

**M.E. (Power Electronics and Drives)**  
**2013 Regulations, Curriculum & Syllabi**



**BANNARI AMMAN INSTITUTE OF TECHNOLOGY**

(An Autonomous Institution Affiliated to Anna University, Chennai  
Approved by AICTE - Accredited by NBA New Delhi, NAAC with 'A' Grade and ISO 9001:2008 Certified)

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## Rules and Regulations

### M. E. / M. Tech. Programmes

(For the batch of students admitted in 2013-2014 and onwards)

*NOTE: The regulations hereunder are subject to amendments as may be decided by the Academic Council of the Institute from time to time. Any or all such amendments will be effective from such date and to such batches of students including those already in the middle of the programme as may be decided by the Academic Council.*

#### 1. Conditions for Admission

- (i) Candidates for admission to the I Semester of M. E. / M. Tech. degree programme will be required to satisfy the conditions of admission thereto prescribed by the Anna University, Chennai and Government of Tamil Nadu.
- (ii) Part-time candidates should satisfy conditions regarding experience, sponsorship, place of work, etc., that may be prescribed by Anna University, Chennai from time to time, in addition to satisfying requirements as in Clause 1(i).

#### 2. Duration of the Programme

- (i) **Minimum Duration:** The programme will lead to the Degree of Master of Engineering (M.E.) / Master of Technology (M. Tech.) of the Anna University, Chennai extend over a period of two years. The two academic years (Part-time three academic years) will be divided into four semesters (Part-time six Semesters) with two semesters per year.
- (ii) **Maximum Duration:** The candidate shall complete all the passing requirements of the M. E. / M. Tech. degree programmes within a maximum period of 4 years / 8 semesters in case of full-time programme and 6 years / 12 semesters in case of part-time programme, these periods being reckoned from the commencement of the semester to which the candidate was first admitted.

#### 3. Branches of Study

The following are the branches of study of M.E. / M.Tech. Programmes

##### M.E.

Branch I	Applied Electronics
Branch II	CAD/CAM
Branch III	Communication Systems
Branch IV	Computer Science and Engineering
Branch V	Embedded Systems
Branch VI	Engineering Design
Branch VII	Power Electronics and Drives
Branch VIII	Software Engineering
Branch IX	Structural Engineering
Branch X	VLSI Design

##### M. Tech.

Branch I	Biotechnology
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#### 4. Structure of Programmes

- (i) **Curriculum:** The curriculum for each programme includes Courses of study and detailed syllabi. The Courses of study include theory Courses (including electives), seminar, practicals, Industrial training / Mini-project, Project Work (Phase I) and Project Work (Phase II) as prescribed by the respective Boards of Studies from time to time.















## **PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)**

- I. Graduates would apply their undergraduate fundamentals to solve complex engineering problems in the field of Power Electronics and Drives
- II. Graduates would demonstrate active participation in Research and Development activities related to Power Electronics and Drives and publish research papers in various technical forums
- III. Graduates of Power Electronics and Drives would familiarize with professional issues, demonstrate profession interaction and work effectively in teams
- IV. Graduates of Power Electronics and Drives would engage themselves in the related areas to suit their career aspirations which will lead to lifelong learning

## **PROGRAMME OUTCOMES (POs)**

- d) able to apply the knowledge gained from undergraduate engineering to identify, formulate, solve problems and challenges in power electronics and drives.
- e) able to understand and design power electronics and drive systems for different applications and conduct experiments, analyze and interpret data.
- f) able to acquire continuous learning skills, plan and conduct a systematic study on significant research.
- g) able to prepare technical reports.
- h) able to understand and integrate new technology.
- i) able to use modern engineering tools
- j) able to communicate professionally.
- k) able to develop confidence for self education and lifelong learning.

## MAPPING OF PEOs & POs

		Programme Educational Objectives	Program Outcomes
PEO :	I	I.Graduates would apply their undergraduate fundamentals to solve complex engineering problems in the field of Power Electronics and Drives	(a),(b)
PEO :	II	II.Graduates would demonstrate active participation in Research and Development activities related to Power Electronics and Drives and publish research papers in various technical forums	(a) (b) (c) (d) (e)and (f)
PEO :	III	III.Graduates of Power Electronics and Drives would familiarize with professional issues, demonstrate profession interaction and work effectively in teams	(b) (c) (d) (e) (f) and(g)
PEO :	IV	IV.Graduates of Power Electronics and Drives would engage themselves in the related areas to suit their career aspirations which will lead to life long learning.	(h)

### M.E. POWER ELECTRONICS AND DRIVES

<b>First Semester</b>							
Code	Course	Objectives & Outcomes		L	T	P	C
		PEOs	POs				
13PE11	Applied Mathematics	I, II	(a)	3	1	0	4
13PE12	Modern Power Semiconductor Devices	II, IV	(a),(b),(c),(h)	3	0	0	3
13PE13	Design and Analysis of Converters	II, III	(a),(b),(c)	3	1	0	4
13PE14	Design and Analysis of Inverters	II, III	(a),(b),(c)	3	1	0	4
13PE15	Modeling and Analysis of Electrical Machines	I, II, III	(a),(b),(c)	3	1	0	4
13PE16	Power Quality Problems and Solutions	II	(a),(b)	3	0	0	3
13PE17	Power Electronics Laboratory	II, III	(b)	0	0	3	2
13PE18	Power Electronics Simulation Laboratory	II,III	(b)	0	0	3	2
<b>Total</b>				<b>18</b>	<b>4</b>	<b>6</b>	<b>26</b>
<b>Second Semester</b>							
Code	Course	Objectives & Outcomes		L	T	P	C
		PEOs	POs				
13PE21	Solid State Drives	I,II,III	(a),(b)	3	1	0	4
13PE22	Electrical Energy Conservation and Management	I,II, IV	(a),(b),(c)	3	1	0	4
13PE23	Power Converters for Renewable Power Systems	III	(a),(b),(c)	3	0	0	3
	Elective			3	0	0	3
	Elective			3	0	0	3
	Elective			3	0	0	3
13PE24	Electrical Drives Laboratory	II,III	(b)	0	0	3	2
13PE25	Technical Seminar	II,III	(d),(e),(f),(g)	0	0	2	1
<b>Total</b>				<b>18</b>	<b>2</b>	<b>5</b>	<b>23</b>

Third Semester							
Code	Course	Objectives & Outcomes		L	T	P	C
		PEOs	POs				
	Elective			3	0	0	3
	Elective			3	0	0	3
	Elective			3	0	0	3
13PE31	<b>Project Work - Phase I</b>	<b>II,III</b>	(d),(e), (f),(g),(h)	-			6
<b>Total</b>				-	-	-	<b>15</b>
Fourth Semester							
Code	Course	Objectives & Outcomes					C
		PEOs	POs	L	T	P	
13PE41	Project Work - Phase II	II,III	(d),(e),(f),(g)	-			<b>12</b>

Note: Hours & Credit Pattern: Minimum number of credits to be earned for the award of M.E. (Power Electronics and Drives)

Programme: 76

**18-05-2013 List Of Electives**

Code	Courses	Objectives & Outcomes		L	T	P	C
		PEOs	POs				
13PE51	Embedded Control of Electric Drives	II,III	(a),(b),(c)	3	0	0	3
13PE52	Virtual Instrumentation Systems	I	(a),(b),(c)	3	0	0	3
13PE53	Digital Signal Processors for Modern Industrial Drives	I,II, III	(a),(b),(c)	3	0	0	3
13PE54	Neuro and Fuzzy Controllers	II, III	(a),(b),(c)	3	0	0	3
13PE55	System Theory	I, II	(a),(b)	3	0	0	3
13PE56	FACTS Controllers	II,III	(a),(b)	3	0	0	3
13PE57	Power Electronics Applications to Power System	I,II, III	(a),(b),(c)	3	0	0	3
13PE58	PWM Converters and Applications	II,III	(a),(b),(c)	3	0	0	3
13PE59	Special Machines and their Controllers	II,III	(a),(b)	3	0	0	3
13PE60	Microcontroller Programming and Applications *	II,III	(a),(b),(c)	3	0	0	3
13PE61	Advanced Digital Signal Processing	I,II,III	(a),(b)	3	0	0	3
13PE62	VLSI Applications to Power Electronics	II,III	(a),(b)	3	0	0	3
13PE63	Switched Mode and Resonant Converters	II,III	(a),(b)	3	0	0	3
13PE64	Automotive Electronics*	III	(a),(b),(c)	3	0	0	3
10PE65	Research Methodology	II,III	(e),(f),(g),(h)	3	0	0	3
<b>Self Study Electives</b>							
13PE01	Emerging Trends in Power Conversion Technology	II	(a),(b),(c)	-	-	-	3
<b>* Open Electives</b>							

## 13PE11 APPLIED MATHEMATICS

3 1 0 4

### Course Objectives (COs):

- To study about the matrix theory used in electrical engineering.
- To study the Fourier series analyses and Fourier Transform.
- To study the various optimization techniques.

### Course Learning Outcomes (CLOs):

- Ability to provide the students with outstanding educational skills that will enable them to integrate undergraduate fundamentals with advanced knowledge to solve Complex power electronics problems
- Ability to get the idea of optimization and the applications.
- Ability to apply the optimization ideas to solve the functional.

### Programme Outcomes (POs):

- a) able to apply knowledge gained from undergraduate engineering discipline to identify, formulate and solve problems and challenges in advanced power electronics and drives

### Unit I

#### Advanced Matrix Theory

Matrix norms – Jordan canonical form – Eigen values - Generalized eigenvectors – Some applications of eigen value problems- Singular value decomposition – Pseudo inverse – Least square approximations – QR algorithm.

10 Hours

### Unit II

#### Calculus of Variations

Variation and its properties – Euler's equation – Functional dependent on first and higher order derivatives – Functional dependent on functions of several independent variables – Some applications – Direct methods: Ritz and Kantorovich methods.

9 Hours

### Unit III

#### Fourier Series

Euler's formula - Drichlet's conditions – General Fourier series –Fourier series expansion to different types of wave forms– change of intervals - Harmonic Analysis.

8Hours

### Unit IV

#### Fast Fourier Transform

Discrete convolution- Periodic sequence and circular convolution- Linear convolution through circular convolution – Discrete Fourier series and discrete Fourier transform – Fast Fourier transform – Decimation in time algorithm, decimation in frequency algorithm - Computation of inverse DFT.

11 Hours

### Unit V

#### Soft Computing Techniques

Particle Swam Optimization - GA – ANT Colony Optimization

7 Hours

**Total: 45+15 Hours**

### References

1. R. Bronson, *Matrix Methods*, New Delhi, Elsevier, 2006.
2. Elsgoltis, *Differential Equations and Calculus of Variations*, Moscow, MIR Publishers, 1970.
3. Erwin Kreyszig, *Advanced Engineering Mathematics*, New Jersey, John Wiley & Sons, 2006.
4. T. Veeraranjan, *Engineering Mathematics*, New Delhi, Tata McGraw-Hill, 2001.
5. Dr. Amit Konar, *Artificial Intelligence and Soft Computing – Behavioral and Cognitive Modeling of the Human Brain*, New York, CRC Press LLC, 1999.
6. Said Mikki and Ahmed Kishk, *Particle Swarm Optimization: Physics – Based Approach*, Vol. 3, No.1, Synthesis Lectures on Computational Electromagnetics, 2008.



## 13PE12 MODERN POWER SEMICONDUCTOR DEVICES

3 0 0 3

### Course Objectives (COs):

- To study the internal structure and the switching and operating characteristics of the basic power devices.
- To study the advanced power devices and its working principle.

### Course Learning Outcomes (CLOs):

- Ability to determine the suitable device for the application.
- Ability to design of semiconductor device and its parameters.
- Ability to design of protection circuits and control circuits
- Ability to determine the reliability of the system.

### Program Outcomes (POs):

- b) able to apply knowledge gained from undergraduate engineering discipline to identify, formulate, solve problems and challenges in advanced power electronics and drives
- c) able to understand and design power electronics and drive systems for different applications and conduct experiments, analyze and interpret data.
- d) able to acquire continuous learning skills, plan and conduct a systematic study on significant research
- h) able to develop confidence for self education and lifelong learning

### Unit I

#### Introduction

Status of development of power semiconductor Devices – Types of static switches – Controlled and uncontrolled – Ideal and real switches – Static and dynamic performance – Use of heat sinks – Switching losses.

8 Hours

### Unit II Power

#### Diodes

Types – Electrical rating – Switching and steady state characteristics – Snubber circuits – Series and parallel operation – Schottky diodes – Fast recovery diodes.

9 Hours

### Unit III

#### Thyristors

Physics of device operation – Electrical rating - Switching and steady state characteristics – Gate circuit requirements – Protection – Series and parallel operation – Driver circuit – Types of thyristors: Asymmetrical thyristor – Reverse conducting Thyristor – Light fired thyristor – Switching losses - TRIACs, GTOs and MCTs - Electrical rating - Switching and steady state characteristics – Protection – Gate circuit requirements.

9 Hours

### Unit IV

#### Power Transistors

Types – Ratings – Static and switching characteristics – Driver circuit – Snubber circuits – Power Darlington - Power MOSFETs -Types – Comparison with BJTs – Structure – Principle of operation – Switching losses – Driver circuit – Snubber circuits.

8 Hours

### Unit V

#### IGBTs and Modern Power Devices

Comparison with power BJT and MOSFET – Structure – Principle of working – Switching characteristics – Gate drive requirements – HV IGBT structure – Principle of working – Comparison with GTO -SITs – Characteristics – Power integrated circuit – Characteristics – Field controlled thyristors – New semiconductor materials for devices – Intelligent power modules. Integrated gate commutated thyristor (IGCT) - Comparison of all power devices.

11Hours

Total: 45 Hours

#### References

1. Joseph Vithayathil, *Power Electronics: Principles and Applications*, Delhi, Tata McGraw-Hill, 2010.
2. Ned Mohan, Tore M. Undeland and William P. Robbins, *Power Electronics: Converters, Applications and Design*, New Jersey, John Wiley and Sons, 2003.
3. M.H. Rashid, *Power Electronics: Circuits, Devices and Application*, New Delhi, Prentice Hall of India, 2004.
4. M D Singh and K B Khanchandani, *Power Electronics*, New Delhi, Tata McGraw-Hill, 2008.
5. B.W. Williams, *Power Electronics: Devices, Drivers, Applications and Passive Components*, New York, McGraw-Hill, 1992.

### 13PE13 DESIGN AND ANALYSIS OF CONVERTERS

3 1 0 4

#### Course Objectives (COs):

- To obtain the switching characteristic of different types of power semi-conductor devices.
- To determine the operation, characteristics and performance parameters of controlled rectifiers.
- To apply switching techniques and basic topologies of DC-DC switching regulators.

#### Course Learning Outcomes (CLOs):

- Ability to analyze the characteristics of Power electronics devices.
- Ability to determine the various parameters of single phase and three phase rectifier.
- Ability to demonstrate the response of chopper for a dc load
- Ability to design a PWM converter and an ac voltage regulator.

#### Program Outcomes (POs):

- a) able to apply knowledge gained from undergraduate engineering discipline to identify, formulate, solve problems and challenges in advanced power electronics and drives
- b) able to understand and design power electronics and drive systems for different applications and conduct experiments, analyze and interpret data.
- c) able to acquire continuous learning skills, plan and conduct a systematic study on significant research

#### Unit I

##### Single Phase AC-DC Converter

Uncontrolled, half controlled and fully controlled converters with R-L, R-L-E loads - Free wheeling diodes - Inverter operation – Dual converter - Performance parameters: harmonics, ripple, distortion, power factor Effect of source impedance and overlap - Design of converter circuits- Classification and analysis of Commutation – Active and passive filters for harmonic mitigation.

11 Hours

#### Unit II

##### Three Phase AC-DC Converter

Uncontrolled and fully controlled – Converter with R, R-L, R-L- E loads - Free wheeling diodes – Inverter operation and its limit – Dual inverter – Performance parameters – Effect of source impedance and over lap – Design of converter circuit – PSPICE simulation of converters – Boost rectifiers.

8 Hours

#### Unit III

##### DC-DC Converters

Principles of step-down and step-up converters – Control strategies –Advanced converters and their design – CUK, LUO, SEPIC, ZETA converters - High frequency DC - DC converters- resonant choppers.

7 Hours

#### Unit IV

##### AC Voltage Controllers

Principle of phase control and ON-OFF control – Single phase and three phase controllers – Various configurations – Analysis with R and R-L loads – Design of AC voltage controller circuits.

**10 Hours**

#### Unit V

##### Cycloconverters

Principle of operation – Single phase and three phase Cycloconverters – Power circuits and gating signals – SMPS – types and design – Matrix Converter and its types.

**9 Hours**

**Total: 45 + 15 Hours**

#### References

1. M.H. Rashid, *Power Electronics: Circuits, Devices and Application*, New Delhi, Prentice Hall of India, 2004.
2. Ned Mohan, Tore M. Undeland and William P. Robbins, *Power Electronics: Converters, Applications and Design*, New Jersey, John Wiley and Sons, 2003.
3. P.C. Sen, *Modern Power Electronics*, New Delhi, S.Chand & Company Ltd, 2005
4. P.S. Bimbira, *Power Electronics*, New Delhi, Khanna Publishers, 2006.
5. M.H. Rashid, *Hand Book of Power Electronics: Circuits, Devices and Application*, New Delhi, Prentice Hall of India, 2007.

### 13PE14 DESIGN AND ANALYSIS OF INVERTERS

**3 1 0 4**

#### Course Objectives (COs):

- To design and analyze the different types of inverters.
- To study the working of advanced types of inverters such as multilevel inverters and resonant inverters.
- Apply switching techniques and basic topologies of DC-AC converters

#### Course Learning Outcomes (CLOs):

- Ability to design inverters for different applications
- Ability to develop gating circuits for inverters
- Ability to design the filters for harmonics reduction

#### Program Outcomes (POs):

- a) able to apply knowledge gained from undergraduate engineering discipline to identify, formulate, solve problems and challenges in advanced power electronics and drives
- b) able to understand and design power electronics and drive systems for different applications and conduct experiments, analyze and interpret data.
- c) able to acquire continuous learning skills, plan and conduct a systematic study on significant research

#### Unit I

##### Basic Inverters

Basic series inverter – Modified series inverter- High frequency series inverter- Design of L and C - Parallel inverter- Design of parallel inverter.- Line commutated inverter – Concepts of PWM techniques.

**9 Hours**

#### Unit II

##### Voltage Source Inverters

Principle of operation of half and full bridge inverters – Three phase inverters with 180 degree and 120 degree conduction mode with star and delta connected loads- Performance parameters – Voltage control of single phase and three phase inverters using various PWM techniques – Various harmonic elimination techniques.

**10 Hours**

### Unit III

#### Current Source and Impedance Source Inverters

Load commutated current source inverter- Single phase and three phase auto sequential current source inverter (ASCI) – Principle of operation of impedance source inverter- Shoot thro zero state – Comparison of current source inverter, Voltage source inverters and impedance source inverter.

11 Hours

### Unit IV

#### Multilevel Inverters

Multilevel concept – Diode clamped – Flying capacitor – Cascade type multilevel inverters – Hybrid multi level inverter- FFT analysis- Comparison of multilevel inverters - Applications of multilevel inverters.

8 Hours

### Unit V

#### Resonant Inverters

Concept of Zero Voltage Switching and Zero Current Switching - Series and parallel resonant inverters - Voltage control of resonant inverters – Class E resonant inverter – Resonant DC Link inverters.

7 Hours

Total : 45 + 15 Hours

### References

1. P.S. Bimbira, *Power Electronics*, New Delhi, Khanna Publishers, 2006.
2. M.H. Rashid, *Hand Book of Power Electronics: Circuits, Devices and Application*, New Delhi, Prentice Hall of India, 2007.
3. Ned Mohan, Tore M. Undeland and William P.Robbins, *Power Electronics: Converters, Applications and Design*, 3rd Edition, John Wiley and Sons, 2002.
4. Jai P. Agrawal, *Power Electronics Systems*, 2nd Edition, Pearson Education, 2002.
5. Bimal K. Bose, *Modern Power Electronics and Motor Drive- Advances and Trends*, 2nd Edition, Pearson Education, 2006.

## 13PE15 MODELING AND ANALYSIS OF ELECTRICAL MACHINES

3 1 0 4

### Course Objectives (COs):

- To analyze the various types of machines and model with different transformation techniques.
- To study the special machines and its model.

### Course Learning Outcomes (CLOs):

- Ability to understand the various electrical parameters in mathematical form.
- Ability to understand the different types of reference frame theories and transformation relationships.
- Ability to find the electrical machine equivalent circuit parameters and modeling of electrical machines.

### Program Outcomes (POs):

- a) able to apply knowledge gained from undergraduate engineering discipline to identify, formulate, solve problems and challenges in advanced power electronics and drives
- b) able to understand and design power electronics and drive systems for different applications and conduct experiments, analyze and interpret data.
- c) able to acquire continuous learning skills, plan and conduct a systematic study on significant research

### Unit I

#### Concepts of Rotating Machines

Calculation of air gap mmf of a single turn full pitch distributed armature windings - Per phase full pitched and short pitched armature coils (AC machines) - Calculation of air gap mmf of a DC machine - Introduction to direct axis and quadrature axis theory in salient pole machines - Calculation of air gap inductances of a synchronous machine.

**10 Hours**

### Unit II

#### Induction Machine Modeling

Static and rotating References: frames, transformation relationships - Stationary circuit variables transformed to the arbitrary Reference frame treating R, L, C elements separately - Application of Reference frame theory to three phase symmetrical induction machine - Direct and quadrature axis model in arbitrarily rotating Reference frame - Voltage and torque equations

**11 Hours**

### Unit III

#### Synchronous Machine modeling

Application of reference frame theory to three phase synchronous machine-dynamic model analysis-Park's equation - Voltage and torque equations - Deviation of steady state phasor relationship from dynamic model - Generalized theory of rotating electrical machine and Kron's primitive machine

**9Hours**

### Unit IV

#### Electrical Machine Equivalent Circuit Parameters

Synchronous machine dynamic equivalent circuit parameters - Standard and derived machine time constants - Frequency response test, Analysis and dynamic modeling of two phase asymmetrical induction machine and single phase induction machine

**7 Hours**

### Unit V

#### Special Machines

Permanent magnet synchronous machine, Surface permanent magnet (square and sinusoidal back emf type) and interior permanent magnet machines - Construction and operating principle - Dynamic modeling and self controlled operation - Dynamic analysis of Switched Reluctance Motors

**8 Hours**

**Total: 45 + 15 Hours**

### References

1. Charles Kingsley Jr., A.E. Fitzgerald and Stephen D.Umans, *Electric Machinery*, New York, McGraw-Hill Higher Education, 2010.
2. Paul C. Krause, Oleg Wasynczuk and Scott D. Sudhoff, *Analysis of Electric Machinery and Drive Systems*, New Jersey, Wiley Student Edition, 2013.
3. R. Krishnan, *Electric Motor & Drives: Modeling, Analysis and Control*, New Delhi, Prentice Hall of India, 2001.
4. T.J.E. Miller and J R Hendershot Jr., *Design of Brushless Permanent Magnet Motors*, USA, Oxford University Press, 1994.
5. T.J.E. Miller, *Reluctance Motor and their Controls*, USA, Oxford University Press, 1993.

## 13PE16 POWER QUALITY PROBLEMS AND SOLUTIONS

3 0 0 3

### Course Objectives (COs):

- To study the power quality problems in grid connected system and isolated systems.
- To study the various power quality issues and mitigations techniques.
- To study about the various harmonics elimination methods.

### Course Learning Outcomes (CLOs):

- Ability to apply knowledge of power quality and harmonics in power systems, and engineering to the analysis and design of electrical circuits
- Ability to design a system, components or process to meet desired needs within realistic constraints and to mitigate PQ problems such as economic, environmental, social, ethical, health and safety.
- Ability to function on multi-disciplinary teams

### Program Outcomes (POs):

- a) able to apply knowledge gained from undergraduate engineering discipline to identify, formulate, solve problems and challenges in advanced power electronics and drives
- b) able to understand and design power electronics and drive systems for different applications and conduct experiments, analyze and interpret data.
- c) able to acquire continuous learning skills, plan and conduct a systematic study on significant research

### Unit I

#### Introduction

Definition of power quality - Power quality, Voltage quality - Power quality issues: Short duration voltage variations, Long duration voltage variations, Transients, Waveform distortion, Voltage imbalance, Voltage fluctuation, Power frequency variations - Sources and Effects of power quality problems - Power quality terms - Power quality and Electro Magnetic Compatibility (EMC) Standards. CBEMA & ITI curves.

9 Hours

### Unit II

#### Short Interruptions and Long Interruptions

Short Interruptions - Introduction - Origin of short interruptions: Voltage magnitude events due to reclosing, Voltage during the interruption- Monitoring of short interruptions - End user issues: Influence on Induction motors, Synchronous motors, Adjustable speed drives.

Long Interruptions Definition - Terminology: Failure, Outage, Interruption - Origin of interruptions - Causes of long interruptions - Principles of regulating the voltage - Voltage regulating devices, Applications: Utility side, End-User side.

10 Hours

### Unit III

#### Voltage Sags and Transients

Voltage Sag-Introduction - Definition - Characterization: Magnitude, Duration - Causes of Voltage Sag - Three Phase Unbalance - Phase angle jumps - Load influence on voltage sags - Overview of mitigation methods.

Transients Definition - Principles of over voltage protection - Types and causes of transients - Devices for over voltage protection - Utility capacitor switching transients - Utility lightning protection – Waveform Distortion.

10 Hours

### Unit IV

#### Harmonics

Introduction - Definition and terms in Harmonics, Harmonics indices, Inter harmonics, Notching - Voltage Vs Current distortion - Harmonics Vs Transients - Sources and effects of harmonic distortion - System response characteristics - Principles of controlling harmonics - Standards and limitation - Mitigation and control techniques.

8 Hours

## Unit V

### Power Quality Solutions

Introduction - Power quality monitoring: Need for power quality monitoring, Evolution of power quality monitoring, Deregulation effect on power quality monitoring - Brief introduction to power quality - measurement equipments and power conditioning equipments - Planning, Conducting and Analyzing power quality survey.

8 Hours

Total : 45 Hours

### References

1. Barry W. Kennedy, *Power Quality Primer*, New York, McGraw-Hill, 2000.
2. C. Sankaran, *Power Quality*, Washington, CRC Press, 2001.
3. Math H.J. Bollen, *Understanding Power Quality Problems: Voltage Sags and Interruptions*, New York, IEEE Press, 1999.
4. J. Arriliaga, N.R. Watson and S. Chen, *Power System Quality Assessment*, England, John Wiley, & Sons, 2000.
5. Dugan, Mark F. Mc Granaghan and H. Wayne Beaty, *Electrical Power Systems Quality*, New York, McGraw-Hill, 2002.

## 13PE17 POWER ELECTRONICS LABORATORY

0 0 3 2

### Course Objectives (COs):

- To obtain the switching characteristic of different types of power semi-conductor devices.
- To determine the operation, characteristics and performance parameters of controlled rectifiers.
- To apply switching techniques and basic topologies of DC-DC switching regulators.

### Course Learning Outcomes (CLOs):

- Ability to draw the characteristics of Power electronics devices.
- Ability to determine the various parameters of single phase and three phase rectifier.
- Ability to demonstrate the response of chopper for a dc load
- Ability to diagnose the various causes of harmonics
- Ability to design a PWM converter and an ac voltage regulator.

### Program Outcomes (POs):

- b) Able to understand and design power electronics and drive systems for different applications and conduct experiments, analyze and interpret data.

### List of Experiments

1. Design of RC & UJT Firing Circuit
2. Design and study of Driver and Commutation Circuits for chopper and inverters.
3. Design and analysis of Series and Parallel Inverter
4. Develop a Single phase 7 level multilevel inverter.
5. Design and analysis of CSI.
6. Analysis of single phase Cycloconverter.
7. Design the MOSFET driver using Driver IC IR2110.

8. Fabricate the OPTO Isolator for Three phase converter
9. Design of firing circuit for three phase voltage source inverter.
10. Generate the three phase SPWM pulse using Embedded controller.
11. Fabricate the Boost converter for Photovoltaic applications.

**Total: 45 Hours**

### **13PE18 POWER ELECTRONICS SIMULATION LABORATORY**

**0 0 3 2**

#### **Course Objectives (COs):**

- To simulate the special types of inverters and converters.
- To design and simulate the different types of converters fed DC and AC drives.

#### **Course Learning Outcomes (CLOs):**

- Ability to design single phase & three phase converters, Design of series & parallel inverter.
- Ability to design converter fed dc drives.
- Ability to design inverter fed ac drive
- Ability to design of ac voltage regulator.

#### **Program Outcomes (POs):**

- b) able to understand and design power electronics and drive systems for different applications and conduct experiments, analyze and interpret data

#### **List of Experiments**

1. Design and development of cuk, Luo and SEPIC converters.
2. Design and Simulation of Series Loaded Resonant Inverter
3. Design and analysis of matrix converter
4. Design and analysis of multi level inverter
5. Design and Simulation of Parallel Loaded Resonant Inverter
6. Design and Simulation of three phase converter Fed DC Drive
7. Design and Simulation of Three Phase AC Voltage Regulator
8. Simulation of Line Commutated Inverter
9. Simulation of ASC Inverter
10. Simulation and analysis of Induction Motor Drive

**Total: 45 Hours**



## 13PE21 SOLID STATE DRIVES

3 1 0 4

### Course Objectives (COs):

- To learn converter and chopper control of dc drives
- To learn the concept of closed loop control of AC and DC drives
- To learn about digital control of drives

### Course Learning Outcomes (CLOs):

- Ability to determine the characteristics of drives
- Ability to design converter fed dc drives and chopper fed dc drives
- Ability to design of closed loop control of drives

### Program Outcomes (POs):

- a) a able to apply knowledge gained from undergraduate engineering discipline to identify, formulate, solve problems and challenges in advanced power electronics and drives
- b) able to understand and design power electronics and drive systems for different applications and conduct experiments, analyze and interpret data.

### Unit 1

#### Converter and chopper control of dc drives

Analysis of series and separately excited dc motor with single phase and three phase converters – modes of operation – power factor improvement – commutation – analysis of series and separately excited dc motor fed from choppers – chopper based implementation of braking schemes.

9 Hours

### Unit 2

#### Control of Induction motor and wound rotor induction motor drive

AC power controller fed induction motor drive – different types - closed loop control – variable frequency operation of three phase induction motors – constant flux operation – dynamic and regenerative braking of CSI and VSI fed drives – Torque slip characteristics of wound rotor induction motor – combined stator voltage control and rotor resistance control – static Kramer drive – sub synchronous and super synchronous operation.

10 Hours

### Unit 3

#### Synchronous motor drives

Synchronous motor types, open loop VSI fed drive and its characteristics – self control model – torque angle and margin angle control – power factor control – brushless excitation systems – closed loop control of load commutated inverter fed synchronous motor drive.

8 Hours

### Unit 4

#### Control and Estimation of induction motor and synchronous motor drive

Field oriented control of induction machines – DC drive analogy - Direct and Indirect methods – Flux vector estimation - Direct Torque control strategy of induction machines – Torque expression with stator and rotor fluxes - Vector control of synchronous motor – Field weakening mode.

9 Hours

### Unit 5

#### Closed loop control and digital control of drive

Closed loop speed control – current and speed loops – P, PI and PID controllers – response comparison – simulation of converter and chopper fed dc drive – Phase locked loop and micro computer control of dc drives –

program flow chart for constant hose power and load disturbed operations – selection of drives and control schemes for lifts and cranes.

9 Hours

Total: 45 +15 Hours

#### References

1. Bimal K. Bose, *Modern Power Electronics and AC Drives*, Pearson Education Asia 2001.
2. Vedam Subramanyam, *Electric Drives – Concepts and Applications*, New Delhi, Tata McGraw Hill, Publishing Company Ltd., 2007.
3. G.K. Dubey, *Power Semiconductor Controlled Drives*, New Jersey, Prentice Hall International, 1989.
4. J.M.D. Murphy and Turnbull, *Thyristor Control of AC Motors*, Pergamon Press, Oxford, 1973.
5. P.C. Sen, *Thyristor DC Drives*, New York, John Wiley and Sons, 1981.
6. Gopal K. Dubey, *Fundamentals of Electrical Drives*, New Delhi, 2<sup>nd</sup> Edition, Narosa Publishing House, 2001.

### 13PE22 ELECTRICAL ENERGY CONSERVATION AND MANAGEMENT

3 1 0 4

#### Course Objectives (COs):

- To study the means of energy conservation
- To study about concepts of energy efficiency in various electrical equipment

#### Course Learning Outcomes (CLOs):

- Ability to understand about the concept of energy audit
- Ability to understand the steps in carrying out a practical energy audit.
- Ability to design energy efficient illumination scheme.

#### Program Outcomes (POs):

- a) able to apply knowledge gained from undergraduate engineering discipline to identify, formulate, solve problems and challenges in advanced power electronics and drives
- b) able to understand and design power electronics and drive systems for different applications and conduct experiments, analyze and interpret data.
- c) able to acquire continuous learning skills, plan and conduct a systematic study on significant research

#### Unit I

##### Electrical Energy Audit

Electrical energy audit - Tools for electrical energy audit - Billing elements - Tariff system - Energy and demand charge - Electrical demand and load factor improvement - Power factor correction - Power demand control - Demand shifting.

9 Hours

#### Unit II

##### Electrical Equipments

Motor efficiency - Idle running - Motor selection - Factors affecting motor performance - Efficiency at low load - High efficiency motors - Reduced speed/variable drives - Load reduction -High-starting torque - Rewound motors - Motor generator sets - Energy efficiency in transformers - Case studies.

8 Hours

#### Unit III

##### Electrical Energy Conservation

Input electrical energy requirements in pumps, fans, and compressors - Load factor estimation in the equipments - Different types of VSD - Energy conservation potential - Electrical energy conservation in refrigeration and A/C system - Operation and maintenance practices for electrical energy conservation - Case examples - Choice

of lighting - Energy saving - Control of lighting - Lighting standards - Light meter audit - Methods to reduce costs - Summary of different lighting technologies.

**11 Hours**

#### **Unit IV**

##### **Energy Efficiency and Demand Side Management**

Basic concepts - Importance of demand side managements - Virtues of DSM - Efficiency gains - Estimation of energy efficiency potential - Cost effectiveness - Payback period - Barriers for energy efficiency and DSM.

**9 Hours**

#### **Unit V**

##### **Economic Operation of Industrial DG Sets**

Advantages, disadvantages and application of DG plants - Maintenance practice - Load matching - PF improvement and parallel operation - Waste heat recovery in industrial DG sets.

**8 Hours**

**Total: 45+15 Hours**

#### **References**

1. Openshaw Taylor E., “*Utilisation of Electrical Energy*”, Orient Longman Ltd, 2003.
2. Donald R. Wulfinghoff, “*Energy Efficiency Manual*”, Energy Institute Press, 1999.
3. Btra, Bombay “*Electrical Energy Conservation*”, Proceedings of National Productivity Council, 1998.
4. Tripathy S.C., “*Electrical Energy Utilization and Conservation*”, Tata Mc Graw Hill, 1991.
5. Cyril G.Veinott, Joseph E. Martin, “*Fractional & Sub Fractional HP Electric Motor*”, McGraw Hill, 1987.
6. Awasthi S.K., “*Energy Conservation*”, ISTE Publication, 1999.
7. [www.bee-india.nic.in](http://www.bee-india.nic.in)

### **13PE23 POWER CONVERTERS FOR RENEWABLE POWER SYSTEM**

**3 0 0 3**

#### **Course Objectives (COs):**

- To study about the modern power converters for renewable energy power harnessing.
- To study about the interfacing of power converters with grids.

#### **Course Learning Outcomes (CLOs):**

- Ability to deal with solid state electronics for control and conversion of electric power.
- Ability to use the skills, modern engineering tools necessary for engineering practice.
- Ability to design a system, component or process to meet desired needs.

#### **Program Outcomes (POs):**

- a) able to apply knowledge gained from undergraduate engineering discipline to identify, formulate, solve problems and challenges in advanced power electronics and drives
- b) able to understand and design power electronics and drive systems for different applications and conduct experiments, analyze and interpret data.
- c) able to acquire continuous learning skills, plan and conduct a systematic study on significant research

#### **Unit I**

##### **Introduction**

Trends in energy consumption - World energy scenario - Energy source and their availability – Conventional and renewable source - Need to develop new energy technologies- MNRE Rules and Regulations-TEDA-Wind and solar survey in India and World.

**8 Hours**

**Unit II**

**Photovoltaic Energy Conversion**

Solar radiation and measurements - Solar cells – Panels and their characteristics – Influence of insulation and temperature – PV arrays –Maximum power point tracking – Applications – Water pumping – Street lighting – DC-DC converters for solar PV systems.

**10 Hours**

**Unit III**

**Wind Energy Systems**

Basic principle of Wind Energy Conversion System – Nature of Wind –Components of Wind Energy Conversion System –Generators for WECS- Classifications of WECS – Self excited induction generator - synchronous generator - Power conditioning schemes.

**8 Hours**

**Unit IV**

**Grid Connected WECS and SECS**

Grid connectors – Wind farm and its accessories – Grid related problems – Generator control – Performance improvements - Different schemes – Matrix converters -Line commutated inverters-Multilevel inverters-Power converters for Grid connected WECS-Grid connected solar energy converter systems.

**11 Hours**

**Unit V**

**Distributed Power Generation Systems**

Solar – PV – Hybrid Systems – Selection of power conversion ratio – Optimization of System components – Storage - Reliability evolution – Types of Cogeneration processes – Power converters for distributed power systems.

**8 Hours**

**Total : 45 Hours**

**References**

1. S. Rao and Parulekar, *Energy Technology – Non Conventional, Renewable and Conventional*, New Delhi, Khanna Publishers, 1999.
2. Mukund R. Patel, *Wind and Solar Power System*, New York, CRC Press LLC, 1999.
3. Ned Mohan, Tore M. Undeland and William P.Robbins, *Power Electronics: Converters, Applications and Design*, New Jersey, John Wiley and Sons, 2003.
4. M.H. Rashid, *Power Electronics Circuits, Devices and Applications*, New Delhi, Prentice Hall of India, 2004.
5. Anbukumar kavitha and Govindarajan Uma, *Experimental Verification of Hopf Bifurcation in DC-DC Luo Converter*, Vol.23, No.6, IEEE Transaction on Power Electronics, 2008, pp 2878-2883.
6. A. Mustafa, Al-Saffar, Esam H.Ismail, Ahmad J.Sabzali and Abbas A.Fardoun, *An Improved Topology of SEPIC Converter with Reduced Output Voltage Ripple*, Vol.23, No.5, IEEE Transactions on Power Electronics, September 2008, pp 2377-2386.

**13PE24 ELECTRICAL DRIVES LABORATORY**

**0 0 3 2**

**Course Objectives (COs):**

- To design and analyze the various DC and AC drives.
- To generate the firing pulses for converters and inverters using digital processors

**Course Learning Outcomes (CLOs) :**

- Ability to demonstrate the Single phase Cycloconverter, Current Commutated Chopper
- Ability to design of single phase Cyclo converter
- Ability to design single phase fully controlled Converters and half controlled Converters

**Program Outcomes (POs):**

- (b). able to understand and design power electronics and drive systems for different applications and conduct experiments, analyze and interpret data

**LIST OF EXPERIMENTS**

1. Buck Boost converter fed DC drives
2. Cycloconverter fed Induction motor drives
3. Permanent Magnet Synchronous Motor Drive.
4. Power Quality Analysis in three phase induction motor drive.
5. Generation of Firing Pulses for Single Phase Inverter and Single Phase Converter with R Load using ATMEL89C51
6. Generation of Firing Pulses for Single Phase Inverter and Single Phase Converter with R Load using TMS320f2407/TMS320f2812
7. Single phase Multi Level Inverter based induction motor drive
8. Simulation of three phase induction motor for 120° and 180°
9. Miniproject

**Total: 45 Hours**

**13PE51 EMBEDDED CONTROL OF ELECTRIC DRIVES**

**3 0 0 3**

**Course Objectives (COs):**

- To design and analyze the various electric drives within an embedded system.
- To interface between processors & peripheral devices related to embedded processing.
- To design and formulate efficient programs on any dedicated processor.
- Apply the basic concepts of systems programming like operating system, assembler compilers etc and the management task needed for developing embedded system.

**Course Learning Outcomes (CLOs):**

- Ability to gain knowledge about hardware units of Embedded System and software Embedded into a System
- Ability to design memory unit and peripherals interfacing with microcontroller
- Ability to apply microcontroller and PIC controller in electric drives
- Ability to design Embedded System Design Using PIC Controllers

**Program Outcomes (POs):**

- a) (a). able to apply knowledge gained from undergraduate engineering discipline to identify, formulate, solve problems and challenges in advanced power electronics and drives
- b) able to understand and design power electronics and drive systems for different applications and conduct experiments, analyze and interpret data.
- c) able to acquire continuous learning skills, plan and conduct a systematic study on significant research

**Unit–I**

**8051 Architecture**

Basic organization - 8051 CPU structure - Memory Organization – Addressing modes - Instruction set  
– Programming – Timing diagram – Memory expansion.

8 Hours

**Unit-II**  
**Peripherals and Versions of 8051**

Parallel Ports – Timers and Counters – Interrupts – Serial Communication – Simple Programs ADC, DAC and Analog Comparator options in P87LPC769 – PWM and Watch dog timer options in P89C66x - Assemblers and Compilers – Generation of .LST and .HEX files for applications using Keil / RIDE IDE.

9 Hours

**Unit-III**  
**Architecture of DSPIC**

Architecture – Timer- I/O ports-PWM module-ADC-Case study.

8 Hours

**Unit-IV**  
**Peripherals Interfacing of DSPIC**

I/O Ports – Timers / Counters – Capture / Compare / PWM modules – Master Synchronous Serial Port (MSSP) module – USART – A / D Converter module – Comparator module - .LST and .HEX files generation for applications using MpLab IDE.

10 Hours

**Unit-V**  
**Applications using 8051 and PIC16f87XA**

Real Time Clock – DC motor speed control – Generation of gating signals for Converters and Inverters – Frequency measurement – Temperature control – Speed control of induction motors – Implementation of PID controller.

10 Hours

**Total: 45 Hours**

**References**

1. Muhammad Ali Mazidi, JaniceGillispie Mazidi, Rolin D. McKinlay, *The 8051Microcontroller and Embedded Systems- Using Assembly and C*, Prentice Hall of India, New Delhi, 2007.
2. Muhammad Ali Mazidi, JaniceGillispie Mazidi, Rolin D. McKinlay, *PIC Microcontroller and Embedded Systems: Using Assembly and C for PIC18*, Prentice Hall of India, New Delhi, 2007.
3. Peatman, *Design with Pic Microcontrollers*, Pearson, 2003.
4. Kenneth Ayala, “The 8051 Microcontroller (With CD)”, Cengage Learning, 3<sup>rd</sup> Edition, 2007,
5. David Calcutt, Fred Cowan, Hassan Parchizadeh, *8051 Microcontrollers - An Application Based Introduction*, Elsevier, 2006.
6. Subrata Ghoshal, “Embedded Systems & Robots: Projects Using The 8051 Microcontroller”, Cengage Learning, 1<sup>st</sup> Edition, 2009.
7. *PIC16F87XA Data Sheet – DS39582B*, Microchip Technology Inc., 2003

**13PE52 VIRTUAL INSTRUMENTATION SYSTEMS**

**3 0 0 3**

**Course Objectives (COs):**

- To provide an overview of Virtual instruments
- To bring out the overview of the software (LabVIEW).
- To know about the programming structure of the software.
- To familiarize the student with the Applications.

**Course Learning Outcomes (CLOs):**

- Ability to understand the concept of virtual instrumentation systems

- Ability to understand the programs with LABVIEW.
- Ability to understand the machine vision techniques.

**Program Outcomes (POs):**

- a) (a able to apply knowledge gained from undergraduate engineering discipline to identify, formulate, solve problems and challenges in advanced power electronics and drives
- b) able to understand and design power electronics and drive systems for different applications and conduct experiments, analyze and interpret data.
- c) able to acquire continuous learning skills, plan and conduct a systematic study on significant research

**Unit I**

**Introduction**

General functional description of a digital instrument - Block diagram of a Virtual Instrument – Physical quantities and analog interface- Hardware and software- User interfaces - Advantages of virtual instruments over conventional instruments – Architecture of a virtual instrument and its relation to the operating system.

**10 Hours**

**Unit II**

**Software Overview**

Lab View – Graphical user interfaces- Controls and inductors – “G” programming – Data flow programming- Editing – Debugging and running a virtual instrument – Graphical programming pallets - Fronts panel objects - Controls, indicators, object properties and their configuration –Typical examples.

**8 Hours**

**Unit III**

**Programming Structures**

FOR loops - WHILE loops - CASE structure - Formula node - Sequence structures - Arrays and clusters - Array operations – Bundle - Bundle/unbundled by name - Graphs and charts - String and file I/O – High level and low file I/Os - Attribute modes local and global variables.

**9 Hours**

**Unit IV Hardware**

**Aspects**

Installing hardware - Installing drives - Configuring the hardware - Addressing the hardware in Lab VIEW - Digital and analog I/O function – Data acquisition – Buffered I/O – Real time data acquisition.

**7 Hours**

**Unit V**

**Lab VIEW Applications**

Motion control - General applications - Feedback devices - Motor drives - Machines vision - Lab VIEW IMAQ vision - Machine vision techniques – Configuration of IMAQ DAQ card – Instrument connectivity - GPIB, serial communication – General, GPIB hardware and software specifications – PX1/PC1 Controller and Chassis configuration and installation.

**11 Hours**

**Total : 45 Hours**

**References**

1. Garry M Johnson, *Labview Graphical Programming*, Tata McGraw Hill book Co, New Delhi, 2006
2. LabVIEW : Basics I & II Manual , National Instruments, Bangalore, 2011
3. Barry Paron, *Sensors, Transducers and Lab VIEW*, New Delhi, Prentice Hall of India, 1998.
4. Jeffrey Travis and Jim Kring , *LabVIEW for Everyone: Graphical Programming made Easy and Fun*, Tata McGraw Hill book Co, New Delhi, 2006.
5. National Instruments Technical Staff, *Lab VIEW: Basics I & II Manual*, National Instruments, 2006.

## 13PE53 DIGITAL SIGNAL PROCESSORS FOR MODERN INDUSTRIAL DRIVES

3 0 0 3

### Course Objectives (COs):

- To study the programmable digital signal processor architecture and programming techniques.
- To know the application of modern DSP controllers for modern drive applications.
- To apply DSP for engineering application programmable digital signal processor

### Course Learning Outcomes (CLOs):

- Ability to understand the filter concept as well as to design the filters for digital implementation
- Ability to determine the harmonics and its elimination methods
- Ability to design DSP based controller for industrial drives

### Program Outcomes (POs):

- a) (a able to apply knowledge gained from undergraduate engineering discipline to identify, formulate, solve problems and challenges in advanced power electronics and drives
- b) able to understand and design power electronics and drive systems for different applications and conduct experiments, analyze and interpret data.
- c) able to acquire continuous learning skills, plan and conduct a systematic study on significant research

### Unit I

#### Fundamentals of Programmable DSPs

Multiplier and Multiplier accumulator – Modified Bus Structures and Memory access in P-DSPs – Multiple access memory – Multi-port memory – VLIW architecture- Pipelining – Special Addressing modes in P-DSPs – On chip Peripherals.

10 Hours

### Unit II

#### TMS320C24XX Processor

Architecture – Assembly language syntax - Addressing modes – Assembly language Instructions - Pipeline structure, Operation – Block Diagram of DSP starter kit – Application Programs for processing real time signals.

7 Hours

### Unit III

#### ADSP 2812 Processor

Architecture – Data formats - Addressing modes – Groups of addressing modes- Instruction sets - Operation – Block Diagram of DSP starter kit – Application Programs for processing real time signals – Generating and finding the sum of series, Convolution of two sequences, Filter design.

9 Hours

### Unit IV

#### DSP Based Electric Drives

Speed control of D.C.motors – Speed control of Induction Motors – PWM and SPWM implementations – Closed loop control – Implementation of Space Vector PWM for speed control of induction motors – Special Electrical machines – Sensor based and sensor less control of PMDC, BLDC and SRM.

11 Hours

### Unit V

#### DSP Based Electrical Systems

Online and Off line UPS systems - Use of DSP for UPS applications – Inverter stage – Converter stage – Battery Charger stage – Harmonic detection – Harmonic Elimination methods – Performance comparison with general purpose microcontrollers

8 Hours

**Total : 45 Hours**



## References

1. B. Venkataramani and M. Bhaskar, *Digital Signal Processors – Architecture, Programming and Applications*, New Delhi, Tata McGraw Hill Publishing Company Limited, 2002.
2. K. Padmanabhan, S. Ananthi and R. Vijayarajeswaran, *A Practical approach to Digital Signal Processing*, New Delhi, New Age Publications, 2003.
3. Texas Instruments Technical Staff, *TMS320C24xx - User Manual*, Texas Instruments.
4. Texas Instruments Technical Staff, *ADSP 2812 - User Manual*, Texas Instruments.
5. www.ti.com

## 13PE54 NEURO AND FUZZY CONTROLLERS

3 0 0 3

### Course Objectives (COs):

- To provide the basic understanding of neural networks and fuzzy logic fundamentals, program the related algorithms and design the required and related systems.
- To expose the concepts of feed forward and feedback neural networks.
- To train about the concept of fuzziness involved in various systems.
- To provide adequate knowledge about fuzzy set theory and application of fuzzy logic control to real time systems.
- To apply neural networks and fuzzy systems to model and solve complicated practical problems.

### Course Learning Outcomes (CLOs):

- Ability to understand the concept of virtual instrumentation systems
- Ability to understand the programs with LABVIEW.
- Ability to understand the machine vision techniques.

### Program Outcomes (POs):

- a) (a able to apply knowledge gained from undergraduate engineering discipline to identify, formulate, solve problems and challenges in advanced power electronics and drives
- b) able to understand and design power electronics and drive systems for different applications and conduct experiments, analyze and interpret data.
- c) able to acquire continuous learning skills, plan and conduct a systematic study on significant research

### Unit I

#### Concepts of Artificial Neural Network

Introduction - Biological neurons and their artificial models - Learning, adaptation and neural network's learning rules - Types of neural networks - Single layer, multilayer - Feed forward, feedback networks; back propagation learning and training - Hopfield network.

10 Hours

### Unit II

#### Neural Networks in Control

Neural network for non- linear systems - Schemes of neuro control - System identification - Forward model and inverse model - Indirect learning neural network control applications.

8 Hours

### Unit III

#### Fuzzy Logic Technique

Fuzzy sets - Fuzzy operation - Fuzzy arithmetic - Fuzzy relations - Fuzzy relational equations - Fuzzy measure - Fuzzy functions - Approximate reasoning - Fuzzy propositions - Fuzzy quantifiers - If-then rules.

9 Hours

#### Unit IV

##### Fuzzy Logic Controllers

Structure of fuzzy logic controller - Fuzzification models - Data base - Rule base - Inference engine - Defuzzification module - Non-linear fuzzy control - PID like FLC – Sliding mode FLC - Sugeno FLC- Adaptive fuzzy control.

11 Hours

#### Unit V Case

##### Studies

Neuro, Artificial Neuro, Fuzzy, Neuro-Fuzzy, Optimal Controllers – Case studies.

7 Hours

Total : 45 Hours

#### References

1. Jacek. M. Zurada, *Introduction to Artificial Neural Systems*, Boston, PWS Publishing Company, 1992.
2. H.J. Zimmerman, *Fuzzy Set Theory-and its Applications*, Boston, Kluwer Academic Publishers, 2001.
3. B. Kosko, *Neural Networks and Fuzzy Systems*, New Delhi, Prentice Hall of India, 1991.
4. G.J. Klir and T.A. Folger, *Fuzzy Sets, Uncertainty and Information*, New Delhi, Prentice-Hall of India, 1988.
5. D. Driankov, H. Hellendroon and M. Rainfrank, *Introduction to Fuzzy Control*, New York, Springer Publications, 2010.
6. Shehu S. Farinwata, Dimitar P. Filev and Reza Langari, *Fuzzy Control Synthesis and Analysis*, New York, John Wiley and Sons, 2000.

### 13PE55 SYSTEM THEORY

3 0 0 3

#### Course Objectives (COs):

- To enable the students to have a fair knowledge about the use of mathematical techniques in control system.
- To learn the concepts of state variable techniques, non-linear systems and basics of optimal and adaptive control.
- To study the observability and controllability of feedback system.

#### Course Learning Outcomes (CLOs):

- Ability to design a mathematical model of a system
- Ability to determine the controllability and observability of a system
- Ability to verify the stability of the system

#### Program Outcomes (POs) :

- a) able to apply knowledge gained from undergraduate engineering discipline to identify, formulate, solve problems and challenges in advanced power electronics and drives
- b) able to understand and design power electronics and drive systems for different applications and conduct experiments, analyze and interpret data.

#### Unit I

##### State Variable Representation

Introduction-Concept of State-State equation for Dynamic Systems-Time invariance and linearity-Non uniqueness of state model-State Diagrams-Physical System and State Assignment.

**9 Hours**

## **Unit II**

### **Solution of State equation**

Existence and uniqueness of solutions to Continuous-time state equations-Solution of Nonlinear and Linear Time Varying State equations-Evaluation of matrix exponential-System modes-Role of Eigen values and Eigenvectors.

**10 Hours**

## **Unit III**

### **Controllability and Observability**

Controllability and Observability-Stabilizability and Detectability-Test for Continuous time Systems- Time varying and Time invariant case-Output Controllability-Reducibility-System Realizations.

**7 Hours**

## **Unit IV**

### **Stability**

Introduction -Equilibrium Points-Stability in the sense of Lyapunov-BIBO Stability-Stability of LTI Systems-Equilibrium Stability of Nonlinear Continuous Time Autonomous Systems-The Direct Method of Lyapunov and the Linear Continuous-Time Autonomous Systems-Finding Lyapunov Functions for Nonlinear Continuous Time Autonomous Systems-Krasovskii and Variable-Gradient Method.

**11 Hours**

## **Unit V**

### **Modal Control**

Introduction-Controllable and Observable Companion Forms-SISO and MIMO Systems-The Effect of State Feedback on Controllability and Observability-Pole Placement by State Feedback for both SISO and MIMO Systems-Full Order and Reduced Order Observers.

**8 Hours**

**Total: 45 Hours**

## **References**

1. M. Gopal, *Modern Control System Theory*, New York, John Wiley & Sons, 1993.
2. K. Ogatta, *Modern Control Engineering*, New Delhi, Prentice Hall of India, 2009.
3. John S. Bay, *Fundamentals of Linear State Space Systems*, New York, McGraw-Hill, 1998.
4. John J. D'Azzo, C. H. Houpis and S. N. Sheldon, *Linear Control System Analysis and Design with MATLAB*, New York, Marcel Dekker Inc., 2003.
5. Z. Bubnicki, *Modern Control Theory*, New York, Springer Berlin Heidelberg, 2005.
6. Richard L. Dorf and Robert H. Bishop, *Modern control Systems*, New Delhi, Prentice Hall of India, 2007

## **13PE56 FACTS CONTROLLER**

**3 0 0 3**

### **Course Objectives (COs):**

- To understand the need for FACTS
- To learn shunt and series compensation techniques
- To learn about controlled voltage and face angle regulator

- To learn the concept of unified power flow controller

**Course Learning Outcomes (CLOs):**

- Ability to understand the operation of the compensator and its applications in power system.
- Ability to understand the various emerging Facts controllers.
- Ability to know about the genetic algorithm used in Facts controller coordination.

**Program Outcomes (POs):**

- a) able to apply knowledge gained from undergraduate engineering discipline to identify, formulate, solve problems and challenges in advanced power electronics and drives
- b) able to understand and design power electronics and drive systems for different applications and conduct experiments, analyze and interpret data.

**Unit – I**

**Introduction to FACTS**

Electrical Transmission Network - Necessity - Power Flow in AC System - relative importance of controllable parameter - opportunities for FACTS - possible benefits for FACTS.

**8 Hours**

**Unit – II**

**Static VAR Compensation**

Need for compensation - introduction to shunt & series compensation - objectives of shunt & series compensation - configuration & operating characteristics - Thyristor Controlled Reactor (TCR) - Thyristor Switched Capacitor (TSC) -Comparison of TCR & TSC.

**10Hours**

**Unit – III**

**Series Compensation**

Variable Impedance Type Series Compensation: Thyristor Switched Series Capacitor (TSSC) - Thyristor Controlled Series Capacitor (TCSC) - Basic operating control schemes for TSSC & TCSC.

**9 Hours**

**Unit – IV**

**Static Voltage Phase Angle Regulator**

Objectives of voltage & phase angle regulators - approaches to Thyristor - Controlled Voltage & Phase Angle Regulator.

**8Hours**

**Unit – V**

**Emerging Facts Controller**

STATCOM - Introduction to Unified Power Flow Controller (UPFC) & Interline Power Flow Controller (IPFC) - basic operating principles UPFC - introduction to sub synchronous resonance.

**10 Hours**

**Total: 45 Hours**

**References**

1. R. Mohan Mathur and Rajiv K.Varma, *Thyristor Based FACTS Controller for Electrical Transmission Systems*, Wiley Interscience Publications, 2002.
2. Narain G. Hingorani & Laszlo Gyugyi, *Understanding FACTS - Concepts & Technology of Flexible AC Transmission Systems*, Standard Publishers, New Delhi, 2001.
3. T. J. E. Miller, *Reactive Power Control in Electric System*, John Wiley & Sons, 1997.
4. G. K. Dubey, *Thyristerized Power Controller*, New Age international (P) Ltd., New Delhi 2001.
5. Narain G. Hingorani, *Flexible AC Transmission*, IEEE Spectrum, April 1993, pp 40 – 45.

6. Narain G. Hingorani, *High Power Electronics in Flexible AC Transmission*, IEEE Power Engineering Review, 1998.

### 13PE57 POWER ELECTRONICS APPLICATIONS TO POWER SYSTEM

3 0 0 3

#### Course Objectives (COs):

- To impart knowledge on different types of converter configurations.
- To study the different Applications of converters in HVDC systems
- To design and analyze the different types of protection schemes for converters.

#### Course Learning Outcomes (CLOs):

- Ability to determine the characteristics of different types of converter configurations for large power control.
- Ability to determine the different control functions required for HVDC link.
- Ability to demonstrate the problems associated with the injection of harmonics in AC and DC system.
- Ability to design different types of converter models for HVDC system based on load flow analysis.
- Ability to design of ac filters and dc filters to suppress harmonics in converter stations.

#### Program Outcomes (POs):

- a) able to apply knowledge gained from undergraduate engineering discipline to identify, formulate, solve problems and challenges in advanced power electronics and drives
- b) able to understand and design power electronics and drive systems for different applications and conduct experiments, analyze and interpret data.
- c) able to acquire continuous learning skills, plan and conduct a systematic study on significant research

#### Unit I

##### Introduction

High Power drives for Power systems controllers – Characteristics – Converters Configuration for Large power control.

7 Hours

#### Unit II

##### Single Phase and Three Phase Converters

Properties – Current and voltage harmonics – Effect of source and load impedance – Choice of best circuit for power systems- Converter Control - Gate Control – Basic means of Control – Control characteristics – Stability of control – Reactive power control - Applications of converters in HVDC systems – Static VAR control - Source of reactive power – Harmonics and filters.

10 Hours

#### Unit III

##### HVDC

HVDC configurations, components of HVDC system: Converter, transformer, smoothing reactor, harmonic filter. Reactive power support, operation of 6-pulse controlled rectifier in inverting mode of operation. Operation of 12-pulse converter. Control of HVDC system, Rectifier and inverter characteristics, mode stabilization, current control, voltage dependent current order limit, combined rectifier-inverter characteristics, valve blocking and by-passing, limitations HVDC system using line commutated converters, modern HVDC system - HVDC light.

11 Hours

#### Unit IV

##### Reactive Power Compensation

Introduction, methods of Var generation, analysis of uncompensated AC line, Passive reactive power compensation, Compensation by a series capacitor connected at the mid point of the line, Effect on Power Transfer capacity, Compensation by STATCOM and SSSC, Fixed capacitor-Thyristor controlled reactor (FC-TCR), Thyristor-switched capacitor- Thyristor controlled reactor (TSC-TCR), static var compensators.

9 Hours

## Unit V

### Static Applications

Static excitation of synchronous generators - Solid state tap changers for transformer - UPS Systems  
- Induction furnace control.

8 Hours

Total: 45 Hours

### References

1. K.R. Padiyar, *HVDC Power Transmission System – Technology and System Interaction*, New Delhi, New Age International, 2002.
2. Erich Uhlmann, *Power Transmission by Direct Current*, New York, Springer Publications, 1975.
3. E.W. Kimbark, *Direct Current Transmission*, Vol.1, New York, Wiley Interscience, 1971.
4. Ned Mohan, *Power Electronics Converters Applications and Design*, New York, John Wiley and Sons, 2002.
5. D.V. Hall, *Elements in Microprocessor & Interfacing: - Programming and Hardware*, New York, McGraw-Hill, 1992.
6. Mohd. Hasan Ali, Bin Wu, Roger A. Dougal, *An Overview of SMES Applications in Power and Energy Systems*, IEEE Transactions on Sustainable Energy, vol. 1, no. 1, April 2010
7. Marcelo Gustavo Molina, Pedro Enrique Mercado, Edson Hirokazu Watanabe, *Improved Superconducting Magnetic Energy Storage (SMES) Controller for High-Power Utility Applications*, IEEE Transactions on Energy Conversion, vol. 26, no. 2, June 2011

## 13PE58 PWM CONVERTERS AND APPLICATIONS

3 0 0 3

### Course Objectives (COs):

- To design and analyze the various types of PWM converter topologies.
- To study the high frequency power converters and its applications.
- To study and formulate the different types of power factor control strategies.
- To study the different types of filtering techniques and its applications for power converters.

### Course Learning Outcomes (CLOs):

- Ability to identify the various types of switched mode inverter topologies.
- Ability to compute the various filtering methods for PWM converters.
- Ability to illustrate the various power factor control techniques.
- Ability to illustrate the various current regulated inverter topologies and special inverter topologies.

### Program Outcomes (POs):

- a) able to apply knowledge gained from undergraduate engineering discipline to identify, formulate, solve problems and challenges in advanced power electronics and drives
- b) able to understand and design power electronics and drive systems for different applications and conduct experiments, analyze and interpret data.
- c) able to acquire continuous learning skills, plan and conduct a systematic study on significant research

## Unit 1

### Switch-Mode DC-AC Inverters

Basic Concepts - Single Phase Inverters - Push Pull - Half Bridge and Full Bridge Square Inverters - Blanking Time .Single Pulse Modulation of Single Phase Square Wave Inverters -Multi pulse modulation - PWM Principles . Sinusoidal Pulse Width Modulation in Single Phase Inverters - Choice of carrier frequency in SPWM - Spectral Content of output - Bipolar and Unipolar Switching in SPWM - Maximum Attainable DC

Voltage Utilization. Reverse Recovery Problem and Carrier Frequency Selection - Output Side Filter Requirements and Filter Design - Ripple in the Inverter Output - DC Side Current. **10 Hours**

## Unit II

### Resonant converters

Switch - mode inductive current switching, Zero Voltage & Zero - Current switching , Resonant switch converters, Basic resonant circuit concepts, Resonant switch converters, ZCS and ZVS resonant switch converters , Comparison of ZCS and ZVS topologies.

**8Hours**

## Unit III

### Special Inverter Topologies

Current Source Inverter - Ideal Single Phase CSI operation, analysis and waveforms - Analysis of Single Phase Capacitor Commutated CSI - Series Inverters - Analysis of Series Inverters - Modified Series Inverter Three Phase Series Inverter

**7 Hours**

## Unit IV

### Switching DC power Supplies and Control Aspects

Linear power supplies, Overview of switching power supplies, switching losses - Fly back and Forward Converters. duty cycle derivation, waveforms, comparison of converters, Problems Voltage feed- forward PWM control, current mode control ,Power supply protection , Electrical isolation in the feedback loop, Designing to meet power supply specifications

**9 Hours**

## Unit V

### Converter Design, Thermal Model and Applications

Selection of output filter capacitor-selection of energy storage inductor-design of high frequency Inductor and high frequency transformer- selection of switches - snubber circuit design- Pulse width modulator circuit-design of driver circuits- Necessity of EMI filter (for Buck, Boost , Flyback & Forward Converters only) Thermal resistance-selection of Heat sinks- simple heat sink calculations DC/DC converter as Power factor Corrector (active shaping of the line current) Offline computer power supply system, Uninterruptible ac power supplies, Space craft power supply etc

**11 Hours**

**Total :45 Hours**

## References

1. R. Krishnan, *Electric Motor & Drives: Modeling, Analysis and Control*, New Delhi, Prentice Hall of India, 2001.
2. Bimal K. Bose, *Modern Power Electronics and Motor Drive- Advances and Trends*, New Delhi, Pearson Education, 2003.
3. Ned Mohan, Tore M. Undeland and William P.Robbins, *Power Electronics: Converters, Applications and Design*, New Jersey, John Wiley and Sons, 2003.
4. M.H. Rashid, *Power Electronics: Circuits, Devices and Application*, New Delhi, Prentice Hall of India, 2004.
5. Umanand L., Bhat S.R., .Design of magnetic components for switched Mode Power converters. , Wiley Eastern Ltd.,1992
6. Robert. W. Erickson, D. Maksimovic .Fundamentals of Power Electronics., Springer International Edition, 2005

## 13PE59 SPECIAL MACHINES AND THEIR CONTROLLERS

3 0 0 3

### Course Objectives:

- To study the speed torque characteristics of various machines.
- To study the construction and operating principle of various types of special machines.
- To study the different types of control techniques for all types of machines.

### Course Learning Outcomes (CLOs):

- Ability to identify the various types of breakdown mechanisms in liquids and solid dielectrics.
- Ability to compute the various instruments used for measurement and generation of high voltages and currents.
- Ability to illustrate the various high voltage testing methods.

### Program Outcomes:

- a) able to apply knowledge gained from undergraduate engineering discipline to identify, formulate, solve problems and challenges in advanced power electronics and drives
- b) able to understand and design power electronics and drive systems for different applications and conduct experiments, analyze and interpret data.

### Unit I

#### Synchronous Reluctance Motors

Constructional features: axial and radial air gap Motors - Operating principle - Reluctance torque – Phasor diagram - Motor characteristics.

8 Hours

### Unit II

#### Switched Reluctance Motors

Constructional features - Principle of operation - Torque equation - Power controllers -Characteristics and control - Microprocessor based controller.

8 Hours

### Unit III

#### Permanent Magnet Synchronous Motors

Principles of operation - EMF, power input and torque expressions - Phasor diagram - Power controllers - Torque speed characteristics - Self control - Vector control - Current control schemes.

9 Hours

### Unit IV

#### Permanent Magnet Brushless DC Motors

Commutation in DC motors - Difference between mechanical and electronic commutators - Hall sensors - Optical sensors - Multiphase Brushless motor - Square wave permanent magnet brushless motor drives - Torque and EMF equation - Torque-speed characteristics – Controllers - Microprocessor based controller.

11 Hours

### Unit V Stepping

#### Motors

Constructional features - Principle of operation - Modes of excitation - torque production in Variable Reluctance (VR) stepping motor - Dynamic characteristics - Drive systems and circuit for open loop control - Closed loop control of stepping motor.

9 Hours



Total : 45Hours

## References

1. T.J.E. Miller and J R Hendershot Jr., *Design of Brushless Permanent Magnet Motors*, USA, Oxford University Press, 1995.
2. T.J.E. Miller, *Reluctance Motor and their Controls*, USA, Oxford University Press, 1995.
3. T. Kenjo, *Stepping Motors and their Microprocessor Control*, England, Clarendon Oxford Press, 1985.
4. T. Kenjo and S. Naganori, *Permanent Magnet and Brushless DC motors*, England, Clarendon Oxford Press, 1989.
5. T. Kenjo, *Power Electronics for the Microprocessor*, England, Clarendon Oxford Press, 1990.
6. B.K. Bose, *Modern Power Electronics & AC drives*, New Delhi, Prentice Hall of India, 2001.
7. R. Krishnan, *Permanent Magnet Synchronous and Brushless DC Motor Drives*, New Delhi, Prentice Hall of India, 2009.

## 13PE60 MICROCONTROLLER PROGRAMMING AND APPLICATIONS

3 0 0 3

### Course Objectives (COs):

- To introduce microprocessors and basics of system design using microprocessors.
- To introduce programming of Embedded C.
- To learn about PIC controller

### Course Learning Outcomes (CLOs):

- Ability to learn processor programming
- Ability to learn programming concepts
- Able to understand microcontrollers

### Program Outcomes (POs):

- a) able to apply knowledge gained from undergraduate engineering discipline to identify, formulate, solve problems and challenges in advanced power electronics and drives
- b) able to understand and design power electronics and drive systems for different applications and conduct experiments, analyze and interpret data.
- c) able to acquire continuous learning skills, plan and conduct a systematic study on significant research

### Unit I

#### Processor Programming & Peripheral Interfacing

Functional block diagram - Signals – Memory interfacing – Timing Diagram –Interrupt structure. Instruction format and addressing modes – Assembly language format – Instruction set – Programming: Loop structure with counting & Indexing - Look up table - Subroutine instructions stack - Study of Architecture and Programming of ICs: 8255 PPI - Interfacing with 8085 - A/D and D/A converter interfacing

11 Hours

### Unit II

#### Embedded C Programming

Initialization of controllers – Variables- Loops – for , while, do-while – conditional statement- if statement – configuring I/O ports – configuring ADC channels - creating look-up- table in controller ROM.

8 Hours

### Unit III

#### PIC Microcontroller - Architecture

P16F877 Architecture and instruction set – Program and Data memory – CPU registers – I/O port expansion – Interrupts – Programming concepts in Assembly and Embedded C.

9 Hours

### Unit IV

#### PIC Microcontroller - Peripherals

Timer0 – Timer 1 - Compare and Capture mode — Timer 2 – PWM outputs – I2C operation – ADC – UART.

8 Hours

### Unit V

#### Embedded Applications using 8051 & 16F877

Stepper Motor Control – DC Motor Control- AC Power Control- Interfacing with LED's -Pushbuttons - Relays – Latches – Keypad matrix – 7 Segment display – LCD – ADC –DAC.

9 Hours

**Total: 45 Hours**

### References

1. Milan Verle , *PIC Microcontrollers mikroElektronika*, mikroElektronika ,1st edition 2008.
2. John. B. Peatman, “*Design with PIC Microcontrollers*”, Pearson Education, 2004.
3. William Kleitz, *Microprocessor and Micro Controller Fundamental of 8085 and 8051 Hardware and Software*, Pearson Education Asia, New Delhi 1998
4. Tim Wilmshurst, “*Designing Embedded Systems with PIC Microcontrollers: Principles and Applications*” Newness Publisher-2007.

## 13PE61 ADVANCED DIGITAL SIGNAL PROCESSING

3 0 0 3

### Course Objectives (COs):

- To study about the discrete random process and spectral estimation techniques
- To understand the algorithm used in linear estimation and prediction
- To study about various filters and multi rate signal processing

### Course Learning Outcomes (CLOs):

- Ability to understand basics of discrete random signal processing
- Ability to estimate the spectrum
- Ability to use the filters for noise cancellation and echo cancellation
- Ability to understand wavelet transforms

### Program Outcomes (POs):

- (a). Able to apply knowledge gained from undergraduate engineering discipline to identify, formulate and solve problems and challenges in advanced power electronics and drives
- (b). Able to understand and design power electronics and drive systems for different applications and conduct experiments, analyze and interpret data

### Unit I

#### Discrete Random Signal Processing

Discrete Random Processes – Ensemble averages, stationary processes, Autocorrelation and Auto covariance matrices – Parseval's Theorem – Wiener-Khintchine Relation – Power Spectral Density – Periodogram Spectral Factorization – Filtering random processes – Low Pass Filtering of White Noise – Parameter estimation: Bias and consistency.

**9 Hours**

### Unit II

#### Spectrum Estimation

Estimation of spectra from finite duration signals – Non- Parametric Methods – Correlation Method – Periodogram Estimator – Performance Analysis of Estimators – Unbiased, Consistent Estimators – Modified periodogram – Bartlett and Welch methods – Blackman – Tukey method - Parametric Methods – AR, MA, and ARMA model based spectral estimation – Parameter Estimation – Yule-Walker equations – Solutions using Durbin's algorithm.

**11 Hours**

### Unit III

#### Linear Estimation and Prediction

Linear prediction – Forward and backward predictions – Solutions of the Normal equations – Levinson-Durbin algorithms – Least mean squared error criterion – Wiener filter for filtering and prediction – FIR Wiener filter and Wiener IIR filters – Discrete Kalman filter.

**8 Hours**

### Unit IV

#### Adaptive Filters

FIR adaptive filters – Adaptive filter based on steepest descent method – Widrow-Hoff LMS adaptive algorithm – Normalized LMS – Adaptive channel equalization – Adaptive echo cancellation – Adaptive noise cancellation – Adaptive recursive filters (IIR) – RLS adaptive filters – Exponentially weighted RLS – Sliding window RLS.

**8 Hours**

### Unit V

#### Multirate Digital Signal Processing

Mathematical description of change of sampling rate – Interpolation and Decimation – Decimation by an integer factor – Interpolation by an integer factor – Sampling rate conversion by a rational factor – Filter implementation for sampling rate conversion – direct form FIR structures – Polyphase filter structures – Time-variant structures – Multistage implementation of multirate system – Application to sub band coding – Wavelet transform and filter bank implementation of wavelet expansion of signals.

**9 Hours**

**Total : 45 Hours**

### References

1. Monson H. Hayes, *Statistical Digital Signal Processing and Modeling*, New Jersey, John Wiley and Sons, 2002.
2. John G. Proakis and Dimitris G. Manolakis, *Digital Signal Processing*, New Delhi, Pearson Education, 2002.
3. John G. Proakis, *Algorithms for Statistical Signal Processing*, New Delhi, Pearson Education, 2002.

## 10PE62 VLSI APPLICATIONS TO POWER ELECTRONICS

3 0 0 3

### Course Objectives (COs):

- To study about the VLSI design strategies.
- To study the applications of VLSI for power electronics and power converters.

### Course Learning Outcomes (CLOs):

Ability to apply knowledge of IC fabrication  
Ability to understand the fabrication steps in IC manufacturing  
Ability to monitor the measurement of resistance, capacitance and inductance  
Ability to achieve goals and objectives of various chips designed for engineering applications.

### Program Outcomes (POs):

- (a). able to apply knowledge gained from undergraduate engineering discipline to identify, formulate and solve problems and challenges in advanced power electronics and drives
- (b). able to understand and design power electronics and drive systems for different applications and conduct experiments, analyze and interpret data

### Unit I

#### Overview of VLSI Design Methodology:

Review of microelectronics and introduction to MOS technologies: (MOS,CMOS, Bi-CMOS) trends and projection-VLSI design process -Architectural design -Logical design -Physical design -Layout styles -Full custom -Semi custom approaches.

9Hours

### Unit II

#### MOS Transistor Theory

Stick diagram- Ids-Vds relationships, Threshold voltage Pass Transistor, MOS,CMOS & Bi CMOS Inverters, Zpu/Zpd, MOS Transistor circuit model, Body effect- Design equations- Second order effects.MOS models and small signal AC characteristics Latch-up in CMOS circuits.

11Hours

### Unit III

#### VLSI Fabrication Techniques

An overview of wafer fabrication - Silicon gate NMOS process - nWell – pWell -Twin tub -Silicon on insulator-CMOS process - Package types - packaging design considerations - VLSI assembly technology - Package fabrication technology.

9 Hours

### Unit IV

#### Circuit Characterization and Performance Estimation

Resistance estimation -Capacitance estimation - Inductance, switching characteristics - transistor sizing - power dissipation and design margining. Charge sharing - Scaling.

8Hours

### Unit V

#### Application for Power Electronics

Typical VLSI applications - control of power electronic converter for power supplies and electric drives- Sensor less control of AC drives - Low power circuit design.

8Hours

**Total:45Hours**

**References**

1. Jan M. Rabaey, *Digital Integrated Circuits*, New Delhi, Prentice Hall of India, 2002
2. John P. Uyemura, *Introduction to VLSI Circuits and Systems*, New Jersey, John Wiley & Sons, 2002.
3. Douglas A. Pucknell and K. Eshragian, *Basic VLSI Design*, New Delhi, Prentice Hall of India, 2000.
4. Neil.H.E. Weste and K. Eshragian, *Principles of CMOS VLSI Design*, USA, Addison-Wesley, 2000.
5. Sung-Mo Kang and Yusuf Leblebici, *CMOS Digital Integrated Circuits- Analysis and Design*, New Delhi, Tata McGraw-Hill, 2003.

**13PE63 SWITCHED MODE AND RESONANT CONVERTERS**

**3 0 0 3**

**Course Objectives (COs):**

- To understand the analyze the basic topologies of switched mode converters
- To understand the different types of modulation schemes and control techniques of the converters
- To estimate the switching and conduction losses taking place in switched mode converters.

**Course Learning Outcomes (CLOs):**

- Ability to construct Buck, Boost, Buck-Boost converter and Half Bridge and Full Bridge Inverters
- Ability to diagnose the cause of switching and conduction losses and switching stresses
- Ability to determine the practical voltage, current and power limit of each converters separately.

**Program Outcomes (POs):**

- a) able to apply knowledge gained from undergraduate engineering discipline to identify, formulate, solve problems and challenges in advanced power electronics and drives
- b) able to understand and design power electronics and drive systems for different applications and conduct experiments, analyze and interpret data.

**Unit-1**

**Converter Topologies**

Buck, Boost, Buck – Boost SMPS Topologies. Basic Operation – Waveforms – modes of operation – switching stresses – switching and conduction losses – optimum switching frequency – practical voltage, current and power limits – design relations – voltage mode control principles.

**9 Hours**

**Unit-II**

**Carrier Modulation**

Switch-Mode dc-ac Inverters - Basic Concepts - Single Phase Inverters - Push Pull - Half Bridge and Full Bridge Square Inverters - Blanking Time - Single Pulse Modulation of Single Phase Square Wave Inverters - Multi pulse modulation - PWM Principles - Sinusoidal Pulse Width Modulation in Single Phase Inverters - Choice of carrier frequency in SPWM - Bipolar and Unipolar Switching in SPWM.

**10 Hours**

**Unit-III**

**Current Control Schemes**

Current Regulated Inverter - Current Regulated PWM Voltage Source Inverters - Methods of Current Control - Hysteresis Control - Variable Band Hysteresis Control - Fixed Switching Frequency Current Control Methods - Switching Frequency Vs accuracy of Current Regulation - Areas of application of Current Regulated VSI.

**9 Hours**

#### Unit-IV

##### Closed Loop Control

Switched Mode Rectifier - Operation of Single/Three Phase Bridges in Rectifier Mode - Control Principles  
- Control of the DC Side Voltage - Voltage Control Loop - The inner Current Control Loop.

7 Hours

#### Unit-V

##### Power Factor Control

Shunt Reactive Power Compensators - Switched Capacitors - Static Reactor Compensators based on thyristor  
- Static Reactive VAR Generators using PWM Current Regulated VSIs - Principles - Control Strategies -  
Series Compensation by PWM-VSI based Voltage Injection Scheme - Principles - Control Strategies.

10 Hours

Total : 45 Hours

#### References

1. Abraham I. Pressman, Keith Billings and Taylor Morey, *Switching Power Supply Design*, New York, McGraw-Hill, 2009.
2. Daniel M. Mitchell, *DC – DC Switching Regulator Analysis*, New York, McGraw-Hill, 1988.
3. Ned Mohan, Tore M. Undeland and William P. Robbins, *Power Electronics: Converters, Applications and Design*, New Jersey, John Wiley and Sons, 2002.
4. Otmar Kilgenstein, *Switched Mode Power Supplies in practice*, New York, John Wiley and Sons, 1989.
5. Keith H. Billings, *Handbook of Switched Modern Power Supplies*, New York, McGraw-Hill, 1999.
6. Mark J. Nave, *Power Line Filter Design for Switched Mode Power Supplies*, New York, Springer Publications, 1991.

### 13PE64 AUTOMOTIVE ELECTRONICS

3 0 0 3

#### Course Objectives (COs):

- To study the internal structure and the switching and operating characteristics of the basic power devices.
- To study the advanced power devices and its working principle.

#### Course Learning Outcomes (CLOs):

- Ability to determine the suitable device for the application.
- Ability to design of semiconductor device and its parameters.
- Ability to design of protection circuits and control circuits
- Ability to determine the reliability of the system.

#### Program Outcomes (POs):

- a) able to apply knowledge gained from undergraduate engineering discipline to identify, formulate, solve problems and challenges in advanced power electronics and drives
- b) able to understand and design power electronics and drive systems for different applications and conduct experiments, analyze and interpret data.
- c) able to acquire continuous learning skills, plan and conduct a systematic study on significant research

#### Unit I

##### Introduction

Evolution of electronics in automobiles – emission laws – introduction to Euro I, Euro II, Euro III, Euro IV, Euro V standards – Equivalent Bharat Standards, Charging systems: Working and design of charging circuit diagram – Alternators – Requirements of starting system - Starter motors and starter circuits.

**9 Hours**

## **Unit II**

### **Ignition And Injection Systems**

Ignition systems: Ignition fundamentals - Electronic ignition systems - Programmed Ignition- Distribution less ignition -Direct ignition – Spark Plugs. Electronic fuel Control: Basics of combustion – Engine fuelling and exhaust emissions –Electronic control of carburetion – Petrol fuel injection – Diesel fuel injection.

**9 Hours**

## **Unit III**

### **Sensor And Actuators**

Working principle and characteristics of Airflow rate, Engine crankshaft angular position, Hall Effect, Throttle angle, temperature, exhaust gas oxygen sensors – study of fuel injector, exhaust gas recirculation actuators, stepper motor actuator, vacuum operated actuator.

**8 Hours**

## **Unit IV**

### **Engine Control Systems**

Control modes for fuel control- engine control subsystems – ignition control methodologies – different ECU's used in the engine management – block diagram of the engine management system. In vehicle networks: CAN standard, format of CAN standard – diagnostics systems in modern automobiles.

**10 Hours**

## **Unit V**

### **Chassis And Safety Systems**

Traction control system – Cruise control system – electronic control of automatic transmission –antilock braking system –electronic suspension system – working of airbag and role of MEMS in airbag systems – centralized door locking system –climate control of cars.

**9 Hours**

**Total: 45 Hours**

### **Reference Books:**

1. Tom Denton."Automobile electrical and electronic system", Edward Arnold publishers, 4<sup>Th</sup> edition 2012.
2. William B. Ribbens, "Understanding Automotive Electronics", Newnes Publishing, 6th Edition 2003.
3. Barry Hollembeak, "Automotive Electricity, Electronics & Computer Controls", Delmar Publishers, 2001.
4. "Fuel System and Emission controls", Check Chart Publication, 2000.
5. Ronald. K. Jurgon, "Automotive Electronics Handbook", McGraw-Hill, 1999

## **13PE65 - RESEARCH METHODOLOGY**

**3 0 0 3**

### **Course Outcomes (COs):**

- To understand the basic research process
- To study about the different types of research
- To know about the report writing

### **Course Learning Outcomes (CLOs):**

- Ability to understand the basic research process, research methodology
- Ability to study about the different types of research and to know about the report writing

**Program Outcomes (POs):**

- e) able to understand and integrate new technology.
- f) able to use modern engineering tools
- g) able to communicate professionally.
- h) able to develop confidence for self education and lifelong learning

**Unit I**

Research methodology – definition, mathematical tools for analysis, Types of research, exploratory research, conclusive research, modeling research, algorithmic research, Research process- steps. Data collection methods-Primary data – observation method, personal interview, telephonic interview, mail survey, questionnaire design. Secondary data- internal sources of data, external sources of data.

**10 Hours**

**Unit II**

Scales – measurement, Types of scale – Thurstone’s Case V scale model, Osgood’s Semantic Differential scale, Likert scale, Q- sort scale. Sampling methods- Probability sampling methods – simple random sampling with replacement, simple random sampling without replacement, stratified sampling, cluster sampling. Non-probability sampling method – convenience sampling, judgment sampling, quota sampling.

**11 Hours**

**Unit III**

Hypotheses testing – Testing of hypotheses concerning means (one mean and difference between two means - one tailed and two tailed tests), concerning variance – one tailed Chi-square test.

**7 Hours**

**Unit IV**

Nonparametric tests- One sample tests – one sample sign test, Kolmogorov-Smirnovtest, run test for randomness, Two sample tests – Two sample sign test, Mann-Whitney U test, K-sample test – Kruskal Wallis test (H-Test)

**8 Hours**

**Unit V**

Introduction to Discriminant analysis, Factor analysis, cluster analysis, multi-dimensional scaling, conjoint analysis. Report writing- Types of report, guidelines to review report, typing instructions, oral presentation

**9 Hours**

**Total :45 Hours**

**References**

1. Panneerselvam, R., Research Methodology, Prentice-Hall of India, New Delhi, 2004.
2. Kothari, C.R., Research Methodology –Methods and techniques, New Age International.



## 13PE01 EMERGING TRENDS IN POWER CONVERSION TECHNOLOGY

3 0 0 3

### Course Objectives (COs):

- To study the various switching techniques to reduce the harmonics on output of power converters.
- To study the recent advancements in power converters.
- To know the digital switching techniques in dc-dc converters
- To know multilevel matrix converter and its applications

### Course Learning Outcomes (CLOs):

- a) An ability to understand the PWM techniques.
- b) An ability to understand voltage lift techniques in of dc-dc converters.
- c) An ability to understand the FFT analysis of multilevel inverters
- d) An ability to know about multilevel matrix converter and source matrix converter.
- e) An ability to know the harmonic mitigations methods.

### Program Outcomes (POs):

- a) able to apply knowledge gained from undergraduate engineering discipline to identify, formulate, solve problems and challenges in advanced power electronics and drives
- b) able to understand and design power electronics and drive systems for different applications and conduct experiments, analyze and interpret data.
- c) able to acquire continuous learning skills, plan and conduct a systematic study on significant research

### Unit 1

#### Switching Techniques

Gating signals – PWM techniques – Types – SPWM, SVPWM and SVM – choice of carrier frequency in SPWM – switch realization – switching losses – efficiency Vs switching frequency – applications – EMI and EMC considerations.

8 Hours

### Unit II

#### DC – DC Converters

Basic of DC – DC converter – hard and soft switching concepts – digital switching techniques - Luo converter - principle of operation – voltage lift techniques - MPPT algorithms – sliding mode control - applications – photovoltaic systems – hybrid vehicles.

10 Hours

### Unit III

#### Advances in Inverters

Multilevel concept – Diode clamped – Flying capacitor – Cascade type multilevel inverters – Hybrid multi level inverter- FFT analysis- Comparison of multilevel inverters - Applications of multilevel inverter - Principle of operation of impedance source inverter- Shoot thro zero state – Application – UPS – Adjustable speed drives.

11 Hours

### Unit IV

#### Matrix Converter

Single phase and three phase – direct indirect – sparse and very sparse – multilevel matrix converter – Z source matrix converter – applications – wind mills – Adjustable speed drives industrial applications - Hybrid vehicles.

8 Hours

## Unit V

### Harmonic Mitigations

Effects of harmonics – harmonics eliminations – selective harmonic elimination – selective sine PWM carrier elimination – Power Factor controlling – active power factor controlling – hysteresis control – voltage feedback control - current feedback control.

8 Hours

Total :45 Hours

### References:

1. Ned Mohan, Undeland and Robbin, *Power Electronics: Converters, Application and Design*, New York, John Wiley and Sons Inc., 2002.
2. Kolar, J.W. Schafmeister, F. Round, S.D. Ertl, H. ETH Zurich and Zurich, *Novel Three-Phase AC-AC Sparse Matrix Converters*, Vol.22, No.5, IEEE Transaction on Power Electronics, Sept. 2007, pp 1649 – 1661.
3. R. Krishnan, *Electric Motor Drives – Modeling, Analysis and Control*, New Delhi, Prentice Hall of India, 2003.
4. D.M. Bellur, M.K. Kazimierczuk and O.H. Dayton, *DC-DC Converters for Electric Vehicle Applications*, Conference on Electrical Insulation and Electrical Manufacturing Expo, 22-24, Oct. 2007, Nashville, USA, pp 286 – 293.
5. S. Masoud Barakati, *Applications of Matrix Converters for Wind Turbine Systems*, Germany, VDM Verlag Publishers, 2008.



