KERALA TECHNOLOGICAL UNIVERSITY

(PALAKKAD CLUSTER - 08)

Proposed Scheme and Syllabus For

M. Tech.

in

POWER ELECTRONICS

(2015 Admission onwards)

OFFERING DEPARTMENT

ELECTRICAL & ELECTRONICS ENGINEERING

Scheme of M. Tech Programme in POWER ELECTRONICS

Semester 1 (Credits: 22)

Exam Slot	Course No:	Name	L - T – P	Internal Marks	End Semester Exam		Credits
					Marks	Duration (hrs.)	
A	08EE6211	Applied Mathematics	3-0-0	40	60	3	3
B	08EE6221	System Dynamics	3-0-0	40	60	3	3
C	08EE6231	Analysis of Power Electronic Circuits I	4-0-0	40	60	3	4
D	08EE6241	Electric Drives	3-0-0	40	60	3	3
E	08EE6251	ELECTIVE I	3-0-0	40	60	3	3
	08GN6101	Research methodology	0-2-0	100	0	0	2
	08EE6271	Seminar	0-0-2	100	0	0	2
	08EE6281	Power Electronics Lab	0-0-2	100	0	0	2

ELECTIVES

08EE6251(**A**) Power Semiconductor Devices & Modeling
08EE6251 (**B**) Dynamics of electrical machines
08EE6251 (C) Optimization Techniques
08EE6251 (D) High voltage AC and DC Transmission

Note: 8 hours/week is meant for departmental assistance by students.

Semester 2 (Credits:19)

Exam Slot	Course No:	Name	L - T - P	Internal Marks	End Semester Exam		Credits
					Marks	Duration (hrs.)	
A	08EE6212	Analysis of Power Electronic Circuits II	3-1-0	40	60	3	3
B	08EE6222	Switched Mode power Converters	3-0-0	40	60	3	3
C	08EE6232	Advanced Electric Drives	3-0-0	40	60	3	3
D	08EE6242	ELECTIVE II	3-0-0	40	60	3	3
E	08EE6252	ELECTIVE III	3-0-0	40	60	3	3
	08EE6262	Mini Project	0-0-2	100	0	0	2
	08EE6272	Advanced Power Electronics Lab	0-0-2	100	0	0	2

ELECTIVE II
08EE6242 (A) Facts and Custom Power Devices
08EE6242 (B)Power Quality
08EE6242 (C) Digital Simulation of Power electronic Systems

ELECTIVE III
08EE6252(A) Embedded Controllers and Real Time systems
08EE6252 (B) DSP and Applications
08EE6252(C) Digital Control Systems

Note: 8 hours / week is meant for departmental assistance by students.

Semester 3(Credits: 14)

Exam Slot	Course No:	Name	L - T - P	Internal Marks	End Semester Exam		Credits
					Marks	Duration (hrs.)	
A	08EE7211	ELECTIVE IV	3-0-0	40	60	3	3
B	08EE7221	ELECTIVE V	3-0-0	40	60	3	3
	08EE7231	Seminar	0-0-2	100	0	0	2
	08EE7241	Project (Phase I)	0-0-12	50	0	0	6

ELECTIVE IV
08EE7211 (A) Special Electric machines and Drives
08EE7211 (B) Industrial Instrumentation
08EE7211 (C) Non linear control systems

ELECTIVE V

08EE7221 (A) Soft computing techniques
08EE7221 (B) Design of Power electronic systems
08EE7221(C) Renewable energy technologies

Note: The students has to undertake the departmental work assigned by HOD

Semester 4 (Credits : 12)

Exam Slot	Course No:	Name	L - T – P	Internal Marks	End Semester Exam		Credits
					Marks	Duration (hrs.)	
	08EE7212	Project (Phase II)	0-0-21	70	30	0	12

Total credits:66

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SEMESTER 1

Course No.	Course Title	L-T-P-Credits
08EE6211	**APPLIED MATHEMATICS**	**3-0-0- 3**

***Course Objective**:* To enable the students apply calculus and optimization techniques in various electrical engineering problems.

Syllabus: Vector Calculus, Differential equations of higher order and fourier transforms, Complex Analysis- Analytic Functions, Optimization techniques

Expected outcome

Students will be able to apply calculus, higher order differential equations, complex functions and optimization techniques to the design and analysis of power electronic circuits.

References:

1. Advanced Engineering Mathematics " Erwin Kreyszig "Wiley.
2. Vector Calculus by" Thomas "and "Fienney" Addison Wesley.
3. Advanced Engineering Mathematics "Allen Jeffery "Academic Press Inc.
4. Advanced Engineering Mathematics "Dennis .G .Zill , "Warren .S . Right "Jones and Bartlett Publishers, Inc .
5. Operations Research by "Manmohan, P.K Gupta, Kanthi Swaroop" , Sultan Chand and sons Publishers

Course Plan

Module	*Contents*	*Contact Hours*	*% marks for semester exam*
I	**Vector Calculus:** Vector Spaces- Definition and Examples, Subspaces, Bases and Dimensions, Linear Transformations, Quotient Spaces, Direct Sum, The matrix of Linear Transformation, Duality. Canonical Forms: Eigen values and Eigenvectors, The minimal Polynomial, Diagonalisability, Triangular sable Operators, Jordan Forms, The Rational Forms. Vector Differential Calculus: Inner Product Spaces, Orthogonalty, The Adjoint of Linear Transformation, Unitary operators, Self Adjoint and Normal Operators, Polar and Singular Value Decomposition.	***8***	***15***

II	**Differential equations of higher order and fourier transforms :** Bernoulis linear equation, Homogenous equation with constant coefficient, cauchys equation ,Legranges linear equations ,Leibnitz higher order differential equation,	***7***	***15***
FIRST INTERNAL EXAM			
III	Fourier and transforms: Periodic functions, fourier series ,even and odd function, half range expansion, fourier integrals, fourier transforms-cosine and sine transforms.	***7***	***15***
IV	**Complex Analysis- Analytic Functions**: Cauchy-Riemann Equations, analyticity, harmonic functions. Power Series: Sequences, uniform convergence, Maclaurin and Taylor series, operations on power series. Complex Integration and Cauchy's Theorem: Curves, parameterizations ,line integral, Cauchy's Theorem. Applications of Cauchy's Theorem: Cauchy's integral formula, Cauchy's inequality and applications, maximum modulus theorem.	***8***	***15***
SECOND INTERNAL EXAM			
V	Laurent Series and Residue Theorem: Laurent series, classification of singularities, evaluation of real integrals, argument principle. Bilinear Transformations and Mappings: Basic mappings, linear fractional transformations, other mappings .Complex analysis applied to potential theory.	***8***	***20***
VI	**Optimization techniques :** Branch and bound method-Gomory's cutting plane method for integer and mixed integer programming- integer polynomial programming – sequential linear discrete programming and non linear programming-Nonlinear programming –Properties of single and multivariable functions Optimality criteria-Direct search methods-Gradient based methods-Newton's method-conjugate Gradient methods-Quasi-Newton Methods-DFP methods-Broyden-Fletcher-Golfarb-Shanno method	***8***	***20***

Internal continuous assessment: 40 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

End semester Examination: 60 marks

Course No.	Course Name	L-T-P-Credits	
08EE6221	**SYSTEM DYNAMICS**	**3-0-0-3**	

Course Objective:

To enable the students analyze systems using state space model , understand the concept of stability and familiarize the optimal control problems.

Syllabus:

State variable representation continuous and discrete systems, Lyapunov stability analysis, controllers and observers, Optimal and Robust Control systems

Expected outcome

The students will be able to analyse and design the control problems.

References

1. Thomas Kailath, Linear systems, Prentice Hall Inc
2. K.Ogata, Modern control Engg (Second Edition), Prentice Hall Inc, 1990
3. K.Ogata, Discrete time control systems, P.H.I
4. M.Gopal, Digital Control and State Variable methods, TMH, 1997
5. M.Gopal, Modern Control System Theory
6. P.Kundur, Power System Stability and Control, McGraw-Hill Publishing Company, 1994
6. C.T.Chen, Linear system theory and design, New York,Holt Rinechart and Winston , 1984
7. Richard.C.Dorf and R.T Bishop, Modern Control System, P.H.I

Course Plan

Module	*Contents*	*Contact Hours*	*% marks for semester exam*
I	State variable representation of system - concept of state - Equilibrium points – Stability - Solution of state equation - eigen values - eigen vectors – modes - modal decomposition - eigen value and stability - mode shape – sensitivity - participation factor -	***8***	***15***
II	State space representation of discrete time systems - Discretization of continuous time state equation	***8***	***15***
FIRST INTERNAL EXAM			

III	Lyapunov stability - definition of stability, asymptotic stability and instability - Lyapunov's second method - Lyapunov's stability analysis of LTI continuous time and discrete time systems - stability analysis of non linear system - Krasovski's theorem - variable gradient method	***8***	***15***
IV	Concepts of controllability and observability - controllability and observability tests for continuous time and discrete time systems -controllability and observability studies based on canonical forms of state model -	***7***	***15***
SECOND INTERNAL EXAM			
V	Effect of state feedback on controllability and observability - pole placement by state feedback for continuous and discrete time systems - Design of full order and reduced order observer for continuous time and discrete time systems	8	***20***
VI	Optimal control - formulation of optimal control problem - Minimum time control problem -minimum energy problem - minimum fuel problem - state regulator problem - output regulator problem – tracking problem - choice of performance measure - optimal control based on quadratic performance measure – optimal control system design using second method Lyapunov - solution of reduced Riccatti equation. Robust control systems – introduction - sensitivity analysis of robustness - system with uncertain parameters - design of robust PID controlled systems.	***9***	***20***

Internal continuous assessment: 40 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

End semester Examination: 60 marks

Course No.	Course Name	L-T-P-Credits
08EE6231	**ANALYSIS OF POWER ELECTRONIC CIRCUITS - I**	**4-0-0-4**

Course Objective:

To enable the students analyze the various power electronic circuits .

Syllabus:

Review of Power Devices, Controlled and uncontrolled rectifiers, DC to DC Converters, AC Voltage regulators and Cycloconverters

Expected outcome

The students will be able to design and analyze different power electronic circuits.

References

1. M.H. Rashid, Power Electronics Circuits, Design and Applications, Pearson Education
2. Mohan, Undeland, Robbins, Power Electronics, John Wiley and Sons
3. William Shepherd, Li Zhang, Power Converter Circuits, Marcel Decker
4. Prof. Ramnarayanan, Course Material on Switch Mode Power Conversion, Electrical Department, IISc, Bangalore
5. Philip T Krein, Elements of Power Electronics, Oxford
6. B K Bose, Modern Power Electronics and AC Drives, PHI
7. B W Williams, Principles and Elements of Power Electronics, University of Strathclyde Glasgow
8. Kazmierkowski, Krishnan, Blaabjerg, Control in Power Electronics, Academic Press
9. Issa Batarseh, Power Electronic Circuits, John Wiley
10. Bin WU, High Power Converters and AC drives, John Wiley
11. D Grahame Holmes, Thomas A Lipo, Pulse Width Modulation for Power Converters: Principles and Practice, IEEE Press
12. M H Rashid (Ed), Power Electronics Handbook, Academic Press

Course Plan

Module	*Contents*	*Hours*	*% marks for semester exam*
I	**Review of Power Devices** – characteristics of Ideal and practical switches – Power diodes – reverse recovery characteristics – power diode types – Diodes with RC,RL, LC and RLC loads –power transistors – power MOSFET – IGBT – Thyristor – GTO – IGCT –	***9***	***15***

	steady state characteristics & switching characteristics – two-transistor model of thyristor - di/dt and dv/dt protection- gate trigger circuits – R, RC & UJT triggering – commutation circuits – natural & forced commutation – class A,B,C,D,E,F commutation - comparison of power devices. **Uncontrolled rectifiers** – single-phase half-wave and full-wave bridge – performance parameters – FF, RF, TUF, DF, HF, input PF - single-phase full-wave bridge with RL load – 3-phase		
II	**Controlled rectifiers** – single-phase half converter and full converters – analysis with R & RL loads – DF, HF, input PF - 3-phase half-wave – full converters & semiconverters – analysis with R & RL loads – continuous conduction & discontinuous conduction – inversion mode - effect of source inductance on 1-phase & 3-phase full converters – overlap angle - single-phase dual converters – circulating & non circulating current operation.	***7***	***15***
FIRST INTERNAL EXAM			
III	**DC-DC converters** – Step-down chopper – step- up chopper - analysis with R & RL load –PWM, frequency modulation control – current limit control – fourier analysis of output voltage - two-quadrant & four-quadrant chopper – voltage commutated chopper – current commutated chopper - switching-mode regulators – buck, boost, buck-boost and cuk regulators – condition for continuous inductor current and capacitor voltage - design of LC filter – comparison of regulators	***7***	***15***
IV	**AC voltage controllers** – ON-OFF control – phase control – 1-phase full wave – analysis with R & RL load – input PF – two stage sequence control with R & RL load – 3-phase full-wave controller with R load – 3-phase bidirectional delta connected controllers	***7***	***15***
SECOND INTERNAL EXAM			
V	**Cycloconverter** – single-phase to single-phase cycloconverter with R & RL load - 3-phase to 1-phase cycloconverter – 3-phase to 3-phase cycloconverter - thyristor-controlled reactor (TCR) - thyristor-switched	***7***	***20***

	capacitor (TSC)		
VI	**Inverters –** 1-phase half bridge and full bridge – HF, THD, DF – 3-phase inverter - 180º and 120º conduction – Analysis with R & RL load – PWM techniques – single pulse, multiple pulse & sinusoidal pulse width modulation – modulation index – voltage control of 3-phase inverters – sine PWM – harmonic reduction – bipolar & unipolar modulation – current source inverter – 1-phase & 3-phase – Variable DC link inverter – boost inverter.	***8***	***20***
Internal continuous assessment: 40 marks Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher. **End semester Examination: 60 marks**			

Course No.	**Course Name**	**L-T-P-Credits**
08EE6241	**ELECTRIC DRIVES**	**3-0-0-3**

Course Objective*:*

To provide fundamental concepts about torque speed and stability relation and methods of speed control of different electrical machines

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Syllabus:

Introduction to electrical drives, DC Drives and its control, Induction motor and synchronous motor drives and their control.

Expected outcome

The students will be able to analyse the torque ,speed and stability relations and speed control of different electric drives

References

1. R. Krishnan, Electical Motor Drives, PHI

2 GK Dubey, Fundamentals of Electrical Drives, Narosa

3. GK Dubey, Power Semi-conductor Controlled Drives, Prentice Hall

4. Bimal K Bose, Modern Power Electronics &AC Drives, PHI

5. S A Nasar, Boldea, Electrical Drives, CRC press
6. M A Elsharkawi, Fundamentals of Electrical Drives, Thomson Learning
7. W Leohnard, Control of Electric Drives, Springer
8. Murphy and Turnbill, Power Electronic Control of AC motors, Pergamon Press
9. Vedam Subarhmanian, Electric Drives, TMH

Course Plan

Module	***Contents***	***Hours***	***% marks for semester exam***
I	Components of electrical Drives – electric machines, power converter, controllers - dynamics of electric drive - torque equation - equivalent values of drive parameters- components of load torques types of load - four quadrant operation of a motor — steady state stability - load equalization – classes of motor duty- determination of motor rating	***8***	***15***
II	DC motor drives – dc motors &their performance (shunt, series, compound, permanent magnet motor, universal motor, dc servomotor) – braking – regenerative, dynamic braking, plugging – Transient analysis of separately excited motor – converter control of dc motors – analysis of separately excited &series motor with 1-phase and 3-phase converters – dual converter.	***7***	***15***
FIRST INTERNAL EXAM			
III	Analysis of chopper controlled dc drives – converter ratings and closed loop control - transfer function of self, separately excited DC motors – linear transfer function model of power converters – sensing and feeds back elements – current and speed loops, P, PI and PID controllers – response comparison – simulation of converter and chopper fed DC drive.	***8***	***15***
IV	Induction motor drives – stator voltage control of induction motor – torque-slip characteristics –operation with different types of loads – operation with unbalanced source voltages and single phasing –analysis of induction	***8***	***15***

	motor fed from non-sinusoidal voltage supply – stator frequency control – variable frequency operation – V/F control, controlled current and controlled slip operation.		
SECOND INTERNAL EXAM			
IV	Effect of harmonics and control of harmonics – PWM inverter drives – multi-quadrant drives – rotor resistance control – slip torque characteristic – torque equations, constant torque operation – slip power recovery scheme – torque equation – torque slip characteristics – power factor – methods of improving power factor –limited sub synchronous speed operation – super synchronous speed operation	***8***	***20***
V	Synchronous motor drives – speed control of synchronous motors – adjustable frequency operation of synchronous motors – principles of synchronous motor control – voltage source inverter drive with open loop control – self controlled synchronous motor with electronic commutation – self controlled synchronous motor drive using load commutated thyristor inverter.	***9***	***20***

Internal continuous assessment: 40 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

End semester Examination: 60 marks

Course No.	Course Name	L-T-P-Credits
08GN6101	**RESEARCH METHODOLOGY**	**0-2-0-2**

Course Objectives

The main objective of the course is to provide a familiarization with research methodology and to induct the student into the overall research process and methodologies. This course addresses:

- The scientific research process and the various steps involved
- Formulation of research problem and research design
- Thesis preparation and presentation.
- Research proposals, publications and ethics

- Important research methods in engineering

- As a tutorial type course, this course is expected to be more learner centric and active involvement from the learners are expected which encourages self-study and group discussions. The faculty mainly performs a facilitator's role.

Syllabus:

Research Concepts, Formulation of Research Task, Mathematical modeling and simulation, Interpretation and report writing

Course Outcome

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

- Discuss research methodology concepts, research problems, research designs, thesis preparations, publications and research methods.
- Analyse and evaluate research works and to formulate a research problem to pursue research
- Prepare a thesis or a technical paper, and present or publish them
- Apply the various research methods followed in engineering research for formulation and design of own research problems and to utilize them in their research project.

References

1. J.W Bames, Statistical Analysis for Engineers and Scientists, McGraw Hill, N.York
2. Schank Fr., Theories of Engineering Experiments, Tata Mc Graw Hill Publication.
3. C. R. Kothari, Research Methodology, New Age Publishers.
4. Willktnsion K. L, Bhandarkar P. L, Formulation of Hypothesis, Himalaya Publication
5. Krishnaswami, "Management research methodology – Integration of methods & Techniques", Pearson

Course Plan

Module	***Contents***	***Hours***	***% marks for semester exam***
I	Research Concepts – concepts – meaning – objectives – motivation. Types of research – descriptive research – conceptual research – theoretical research – applied research – experimental research. Research process – Criteria for good research – Problems encountered by Indian researchers.	***8***	***15***

II	Formulation of Research Task – Literature Review – Importance & Methods – Sources – Quantification of Cause Effect Relations – Discussions	***7***	***15***
FIRST INTERNAL EXAM			
III	Field Study – Critical Analysis of Generated Facts – Hypothetical proposals for future development and testing, selection of Research task	7	***15***
IV	Mathematical modeling and simulation – Concepts of modeling – Classification of mathematical models – Modeling with – Ordinary differential equations	***8***	***15***
SECOND INTERNAL EXAM			
V	Difference equations – Partial differential equations – Graphs – Simulation – Process of formulation of model based on simulation.	***7***	***20***
VI	Interpretation and report writing – Techniques of interpretation – Precautions in interpretation – Significance of report writing – Different steps in report writing – Layout of research report – Mechanics of writing research report – Layout and format – Style of writing – Typing – References – Tables – Figures – Conclusion – Appendices	***8***	***20***
Internal continuous assessment: 40 marks Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher. **End semester Examination: 60 marks**			

EPE10 105: ELECTIVE

Course No.	Course Name	L-T-P-Credits
08EE6251 (A)	**POWER SEMICONDUCTOR DEVICES & MODELING**	**3-0-0-3**

Course Objective:

The purpose is to make students cognizant of the intricacies of common power semiconductor devices in their devices in their device physics and operation.

Syllabus:

Power switching devices, Current Controlled Devices, Voltage Controlled Devices, Firing and Protection Circuits, Thermal Protection

Expected outcome

The students will be able to analyse the device physics and operation of various power semiconductor devices and also the new developments in this area.

References

1.MohanUndeland,Robins,'Power Electronics-concepts,applications and design',John Wiley and sons
2.M D Singh,K K Khanchandani,'Power Electronics,Tata McGraw Hill
3.B W Williams ,'Principles and elements of Power Electronics',University of Strathclyde'Glasgow
4.Kassakian JG etal.,'Principles of Power Electronics',Addison Wesley

Course Plan

Module	*Contents*	*Hours*	*% marks for semester exam*
I	Power switching devices overview- Relevance of switches and high frequency in converters-symbols- attributes and application requirements of power switches Power handling capability- SOA- Strategy of device selection-On state and switching losses – EMI due to switching- Conduction in semiconductors- drift-diffusion-Energy gap in semiconductors – Significance and application of static and dynamic characteristics-Failure of signal diode for high power applications	*7*	*15*

II	Significance of n- layer in a diode – Power diode- Construction- Static and dynamic characteristics Current controlled devices- BJTs- Construction- device physics- Static and dynamic characteristics- Vcbo and Vceo – Negative temperature coefficient and secondary breakdown – Power darlington – Increase of β – Construction	***8***	***15***
FIRST INTERNAL EXAM			
III	SCR- Construction and device physics – 2 transistor analogy- gate and switching characteristics Converter grade and inverter grade – series and parallel operation- Comparison of BJT and thyristor- Steady state and dynamic models of BJT and thyristor	***7***	***15***
IV	Voltage controlled devices- power MOSFETs and IGBTs- Principle of voltage controlled devices-construction-types-device physics-static and switching characteristics-steady state and dynamic models of MOSFETs and IGBTs Basics of GTO,MCT,FCT,RCT and IGCT	***8***	***15***
SECOND INTERNAL EXAM			
V	Firing and protection circuits-necessity of isolation-pulse transformers-optocoupler-gate drive circuit: SCR,MOSFET,IGBT and base driving for power BJT-over voltage ,overcurrent and gate protection-design of snubbers and magnetic circuits.	***8***	***20***
VI	Thermal protection-Heat transfer-conduction-convection-radiation-liquid cooling-vapour phase cooling-guidance for heat sink selection-thermal resistance and impedance-electrical analogy of thermal components-Heat sink types and design-mounting types	***8***	***20***
Internal continuous assessment: 40 marks Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher. **End semester Examination: 60 marks**			

Course No.	Course Name	L-T-P-Credits
08EE6251(B)	**DYNAMICS OF ELECTRICAL MACHINES**	**3-0-0-3**

Course Objective

To make the students aware of the generalized modeling and analysis of different electrical machines used for industrial drive applications..

Syllabus:

Introduction to the analysis of electrical machines .Modelling of DC , induction and synchronous machines

Expected outcome

The students will be able to model and analyze different electrical machines used for industrial drive applications.

References

1. PS. Bhimbra, Generalized Theory of Electrical Machines, Khanna Publishers
2. Krauss, Wasyncsuk and Sudholf, Analysis of Electrical Machines and Drive Systems, John Wiley
3. A E Fitzgerald, Kingsley, Umans, Electric Machinery, McGraw Hill
4. Adkins and Harey, General Theory of AC Machines
5. Bimal K Bose, Modern Power Electronics &AC Drives, Pearson Education

Course Plan

Module	*Contents*	*Hours*	*% marks for semester exam*
I	Introduction – Unified approach to the analysis of electrical machine – basic two-pole machine – Kron's primitive machine – voltage, power and torque equation – linear transformation from 3-phase to 2-phase - transformation from rotating axes to stationary axes – power invariance –.	***9***	***15***
II	Park's transformation for 3-phase synchronous and induction machines. DC machines – application of generalized theory to separately excited, shunt, series and compound machines	***7***	***15***

FIRST INTERNAL EXAM			
III	Sudden short circuit of separately excited generator - separately excited dc motor - steady state and transient analysis – transfer functions of separately excited dc generator &motor..	***8***	***15***
IV	Polyphase synchronous machines – generalized machine equations – steady state analysis of salient pole and non salient pole machines – phasor diagrams – power angle characteristics – reactive power – short circuit ratio transient analysis – sudden 3-phase short circuit at generator terminals – reactance – time constants – transient power angle characteristics.	***8***	***15***
SECOND INTERNAL EXAM			
V	Induction machines – 3-phase induction machine-generalized model – voltage equation – steady state analysis – equivalent circuit – torque-slip characteristics – effect of voltage and frequency variations – electric transients in induction machines	***8***	***20***
VI	speed control of induction motor – introduction to vector control – applications in speed control of induction machine – single phase induction motor – generalized model – voltage and torque equations – steady state analysis.	***8***	***20***

Internal continuous assessment: 40 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

End semester Examination: 60 marks

Course No.	Course Name	L-T-P-Credits
08EE62	**OPTIMIZATION TECHNIQUES**	**3-0-0-3**

51(C)		

Course Objective:

To enable the students apply different optimization techniques to both linear and non-linear systems.

Syllabus:

Linear programming, Unconstrained dimensional optimization techniques, Constrained optimization techniques & dynamic programming, Recent developments in optimization techniques

Expected outcome

The students will be able to apply different optimization techniques to both linear and non linear systems.

References

1. Rao S.S, Optimisation:Theory and Application, Wiley Eastern Press
2. Pierre, D.A., Optimisation, Theory with Applications, John Wiley & Sons
3. Fox, R.L., Optimisation method for Engineering Design, Addition Wesley
4. Hadely,G., Linear Programming, Addition Wesley
5. Bazaara & Shetty, 'Non-linear Programming'
6. D.E. Goldberg, Genetic Algorithm in Search, Optimization, and Machine Learning, Addison-Wesly, 1989.
7. Marco Dorigo, Vittorio Miniezza and Alberto Colorni, "Ant System:Optimization by a colony of Cooperation Agent", IEEE transaction on system man and Cybernetics-Part B:cybernetics, Volume 26, No 1, pp. 29-41,1996.
8. Shi, Y. Eberhart, R.C., "A Modified Particle Swarm Optimizer", Proceedings of the IEEE International conference on Evolutionary Computation, Anchorage, AK, pp. 69-73, May 1998
9. Recent literature should also be referred

Course Plan

Module	***Contents***	***Hours***	***% marks for semester exam***
I	**Linear programming:** Statement and classification of optimization problems overview of optimization techniques standard form of linear programming problems-Definitions and theorems-Simplex method-Revised simplex method-Duality and Dual simplex method-Sensitivity analysis.	***8***	***15***
II	**Unconstrained dimensional optimization techniques**: Necessary and sufficient conditions-search methods(unrestricted Fibonacci and golden)-Interpolation methods(Quadratic, Cubic and direct root method).	***7***	***15***

FIRST INTERNAL EXAM			
III	**Direct search methods**-Random search-pattern search and Rosen Brock's hill climbing method-**Descent methods**-Steepest descent, conjugate gradient, Quasi Newton and DFE method.	***7***	***15***
IV	**Constrained optimization techniques & dynamic programming:** Necessary and sufficient conditions-Equality and inequality constraints-Kuhn-Tacker conditions-Gradient projection method-cutting plane method-	***7***	***15***
SECOND INTERNAL EXAM			
V	Penalty function method(Interior and exterior).Principle of optimality-recurrence relation-Computation procedure-continuous dynamic programming.	***7***	***20***
VI	**Recent developments in optimization techniques:** Rosenbrocks Rotating Coordinate Method-Tabu search-Simulated Annealing-Genetic Algorithm-Particle Swarm Optimization –Ant colony Optimization-Bees Algorithm.	***8***	***20***

Internal continuous assessment: 40 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

End semester Examination: 60 marks

Course No.	Course Name	L-T-P-Credits
08EE6251 (D)	**HIGH VOLTAGE DC AND AC TRANSMISSION**	**3-0-0-3**

Course Objective*:*

To give the students an in depth knowledge of the configuration and working of HVDC & AC systems .

Syllabus:

General Aspects, Converter circuits and analysis, Bridge converters-Analysis, Control, Protection and Harmonics Filters, Lightning, Travelling waves and switching Transients, Protective device in HVAC transmission, Interaction between AC & dc System

Expected outcome

The students will be able to analyse the configuration and working of HVDC and AC systems

References

1. Kimbark,E.W., Direct current transmission-Vol.1, Wiley Interscience, New York, 1971
2. Arrilaga,J., High Voltage Direct current transmission, Peter Pereginver Ltd., London,UK.
3. Allen Greenwood, Electrical Transients in power system, Wiley Interscience
4. Diesendorf,W., Overvoltage on High voltage system, Rensselaer Book store ,Troy, New York,1971
5. Klaus Ragallea, Surges and high voltage networks, Plenum Press
6. Padiyar,K.R., HVDC Transmission system, Wiley Eastern Limited, NewDelhi
7. R.D.Begamudre, High Voltage Engineering, New Age International Publishers

Course Plan

Module	*Contents*	*Hours*	*% marks for semester exam*
I	**General Aspects, Converter circuits and analysis**: HVDC links - comparison –Economic, Technical performance – Reliability – Limitations - Properties of thyristor converter circuits- assumptions-Choice of best circuit for HVDC converters-Transformer connections - Analysis with gate control but no overlap less than 60 degrees- operation of inverters	*8*	*15*
II	**Bridge converters-Analysis, Control, Protection and Harmonics Filters:** Converter Inverter circuits for HVDC Transmission-basic means of control –Power reversal-desired features of control – actual control characteristics. Converter disturbance –bypass action in bridges- commutation failure-basics of protection-	*8*	*15*
FIRST INTERNAL EXAM			
III	DC Reactors-Voltage and current oscillations-Circuit breakers - Over voltage protection-Characteristics and uncharacteristic harmonics-troubles due to harmonics-harmonic filters-Converter charts of direct current and voltage- active and reactive power.	*7*	*15*
IV	**Lightning, Travelling waves and switching Transients**: Mathematical model to represent lightning-Travelling wave in transmission lines-Circuits with distributed constants- Wave equations- Reflection and Refraction of travelling waves-Travelling waves at different line terminations-effect of short length of cables- Shape and attenuation and distortion of travelling waves-	*8*	*15*
SECOND INTERNAL EXAM			

V	Selection of typical wave to represent over voltages- Switching transients- the circuit closing transient-the recovery transient initiated by the removal of the short circuit – Double frequency transients- Abnormal switching transients- Current suppression- capacitance switching- Arcing ground-Transformer inrush current – Ferro resonance- neutral connections- Transients in switching a three phase reactor –Three phase capacitor	***8***	***20***
VI	**Protective device in HVAC transmission, Interaction between AC & dc System**: Basic ideas about protection – surge diverters- surge absorbers- ground fault neutralizers- Protection of lines and stations by shielding- Ground wires – counter poises-Driven rods-Modern lightning arrestors- Insulation co ordination- Protection of alternators- Industrial drive system. Interaction between AC & DC systems- Voltage interaction-Harmonic instabilities- Smoothing Reactors – Overhead lines – Cable Transmission-Earth Electrodes-Design of back to back thyristor convertor system.	***9***	***20***

Course No.	**Course Name**	**L-T-P-Credits**
08EE6271	**SEMINAR**	**0-0-2-2**

Course Objective:

To assess the debating capability of the student to present a technical topic. Also to impart training to a student to face audience and present his ideas and thus creating in him self esteem and courage that are essential for an engineer.

Expected outcome

The students will develop an ability to give oral presentation related to a technical topic and also to write technical documents**.**

Individual students are required to choose a topic of their interest from power electronics and drive related topics preferably from outside the M.Tech syllabus and give a seminar on that topic about 30 minutes. A committee consisting of at least three faculty members (preferably specialized in power electronics) shall assess the presentation of the seminar and award marks to the students. Each student shall submit two copies of a write up of his seminar topic. One copy shall be returned to the student after duly certifying it by the chairman of the assessing committee

and the other will be kept in the departmental library. Internal continuous assessment marks are awarded based on the relevance of the topic, presentation skill, quality of the report and participation.

Internal continuous assessment: 100 marks

Course No.	Course Name	L-T-P-Credits
08EE6281 (P)	**POWER ELECTRONICS LABORATORY**	**0-0-2-2**

***Course Objective**:*

To provide practical knowledge through hardware implementation & simulation of power electronic circuits

Expected outcome

The students will be able to design, simulate and implement different power electronic circuits.

LIST OF EXPERIMENTS

A) HARDWARE

1. Single Phase Semi-converter with R-L load for continuous & discontinuous conduction modes
2. Single Phase Full-converter with R-L load for continuous & discontinuous conduction modes
3. Controlled and Uncontrolled rectifier with different types of filters - continuous & discontinuous modes of operation
4. Transformer and Inductor design
5. Transfer function of armature controlled DC Motor
6. Single Phase AC Voltage Controller
7. Digital firing circuit
8. Three Phase Full-converter with R-L-E load
9. Current & voltage commutated thyristorized chopper
10. Study of harmonic pollution by power electronics loads using power quality analyser

B) SIMULATION

1. 3-phase full converter and semi-converter with R, RL and RLE loads
2. 3-phase ac voltage controller
3. Closed loop control of DC-DC converter
4. 3-phase sine PWM inverter
5. Measurement of THD of current & voltage waveforms of controlled & uncontrolled 3-phase rectifiers.

Out of the above, a minimum of SIX hardware experiments and FOUR simulation experiments are to be conducted. Simulation can be done using any of the software packages like MATLAB/SIMULINK, PSPICE, PSCAD etc.

Internal continuous assessment: 100 marks

a. Regularity – 30%

b. Record – 20%

c. Test and Viva – 50%

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SEMESTER II

Course No.	Course Name	L-T-P-Credits
08EE6212	**ANALYSIS OF POWER ELECTRONIC CIRCUITS - II**	**3-0-0-3**

Course Objective:

To provide a strong foundation to the students on advanced converter techniques and their control in modern Power Electronic Systems.

Syllabus:

PWM strategies for Inverters, Multilevel inverters, Different control Methods, current control , Z -source inverters, PWM Voltage Source Inverters, Matrix converter.

Expected outcome

The students will be able to analyze and apply advanced converter techniques and their control in modern power electronic systems.

References

1. Fang Lin Luo & Hong Ye, *Power Electronics, Advanced Conversion Technologies*, CRC Press
2. Branko L Dokic & Branko Blanusa, *Power Electronics, Converters and Regulators*, , Springer
3. Barry Williams, *Principles and Elements of Power Electronics*, University of Strathclyde
4. Muhammad H. Rashid, *Power Electronics Circuits, Design and Applications*, Pearson Education
5. Muhammad H Rashid (Ed), *Power Electronics Handbook,* Academic Press
6. William Shepherd & Li Zhang, Power Converter Circuits, Marcel Dekker Inc

Course Plan

Module	*Contents*	*Hours*	*% marks for semester exam*
I	PWM Strategies for Inverters - Review of Sinusoidal PWM – Trapezoidal modulation, staircase modulation, stepped modulation, harmonic injected modulation, delta modulation – Third harmonic PWM - Space Vector Modulation – concept of space vector - space vector switching - over modulation	***8***	***15***

II	Power factor improvement of rectifier circuits – Extinction angle control, symmetric angle control, PWM control - 1-phase sinusoidal PWM, 3-phase PWM rectifier -	***7***	***15***
FIRST INTERNAL EXAM			
III	1-phase series converters – semi converters & full converters – Twelve-pulse converter Z-source inverter – equivalent circuit & operation – shoot-through zero state – modified carrier based PWM inverter with shoot-through zero state – modulation index and boost factor [1]	***8***	***15***
IV	Multilevel inverters – Diode-clamped multilevel inverter – improved diode-clamped inverter - Flying-capacitors multilevel inverter – cascaded multilevel inverter – PWM for multilevel inverters - comparison	***7***	***15***
SECOND INTERNAL EXAM			
V	Current Regulated PWM Voltage Source Inverters - Methods of Current Control, hysteresis Control-hysteresis current controller used in specific application- Variable Band Hysteresis Control, Fixed Switching Frequency Current Control Methods	***8***	***20***
VI	Matrix converter – principle – matrix converter switches - 3-phase matrix converter – switching control strategy - Venturini control method – principle – switching duty cycles –modulation matrix – realization of input filter - commutation and protection issues in matrix converter	***8***	***20***

Internal continuous assessment:40 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

End semester Examination: 60 marks

Question pattern

Answer any 5 questions by choosing at least one question from each module.

Course No.	Course Name	L-T-P-Credits
08EE6222	**SWITCHED MODE POWER CONVERTERS**	**3-0-0-3**

Course Objective:

To acquaint the students with working, analysis and modelling of different types of converters.

Syllabus:

Review of Buck, Boost, Buck-Boost topologies, Flyback converters, Voltage and current mode control of SMPS, Modelling of SMPS, Resonant converters.

Expected outcome

The Students will be able to analyse, design and model different types of converters.

References

1 Ned Mohan, Power Electronics:Converters,Applications And Design , John Wiley & Sons
2 Abraham I Pressman , Switching Power Supply Design , McGraw-Hill Publishing Company
3 R. W. Erickson , Fundamental of Power Electronics , Chapman & Hall Publishers
4 William Shepherd, Li Zhang, Power Converter Circuits, CRC Taylor Francis

Course Plan

Module	*Contents*	*Hours*	*% marks for semester exam*
I	Review of Buck, Boost, Buck-Boost topologies - basic operation – Waveforms - modes of operation - voltage mode control principles. Push-pull and Forward converter - basic operation – waveforms - modes of operation – Transformer design - voltage mode control principles.	***7***	***15***
II	Half and Full Bridge Converters - basic operation – waveforms - modes of operation -voltage mode control principles. Fly back Converter - basic operation – waveforms - modes of operation - voltage mode control principles.	***7***	***15***

FIRST INTERNAL EXAM			
III	Voltage Mode Control of SMPS - Loop gain and Stability Considerations - Shaping the Error Amplifier gain versus frequency characteristics - Error amplifier Transfer function – Tran conductance Error amplifiers. Current Mode Control of SMPS – Current Mode Control Advantages - Current Mode versus Voltage Mode Control of SMPS – Current Mode Deficiencies - Slope Compensation.	***9***	***15***
IV	Modelling of SMPS - Basic AC modelling Approach – Modelling of non ideal fly back converter -State Space Averaging – basic state space averaged model	***7***	***15***
SECOND INTERNAL EXAM			
V	State space averaging of non ideal buckboost converter - Circuit averaging and averaged switch modelling – Modeling of pulse width modulator	***7***	***20***
VI	Introduction to Resonant Converters – Classification of Resonant Converters – Basic Resonant circuit concepts – load resonant converters – resonant switch converters – Zero voltage switching, clamped voltage topologies – resonant DC Link inverters with zero voltage switching – High frequency link integral half cycle converter	***8***	***20***

Course No.	**Course Name**	**L-T-P-Credits**
08EE6232	**ADVANCED ELECTRIC DRIVES**	**3-0-0-3**

Course Objective*:*

To provide the students the knowledge of fundamental concepts in modeling and control schemes used in advanced AC drives systems

Syllabus:

Modeling of Induction machines, different control methods of induction motors, Permanent magnet synchronous and brushless DC motor drives.

Expected outcome

The students will be able to analyse, design and model AC drive systems and the various control schemes.

References

1. R Krishnan, Electric Motor Drives, PHI
2. D W Novotny and T A Lipo, Vector Control and Dynamics of AC Drives, Oxford University Press
3. B K Bose, Modern Power Electronics and AC Drives, PHI
4. Leonhard, Control of Electric Drives, Springer
5. Kazmierkowski, Krishnan, Blaabjerg, Control in Power Electronics-Selected Problems, Academic Press
6. John Chiasson, Modeling and High Performance Control of Electric Machines, Wiley-IEEE Press
7. I Boldea, S A Nasar, Electric Drives, CRC Press
8. K Rajashekara, Sensorless Control of AC motors, IEEE Press
9. I Boldea, S A Nasar, Vector Control of AC Drives, CRC Press
10. J Holtz, Sensorless Control of Induction Motor Drives, Proceedings of the IEEE, August 2002, PP 1359-1394.

Course Plan

Module	***Contents***	***Hours***	***% marks for semester exam***
I	Modeling - Dynamic modeling of induction machines – 3-phase to 2-phase transformation – power equivalence – generalized model in arbitrary reference frame – electromagnetic torque – derivation of stator reference frame model, rotor reference frame model, synchronously rotating reference frame model – equations in flux linkages - dynamic d-q model of synchronous machines.	***9***	***15***
II	Vector Control - Vector controlled induction motor drive – Principle of vector or field oriented control– direct rotor flux oriented vector control – estimation of rotor flux and torque– implementation with current source and voltage source inverters - Stator flux oriented vector control - Indirect rotor flux oriented vector control scheme - implementation – tuning - Dynamic simulation -	7	***15***
FIRST INTERNAL EXAM			

III	Parameter sensitivity and compensation of vector controlled induction motors - Selection of Flux level - Flux weakening operation - Speed controller design – simulation of vector control of induction motor using MATLAB/SIMULINK.	***5***	***15***
IV	Doubly-fed machine speed control by rotor rheostat – static kramer drive – phasor diagram, equivalent – speed control – power factor improvement – Static Scherbius drive – Modes of operation –	***6***	***15***
SECOND INTERNAL EXAM			
V	Direct torque control of induction motor – principle – control strategy – space vector modulation – reduction of torque and flux ripple – comparison of DTC and FOC – simulation of DTC of induction motor using MATLAB/SIMULINK	8	***20***
VI	Permanent magnet synchronous and brushless DC motor drives – types of permanent magnet synchronous machines – Vector control of PM synchronous machine – model of PMSM – Vector control – control strategies – constant torque-angle control, unity power factor control, constant mutual flux-linkages control, optimum torque per ampere control, flux weakening operation, direct flux weakening algorithm, speed-controlled PMSM drive sensorless PMSM drive – PM brushless DC motor – modeling – drive scheme – Switched reluctance motor drives.	***9***	***20***

Internal continuous assessment: 40 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

End semester Examination: 60 marks

ELECTIVE II

Course No.	Course Name	L-T-P-Credits
08EE6242(A)	**FACTS AND CUSTOM POWER DEVICES**	**3-0-0-3**

Course Objective:

To impart knowledge about the operation, control and application of different FACTS devices and custom power devices.

Syllabus:

FACTS concepts and controllers, Static Shunt and Series Compensators, UPFC and IPFC, Power Quality and introduction to custom power devices.

Expected outcome

The students will be able to analyse the operation, control and application of different FACTS devices and custom power devices.

References

1. K. R. Padiyar, FACTS Controllers in Power Transmission and Distribution, New Age International
2. N.G. Hingorani & L. Gyugyi, Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems, IEEE Press
3. T.J.E Miller, Reactive Power Control in Electric Systems, John Wiley & Sons. Ned Mohan et.al, Power Electronics, John Wiley and Sons.
4. Dr Ashok S & K S Suresh Kumar "FACTS Controllers and applications" course book for STTP, 2003.

Course Plan

Module	*Contents*	*Hours*	*% marks for semester exam*
I	FACTS and preliminaries: FACTS concept and general system considerations - power flow in AC system - definitions on FACTS - basic types of FACTS controllers. Converters for Static Compensation - Three phase converters and standard modulation strategies (Programmed Harmonic Elimination and SPWM) - GTO Inverters - Multi-Pulse Converters and Interface Magnetics -	***7***	***15***

II	Transformer Connections for 12, 24 and 48 pulse operation - Multi-Level Inverters of Diode Clamped Type and Flying Capacitor Type and suitable modulation strategies (includes SVM) - Multi-level inverters of Cascade Type and their modulation - Current Control of Inverters.	***7***	***15***
FIRST INTERNAL EXAM			
III	Static Shunt and Series Compensators: Static Shunt Compensators - SVC and STATCOM – operation and control of TSC, TCR, STATCOM - Compensator Control - Comparison between SVC and STATCOM - STATCOM for transient and dynamic stability enhancement.	***7***	***15***
IV	Static Series Compensation - GCSC, TSSC, TCSC and SSSC - operation and control - external system control for series compensators - SSR and its damping - static voltage and phase angle regulators - TCVR and TCPAR - operation and control.	***9***	***15***
SECOND INTERNAL EXAM			
V	UPFC and IPFC: The Unified Power Flow Controller - operation, comparison with other FACTS devices - control of P and Q - dynamic performance - Special Purpose FACTS Controllers – Interline Power Flow Controller - operation and control.	***8***	***20***
VI	Power Quality and introduction to custom power devices: Power Quality issues related to distribution systems – custom power devices – Distribution STATCOM – Dynamic Voltage restorer – Unified Power Quality Conditioner – Application of D-STATCOM, DVR and UPQC for improving power quality in distribution systems.	***9***	***20***

Internal continuous assessment: 40 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

End semester Examination: 60 marks

Course No.	Course Name	L-T-P-Credits
08EE6242 (B)	**POWER QUALITY**	**3-0-0-3**

Course Objective:

To familiarize the students with power quality problems and measurements.

To introduce the impact of and on the device and different mitigation techniques.

Syllabus:

Overview of power quality phenomena, IEEE guides, standards and recommended practices., Modeling of networks , Power quality applications, Power quality improvement methods.

Expected outcome

Students will be able to analyse the various power quality issues and mitigation techniques.

References

1. Heydt, G.T., Electric Power Quality , Stars in a Circle Publications, Indiana
2. Ewald F Fuchs, Mohammad A.S., Power Quality in Power Systems and Electrical Machines, Elsevier, Academic Press REFERENCES
3. Bollen, M.H.J., Understanding Power Quality Problems: Voltage sags and interruptions, IEEE Press, New York
4. Arrillaga. J, Watson, N.R., Chen, S., Power System Quality Assessment, Wiley, New York, 2000.

Course Plan

Module	*Contents*	*Hours*	*% marks for semester exam*

I	Overview of power quality phenomena-classification of power quality issues-power quality measures and standards-flicker-transient phenomena-Harmonics-sources of harmonics-occurrence of power quality problems-power acceptability curves-IEEE guides, standards and recommended practices.	***9***	***15***
II	Modeling of networks and components under non-sinusoidal conditions-transmission and distribution systems-shunt capacitors-transformers-electric machines.	***7***	***15***
FIRST INTERNAL EXAM			
III	Ground systems-loads that cause power quality problems-power quality problems created by drives and its impact on drives.	***7***	***15***
IV	Power quality application of state estimation-flicker-impulses-high frequency issues-common mode and transverse mode noise-geometric interference-susceptibility of loads-loss of life of power system components	***9***	***15***
SECOND INTERNAL EXAM			
V	Power quality improvement: harmonic filters-active filters-phase multiplication-power conditioners-	***7***	***20***
VI	Uninterruptible power sources-constant voltage transformers-static compensators and static watt Compensators	***8***	***20***

Internal continuous assessment: 40 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

End semester Examination: 60 marks

Course No.	**Course Name**	**L-T-P-Credits**

08EE6242 (C)	DIGITAL SIMULATION OF POWER ELECTRONIC SYSTEMS	3-0-0-3

Course Objective:

To enable the students model and analyze the power electronics systems with the software tools .

Syllabus:

Modeling of Power Semiconductor Devices, Modeling of Control Circuits for Power Electronic Switches, introduction to Software ORCAD- Pspice, Dynamic modeling and simulation using MATLAB.

Expected outcome

The students will be able to model power electronic systems using different approaches and use software tools for analysis

References

1. V Rajagopalan, Computer Aided Analysis of Power Electronic Systems, Marcel Dekker, Inc.
2. Erickson, Maksimovic, Fundamentals of Power Electronics - 2nd edition, Springer
3. Randall Shaffer, Fundamentals of Power Electronics with MATLAB, Firewall Media, India
4. Mohan, Undeland, Robbins, Power Electronics, 3rd edition, John Wiley
5. Jai P Agrawal, Power Electronic Systems-Theory and Design, Pearson
6. ORCAD PSpice Basics: Circuit Analysis Software, User's Guide, ORCAD

Course Plan

Module	*Contents*	*Hours*	*% marks for semester exam*
I	Principles of Modeling Power Semiconductor Devices - Macro models versus Micro models - Thyristor model - Semiconductor Device modeled as Resistance, Resistance-Inductance and Inductance-Resistance-Capacitance combination - Modeling of Electrical Machines.	***9***	***15***
II	Modeling of Control Circuits for Power Electronic Switches. Computer Formulation of Equations for Power Electronic Systems –Review of graph theory as applied to Electric networks- Systematic method of Formulating State Equations - Computer Solution of State Equations - Explicit Integration	***7***	***15***

	method -Implicit Integration method.		
FIRST INTERNAL EXAM			
III	AC equivalent circuit modeling: Basic AC modeling approach-State space averaging-circuit averaging and averaged switch modeling-Modeling the PWM.	***8***	***15***
I V	Analysis Using Software Tools Circuit Analysis Software ORCAD- PSpice - Simulation Overview - Creating and Preparing a Circuit for Simulation - Simulating a Circuit with PSpice - Simple Multi-run Analyses - Statistical Analyses - Simulation Examples of Power Electronic systems- Creating Symbols -Creating - Models - Analog Behavioral Modeling - Setting Up and Running analyses – Viewing Results- Examples of Power Electronic Systems.	***8***	***15***
SECOND INTERNAL EXAM			
V	Dynamic modeling and simulation of DC-DC converters using MATLAB - Simulation of State Space Models –	***8***	***20***
VI	Modeling and simulation of inverters using MATLAB	***8***	***20***

Internal continuous assessment: 40 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

End semester Examination: 60 marks

ELECTIVE III

Course No.	Course Name	L-T-P-Credits

08EE6252 (A)	EMBEDDED CONTROLLERS IN REAL TIME SYSTEMS	3-0-0-3

***Course Objective**:*

To introduce the students embedded controllers, its architecture, applications and real time systems.

Syllabus:

Introduction to 8051 and its applications, Real-time Systems, PIC Processors, FPGA devices, DSP architecture and pipelining

Expected outcome

The students will be able to analyse the architecture, applications and real time systems related to embedded controllers.

References

1. Mazidi & Mazidi, Embedded System Design using 8051 Microcontroller, Pearson
2. Ajay V DeshMukh, Microcontrollers -Theory and Applications, TMH
3. Phillip A Laplante, Real Time Systems Design and Analysis, PHI
4. Daniel W Lewis, Fundamentals of Embedded Software, Pearson
5. Sen M Kuo, Woon Seng Gan, Digital Signal Processors-Architecture, Implementation and Applications, Pearson
6. H A Toliyat, S Campbell, DSP Based Electro Mechanical Motion Control, CRC Press,
7. Avtar Singh, S Srinivasan, Digital Signal Processing, Thomson Brooks
8. Phil Lapsley, Bler, Sholam, E A Lee, DSP Processor Fundamentals, IEEE Press
9. Wayne Wolf, FPGA Based System Design, Pearson
10. Scott Hauck, The Roles of FPGAs in Reprogrammable Systems, Proceedings of the IEEE, Vol. 86, No. 4, pp. 615-639, April, 1998

Course Plan

Module	*Contents*	*Hours*	*% marks for semester exam*
I	8051 Microcontroller - Assembly Language programming and C Programming- Instruction set – Interrupts - Timers – Memory- I/O ports – Serial Communication - Interfacing –Key board, LED display, External memory, ADC, DAC, LCD, RTC – Typical applications- DC motor speed control, speed measurement, Temperature control, Stepper motor control, PID control.	***9***	***15***

II	Real-time Systems - Introduction to real time systems-interrupt driven systems-context switching-scheduling-round robin preemptive-rate monotonic	***7***	***15***
FIRST INTERNAL EXAM			
III	Foreground and Background systems-Intertask communication- Buffering data-Mailboxes-Critical regions-Semaphores-Deadlock-Process stack management- Dynamic allocation-Response time calculation-Interrupt latency.	***7***	***15***
IV	PIC Processors - RISC concepts - PIC processors-overview-16F877 - Architecture – Elementary Assembly Language Programming- Interrupts – Timers – Memory – I/O ports – SPI – I2C bus - A/D converter - USART- PWM – Interfacing - Introduction to FPGA Devices.	***8***	***15***
SECOND INTERNAL EXAM			
V	DSP Architecture - Introduction to DSP architecture- computational building blocks – Address generation unit- Program control and sequencing- Speed issues- Harvard Architecture, Parallelism, Pipelining.	***7***	***20***
VI	TMS 320F2407- Architecture- Addressing modes-I/O functionality, Interrupts, ADC, PWM, Event managers- Elementary Assembly Language Programming- Typical applications-buck boost converter, stepper motor control- Software and Hardware Development Tools.	***8***	***20***

Internal continuous assessment: 40 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

End semester Examination: 60 marks

Course No.	Course Name	L-T-P-Credits
08EE6252 (B)	**DSP AND ITS APPLICATIONS**	**3-0-0-3**

Course Objective:

To enable the students design and analyze various digital systems ,the architecture and applications of digital signal processors

Syllabus:

Review of FFT, Fast FFT and FIT FFT Transforms, IIR filters and design ,Digital signal processors and architecture, its applications.

Expected outcome

The students will be able to do analysis of digital systems and design of digital filters.

References

1. Oppenheim A. V. & Schafer R. W., Discrete- time Signal Processing, Pearson Education
2. Proakis J. G. & Manolakis D. G., Digital Signal Processing, Principles, algorithms & applications, Pearson Education.
3. Li Tan, Digital Signal Processors- Architectures, Implementations and applications, Academic Press (Elsevier)
4. Sen M. Kuo & Woon-Seng S. Gan, Digital Signal Processors- Architectures, Implementations and Applications, Pearson Education.
5. A. V. Oppenheim & R. W. Schafer, Digital Signal Processing, Prentice- Hall of India
6. Sanjit K. Mitra, Digital Signal Processing- A computer based approach, Tata Mc Graw Hill
7. Emmanuel C. Ifeachor, Barrie W. Jervis, Digital Signal Processing- A practical approach, Pearson education.
8. Ludeman, Fundamentals of Digital Signal Processing, Wiley India Pvt. Ltd.

Course Plan

Module	*Contents*	*Hours*	*% marks for semester exam*
I	Review of signals and systems – Review of discrete-time Fourier transform (DTFT) – Discrete Fourier Transform – properties – inverse DFT – relationship between DFT and Z-transform – circular convolution – linear convolution using DFT – overlap add/save method – Fast Fourier Transform (FFT) - Decimation-in-time (DIT) & Decimation-in-	***8***	***15***

	Frequency (DIF) FFT algorithms.		
II	Realization of IIR filters – direct form I & II – cascade – parallel – lattice-ladder – state space realizations – type I & II – realization of FIR filters – direct form – cascade – linear phase realizations – lattice – conversion from lattice to direct form	***8***	***15***
FIRST INTERNAL EXAM			
III	Digital filter design – analog to digital transformation –backward-difference technique – impulse invariant – bilinear transformation – design of IIR filter from analog filter – Butterworth & Chebyshev filter – FIR filter design – Fourier series method – design using windows – Rectangular, Bartlett, Hanning, Hamming, Blackman, Kaiser windows - comparison of FIR & IIR filters.	***7***	***15***
IV	Multirate digital signal processing – sampling rate conversion – decimation, interpolation – sampling rate alternation or conversion – filter design and implementation for sampling rate alternation – direct form FIR digital filter structure, polyphase filter structure, time-varying digital filter structure – sampling rate conversion by an arbitrary factor .Finite word length effects – fixed point and floating point formats – quantization errors – limit cycle oscillations	***7***	***15***
SECOND INTERNAL EXAM			
V	Digital signal processors – selection of digital signal processors – Von Neumann & Harvard architecture – Multiply Accumulate Unit (MAC) - architecture of DSP processor - fixed point & floating point (block diagram approach) - applications of digital signal processors	***7***	***20***
VI	Applications of DSP – speech processing – speech analysis, synthesis and compression – radar signal processing – image processing – image formation, recording, compression, restoration, enhancement – echo cancellation .Execution of simple programs using digital signal processor – solution of specific	***8***	***20***

	problems in digital signal processing using MATLAB programs		
Internal continuous assessment: 40 marks Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher. **End semester Examination: 60 marks**			

Course No.	**Course Name**	**L-T-P-Credits**
08EE6252 (C)	**DIGITAL CONTROL SYSTEMS**	**3-0-0-3**

Course Objective:

To familiarize the students digital controllers ,its analysis and design concepts.

Syllabus:

Introduction to digital systems, pulse transfer functions ,Stability analysis, design of digital controllers, state space analysis

Expected outcome

The students will be able to design and analyze digital control systems

References

1. K. Ogata, Discrete- time control systems, PHI
2. M. Gopal, Digital Control and State Variable Methods, Tata McGraw Hill
3. B. C. Kuo, Digital Control Systems, Prentice Hall
4. Charles L. Philip and Troy Nagle, Digital control Systems, Prentice Hall

Course Plan

Module	***Contents***	***Hours***	***% marks for semester exam***

I	Introduction to discrete time control system- Block diagram of a digital control system-Typical examples-Sampling process- Data reconstruction and hold circuits-Zero and first order hold- Review of z- transforms and inverse z-transforms- solution of difference equations- pulse transfer function- pulse transfer function with dead time- system time response- Realization of pulse transfer functions (Digital Controllers)- Direct Programming- Standard Programming- Series programming- parallel programming- ladder programming.	***9***	***15***
II	Review of stability analysis in z- plane- Jury's stability test and extension of Routh's stability criterion to discrete systems- Transient and Steady state response analysis- transient response specifications- steady state error analysis.	***7***	***15***
FIRST INTERNAL EXAM			
III	Construction of root loci- effect of sampling period on transient response specifications- frequency response specifications- Nyquist stability criterion in the z- plane-Digital Controllers- PI, PD & PID Controllers- Lag, lead, and lag-lead compensators- Design of lag compensator and lead compensator based on root locus and Bode plot approaches	***7***	***15***
IV	State Space analysis of digital control systems- state space representation of discrete time systems- Transfer function from state model- Diagonal/ Jordan Canonical forms from transfer function-	***7***	***10***
SECOND INTERNAL EXAM			
V	Solution of linear time invariant discrete time state equations- discretization of continuous time space equation- representing state models in CCF, OCF, DCF/ JCF using transformation matrix	***7***	***15***
VI	Concept of controllability and observability for a linear time invariant discrete time control system- condition for controllability and observability-	***8***	***15***

	state feedback- condition for arbitrary pole placement- design via pole placement- state observers- design of full order state observer.		

Internal continuous assessment: 40 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

End semester Examination: 60 marks

Course No.	Course Name	L-T-P-Credits
08EE6262 (P)	**MINI PROJECT**	**0-0-4-2**

***Course Objective**:*

- *To estimate the ability of the student in transforming the theoretical knowledge studied so far into a working model of a power electronic system.*
- *For enabling the students to gain experience in organisation and implementation of a mini project and thus acquire the necessary confidence to carry out hardware implementation of main project..*

Expected outcome

Students will be able to design and develop a working model of the given power electronic circuit and gain experience in developing the hardware models for the main project.

This is a hardware based mini project and each student is expected to develop a power electronic based system with practical applications .Student has to design, fabricate, test and assemble a power electronics based system in an enclosure with appropriate terminals and control mounted on an enclosure. This should be a working model. The basic concepts of product design may be taken into consideration while designing the project.

Internal continuous assessment: 100 marks

Course No.	Course Name	L-T-P-Credits

08EE6272 (P)	ADVANCED POWER ELECTRONICS LAB	0-0-2-2

Course Objective:

To provide practical knowledge through hardware implementation & simulation of power electronic circuits

Expected outcome

The students will be able to design, simulate and implement different power electronic circuits.

LIST OF EXPERIMENTS

1. Simulation of Closed loop control of converter fed DC motor drives
2. Simulation of Closed loop control of chopper fed DC motor drives
3. Simulation of sine PWM & space vector PWM
4. Simulation of 3-phase induction motor drive using V/f control
5. Simulation of Brushless DC Motor drive
6. Simulation of Multilevel Inverters
7. MOSFET/ IGBT/Transistor based DC Choppers (Buck , Boost & Cuk)
8. Half bridge square wave inverter
9. Single-phase Sine triangle PWM inverter
10. Microcontroller based control of dc-dc converter
11. Closed loop control of Brushless DC motors
12. Closed loop control of Switched reluctance motors.
13. Closed loop control of permanent magnet synchronous motors.

(At least 10 experiments in the list are to be conducted in the laboratory. Additional experiments and simulation assignments can also be given by the department)

Out of the above, a minimum of SIX hardware experiments and FOUR simulation experiments are to be conducted. Simulation can be done using any of the software packages like MATLAB/SIMULINK, PSPICE, PSCAD etc.

Internal continuous assessment: 100 marks

a. Regularity – 30%

b. Record – 20%

c. Test and Viva – 50%

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SEMESTER III

ELECTIVE IV

Course No.	Course Name	L-T-P-Credits
08EE7211 (A)	**SPECIAL ELECTRICAL MACHINES AND DRIVES**	**3-0-0-3**

Course Objective:

To introduce special types of electric machines and their controls for special applications.

Syllabus:

Stepper motor, switched Reluctance motor, Permanent Magnet brushless DC motor, Permanent magnet synchronous motors, their dynamic characteristics and control.

Expected outcome

The students will be able to analyse special electric machines and their control for special applications.

References

1. Kenjo T, Sugawara A, Stepping Motors and Their Microprocessor Control, Clarendon Press, Oxford
2. Miller T J E, Switched Reluctance Motor and Their Control, Clarendon Press, Oxford
3. Miller T J E, Brushless Permanent Magnet and Reluctance Motor Drives, Clarendon Press, Oxford
4. B K Bose, Modern Power Electronics & AC drives, Pearson Education
5. Kenjo T, Power Electronics for the Microprocessor Age, Oxford University Press
6. Ali Emadi (Ed), Handbook of Automotive Power Electronics and Motor Drives, CRC Press
7. R Krishnan, Electric Motor Drives – Modeling, Analysis and Control, PHI
8. H A Toliyat, S Campbell, DSP Based Electro Mechanical Motion Control, CRC Press

Course Plan

Module	*Contents*	*Hours*	*% marks for semester exam*
I	Stepping Motors, Constructional features, principle of operation, modes of excitation, single phase stepping motors, torque production in variable Reluctance (VR) stepping motor, Dynamic characteristics, Drive systems and circuit for open loop control, Closed loop control of stepping motor, microprocessor based controller	***9***	***15***
II	Switched Reluctance Motors Constructional features, principle of operation. Torque equation, Power controllers, Characteristics and control. Microprocessor based controller. Sensor less control.	***7***	***15***
FIRST INTERNAL EXAM			
III	Synchronous Reluctance Motors Constructional features: axial and radial air gap Motors. Operating principle, reluctance torque – Phasor diagram, motor characteristics.	***7***	***15***

IV	Permanent Magnet Brushless DC Motors Commutation in DC motors, Difference between mechanical and electronic commutators, Hall sensors, Optical sensors.	***7***	***15***
SECOND INTERNAL EXAM			
V	Multiphase Brushless motor, Square wave permanent magnet brushless motor drives, Torque and emf equation, Torque-speed characteristics, Controllers-Microprocessor based controller. Sensorless control.	***7***	***20***
VI	Permanent Magnet Synchronous Motors Principle of operation, EMF, power input and torque expressions, Phasor diagram, Power controllers, Torque speed characteristics, Self control, Vector control, Current control schemes - Sensor less control.	***9***	***20***

Internal continuous assessment: 40 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

End semester Examination: 60 marks

Course No.	**Course Name**	**L-T-P-Credits**
08EE7211 (B)	**INDUSTRIAL INSTRUMENTATION**	**3-0-0-3**

Course Objective:

- To make the students aware of the different transducers used in industry and signal conditioning .
- To familiarize the process control elements and their control characteristics .

Syllabus:

Signal conditioning, analog and digital, Final Control Element, Actuators, Signal Conditioning of Transducer, Controller Principles, pneumatic controllers, Control Loop Characteristics,

Expected outcome

The students will be able to analyse the control characteristics of different process control elements and select them for various applications.

References

1. Curtis D. Johnson, Process Control Instrumentation Technology, Pearson Education
   Curtis D. Johnson, Microprocessors in Process Control, PHI
2. George Stephanopoulis, Chemical Process Control
3. Caughner, Process Analysis and Control
4. Deshpande and Ash, Elements of computer process control of Industrial processes, ISA
5. Jayantha K. Paul, Real- Time microcomputer control of Industrial processes, Kluwer Publications, Netherlands
6. S. K. Singh, Computer Aided Process Control, PHI
7. Dale E. Seborg, Thomas F. Edgar, Duncan A. Mekkichamp, Process Dynamics and Control, Wiley India

Course Plan

Module	*Contents*	*Hours*	*% marks for semester exam*
I	Signal Conditioning – Analog – Digital - Signal conversions - Process Control Principles - Identification of elements, block diagram, the loop, control system evaluation stability, regulation, evaluation criteria, and cyclic response.	***9***	***15***
II	Final Control Element: Final control operation, signal conversions, analog electrical signal, digital electrical signals, Direct action – pneumatic signals.	***7***	***15***
FIRST INTERNAL EXAM			
III	Actuators – electrical actuators, pneumatic actuators, control elements – fluid valves. Signal Conditioning of Transducers- Temperature Transducers - flow transducers.	***7***	***15***
IV	Controller Principles - Process characteristics, control system parameters, controller modes, discontinuous controller modes, continuous controller modes, composite controller modes.	***7***	***15***

SECOND INTERNAL EXAM			
V	Analog Controllers - Electronic controller – Direct action, reverse action, proportional mode, integral mode, derivative mode, composite controller modes - Pneumatic controllers – implementation of PI, PID, PD - Design consideration.	***8***	***20***
VI	Control Loop Characteristics: Control system configurations, cascade control, multivariable control, feed forward control, Split range control, inferential control, Adaptive control, control system quality – loop disturbance, optimum control, measure of quality, Stability, process loop tuning	***8***	***20***

Internal continuous assessment: 40 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

End semester Examination: 60 marks

Course No.	**Course Name**	**L-T-P-Credits**
08EE7211 (C)	**NONLINEAR CONTROL SYSTEMS**	**3-0-0-3**

Course Objective:

To familiarize

- the characteristics and analysis of nonlinear systems using phase plane and describing function method
- the concept of Lyapunov stability and linearization procedures
- the advanced control techniques: sliding mode, back stepping

Syllabus:

Characteristics of nonlinear systems, describing functions, Stability of Nonlinear Systems using Lypunov methods, Analysis of feedback systems-Circle Criterion - Popov Criterion - simultaneous Lyapunov functions, Sliding Mode Control, Lyapunov Redesign

Expected outcome

The students will be able to analyze and check the stability of non liner systems.

References

1. Hassan K Khalil, Nonlinear Systems, Prentice - Hall International (UK) 1996

2. Slotine & W.LI, Applied Nonlinear Control Prentice Hall, Engloe wood NewJersey 1991

3. A Isidori, Nonlinear Control systems Springer verlag New york 1995

4. C Edwards, S Spurgeon, Sliding mode Control, Theory and Applications, CRC Press, 1998.
5. V. Utkin, J Guldner,J Shi, Sliding Mode Control in Electro Mechanical Systems, CRC Press, 2009.

Course Plan

Module	***Contents***	***Hours***	***% marks for semester exam***
I	Characteristics of nonlinear systems - classification of equilibrium points - limit cycles - analysis of systems with piecewise constant inputs using phase plane analysis - describing function of standard nonlinearities- study of limit cycles (amplitude and frequency) using Single input Describing Function(SIDF).	***8***	***15***
II	Stability of Nonlinear Systems- Lyapunov stability - local stability - local linearization and stability in the small - Direct method of Lyapunov - generation of Lyapunov function for linear and nonlinear systems – variable gradient method.	***7***	***15***
FIRST INTERNAL EXAM			
III	Centre manifold theorem - region of attraction - Invariance theorems - Input output stability - L stability - L stability of state models - L2 stability-	***7***	***15***

	Lyapunov based design		
IV	Analysis of feedback systems-Circle Criterion - Popov Criterion - simultaneous Lyapunov functions - Feedback linearization - stabilization - regulation via integral control - gain scheduling - input state linearization - input output linearization - state feedback control - stabilization - tracking - integral control	***9***	***15***
SECOND INTERNAL EXAM			
V	Sliding Mode Control- Concept of variable - structure controller and sliding control, reaching condition and reaching mode, existence condition- implementation of switching control laws.	***8***	***20***
VI	Reduction of chattering in sliding mode, Lyapunov Redesign: Stabilization-Nonlinear Damping, Back stepping Control	***8***	***20***

Internal continuous assessment: 40 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

End semester Examination: 60 marks

ELECTIVE V

Course No.	Course Name	L-T-P-Credits
08EE7221 (A)	**SOFT COMPUTING TECHNIQUES**	**3-0-0-3**

Course Objective:

To acquaint the students with soft computing methodologies such as neural networks, fuzzy logic,

genetic algorithms and hybrid algorithms and enable the students to implement real time intelligent and adaptive systems.

Syllabus:

Introduction to Fuzzy logic, Fuzzification, Defuzzification methods, Artificial Neural Networks concepts, Fundamentals of genetic algorithms and hybrid systems.

Expected outcome

The students will be able to apply soft computing methodologies to implement real time intelligent and adaptive systems.

References

1. S.Rajasekharan, G.A.Vijayalakshmi Pai, Neural Network, Fuzzy Logic and Genetic Algorithms Synthesis and Applications, Prentice Hall India.
2. S.N.Sivanandam, S.N.Deepa, Principles of Soft Computing, Wiley India.
3. Timothy J Ross, Fuzzy logic with Engineering Applications, McGraw Hill ,New York.
4. S.Haykins, Neural Networks a Comprehensive foundation, Pearson Education.
5. D.E.Goldberg, Genetic Algorithms in Search Optimisation and Machine Learning, Pearson Education.
6. Recent Literature.

Course Plan

Module	*Contents*	*Hours*	*% marks for semester exam*
I	Introduction to Fuzzy logic: Fuzzy sets- Fuzzy set operations- Fuzzy relations-Cardinality of Fuzzy relations- Operations on Fuzzy relations-Properties of Fuzzy relations-Membership Functions-Features of Membership functions- Fuzzification-Methods of Membership value Assignments- Fuzzy Rule Base-Defuzzification- Deffuzzification methods- Fuzzy logic controller(Block Diagram)	***7***	***15***
II	Artificial Neural Networks: Basic concepts-Neural network Architectures-Single layer feed forward network- Multilayer feed forward network.	***7***	***15***
FIRST INTERNAL EXAM			
III	Recurrent Networks-Characteristics of Neural Networks-Learning methods. Perceptron networks-Back Propagation networks-Radial base function network-Hopfield network- Kohonen Self	***7***	***15***

IV	Fundamentals of genetic algorithms: Basic concepts- working principle – encoding – different methods – Fitness function – reproduction-different methods. Genetic modelling-inheritance- Crossover mutation- Convergence of genetic algorithm.	***8***	***15***
SECOND INTERNAL EXAM			
V	Hybrid systems: Neural network, fuzzy logic and genetic algorithm hybrids – Neuro fuzzy hybrids-neuro genetic hybrids-Fuzzy genetic hybrids	***8***	***20***
VI	Genetic algorithm based back propagation network-Fuzzy back propagation networks -fuzzy logic controlled genetic algorithms.	***8***	***20***

Internal continuous assessment: 40 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

End semester Examination: 60 marks

Course No.	Course Name	L-T-P-Credits
08EE7221 (B)	**Design of Power Electronics System**	**3-0-0-3**

Course Objective:

To enable the students to design control circuits and cooling system for power electronics based system.

Syllabus:

Design of gate and base drive circuits, snubber circuits and het sink design concepts, Demonstration Design.

Expected outcome

The students can design the control and cooling circuits for the power electronic circuits.

References

1.Ned Mohan, Tore M. Undeland and William P.Riobbins, " Power Electronics—Converters, Applications and Design" Third Edition, John Wiley and Sons. Inc2014

2.Muhammad H. Rashid, " Power Electronics, Circuits, Devices and Application"' Third Edition, Prentice Hall of India Private Limited, 2004

3.Joseph Vithayathil, " Power Electronics-Principle and Applications'' , Tata McGraw Hill Education Pvt Ltd, 2010.

4. Barry W. Williams, "Principles of Elecments of Power Electronics Deviceses, Drivers, Applications and Passive Components", Barry W. Williams, 2006.

5.Daniel W. Hart, "Power Electronics", Tata McGraw Hill, 2011.

Course Plan

Module	*Contents*	*Hours*	*% marks for semester exam*
I	Design of Gate and Base Drive Circuits: Design consideration, dc – coupled drive circuits isolated drive circuits, cascade-connected drive circuits Thyristor drive circuits power device protection in drive circuits layout considerations.	***8***	***15***
II	Snubber circuits: Function and type of Snubber circuits, diode snubbers thyristor snubber circuits, Transistor snubber circuits	***7***	***15***
FIRST INTERNAL EXAM			
III	Turn off and turn-on snubber, overvoltage snubber, snubber for bridge circuit configurations, GTO snubber considerations.	***8***	***15***
IV	Cooling and Design of heat sinks: Control of device temperature, heat transfer by conduction, heat sinks,heat transfer by radiation and	8	***15***

	convection		
SECOND INTERNAL EXAM			
V	Demonstration Design: Typical specification of power converters , EMI and layout fundamentals, design of power circuits to meet specification	***7***	***20***
VI	Design of resonant inverters, switch mode converter, single phase ac-dc inverter.	***7***	***20***

Internal continuous assessment: 40 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

End semester Examination: 60 marks

Course No.	**Course Name**	**L-T-P-Credits**
08EE7221 (C)	**RENEWABLE ENERGY TECHNOLOGIES**	**3-0-0-3**

Course Objective:

To have an understanding of various commercial renewable energy sources and method of conversion to electric energy.

Syllabus:

Renewable energy utilization, Wind energy, Solar energy and other renewable energy technologies

Expected outcome

The students will be able to design and model power electronic circuits for efficient conversion of energy in renewable energy technologies.

References

1. Thomas B Johansson , "Renewable Energy: "Sources for Fuels and Electricity", Island Press, Washington, 1993 .
2. John W Twidell and A D Weir , " Renewable Energy Sources",ELBS,1986.
3. N K Bansal, M Kleeman and M Mellis , "Renewable Energy Resources and conversion Technology " , Tata McGraw Hill , 1990.
4. S N Bhadra , D Kastha and S Banarji , " Wind Electrical Systems " ,Oxford University Press , 2005
5. Marcelo Godoy Simões and Felix A. Farret, "*Renewable Energy Systems: Design and*

Analysis with Induction Generators", CRC Press, ISBN 0849320313, 2004.
6. Ion Boldea, "*Variable Speed Generators"*, CRC Press, ISBN 0849357152, 2006.
7. S.N. Bhadra, D.Kastha and S.Banerje, "*Wind Electrical Systems"*, Oxford Uni Press, 2005.
8. Siegfried Heier, Rachel Waddington, "*Grid Integration of Wind Energy Conversion Systems"*, 2nd Edition', Wiley, 2006,
9. Freries LL , "*Wind Energy Conversion Systems"*, Prentice Hall, U.K., 1990
10. Chetan Singh Solanki, "*Solar Photovoltaics-Fundamentals, Technologies and Applications"*, PHI Learning Pvt. Ltd., New Delhi, 2011
11. Van Overstraeton and Mertens R.P., "*Physics, Technology and use of Photovoltaics"*, Adam Hilger, Bristol,1996.
12. John F.Walker & Jenkins. N , "*Wind Energy Technology*", John Wiley and sons, Chichester, UK, 1997.
13. Freries LL ,"*Wind Energy Conversion Systems"*, Prentice Hall, U.K., 1990

Course Plan

Module	***Contents***	***Hours***	***% marks for semester exam***
I	Renewable energy Sources: Renewable energy utilization in ancient times, classification of RE technologies – stand alone, hybrid and grid – connected; Recent developments in renewable energy sector- global and national energy policies	***8***	***15***
II	Wind energy – energy in the wind – aerodynamics - rotor types – forces developed by blades - Aerodynamic models – braking systems – tower - control and monitoring system	***7***	***15***
FIRST INTERNAL EXAM			
III	Design considerations-power curve - power speed characteristics. Choice of electrical generators Wind turbine generator systems-fixed speed induction generator-performance analysis	***7***	***15***
IV	Solar energy – Solar radiation and measurements; PV cell-principle, types and construction; modeling of PV cell, Maximum power tracking; SPV systems – stand alone and grid-connected.	8	***15***
SECOND INTERNAL EXAM			

V	Other renewable energy technologies; Biomass – gasifiers; small hydro-resource assessment, selection of turbines, Electronic load controller;	***7***	***15***
VI	Wave, Tidal, Ocean thermal and Geothermal energy systems – principles and technologies; Energy storage systems.	***8***	***10***

Internal continuous assessment: 40 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

End semester Examination: 60 marks

Course No.	Course Name	L-T-P-Credits
08EE7231 (P)	**SEMINAR**	**0-0-2-2**

Course Objective:

To assess the debating capability of the student to present a technical topic. Also to impart training to a student to face audience and present his ideas and thus creating in him self esteem and courage that are essential for an engineer.

Expected outcome

The students will develop confidence to face the audience and present their ideas on a technical topic**.**

Individual students are required to choose a topic of their interest from power electronics and drive related topics preferably from outside the M.Tech syllabus and give a seminar on that topic about 30 minutes. A committee consisting of at least three faculty members (preferably specialized in power electronics) shall assess the presentation of the seminar and award marks to the students. Each student shall submit two copies of a write up of his seminar topic. One copy shall be returned to the student after duly certifying it by the chairman of the assessing committee and the other will be kept in the departmental library. Internal continuous assessment marks are awarded based on the relevance of the topic, presentation skill, quality of the report and participation.

Internal continuous assessment: 100 marks

Course No.	Course Name	L-T-P-Credits
08EE7241 (P)	**MAIN PROJECT PHASE I**	**0-0-12-6**

Course Objective:

To improve the professional competency and research aptitude by touching the areas which otherwise not covered by theory or laboratory classes. The project work aims to develop the work practice in students to apply theoretical and practical tools/techniques to solve real life problems related to industry and current research.

The project work can be a design project/experimental project and/or computer simulation project on any of the topics in power electronics/drives related topics. The project work is allotted individually on different topics. The students shall be encouraged to do their project work in the parent institute itself. If found essential, they may be permitted to carry out their main project outside the parent institute, subject to the conditions specified in the MTech regulations.

The student is required to undertake the Main project phase 1 during the third semester and the same is continued in the 4thsemester (Phase 2). Phase 1 consist of preliminary thesis work, two reviews of the work and the submission of preliminary report. First review would highlight the topic, objectives, methodology and expected results. Second review evaluates the progress of the work, preliminary report and scope of the work which is to be completed in the 4th semester.

Project Evaluation:

Progress evaluation by the Project Supervisor: 20 Marks

Presentation and evaluation by the committee: 30 Marks

Total marks for the Project Phase 1: 50 Marks

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SEMESTER IV

Course No.	Course Name	L-T-P-Credits
08EE7212 (P)	**MAIN PROJECT PHASE II**	**0-0-21-12**

Course Objective:

To improve the professional competency and research aptitude by touching the areas which otherwise not covered by theory or laboratory classes. The project work aims to develop the work practice in students to apply theoretical and practical tools/techniques to solve real life problems related to industry and current research.

Main project phase 2 is a continuation of project phase 1 started in the third semester. There would be two reviews in the fourth semester, first in the middle of the semester and the second at the end of the semester. First review is to evaluate the progress of the work, presentation and discussion. Second review would be a pre-submission presentation before the evaluation committee to assess the quality and quantum of the work done. . At least one technical paper is to be prepared for possible publication in journal or conferences. The technical paper is to be submitted along with the thesis.

Project Evaluation:

Project evaluation by the supervisor/s: 30 Marks

Presentation & evaluation by the Committee: 40 Marks

Evaluation by the External expert: 30 Marks

Total marks for the Project Phase 2: 100 Marks