compensators (continued): Numerical Examples (from 6.11to 20).

Loads That Cause Power Quality Problems: Introduction, State of the Art on Nonlinear Loads, Classification of Nonlinear Loads, Power Quality Problems Caused by Nonlinear Loads, Analysis of Nonlinear Loads, Modelling, Simulation, and Performance of Nonlinear Loads, Numerical Examples. ■

Course outcomes:

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

- Explain causes, effects of PQ problems and classification of mitigation techniques for PQ problems.
- Explain PQ standards, terminology and monitoring requirements through numerical problems.
- Explain passive shunt and series compensation using lossless passive components.
- Explain the design, operation and modeling of active shunt compensation equipment.
- Explain the design, operation and modeling of active series compensation equipment.
- Explain the design operation and modeling of unified power quality compensators.
- Discuss mitigation of power quality problems due to nonlinear loads.■

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module. ■

Textbook

1. Power Quality Problems and Mitigation Techniques, Bhim Singh, Ambrish Chandra, Kamal Al-Haddad, Wiley, 2015.

FPGA AND PROGRAMMABLE LOGIC			
Course Code	20ECD322	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Module-1

Recapitulation of combinational logic circuits. Timing hazards in combinational circuits. Introduction to the history and development of programmable logic. Birth of hardware description languages. Types of programmable logic devices, simple PLDs and CPLDs. ■

Module-2

Architecture of FPGA - generic features. Definition and construction of FPGA. Architecting an FPGA. Performance, density and capacity of an FPGA. Programmability issues. A study of the XC4000 configurable logic block. Introduction to major FPGA families, Xilinx, Altera and Cypress. ■

Module-3

Programming of FPGAs. Introduction to VHDL hardware description language. Programming elements, constructs and syntax. Entities and architecture, Creating combinational and synchronous logic. Details of function and procedures. Topics on identifiers, data objects, data types and attributes. Synthesis and fitting of designs. ■

Module-4

Simulation and verification of the programs. Considerations of area, speed and device resource utilization in FPGA technology. Creating test benches. Systematic study of implementing state machines using VHDL. ■

Module-5

FPGA versus CPLD and case studies. Pipe lining and resource sharing concepts. Applications of FPGA in electric drives and communication devices. Future advances in FPGA technology. ■

Course outcomes:

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

- Implement an electronic application in a suitable FPGA by using VHDL hardware description language.
- Identify and design state machines using HDL and come up with an integrated chip (IC) solution in the form of a FPGA to be used in the area of drives.
- Carry out reverse engineering of a product by using alternative FPGA solutions. ■

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module. ■

Text/Reference Books

1. VHDL for Programmable logic, Kevin Skahill, Pearson Education, 2004.

2. Digital Design, Principles and Practices, John F. Wakerly, Pearson Prentice Hall.

SENSORLESS AC MOTOR CONTROL			
Course Code	20ECD323	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Module-1

Dynamical Models of AC Machines: Applications of AC Machines, Electric Vehicles: Traction System, The Concordia/Clark and Park Transformations, Permanent Magnet Synchronous Motor, Induction Motor, Operating Conditions and Benchmark, Conclusions. ■

Module-2

Observability Property of AC Machines: Observability Property of AC Machines, Observability, Permanent Magnet Synchronous Motor, Induction Motor Observability Analysis, Normal Forms for Observer Design, Conclusions. ■

Module-3

Observer Design for AC Motors: Observers for Nonlinear Systems, PMSM Adaptive Interconnected Observers, High Order Sliding Mode Observers for PMSM, Adaptive Interconnected Observer for the Induction Motor, Conclusions. ■

Module-4

Robust Synchronous Motor Controls Designs (PMSM and IPMSM): Backstepping Control, High-Order Sliding Mode Control, Conclusions.

Robust Induction Motor Controls Design (IM): Field-Oriented Control, Integral Backstepping Control and Field-Oriented Control, High-Order Sliding Mode Control, Conclusions. ■

Module-5

Sensorless Output Feedback Control for SPMSM and IPMSM: Robust Adaptive Backstepping Sensorless Control, Robust Adaptive High Order Sliding Mode Control, Conclusions.

Sensorless Output Feedback Control for Induction Motor: Classical Sensorless Field-Oriented Control, Robust Adaptive Observer-Backstepping Sensorless Control, Robust Adaptive High Order Sliding Mode Control, Conclusions.■

Course outcomes:

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

- Describe the mechanical and electrical behavior of alternating current (AC) machines.
- Models the machines using Clark and Park transformations.
- Explain the application of observability theory and observer normal forms to AC machines.
- Design observers for nonlinear systems, adoptive interconnected observers and higher order sliding mode observers for PMSM.
- Design a robust controller for AC motors by back stepping techniques and sliding mode technique.
- Perform the feedback control of AC motors using robust controllers.■

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module. ■

Textbook

1. Sensorless AC Electric Motor Control Robust Advanced Design Techniques and Applications, Alain Glumineau et al, Springer, 2015.

DATA ANALYTICS FOR THE SMART GRID			
Course Code	20ECD324	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	4:0:0	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

Putting the Smarts in the Smart Grid: Goal, The Imperative for the Data-Driven Utility, Big Data: We'll Know It When We See It, What Are Data Analytics? Starting from Scratch, Finding Opportunity with Smart Grid Data Analytics.
Building the Foundation for Data Analytics: Chapter Goal, Perseverance Is the Most Important Tool, Building the Analytical Architecture.
Transforming Big Data for High-Value Action: Goal, The Utility as a Data Company, Algorithms, Seeing Intelligence, Assessing the Business Issues. ■

Module-2

Applying Analytical Models in the Utility: Goal, Understanding Analytical Models, Using Descriptive Models for Analytics, Using Diagnostic Models for Analytics, Predictive Analytics, Prescriptive Analytics, An Optimization Model for the Utility, Toward Situational Intelligence.
Enterprise Analytics: Goal, Moving Beyond Business Intelligence.
Operational Analytics: Goal, Aligning the Forces for Improved Decision-Making, The Opportunity for Insight, Focus on Effectiveness, Distributed Generation Operations: Managing the Mix-Up, Grid Management, Resiliency Analytics, Extracting Value from Operational Data Analytics. ■

Module-3

Customer Operations and Engagement Analytics: Goal, Increasing Customer Value, What's in It for the Customer?
Analytics for Cybersecurity: Goal, Cybersecurity in the Utility Industry, The Role of Big Data Cybersecurity Analytics.
Sourcing Data: Goal, Sourcing the Data, Working with a Variety of Data Sources. ■

Module-4

Big Data Integration, Frameworks, and Databases: Goal, This Is Going to Cost, Storage Modalities, Data Integration, The Costs of Low-Risk Approaches, Let the Data Flow, Other Big Data Databases, The Curse of Abundance.
Extracting Value: Goal, We Need Some Answers Here, Mining Data for Information and Knowledge, The Process of Data Extraction, Stream Processing, Avoid Irrational Exuberance. ■

Module-5

Envisioning the Utility: Goal, Big Data Comprehension, Why Humans Need Visualization, The Role of Human Perception, The Utility Visualized, Making Sense of It All.
A Partnership for Change: Goal, With Big Data Comes Big Responsibility, Privacy, Not Promises, Privacy Enhancement, The Utility of the Future Is a Good Partner. ■

Course outcomes:

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

- Discuss the key role of data analytics; its architecture and the challenges of creating and implementing them.
- Discuss useful analytical models, traditional business functions and issues affecting how analytics are used in the control room.
- Discuss the methods to increase residential customer lifetime value, vulnerabilities, threats, and analytic approaches to responding to cyber warfare against the utility,
- Discuss the elements of big data infrastructure, their difficulties and benefits in adapting to the needs of high-volume and varied data types,
- Explain the basic concepts of data visualization and the importance of utility becoming trusted steward of big data. ■

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module. ■

Textbook

1. Big Data Analytics Strategies for the Smart Grid, Carol L. Stimmel, CRC Press, 2015.

PLC APPLICATIONS IN ELECTRIC DRIVES			
Course Code	20ECD331	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Module-1

INTRODUTION: Introduction to Programmable logic controller (PLC), role in automation (SCADA), Advantages and disadvantages, hardware, internal architecture, sourcing and sinking, characteristics of I/O Devices, list of input and output devices, examples of applications. I/O processing, input/output units, signal Conditioning, remote connections, networks, processing inputs I/O addresses.
PROGRAMMING: Ladder programming- ladder diagrams, logic functions, latching, multiple outputs, Entering programs, functional blocks, programme examples like location of stop and emergency switches. ■

Module-2

PROGRAMMING LANGUAGES: Instruction list, sequential functions charts and structured text, jump And call subroutines.
INTERNAL RELAYS: ladder programmes, battery- backed relays, one - shot operation, set and reset, Master control relay. ■

Module-3

Programming Timers: Mechanical timing relays, timer instructions, on-delay timer instructions, off-delay timer instructions, retentive timer, cascading timer.
Programming counters: Counter instructions, up-counter, down-counter, cascading counters, incremental encoder-counter applications, combining counter and timer functions■

Module-4

Program control instructions: Master control reset instructions, jump instructions, subroutine functions, immediate input and immediate output instructions, forcing external I/O addresses, safety circuitry, selectable timed interrupt, fault routine, temporary end instructions, suspend instruction. Data manipulation instruction, math instruction.
Sequencer and Shift register instructions: Mechanical sequencer, sequencer instructions, sequencer programs, bit shift registers, word shift operations. ■

Module-5

PLC installation practices, editing and troubleshooting: Leaky inputs and outputs, grounding, program editing and commissioning, programming and monitoring, voltage variations and searches. Applications of PLC in controlling DC motors control of induction motors using PLC. ■

Course outcomes:
At the end of the course the student will be able to:
- Understand and analyse the ladder diagrams.
- Program internal relays.
- Explore the principles of timers, counters and registers.
- Gain a thorough knowledge of application of PLC to various electrical machines. ■

Question paper pattern:
The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.
- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module. ■

Text/Reference Books

1. Programmable Logic controllers, Frank D. Petruzella, McGraw Hill, 4th Edition, 2016.
2. Programmable Logic controllers, W Bolton, Elsevier- newness, 5th Edition, 2009.
3. Programmable logic controllers - principles and applications, John W Webb, Ronald A Reis, Pearson education, 5th Edition, 2007.
4. Programmable Controller Theory and Applications, A Bryan, E. A Bryan, An industrial text Company publication, 2nd edition, 1997.
5. Programmable Controllers, an Engineers Guide, E. A Paar, Newness, 3rd edition, 2003.

AC DRIVES WITH INVERTER OUTPUT FILTERS			
Course Code	20ECD332	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Module-1

Electric Drives with LC Filters: Preliminary Remarks General Overview of AC Drives with Inverter Output Filters, Remarks on Simulation Examples.

Problems with AC Drives and Voltage Source Inverter Supply Effects: Effects Related to Common Mode Voltage, Determination of the Induction Motor CM Parameters, Prevention of Common Mode Current: Passive Methods, Active Systems for Reducing the CM Current, Common Mode Current Reduction by PWM Algorithm Modifications. ■

Module-2

Model of AC Induction Machine: Introduction, Inverse-Γ Model of Induction Machine, Per-Unit System, Machine Parameters, Simulation Examples.

Inverter Output Filters: Structures and Fundamentals of Operations, Output Filter Model, Design of Inverter Output Filters, dV/dt Filter, Motor Choke, Simulation Examples. ■

Module-3

Estimation of the State Variables in the Drive with LC Filter: Introduction, The State Observer with LC Filter Simulator, Speed Observer with Simplified Model of Disturbances, Speed Observer with Extended Model of Disturbances, Speed Observer with Complete Model of Disturbances, Speed Observer Operating for Rotating Coordinates, Speed Observer Based on Voltage Model of Induction Motor, Speed Observer with Dual Model of Stator Circuit, Adaptive Speed Observer, Luenberger Flux Observer, Simulation Examples. ■

Module-4

Control of Induction Motor Drives with LC Filters: Introduction, A Sinusoidal Filter as the Control Object, Field Oriented Control, Nonlinear Field Oriented Control, Multiscalar Control, Electric Drive with Load-Angle Control, Direct Torque Control with Space Vector Pulse Width Modulation, Simulation Examples.

Current Control of the Induction Motor: Introduction, Current Controller, Investigations, Simulation Examples of Induction Motor with Motor Choke and Predictive Control, Summary and Conclusions. ■

Module-5

Diagnostics of the Motor and Mechanical Side Faults: Introduction, Drive Diagnosis Using Motor Torque Analysis, Diagnosis of Rotor Faults in Closed-Loop Control, Simulation Examples of Induction Motor with Inverter Output Filter and Load Torque Estimation, Conclusions.

Multiphase Drive with Induction Motor and an LC Filter: Introduction, Model of a Five-Phase Machine, Model of a Five-Phase LC Filter, Five-Phase Voltage Source Inverter, Control of Five-Phase Induction Motor with an LC Filter, Speed and Flux Observer, Induction Motor and an LC Filter for Five-Phase Drive, Investigations of Five-Phase Sensorless Drive with an LC Filter, FOC Structure in the Case of Combination of Fundamental and Third Harmonic Currents, Simulation Examples of Five-Phase Induction Motor with a PWM Inverter. ■

Course outcomes:

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

- Explain the problems associated with the ac drives in voltage and current common mode.
- Explain the effects of voltage source inverter supply.
- Explain modeling of a squirrel cage motor and machine Parameters.
- Explain the structure and operation of output filter and its design.
- Explain the estimation state variables for drive systems with a sinusoidal filter.
- Explain closed loop control of an induction motor and predictive motor current control for a drive system.
- Explain the diagnostics of drives and faults in rotor in closed loop control.
- Explain modeling, simulation and control of multiphase drives. ■

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module. ■

Textbook

1. Variable Speed AC drives with inverter Output Filters, Jaroslaw Guzinski et al, Wiley, 2015.

SNEAK CIRCUITS IN CONVERTERS			
Course Code	20ECD333	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Module-1

Sneak Circuit and Power Electronic Systems: Reliability of Power Electronic Systems, Sneak Circuit, Sneak Circuit Analysis, Power Electronic System and Sneak Circuit Analysis.
Sneak Circuits of Resonant Switched Capacitor Converters: Introduction, Sneak Circuits of Basic RSC Converter, Sneak Circuits of High-Order RSC Converter. ■

Module-2

Sneak Circuits of DC-DC Converters: Introduction, Buck Converter, Boost Converter, Buck-Boost Converter, Sneak Circuit Conditions of Buck, Boost, and Buck-Boost Converters, Cúk Converter, Sepic Converter, Zeta Converter, Sneak Circuit Conditions of Cúk, Sepic, and Zeta Converters. ■

Module-3

Sneak Circuits of Soft-Switching Converters: Introduction, Sneak Circuits of Full-Bridge ZVS PWM Converter, Sneak Circuits of Buck ZVS Multi-Resonant Converter, Sneak Circuits of Buck ZVT PWM Converter.
Sneak Circuits of other Power Electronic Converters: Introduction, Sneak Circuits of Z-Source Inverter, Sneak Circuits of Synchronous DC-DC Converters. ■

Module-4

Sneak Circuit Path Analysis Method for Power Electronic Converters: 1 Introduction, Basic Concepts, Sneak Circuit Path Analysis Based on Adjacency Matrix, Sneak Circuit Path Analysis Based on Connection Matrix, Sneak Circuit Path Analysis Based on Switching Boolean Matrix, Comparison of Three Sneak Circuit Path Analysis Methods.
Sneak Circuit Mode Analysis Method for Power Electronic Converters: Introduction, Mesh Combination Analytical Method, Sneak Operating Unit Analytical Method, Sneak Circuit Operating Mode Analytical Method, Results of Sneak Circuit Mode Analysis Method on Cúk Converter.

Module-5

Elimination of Sneak Circuits in Power Electronic Converters: Introduction, Sneak Circuit Elimination for RSC Converters, Sneak Circuit Elimination for Z-Source Inverter, Sneak Circuit Elimination for Buck ZVT PWM Converter.
Application of Sneak Circuits in Power Electronic Converters: Introduction, Improvement of Power Electronic Converter Based on Sneak Circuits, Reconstruction of Power Electronic Converter Based on Sneak Circuits, New Functions of Power Electronic Converter Based on Sneak Circuits, Fault Analysis of Power Electronic Converter Based on Sneak Circuits. ■

Course outcomes:
At the end of the course the student will be able to:
- Identify the presence of sneak circuit in power electronic converters.
- Analyze sneak circuit in power electronic converters.
- Discuss some sneak circuit phenomena in converters and inverters.
- Use graph theory to discover the sneak circuit phenomenon in converters using paths and mode analysis.
- Explain the methods to eliminate sneak circuits in power electronic converters.
- Explain utilization of sneak circuits to improve the performance of power electronic converters. ■

Question paper pattern:
The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.
- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module. ■

Textbook

1. Sneak Circuits of Power Electronic Converters, Bo Zhang and Dongyuan Qiu, Wiley, 2015.

CYBERSECURITY IN THE ELECTRICITY SECTOR			
Course Code	20ECD334	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Module-1

Introduction: Transformation, Dependence on the ICT, 8Cybersecurity, Priority Critical Infrastructure.
State of Cybersecurity in the Electricity Sector: Introduction, Vulnerabilities, Threats, Challenges, Initiatives, Future Directions. ■

Module-2

Cybersecurity Standards Applicable to the Electricity Sector: Introduction, Literature Search, Literature Analysis, Standards' Selection and Evaluation Criteria, Results, Most Relevant Standards, Standards' Limitations, Standards' Implementation and Awareness. ■

Module-3

A Systematic Approach to Cybersecurity Management: Introduction, Cybersecurity Management Approaches in Standards, The Systematic Approach to Cybersecurity Management in the Electricity Sector. ■

Module-4

Cost of Cybersecurity Management: Introduction, Economic Studies, Organisation Management Studies, Cost-Benefit Analysis, Cost Calculators, Costing Metrics, CAsPeA.
Cybersecurity Assessment: Introduction, Security Assessment Methods for the Electricity Sector, Cybersecurity Test beds for Power Systems, JRC Cybersecurity Assessment Method, Laboratory Infrastructure, MAlSim. ■

Module-5

Cybersecurity Controls: Introduction, Standard Technical Solutions, Information Sharing Platform on Cybersecurity Incidents for the Energy Sector, Situation Awareness Network. ■

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

- Discuss the current cybersecurity situation in the electricity sector and the relevant standards that can be employed for cybersecurity.
- Explain cybersecurity management approach and the methods for the electricity sector.
- Explain available solutions that support the cost-benefit analyses involved in cybersecurity management and cybersecurity assessment approach.
- Discuss cybersecurity controls, for reducing cyber risks. ■

Question paper pattern:
The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module. ■

Textbook

1. Cybersecurity in the Electricity Sector, Rafal Leszczyna, Springer, 2019

PROJECT WORK PHASE – 1			
Course Code	20ECD34	CIE Marks	100
Number of contact Hours/Week	2	SEE Marks	--
Credits	02	Exam Hours	--

Course objectives:

- Support independent learning.
- Guide to select and utilize adequate information from varied resources maintaining ethics.
- Guide to organize the work in the appropriate manner and present information (acknowledging the sources) clearly.
- Develop interactive, communication, organisation, time management, and presentation skills.
- Impart flexibility and adaptability.
- Inspire independent and team working.
- Expand intellectual capacity, credibility, judgement, intuition.
- Adhere to punctuality, setting and meeting deadlines.
- Instil responsibilities to oneself and others.
- Train students to present the topic of project work in a seminar without any fear, face audience confidently, enhance communication skill, involve in group discussion to present and exchange ideas. ■

Project Phase-1 Students in consultation with the guide/s shall carry out literature survey/ visit industries to finalize the topic of the Project. Subsequently, the students shall collect the material required for the selected project, prepare synopsis and narrate the methodology to carry out the project work.

Seminar: Each student, under the guidance of a Faculty, is required to

- Present the seminar on the selected project orally and/or through power point slides.
- Answer the queries and involve in debate/discussion.
- Submit two copies of the typed report with a list of references.

The participants shall take part in discussion to foster friendly and stimulating environment in which the students are motivated to reach high standards and become self-confident. ■

Course outcomes:

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

- Demonstrate a sound technical knowledge of their selected project topic.
- Undertake problem identification, formulation and solution.
- Design engineering solutions to complex problems utilising a systems approach.
- Communicate with engineers and the community at large in written an oral forms.
- Demonstrate the knowledge, skills and attitudes of a professional engineer. ■

Continuous Internal Evaluation

CIE marks for the project report (50 marks), seminar (30 marks) and question and answer (20 marks) shall be awarded (based on the quality of report and presentation skill, participation in the question and answer session by the student) by the committee constituted for the purpose by the Head of the Department. The committee shall consist of three faculty from the department with the senior most acting as the Chairperson. ■

MINI PROJECT			
Course Code	20ECD35	CIE Marks	40
Number of contact Hours/Week	2	SEE Marks	60
Credits	02	Exam Hours/Batch	03

Course objectives:

- To support independent learning and innovative attitude.
- To guide to select and utilize adequate information from varied resources upholding ethics.
- To guide to organize the work in the appropriate manner and present information (acknowledging the sources) clearly.
- To develop interactive, communication, organisation, time management, and presentation skills.
- To impart flexibility and adaptability.
- To inspire independent and team working.
- To expand intellectual capacity, credibility, judgement, intuition.
- To adhere to punctuality, setting and meeting deadlines.
- To instil responsibilities to oneself and others.
- To train students to present the topic of project work in a seminar without any fear, face audience confidently, enhance communication skill, involve in group discussion to present and exchange ideas. ■

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

Course outcomes:

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

- Present the mini-project and be able to defend it.
- Make links across different areas of knowledge and to generate, develop and evaluate ideas and information so as to apply these skills to the project task.
- Habituated to critical thinking and use problem solving skills.
- Communicate effectively and to present ideas clearly and coherently in both the written and oral forms.
- Work in a team to achieve common goal.
- Learn on their own, reflect on their learning and take appropriate actions to improve it. ■

CIE procedure for Mini - Project:

The CIE marks awarded for Mini - Project, shall be based on the evaluation of Mini - Project Report, Project Presentation skill and Question and Answer session in the ratio 50:25:25.The marks awarded for Mini - Project report shall be the same for all the batch mates.

Semester End Examination

SEE marks for the mini-project shall be awarded based on the evaluation of Mini-Project Report, Presentation skill and Question and Answer session in the ratio 50:25:25 by the examiners appointed by the University. ■

M.TECH MICRO ELECTRONICS AND CONTROL SYSTEMS (EMS) Choice Based Credit System (CBCS) and Outcome Based Education(OBE) SEMESTER - III			
INTERNSHIP / PROFESSIONAL PRACTICE			
Course Code	20ECDI36	CIE Marks	40
Number of contact Hours/Week	2	SEE Marks	60
Credits	06	Exam Hours	03

Course objectives:
Internship/Professional practice provide students the opportunity of hands-on experience that include personal training, time and stress management, interactive skills, presentations, budgeting, marketing, liability and risk management, paperwork, equipment ordering, maintenance, responding to emergencies etc. The objective are further,

To put theory into practice.

To expand thinking and broaden the knowledge and skills acquired through course work in the field.

To relate to, interact with, and learn from current professionals in the field.

To gain a greater understanding of the duties and responsibilities of a professional.

To understand and adhere to professional standards in the field.

To gain insight to professional communication including meetings, memos, reading, writing, public speaking, research, client interaction, input of ideas, and confidentiality.

To identify personal strengths and weaknesses.

To develop the initiative and motivation to be a self-starter and work independently. ■

Internship/Professional practice: Students under the guidance of internal guide/s and external guide shall take part in all the activities regularly to acquire as much knowledge as possible without causing any inconvenience at the place of internship.

Seminar: Each student, is required to

- Present the seminar on the internship orally and/or through power point slides.
- Answer the queries and involve in debate/discussion.
- Submit the report duly certified by the external guide.
- The participants shall take part in discussion to foster friendly and stimulating environment in which the students are motivated to reach high standards and become self-confident. ■

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

- Gain practical experience within industry in which the internship is done.
- Acquire knowledge of the industry in which the internship is done.
- Apply knowledge and skills learned to classroom work.
- Develop a greater understanding about career options while more clearly defining personal career goals.
- Experience the activities and functions of professionals.
- Develop and refine oral and written communication skills.
- Identify areas for future knowledge and skill development.
- Expand intellectual capacity, credibility, judgment, intuition.
- Acquire the knowledge of administration, marketing, finance and economics. ■

Continuous Internal Evaluation
CIE marks for the Internship/Professional practice report (20 marks), seminar (10 marks) and question and answer session (10 marks) shall be awarded (based on the quality of report and presentation skill, participation in the question and answer session by the student) by the committee constituted for the purpose by the Head of the Department. The committee shall consist of three faculty from the department with the senior most acting as the Chairperson. ■

Semester End Examination
SEE marks for the internship report (30 marks), seminar (20 marks) and question and answer session (10 marks) shall be awarded (based on the quality of report and presentation skill, participation in the question and answer session) by the examiners appointed by the University. ■

M.TECH TITLE OF THE PROGRAMME (XXX) Choice Based Credit System (CBCS) and Outcome Based Education(OBE) SEMESTER - IV			
PROJECT WORK PHASE -2			
Course Code	20ECD41	CIE Marks	40
Number of contact Hours/Week	4	SEE Marks	60
Credits	20	Exam Hours	03

Course objectives:

- To support independent learning.
- To guide to select and utilize adequate information from varied resources maintaining ethics.
- To guide to organize the work in the appropriate manner and present information (acknowledging the sources) clearly.
- To develop interactive, communication, organisation, time management, and presentation skills.
- To impart flexibility and adaptability.
- To inspire independent and team working.
- To expand intellectual capacity, credibility, judgement, intuition.
- To adhere to punctuality, setting and meeting deadlines.
- To instil responsibilities to oneself and others.
- To train students to present the topic of project work in a seminar without any fear, face audience confidently, enhance communication skill, involve in group discussion to present and exchange ideas. ■

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

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

- Present the project and be able to defend it.
- Make links across different areas of knowledge and to generate, develop and evaluate ideas and information so as to apply these skills to the project task.
- Habituated to critical thinking and use problem solving skills
- Communicate effectively and to present ideas clearly and coherently in both the written and oral forms.
- Work in a team to achieve common goal.
- Learn on their own, reflect on their learning and take appropriate actions to improve it. ■

Continuous Internal Evaluation:
Project Report: 20 marks. The basis for awarding the marks shall be the involvement of the student in the project and in the preparation of project report. To be awarded by the internal guide in consultation with external guide if any.
Project Presentation: 10 marks.
The Project Presentation marks of the Project Work Phase -II shall be awarded by the committee constituted for the purpose by the Head of the Department. The committee shall consist of three faculty from the department with the senior most acting as the Chairperson.
Question and Answer: 10 marks.
The student shall be evaluated based on the ability in the Question and Answer session for 10 marks.
Semester End Examination
SEE marks for the project report (30 marks), seminar (20 marks) and question and answer session (10 marks) shall be awarded (based on the quality of report and presentation skill, participation in the question and answer session) by the examiners appointed by the University. ■