APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

Cluster No. 10 for PG Programs

(Engineering Colleges in Kannur, Wayand & Kasaragod Districts)

Curriculum, Scheme of Examinations and Syllabi for M. Tech. Degree Program with effect from Academic Year 2015 - 2016

Electrical & Electronics Engineering

M. Tech.

in

Power Electronics & Drives

(No. of Credits: 66)

SCHEME OF M. TECH PROGRAMME IN
POWER ELECTRONICS AND DRIVES

FIRST SEMESTER

Slot	Code	Subject	Hours/Week			ICA	ESE		Total	Credit
			L	T	P		Hrs	Marks		
A	10EE6101	Computational Techniques	3	1	0	40	4	60	100	4
B	10EE6103	Design & Analysis of Power Electronic Systems	3	0	0	40	3	60	100	3
C	10EE6105	Advanced Machine Drives	3	0	0	40	3	60	100	3
D	10EE6107	Power Converters- I	3	0	0	40	3	60	100	3
E	10EE6xxx	Elective-I	3	0	0	40	3	60	100	3
F	10GN6001	Research Methodology	0	2	0	100	-	0	100	2
G	10EE6109	Seminar-I	0	2	0	100	-	0	100	2
H	10EE6111	Power Electronics Lab	0	0	2	100	-	0	100	1
	TOTAL		15	5	2	500		300	800	21

L-Lecture T-Tutorial P-Practical
ICA-Internal Continuous Assessment
ESE-End Semester Examination

ELECTIVE I

10EE6113 Special Machines
10EE6115 Computer Aided Design of Electrical Machines
10EE6117 Power Quality Issues and Remedial Measures
10EE6203 System Theory
10EC6105 Advanced Digital Signal Processing

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

SECOND SEMESTER

Slot	Code	Subject	Hours/Week			ICA	ESE		Total	Credit
			L	T	P		Hrs	Marks		
A	10EE6102	Power Converters- II	3	1	0	40	4	60	100	4
B	10EE6104	Control Techniques in Power Electronics	3	0	0	40	3	60	100	3
C	10EE6106	Machine Analysis and Control	3	0	0	40	3	60	100	3
D	10EE61xx	Elective-II	3	0	0	40	3	60	100	3
E	10EE61xx	Elective-III	3	0	0	40	3	60	100	3
F	10EE6108	Mini Project	0	0	4	100	-	0	100	2
H	10EE6112	Advanced Drives Lab	0	0	2	100	-	0	100	1
	TOTAL		15	1	6	400		300	700	19

L-Lecture T-Tutorial P-Practical
ICA-Internal Continuous Assessment
ESE- End Semester Examination

ELECTIVES II

10EE6114 Industrial Control Electronics

10EE6116 Power Conversion in Renewable Energy Systems

10EE6122 Microcontroller Applications in Power Electronics

10EE6124 High voltage DC and AC Transmission

10ME6116 Design of Experiments

10ME6122 Quality Management system and Reliability

10ME6124 Project Engineering and Management

ELECTIVES III

10EE6118 Power Semiconductor Devices

10EE6126 Energy Management

10EE6128 Wind Energy Conversion Systems

10EE6132 Distributed Generation and Micro grid

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

THIRD SEMESTER

Slot	Code	Subject	Hours/Week			ICA	ESE		Total	Credit
			L	T	P		Hrs	Marks		
A	10EE7xxx	Elective-IV	3	0	0	40	3	60	100	3
B	10EE7xxx	Elective-V	3	0	0	40	3	60	100	3
H	10EE7101	Seminar-II	0	2	0	100	-	0	100	2
	10EE7103	Project-Phase I	0	0	14	50	-	0	50	6
	TOTAL		6	2	14	230		120	350	14

L-Lecture T-Tutorial P-Practical

ICA-Internal Continuous Assessment

ESE- End Semester Examination

ELECTIVE IV

10EE7105 FACTS Controllers

10EE7107 Electric Vehicle Systems

10EE7117 Soft computing technique

10EC7207 Micro Electro Mechanical Systems

ELECTIVES V

10EE7109 Induction Generators

10EE7111Custom Power Devices

10EE7113 Analysis, Modelling and Control of Electric Drives

10EE7115 Advanced control of PWM inverter fed induction motors

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

FOURTH SEMESTER

Slot	Code	Subject	Hours/Week			ICA	ESE		Total	Credit
			L	T	P		Hrs	Marks		
	10EE7104	Project –Phase II	-	-	22	70	-	30	100	12
	TOTAL		-	-	22	70		30	100	12

L-Lecture T-Tutorial P-Practical ICA-Internal Continuous Assessment
ESE-End Semester Examination

Note: 8 hours/week is meant for departmental assistance by students.
Industrial Training (During inter semester holidays of 2nd& 3rd Semesters)

[Total Credits: 66]

SEMESTER I

Course No.	Course Name	L-T-P-Credits	Year of Introduction
10EE6101	COMPUTATIONAL TECHNIQUES	3 - 1 - 0 : 4	2015

Course Prerequisites

Basic knowledge of engineering mathematics at UG level.

Course Objectives

To equip the student with mathematical techniques necessary for computing applications in engineering systems

Syllabus

Introduction to numerical techniques. Numerical/analytical solution of ordinary differential equations and partial differential equations. Stability of the numerical methods. Iterative solutions. Matrix equations. Ill conditioning and norms. Linear and unconstrained optimization. Simplex methods. Spectral methods.

Expected Outcomes

Upon the completion of this course, students will have the ability:

- To solve equations using numerical iteration techniques including Newton's method, interpolation methods
- To solve equations using numerical iteration techniques including Triangularization techniques, Eigenvalues etc
- To apply numerical techniques for the solution of differential equation of dynamic systems
- To use MATLAB/Scilab platforms for the solution of equations
- To apply numerical techniques for the solution of partial differential equation
- To acquire knowledge of various unconstrained opimationsation

Text book:

1. Erwin Kreyszig, Advanced Engineering Mathematics 9th Edition, Wiley International Edition Press, Numerical Recipes for scientific computing,

References:

2. Bhaskar Dasgupta, Applied Mathematical Methods, Pearson,
3. Arfken, Weber and Harris, Mathematical Methods for Physicists, A comprehensive guide, 7th Edition, Elsevier, 2013

Course plan

Module	Content	Hours	Semester Exam Marks (%)
I	Solution of equations by iterations – Newton's method – secant method – interpolation – Lagrange interpolation – Newton's divided difference, forward difference, backward difference equations – spline interpolation – numeric integration and differentiation	10	15
II	Gaussian elimination – LU factorization – Matrix inversion – Gauss-Siedel iteration – Ill conditioning and norms – least squares method – eigen value problems – power method for eigen values – Tridiagonalization and QR factorization	10	15
First Internal Examination			
III	Analytical and numerical solutions of ordinary differential equations representing physical systems – mass, spring, damper	8	15

	systems - RLC circuits – simple pendulum – inverted pendulum – Euler's forward difference, backward difference and symmetric methods – stability of Euler's methods – Runge Kutta methods – stability of Runge Kutta methods		
IV	Matlab/Scilab Laboratory sessions: Numerical integration and differentiation. Euler's method and Runge Kutta methods for systems of linear and nonlinear differential equations PDEs: Elliptic, parabolic and hyperbolic Elliptic PDE's: difference equations for Laplace and Poisson Equations – Dirichlet, Neumann and Mixed problems – relaxation methods	8	15
Second Internal Examination			
V	Parabolic PDE's: Heat equation – analytical and numerical solutions – Crank Nicholson method. Hyperbolic PDE's: Wave equation – analytical and numerical solutions – Lax Wendroff method Introduction to numerical spectral methods - Matlab/Scilab Laboratory sessions: Solution of heat and wave equations for different initial and boundary conditions.	10	20
VI	Unconstrained Optimization – single variable optimization – iterative methods – multivariate optimization – direct methods – steepest descent method – Newton's method – Linear programming problem – simplex method Matlab/Scilab Laboratory sessions: Simple optimization problems.	10	20
		56	100
Cluster Level End Semester Examination			

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 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.

Two internal tests, each having 15 marks each summing to a total of 30 marks
Tutorials / Assignments / Course Seminars summing to a total of 10 marks, and
Cluster level end-semester examination having 60 marks

Course No.	Course Name	L-T-P-Credits	Year of Introduction
10EE6103	**DESIGN AND ANALYSIS OF POWER ELECRONICS SYSTEMS**	**3 - 0 - 0 : 3**	**2015**

Course Prerequisites

Basic knowledge of Power electronics, and Network Analysis at UG Level.

Course Objectives

To develop design and analysis skills of Power Electronic Systems.

Syllabus

Switched DC source with RL, RC and RLC load – half wave uncontrolled rectifier circuit analysis-power switches- half wave controlled rectifiers – rectifier fed d.c. motor drives- Choppers – d.c.motor drives -Magnetics design - AC inductor design -Thermal design

Expected Outcomes

Upon the completion of this course, students will have the ability:

- To analyse the operation and performance of uncontrolled rectifiers with different load conditions,
- to analyse the operation and performance of controlled half wave rectifiers
- to apply controlled rectifiers for drive application
- to analyse various chopper circuits
- to design inductor and transformer for controller applications
- to acquire knowledge on thermal design considerations

Text books

1. S B Dewan,G R Slemon and A Straughen, "Power Semiconductor circuits" – Wiley India 2009
2. Robert W Erickson and Dragan Maksimovic, "Fundamentals of Power Electronics", Springer international, Second Edition 2009.
3. L Umanand, "Power electronics Essentials and Applications" Wiley India Pvt Ltd, 2010.
4. L Umanand and S P Bhat "Design of Magnetic Components for Switched Mode Power converters" — New Age International, 1992.
5. Joseph Vithayathil, "Power electronics: Principles and Applications" McGraw Hill Education, 2010.
6. Cyril W Lander, "Power Electronics" Tata McGraw Hill, Third Edition, 1993.

Course plan

Module	Content	Hours	Semester Exam Marks (%)
I	Switched DC source with RL, RC and RLC load – recovery of trapped energy – RLC load with an ac source.-Rectifier Circuit analysis-Uncontrolled Half wave Rectifier.	8	15
II	Models of power switches – Operation of thyristor-Controlled Half wave Rectifier- commutation of thyristors –types.	6	15
First Internal Examination			
III	Single phase and three phase controlled rectifiers-Rectifier fed d.c motor drive – dual converter – d.c series motor drive-numerical examples	8	15
IV	Choppers – analysis of type A, type B, four quadrant chopper-d.c motor drive	6	15
Second Internal Examination			
V	Magnetics design – transformer modeling – loss mechanism in magnetic devices – eddy currents in winding conductors – types of magnetic devices – BH loops, core and copper losses – inductor design constraints – design procedure – multiple	8	20

	winding magnetics design – transformer design constraints – design procedure – AC inductor design		
VI	Thermal design – control of semiconductor device temperatures - various heat transfer modes, heat sink design. Numerical examples.	6	20
		42	100
Cluster Level End Semester Examination			

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 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.

Two internal tests, each having 15 marks each summing to a total of 30 marks
Tutorials / Assignments / Course Seminars summing to a total of 10 marks, and
Cluster level end-semester examination having 60 marks

Course No.	Course Name	L-T-P-Credits	Year of Introduction
10EE 6105	ADVANCED MACHINE DRIVES	3 - 0 - 0 : 3	2015

Course Prerequisites

Basic knowledge in Electrical machines and Power electronics at UG level.

Course Objectives

1. To give an idea about the dynamics and control of conventional and modern electrical drives
2. To develop power electronics based control for accurate speed control for various applications

Syllabus

Electric drive systems- Dynamics- Rating and heating of motors- DC drives- Induction motor drives- Synchronous motor drives- Drives for specific applications--Control techniques of electric drives- Transfer function and state variable representation of drive systems – Closed Loop control of drives- Microprocessors based control

Expected Outcomes

1. Understand basic requirements placed by mechanical systems on electric drive.
2. To understand and develop the speed controllers for the dc motor drives to satisfy four-quadrant operation to meet mechanical load requirements.
3. To understand and develop the speed controllers for induction motor drives to satisfy four-quadrant operation to meet mechanical load requirements.
4. To understand and develop the speed controllers for synchronous motor drives to satisfy four-quadrant operation to meet mechanical load requirements.
5. Able to select the electrical motor drives for various mechanical load applications in energy efficient manner using power electronics.
6. To understand and develop controllers for electric motor drive applications.

Text Books:

1. Vedam Subrahmanyam, "Electric Drives: Concepts & Applications", 2nd Edition, Tata McGraw-Hill Education, 2010.
2. G. K. Dubey, "Fundamentals of Electric Drives" 2nd Edition, Narosa Publications, 2002.

References:

1. Jingde Gao, Linzheng Zhang and Xiangheng Wang, "AC Machine Systems", Springer, 2009
2. Rik De Doncker, Duco W J Pulle and Andre Veltman, " Advanced Electrical Drives: Analysis, Modeling, Control " 1st Edition. Springer-verlag Gmbh, 2010.

Course plan

Module	Content	Hours	Semester Exam Marks (%)
I	**Dynamics of a drive**s: Elements of electric drives- Dynamics of a drive system –Components of load torques- Steady state stability. **Motor power rating**: Requirements of a drive motor – Power losses, Heating and Cooling of electric motor – Classes of duty and Selection of electric motor	8	15
II	**DC drives**: Phase controlled rectifier fed dc drives- Separately excited motor and Series motors drives- Single phase and three phase drives- Chopper fed drives- Reversible drives-	6	15
First Internal Examination			
III	**Induction motor drives**: Stator Voltage control- Rotor resistance control- Chopper control- Slip energy recovery schemes-V/f control- Cyclo converter fed motors- VSI & CSI fed motors- PWM drives- Field oriented control	8	15

IV	**Synchronous motor drives**: Variable frequency supply- Self control- VSI & CSI fed motors- Permanent magnet synchronous motors – Cyclo converter fed synchronous motor Drive circuits for stepper motor-switched reluctance motor drives	6	15
Second Internal Examination			
V	**Drive Applications:** Drive considerations for textile mills, steel rolling mills, cranes and hoists, cement mills, sugar mills, machine tools, paper mills, coal mines, centrifugal pumps, turbo compressors- ac & dc drives- Traction Drives. Basics of solar powered pump drives and electric vehicles.	8	20
VI	**Control techniques**: Block diagram representation of drive systems – Transfer function and state variable representation of dc drive systems – Closed Loop control of drives- Torque, speed and position control schemes- **Microprocessors based control**: Application areas- Block diagram schemes for control of ac, dc drives and stepper motors – Aspects of microprocessor based control system design.	6	20
		42	100
Cluster Level End Semester Examination			

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 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.

Two internal tests, each having 15 marks each summing to a total of 30 marks Tutorials / Assignments / Course Seminars summing to a total of 10 marks, and Cluster level end-semester examination having 60 marks

Course No.	Course Name	L-T-P-Credits	Year of Introduction
10EE6107	**POWER CONVERTERS I**	**3 - 0- 0 : 3**	**2015**

Course Prerequisites

Basic knowledge of Power Electronic circuits and devices at UG Level.

Course Objectives

To develop solid foundation in analyzing DC-DC and AC-DC converters

Syllabus

Line frequency single phase and three phase AC-DC fully controlled rectifiers, Multi pulse AC-DC converters, DC-DC converters, Resonant converters and switching power supplies.

Expected Outcomes

1. Acquire knowledge about fundamental concepts of harmonic standards and its effect on AC supply.
2. Ability to analyze various Resonant DC-DC converts used in power electronics.
3. Ability to analyze various DC-DC converts used in power electronics for various applications.
4. Ability to analyze various Switched mode DC-DC converts used in power electronics for various applications.
5. Ability to develop and analyze the PFC rectifier converters for various applications.
6. Foster ability to understand the use of power converters in commercial and industrial applications.

Text books

1. Ned Mohan, T M Undeland and William P Robbins, "Power Electronics Converters, Application And Design", 3rd Edition, John Wiley & Sons, 2003
2. M D Singh and Khanchandani, "Power Electronics" 2nd Edition, Tata Mcgraw Hill, 2006.
3. Robert W Erickson and Dragan Maksimovic, "Fundamentals of Power Electronics", Springer international, Second Edition 2009.
4. Joseph Vithayathil, "Power electronics: Principles and Applications" McGraw Hill Education, 2010.
5. Cyril W Lander, "Power Electronics" Tata McGraw Hill, Third Edition, 1993.
6. Fang Lin Luo and Hong Ye, "Renewable energy systems advanced conversion technologies & Applications", CRC Press, 2012.

Course plan

Module	Content	Hours	Semester Exam Marks (%)
I	Current harmonics in rectifiers – harmonic standards – Single phase and three phase fully controlled rectifiers - power factor, Total harmonic distortion, displacement power factor- Effect of source inductance on current commutation.	8	15
II	Resonant DC-DC converters – 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 converters	6	15
First Internal Examination			
III	DC- DC converters (CCM&DCM operation) : Buck converter- Boost converter- Buck boost Converter- Cuk converter – LUO converter – SEPIC converter	8	15

IV	Switching DC Power Supplies – Forward, flyback, pushpull, half bridge and full bridge converter circuit, operation, waveforms and design, small signal analysis of DC-DC converters and closed loop control – transfer function of dc-dc converters – stability analysis	6	15
Second Internal Examination			
V	PFC converters: Multiple converter – Boost PFC rectifiers- Vienna rectifiers – Third harmonic injection techniques – Minnesota rectifiers – Modeling and simulation of all rectifiers.	8	20
VI	Applications: Residential and industrial applications of power electronics – induction heating, welding, electronic ballast – utility applications - back to back HVDC transmission, UPS, static var compensators and active filters.	6	20
		42	100
Cluster Level End Semester Examination			

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 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.

Two internal tests, each having 15 marks each summing to a total of 30 marks
Tutorials / Assignments / Course Seminars summing to a total of 10 marks, and
Cluster level end-semester examination having 60 marks

Course No.	Course Name	L-T-P-Credits	Year of Introduction
10EE6113	SPECIAL MACHINES	3 - 0- 0 : 3	2015

Course Prerequisites

Basic knowledge of Electrical Machines at UG Level.

Course Objectives

To impart knowledge about special machines

Syllabus

Stepper motor, Servomotor, Synchronous Reluctance motor, Switched reluctance motor, Permanent magnet BLDC motor & PMAC Motor, Linear Induction motor.

Expected Outcomes

At the end of the course students will be able:

- To analyse the operation and control of stepper motor
- To acquire knowledge on the construction and operation of both ac and dc servomotor
- To compare the functioning of various types of synchronous reluctance motors
- To describe the operation and features of switched reluctance motors
- To analyse the characteristics and control of different types of permanent magnet motors
- To acquire basic knowledge on the linear induction motor

Text books

1. T.J.E. Miller, Brushless Permanent-Magnet and Reluctance Motor Drives, Clarendon Press,1989.
2. R.Krishnan, Switched Reluctance Motor Drives-Modelling, Simulation, Analysis, Design and application, CRC press New York,2001
3. T. Kenjo, ‘Stepping Motors and Their Microprocessor Controls’, Clarendon Press London, 1984.
4. T.J.E. Miller, Switched Reluctance Motors And Their Control , Magna physics Publishing, Oxford, 1993.
5. T.J.E. Miller, Electronic Control of Switched Reluctance Machines, Newnes Power Engineering Series, 2001.
6. Vincent Del Toro, Electric Machines and Power Systems, Prentice Hall,1985.
7. M D Desai, Control system components, PHI Learning, 2008.
8. K Venkataratnam, Special Electrical Machines, Orient Blackswan Pvt Ltd.-New Delhi, 2008
9. R Krishnan, Electric Motor Drives, Modeling, Analysis, and control, PHI Learning, 2001
10. Nasar S.A., Boldea I., Linear Motion Electric Machine, John Wiley & Sons, 1976.

Course plan

Module	Content	Hours	Semester Exam Marks (%)
I	**Stepper motor:** Constructional features - Principle of operation-permanent magnet stepper motor - variable reluctance motor - hybrid motor-single and multi stack configurations - Torque equations - modes of excitations - drive circuits-microprocessor control of stepping motors - closed loop control – applications.	8	15
II	**Servomotor:** DC servomotors- construction - principle of operation-transfer function - armature control and field control - AC servomotor-construction - theory of operation - shaded pole ac servomotors –applications.	6	15
First Internal Examination			
III	**Synchronous Reluctance motor**: Constructional features - Types - Principle of operation - Axial and radial flux motors - operating principles - variable reluctance motor - hybrid	8	15

	motor - voltage and torque equations – characteristics – applications.		
IV	**Switched reluctance motor**: Constructional features - principle of operation - torque production - steady state performance prediction-Analytical method - Power converters and their controllers - Methods of rotor position sensing - Closed loop control of SRM – Characteristics – applications.	6	15
Second Internal Examination			
V	**Permanent magnet motor:** Permanent magnet brushless DC motors - Permanent magnetic materials - Magnetic characteristics - Principle of operation -Types-Magnetic circuit analysis - Torque equations - Power controllers - Motor characteristics and control, Permanent magnet synchronous motors-Principle of operation--Torque equations-characteristics and control.	8	20
VI	**Linear Induction motor** Linear induction motor- Double sided linear induction motor from rotary type Induction motor – Scheme of LIM drive for electric traction – development of single sided LIM – Equivalent circuit- applications.	6	20
		42	100
Cluster Level End Semester Examination			

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 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.

Two internal tests, each having 15 marks each summing to a total of 30 marks
Tutorials / Assignments / Course Seminars summing to a total of 10 marks, and
Cluster level end-semester examination having 60 marks

Course No.	Course Name	L-T-P-Credits	Year of Introduction
10EE 6115	**COMPUTER AIDED DESIGN OF ELECTRICAL MACHINES**	**3 - 0- 0 : 3**	**2015**

Prerequisite: Knowledge about design of electrical machines

Course Objectives

To introduce the technique of Finite Element Methods in the area of electrical machines

Syllabus

Computer aided design of electrical machines - Analysis and synthesis methods - - Mathematical Formulation of Field Problems-Development of torque/force - E - Electrical Vector/Scalar potential - Stored energy in field problems – Inductances - Laplace and Poisson's Equations - Energy functional - Principle of energy conversion. Philosophy of FEM- Finite Difference method - Finite Element Method - Energy minimization - Variational method - 2D Field problems - Solution techniques.CAD Packages - Setting up solution - Post processing. Design Applications-Design of Solenoid Actuator - Induction Motor - Switched Reluctance Motor – Synchronous Machines.

Course Outcome

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

- Basic concept of electric machine
- Apply FEM methods for field plotting
- Design electromagnetic machines

References

1. S J Salon, "*Finite Element Analysis of Electrical Machines*", Kluwer Academic Publishers, London, 1995.
2. Vlado Ostovic, "*Computer Aided Analysis of Electric Machines*", PHI (UK) Ltd, 1994.
3. Silvester and Ferrari, *"Finite Elements for Electrical Engineer"*, Cambridge University Press, 1983.
4. S R H Hoole, *"Computer-Aided, Analysis and Design of Electromagnetic Devices"*, Elsevier1989.
5. D A Lowther, P PSilvester, *"Computer Aided Design in Magnetics"*, Springer Verlag, New York, 1986.
6. M Ramamoorthy, "Computer Aided Design of Electrical Equipments", Affiliated East West Press, 2008.
7. C W Trowbridge, *"An Introduction to Computer Aided Electromagnetic Analysis"*, Vector Field Ltd, 1990.
8. Chee-Mun Ong, *"Dynamic Simulations of Electric Machinery: Using MATLAB/SIMULINK"*, Prentice Hall, 1998.
9. *User Manuals of Software Packages like MAGNET, ANSOFT& ANSYS.*
10. *Chee-Mun Ong, "Dynamic Simulations of Electric Machinery: Using MATLAB/SIMULINK", Prentice Hall, 1998.*

COURSE PLAN

Module	Contents	Hours	Semester Exam Marks %
I	Computer aided design of electrical machines - Conventional design procedures - Analysis and synthesis methods - Limitations - Need for field analysis based design.- Mathematical Formulation of Field Problems-Development of torque/force - Electromagnetic Field Equations - Magnetic Vector/Scalar- potential	8	15
II	Electrical Vector/Scalar potential - Stored energy in field problems – Inductances - Laplace and Poisson's Equations -	6	15

	Energy functional - Principle of energy conversion.		
FIRST INTERNAL EXAM			
III	Philosophy of FEM- Mathematical Models - Differential/Integral equations - Finite Difference method - Finite Element Method	8	15
IV	Energy minimization - Variational method - 2D Field problems - Discretisation- Shape functions - Stiffness matrix - Solution techniques.	6	15
SECOND INTERNAL EXAM			
V	CAD Packages-Elements of a CAD System - Preprocessing - Modeling - Meshing -Material properties - Boundary Conditions - Setting up solution - Postprocessing.	8	20
VI	Design Applications-Design of Solenoid Actuator - Induction Motor - Switched Reluctance Motor – Synchronous Machines-case studies.	6	20
		42	
ESE			

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 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.

Two internal tests, each having 15 marks each summing to a total of 30 marks
Tutorials / Assignments / Course Seminars summing to a total of 10 marks, and
Cluster level end-semester examination having 60 marks

Course No.	Course Name	L-T-P-Credits	Year of Introduction
10EE6117	**POWER QUALITY ISSUES AND REMEDIAL MEASURES**	**3 - 0- 0 : 3**	**2015**

Course Prerequisites

Basic knowledge of Electrical power systems & power Electronics at UG Level.

Course Objectives

To give the Student:-

- An introduction to various power quality problems in the electrical power systems.
- Analyse the power quality problem and identify the remedial measures.
- Design and development of power electronics based solutions to power quality problems.

Syllabus

Introduction to power quality- power quality measures and standards- Important harmonic introducing devices- Harmonics and measurements-Power quality Improvement-DSTATCOM-DVR-UPQC- Active Power Factor Correction.

Expected Outcomes

1. Students who successfully complete this course will have demonstrated an ability to comprehend the various power quality problems in the electrical systems
2. The students will be able to identify and analyse important harmonic introducing devices
3. The students will be able to understand harmonics and measurement of harmonics.
4. Apply the basics of electrical engineering to identify the remedial measures to power quality problems using shunt connected compensators.
5. Design and development of the remedial measures to power quality problems using series and hybrid connected compensators.
6. Design and development of the remedial measures to power quality problems using Active Power Factor Correction

REFERENCES:

1. G T Heydt, Electric Power Quality, Star in a circle publications, 1994
2. Dugan, Electric Power Systems Quality, Mcgraw Hill Education, 2012.
3. K R Padiyar, FACTS controllers in Power Transmission and Distribution, New Age publications, New Delhi, 2007.
4. R Sastry Vedam, power quality VAR compensation in power systems, CRC press, NewYork, 2009.
5. A Ghosh and G Ledwich, "power quality improvement using custom power devices", IEEE Press, 2001.
6. Ned Mohan, T M Undeland and William P Robbins, "Power Electronics Converters, Application And Design", 3rd Edition, John Wiley & Sons, 2003

Course plan

Module	Content	Hours	Semester Exam Marks (%)
I	**Introduction**-power quality-voltage quality-overview of power quality phenomena classification of power quality issues-power quality measures and standards-THD-TIF-DIN-C message weights-flicker factor-transient phenomena-occurrence of power quality problems power acceptability curves-	8	15
II	**Important harmonic introducing devices-** SMPS-Three phase power converters – arcing devices- saturable devices-	6	15

	fluorescent lamps- effect of power system harmonics on equipment and loads.		
First Internal Examination			
III	Balancing of source currents- Steinmetz network. **Harmonics and measurements**: Power factor reduction due to harmonics-Distortion power-distortion power factor and displacement power factor- Triplen harmonics. Power Quality Analysers-Voltage, Current, Power and Energy measurements	8	15
IV	**Power quality Improvement:-DSTATCOM for** Harmonic Filtering, reactive power compensation and load balancing- d-q domain control and IRPT control of three phase DSTATCOM- Three-phase four-wire systems.	6	15
Second Internal Examination			
V	**Dynamic Voltage Restorers** for sag, swell and flicker problems – structure and control- Series active power filtering techniques for harmonic cancellation and isolation- Uninterruptible power supplies-constant voltage transformers	8	20
VI	**UPQC:** Structure and control-Left shunt UPQC-Right shunt UPQC **Active Power Factor Correction:** Single Phase Front End, Control Methods for Single Phase APFC, Three Phase APFC and Control Techniques.	6	20
		42	100
Cluster Level End Semester Examination			

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 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.

Two internal tests, each having 15 marks each summing to a total of 30 marks
Tutorials / Assignments / Course Seminars summing to a total of 10 marks, and
Cluster level end-semester examination having 60 marks

Course No.	Course Name	L-T-P-Credits	Year of Introduction
10EE6203	**SYSTEM THEORY**	**3 - 0- 0 : 3**	**2015**

Course Prerequisites

Basic knowledge about control systems and controllers.

Course Objectives

To give the Student:-

• A foundation in the fundamentals of control system and controllers.

• To develop an application of controlles in real time.

• Optimal control design of various systems.

Syllabus

Fundamental concepts and overview; State variables ;State space analysis of discrete systems; Lyapunov's stability analysis; Krasovski's theorm; Controllability and observability in canonical form; Optimal control design using Lyapunov's method; Riccattic equations for optimal control ; Analysis and control of Robust control systems.

Expected Outcomes

Students who successfully complete this course will have demonstrated an ability

- To analyse the system performance of state space models
- To apply Liapunov stability analysis for both linear and nonlinear systems
- To acquire knowledge on the controllability and observability
- To identify and formulate various optimal control problems
- To solve various optimal control problems
- To select performance measures
- To acquire knowledge of robustness of control systems

Text Books:

1. Ogata K., Modern control Engg, (second edition)Prentice Hall Inc.1990
2. Ogata K., Discrete time control systems, Prentice Hall Inc.1995.
3. Gopal M., Digital Control and state variable methods, TMH,1997

References:

4. *Ogata K., Modern control Engg, (second edition)Prentice Hall Inc.2015*
5. *Richard C. Dorf and Bishop R.T., Modern Control System*, Prentice Hall; 12 edition, 2010.

Course plan

Module	Content	Hours	Semester Exam Marks (%)
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- State space representation of discrete time systems -Discretization of continuous time state equation.	8	15
II	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.	6	15
First Internal Examination			
III	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 -effect of state feedback on controllability and observability - pole	8	15

	placement by state feedback for continuous and discrete time systems .		
IV	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.	6	15
Second Internal Examination			
V	Choice of performance measure -optimal control based on quadratic performance measure -optimal control system design using second method Lyapunov -solution of reduced Riccatti equation.	8	20
VI	Design of full order and reduced order observer for continuous time and discrete time systems Robust control systems -introduction -sensitivity analysis of robustness -system with uncertain parameters -design of robust PID controlled systems.	6	20
		42	100
Cluster Level End Semester Examination			

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 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.

Two internal tests, each having 15 marks each summing to a total of 30 marks
Tutorials / Assignments / Course Seminars summing to a total of 10 marks, and
Cluster level end-semester examination having 60 marks

Course No.	Course Name	L-T-P-Credits	Year of Introduction
10EC6105	**ADVANCED DIGITAL SIGNAL PROCESSING**	**3 – 0 - 0 : 3**	**2015**

Course Prerequisites
(1) Basic knowledge in signals and systems at UG level;
(2) Basic knowledge in transforms at UG level.

Course Objectives
(1) To attain a good analytical ability in digital filter design;
(2) To investigate the applications of digital signal processing.

Syllabus
Review of transforms, Z-Transform, Discrete Time Fourier Transform (DTFT), Discrete Fourier Transform (DFT), Discrete Cosine Transform (DCT), Short Time Fourier Transform (STFT), LTI systems as frequency selective filters, Invertibility of LTI systems, Design of digital filters by placement of poles and zeros, FIR filter structures, IIR filter structures, Design of FIR filters, Linear Phase Systems, Window method, Frequency sampling method, Finite word length effects, Design of IIR filters, Pole zero placement, Impulse invariance, Bilinear Z transformation, Finite word length effects, Adaptive Digital Filters, Wiener filter, LMS adaptive algorithm, Recursive least squares algorithm, Power Spectrum Estimation, Estimation of spectra from finite-duration signals, Non-parametric and Parametric methods for Power Spectrum Estimation.

Expected Outcomes
The students are expected to :
(1) Attain a good analytical ability in digital filter design;
(2) Know various applications of digital signal processing.

References:

1. Proakis and Manolakis, *Digital Signal Processing: Principles, Algorithms, and Applications,* 4/e, Pearson Education, 2007.
2. Ifeachor and Jervis, *Digital Signal Processing, A practical Approach,* 2/e, Pearson Education, 2002.
3. Johnny R. Johnson, *Introduction to Digital Signal Processing,* PHI, 1992.
4. Ashok Ambardar, *Digital Signal Processing: A Modern Introduction,* Thomson, IE, 2007.
5. Douglas F. Elliott, *Handbook of Digital Signal Processing- Engineering Application,* Academic Press, 1979.
6. Robert J. Schilling and Sandra L. Harris, *Fundamentals of Digital Signal Processing using MATLAB,*Thomson, 2005.
7. Ingle and J. G. Proakis, *Digital Signal Processing Using MATLAB,* Thomson, 1/e,1999.

Course plan

Module	Content	Hours	Semester Exam Marks
I	**Review of transforms** : Z-Transform, ROC, Poles & Zeros, Discrete Time Fourier Transform (DTFT), Discrete Fourier Transform (DFT), DFT as a linear transformation, Frequency analysis of signals and systems using DFT, Discrete Cosine Transform (DCT), Short Time Fourier Transform (STFT). **LTI systems as filters** : Invertibility of LTI systems, Minimum phase, Maximum phase and mixed phase systems, All-pass filters, Design of digital filters by placement of poles and zeros, Linear filtering methods based on DFT.	8	15
II	**Digital Filter Structures** : Generalized input-output relationship, IIR Transfer Function, FIR Transfer Function, Signal Flow Graphs, FIR filter structures, Direct Form-I, Direct Form-II, Frequency Sampling, Cascade, Lattice, IIR filter structures, Direct Form-I, Transposed, Direct Form-II, Canonical, Parallel, Cascade, Lattice-Ladder structures.	6	15
First Internal Examination			

III	**Design of FIR filters** : Linear Phase Systems, Specifications, Coefficient calculation methods, Desired impulse responses, Window method, Frequency sampling method, Comparison of methods, Filter realization, Finite word length effects, Implementation examples, FIR filter design using Octave/ MATLAB.	8	15
IV	**Design of IIR filters** : Specifications, Coefficient calculation method, Pole zero placement, Transformation rules, Impulse invariance, Bilinear Z transformation (BZT), Butterworth and Chebyschev approximations, Filter realization, Finite word length effects, Implementation examples, IIR filter design using Octave/ MATLAB.	6	15
Second Internal Examination			
V	**Adaptive Digital Filters** : Concepts, Wiener filter, LMS adaptive algorithm, Recursive least squares algorithm, Lattice Ladder filters, Application of Adaptive filters.	8	20
VI	**Power Spectrum Estimation** : Estimation of spectra from finite duration signals, Non-parametric and Parametric methods for Power Spectrum Estimation	6	20
	TOTAL	42	100
Cluster Level End Semester Examination			

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 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.

Two internal tests, each having 15 marks each summing to a total of 30 marks
Tutorials / Assignments / Course Seminars summing to a total of 10 marks, and
Cluster level end-semester examination having 60 marks

Course No.	Course Name	L - T - P - Credits	Year of Introduction
10GN6001	**RESEARCH METHODOLOGY**	**0 - 2 - 0 : 2**	**2015**

Course Prerequisites

(1) Basic skill of analyzing data earned through the project work at UG level;
(2) Basic knowledge in technical writing and communication skills earned through seminar at UG level.

Course Objectives

(1) To attain a perspective of the methodology of doing research;
(2) To develop skills related to professional communication and technical report writing.
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

Overview of research methodology - research process - scientific methods -research problem and design - research design process - formulation of research task, literature review and web as a source - problem solving approaches - experimental research - ex post facto research. Thesis writing - reporting and presentation - interpretation and report writing - principles of thesis writing- format of reporting, oral presentation - seminars and conferences, Research proposals - research paper writing - publications and ethics - considerations in publishing, citation, plagiarism and intellectual property rights. Research methods – modeling and simulation - mathematical modeling – graphs - heuristic optimization - simulation modeling - measurement design – validity – reliability – scaling - sample design - data collection methods and data analysis.

Expected Outcomes

The students are expected to :
(1) Be motivated for research through the attainment of a perspective of research methodology;
(2) Analyze and evaluate research works and to formulate a research problem to pursue research;
(3) Develop skills related to professional communication, technical report writing and publishing papers.

References

1. C.R Kothari, *Research Methodology: Methods & Techniques*, New Age International Publishers, 2004.
2. R. Panneerselvam, Research *Methodology*, Prentice Hall of India, New Delhi, 2012.
3. K. N. Krishnaswamy, Appa Iyer Sivakumar, and M. Mathirajan, *Management Research Methodology, Integration of Principles*, Pearson Education, 2009.
4. Deepak Chawla, and MeenaSondhi, *Research Methodology – Concepts & Cases,* Vikas Publishing House, 2011.
5. J.W. Bames, *Statistical Analysis for Engineers and Scientists*, McGraw Hill, New York, 1994.
6. Schank Fr., *Theories of Engineering Experiments*, Tata McGraw Hill Publication.
7. Willktnsion K. L, Bhandarkar P. L, *Formulation of Hypothesis*, Himalaya Publication.
8. Douglas C Montgomery, *Design and analysis of experiments,* Wiley International
9. Ranjit Kumar, *Research Methodology: A step by step guide for beginners,* Pearson Education.
10. Donald Cooper, *Business Research Methods*, Tata McGraw Hill, New Delhi.
11. Leedy P D, *Practical Research : Planning and Design,* 4th Edition, N W MacMillan Publishing Co
12. Day R A, *How to Write and Publish a Scientific Paper,* Cambridge University Press, 1989
13. Coley S M and Scheinberg C A, *Proposal Writing,* 1990, Newbury Sage Publications.
14. Sople, *Managing Intellectual Property: The Strategic Imperative*, Prentice Hall of India,

New Delhi, 2012
15. Manna, Chakraborti, *Values and Ethics in Business Profession*, Prentice Hall of India, New Delhi, 2012.
16. Vesilind, *Engineering, Ethics and the Environment*, Cambridge University Press.
17. Wadehra, B.L. *Law relating to patents, trademarks, copyright designs and geographical indications*, Universal Law Publishing

Course plan

Module	Content	Hrs	Semester Exam Marks (%)
I	**Overview of Research Methodology**: Research concepts, meaning, objectives, motivation, types of research, research process, criteria for good research, problems encountered by Indian researchers, scientific method, research design process.	5	15
II	**Research Problem and Design** : Formulation of research task, literature review, methods, primary and secondary sources, web as a source, browsing tools, formulation of research problems, exploration, hypothesis generation, problem solving approaches, introduction to TRIZ (TIPS), experimental research, principles, laboratory experiment, experimental designs, ex post facto research, qualitative research.	5	15
First Internal Examination			
III	**Thesis Writing, Reporting and Presentation** : Interpretation and report writing, techniques of interpretation, precautions in interpretation, significance of report writing, principles of thesis writing, format of reporting, different steps in report writing, layout and mechanics of research report, references, tables, figures, conclusions, oral presentation, preparation, making presentation, use of visual aids, effective communication, preparation for presentation in seminars and conferences.	4	15
IV	**Research proposals, Publications, Ethics and IPR** : Research proposals, development and evaluation, research paper writing, layout of a research paper, journals in engineering, considerations in publishing, scientometry, impact factor, other indexing like h-index, citations, open access publication, ethical issues, plagiarism, software for plagiarism checking, intellectual property right (IPR), patenting case studies.	5	15
Second Internal Examination			
V	**Research Methods - Modeling and Simulation** : Modeling and simulation, concepts of modeling, mathematical modeling, composite modeling, modeling with ordinary differential equations, partial differential equations (PDE), graphs, heuristics and heuristic optimization, simulation modeling.	5	20
VI	**Research Methods - Measurement, Sampling and Data Acquisition** : Measurement design, errors, validity and reliability in measurement, scaling and scale construction, sample design, sample size determination, sampling errors, data collection procedures, sources of data, data collection methods, data preparation and data analysis.	4	20

Three internal tests, each having 20 marks summing to a total of 60 marks
Tutorials / Assignments / Course Seminars summing to a total of 40 marks

10EE 6109	SEMINAR-I	0-2-0:2	2015

Course Objectives

The basic objective of this course is to improve the oral communication skill of the students.

Syllabus

Individual students are required to choose a topic of their interest in consultation with faculty and present for about 30 minutes. They will be guided about sound modulation, sequence of presentation, eye contact and writing on the black board.

Students have to submit a report on the topic in the prescribed format.

Expected Outcomes

Upon the completion of this course, students will have the ability:

- To enhance the reading ability required for the literature review
- To identify hot research topics in the relevant field
- To analyze technical problems in a critical way;
- To develop skills regarding professional communication
- To write technical reports
- To make effective power point presentation

Internal Continuous Assessment: 100 marks

Presentation (Verbal & Nonverbal Communication skills) : 20 Marks

Breadth of the topic (Coverage : Content of the slides and speech) : 20 Marks

Depth of knowledge (Ability to answer questions) : 30 Marks

Seminar Report in the prescribed format given by the Institution : 30 marks

Course No.	Course Name	L-T-P-Credits	Year of Introduction
10EE6111	**POWER ELECTRONICS LAB**	**0 - 0 - 2 : 1**	**2015**

Course Prerequisites

Basic knowledge of Power Electronics at UG Level.

Course Objectives

To design and develop power electronic converters.

Syllabus

- AC-DC Converters
- DC-DC Converters
- DC-AC Converters
- AC-AC converters

Expected Outcomes

Upon the completion of this course, students will have the ability to:

- Design and implement various DC-DC chopper circuits
- Analyse the performance of both 1-ph and 3-ph AC-DC converters
- Compare the performance of various 1-ph and 3-ph DC-AC inverters
- Develop cycloconverters
- Develop various control schems including PWM
- Model and analyse the performance of controllers in MATALB type platforms
- Familiarize with harmonic analysis for power quality studies

References

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

Course Plan

Sl. No.	Experiments
1	Study the performance of a single-phase half wave and full wave AC-DC phase controlled converter. Record AC supply voltage and current waveform, harmonic spectrum, THD, crest factor, rms value, distortion factor, displacement factor and power factor, output DC voltage average value, peak-peak ripple and ripple factor for various loads.
2	Study the performance of a three-phase bridge rectifier.
3	Study the performance of 12-pulse and 24-pulse uncontrolled three-phase bridge rectifiers.
4	Study the performance DC- DC step down Chopper in the open loop and record the DC supply voltage, supply current, load voltage and load current, device voltage and current in Resistive load and DC motor load.
5	Study the performance DC- DC buck converter in CCM and DCM mode.
6	Study the performance DC- DC boost converter in CCM and DCM mode.
7	Study the performance DC- DC buck-boost converter in CCM and DCM mode.
8	Study the performance of a DC-AC single-phase inverter with triangular carrier PWM Control. AC voltage and current waveform, harmonic spectrum, THD, crest factor, rms value, distortion factor, displacement factor and power factor, input DC current average value and waveform in DC-AC single-phase inverter.
9	Study the performance of a DC-AC three-phase inverter with 120 degree and 180 degree conduction. AC supply voltage and current waveform, Harmonic spectrum, THD, crest

	factor, rmsvalue, distortion factor, displacement factor and power factor, input DC current average value and waveform.
10	Study the performance of a DC-AC three-phase inverter with PWM control.
11	Study the performance of single-phase AC voltage controllers with (i) resistive (R), (ii) resistive-inductive (R-L) and (iii) single-phase motor loads at two firing angles. AC supply voltage, load voltage and current waveform, harmonic spectrum, THD, crest factor, rms value, distortion factor, displacement factor, active power, reactive power and apparent power and power factor for R and R-L loads
12	Study the performance of step up and step down cycloconverter.
13	Control of dc-dc converters (Buck, Boost and Buck-Boost converter) using discrete ICs like TL494/SG3525/UC3842, Power loss computation, Selection of heatsinks and PCB design.
14	Study of harmonic pollution by power electronics loads using power quality analyser
	(Out of the above, a minimum of SIX hardware experiments and SIX simulation studies are to be conducted. Simulation can be done using any of the software packages like MATLAB/SIMULINK, ORCAD, PSCAD etc.)

Internal Continuous Assessment: 100 marks

1. Practical Records / Results summing to a total of 40 Marks
2. Regular Class Viva-Voce summing to a total of 20 Marks
3. Final Test (Internal & Objective Type) having 40 Marks

SEMESTER II

Course No.	Course Name	L-T-P-Credits	Year of Introduction
10EE6102	POWER CONVERTERS II	3-1-0 : 4	2015

Course Prerequisites

Basic knowledge of Power Electronic circuits and devices at UG Level.

Course Objectives

To impart knowledge about AC – AC and DC – AC converters

Syllabus

single phase full bridge inverter- Three phase inverter- 120 conduction with star connected load and with delta connected load-multi pulse modulation- sinusoidal pulse width modulation- Multi level inverters- Cyclo converters—advanced modulation techniques

Expected Outcomes

1. Acquire knowledge about various single phase inverter.
2. Ability to analyze and develop various control techniques for single phase inverter for reducing harmonics.
3. Ability to analyze various three phase inverter used in power electronics for various applications.
4. Ability to analyze and develop various three phase multilevel inverters.
5. Ability to develop and analyze AC voltage controllers for various applications.
6. Foster ability to understand the cyclonverters and matrix converters.

Text books

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

Course plan

Module	Content	Hours	Semester Exam Marks (%)
I	**Single Phase inverters:** Basic concept of switch –mode inverters, Pulse width modulation switching scheme, Linear modulation and over modulation- Single phase half bridge inverter- Single phase full bridge inverter- Unipolar and bipolar switching's- voltage cancellation control- Ripple in the single phase inverter - Push pull inverter switch utilization.	10	15
II	**Voltage control of Single phase inverter:** Single pulse width modulation, Multiple-pulse width modulation, modified sinusoidal pulse-width modulation, phase-displacement control. Trapezoidal modulation, staircase modulation, Harmonic injection modulation, Delta modulation.	8	15
First Internal Examination			
III	**Three Phase Inverters:** 180- Degree Conduction, 120 – Degree Conduction, Harmonic analysis – Delta connected and star	10	15

	connected load. Sinusoidal PWM, Third harmonic PWM, 60 degree PWM, Space vector modulation, Effect of blanking time on voltage in PWM inverters. Current source inverters.		
IV	**Multi level inverter:** Diode-clamped multilevel inverter, Flying capacitor multilevel inverter, Cascade multilevel inverter. Operation and control.	8	15
Second Internal Examination			
V	**AC Voltage Controllers:** On-Off control, Phase control, Bidirectional controllers with resistive and inductive loads, Three phase full wave controllers, three phase bidirectional delta connected controllers.	10	20
VI	**Cycloconverters:** Single phase to single phase cycloconverter, Three phase to three phase cycloconverter, single phase to three phase cyclo converters, Three phase to three phase bridge cycloconverter. Operation in blocked mode and current circulating mode. Load commuted cycloconverters. Matrix converter.	10	20
		56	100
Cluster Level End Semester Examination			

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 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.

Two internal tests, each having 15 marks each summing to a total of 30 marks
Tutorials / Assignments / Course Seminars summing to a total of 10 marks, and
Cluster level end-semester examination having 60 marks

Course No.	Course Name	L-T-P-Credits	Year of Introduction
10EE 6104	CONTROL TECHNIQUES IN POWER ELECTRONICS	3 - 0 - 0 : 3	2015

Course Prerequisites

Basic knowledge in power electronic converters and control systems at UG level.

Course Objectives

1. To have an advanced level knowledge on modeling and analysis of power electronic converters
2. To design and develop controllers for power electronics based switching circuits

Syllabus

Principles of steady state converter analysis- Steady state equivalent circuit modeling- Analysis of discontinuous conduction mode- AC modeling approach- State space averaging- Circuit averaging- Graphical construction of impedances and converter transfer function- Controller design- Measurement of ac transfer functions, impedances and loop gains- AC and DC equivalent circuit modeling of the discontinuous conduction mode- Current Programmed control

Expected Outcomes

Students who complete this course will have an ability to:

- Model and analyse the steady state switching converters ;
- Select proper ac modeling approach for the converters
- Use graphical methods for the Bode plot of transfer functions
- Design controllers from the stability point of view
- Develop ac and dc equivalent models for DCM switching networks
- Acquire basic knowledge of current programmed control

References:

Robert W Erickson, Dragan Maksimovic, Fundamentals of Power Electronics 2nd Edition, Springer IN, 2005

Ali Emadi et.al, Integrated Power Electronic Converters and Digital Control, CRC Press, 2009

Course plan

Module	Content	Hours	Semester Exam Marks (%)
I	**Steady state converter analysis**: Principles of steady state converter analysis, Steady state equivalent circuit modeling, losses and efficiency- analysis of discontinuous conduction mode,	8	15
II	**AC modeling approach**: Basic AC modeling approach- small signal modeling- State space averaging- Circuit averaging and averaged switch modeling, Canonical circuit model, PWM model	6	15
First Internal Examination			
III	**Converter transfer functions**: Review of bode plots- Analysis of converter transfer functions- Graphical construction of impedances and converter transfer function- Effect of negative feedback on the network transfer functions- Construction of Closed loop transfer functions- Measurement of AC transfer functions and impedances-	8	15
IV	**Controller design**: Stability analysis- damping factor- Phase margin- Regulator design- Lag, Lead compensator design- Measurement of loop gains	6	15
Second Internal Examination			
V	**Discontinuous conduction mode:** AC and DC equivalent circuit modeling of the DCM- DCM averages switch model- Small signal AC modeling of DCM switch network- High frequency dynamics of converters in DCM	8	20

VI	**Current Programmed control**: Oscillations for D>0.5- First order models- Current programmed control in DCM	6	20
		42	100
Cluster Level End Semester Examination			

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 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.

Two internal tests, each having 15 marks each summing to a total of 30 marks
Tutorials / Assignments / Course Seminars summing to a total of 10 marks, and
Cluster level end-semester examination having 60 marks

Course No.	Course Name	L-T-P Credits	Year of Introduction
10EE 6106	**MACHINE ANALYSIS AND CONTROL**	**3-0-0 : 3**	**2015**

Course Prerequisites

Basic knowledge of Electrical machines.

Course Objectives

To develop understanding of machine analysis

Syllabus

Electromagnetic Energy conversion, reference frame theory, transformation of reference frames, DC machines voltage and torque equations, dynamic characteristics of permanent magnet and shunt DC motors, Induction machines voltage and torque equations in reference frame variables, synchronous machine – torque and voltage in arbitrary reference frame and rotor reference frame. Simulations

Expected Outcomes

The students are expected to apply the modeling and analysis to various kinds of electrical machines

Text books

1. Kraus PC, Analysis of Electrical Machines, Mc Graw Hill Book Company
2. Paul C Krause, Oleg Wasynczuk, scott D. Sudhoff, Analysis of Electric Machinery and Drive System, Wiley Interscience
3. Sengupta D.P. & Lynn J.B., Electrical Machine Dynamics, The Macmillan Press Ltd.
4. Jones C.V., The Unified Theory of Electrical Machines, Butterworth
5. Woodson & Melcher, Electromechanical Dynamics, John Wiley & Sons
   Boldia I. & Nasar S.A., Electrical Machine Dynamics, The Macmillan Press Ltd

Course plan

Module	Content	Hours	Semester Exam Marks (%)
I	**Electromechanical energy conversion**: General expression of stored magnetic energy, co-energy and force/ torque – example using single and doubly excited system –calculation of air gap mmf and per phase machine inductance and voltage Equations.	8	15
II	**DC Machine Modelling:** Voltage and toque equations – dynamic characteristics of permanent magnet and shunt DC motors – state equations - solution of dynamic characteristic by Laplace transformation.	6	15
First Internal Examination			
III	**Reference-Frame Theory**: Static and rotating reference frames – transformation of variables –transformation between reference frames –two phase to three phase transformation- power equivalence.	6	15
IV	**Dynamic modeling of three phase Induction Machines:** Generalized model in arbitrary reference frame-Electromagnetic torque-Derivation of commonly used Induction machine models-Stator reference frame model-Rotor reference frame model-Synchronously rotating reference frame model-Equations in flux linkages-per unit model-Dynamic Simulation frame.	8	15
Second Internal Examination			

V	**Modelling of Synchronous Machines:** Synchronous machine inductances –voltage equations in the rotor's dq0 reference frame-electromagnetic torque-current in terms of flux linkages-simulation of three phase synchronous machine- modeling of PM Synchronous motor.	8	20
VI	**Theory of brushless DC Machines:** Voltage and Torque Equations in machine variable, in rotating reference frame variables.	6	20
		42	100
Cluster Level End Semester Examination			

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 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.

Two internal tests, each having 15 marks each summing to a total of 30 marks
Tutorials / Assignments / Course Seminars summing to a total of 10 marks, and
Cluster level end-semester examination having 60 marks

Course No.	Course Name	L-T-P-Credits	Year of Introduction
10EE 6114	**INDUSTRIAL CONTROL ELECTRONICS**	**3 – 0 - 0:3**	**2015**

Prerequisite: Knowledge in Analog and Digital Electronics

Course Objectives

To gives a comprehensive coverage of various control electronics used in the industries. This combines the analog and digital concepts together with Power Electronics for the design of the controllers. Microcontrollers and Digital Signal processors for control applications

Syllabus

Analog Controllers - Proportional controllers, Digital control schemes, control algorithms, programmable logic controllers. Signal conditioners- Isolation circuits –Opto-Electronic devices and control - interrupter modules and photo sensors; Fiber-optics; Bar code equipment, application of barcode in industry.Introduction to microprocessors, microcontrollers, Digital Signal Processors. Basic building blocks, architecture ofTMS320LF 28xx DSP, instruction set, programming, application development, PI controller, Clarks and Park transformation, PWM generation, PLL and unit sine wave generation.

Course Outcome

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

- Design of PE based system
- Select suitable power devices and feedback circuit elements
- Use of DSP for control applications
- Provide electric isolation of power & drive circuits

References

1. Michael Jacob, "*Industrial Control Electronics – Applications and Design*", Prentice Hall, 1995.
2. Thomas E. Kissell, "*Industrial Electronics*", Prentice Hall India, 2003
3. James Maas, "*Industrial Electronics*", Prentice Hall, 1995.
4. Toliyat, Hamid A. and SlevenCampell, "*DSP Based Electomechanical Motion Control*", CRC Press 2003.
5. TMS 320 F 240 Technical Reference Manual.
6. Application notes on DSP based Motor Control. www.ti.com

COURSE PLAN

Module	Contents	Contact Hours	Sem.Exam Marks:%
I	Analog Controllers - Proportional controllers, Proportional – Integral controllers, PID Controllers, derivative overrun, integral windup, cascaded control, Feed forward control	6	15
II	Digital control schemes, control algorithms, programmable logic controllers.Signal conditioners- Instrumentation amplifiers – voltage to current, current to voltage, voltage to frequency, frequency to voltage converters	8	15
FIRST INTERNAL EXAM			
III	Isolation circuits – cabling; magnetic and electro static shielding and grounding.	6	15
IV	Opto-Electronic devices and control, electronic circuits for photo-electric switches-output signals for photo-electric controls; Applications of opto-isolation	8	15

SECOND INTERNAL EXAM			
V	Interrupter modules and photo sensors; Fiber-optics; Bar code equipment, application of barcode in industry.	6	20
VI	Introduction to microprocessors, microcontrollers, Digital Signal Processors. Basic building blocks, architecture ofTMS320LF 28xx DSP, instruction set, programming, application development, PI controller, Clarks and Park transformation, PWM generation, PLL and unit sine wave generation.	8	20
Cluster Level End Semester Examination			

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 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.

Two internal tests, each having 15 marks each summing to a total of 30 marks
Tutorials / Assignments / Course Seminars summing to a total of 10 marks, and
Cluster level end-semester examination having 60 marks

Course No.	Course Name	L-T-P-Credits	Year of Introduction
10EE6116	**POWER CONVERSION IN RENEWABLE ENERGY SYSTEMS**	**3 – 0 – 0 : 3**	**2015**

Course Prerequisites

Basic knowledge in Electrical power systems and Power electronics at UG level.

Course Objectives

1. To give an idea about the renewable energy sources and the application of power electronic devices and converters in renewable energy systems.

Syllabus

solar photo voltaic systems, bioenergy, wind energy, fuel cells, ocean energy, MHD, Geothermal and Small hydro systems.

Expected Outcomes

Students who complete this course will have an ability

- To acquire basic concepts of solar thermal and solar PV conversion techniques.
- To analyse various biomass to enrgy conversion technologies
- To design and develop wind energy conversion system
- To design fuel cell and MHD systems for power generation
- To design ocean energy conversion systems such as OTEC, Tide and wave energy conversion systems
- To design small hydro power systems

References:

1. D P Kothari and Nagrath, "Modern Power System Analysis", Mcgraw Hill, 2011.
2. Thomas Ackerman, "Wind power in power systems", John Wiley& Sons, London, 2005..
3. M G Simoes and F A Farret, "Alternate energy systems," CRCPress, London, 2008.
4. Domkundvar , "Solar Energy Resources" Dhanpatrai& Sons , New Delhi.
5. J P Lyons and V Vlatkovic, "power electronics and alternative energy generation", in proc IEEE power electronics specialist conference, vol.1, no 1, pp.16-21, Aachen 2004.
6. P F Rebeiro, B K Jhonson, M L Crow, A Arsoy and Y Liu, "Energy Storage systems for advanced power application", in proc IEEE conf. vol.89, no 12, Dec. 2001.

Course plan

Module	Content	Hours	Semester Exam Marks
I	**Introduction** of renewable energy sources and potential- **Solar energy** needs and its utilization-Solar thermo mechanical systems-direct conversion to electricity- grid interactive PV systems-Isolated PV systems- requirement for maximum power tracking (MPPT) - dc to dc converter topologies for MPPT- control algorihms for MPPT	8	15
II	Introduction to biomass -Resource potential –technology and applications - Biomass gasifiers.-–Electrical energy conversion methods–biomass conversion process. Biogas plants- Technology and status- Biogas generation-types of biogas plant-community biogas plants.	6	15
First Internal Examination			
III	**Wind energy** – Resonance potential –Vertical axis and horizontal axis wind turbines –Gilberts limit- Power coefficient – wind farms –Power plants –Generators for WECS- Induction Generators- Solid state converters and control	8	15
IV	**Fuel cells:** Introduction – working –efficiency –classification –	6	15

	performance characteristics – dc- dc converters and control		
Second Internal Examination			
V	**Geothermal Energy-** Resources of Geothermal –vapour dominant system-liquid dominant binary cycle. Total flow of geothermal power unit**-** energy conversion systems. **MHD**: Principle –simplified analysis of MHD- factors affecting the efficiency of MHD-types-present status of MHD generation.	8	20
VI	**Ocean energy conversion: OTEC** –Principle –cycle, operation of OTEC systems .Location of plants –types –technology and applications- Tidal and wave energy. **Small hydropower generation**-turbines and generators- grid tied systems- stand alone systems- induction generators- Electronic load controllers.	6	20
	TOTAL	42	100
Cluster Level End Semester Examination			

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 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.

Two internal tests, each having 15 marks each summing to a total of 30 marks
Tutorials / Assignments / Course Seminars summing to a total of 10 marks, and
Cluster level end-semester examination having 60 marks

Course No.	Course Name	L-T-P Credits	Year of Introduction
10EE6118	**POWER SEMICONDUCTOR DEVICES**	**3 – 0 – 0 : 3**	**2015**

Course Prerequisites

Basic knowledge on Electronic circuits and systems.

Course Objectives

An understanding of the physics of power semiconductor devices

Get familiarised with various power semiconductor devices.

An idea about the detailed characteristics and phenomena of power semiconductors.

Syllabus

An introduction to various material properties like intrinsic carrier concentration, band gap narrowing, carrier mobility etc; expertise with punch through diode and linearly graded junction diode; Schottky rectifier and power MOSFET; detailed study of BJT; Darlington configuration; thyristor and TRIAC; IGBT.

Expected Outcomes

Students who successfully complete this course have demonstrated an ability to understand the general material properties of power semiconductors; expertise in the fundamental concepts of various power semiconductor devices along with its detailed characteristics and related phenomena's.

Text Books:

1. *M.D. Singh and Khanchandani, Power Electronics, 2nd edition, Tata McGraw Hill*
2. *Joseph Vithayathil, Power Electronics principles and applications, Tata McGraw Hill*

Reference

3. *P. Jayant Baliga, Fundamentals of power semiconductor devices, Springer*

Course plan

Module	Content	Hours	Semester Exam Marks (%)
I	Material properties – intrinsic carrier concentration – band gap narrowing – built in potential – zero bias depletion width – impact ionization coefficients – carrier mobility – resistivity – recombination lifetime. Avalanche breakdown – abrupt one-dimensional diode – ideal specific on-resistance – abrupt punch through diode – linearly graded junction diode – edge terminations – open base transistor breakdown – surface passivation	8	15
II	Schottky rectifier: structure – forward conduction – reverse blocking – device capacitance – trade off analysis. P – I – N rectifiers: structure – reverse blocking – switching performance – buffer layer – non punch through – trade off curves	6	15
First Internal Examination			
III	Power MOSFET: Structure - Blocking voltage – forward conduction characteristics –on resistance – cell optimization – transfer characteristics – output characteristics – device capacitances – gate charge – high frequency operation – switching characteristics – safe operating area – integral body diode – high temperature characteristics .	8	15
IV	Bipolar junction transistor: structure – static blocking characteristics – current gain – emitter current crowding – output	6	15

	characteristics – on state characteristics – switching characteristics safe operating area – Darlington configuration.		
Second Internal Examination			
V	Thyristors: structure – blocking characteristics – on state characteristics – switching characteristics – light operated thyristors – self protected thyristors – gate turn off thyristor – triac	8	20
VI	IGBT: structure – device operating and output characteristics – equivalent circuit – blocking characteristics – on state characteristics – current saturation model – switching characteristics – power loss optimization – safe operating area – blocking voltage scaling – high temperature operation.	6	20
		42	100
Cluster Level End Semester Examination			

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 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.

Two internal tests, each having 15 marks each summing to a total of 30 marks
Tutorials / Assignments / Course Seminars summing to a total of 10 marks, and
Cluster level end-semester examination having 60 marks

Course No.	Course Name	L-T-P-Credits	Year of Introduction
10EE6122	**MICROCONTROLLER APPLICATIONS IN POWER ELECTRONICS**	**3- 0 - 0 : 3**	**2015**

Course Prerequisites

Digital Electronics, C programming, a Course in Microprocessors at the UG Level.

Course Objectives

To give the Student:-

- A basic idea about Microcontrollers in general and 8051 in detail.
- The ability to write programs in assembly language using 8051 instructions.
- The ability to write microcontroller programs using C langauge.

Syllabus

8051 family – architecture of 8051 – 8051 programming model – 8051 pin diagram – internal RAM organization – ports – program status word – register – 8051 assembly language programming – register banks and stack – addressing modes – external data modes Instruction set of 8051 – arithmetic operations – logical operations – data transfer operations – control transfer operations

8051 programming in C – timer programming in assembly language and C – serial port programming in assembly language and C – interfacing to external memory

Expected Outcomes

1. Students who successfully complete this course will have the skill to
2. Acquire knowledge on the microcontroller development systems
3. Identify and assemble the buiding blocks for 8051 controller
4. Familirize with various addressing modes of 8051
5. Familiarize with instruction set of 8051
6. Write programs in assembly language and C language for 8051
7. Implement microcontroller based PE systems.

REFERENCES:

1. Muhammad Ali Mazidi, Janice Gillispie Mazidi and Rolin D.McKinlay, 'The 8051 Microcontroller and Embedded Systems Using Assembly and C', Pearson Education, Inc.2013
2. Kenneth J Ayala, 'The 8051 Microcontroller Architecture, Programming & Applications".
3. Kenheth J. Hintz and Daniel Tabak, 'Microcontrollers - Architecture, Implementation and programming' McGraw Hill, USA, 1992.

Course plan

Module	Content	Hours	Semester Exam Marks (%)
I	Evolution of micro-controllers – comparison between micro processor and microcontrollers- Micro-controller development systems – simulators.	6	15
II	8051 family – architecture of 8051 – 8051 programming model – 8051 pin diagram –internal RAM organization – ports – program status word – registers	8	15
First Internal Examination			
III	8051 assembly language programming – register banks and stack – addressing modes – external data moves.	8	15

IV	Instruction set of 8051 – arithmetic operations – logical operations – data transfer operations – control transfer operations	6	15
Second Internal Examination			
V	8051 programming in C – timer programming in assembly language and C	8	20
VI	Serial port programming in assembly language and C – Typical applications in the control of power electronic converters for power supplies and electric motor drives.	6	20
		42	100
Cluster Level End Semester Examination			

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 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.

Two internal tests, each having 15 marks each summing to a total of 30 marks
Tutorials / Assignments / Course Seminars summing to a total of 10 marks, and
Cluster level end-semester examination having 60 marks

Course No.	Course Name	L-T-P-Credits	Year of Introduction
10EE 6124	HIGH VOLTAGE DC AND AC TRANSMISSION	3-0-0-3	2015

Prerequisite: Fundamental Knowledge about the power flow in transmission line.

Course Objectives

To understand the concept, planning of DC power transmission and comparison with AC Power transmission
To analyze HVDC converters
To study about compounding and regulation
To analyze harmonics and design of filters
To learn about HVDC cables and simulation tools

Syllabus

INTRODUCTION - Introduction of DC Power transmission technology –Description of DC transmission system – Planning for HVDC transmission –Analysis of HVDC Converters– Choice of converter configuration –Converter bridge characteristics – Detailed analysis of converters.Compounding and Regulations - General –Inverter compounding –Transmission characteristics with the rectifier and inverter compounding – Communication link – Transformer tap changing. Harmonics and filters and Simulation – Generation of harmonics – Design of AC filters and DC filters –Introduction to system simulation – Modeling of HVDC systems for digital dynamic simulation.

Course Outcome

After successful completion of this course the students able to

1. To acquire the basic principles and technology of DC transmission,
2. To analyse HVDC converter and control of power flow,
3. To analyze the Transmission characteristics with the rectifier and inverter
4. To model HVDC lines and converters
5. TO design AC filters and DC filters
6. To analyse the effects of harmonic in DC lines

References

1. Padiyar, K. R., "*HVDC Power Transmission System*", Wiley Eastern Limited, New Delhi 1990, First edition.
2. Edward Wilson Kimbark, "*Direct Current Transmission*", Vol. I, Wiley Interscience, New York, London, Sydney, 1971.
3. Colin Adamson and Hingorani N G, "*High Voltage Direct Current Power Transmission*",Garraway Limited, London, 1960.
4. Arrillaga, J., "*High Voltage Direct Current Transmission*", Peter Pregrinus, London, 1983.
5. Rakosh Das Begamudre, "*Extra High Voltage AC Transmission Engineering*", New AgeInterantional (P) Ltd., New Delhi, 1990.

COURSE PLAN
COURSE NO: 10EE 6124 COURSE TITLE: HIGH VOLTAGE DC AND AC TRANSMISSION (L-T-P: 3-0-0) CREDITS: 3

Module	Contents	Contact Hours	Sem.Exam Marks:%
I	INTRODUCTION - Introduction of DC Power transmission technology – Comparison of AC and DC transmission – Application of DC transmission – Description of DC transmission system	6	15
II	Planning for HVDC transmission – Modern trends in DC transmission.ANALYSIS OF HVDC CONVERTERS - Pulse number – Choice of converter configuration	8	15
FIRST INTERNAL EXAM			

III	Simplified analysis of Graetz circuit – Converter bridge characteristics – Characteristics of a twelve pulse converter – Detailed analysis of converters.	6	15
IV	COMPOUNDING AND REGULATIONS - General – Required regulation – Inverter compounding – Uncompounded inverter – Rectifier compounding – Transmission characteristics with the rectifier and inverter compounding –	8	15
SECOND INTERNAL EXAM			
V	Communication link – Current regulation from the inverter side – Transformer tap changing. HARMONICS AND FILTERS and SIMULATION - Introduction – Generation of harmonics – Design of AC filters and DC filters	6	20
VI	Interference with neighbouring communication lines. Introduction to system simulation – Philosophy and tools – HVDC system simulation – Modeling of HVDC systems for digital dynamic simulation.	8	20
Cluster Level End Semester Examination			

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 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.

Two internal tests, each having 15 marks each summing to a total of 30 marks
Tutorials / Assignments / Course Seminars summing to a total of 10 marks, and
Cluster level end-semester examination having 60 marks

Course No.	Course Name	L-T-P-Credits	Year of Introduction
10EE6126	ENERGY MANAGEMENT	3 - 0 - 0 :3	2015

Course Prerequisites

Basic knowledge of Electrical & Mechanical Engineering at UG Level.

Course Objectives

The course is designed to provide students knowledge and ability to understand the principles of energy management and apply this to practical systems.

Syllabus

Importance of energy management. Energy auditing-Electric motors- Variable speed drives; Pumps and Fans-Reactive Power management-Lighting- Compressed Air Systems, Refrigeration & air conditioning systems-Boiler -Cogeneration- Electric water heating-Solar Water Heaters- solar PV systems.

Expected Outcomes

After successful completion of this course the students able to

1. To acquire the need of energy conservation
2. To analyse Types and objectives of energy auditing
3. To analyze the methods for reactive power compensation
4. To analyze tools for economics of energy conservation
5. To analyze the ECO (Energy Conservation opportunity) in electric systems such as motors, lighting etc.
6. To analyze the ECO (Energy Conservation opportunity) in mechanical systems such as boilers, pumps, compressors, water heaters etc.

Text books

1. Guide Book for National Certification Examination for Energy Managers & Energy Auditors – Bureau of Energy Efficiency, Ministry of Power, Govt of India.
2. Handbook on Energy Audit and Environment Management , Y P Abbi and Shashank Jain, TERI, 2006
3. Utilization, Generation & Conservation of Electrical Energy, Sunil S.Rao, Khanna publishers, 2007.
4. Anthony J. Pansini, Kenneth D. Smalling, .Guide to Electric Load Management., Pennwell Pub; (1998)
5. Partab H., 'Art and Science of Utilisation of Electrical Energy', Dhanpat Rai and Sons, New Delhi. 1975
6. Tripathy S.C.,'Electric Energy Utilization And Conservation', Tata McGraw Hill, 1991
7. L.C.Witte, P.S.Schmidt, D.R.Brown , Industrial Energy Management and Utilisation, Hemisphere Publ, Washington,1988.

Course plan

Module	Content	Hours	Semester Exam Marks (%)
I	Importance of energy management. Energy auditing: methodology System approach and End use approach to efficient use of Electricity; Electricity tariff types; Types and objectives-audit instruments- specific energy analysis-Minimum energy paths-consumption models-Case study. Demand side management.	8	15
II	Electric motors- Energy efficient controls and starting -Motor Efficiency and Load Analysis- Energy efficient motors-Case study; Load Matching and selection of motors-Variable speed drives.	6	15

First Internal Examination			
III	Reactive Power management-Capacitor Sizing-Degree of Compensation-Capacitor losses- Location-Placement-Maintenance, case study. Peak Demand controls-Methodologies- Types of Industrial loads-Optimal Load scheduling-case study.	8	15
IV	ECO assessment and Economic methods- Simple payback period- time value of money-Net Present value- Internal rate of return- Lighting- Energy efficient light sources-Energy conservation in Lighting Schemes- Electronic ballast-Power quality issues-Luminaries, case study	6	15
Second Internal Examination			
V	Energy conservation in **Pumps**- Optimal selection and sizing -Case study- Fans (flow control), Refrigeration & air conditioning systems. **Boiler** -efficiency testing, excess air control, Steam distribution & use- steam traps, condensate recovery, flash steam utilization **Cogeneration**-Types and Schemes-Optimal operation of cogeneration plants-case study;	8	20
VI	Power Consumption in Compressors, Energy conservation measures. **Water heating**-Gysers-Solar Water Heaters- solar PV systems.	6	20
		42	100
Cluster Level End Semester Examination			

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 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.

Two internal tests, each having 15 marks each summing to a total of 30 marks
Tutorials / Assignments / Course Seminars summing to a total of 10 marks, and
Cluster level end-semester examination having 60 marks

Course No.	Course Name	L-T-P-Credits	Year of Introduction
10EE6128	WIND ENERGY CONVERSION SYSTEMS	3-0-0: 3	2015

Course Prerequisites

Basic knowledge in Electrical machines and power electronics *at UG level*.

Course Objectives

To introduce the various electrical generators and appropriate power electronic controllers employed in wind energy systems. To teach the students the steady-state analysis and operation of different existing configurations of electrical systems in wind energy and also the recent developments taking place in this field.

Syllabus

Introduction to wind energy technology- generators and control aspects of WECS- Reactive power compensation for induction generator based WECS- Offshore WECS- Modelling of Grid connected induction generator wind farm-DFIG in WECS-Operation of PMSGs-

Expected Outcomes

Students shall be able to

1. Acquire the principles of aerodynamics and operation of systems in wind energy
2. To design and implement the electrical systems
3. To analyse the closed loop control for specific applications.
4. To Model Grid connected induction generator wind farm
5. To analyse the application of DFIG in WECS
6. To analyse the application of PMSG in WECS

References:

1. D P Kothari and Umashankar “wind energy systems and applications” Narosa publications, new delhi, 2014
2. S.N. Bhadra, D.Kastha and S.Banerje, ‘Wind Electrical Systems’, Oxford University Press, 2005.
3. Siegfried Heier, Rachel Waddington, ‘Grid Integration of Wind Energy Conversion Systems, 2nd Edition’, Wiley, June 2006, ISBN: 978-0-470-86899-7.
4. FreriesLL , ‘Wind Energy Conversion Systems’, Prentice Hall, U.K., 1990.

Course plan

Module	Content	Hours	Semester Exam Marks
I	**Introduction to wind energy technology**- Aerodynamics and design of Wind turbines- horizontal axis and vertical axis wind turbines- Betz limit- power coefficient.	8	15
II	**Generators and control aspects of WECS**- Generator configuration and power electronic interface- Power quality issues-.	6	15
First Internal Examination			
III	**Reactive power compensation** for induction generator based WECS-types of reactive power compensation- shunt and series compensators	8	15
IV	**Offshore WECS**- Modelling of Grid connected induction generator wind farm	6	15
Second Internal Examination			
V	**DFIG in WECS-** Different operating modes- steady-state	8	20

	equivalent circuit- performance analysis- DFIG for standalone applications- operation of DFIGs with different power electronic configurations for standalone and grid-connected operation..		
VI	**Operation of PMSGs**- steady-state analysis- performance characteristics- operation of PMSGs with different power electronic configurations for standalone and grid-connected Operation.	6	20
	TOTAL	42	100
Cluster Level End Semester Examination			

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 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.

Two internal tests, each having 15 marks each summing to a total of 30 marks
Tutorials / Assignments / Course Seminars summing to a total of 10 marks, and
Cluster level end-semester examination having 60 marks

Course No.	Course Name	L-T-P-Credits	Year of Introduction
10EE6132	**DISTRIBUTED GENERATION AND MICRO GRID**	**3-0-0: 3**	**2015**

Course Prerequisites

Basic knowledge in Electrical power systems and Power electronics at UG level.

Course Objectives

2. To give an idea about the renewable energy sources and the integration with grid.

Syllabus

Need for Distributed generation, Grid integration of DGs –Energy storage elements-Technical impacts of DGs –Impact of DGs upon transient and dynamicstability of existing distribution systems.

Economic and control aspects of DGs –Power quality issues-Reliability of DG based systems – Steady-state and Dynamic analysis-Introduction to micro-grids – Microgridswith power electronic interfacing units.

Expected Outcomes

Students who complete this course will have an ability to understand the fundamental concepts of generating electrical energy from renewable energy systems and connecting with electrical grid.

References:

1. H. Lee Willis, Walter G. Scott ,'Distributed Power Generation – Planning and Evaluation', Marcel Decker Press, 2000.
2. M.GodoySimoes, Felix A.Farret, 'Renewable Energy Systems – Design and Analysis with Induction Generators', CRC press.
3. Robert Lasseter, Paolo Piagi, ' Micro-grid: A Conceptual Solution', PESC 2004, June 2004.
4. F. Katiraei, M.R. Iravani, 'Transients of a Micro-Grid System with Multiple Distributed Energy Resources', International Conference on Power Systems Transients (IPST'05) in Montreal, Canada on June 19-23, 2005.

Course plan

Module	Content	Hours	Semester Exam Marks
I	Need for Distributed generation, renewable sources in distributed generation, current scenario in Distributed Generation, Planning of DGs – Sitting and sizing of DGs – optimal placement of DG sources in distribution systems.	8	15
II	Grid integration of DGs – Different types of interfaces - Inverter based DGs and rotating machine based interfaces - Aggregation of multiple DG units. Energy storage elements: Batteries, ultra-capacitors, flywheels	6	15
First Internal Examination			
III	Technical impacts of DGs – Transmission systems, Distribution systems, De-regulation –Impact of DGs upon protective relaying – Impact of DGs upon transient and dynamic stability of existing distribution systems.	8	15
IV	Economic and control aspects of DGs –Market facts, issues and challenges - Limitations of DGs. Voltage control techniques, Reactive power control, Harmonics, Power quality issues. Reliability of DG based systems – Steady-state and Dynamic analysis.	6	15
Second Internal Examination			
V	Introduction to micro-grids – Types of micro-grids – autonomous and non-autonomous grids – Sizing of micro-grids-	8	20

	modeling& analysis- Micro-grids with multiple DGs.		
VI	Micro grids with power electronic interfacing units. Transients in micro-grids - Protection of micro-grids – Case studies.	6	20
	TOTAL	42	100
Cluster Level End Semester Examination			

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 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.

Two internal tests, each having 15 marks each summing to a total of 30 marks
Tutorials / Assignments / Course Seminars summing to a total of 10 marks, and
Cluster level end-semester examination having 60 marks

Course No.	Course Name	L-T-P: Credits	Year of Introduction
10ME6116	**DESIGN OF EXPERIMENTS**	**3-0-0 : 3**	**2015**

Prerequisites

Fundamentals of statistics at the UG level

Objectives

This course exposes the students to the basic statistical concepts, sampling techniques, principles and applications of Design of Experiments.

Syllabus

History of design of experiment; strategy, principle and application of DOE-A rationale for randomization Restricted randomization- Testing significance of effects in a 2^k factorial experiment-Developing a mathematical model - Experiments with single factorial design and application of ANOVA- 2k and 3k factorial design

Expected Outcomes

On completion of this course, the students will able to

- Conduct the experiments using factorial designs.
- Get the basic idea of Factorial design, 2k and 3k factorial design; blocking and confounding techniques in 2k factorial design.
- Get familiarized with the purpose of randomization.
- Interpret experimental results

References

1. Lawson, J. & Erjavec, J., "Modern Statistics for Engineering and Quality Improvement ", Thomson Duxbury, Indian EPZ edition
2. Nibtginertm Diygkas C, "Design and Analysis of Experiments". Fifth ed,-John Wiley & Sons
3. Box, George E P, Hunter William G, Hunter Sturat J : "Statistics for Experimenters" John Wiley & Sons
4. Douglas C. Montgomery, "Design and Analysis of Experiments", 8th Edition, , John Wiley

Course Plan

Module	Content	Hours	Semester Exam Marks (%)
I	History of design of experiment; strategy, principle and application of DOE; basic statistical concepts, sampling techniques and distributions; inferences about means and standard deviations and considerations of different hypothesis; Experiments with single factorial design and application of ANOVA; randomized blocking and Latin squares.	6	15
II	An Introduction to Design of Experiments; The problem of interpreting experimental results; The purpose of randomization; A rationale for randomization, Restricted randomization.	6	15
First Internal Examination			
III	Hypothesis Testing rationale; Comparing two methods experimentally; Introduction to Factorial Experiments and DOE Terminology; Yate's algorithm for calculation of effects in a 2^k design; Testing significance of effects in a 2^k factorial experiment; Normal Probability Plot on ordinary graph paper.	8	15
IV	Developing a mathematical model; Residual Analysis, testing for model adequacy; Finding the Alias Structure of a Fractional Factorial; strategy, principle and application of DOE; basic statistical concepts, sampling techniques and distributions	8	15
Second Internal Examination			
V	Inferences about means and standard deviations and	8	20

	considerations of different hypothesis; Factorial design, 2k and 3k factorial design; blocking and confounding techniques in 2k factorial design;		
VI	Concept of fractioning of factorial design; Response surface method; Introduction to robust design, robust parameter design for single response system; Experiments with non-normal data.	8	20
Cluster Level End Semester Examination			

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 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.

Two internal tests, each having 15 marks each summing to a total of 30 marks
Tutorials / Assignments / Course Seminars summing to a total of 10 marks, and
Cluster level end-semester examination having 60 marks

Course No.	Course Name	L-T-P: Credits	Year of Introduction
10ME6122	**QUALITY AND RELIABILITY ENGINEERING**	**3-0-0 : 3**	**2015**

Course Prerequisites

Fundamental knowledge in probability theory and statistics is desirable.

Course Objectives

To learn in depth the quality and reliability aspects with emphasis on an industrial organizational environment.

Syllabus

Traditional Quality Control-Total Quality management-QMS-ISO9000 standards- Taguchi methods-Six sigma concepts- Design of experiments- Reliability- Total Productive Maintenance-Reliability management.

Expected Outcomes

After completing the course, the students will be able to

- Identify and describe various areas in the quality control and reliability engineering fields.
- Plan and design a quality control program in an industry/organization.
- Estimate the reliability of complex engineering systems
- Gain good understanding of the principles of total productive maintenance

References

1. Dale H; Besterfield, Total quality Mangement,Pearson Education Inc
2. Caplen, Practical Approach to Quality Control, Random House
3. O'Connor, Practical Reliability Engineering, John Wiley and Sons
4. Ryan, Statistical Methods for Quality Improvement, John Wiley and Sons
5. Ross, Taguchi Techniques for Quality Engineering, McGraw Hill Publishers
6. Douglas C. Montgomery. Design and Analysis of Experiments, John Wiley and Sons
7. Balaguruswami E. , Reliability Engineering, Tata Mc Graw Hill Publishing Co. Pvt Ltd

Course plan

Module	Content	Hours	Semester Exam Marks (%)
I	Basic concepts and definition, Traditional Quality Control,Total Quality management, Deming's principles, Customer focus, Employee involvement, Continuous process improvement, PDCA cycle	8	15
II	Seven step process, Kaizen, Quality measurements, Quality costs, QFD, QMS-ISO9000 standards-requirements and documentation, Taguchi methods, quality loss function, Parameter design and Tolerance design concepts	8	15
First Internal Examination			
III	Six sigma concepts –define and measure phase, flow charting, basic tools, probability and hazard plotting, Six sigma measurements, basic control charts and process performance matrices, Measurement systems analysis.	8	15
IV	Design of experiments-basics, single factor, two factor experiments. ANOVA, Taguchi approach to design of experiments, orthogonal arrays, Signal to noise ratio, RSM-concepts and methods.	8	15
Second Internal Examination			
V	Fundamental aspects of reliability, Reliability mathematics, Reliability testing and evaluation methods. FMEA, Failure data	8	20

	analysis.		
VI	Total Productive Maintenance, maintainability and Availability Concepts, Reliability management.	8	20
Cluster Level End Semester Examination			

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 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.

Two internal tests, each having 15 marks each summing to a total of 30 marks
Tutorials / Assignments / Course Seminars summing to a total of 10 marks, and
Cluster level end-semester examination having 60 marks

Course No.	Course Name	L-T-P: Credits	Year of Introduction
10ME6124	**PROJECT ENGINEERING AND MANAGEMENT**	**3-0-0 : 3**	**2015**

Course Prerequisites

Basic knowledge of Industrial Engineering or Management at the UG Level

Course Objectives

This course examines project management in theory and practice and the roles and responsibilities of the project manager. The course offers a practical approach to managing projects, focusing on organizing, planning, and controlling the efforts of the project.

Syllabus

Overview of Project Management - Project Management Concepts and Techniques - Project Cost Estimation - Project Planning and Scheduling- Resource Constrained Scheduling - Project Monitoring and Control - Management of Special Projects.

Expected Outcomes

On completion of the course, the students are expected to have

- A thorough understanding of the principles of project management;
- The ability to lead a project team;
- The ability to accomplish projects on schedule without cost and time overruns;
- The knowledge on the procedure for implementing big and special projects.

Reference Books

1. Shtub, Bard and Globerson Project Management: Processes, Methodologies, and Economics, 2/E, Prentice Hall Inc, 2005.
2. Lock, Project Management Handbook, Gover Publishing Ltd, 1981.
3. Cleland and King, Project Management Handbook 2nd Edition, Wiley, 1988.
4. Wiest and Levy, A Management Guide to PERT/CPM Prentice Hall of India New Delhi.
5. Horald Kerzner, Project Management: A Systemic Approach to Planning, Scheduling and Controlling, CBS Publishers, 2002.
6. S. Choudhury, Project Scheduling and Monitoring in Practice, South Asian Publishers, Delhi, 1983.

Course Plan

Module	Content	Contract hours	Semester Exam Marks %
I	Introduction to Project management, Characteristics of projects, Definition and objectives of Project Management, Stages of Project Management, Project Planning Process, Establishing Project organization, role of Project Manager-.	6	15
II	Project screening and Selection Techniques - Structuring concepts and Tools - Work Breakdown Structure, Organisation Breakdown Structure, and Linear Responsibility Chart - Project Planning Tools- Bar charts, Line of Balance – Critical Path Method, and Project Evaluation and Review Technique- Risk Analysis and Management	10	15
First Internal Examination			
III	Types of Estimates and Estimating Methods- Capital Cost Estimation - Project Budgeting - Project cash flow analysis	6	15
IV	Project Scheduling with Resource Constraints- Resource Leveling- Resource constrained scheduling with multiple resources- linear programming formulation – Introduction to	10	15

	staff scheduling and rostering		
Second Internal Examination			
V	Monitoring Techniques and time control System- Project Cost Control -Time cost Tradeoff procedure, lowest cost schedule- Computer applications in project management	8	20
VI	Management of Software Engineering Projects, New Product Development Projects, R&D Projects and Large Scale Construction Projects -Case Studies	8	20
End Semester Cluster Level Examination			

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 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.

Two internal tests, each having 15 marks each summing to a total of 30 marks
Tutorials / Assignments / Course Seminars summing to a total of 10 marks, and
Cluster level end-semester examination having 60 marks

Course No.	Course Name	L - T - P - Credits	Year of Introduction
10EE 6108	**MINI PROJECT**	**0 - 0 - 4 - 2**	**2015**

Course Prerequisites

(1) The habit of reading technical magazines, conference proceedings and journals;
(2) Skills in hardware/software implementation techniques earned through UG studies;
(3) The course Seminar-1 in the first semester.

Course Objectives

(1) To support the problem based learning approach and to enhance the reading habit among students;
(2) To enhance the skills regarding the implementation aspects of small hardware/software projects.

Guidelines

Each student has to do a mini project related to the branch of specialization under the guidance of a faculty member. It has to be approved by a committee constituted by the institute concerned. It is recommended that the same faculty member may serve as his/her Project Supervisor during 3rd& 4th semesters. The mini project is conceptualized in such a way that, some the outcomes of the work can be utilized in the selection of the thesis. Hence on completion of mini project the student can suggest possible list of their thesis topic in the second semester itself. The implementation of the mini project can be software and/or hardware based one. Mini project is envisaged as a way for implementing *problem based learning*. Problems of socially relevance and/or problems identified by the institute/ research organizations/ industry/ state should be given high priority. In such interdisciplinary and inter institutional projects, a student can have co-guide(s) from other department/ institute/ research organizations/ industry. The university encourages *interdisciplinary projects* and *problem based learning strategy*. The references cited for the mini project shall be *authentic*.

Expected Outcomes

The students are expected to :

- Develop skills regarding enumerating and selecting hot research problems
- Develop skills for subsequent design and analysis
- Implement the hardware/software building blocks of the system
- Be motivated and successful in the selection of the topic for the main project
- Communicate in an effective way and to write technical reports
- Apply various tools for the analysis of the results and performance of the work.

References

1. J.W. Bames, *Statistical Analysis for Engineers and Scientists*, McGraw Hill, New York.
2. Schank Fr., *Theories of Engineering Experiments*, Tata McGraw Hill Publication.
3. Douglas C Montgomery, *Design and analysis of experiments*, Wiley International
4. Leedy P D, *Practical Research : Planning and Design,* 4th Edition, N W MacMillan Publishing Co

Course plan

Item	Description	Time	
1	Abstract Submission	2 Weeks	
2	Allotment of Topic	1 Week	
3	Preliminary Presentation Sessions	1 Week	
4	Implementation Phase	9 Weeks	
5	Final Presentation-cum Demonstration	1 Week	

1. Preliminary Presentation evaluated by the Progress Evaluation Committee (PEC) : 20 Marks
2. Progress Evaluation (Guide and/or Co-guide): 30 Marks
3. Final Presentation-cum-demonstration evaluated by the PEC: 30 Marks
4. Report (Mandatory): 20 Marks

ourse No.	Course Name	L-T-P-Credits	Year of Introduction
10EE6112	**ADVANCED DRIVES LAB**	**0- 0 - 2 : 1**	**2015**

Course Prerequisites

Basic knowledge of Power Electronics and drives at UG Level.

Course Objectives

To design and develop power electronic drives and control.

Syllabus

- DC motor drives
- Induction motor drives
- BLDC motor drives
- Switched Reluctance motor Drives
- PMDC motor drives

Expected Outcomes

Upon the completion of this course, students will have the ability to:

- Design and implement various speed control techniques for dc drives
- Design and implement various speed control techniques for ac drives
- Analyse the performance of speed control techniques for BLDC/SRM type drives
- Familiarize with the DSP based control schemes
- Obtain and analyse the characteristics of Fuel cell and PV cells
- Model and analyse the performance of wind energy conversion systems

References

1. Power Electronics Converters, Application And Design – Ned Mohan, T M Undeland, William P Robbins, John Wiley & Sons 2003
2. Power Electronics – M D Singh, Khanchandani, 2nd Edition, Tata Mcgraw Hill
3. Power Electronics Principles And Applications – Joseph Vithayathil – Tata Mcgraw Hill
4. Power Electronics – Cyril W Lander – Tata Mcgraw Hill
5. Electric Drives – Vedam Subrahmanyam – Tata McGraw Hill – 2nd Edition
6. Fundamentals of Electric Drives – G. K. Dubey, Narosa Publications-2nd Edition.
7. AC Machine Systems – Jingde Gao, Linzheng Zhang, Xiangheng Wang, Springer
8. Advanced Electric Drives – Rik De Doncker, Duco W J Pulle, Andre Veltman – Springer

Course plan

Sl. No.	Experiments
1	Speed control of controlled rectifier based DC motor drive
2	Speed control of DC-DC converter based DC motor drive
3	Speed control of PMDC motor drive
4	V/f control of three phase induction motors.
5	Vector control of three phase induction motors.
6	Speed control of three phase synchronous motors.
7	Speed control of BLDC motor drive
8	Speed control of SRM motor drive
9	DSP based speed control of induction motor
10	Dspace based speed control of induction motor
11	Study of VI characteristics of solar panel
12	Study of VI characteristics of fuel cell.
13	Study of characteristics of wind energy conversion system

Internal Continuous Assessment: 100 marks

i) Practical Records /outputs 40%

ii) Regular Class Viva-Voce 20%

iii) Final Test (Objective) 40%

SEMESTER III

Course No.	Course Name	L-T-P Credits	Year of Introduction
10EE7105	**FACTS CONTROLLERS**	**3 – 0 – 0 : 3**	**2015**

Course Prerequisites

Basic knowledge of Power Electronic Converts and Electrical Power Technology at UG Level.

Course Objectives

The course is designed to provide students knowledge of FACTS Controllers, reactive power control techniques and power quality improvements in AC Transmission and Distribution systems.

Syllabus

The concept of flexible AC transmission - reactive power control in electrical power transmission lines -uncompensated transmission line – Overview of FACTS devices series and shunt compensation- Static Var Compensator (SVC) – Thyristor Switched Series capacitor (TCSC) – Unified Power Flow controller (UPFC) - Integrated Power Flow Controller (IPFC)- Special Purpose FACTS Controllers

Expected Outcomes

The students are expected to apply the general principles of Facts Controllers to Transmission and Distribution system.

Text books

1. Hingorani, Understanding FACTS Controllers
2. K R Padiyar, FACTS controllers in Power Transmision and Distribution, New Age publications, New Delhi, 2007Utilization, Generation & Conservation of Electrical Energy, Sunil S.Rao, Khanna publishers, 2007.
3. Enrique Acha, Claudio R. Fuerte-Esquivel, Hugo Ambriz-Perez and Cesar Anglele-Camacho, Facts Modelling and Simulation in power Networks, John wiley & Sons, Ltd, 2004.
4. Vijay K Sood, HVDC and Facts Controllers Application of static converters in power systems, Kluwer academic publishers, New York, Boston London, London, Moscow, 2004.
5. J.Arrillaga, Y.H Liu and N. R Watson, Flexible Power Transmission the HVDC options.John Wiley & Sons,Ltd, John Wiley & Sons Ltd, The Atrium, Southern Gate, Chichester,
   England, 2007

Course plan

Module	Content	Hours	Semester Exam Marks (%)
I	FACTS Concept and General System Considerations. Power Flow in AC System Definitions on FACTS. Basic Types of FACTS Controllers.	8	15
II	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.	6	15
First Internal Examination			
III	Static Series Compensation. GCSC, TSSC, TCSC and SSSC. Operation and Control. External System Control for Series Compensators. SSR and its damping	8	15

IV	Static Voltage and Phase Angle Regulators. TCVR and TCPAR. Operation and Control, Switching converter based Voltage and phase angle regulators, Hybrid phase angle regulators.	8	15
Second Internal Examination			
V	Combined Compensators, UPFC and IPFC. The Unified Power Flow Controller. Operation, Comparison with other FACTS devices, control of P and Q, Dynamic Performance, Multifunctional Facts Controllers.	8	20
VI	Special Purpose Facts Controllers, NGH-SSR Damping Scheme, Thyristor-Controlled Braking Resistor (TCBR), Fault current Limiter(FCL), Thyristor controlled voltage limiter(TCVL)	6	20
		42	100
Cluster Level End Semester Examination			

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 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.

Two internal tests, each having 15 marks each summing to a total of 30 marks
Tutorials / Assignments / Course Seminars summing to a total of 10 marks, and
Cluster level end-semester examination having 60 marks

Course No.	Course Name	L-T-P-Credits	Year of Introduction
10EE7107	ELECTRIC VEHICLE SYSTEMS	3 - 0 – 0: 3	2015

Course Prerequisites

Basic knowledge of four stroke and two storke engines, Various type of motors used for traction purpose; DC series, Slip ring IM, Basics of Electrical Drives, Fuel Cell - UG Level.

Course Objectives

This course is designed to understand electric vehicles and to develop design skills for electric vehicles. This course will introduce general aspects of Electric Vehicles (HEV), including architectures, modeling, sizing, vehicle control. It will cover vehicle dynamics, energy storage sources, electric propulsion systems, power electronics design, and EV drives.

Syllabus

Fundamentals of Vehicle Propulsion and Brake: - Vehicle Resistance - Dynamic Equation - Tire–Ground Adhesion and Maximum Tractive Effort - Power Train Tractive Effort and Vehicle Speed - Vehicle Power Plant and Transmission Characteristics - Vehicle Performance

Internal Combustion Engines – 4 stroke spark ignited and compression ignited engines – 2 stroke engines – Wankel rotary engines – strirling engines – gas turbine engines – quasi isothermal brayton cycle engines

Electric vehicles: configuration – performance – tractive effort in normal driving – energy consumption

Hybrid electric vehicles: series and parallel electric drive trains

Electric propulsion systems: DC motor drives – Induction motor drives – permanent magnet BLDC motor drives – SRM drives – SRM design

Parallel (Mechanically Coupled) Hybrid Electric Drive Train Design - Design and Control Methodology of Series–Parallel (Torque and Speed Coupling) Hybrid Drive Train - Statistics of Daily Driving Distance - Energy Management Strategy - Energy Consumed in Braking and Transmission - Regenerative Breaking - Control Strategy for Optimal Energy Recovery

Fuel Cells - Fuel Cell Hybrid Electric Drive Train Design - Power and Energy Design of Energy Storage

Expected Outcomes

1. Identify the various fundamentals in the traction design problems
2. Understand the various factors that influence the vehicle tractive power and performance.
3. Able to design hybrid electric vehicle system depending on the power requirement, input available, energy management requirement, alternate fuel system etc.
4. Propose various electric driving motors and Power electronics drives systems for electrical vehicle.

Text books

1. Modern Electric Vehicles, Hybrid Electric and Fuel Cell Vehicles – 2nd Edition – Meherdad Ehsani, Yimin Gao, Ali Emadi – CRC Press

2. Electric Vehicle Technology Explained – James Larminie, John Lowry – John Wiley & Sons

3. Batteries for Electric Vehicles (Electronic & Electrical Engineering Research Studies Power Sources Technology) - D Rand - Wiley-Blackwell (21 January 1998)

4. Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design, Second Edition (Power Electronics and Applications Series) - Mehrdad Ehsani, Yimin Gao, Ali Emadi, Standardsmedia (2009)

References

1. Propulsion System for Hybrid Vehicle” 2nd Edition” by John M. Miller

2. History of Electric Vehicles Bellis

Course plan			
Module	**Content**	**Hours**	**Semester Exam Marks**
I	Fundamentals of Vehicle Propulsion and Brake: - Vehicle Resistance - Dynamic Equation - Tire–Ground Adhesion and Maximum Tractive Effort - Power Train Tractive Effort and Vehicle Speed - Vehicle Power Plant and Transmission Characteristics - Vehicle Performance.	6	15
II	Internal Combustion Engines – 4 stroke spark ignited and compression ignited engines – 2 stroke engines – Wankel rotary engines – strirling engines – gas turbine engines – quasi isothermal brayton cycle engines Electric vehicles: configuration – performance – tractive effort in normal driving – energy consumption Hybrid electric vehicles: series and parallel electric drive trains	8	15
First Internal Examination			
III	Electric propulsion systems: DC motor drives – Induction motor drives – permanent magnet BLDC motor drives – SRM drives – SRM design	6	15
IV	Parallel (Mechanically Coupled) Hybrid Electric Drive Train Design - Design and Control Methodology of Series–Parallel (Torque and Speed Coupling) Hybrid Drive Train - Statistics of Daily Driving Distance	8	15
Second Internal Examination			
V	Energy Management Strategy - Energy Consumed in Braking and Transmission - Regenerative Breaking - Control Strategy for Optimal Energy Recovery Fuel Cells -	8	20
VI	Fuel Cell Hybrid Electric Drive Train Design - Power and Energy Design of Energy Storag	6	20
Total		42	100
Cluster Level End Semester Examination			

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 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.

Two internal tests, each having 15 marks each summing to a total of 30 marks
Tutorials / Assignments / Course Seminars summing to a total of 10 marks, and
Cluster level end-semester examination having 60 marks

Course No.	Course Name	L-T-P-Credits	Year of Introduction
10EE7109	**INDUCTION GENERATORS**	**3-0-0-3**	**2015**

Course Prerequisites

Basic knowledge of Induction machine at UG Level.

Course Objectives

1. To develop understanding of techniques to analyze induction generators.
2. This course is designed to understand the application and characteristics of various types Induction generator in different power generating area.
3. Enable students to do transient modeling of induction generators and simulation.
4. Understand the vector, scalar and field oriented control of induction generators.

Syllabus

Steady state model of Induction Generator–doubly fed induction generator-Transient models of induction generator: Self excited induction generator-Scalar control – background and schemes, vector control – Doubly fed induction generators: features – sub synchronous and super synchronous modes of operation– stand alone DFIG-Applications of induction generators in alternative sources of energy.

Expected Outcomes

1. Able to model the steady state and transient models of induction generator for various operating conditions.
2. Understand the characteristics and operational features on induction generators.
3. Analyze the factors to optimize maximum power output from an induction generators.
4. Describe the working and control of DFIG and its application.

Text books

1. Modeling and Analysis with Induction Generators, Third Edition, M. Godoy Simões, Felix A. Farret, CRC Press.

References

1. M Godoy Simoes, Felix A Farret, Alternative Energy Systems – Design and Analysis with Induction Generators, CRC Press
2. Vladislav Akhmatov, Induction Generators for wind power – Multiscience publishing Co

Course plan

Module	Content	Hours	Semester Exam Marks
I	Steady state model of Induction Generator: Classical steady state representation of the asynchronous machine – generated power – induced torque – representation of induction generator losses – measurement of parameters – high efficiency induction generator – doubly fed induction generator	8	15
II	Transient models of induction generator: Induction machine in transient state – state space based modeling of induction generator – partition of state matrix with RLC load – transient simulation of induction generators	6	15
First Internal Examination- 15 Marks			
III	Self excited induction generator: performance – magnetization curves and self excitation – mathematical description of self	8	15

	excitation process – series capacitors and composed excitation – characteristics and construction features of induction generator		
IV	Scalar control – background and schemes, vector control – axis transformation – space vector notation – field oriented control.	6	15
Second Internal Examination- 15 Marks			
V	Optimized control for induction generators – optimization principles – hill climbing control based maximum power search – fuzzy logic control based maximum power search.	8	20
VI	Doubly fed induction generators: features – sub synchronous and super synchronous modes – operation – interconnected and stand alone operation – field oriented control – active and reactive power control – stand alone DFIG-Applications of induction generators in alternative sources of energy	6	20
Total		42	100
Cluster Level End Semester Examination			

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 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.

Two internal tests, each having 15 marks each summing to a total of 30 marks
Tutorials / Assignments / Course Seminars summing to a total of 10 marks, and
Cluster level end-semester examination having 60 marks

Course No.	Course Name	L-T-P-Credits	Year of Introduction
10EE7111	**CUSTOM POWER DEVICES**	**3 - 0 - 0 : 3**	**2015**

Course Prerequisites

Basic knowledge of Electrical power systems and power electronics at UG Level.

Course Objectives

The course is designed to provide students a strong background in the design and development of custom power devices for power quality improvement

Syllabus

Power quality –Power electronic application in Transmission systems and distribution systems-Custom power devices-Network configuring and compensating devices- SSCL, SSB, SSTS, custom power park- DSTATCOM-compensator for single phase and three phase loads - DVR-Rectifier and capacitor supported-DVR structure-UPQC structure and control of left shunt and right shunt UPQC-Active filters-shunt,series, hybrid filters

Expected Outcomes

- Identify the various issues in power quality
- To analyse the classification of custom power devices.
- To anlyse the network configuring type custom power devices
- To analyse the compensation type custom power devices
- To design shunt connected DSTATCOM for power quality improvement
- To design DVR and UPQC for power quality improvement
- To analyse the principles of CVT and UPS for power quality improvement

Referrences

1) L Ghosh and G Ledwich,"Power quality enhancement using custom power Devices," Kluwer Publications, London, 2003
2) K R Padiyar, "FACTS controllers in Power Transmision and Distribution," New Age publications, New D elhi, 2007
3) R Sastry Vedam,"Ppower quality VAR compensation in power systems," CRC press, NewYork,2009
4) H Akagi, New Trends in active filters for power conditioning, IEEE TIA, vol.32,no.6,pp1312-1322,1996.
5) B Singh, P Jayaprakash, R Somayajulu, D P Kothari, "Reduced Rating VSC With a Zig-Zag Transformer for Current Compensation in a Three-Phase Four-Wire Distribution System", IEEE Transactions on Power Delivery, Vol. 24, Jan. 2009.

Course plan

Module	Content	Hours	Semester Exam Marks (%)
I	Power quality –Power electronic application in Transmission systems and distribution systems-distributed generation- Power quality terms -transients, over voltage, under voltage, sag, swell, harmonics, flicker- PQ problems-poor power factor, unbalanced loads, disturbances in supply voltage.	8	15
II	Custom power devices-Network configuring and compensating devices- SSCL, SSB, SSTS, custom power park- Structure and control of power converters-open loop voltage control and closed loop voltage control- custom power park	6	15
First Internal Examination			
III	DSTATCOM-compensator for single phase and three phase loads -generating reference current using instantaneous	8	15

	reactive power theory and SRF theory- reference signal generation-		
IV	Neutral current compensation in three phase four wire systems- zig-zag transformers- active techniques- -three phase four wire DSTATCOM – Various structures-design and simulation methods- A case study	6	15
Second Internal Examination			
V	DVR-Rectifier supported and capacitor supported-DVR structure – DVR control- reference signal generation- design and simulation methods- A case study	8	20
VI	UPQC structure and control of left shunt and right shunt UPQC-Active filters-shunt, series, hybrid filters-Uninterrupted Power supplies- Constant Voltage Transformers	6	20
		42	100
Cluster Level End Semester Examination			

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 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.

Two internal tests, each having 15 marks each summing to a total of 30 marks
Tutorials / Assignments / Course Seminars summing to a total of 10 marks, and
Cluster level end-semester examination having 60 marks

Course No.	Course Name	L-T-P-Credits	Year of Introduction
10EE7113	**ANALYSIS, MODELLING AND CONTROL OF ELECTRIC DRIVES**	**3 – 0 – 0 : 3**	**2015**

Course Prerequisites

Basic knowledge of Electrical machines and drives at UG Level.

Course Objectives

To impart analysis modeling and control of electric drives

Syllabus

Modeling and Control of DC Machines- Synchronous Machine Modeling Concepts- Control of Synchronous Machine Drives- Induction Machine Modeling Concepts- Control of Induction Machine Drives- Switched Reluctance Drive Systems

Expected Outcomes

The students are expected to apply the modeling concepts to electric drives.

Text books

1. Doncker, W J Pulle, Andre Veltman – Advanced electric Drives Modelling Analysis and Control – Springer
2. Kraus PC, Analysis of Electrical Machines, Mc Graw Hill Book Company
3. Paul C Krause, Oleg Wasynczuk, sCott D. Sudhoff, Analysis of Electric Machinery and Drive System, Wiley Interscience

Course plan

Module	Content	Hours	Semester Exam Marks (%)
I	**Modeling and Control of DC Machines-** Separately Excited, Current-Controlled DC Machine, Field-Oriented Machine Model, Control of Separately Excited DC Machines	8	15
II	**Synchronous Machine Modeling Concepts-** Non-salient Machine- Salient Synchronous Machine .	6	15
First Internal Examination			
III	**Control of Synchronous Machine Drives-** Control of Non-salient Synchronous Machines- Control of Salient Synchronous Machines- Field-Oriented Control of a Current-Controlled Synchronous Machine- Field-Oriented control of a Voltage-Source Connected Synchronous Machine.	8	15
IV	**Induction Machine Modeling Concepts-** Induction Machine with Squirrel-Cage Rotor- Zero Leakage Inductance Models of Induction Machines- Machine Models with Leakage Inductances- Parameter Identification and Estimates- Single-Phase Induction Machines.	6	15
Second Internal Examination			
V	**Control of Induction Machine Drives-** Voltage-to-Frequency (V/f) Control- Field-Oriented Control- Operational Drive Boundaries for Rotor Flux Oriented Control. Field Weakening for Rotor Flux Oriented IM Drives- Interfacing FOC with Current-Controlled IM- Interfacing FOC with Voltage-Source-Connected IM.	8	20
VI	**Switched Reluctance Drive Systems-** Basic Machine Concepts- Operating Principles- Multi-Phase Machines- Control of Switched Reluctance Drives	6	20

		42	100
Cluster Level End Semester Examination			

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 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.

Two internal tests, each having 15 marks each summing to a total of 30 marks Tutorials / Assignments / Course Seminars summing to a total of 10 marks, and Cluster level end-semester examination having 60 marks

Course No.	Course Name	L-T-P-Credits	Year of Introduction
10EE7115	**ADVANCED CONTROL OF PWM INVERTER FED INDUCTION MOTORS**	**3 - 0 - 0 : 3**	**2015**

Course Prerequisites

Basic knowledge of Electrical Machines and drives at UG Level.

Course Objectives

To develop understanding of techniques of control of PWM Inverter fed Induction Motors

Syllabus

Principles for vector and field-oriented control – Complex-valued dq-model of induction machines- Generalized flux-vector control- Parameter sensitivity- Principles for speed sensor-less control

Expected Outcomes

The students are expected to apply the general principles of power quality improvement using custom power deices.

Referrences

1) Extract of D. W. Novotny and T. A. Lipo, Vector Control and Dynamics of AC Drives, Oxford University Press,1996.
2) P. L. Jansen and R. D. Lorenz, A Physically Insightful Approach to the Design and Accuracy Assessment of Flux Observers for Field Oriented Induction Machine Drives, IEEE Trans. on Industry Applications, Vol. 30, No. 1, Jan./Feb. 1994, pp. 101110.
3) Ion Boldea and Syed. A. Nasar, Electric Drives,2nd edition CRC Press, 1998.
4) J. Holtz and K. Rajashekara, Methods for Speed Sensorless Control of AC Drives, in Sensorless Control of AC motors. IEEE Press Book, 1996.
5) R. W. De Doncker and D. W. Novotny, The Universal Field Oriented Controller, IEEE Trans. on Industry Applications, Vol. 30, No. 1, Jan./Feb. 1994, pp. 92100.
6) J. Holtz, The Representation of AC Machine Dynamics by Complex Signal Flow Graphs, IEEE Transactions on Industrial Electronics, Vol. 42, No. 3, 1995, pp. 263271.

Course plan

Module	Content	Hours	Semester Exam Marks (%)
I	Complex vector analysis of induction machines- complex Vector Equivalent circuit- turns ratio and d,q models, modified equivalent circuits.	8	15
II	Principles for vector and field-oriented DC Machine Torque control- requirements for torque control- synchronous machine vector control- Synchronous Machine Steady state d,q Model- Torque control implementations of synchronous machines.	6	15
First Internal Examination			
III	Current controllers in stationary and synchronous coordinates. Rotor-flux oriented control of current-regulated induction machine - Dynamic model of IM in rotor-flux coordinates. Indirect rotor-flux oriented control of IM - Direct rotor-flux oriented control of IM.- Methods to estimation of rotor-flux	8	15
IV	Generalized flux-vector control using current- and voltage decoupling networks-. Current and voltage decoupling networks. Airgap-oriented control. Voltage-fed vector control. Stator-flux oriented vector control.	6	15
Second Internal Examination			
V	Parameter sensitivity, selection of flux level and field	8	20

	weakening - Parameter detuning in steady-state operation. Parameter detuning during dynamics. Selection of flux level. Control strategies for used in the over-speed region.		
VI	Principles for speed sensor-less control - Principles for speed sensor-less control. Sensor-less methods for scalar control. Sensor-less methods for vector control .Introduction to observer-based techniques.	6	20
		42	100
Cluster Level End Semester Examination			

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 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.

Two internal tests, each having 15 marks each summing to a total of 30 marks Tutorials / Assignments / Course Seminars summing to a total of 10 marks, and Cluster level end-semester examination having 60 marks

Course No.	Course Name	L-T-P-Credits	Year of Introduction
10EE7117	**SOFT COMPUTING TECHNIQUES**	**3 - 0 - 0 : 3**	**2015**

Course Prerequisites

Basic knowledge of Engineering at UG Level.

Course Objectives

1. Learn the various soft computing techniques
2. Be familiar with design of various neural networks.
3. Learn genetic programming.
4. Be exposed to hybrid systems.

Syllabus

Fuzzy Set Theory, Regression and Optimization, Neural Networks, Neuro-Fuzzy Modeling, Advanced Neuro-Fuzzy Modeling, Neuro-Fuzzy Control, Advanced Applications.

Expected Outcomes

The students are expected to apply the soft computing techniques in Electrical Engineering control applications.

References

1) S.Rajasekaran and G.A.Vijayalakshmi Pai, "Neural Networks, Fuzzy Logic and Genetic Algorithm: Synthesis & Applications", Prentice-Hall of India Pvt. Ltd., 2006.
2) George J. Klir, Ute St. Clair, Bo Yuan, “Fuzzy Set Theory: Foundations and Applications” Prentice Hall, 1997.
3) David E. Goldberg, “Genetic Algorithm in Search Optimization and Machine Learning” Pearson Education India, 2013.
4) James A. Freeman, David M. Skapura, “Neural Networks Algorithms, Applications, and Programming Techniques, Pearson Education India, 1991.
5) Simon Haykin, “Neural Networks Comprehensive Foundation” Second Edition, Pearson Education, 2009
6) J.S.R.Jang, C.T. Sun and E.Mizutani, “Neuro-Fuzzy and Soft Computing”, PHI / Pearson Education 2004.
7) S.N.Sivanandam and S.N.Deepa, "Principles of Soft Computing", Wiley India Pvt Ltd, 2011.

Course plan

Module	Content	Hours	Semester Exam Marks (%)
I	Introduction to Neuro-Fuzzy and Soft Computing, Fuzzy Set Theory, Fuzzy Sets Fuzzy Rules and Fuzzy Reasoning, Fuzzy Inference Systems.	8	15
II	Regression And Optimization, Least-Squares Methods for System Identification, Derivative-Based Optimization, Derivative-Free Optimization.	6	15
First Internal Examination			
III	Neural networks, Adaptive Networ, Supervised Learning Neural Networks, Learning from Reinforcement, Unsupervised Learning and Other Neural Networks.	8	15
IV	Neuro-fuzzy modeling, ANFIS: Adaptive-Networks-based Fuzzy Inference System, Coactive Neuro-Fuzzy Modeling: Towards Generalized ANFIS.	6	15

Second Internal Examination			
V	Advanced Neuro-fuzzy modeling, Classification and Regression Trees, Data Clustering Algorithms, Rule base Structure Identification, Neuro-Fuzzy Control, Neuro-Fuzzy Control.	8	20
VI	Advanced applications, ANFIS Applications, Fuzzy-Filtered Neural Networks, Fuzzy Theory and Genetic Algorithms in Game Playing, Soft Computing for Color Recipe Prediction.	6	20
		42	100
Cluster Level End Semester Examination			

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 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.

Two internal tests, each having 15 marks each summing to a total of 30 marks
Tutorials / Assignments / Course Seminars summing to a total of 10 marks, and
Cluster level end-semester examination having 60 marks

Course No.	Course Name	L-T-P-Credits	Year of Introduction
10EC7207	**MICRO ELECTRO MECHANICAL SYSTEMS**	**3-0-0- 3**	**2015**

Course Prerequisites

Basic knowledge of electronic and mechanical components at UG/PG Level.

Course Objectives

The course is designed to provide students a strong background and fundamental basis of MEMS and devices, such as microactuators and microsensors, as well as their principles of operation.

Syllabus

Overview Of Mems, Micro Fabrications And Micromachining, Physical Microsensors, Micro Actuators, Case Studies

Expected Outcomes

The students are expected to apply working principles of currently available microsensors, actuators, microsystem conceptual design of microdevices and systems.

References

1. Marc Madou, "Fundamentals of Microfabrication", CRC press 1997.
2. Stephen D. Senturia," Micro system Design", Kluwer Academic Publishers,2001
3. B.H. Bao, "Analysis and design principles of MEMS Devices", Elsevier, 2005.
4. Tai Ran Hsu ,"MEMS and Microsystems Design and Manufacture" ,Tata McGraw Hill, 2002.
5. Chang Liu, "Foundations of MEMS", Pearson education India limited, 2006.

Module	Content	Hours	Semester Exam Marks (%)
I	**OVERVIEW OF MEMS:** History of MEMS, MEMS and Microsystems, Scaling laws in Miniaturization. Materials for MEMS and Microsystems.	6	15
II	**MICRO FABRICATIONS AND MICROMACHINING**: Microsystem Design and Fabrication, Microsystem fabrication processes- Photolithography, Ion Implantation, Diffusion, Oxidation	4	15
	Chemical and Physical Vapor deposition, Deposition by Epitaxy, Etching. Bulk Micro manufacturing, Surface micromachining, LIGA process.	4	
First Internal Examination			
III	**PHYSICAL MICROSENSORS**: Design of Acoustic wave sensors, resonant sensor,Vibratory gyroscope, Capacitive and Piezo Resistive Pressure sensors	8	15
IV	**MICROSENSORS:** Engineering mechanics behind these Micro sensors.	6	15
Second Internal Examination			
V	**MICROACTUATORS:** Design of Actuator, Actuation using thermal forces, Actuation using shape memory Alloys, Actuation using piezoelectric crystals.	4	20
	Actuation using Electrostatic forces (Parallel plate, Torsion bar, Comb drive actuators), Micromechanical Motors and pumps.	4	
VI	**CASE STUDIES**: Ink jet pointer heads, Micro mirror TV Projector, DNA chip, Micro arrays, and RF electronic devices. Total	6	20
		42	
Cluster Level End Semester Examination			

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 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.

Two internal tests, each having 15 marks each summing to a total of 30 marks
Tutorials / Assignments / Course Seminars summing to a total of 10 marks, and
Cluster level end-semester examination having 60 marks

Course No.	Course Name	L - T - P - Credits	Year of Introduction
10EE7101	SEMINAR - II	0 - 0 - 2 - 2	2015

Course Prerequisites

(1) The habit of reading technical magazines, conference proceedings, journals etc.;
(2) Knowledge in technical writing and communication skills earned through seminar at UG level and in first semester;
(3) The course Seminar-I in the first semester.

Course Objectives

1) To enhance the reading ability required for identification of the thesis area and its literature review.
2) To develop skills regarding professional communication and technical report writing;
3) To establish the fact that student is not a mere recipient of ideas, but a participant in discovery and inquiry.
4) To arrive at a conclusion for doing Project Phase I.
5) To learn how to prepare and publish technical papers.

Guidelines

Students have to present a second seminar in 3rd semester. It is highly recommended that seminar-2 may report the literature survey being conducted as a requirement for doing the main project. Since the topic for the main project topic is to be finalized at the end of the second semester/ in the beginning of the 3rd semester, one can perform the literature search and present it as a seminar towards the middle of the semester. The Progress Evaluation Committee (PEC) formed in the second semester itself, may be the panel of evaluators for Seminar-II also. The presentation of seminar-II shall be of 20 minutes duration with another 5 minutes allocated for a discussion session. The committee shall evaluate the seminar based on the style of presentation, technical context, and coverage of the topic, adequacy of references, depth of knowledge and the overall quality. Moreover, each student has to submit a seminar report in the prescribed format given by the Institution. It is recommended that the report for seminar-II may be in the form of a technical paper which is suitable for publishing in Conferences / Journals as a review paper. This makes a student learn how to publish a paper and consequently develops a publishing culture among the PG student community. The references cited in the report shall be *authentic*.

Expected Outcomes

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

- Be motivated in reading which equip them in identification of thesis area and its literature review;
- Develop the capacity to observe intelligently and propose and defend opinions and ideas with tact and conviction;
- Develop skills regarding professional communication and oral presentation;
- Arrive at a conclusion for doing Project Phase 1;
- Develop skills for technical report writing
- Learn the methodology of publishing technical papers.

References

1. M. Ashraf Rizvi, *Effective Technical Communication*, Tata McGraw Hill, New Delhi, 2005
2. Day R A, *How to Write and Publish a Scientific Paper*, Cambridge University Press, 1989
3. Coley S M and Scheinberg C A, *Proposal Writing*, 1990, Newbury Sage Publications.

Course plan

Item	Description	Time	
1	Abstract Submission	3 Weeks	
2	Allotment of Topic and Scheduling Seminars	1 Week	
3	Literature Review and Presentation Sessions	6 Weeks	
4	Report Submission	3 Weeks	
5	Publishing Grades	1 Week	

1. Presentation (Verbal & Nonverbal Communication skills) : 20 Marks
2. Breadth of the literature review (Coverage : Content of the slides and speech) : 20 Marks
3. Depth of knowledge (Ability to answer questions) : 30 Marks
4. Seminar Report / Paper in the prescribed format given by the Institution : 30 marks

Course No.	Course Name	L - T - P - Credits	Year of Introduction
10EE7103	PROJECT(PHASE I)	0 - 0 - 12 : 6	2015

Course Prerequisites

(1) The habit of reading technical magazines, conference proceedings and journals;
(2) Interest solving in socially relevant or research problems;
(3) Skills in hardware/software implementation techniques earned from UG studies and the mini project done in second semester;
(4) The courses Research Methodology, Mini Project, and Seminar-2 done in previous semesters.

Course Objectives

(1) To start experimentation based on the background knowledge acquired through the literature survey performed for seminar-II;
(2) To work on the topic, familiarize with the design and analysis tools required for the project work and plan the experimental platform, if any, required for project work;
(3) To develop the skill of identifying research problems/ socially relevant projects;
(4) To enhance the skills regarding the implementation aspects of hardware/ software projects.

Guidelines

Each student has to identify a topic related to the branch of specialization for his/her main project under the guidance of a faculty member and the related experimentations namely project - phase I, should be started in the 3rd semester. The project topic has to be approved by a committee constituted by the department. This committee, namely Progress Evaluation Committee (PEC), should study the feasibility of each project work before giving consent. It is recommended that students should execute the project work using the facilities of the institute itself. However, external projects can be taken up in the 4th semester, if that work solves a technical problem of the external firm. Prior sanction should be obtained from the Head of Institution before taking up external project work.

Project work is to be carried out in the 3rd and 4th semesters and also to be evaluated in both semesters. It is recommended that the same faculty member may serve as his/her Project Supervisor during 4th semester also. This project phase is conceptualized in such a way that, the outcomes of the work may be continued for the project - phase II. Hence on completion of this project phase, the student will make a presentation based on the work and suggest future plan for his project - phase II. The implementation of the project - phase I can be software and/or hardware based one. This project phase is also envisaged as a way for implementing *problem based learning*. Problems of socially relevance and/or problems identified by the institute/ research organizations/ industry/ state should be given high priority. In such interdisciplinary and inter institutional projects, a student can have co-guide(s) from other department/ institute/ research organizations/ industry. The university encourages *interdisciplinary projects* and *problem based learning strategy*. The following guidelines also have to be followed.

1. The student will submit a detailed *project report* for project -phase I;
2. The student will present *at least* two seminars;
3. The *first one* in the beginning of the semester will highlight the topic, objectives and methodology;
4. A *progress seminar* can be conducted in the middle of the semester (optional);
5. The *third seminar* will be an end-semester presentation of the work they have completed till the end of the 3rd semester and the scope of the work which is to be accomplished in the 4th semester, mentioning the expected results.

All such presentations are to be evaluated internally by the progress evaluation committee (PEC). All the references cited in the report for project - phase I shall be *authentic*.

Expected Outcomes

The students are expected to :
(1) Develop the skill of identifying industrial/ research problems/ socially relevant projects;
(2) Develop skills regarding enumerating and selecting problems, subsequent analysis, and

effective implementation of the solution;
(3) Have hands on experience in design and analysis tools required for the project work;
(4) Plan the experimental platform, if any, required for project work, which will be helpful in actual real life project planning;
(5) Enhance the skills regarding the implementation aspects of hardware/ software projects;
(6) Acquire documentation and problem solving skills;
(7) Develop professionalism;
(8) Effectively communicate technical information by means of written and oral reports.

References

1. J.W. Bames, *Statistical Analysis for Engineers and Scientists*, McGraw Hill, New York.
2. Schank Fr., *Theories of Engineering Experiments*, Tata McGraw Hill Publication.
3. Douglas C Montgomery, *Design and analysis of experiments*, Wiley International
4. Leedy P D, *Practical Research : Planning and Design*, 4th Edition, N W MacMillan Publishing Co.

Course plan

Item	Description	Time	
1	Abstract Submission	2 Week	
2	Allotment of Topic	1 Week	
3	Preliminary Presentation Sessions	1 Week	
4	Implementation Phase	9 Weeks	
5	Final Presentation-cum Demonstration	1 Week	

Marks: 50 for Project Progress Evaluation

1. Preliminary presentation, evaluated by the PEC: 15 Marks
2. Progress evaluation by the Project Supervisor/s: 20 Marks
3. End-semester presentation, evaluated by the PEC: 15 Marks

FOURTH SEMESTER

Course No.	Course Name	L - T - P - Credits	Year of Introduction
10EE7104	PROJECT (PHASE -II)	0 - 0 - 24 - 12	2015

Course Prerequisites

(1) The habit of reading technical magazines, conference proceedings and journals;
(2) Interest in solving socially relevant or research problems;
(3) Skills in hardware/ software implementation techniques earned from UG studies and mini project in the second semester;
(4) The courses Research Methodology, Seminar-II and Project - Phase I done in previous semesters.

Course Objectives

(1) To implement and complete the M. Tech. thesis work, which is normally based on Project - Phase 1;
(2) To have a continuous work on the topic, and get improved results;
(3) To develop the skill of achieving specific research target in a limited time;
(4) To develop skills regarding professional communication and technical report writing.

Guidelines

Each student has to complete the project - phase II under the guidance of a faculty member, as specified in phase-I, since this phase is generally an extension of the previous phase. It is recommended that students should execute the project work using the facilities of the institute itself. However, external projects can be taken up in this semester, if that work solves a technical problem of the external firm. Prior sanction should be obtained from the Head of Institution before taking up external project work. This project phase is also envisaged as a way for implementing *problem based learning*. Problems of socially relevance and/or problems identified by the institute/ research organizations/ industry/ state should be given high priority. In such interdisciplinary and inter institutional projects, a student can have co-guide(s) from other department/ institute/ research organizations/ industry. The university encourages *interdisciplinary projects* and *problem based learning strategy*. The following guidelines also have to be followed.

1. The student will submit a detailed report for project - phase II;
2. The student will present at least *three* seminars
3. The *first seminar* in the beginning of the semester will highlight the topic, objectives, methodology and the background knowledge and preliminary results carried over from the phase I;
4. A *progress seminar* can be conducted in the middle of the semester;
5. The *third seminar*, could be a *pre-submission seminar*, will be a presentation of the work they have completed till the end of 4^{th} semester and the scope for future work. The pre-submission seminar has to be presented before the Progress evaluation committee (PEC) for being assessed for the quality and quantum of the work. This would be the qualifying exercise for the students for getting approval from the Department Committee for the submission of the Thesis.
6. Incorporating the suggestions by the PEC, each student has to convert the project - phase II report to a Thesis and to submit to the University (Cluster) for external evaluation. At least one technical paper is to be published in Journals / Conferences so as to meet the requirements for final external submission.
7. The University will appoint an External Expert to evaluate the Thesis through a final presentation by the student.

The comments of the examiners during this presentation should be incorporated in the work and the approved Thesis is to be submitted to the Institution as hard bound copies, before the program exit by the student. All the references cited in the Thesis shall be *authentic*.

Expected Outcomes

The students are expected to :

(1) Develop the skill of identifying industrial/ research problems/ socially relevant projects;
(2) Develop skills regarding enumerating and selecting problems, subsequent analysis, and effective implementation of the solution;
(3) Have hands on experience in design and analysis tools required for the project work ;
(4) Plan the experimental platform, if any, required for project work, which will be helpful in actual real life project planning;
(5) Enhance the skills regarding the implementation aspects of hardware/ software projects;
(6) Acquire documentation and problem solving skills;
(7) Develop professionalism;
(8) Effectively communicate technical information by means of written and oral reports.

References

1. J.W. Bames, *Statistical Analysis for Engineers and Scientists*, McGraw Hill, New York.
2. Schank Fr., *Theories of Engineering Experiments*, Tata McGraw Hill Publication.
3. Douglas C Montgomery, *Design and analysis of experiments,* Wiley International
4. Leedy P D, *Practical Research : Planning and Design,* 4th Edition, N W MacMillan Publishing Co

Course plan

Item	Description	Time	
1	Implementation Phase	10 Weeks	
2	Thesis Preparation	3 Weeks	
3	Pre-submission seminar-cum Demonstration	1 Week	
4	Evaluation by the External expert	4 Weeks	

Marks: 100 for Final Evaluation

1. Preliminary presentation, evaluated by the PEC: 20 Marks
2. Project evaluation by the supervisor/s: 30 Marks
3. Pre-submission seminar evaluated by the PEC: 20 Marks
4. Evaluation of the thesis presentation by an External Expert: 30 Marks

ASSESSMENT CRITERIA

A. Evaluation of Theory Courses

The university follows a continuous academic evaluation procedure. This includes two internal examinations and one end semester cluster level University examination. Besides, students should be given proper assignments / course seminars which are essential aspects of a student-centric teaching approach. The continuous assessment procedure and corresponding weights for awarding 100 marks for a theory subject are as follows.

1. Two internal tests, each having 15 marks each summing to a total of 30 marks
2. Tutorials / Assignments / Course Seminars summing to a total of 10 marks, and
3. Cluster level end-semester examination having 60 marks

B. Evaluation of Research Methodology

The course Research Methodology should be a common one for all specializations, which is envisaged to provide a research orientation for PG students. The teaching - learning process for this course should be a student-centric one in which the faculty-in-charge would take the role of a facilitator in the system. Students should be given proper guidelines for practicing the various methodologies which aims at the overall improvement of their skills required for pursuing research. The continuous assessment procedure and corresponding weights for awarding 100 marks (fully internal) for Research Methodology are as follows.

1. Three internal tests, each having 20 marks summing to a total of 60 marks
2. Tutorials / Assignments / Course Seminars summing to a total of 40 marks

C. Evaluation of Practical Courses

The continuous assessment procedure and corresponding weights for awarding 100 marks for a practical subject are as follows.

1. Practical Records / Results summing to a total of 40 Marks
2. Regular Class Viva-Voce summing to a total of 20 Marks
3. Final Test (Internal & Objective Type) having 40 Marks

D. Evaluation of Seminar -I

The weights for awarding 100 marks (totally internal) for the seminar-I is as follows.

1. Presentation (Verbal & Nonverbal Communication skills) : 20 Marks
2. Breadth of the topic (Coverage : Content of the slides and speech) : 20 Marks
3. Depth of knowledge (Ability to answer questions) : 30 Marks
4. Seminar Report in the prescribed format given by the Institution : 30 marks

E. Evaluation of the Mini Project

The weights for awarding 100 marks (totally internal) is as follows.

1. Preliminary Presentation evaluated by the Progress Evaluation Committee (PEC) : 20 Marks

2. Progress Evaluation (Guide and/or Co-guide): 30 Marks

3. Final Presentation-cum-demonstration evaluated by the PEC: 30 Marks

4. Report (Mandatory): 20 Marks

F. Evaluation of Seminar-II

The weights for awarding 100 marks (totally internal) for the seminar-II is as follows.

1. Presentation (Verbal & Nonverbal Communication skills) : 20 Marks
2. Breadth of the literature review (Coverage : Content of the slides and speech) : 20 Marks
3. Depth of knowledge (Ability to answer questions) : 30 Marks
4. Seminar Report / Paper in the prescribed format given by the Institution : 30 marks

G. Evaluation of the Project Work

The weights for awarding 150 marks for Project shall be as follows.

A. 3rd Semester - Marks: 50 for Project Progress Evaluation

1. Preliminary presentation, evaluated by the PEC: 15 Marks
2. Progress evaluation by the Project Supervisor/s: 20 Marks
3. End-semester presentation, evaluated by the PEC: 15 Marks

B. 4th Semester - Marks: 100 for Final Evaluation

1. Preliminary presentation, evaluated by the PEC: 20 Marks
2. Project evaluation by the supervisor/s: 30 Marks
3. Pre-submission seminar evaluated by the PEC: 20 Marks
4. Evaluation of the thesis presentation by an External Expert: 30 Marks