VISVESVARAYA TECHNOLOGICAL UNIVERSITY
BELAGAVI

Scheme of Teaching and Examination and Syllabus

M.Tech in

COMPUTER APPLICATION IN INDUSTRIAL DRIVES (ECD)

Eligibility: Bachelor's degree in Engineering or Technology in

(a)Electrical and Electronics Engineering (b) AMIE in appropriate branch (c) GATE: EE

(Effective from Academic year 2016-17)

BOARD OF STUDIES IN ELECTRICAL AND ELECTRONICS ENGINEERING

December 2016

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI

SCHEME OF TEACHING AND EXAMINATION - 2016-17

M.Tech COMPUTER APPLICATION IN INDUSTRIAL DRIVES (ECD)

CHOICE BASED CREDIT SYSTEM (CBCS)

(Total number of credits prescribed for the programme - 85)

I SEMESTER

Sl. No	Subject Code	Title	Teaching Hours /Week		Examination				Credits
			Theory	Practical/ Field work/ Assignment	Duration in hours	I.A. Marks	Theory/ Practical Marks	Total Marks	
1	16EEE11	Applied Mathematics	04	--	03	20	80	100	4
2	16ECD12	Power Semiconductor Devices and Components	04	--	03	20	80	100	4
3	16ECD13	Power Electronic Converters	04	--	03	20	80	100	4
4	16ECD14	AC and DC Drives - 1	04	--	03	20	80	100	4
5	16ECD15X	Elective -I	03	--	03	20	80	100	3
6	16ECDL16	Power Electronics Laboratory	-	3	03	20	80	100	2
7	16ECD17	Seminar	-	3	-	100	-	100	1
TOTAL			**19**	**06**	**18**	**220**	**480**	**700**	**22**

Number of credits completed at the end of I semester: 22

Elective - I

Courses under Code 16ECD15X	Title
16ECD151	Special Electrical Machines
16ECD152	Power System Harmonics
16ECD153	Advanced Control Systems
16ECD154	EMC in Power Electronics

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M.Tech COMPUTER APPLICATION IN INDUSTRIAL DRIVES (ECD)

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(Total number of credits prescribed for the programme - 85)

II SEMESTER

Sl. No	Subject Code	Title	Teaching Hours /Week		Examination				Credits
			Theory	Practical/ Field work/ Assignment	Duration in hours	I.A. Marks	Theory/ Practical Marks	Total Marks	
1	16ECD21	AC and DC Drives - 2	04	--	03	20	80	100	4
2	16ECD22	DSP Applications to Drives	04	--	03	20	80	100	4
3	16ECD23	Hybrid Electric Vehicles	04	--	03	20	80	100	4
4	16ECD24	Modelling and Design Of Controllers	04	--	03	20	80	100	4
5	16ECD25X	Elective - II	03	--	03	20	80	100	3
6	16ECDL26	Drives Laboratory	-	3	03	20	80	100	2
7	16ECD27	Seminar	-	3	-	100	-	100	1
TOTAL			**19**	**06**	**18**	**220**	**480**	**700**	**22**

Number of credits completed at the end of II semester: 22+ 22 = 44

Elective - II

Courses under Code 16ECD25X	Title
16ECD251	Power Quality Problems and Mitigation
16ECD252	Electric Drive Design
16ECD253	Vector Control of Three-Phase AC Machines
16ECD254	Automatic Control and Power Electronics

Note: Project Phase-1: 6-week duration shall be carried out between 2nd and 3rd Semester vacation. Candidates in consultation with the guide shall carry out literature survey/ visit industries to finalize the topic of Project.

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(Total number of credits prescribed for the programme – 85)

III SEMESTER

Sl. No	Subject Code	Title	Teaching Hours /Week		Examination				Credits
			Theory	Practical/ Field work/ Assignment	Duration in hours	I.A. Marks	Theory/ Practical Marks	Total Marks	
1	16ECD31	Seminar / Presentation on Internship. (After 8 weeks from the date of commencement)	Internship is for a period of 16 weeks		--	25	--	25	20
2	16ECD32	Report on Internship	--	--	--	25	--	25	
3	16ECD33	Evaluation and Viva-Voce of Internship	--	--	--	--	50	50	
4	16ECD34	Evaluation of Project phase -1	--	--	--	50	--	50	1
		TOTAL	--	--	--	**100**	**50**	**150**	**21**

Number of credits completed at the end of III semester: 22+ 22 + 21 = 65

Note:

Internship of 16 weeks shall be carried out during III semester.

Major part of the Project work shall also be carried out during the III semester in consultation with the Guide/s.

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI

SCHEME OF TEACHING AND EXAMINATION – 2016-17

M.Tech COMPUTER APPLICATION IN INDUSTRIAL DRIVES (ECD)

CHOICE BASED CREDIT SYSTEM (CBCS)

(Total number of credits prescribed for the programme – 85)

IV SEMESTER

Sl. No	Subject Code	Title	Teaching Hours /Week		Examination				Credits
			Theory	Practical/ Field work/ Assignment	Duration in hours	I.A. Marks	Theory/ Practical Marks	Total Marks	
1	16ECD41	Predictive Control of Drives	04	--	03	20	80	100	4
2	16ECD42X	Elective - 3	03	--	03	20	80	100	3
3	16ECD43	Evaluation of Project phase - 2	--	--	--	50	-	50	3
4	16ECD44	Evaluation of Project and Viva-Voce	--	--	--	--	100 + 100	200	10
		TOTAL	**07**	**--**	**06**	**90**	**360**	**450**	**20**

Number of credits completed at the end of IV semester: 22+ 22 + 21 + 20 = 85

Elective - 3

Courses under Code 16ECD42X	Title
16ECD421	AC drives with inverter Output Filters
16ECD422	Digital Power Electronics
16ECD423	Sensorless AC Motor Control
16ECD424	Sneak Circuits in Converters

Note: 1. Project Phase-1: 6-week duration shall be carried out between 2nd and 3rd Semester vacation. Candidates in consultation with the guide shall carry out literature survey/ visit industries to finalize the topic of Project.

2. Project Phase-2: 16-week duration during 4th semester**.** Evaluation shall be done by the committee comprising of HoD as Chairman, Guide and Senior faculty of the department.

3. **Project Evaluation**: Evaluation shall be taken up at the end of 4th semester. Project work evaluation and Viva-Voce examination shall conducted

4**. Project evaluation:**

a. Internal Examiner shall carry out the evaluation for 100 marks.
b. External Examiner shall carry out the evaluation for 100 marks.
c .The average of marks allotted by the internal and external examiner shall be the final marks of the project evaluation.
d. Viva-Voce examination of Project work shall be conducted jointly by Internal and External examiner for 100 marks.

*** END ***

M.TECH COMPTER APPLICATIONS TO INDUSTRIAL DRIVES (ECD) CHOICE BASED CREDIT SYSTEM (CBCS) SEMESTER - I			
APPLIED MATHAMATICS (Core Course)			
Course Code	16EEE11	IA Marks	20
Number of Lecture Hours/Week	04	Exam Hours	03
Total Number of Lecture Hours	50	Exam Marks	80
Credits - 04			

Course objectives:

- The objectives of this course is to acquaint the students with principles of advanced mathematics through linear algebra, transform methods for differential equations, calculus of variations and linear and non-linear programming, that serve as an essential tool for applications of electrical engineering sciences. ■

Module-1		**Teaching Hours**
Numerical Methods: Solution of algebraic and transcendental equations- iterative methods based on second degree equation – Muller method(no derivation), Chebyshev method. Fixed point iteration method (first order), acceleration of convergence- Δ^2 - Aitken's method. System of non-linear equations – Newton-Raphson method. Complex roots by Bairstow's method. ■		**10**
Revised Bloom's Taxonomy Level	L_2 – Understanding, L_3 – Applying	
Module-2		
Numerical Solution of Partial Differential Equations: Classification of second order equations, parabolic equations-solution of one dimensional heat equation, explicit method, Crank-Nicolson method. Hyperbolic equations- solution of one dimensional wave equation and two-dimensional Laplace equation by explicit method. ■		**10**
Revised Bloom's Taxonomy Level	L_3 – Applying	
Module-3		
Linear Algebra: Vector spaces, linear dependent, independence, basis and dimension, elementary properties, examples. **Linear Transformations**: Definition, properties, range and null space, rank and nullity, algebra of linear transformations-invertible, singular and non-singular transformations, representation of transformations by matrices. ■		**10**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding	
Module-4		
System of linear algebraic equations and Eigen value problems: Iterative methods - Gauss-Seidal method, SOR method, Eigen value problems – Gerschgorian circle theorem, Eigen values and Eigen vectors of real symmetric matrices -Jacobi method. **Interpolation:** Hermite interpolation, spline interpolation, numerical solution of differential equations – Numerov method. ■		**10**
Revised Bloom's Taxonomy Level	L_3 – Applying	
Module-5		
Optimization: Linear programming- formulation of the problem, general linear programming problem, simplex method, artificial variable technique, Big M-method. **Graph Theory:** Basic terminologies, types of graphs, sub graphs, graphs isomorphism, connected graphs-walks, paths, circuits, connected and disconnected graphs, operations on graphs, Eulerian paths and circuits, Hamiltonian paths and circuits, applications to electrical circuits. ■		**10**
Revised Bloom's Taxonomy Level	L_3 – Applying, L_4 – Analysing.	

M.TECH COMPTER APPLICATIONS TO INDUSTRIAL DRIVES (ECD)
16EEE11 APPLIED MATHAMATICS (Core Course) (continued)
CHOICE BASED CREDIT SYSTEM (CBCS)

Course outcomes:

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

1. Employ numerical techniques in order to achieve more accurate values in the computation of roots of algebraic and non-linear equations.
2. Utilize analytical and numerical schemes to solve partial differential equations applicable to engineering problems.
3. Understand vector spaces, basis, linear transformations and the process of obtaining matrix of linear transformations arising in magnification and rotation of images.
4. Apply standard iterative methods to compute Eigen values and solve ordinary differential equations.
5. Employ linear and non-linear programming techniques in simulation of network systems and optimization of electrical circuits. ■

Graduate Attributes (As per NBA):

Critical Thinking, Problem Solving, Research Skill, Usage of Modern Tools.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 16 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions 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	Linear Algebra and its Applications	David C.Lay et al	Pearson	5th Edition,2015
2	Numerical methods in Engineering and Science (with C, C++ & MATLAB)	B.S.Grewal	Khanna Publishers	2014
3	Graph Theory with Applications to Engineering and Computer Science	Narsingh Deo	PHI	2012
4	Numerical Methods for Scientific and Engineering Computation	M. K. Jain et al	New Age International	9^{th} Edition, 2014
5	Higher Engineering Mathematics	B.S. Grewal	Khanna Publishers	43^{rd} Edition,2015
6	Linear Algebra	K.Hoffman et al	PHI	2011
7	**Web links:**1. *http://nptel.ac.in/courses.php?disciplineId=111* 2. *http://www.class-central.com/Course/math(MOOCs)* 3.*www.wolfram.com*			

M.TECH COMPTER APPLICATIONS TO INDUSTRIAL DRIVES (ECD) CHOICE BASED CREDIT SYSTEM (CBCS) SEMESTER - I			
POWER SEMICONDUCTOR DEVICES AND COMPONETS (Core Course)			
Subject Code	16ECD12	IA Marks	20
Number of Lecture Hours/Week	04	Exam Hours	03
Total Number of Lecture Hours	50	Exam Marks	80
Credits - 04			

Course objectives:

- To enhance the knowledge of fundamentals of semiconductor physics, power electronics and power computation in circuits
- To enhance the knowledge of fundamentals of various semiconductor devices, their operation and characteristics.
- To explain the design and operation of drive circuits and snubber circuits.
- To explain the controlling of temperature rise of the semiconductor devices and designing of magnetic components used for the power electronic circuits. ■

Module-1		**Teaching Hours**
Power Electronics: Introduction, Converter Classification, Power Electronics Concepts, Electronic Switches, Switch Selection, Spice, PSpice and Capture, Representation of switches in Pspice -The Voltage-Controlled Switch, Transistors, Diodes and Thyristors (SCRs). **Power Computations**: Introduction, Power and Energy, Inductors and Capacitors, Energy Recovery, Effective Values, Apparent Power and Power Factor, Power Computations for Sinusoidal AC Circuits, Power Computations for Nonsinusoidal Periodic Waveforms, Power Computations Using Pspice. **Basic Semiconductor Physics:** Introduction, Conduction Processes in Semiconductors pn Junctions, Charge Control Description of pn-Junction Operation, Avalanche Breakdown. ■		**10**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding.	
Module-2		
Power Diodes: Introduction, Basic Structure and I – V characteristics, Breakdown Voltage Considerations, On –State Losses, Switching Characteristics, Schottky Diodes. **Bipolar Junction Transistors:** Introduction, Vertical Power Transistor Structures, Z-V Characteristics, Physics of BJT Operation, Switching Characteristics, Breakdown Voltages, Second Breakdown, On-State Losses, Safe Operating areas. **Power MOSFETs :** Introduction, Basic Structure, I-V Characteristics, Physics of Device Operation, Switching Characteristics, Operating Limitations and Safe Operating Areas. ■		**10**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding.	
Module-3		
Thyristors: Introduction, Basic Structure, I-V Characteristics, Physics of Device Operation, Switching Characteristics, Methods of Improving di/dt and dv/dt Ratings. **Gate Turn-Off Thyristors:** Introduction, Basic Structure and Z-V Characteristics, Physics of Turn-Off Operation, GTO Switching Characteristics, Overcurrent Protection of GTOs. **Insulated Gate Bipolar Transistors:** Introduction, Basic Structure, I-V Characteristics, Physics of Device Operation, Latchup in IGBTs, Switching Characteristics, Device Limits and SOAs. **Emerging Devices and Circuits:** Introduction, Power Junction Field Effect Transistors, Field-Controlled Thyristor, JFET-Based Devices versus Other Power Devices, MOS-Controlled Thyristors, Power Integrated Circuits, New Semiconductor Materials for Power Devices. ■		**10**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding.	

M.TECH COMPTER APPLICATIONS TO INDUSTRIAL DRIVES (ECD) 16ECD12 POWER SEMICONDUCTOR DEVICES AND COMPONETS (Core Course) (continued) CHOICE BASED CREDIT SYSTEM (CBCS)		
Module-4		**Teaching Hours**
Snubber Circuits: Function and Types of Snubber Circuits, Diode Snubbers, Snubber Circuits for Thyristors, Need for Snubbers with Transistors, Turn-Off Snubber, Overvoltage Snubber, Turn-On Snubber, Snubbers for Bridge Circuit Configurations, GTO Snubber Considerations. **Gate and Base Drive Circuits:** Preliminary Design Considerations, dc-Coupled Drive Circuits, Electrically Isolated Drive Circuits, Cascode-Connected Drive Circuits, Thyristor Drive Circuits, Power Device Protection in Drive Circuits, Circuit Layout Considerations ■		**10**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing.	
Module-5		
Component Temperature Control and Heat Sinks: Control of Semiconductor Device Temperatures, Heat Transfer by Conduction, Heat sinks, Heat Transfer by Radiation and Convection. **Design of Magnetic Components:** Magnetic Materials and Cores, Copper Windings, Thermal Considerations, Analysis of a Specific Inductor Design, Inductor Design Procedures, Analysis of a Specific Transformer Design, Eddy Currents, Transformer Leakage Inductance, Transformer Design Procedure, Comparison of Transformer and Inductor Sizes. ■		**10**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing.	

Course outcomes:

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

- Discuss power electronic concepts, electronic switches and semiconductor physics.
- Explain representation of switches in P-spice and power computations.
- Explain the internal structure, the principle of operation, characteristics and base drive circuits of power semiconductor devices; power diodes, power BJT, power MOSFET.
- Explain the internal structure, the principle of operation, characteristics and base drive circuits of power semiconductor devices; thyristors, power IGBT, power FET.
- Design Snubber circuits for the protection of power semiconductor devices.
- Design gate and base drive circuits for power semiconductor devices
- Design a heat sink to control the temperature rise of semiconductor devices
- Design magnetic components inductors and transformers used in the power electronic circuits. ■

Graduate Attributes (As per NBA):

Engineering Knowledge Problem, Analysis, Design / development of solutions, Ethics.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 16 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. ■

Text/Reference Books

1	Power Electronics	Daniel W Hart	McGraw Hill	
2	Power Electronics Converters, Applications, and Design	Ned Mohan et al	Wiley	3rd Edition,2014
3	Semiconductor Device Modeling with Spice	G. Massobrio, P. Antognetti	McGraw-Hill	2nd Edition, 2010
4	Power Semiconductor Devices	B. Jayant Baliga	Springer	2008

M.TECH COMPTER APPLICATIONS TO INDUSTRIAL DRIVES (ECD)
CHOICE BASED CREDIT SYSTEM (CBCS)
SEMESTER - I

POWER ELECTRONIC CONVERTERS (Core Course)

Subject Code	16ECD13	IA Marks	20
Number of Lecture Hours/Week	04	Exam Hours	03
Total Number of Lecture Hours	50	Exam Marks	80

Credits - 04

Course objectives:

- To impart knowledge of PWM techniques in controlling the converter operation.
- To impart knowledge of designing and analyzing DC – DC PWM converters and control modules.
- To impart knowledge of designing and analyzing DC – AC and AC – DC converters.
- To impart knowledge of analyzing different types of resonant converters and their control.
- To impart knowledge of AC –AC converters and multilevel controllers. ■

Module-1	Teaching Hours
PWM 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. ■	**10**
Revised Bloom's Taxonomy Level: L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing.	

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. ■	**10**
Revised Bloom's Taxonomy Level: L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing.	

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.■	**10**
Revised Bloom's Taxonomy Level: L_2 – Understanding, L_3 – Applying, L_4 – Analysing, L_5 – Evaluating.	

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	**10**

M.TECH COMPTER APPLICATIONS TO INDUSTRIAL DRIVES (ECD)
16ECD13 POWER ELECTRONIC CONVERTERS (Core Course) (continued)
CHOICE BASED CREDIT SYSTEM (CBCS)

Module-4 (continued)		Teaching Hours
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. ■		
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing.	
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. ■		**10**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing.	

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. ■

Graduate Attributes (As per NBA):

Engineering Knowledge, Problem analysis.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 16 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. ■

Text/Reference Books

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

M.TECH COMPTER APPLICATIONS TO INDUSTRIAL DRIVES (ECD)
CHOICE BASED CREDIT SYSTEM (CBCS)
SEMESTER - I

AC and DC DRIVES - 1 (Core Course)

Subject Code	16ECD14	IA Marks	20
Number of Lecture Hours/Week	04	Exam Hours	03
Total Number of Lecture Hours	50	Exam Marks	80

Credits - 04

Course objectives:

- To impart knowledge on mathematical Modeling of DC machine and phase control of DC motor drives.
- To explain controlling of DC motor by Choppers.
- Mathematical modeling of poly phase induction motor for controlling the speed by phase control.
- To impart knowledge on control of induction motor drives through frequency. ■

Module-1	Teaching Hours
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. ■	**10**
Revised Bloom's Taxonomy Level: L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing.	
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. ■	**10**
Revised Bloom's Taxonomy Level: L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing.	
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.■	**10**
Revised Bloom's Taxonomy Level: L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing.	
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. ■	**10**
Revised Bloom's Taxonomy Level: L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing.	

M.TECH COMPTER APPLICATIONS TO INDUSTRIAL DRIVES (ECD)
16ECD14 AC and DC DRIVES - 1 (Core Course) (continued)
CHOICE BASED CREDIT SYSTEM (CBCS)

Module-5		**Teaching Hours**
Frequency – Controlled Induction Motor Drives: Introduction, Static Frequency Changers, Voltage Source Inverter – Driven Induction Motor. ■		**10**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing.	

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. ■

Graduate Attributes (As per NBA):

Engineering Knowledge, Problem Analysis, Design / development of solutions, Ethics.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 16 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. ■

Text Book

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

M.TECH COMPTER APPLICATIONS TO INDUSTRIAL DRIVES (ECD)
CHOICE BASED CREDIT SYSTEM (CBCS)
SEMESTER - I

SPECIAL ELECTRICAL MACHINES (Elective Course)

Subject Code	16ECD151	IA Marks	20
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	40	Exam Marks	80

Credits - 03

Course objectives:

- To impart knowledge on the Construction, principle of operation, control and performance of stepping motors.
- To impart knowledge on the Construction, principle of operation, control and performance of switched reluctance motors and permanent magnet brushless D.C. motors.
- To impart knowledge on the Construction, principle of operation and performance of permanent magnet synchronous motors and synchronous reluctance motor.
- To impart knowledge on single phase special machines and servo motors.
- To impart knowledge on Linear electrical machine and permanent magnet axial flux machines. ■

Module-1		Teaching Hours
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. ■		**08**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding.	
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. ■		**08**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding.	
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. ■		**08**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding.	
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. ■		**08**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding.	
Module-5		
Linear Electric Machines: Linear Induction Motor, Linear Synchronous Motor, DC Linear Motor, Linear Reluctance Motor, Linear Levitation Machines.		**08**

M.TECH COMPTER APPLICATIONS TO INDUSTRIAL DRIVES (ECD) 16ECD151 SPECIAL ELECTRICAL MACHINES (Elective Course) (continued) CHOICE BASED CREDIT SYSTEM (CBCS)		
Module-5 (continued)		**Teaching Hours**
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. ■		**08**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding.	

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. ■

Graduate Attributes (As per NBA):

Engineering Knowledge, Problem analysis.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 16 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. ■

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

<table>
<tr><td colspan="4">M.TECH COMPTER APPLICATIONS TO INDUSTRIAL DRIVES (ECD)
CHOICE BASED CREDIT SYSTEM (CBCS)
SEMESTER - I</td></tr>
<tr><td colspan="4">POWER SYSTEM HARMONICS (Elective Course)</td></tr>
<tr><td>Subject Code</td><td>16ECD152</td><td>IA Marks</td><td>20</td></tr>
<tr><td>Number of Lecture Hours/Week</td><td>03</td><td>Exam Hours</td><td>03</td></tr>
<tr><td>Total Number of Lecture Hours</td><td>40</td><td>Exam Marks</td><td>80</td></tr>
<tr><td colspan="4">Credits - 03</td></tr>
</table>

Course objectives:

- To explain about different sources of harmonics in power system.
- To explain effects of harmonics and mitigation of harmonics.
- To explain modeling of power system components for harmonic studies.
- Introducing different methods of harmonic studies. ■

<table>
<tr><td colspan="2">Module-1</td><td>Teaching Hours</td></tr>
<tr><td colspan="2">Fundamentals of Harmonics: Introduction, Examples of harmonic waveforms, characteristics of harmonics in power systems, measurement of harmonic distortion, power in passive elements, calculation of passive elements, resonance, capacitor banks and reactive power supply, capacitor banks and power factor correction, bus voltage rise and resonance, harmonics in transformers.
Harmonics in Power system: Introduction, sources of harmonics, transformers, rotating machines, fluorescent lights, static var compensators, cycloconverters. Single phase controlled rectifiers, three phase converters. ■</td><td rowspan="2">08</td></tr>
<tr><td>Revised Bloom's Taxonomy Level</td><td>L_1 – Remembering, L_2 – Understanding.</td></tr>
<tr><td colspan="3">Module-2</td></tr>
<tr><td colspan="2">Effects of Harmonic Distortion on Power System: Introduction, thermal losses in a harmonic environment, harmonic effects on power system equipment, capacitor banks, transformers, rotating machines, protection, communication and electronic equipment.
Mitigation of Power system Harmonics: Introduction, harmonic filters, power converters, transformers, rotating machines, capacitor banks, harmonic filter design, active filters. ■</td><td rowspan="2">08</td></tr>
<tr><td>Revised Bloom's Taxonomy Level</td><td>L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing.</td></tr>
<tr><td colspan="3">Module-3</td></tr>
<tr><td colspan="2">Limits of Harmonic Distortion: Introduction, voltage harmonic distortion limits, current harmonic distortion limits.
Harmonic studies – Modelling of System Components: Introduction, impedance in the presence of harmonics, skin effect, modelling of the high voltage grid, generator modelling, modelling of shunt capacitor banks, series capacitor banks, load models, induction motor modelling.
Transformer Modelling: Introduction, modelling of two winding transformers, phase sequence admittance matrices, transmission of voltage and current across two winding transformers, transmission matrices and phase admittance matrix, modelling of three and four winding transformers.■</td><td rowspan="2">08</td></tr>
<tr><td>Revised Bloom's Taxonomy Level</td><td>L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing.</td></tr>
<tr><td colspan="3">Module-4</td></tr>
<tr><td colspan="2">Modelling of Transmission lines/Cables: Introduction, skin effect, modelling of power lines, Line's series impedance, mutual coupling between conductors, mutually coupled lines, line's shunt capacitance, surge impedance and velocity of propagation, line's series impedance and shunt capacitance – single phase equivalents, the transmission (ABCD) matrix, the admittance matrix, conversion between the transmission and admittance matrices, the nominal pi model – single phase equivalent, the equivalent pi model – voltage and current the line, line losses, the equivalent pi model – single phase equivalent, variations in the network's short circuit capacity, examples – the nominal and equivalent models. ■</td><td rowspan="2">08</td></tr>
<tr><td>Revised Bloom's Taxonomy Level</td><td>L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing.</td></tr>
<tr><td colspan="3"></td></tr>
</table>

M.TECH COMPTER APPLICATIONS TO INDUSTRIAL DRIVES (ECD) 16ECD152 POWER SYSTEM HARMONICS (Elective Course) (continued) CHOICE BASED CREDIT SYSTEM (CBCS)		
Module-5		**Teaching Hours**
Power System Harmonic Studies: Introduction, harmonic analysis using a computer program, harmonic analysis using spread sheet, harmonic distortion limits, harmonic filter rating, and practical considerations. Harmonic study of simple system, 300 -22 kV power system and low voltage system. ■		**08**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing.	

Course outcomes:

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

- Explain the fundamentals that facilitate the understanding of the issues of harmonics.
- Explain the causes for generation of harmonics in power system.
- Explain the effects of harmonics distortion on power system equipment and loads.
- Explain the methods used to suppress the harmonics in power systems.
- Discuss standard limits of harmonic distortion and modeling of power system components for harmonic analysis study.
- Model transmission lines and cables for harmonic analysis.
- Discuss implementation of harmonic studies. ■

Graduate Attributes (As per NBA):

Engineering Knowledge, Problem Analysis, Design / development of solutions, Modern Tool Usage, Ethics.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 16 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. ■

Text/Reference Books

1	Power System Harmonics	George J Wakileh	Springer	Reprint, 2014
2	Power System Harmonic Analysis	Jos Arrillaga et al	Wiley	Reprint, 2014
3	Power System Harmonic	J. Arrillaga, N.R. Watson	Wiley	2nd Edition, 2003
4	Harmonics and Power Systems	Francisco C. DE LA Rosa	CRC Press	1st Edition, 2006

M.TECH COMPTER APPLICATIONS TO INDUSTRIAL DRIVES (ECD) CHOICE BASED CREDIT SYSTEM (CBCS) SEMESTER - I			
ADVANCED CONTROL SYSTEMS (Elective Course)			
Subject Code	16ECD153	IA Marks	20
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	40	Exam Marks	80
Credits - 03			

Course objectives:

- To impart basic knowledge about digital control through signal conversion, their representation, z – transform, stability analysis in the z – plane, signal reconstruction .etc.
- Development of models of systems in the digital domain, and their implementation.
- To perform state variable method of analysis of digital control systems.
- To impart knowledge of optimal control system analysis in continuous and discrete time domains.
- To impart knowledge about the analysis of nonlinear control systems. ■

Module-1		**Teaching Hours**
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. ■		**08**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing.	
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. ■		**08**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing.	
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. ■		**08**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing.	
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. ■		**08**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing.	

M.TECH COMPTER APPLICATIONS TO INDUSTRIAL DRIVES (ECD)
16ECD153 ADVANCED CONTROL SYSTEMS (Elective Course) (continued)
CHOICE BASED CREDIT SYSTEM (CBCS)

Module-5		**Teaching Hours**
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. ■		**08**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing.	

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. ■

Graduate Attributes (As per NBA):

Engineering Knowledge, Problem Analysis, Design / development of solutions, Modern Tool Usage, Ethics.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 16 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. ■

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

M.TECH COMPTER APPLICATIONS TO INDUSTRIAL DRIVES (ECD)
CHOICE BASED CREDIT SYSTEM (CBCS)
SEMESTER - I

EMC IN POWER ELECTRONICS (Elective Course)

Subject Code	16ECD154	IA Marks	20
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	40	Exam Marks	80

Credits - 03

Course objectives:

- To explain different electromagnetic disturbances and their classification.
- To explain measurement of the high frequency characteristics of EMI filter elements, their selection and measurement.
- To explain suppression of noise in relay systems.
- To explain designing and analysis of EMI filters.
- To explain conduction of test as per IEC specifications and reducing internal EMI. ■

Module		Teaching Hours
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. ■		**08**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing.	
Module-2		
EMI Filter Elements: Measuring High Frequency Characteristics OF EMI Filter Elements, Capacitors, Choke Coils, Resistors. ■		**08**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing.	
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. ■		**08**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing.	
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. ■		**08**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing.	
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. ■		**08**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing.	

M.TECH COMPTER APPLICATIONS TO INDUSTRIAL DRIVES (ECD)
16ECD154 EMC IN POWER ELECTRONICS (Elective Course) (continued)
CHOICE BASED CREDIT SYSTEM (CBCS)

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. ■

Graduate Attributes (As per NBA):

Engineering Knowledge, Problem Analysis, Design / development of solutions, Modern Tool Usage, Ethics.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 16 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. ■

Text Book

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

M.TECH COMPTER APPLICATIONS TO INDUSTRIAL DRIVES (ECD)
CHOICE BASED CREDIT SYSTEM (CBCS)
SEMESTER - I

POWER ELECTRONICS LABORATORY

Subject Code	16ECDL16	IA Marks	20
Number of Practical Hours/Week	03	Exam Hours	03
Total Number of Practical Hours	40	Exam Marks	80

Credits - 02

Course objectives:

- To conduct experiment on various power electronic devices to analyze their static and dynamic characteristics.
- To conduct experiments and enhance understanding of different power electronic converters. ■

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.

Revised Bloom's Taxonomy Level	L_3 – Applying, L_4 – Analysing, L_5 – Evaluating, L_6 – Creating

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. ■

Graduate Attributes (As per NBA):

Engineering Knowledge, Problem Analysis, Conduct investigations of complex Problems, Modern Tool Usage, Individual and Team work, Communication.

M.TECH COMPTER APPLICATIONS TO INDUSTRIAL DRIVES (ECD) CHOICE BASED CREDIT SYSTEM (CBCS) SEMESTER - I			
SEMINAR			
Course Code	16ECD17	IA Marks	100
No. of Lecture Hours/Week	--	Exam Hours	--
Number of contact Hours/week	03	Number of Tutorial Hours/week	--
Total No. of contact Hours	--	Exam Marks	--
Credits - 01			

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, 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 Internal Assessment 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 Chairman. ■

Marks distribution for internal assessment of the course 16ECD17 seminar:
Seminar Report: 30 marks
Presentation skill:50 marks
Question and Answer:20 marks

Graduate Attributes (As per NBA):
Engineering Knowledge, Problem Analysis, Design / development of solutions, Conduct investigations of complex Problems, Modern Tool Usage, Engineers and society, Environment and sustainability, Ethics, Individual and Team work, Communication.

*** END ***

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI

SCHEME OF TEACHING AND EXAMINATION - 2016-17

M.Tech COMPUTER APPLICATION IN INDUSTRIAL DRIVES (ECD)

CHOICE BASED CREDIT SYSTEM (CBCS)

(Total number of credits prescribed for the programme - 85)

II SEMESTER

Sl. No	Subject Code	Title	Teaching Hours /Week		Examination				Credits
			Theory	Practical/ Field work/ Assignment	Duration in hours	I.A. Marks	Theory/ Practical Marks	Total Marks	
1	16ECD21	AC and DC Drives - 2	04	--	03	20	80	100	4
2	16ECD22	DSP Applications to Drives	04	--	03	20	80	100	4
3	16ECD23	Hybrid Electric Vehicles	04	--	03	20	80	100	4
4	16ECD24	Modelling and Design Of Controllers	04	--	03	20	80	100	4
5	16ECD25X	Elective - II	03	--	03	20	80	100	3
6	16ECDL26	Drives Laboratory	-	3	03	20	80	100	2
7	16ECD27	Seminar	-	3	-	100	-	100	1
TOTAL			**19**	**06**	**18**	**220**	**480**	**700**	**22**

Number of credits completed at the end of II semester: 22+ 22 = 44

Elective - II

Courses under Code 16ECD25X	Title
16ECD251	Power Quality Problems and Mitigation
16ECD252	Electric Drive Design
16ECD253	Vector Control of Three-Phase AC Machines
16ECD254	Automatic Control and Power Electronics

Note: Project Phase-1: 6-week duration shall be carried out between 2nd and 3rd Semester vacation. Candidates in consultation with the guide shall carry out literature survey/ visit industries to finalize the topic of Project.

M.TECH COMPTER APPLICATIONS TO INDUSTRIAL DRIVES (ECD)
CHOICE BASED CREDIT SYSTEM (CBCS)
SEMESTER - II

AC AND DC DRIVES - 2 (Core Course)

Course Code	16ECD21	IA Marks	20
Number of Lecture Hours/Week	04	Exam Hours	03
Total Number of Lecture Hours	50	Exam Marks	80

Credits - 04

Course objectives:

- To explain the design aspects of current source induction motor drives. The principle of direct and indirect vector control, their derivations, control schemes and their implementations and tuning of vector controllers.
- To explain the analysis of indirect vector controlled induction motor drive, design of controller and applications of indirect vector controlled induction motor drives.
- To explain the operation of permanent magnet synchronous motor and its control strategies, flux weakening operation and design of speed controller for permanent magnet synchronous motor.
- To model and analyze and simulate permanent magnet brushless DC motor.
- To explain the basic concepts, operating principles and control of switched reluctance drives.
- To explain the use of artificial intelligence techniques for intelligent control of Power Electronics and to discuss the design methods along with some applications. ■

Module-1		Teaching Hours
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. ■		**10**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding.	

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. ■		**10**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding.	

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. ■		**10**
Revised Bloom's Taxonomy Level	L_1 - Remembering, L_2 - Understanding, L_3 - Applying, L_4 – Analysing.	

Module-4		
Switched Reluctance Drive Systems: Basic Machine Concepts, Operating Principles, Multi-Phase Machines, Control of Switched Reluctance Drives, Switched Reluctance Demonstration Machine. ■		**10**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding.	

M.TECH COMPTER APPLICATIONS TO INDUSTRIAL DRIVES (ECD)
16ECD21 AC AND DC DRIVES - 2 (Core Course) (continued)
CHOICE BASED CREDIT SYSTEM (CBCS)

Module-5		**Teaching Hours**
Expert System, Fuzzy Logic, and Neural networks for Drives: Introduction, Expert System, Fuzzy Logic, Neural Network. ■		**10**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding.	

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. ■

Graduate Attributes (As per NBA):

Engineering Knowledge, Problem Analysis, Design / development of solutions, Modern Tool Usage.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 16 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. ■

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

M.TECH COMPTER APPLICATIONS TO INDUSTRIAL DRIVES (ECD)
CHOICE BASED CREDIT SYSTEM (CBCS)
SEMESTER - II

DSP APPLICATIONS TO DRIVES (Core Course)

Course Code	16ECD22	IA Marks	20
Number of Lecture Hours/Week	04	Exam Hours	03
Total Number of Lecture Hours	50	Exam Marks	80

Credits - 04

Course objectives:

- To explain the architectural features of TMSLF2407 DSP processor, its peripherals.
- To explain C2xxDSP CPU, its components and instruction set, and the peripheral interface.
- To explain General Purpose Input /Output (GPIO) Functionality, interrupts on TMS320LF2407 and the Analog to digital conversion (ADC).
- To describe the capability of event managers of DSP.
- To explain the implementation of DC – DC converters and control of stepper motor permanent magnet brushless DC Motor using DSP and perform Clarke's and Park's transformations on DSP processor.
- Discuss space vector pulse width modulation technique and the DSP based control of motors. ■

Module	Teaching Hours
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. ■	**10**
Revised Bloom's Taxonomy Level: L_1 – Remembering, L_2 – Understanding.	
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. ■	**10**
Revised Bloom's Taxonomy Level: L_1 – Remembering, L_2 – Understanding.	
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. ■	**10**
Revised Bloom's Taxonomy Level: L_1 - Remembering, L_2 - Understanding, L_3 - Applying, L_4 – Analysing.	
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.	**10**

M.TECH COMPTER APPLICATIONS TO INDUSTRIAL DRIVES (ECD)
16ECD22 DSP APPLICATIONS TO DRIVES (Core Course) (continued)
CHOICE BASED CREDIT SYSTEM (CBCS)

Module-4 (continued)		Teaching Hours
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. ■		**10**
Revised Bloom's Taxonomy Level	L_1 - Remembering, L_2 - Understanding, L_3 - Applying, L_4 – Analysing.	
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. ■		**10**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing.	

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. ■

Graduate Attributes (As per NBA):

Engineering Knowledge, Problem Analysis, Design / development of solutions, Modern Tool Usage, Individual and Team work, Communication, Lifelong Learning.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 16 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. ■

Text Book

1	DSP-Based Electromechanical Motion Control	Hamid A. Toliyat	CRC Press	2004

M.TECH COMPTER APPLICATIONS TO INDUSTRIAL DRIVES (ECD)
CHOICE BASED CREDIT SYSTEM (CBCS)
SEMESTER - II

HYBRID ELECTRIC VEHICLES (Core Course)

Course Code	16ECD23	IA Marks	20
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	50	Exam Marks	80

Credits - 04

Course objectives:

- To explain the basics of electric and hybrid electric vehicles, their architecture, technologies and fundamentals.
- To explain plug – in hybrid electric vehicle architecture, design and component sizing and the power electronics devices used in hybrid electric vehicles.
- To discuss various electric drives suitable for hybrid electric vehicles.
- To discuss different energy storage technologies used for hybrid electric vehicles and their control.
- To explain modeling and simulation of electric hybrid vehicles by different techniques, sizing of components and design optimization and energy management. ■

Module-1	Teaching Hours
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. ■	**10**
Revised Bloom's Taxonomy Level: L_1 – Remembering, L_2 – Understanding.	

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. ■	**10**
Revised Bloom's Taxonomy Level: L_1 – Remembering, L_2 – Understanding.	

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. ■	**10**
Revised Bloom's Taxonomy Level: L_1 – Remembering, L_2 – Understanding.	

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. ■	**10**
Revised Bloom's Taxonomy Level: L_1 – Remembering, L_2 – Understanding.	

M.TECH COMPTER APPLICATIONS TO INDUSTRIAL DRIVES (ECD)
16ECD23 HYBRID ELECTRIC VEHICLES (Core Course) (continued)
CHOICE BASED CREDIT SYSTEM (CBCS)

Module-5	**Teaching Hours**
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. ■	**10**
Revised Bloom's Taxonomy Level: L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing.	

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. ■

Graduate Attributes (As per NBA):
Engineering Knowledge, Problem Analysis, Modern Tool Usage, Individual and Team work, Communication.

Question paper pattern:
- The question paper will have ten questions.
- Each full question is for 16 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. ■

Text Book

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

<table>
<tr><td colspan="4" align="center">M.TECH COMPTER APPLICATIONS TO INDUSTRIAL DRIVES (ECD)
CHOICE BASED CREDIT SYSTEM (CBCS)
SEMESTER - I</td></tr>
<tr><td colspan="4" align="center">MODELLING AND DESIGN OF CONTROLLERS (Core Course)</td></tr>
<tr><td>Course Code</td><td>16ECD24</td><td>IA Marks</td><td>20</td></tr>
<tr><td>Number of Lecture Hours/Week</td><td>04</td><td>Exam Hours</td><td>03</td></tr>
<tr><td>Total Number of Lecture Hours</td><td>50</td><td>Exam Marks</td><td>80</td></tr>
<tr><td colspan="4" align="center">Credits - 04</td></tr>
</table>

Course objectives:

- To impart knowledge required for modeling and computer simulation of power electronic converters and systems.
- To explain control system essentials in representing system in digital domain.
- To explain the designing of digital controllers by different methods.
- To explain the design and analysis of optimal and robust controllers by different methods.
- To impart knowledge of discrete computation essentials. ■

<table>
<tr><td colspan="2">Module-1</td><td>Teaching Hours</td></tr>
<tr><td colspan="2">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. ■</td><td rowspan="2">10</td></tr>
<tr><td>Revised Bloom's Taxonomy Level</td><td>L_1 – Remembering, L_2 – Understanding, L_3 – Applying.</td></tr>
<tr><td colspan="3">Module-2</td></tr>
<tr><td colspan="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. ■</td><td rowspan="2">10</td></tr>
<tr><td>Revised Bloom's Taxonomy Level</td><td>L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing.</td></tr>
<tr><td colspan="3">Module-3</td></tr>
<tr><td colspan="2">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. ■</td><td rowspan="2">10</td></tr>
<tr><td>Revised Bloom's Taxonomy Level</td><td>L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing.</td></tr>
<tr><td colspan="3">Module-4</td></tr>
<tr><td colspan="2">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. ■</td><td rowspan="2">10</td></tr>
<tr><td>Revised Bloom's Taxonomy Level</td><td>L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing.</td></tr>
<tr><td colspan="3">Module-5</td></tr>
<tr><td colspan="2">Discrete Computation Essentials: Numeric Formats, Tracking the Base Point in the Fixed Point System, Normalization And Scaling, Arithmetic Algorithms. ■</td><td rowspan="2">10</td></tr>
<tr><td>Revised Bloom's Taxonomy Level</td><td>L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing.</td></tr>
<tr><td colspan="3"></td></tr>
</table>

M.TECH COMPTER APPLICATIONS TO INDUSTRIAL DRIVES (ECD)
16ECD24 MODELLING AND DESIGN OF CONTROLLERS (Core Course) (continued)
CHOICE BASED CREDIT SYSTEM (CBCS)

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.■

Graduate Attributes (As per NBA):

Engineering Knowledge, Problem Analysis, Design / development of solutions, Ethics.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 16 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. ■

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

M.TECH COMPTER APPLICATIONS TO INDUSTRIAL DRIVES (ECD) CHOICE BASED CREDIT SYSTEM (CBCS) SEMESTER - II			
POWER QUALITY PROBLEMS AND MITIGATION (ELECTIVE COURSE)			
Course Code	16ECD251	IA Marks	20
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	40	Exam Marks	80
Credits - 03			

Course objectives:

- To give an introduction on power quality (PQ), causes and effects of PQ problems, requirement of PQ improvements, and mitigation aspects of PQ problems.
- To give PQ definitions, terminologies, standards, benchmarks, monitoring requirements through numerical problems.
- To explain passive shunt and series compensation using lossless passive LC components, active shunt compensation using DSTATCOM (distribution static compensators), active series compensation using DVR (dynamic voltage restorer), and combined compensation using UPQC (unified power quality compensator) for mitigation of current-based PQ problems.
- To explain classification, modeling and analysis of various nonlinear loads which cause the power quality problems. ■

Module-1		**Teaching Hours**
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. ■		**08**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing.	
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. ■		**08**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing.	
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. ■		**08**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing.	
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). ■		**08**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing.	

M.TECH COMPTER APPLICATIONS TO INDUSTRIAL DRIVES (ECD) 16ECD251 POWER QUALITY PROBLEMS AND MITIGATION (Elective Course) (continued) CHOICE BASED CREDIT SYSTEM (CBCS)		
Module-5		**Teaching Hours**
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. ■		**08**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing.	

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. ■

Graduate Attributes (As per NBA):

Engineering Knowledge, Problem Analysis, Design / development of solutions, Modern Tool Usage, Engineers and society, Ethics, Individual and Team work, Communication, Lifelong Learning.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 16 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. ■

Text Book

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

M.TECH COMPTER APPLICATIONS TO INDUSTRIAL DRIVES (ECD) CHOICE BASED CREDIT SYSTEM (CBCS) SEMESTER - II			
ELECTRIC DRIVE DESIGN (Elective Course)			
Course Code	16ECD252	IA Marks	20
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	40	Exam Marks	80
Credits - 03			

Course objectives:

- To define a drive, identify the components of a drive, explain the function and specifications of driven body, its transient behavior and transmission types and characterization of transmission system.
- To identify the motors used for the drives, their characteristics and to develop dynamic equations for the design a drive.
- To develop the thermal equations for the behavior of the electrical machine to study the dynamic behavior of the drive.
- To study the electrical and electromagnetic peripherals such as voltages sources, auto transformers and other devices used for starting the electrical motors and power electronics devices to control the operation of the motor.
- To study sensors for controlling the position and speed of the motor, performance limits of direct drives and motors with external rotors and realization of power electronics and control systems associated with a drive. ■

Module-1		Teaching Hours
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. ■		**08**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding.	
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. ■		**08**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding.	
Module-3		
Motors - Characterization: Characteristics, Scaling laws, Parametric expression. **Global Design of an Electric Drive**: Introduction, Dynamic equations, Example. ■		**08**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding.	
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. ■		**08**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding.	

M.TECH COMPTER APPLICATIONS TO INDUSTRIAL DRIVES (ECD)
16ECD252 ELECTRIC DRIVE DESIGN (Elective Course) (continued)
CHOICE BASED CREDIT SYSTEM (CBCS)

Module-5		**Teaching Hours**
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. ■		**08**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding.	

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. ■

Graduate Attributes (As per NBA):

Engineering Knowledge, Problem Analysis.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 16 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. ■

Text Book

1	Electric Drives	Marcel Jufer	Wiley	2010

M.TECH COMPTER APPLICATIONS TO INDUSTRIAL DRIVES (ECD)
CHOICE BASED CREDIT SYSTEM (CBCS)
SEMESTER - II

VECTOR CONTROL OF THREE-PHASE AC MACHINES (Elective Course)

Course Code	16ECD253	IA Marks	20
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	40	Exam Marks	80

Credits - 03

Course objectives:

- To formulate space vectors and space vector philosophy using three phase ac machine and use space vector modulation in the control of inverter.
- To study the machine mathematical models in designing the controllers and observers for control of the machines.
- To explain principles of the actual-value measurement, to highlight its problems and to answer some related questions of the field orientation.
- To design a current vector controller with dead beat behavior for an ac drive.
- To use the equivalent circuits with constant parameters in designing the controllers and automated computation of the electrical motor parameters.
- To study the range and effects of temperature-dependent changes of the rotor resistance on other characteristic quantities and adaptation methods with a parametric error model. ■

Module-1	Teaching Hours
Principles of Vector Orientation and Vector Orientated Control Structures for Systems Using Three-Phase AC Machines: Formation of the Space Vectors and Its Vector Orientated Philosophy, Basic Structures with Field-Orientated Control for Three-Phase AC Drives. **Inverter Control with Space Vector Modulation:** Principle of Vector Modulation, Calculation and Output of the Switching Times, Restrictions of the Procedure, Realization Examples, Special Modulation Procedures, Degrees of Freedom in Modulation. ■	**08**
Revised Bloom's Taxonomy Level: L_1 – Remembering, L_2 – Understanding.	
Module-2	
Machine Models as Prerequisite to Design the Controllers and Observers: General Issues of State Space Representation, Induction Machine with Squirrel-Cage Rotor (IM), Permanent Magnet Excited Synchronous Machine (PMSM),Generalized Current Process Model for the Two Machine Types IM and PMSM, Nonlinear Properties of the Machine Models and the Way to Nonlinear Controllers. ■	**08**
Revised Bloom's Taxonomy Level: L_1 – Remembering, L_2 – Understanding.	
Module-3	
Problems of Actual-Value Measurement and Vector Orientation: Acquisition of the Current, Acquisition of the Speed, Possibilities for Sensor-Less Acquisition of the Speed,Field Orientation and Its Problems. **Dynamic Current Feedback Control for Fast Torque Impression in Drive Systems:** Survey About Existing Current Control Methods, Environmental Conditions, Closed Loop Transfer Function and Control Approach, Design of a Current Vector Controller with Dead-Beat Behaviour, Design of a Current State Space Controller with Dead-Beat Behaviour, Treatment of the Limitation of Control Variables. ■	**08**
Revised Bloom's Taxonomy Level: L_1 – Remembering, L_2 – Understanding.	
Module-4	
Equivalent Circuits and Methods to Determine the System Parameters: Equivalent Circuits with Constant Parameters, Modelling of the Nonlinearities of the IM, Parameter Estimation from Name Plate Data, Automatic Parameter Estimation for IM in Standstill. ■	**08**
Revised Bloom's Taxonomy Level: L_1 – Remembering, L_2 – Understanding.	

M.TECH COMPTER APPLICATIONS TO INDUSTRIAL DRIVES (ECD)
16ECD253 VECTOR CONTROL OF THREE-PHASE AC MACHINES (Elective Course) (continued)
CHOICE BASED CREDIT SYSTEM (CBCS)

Module-5	**Teaching Hours**
On-Line Adaptation of the Rotor Time Constant for IM Drives: Motivation, Classification of Adaptation Methods, Adaptation of the Rotor Resistance with Model Methods. **Optimal Control of State Variables and Set Points for IM Drives:** Objective, Efficiency Optimized Control, Stationary Torque Optimal Set Point Generation, Comparison of the Optimization Strategies, Rotor Flux Feedback Control. ■	**08**
Revised Bloom's Taxonomy Level: L_1 – Remembering, L_2 – Understanding.	

Course outcomes:

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

- Explain space vectors and their philosophy using three phase ac machine and use it in the control of inverter.
- Use the machine mathematical models in designing the controllers and observers for control of the machines.
- Explain principles of the actual-value measurement.
- Design a current vector controller with dead beat behavior for an ac drive.
- Design controllers using equivalent circuits of motors with constant parameters.
- Perform automated computation of the electrical motor parameters.
- Explain the range and effects of temperature-dependent changes of the rotor resistance on other characteristic quantities. ■

Graduate Attributes (As per NBA):

Engineering Knowledge, Problem Analysis.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 16 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. ■

Text Book

1	Vector Control of Three-Phase AC Machines System Development in the Practice	Nguyen Phung Quang, Jörg-Andreas Dittrich	Springer	2^{nd} Edition, 2015

M.TECH COMPTER APPLICATIONS TO INDUSTRIAL DRIVES (ECD)
CHOICE BASED CREDIT SYSTEM (CBCS)
SEMESTER - II

AUTOMATIC CONTROL AND POWER ELECTRONICS (Elective Course)

Course Code	16ECD254	IA Marks	20
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	40	Exam Marks	80

Credits - 03

Course objectives:

- To define sliding mode control and variable structure systems and to use the sliding mode control in the control of different converters.
- To apply linear feedback control for approximately linearized nonlinear system namely power electronic converters.
- To use different nonlinear methods in controlling the power electronics devices. ■

Module-1		Teaching Hours
Sliding Mode Control: Introduction, Variable Structure Systems, Control of the Boost Converter, Control of the Buck-Boost Converter, Control of the C´uk Converter, Control of the Zeta Converter, Control of the Quadratic Buck Converter, Multi-variable Case, Control of the Boost-Boost Converter, Control of the Double Buck-Boost Converter, $\Sigma - \Delta$ Modulation. ■		**08**
Revised Bloom's Taxonomy Level	L_1 - Remembering, L_2 - Understanding, L_3 – Applying.	
Module-2		
Approximate Linearization in the Control of Power Electronics Devices: Introduction, Linear Feedback Control, The Buck Converter. ■		**08**
Revised Bloom's Taxonomy Level	L_1 - Remembering, L_2 - Understanding, L_3 – Applying.	
Module-3		
Approximate Linearization in the Control of Power Electronics Devices (continued): The Boost Converter, The Buck-Boost Converter, The C´uk Converter, The Zeta Converter, The Quadratic Buck Converter, The Boost-Boost Converter. ■		**08**
Revised Bloom's Taxonomy Level	L_1 - Remembering, L_2 - Understanding, L_3 – Applying.	
Module-4		
Nonlinear Methods in the Control of Power Electronics Devices: Introduction, Feedback Linearization, Passivity Based Control. ■		**08**
Revised Bloom's Taxonomy Level	L_1 - Remembering, L_2 - Understanding, L_3 – Applying.	
Module-5		
Nonlinear Methods in the Control of Power Electronics Devices (continued): Exact Error Dynamics Passive Output Feedback Control, Error Dynamics Passive Output Feedback, Control via Fliess' Generalized Canonical Form, Nonlinear Observers for Power Converters.■		**08**
Revised Bloom's Taxonomy Level	L_1 - Remembering, L_2 - Understanding, L_3 – Applying.	

M.TECH COMPTER APPLICATIONS TO INDUSTRIAL DRIVES (ECD)
16ECD254 AUTOMATIC CONTROL AND POWER ELECTRONICS (Elective Course) (continued)
CHOICE BASED CREDIT SYSTEM (CBCS)

Course outcomes:

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

- Discuss sliding mode control and variable structure systems.
- Control of power electronic converters using sliding mode control.
- Explain approximate linearization in power electronic converters.
- Control power electronic converters using linear feedback control.
- Explain feedback linearization.
- Use nonlinear methods in controlling the power electronics devices. ■

Graduate Attributes (As per NBA):

Engineering Knowledge, Problem Analysis.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 16 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. ■

Text Book

1	Control Design Techniques in Power Electronics Devices	Hebertt Sira-Ramírez et al	Springer	2006

M.TECH COMPTER APPLICATIONS TO INDUSTRIAL DRIVES (ECD) CHOICE BASED CREDIT SYSTEM (CBCS) SEMESTER - II			
DRIVES LABORATORY			
Course Code	16ECDL26	IA Marks	20
Number of Practical Hours/Week	03	Exam Hours	03
Total Number of Practical Hours	40	Exam Marks	80
Credits - 02			

Course objectives:

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

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).

Revised Bloom's Taxonomy Level	L_1 - Remembering, L_2 - Understanding, L_3 - Applying, L_4 - Analysing, L_5 – Evaluating.

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. ■

Graduate Attributes (As per NBA):

Engineering Knowledge, Problem Analysis, Conduct investigations of complex Problems, Modern Tool Usage, Individual and Team work, Communication.

M.TECH COMPTER APPLICATIONS TO INDUSTRIAL DRIVES (ECD) CHOICE BASED CREDIT SYSTEM (CBCS) SEMESTER - II			
SEMINAR			
Course Code	16ECD27	IA Marks	100
No. of Lecture Hours/Week	--	Exam Hours	--
Number of contact Hours/week	03	Number of Tutorial Hours/week	--
Total No. of contact Hours	--	Exam Marks	--
Credits - 01			

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, 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 Internal Assessment 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 Chairman. ■

Marks distribution for internal assessment of the course 16ECD27 seminar:
Seminar Report: 30 marks
Presentation skill:50 marks
Question and Answer:20 marks

Graduate Attributes (As per NBA):
Engineering Knowledge, Problem Analysis, Design / development of solutions, Conduct investigations of complex Problems, Modern Tool Usage, Engineers and society, Environment and sustainability, Ethics, Individual and Team work, Communication.

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI
SCHEME OF TEACHING AND EXAMINATION – 2016-17
M.Tech COMPUTER APPLICATION IN INDUSTRIAL DRIVES (ECD)
CHOICE BASED CREDIT SYSTEM (CBCS)
(Total number of credits prescribed for the programme – 85)

III SEMESTER

Sl. No	Subject Code	Title	Teaching Hours /Week: Theory	Teaching Hours /Week: Practical/ Field work/ Assignment	Examination: Duration in hours	Examination: I.A. Marks	Examination: Theory/ Practical Marks	Examination: Total Marks	Credits
1	16ECD31	Seminar / Presentation on Internship. (After 8 weeks from the date of commencement)	Internship is for a period of 16 weeks		--	25	--	25	20
2	16ECD32	Report on Internship	--	--	--	25	--	25	
3	16ECD33	Evaluation and Viva-Voce of Internship	--	--	--	--	50	50	
4	16ECD34	Evaluation of Project phase -1	--	--	--	50	--	50	1
		TOTAL	--	--	--	**100**	**50**	**150**	**21**

Number of credits completed at the end of III semester: 22+ 22 + 21 = 65

Note:
Internship of 16 weeks shall be carried out during III semester.
Major part of the Project work shall also be carried out during the III semester in consultation with the Guide/s.

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI
SCHEME OF TEACHING AND EXAMINATION – 2016-17
M.Tech COMPUTER APPLICATION IN INDUSTRIAL DRIVES (ECD)
CHOICE BASED CREDIT SYSTEM (CBCS)
(Total number of credits prescribed for the programme – 85)

IV SEMESTER

Sl. No	Subject Code	Title	Teaching Hours /Week		Examination				Credits
			Theory	Practical/ Field work/ Assignment	Duration in hours	I.A. Marks	Theory/ Practical Marks	Total Marks	
1	16ECD41	Predictive Control of Drives	04	--	03	20	80	100	4
2	16ECD42X	Elective - 3	03	--	03	20	80	100	3
3	16ECD43	Evaluation of Project phase - 2	--	--	--	50	-	50	3
4	16ECD44	Evaluation of Project and Viva-Voce	--	--	--	--	100 + 100	200	10
		TOTAL	**07**	**--**	**06**	**90**	**360**	**450**	**20**

Number of credits completed at the end of IV semester: 22+ 22 + 21 + 20 = 85

Elective - 3

Courses under Code 16ECD42X	Title
16ECD421	AC drives with inverter Output Filters
16ECD422	Digital Power Electronics
16ECD423	Sensorless AC Motor Control
16ECD424	Sneak Circuits in Converters

Note: 1. Project Phase-1: 6-week duration shall be carried out between 2nd and 3rd Semester vacation. Candidates in consultation with the guide shall carry out literature survey/ visit industries to finalize the topic of Project.
2. Project Phase-2: 16-week duration during 4th semester**.** Evaluation shall be done by the committee comprising of HoD as Chairman, Guide and Senior faculty of the department.
3. **Project Evaluation**: Evaluation shall be taken up at the end of 4th semester. Project work evaluation and Viva-Voce examination shall conducted
4**. Project evaluation:**

a. Internal Examiner shall carry out the evaluation for 100 marks.
b. External Examiner shall carry out the evaluation for 100 marks.
c .The average of marks allotted by the internal and external examiner shall be the final marks of the project evaluation.
d. Viva-Voce examination of Project work shall be conducted jointly by Internal and External examiner for 100 marks.

M.TECH COMPTER APPLICATIONS TO INDUSTRIAL DRIVES (ECD) CHOICE BASED CREDIT SYSTEM (CBCS) SEMESTER - IV			
PREDICTIVE CONTROL OF DRIVES (Core Course)			
Course Code	16ECD41	IA Marks	20
Number of Lecture Hours/Week	04	Exam Hours	03
Total Number of Lecture Hours	50	Exam Marks	80
Credits - 04			

Course objectives:

- To explain the mathematical modeling of machine drives and power converter using space vector description of physical variables such as voltage, current and flux, and converting the space vector based model to various reference frames.
- To explain control of semiconductor switches in the implementation of control systems and the PWM implementation of control systems
- To 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.
- To explain Implementation of P and PI controllers for both current controllers as inner-loop controllers, and velocity and *DC* voltage controllers as outer-loop controllers.
- To explain tuning of P and PI controllers for different applications and to study the performance robustness of the controllers. ■

Module-1		**Teaching Hours**
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. ■		**10**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing.	
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. ■		**10**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing.	
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. ■		**10**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing.	

M.TECH COMPTER APPLICATIONS TO INDUSTRIAL DRIVES (ECD)
16ECD41 PREDICTIVE CONTROL OF DRIVES (Core Course) (continued)
CHOICE BASED CREDIT SYSTEM (CBCS)

Module-4		**Teaching Hours**
FCS Predictive Control in $d - q$ 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. ■		**10**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing.	
Module-5		
FCS Predictive Control in $\alpha - \beta$ 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.■		**10**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing.	

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. ■

Graduate Attributes (As per NBA):

Engineering Knowledge, Problem Analysis, Design / development of solutions, Modern Tool Usage, Individual and Team work, Communication, Lifelong Learning.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 16 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. ■

Text Book

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

M.TECH COMPTER APPLICATIONS TO INDUSTRIAL DRIVES (ECD) CHOICE BASED CREDIT SYSTEM (CBCS) SEMESTER - IV			
AC DRIVES WITH INVERTER OUTPUT FILTERS (Elective Course)			
Course Code	16ECD421	IA Marks	20
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	40	Exam Marks	80
Credits - 03			

Course objectives:

- To give an overview of AC drives with filters, to explain the problems associated with the ac drives in voltage and current common mode and the voltage source inverter supply effects.
- To explain modeling of a squirrel cage motor, Per-Unit System, and Machine Parameters, the structure and operation of output filter model and its design.
- To explain the estimation state variables for drive systems with a sinusoidal filter and study of state observer with a filter simulator using different models.
- To explain the control of an induction motor operating in closed loop without a speed sensor by different methods considering a sinusoidal filter as the control object and to describe predictive motor current control for a drive system with a motor choke.
- To explain the diagnostics of drives and faults in rotor in closed loop control based on the analysis of the calculated electromagnetic torque and load torques of the motor induction motor.
- To explain modeling, simulation and control of multiphase drives with induction motor and LC filter. ■

Module-1		Teaching Hours
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. ■		**08**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing.	
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. ■		**08**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing.	
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. ■		**08**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing.	
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. ■		**08**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing.	

M.TECH COMPTER APPLICATIONS TO INDUSTRIAL DRIVES (ECD)
16ECD421 AC DRIVES WITH INVERTER OUTPUT FILTERS (Elective Course) (continued)
CHOICE BASED CREDIT SYSTEM (CBCS)

Module-5	**Teaching Hours**
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. ■	**08**
Revised Bloom's Taxonomy Level — L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing.	

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. ■

Graduate Attributes (As Per NBA):

Engineering Knowledge, Problem Analysis, Conduct investigations of complex Problems, Communication.

Question Paper pattern:

- The question Paper will have ten questions.
- Each full question is for 16 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. ■

Text Book

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

M.TECH COMPTER APPLICATIONS TO INDUSTRIAL DRIVES (ECD) CHOICE BASED CREDIT SYSTEM (CBCS) SEMESTER - IV			
DIGITAL POWER ELECTRONICS (Elective Course)			
Course Code	16ECD422	IA Marks	20
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	40	Exam Marks	80
Credits - 03			

Course objectives:

- To give introduction to multi quadrant operation and choppers, digital power electronic circuits, power semiconductor devices applied in power electronics and the important factors involved in digital power electronics.
- To explain basic mathematics of digital control systems and mathematical modeling of digitally controlled power electronic devices such as rectifiers, inverters and converters
- To explain open loop and closed loop control of power electronic devices and energy factor application of AC and DC motor drives. ■

Module-1		Teaching Hours
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. ■		**08**
Revised Bloom's Taxonomy Level	L_1 - Remembering, L_2 - Understanding, L_3 – Applying.	
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. ■		**08**
Revised Bloom's Taxonomy Level	L_1 - Remembering, L_2 - Understanding, L_3 – Applying.	
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. ■		**08**
Revised Bloom's Taxonomy Level	L_1 - Remembering, L_2 - Understanding, L_3 – Applying.	

M.TECH COMPTER APPLICATIONS TO INDUSTRIAL DRIVES (ECD) 16ECD422 DIGITAL POWER ELECTRONICS (Elective Course) (continued) CHOICE BASED CREDIT SYSTEM (CBCS)		
Module-4		**Teaching Hours**
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. ■		**08**
Revised Bloom's Taxonomy Level	L_1 - Remembering, L_2 - Understanding, L_3 – Applying.	
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. ■		**08**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding, L_3 – Applying.	

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. ■

Graduate Attributes (As per NBA):

Engineering Knowledge, Problem Analysis.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 16 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. ■

Text Book

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

M.TECH COMPTER APPLICATIONS TO INDUSTRIAL DRIVES (ECD)
CHOICE BASED CREDIT SYSTEM (CBCS)
SEMESTER - IV

SENSORLESS AC MOTOR CONTROL (Elective Course)

Course Code	16ECD423	IA Marks	20
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	40	Exam Marks	80

Credits - 03

Course objectives:

- To give the basic concepts describing the mechanical and electrical behavior of alternating current (AC) machines and modeling of the these machines using Clark and Park transformations.
- To introduce definitions and concepts about the observability theory and observer normal forms for nonlinear systems, and the application of these concepts to AC machines.
- To design and develop observers for nonlinear systems, adoptive interconnected observers and higher order sliding mode observers for PMSM.
- To design a robust controller for AC motors by Backstepping techniques and sliding mode technique.
- To perform the feedback control of AC motors using robust controllers. ■

Module-1		Teaching Hours
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. ■		**08**
Revised Bloom's Taxonomy Level	L_1 - Remembering, L_2 - Understanding, L_3 – Applying.	
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. ■		**08**
Revised Bloom's Taxonomy Level	L_1 - Remembering, L_2 - Understanding, L_3 – Applying.	
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. ■		**08**
Revised Bloom's Taxonomy Level	L_1 - Remembering, L_2 - Understanding, L_3 – Applying.	
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. ■		**08**
Revised Bloom's Taxonomy Level	L_1 - Remembering, L_2 - Understanding, L_3 – Applying.	
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.■		**08**
Revised Bloom's Taxonomy Level	L_1 - Remembering, L_2 - Understanding, L_3 – Applying.	

M.TECH COMPTER APPLICATIONS TO INDUSTRIAL DRIVES (ECD)
16ECD423 SENSORLESS AC MOTOR CONTROL (Elective Course) (continued)
CHOICE BASED CREDIT SYSTEM (CBCS)

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 backstepping techniques and sliding mode technique.
- Perform the feedback control of AC motors using robust controllers. ■

Graduate Attributes (As per NBA):

Engineering Knowledge, Problem Analysis, Design / development of solutions.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 16 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. ■

Text Book

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

M.TECH COMPTER APPLICATIONS TO INDUSTRIAL DRIVES (ECD)
CHOICE BASED CREDIT SYSTEM (CBCS)
SEMESTER - IV

SNEAK CIRCUITS IN CONVERTERS (Elective Course)

Course Code	16ECD424	IA Marks	20
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	40	Exam Marks	80

Credits - 03

Course objectives:

- To give an introduction of sneak circuit, explain sneak circuits in power electronic converters, and an overview of definition, history, and analysis methods for sneak circuits.
- To analyze the sneak circuits in different converter circuits
- To discuss some sneak circuit phenomena in soft-switching converters, and multi resonant converters. Z –source inverter and synchronous DC – DC converters.
- To apply graph theory to discover the sneak circuit phenomenon using paths and mode analysis. In converters.
- To explain the methods to eliminate sneak circuits in power electronic converters and utilization of sneak circuits to improve the performance of power electronic converters. ■

Module-1		Teaching Hours
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. ■		**08**
Revised Bloom's Taxonomy Level	L_1 - Remembering, L_2 - Understanding, L_3 - Applying, L_4 – Analysing.	
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. ■		**08**
Revised Bloom's Taxonomy Level	L_1 - Remembering, L_2 - Understanding, L_3 - Applying, L_4 – Analysing.	
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. ■		**08**
Revised Bloom's Taxonomy Level	L_1 - Remembering, L_2 - Understanding, L_3 - Applying, L_4 – Analysing.	
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.		**08**
Revised Bloom's Taxonomy Level	L_1 - Remembering, L_2 - Understanding, L_3 - Applying, L_4 – Analysing.	

M.TECH COMPTER APPLICATIONS TO INDUSTRIAL DRIVES (ECD)
16ECD424 SNEAK CIRCUITS IN CONVERTERS (Elective Course) (continued)
CHOICE BASED CREDIT SYSTEM (CBCS)

Module-5		**Teaching Hours**
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. ■		**08**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing.	

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. ■

Graduate Attributes (As per NBA):

Engineering Knowledge, Problem Analysis, Design / development of solutions, Conduct investigations of complex Problems, Lifelong Learning.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 16 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. ■

Text Book

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

*** END ***