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# Fr. C. Rodrigues Institute of Technology

Sector 9A, Vashi, Navi Mumbai, 400703, Maharashtra, India

www.fcrit.ac.in

## An Autonomous Institute Affiliated to the University of Mumbai

## Department of Electrical Engineering

## Curriculum Structure Master of Technology in Electrical Engineering

## (Power Electronics and Drives)

## &

## First and Second Year Syllabus

**Prepared by : Board of Studies for Department of Electrical Engineering**

**Approved By: Academic Council of Fr. C. Rodrigues Institute of Technology**

**Revision: 2024**

**Effective from :2024-25**

## A. Abbreviations

| | |
|---|---|
| PED | Power Electronics and Drives |
| PEDC | Core Course |
| PEDPE | Program Eective |
| PEDIE | Institute Eective |
| PEDL | Lab Course |
| PEDSBL | Skill based Lab |
| PEDMP | Major Project |
| PEDOCC | Online Credit Course |

**B. Credit Structure**

| M. Tech in Power Electronics and Drives | | | | | |
|---|---|---|---|---|---|
| **Type of Course** | **Semester-wise Credit Distribution** | | | | |
| | **I** | **II** | **III** | **IV** | **Total** |
| **Core Course (PEDC)** | 6 | 6 | -- | -- | 12 |
| **Program Eective (PEDPE)** | 6 | 6 | -- | -- | 12 |
| **Institute level Eective (PEDIE)** | 3 | 3 | -- | -- | 06 |
| **Lab Course (PEDL)** | 1 | 1 | -- | -- | 02 |
| **Skill based Lab (PEDSBL)** | 2 | 2 | -- | -- | 04 |
| **Major Project (PEDMP)** | -- | -- | 10 | 16 | 26 |
| **Online Credit Course (PEDOCC)** | -- | -- | 6 | -- | 06 |
| **Total Credits** | **18** | **18** | **16** | **16** | **68** |

**C. Scheme** **Semester I**

| Course Code | Course Name | Teaching Scheme (Contact Hours) | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|
| | | Theory | Pract. | Tut. | Theory | Pract. | Tut. | Total |
| PEDC101 | Electrical Drives and its Application | 3 | -- | -- | 3 | -- | -- | 3 |
| PEDC102 | Power Electronic Converters | 3 | | -- | 3 | | -- | 3 |
| PEDPE101X | Program Elective 1 | 3 | -- | -- | 3 | -- | -- | 3 |
| PEDPE102X | Program Elective 2 | 3 | -- | -- | 3 | -- | -- | 3 |
| PEDIE101X | Institute Elective 1 | 3 | -- | -- | 3 | -- | -- | 3 |
| PEDL101 | Drives And Control Lab | -- | 2 | -- | -- | 1 | -- | 1 |
| PEDSBL101 | Skill Based Lab-I Power Electronics System Design Lab | -- | 4$ | -- | -- | 2 | -- | 2 |
| **Total** | | **15** | **06** | **--** | **15** | **03** | **--** | **18** |

| Course Code | Course Name | Examination Scheme | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Theory | | | | | Term Work | Pract/ Oral | Total |
| | | Internal Assessment | | | End Sem. Exam | Exam. Duration (in Hrs) | | | |
| | | Test-1 | Test-2 | Avg | | | | | |
| PEDC101 | Electrical Drives and Application | 20 | 20 | 20 | 80 | 3 | -- | -- | 100 |
| PEDC102 | Power Electronic Converters | 20 | 20 | 20 | 80 | 3 | -- | -- | 100 |
| PEDPE101X | Program Elective 1 | 20 | 20 | 20 | 80 | 3 | -- | -- | 100 |
| PEDPE102X | Program Elective 2 | 20 | 20 | 20 | 80 | 3 | -- | -- | 100 |
| PEDIE101X | Institute Elective 1 | 20 | 20 | 20 | 80 | 3 | -- | -- | 100 |
| PEDL101 | Drives And Control Laboratory | -- | -- | -- | -- | -- | 25 | 25 | 50 |
| PEDSBL101 | Skill Based Lab-I Power Electronics System Design Lab | -- | -- | -- | -- | -- | 50 | 50 | 100 |
| **Total** | | **--** | **--** | **100** | **400** | **--** | **75** | **75** | **650** |

**Program Elective - 1**
PEDPE1011: Machine Learning Techniques in Power System
PEDPE1012: Power Quality in Power System
PEDPE1013: Electric Vehicle Technology

**Program Elective - 2**
PEDPE1021: Digital Signal Controller
PEDPE1022: Micro-grid Technology
PEDPE1022: IoT application in Electrical Engineering

**Institute Elective-1**
PEDIE1011: Reliability Engineering
PEDIE1012: Cyber Security and Laws
PEDIE1013: Energy Audit and Management
PEDIE1014: Operation Research

## Semester II

| Course Code | Course Name | Teaching Scheme(Contact Hours) | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|
| | | Theory | Pract. | Tut. | Theory | Pract. | Tut. | Total |
| PEDC201 | Advanced Power Electronics | 3 | -- | -- | 3 | -- | -- | 3 |
| PEDC202 | Digital Control of Electrical Drives | 3 | | -- | 3 | | -- | 3 |
| PEDPE201X | Program Elective 3 | 3 | -- | -- | 3 | -- | -- | 3 |
| PEDPE202X | Program Elective 4 | 3 | -- | -- | 3 | -- | -- | 3 |
| PEDIE201X | Institute Elective 2 | 3 | -- | -- | 3 | -- | -- | 3 |
| PEDL201 | DSP Applications Lab | -- | 2 | -- | -- | 1 | -- | 1 |
| PEDSBL201 | Skill Based Lab-II Design of Large PED Systems | -- | 4[$] | -- | -- | 2 | -- | 2 |
| **Total** | | **15** | **06** | **--** | **15** | **03** | **--** | **18** |

| Course Code | Course Name | Examination Scheme | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Theory | | | | | Term Work | Prac / Oral | Total |
| | | Internal Assessment | | | End Sem. Exam | Exam. Duration (in Hrs) | | | |
| | | Test-1 | Test-2 | Avg | | | | | |
| PEDC201 | Advanced Power Electronics | 20 | 20 | 20 | 80 | 3 | -- | -- | 100 |
| PEDC202 | Digital Control of Electrical Drives | 20 | 20 | 20 | 80 | 3 | -- | -- | 100 |
| PEDPE201X | Program Elective 3 | 20 | 20 | 20 | 80 | 3 | -- | -- | 100 |
| PEDPE202X | Program Elective 4 | 20 | 20 | 20 | 80 | 3 | -- | -- | 100 |
| PEDIE201X | Institute Elective 2 | 20 | 20 | 20 | 80 | 3 | -- | -- | 100 |
| PEDL201 | DSP Applications Laboratory | -- | -- | -- | -- | -- | 25 | 25 | 50 |
| PEDSBL201 | Skill Based Lab-II Design of Large PED Systems | -- | -- | -- | -- | -- | 50 | 50 | 100 |
| **Total** | | **--** | **--** | **100** | **400** | **--** | **75** | **75** | **650** |

**Note 1:** Skill Based Lab- I and II are focused on the learning through experience. SBL shall facilitate the learner to acquire the fundamentals of practical engineering in his or her specialization in a project-oriented environment. The learning through skill based labs can be useful in facilitating their research work and hence useful in early completion of their dissertation work.

**Program Elective - 3**

PEDPE2011: Power Electronics in Power Systems
PEDPE2012: Industrial Load Modeling and Control
PEDPE2013: DSP Applications in Power Conversion Systems

**Program Elective - 4**

PEDPE2021: Design of Electric Vehicle System
PEDPE2022: Design of Power Converters
PEDPE2023: Power Converters for Renewable Energy

**Institute Elective - 2**

PEDIE2011: Environmental Management
PEDIE2012: Entrepreneurship Development
PEDIE2013: Finance Management
PEDIE2014: Project Management

## Semester III

| Course Code | Course Name | Teaching Scheme (Contact Hours) | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|
| | | Theory | Pract. | Tut. | Theory | Pract. | Tut. | Total |
| PEDMP301 | Major Project: Dissertation -I | -- | 20 | -- | -- | 10 | -- | 10 |
| **Total** | | **00** | **20** | **00** | **00** | **10** | **--** | **10** |

| Course Code | Course Name | Examination Scheme | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Theory | | | | | Term Work | Pract/ Oral | Total |
| | | Internal Assessment | | | End Sem. Exam | Exam. Duration (in Hrs) | | | |
| | | Test-1 | Test-2 | Avg | | | | | |
| PEDMP301 | Major Project: Dissertation -I | -- | -- | -- | -- | -- | 100 | -- | 100 |
| **Total** | | **--** | **--** | **--** | **--** | -- | **100** | **--** | **100** |

## Online Credit Courses

| Course Code | Course Name | Teaching Scheme (Contact Hours) | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|
| | | Theory | Pract. | Tut. | Theory | Pract. | Tut. | Total |
| PEDOCC301 | Online Credit Course - I | -- | -- | -- | -- | -- | -- | 3 |
| PEDOCC301 | Online Credit Course - II | -- | -- | -- | -- | -- | -- | 3 |
| **Total** | | **--** | **--** | **--** | **00** | **00** | **00** | **06** |

**Note 2:** It is mandatory to complete the Online Credit Courses (OCC) available on NPTEL / Swayam /MOOC or similar platform approved by BOS. These two courses shall be completed in any semester I or II or III, but not later end of the Semester III. College shall make a provision that credits earned with OCC- I and OCC-II shall be accounted in the third semester grade-sheet with actual names of courses. The learner shall be allowed to take up these courses from his or her institute or organisation/ industry where his / her major project is carried out. The students shall complete the courses and shall qualify the exam conducted by the respective authorities/ instructor from the platform. The fees for any such courses and the corresponding examination shall be borne by the learner.

**Online Credit Course – I**

The learner shall opt for the course in the domain of Research Methodology **or** Research & Publication Ethics or IPR. The opted course shall be of 3 credits of equivalent number of weeks.

**Online Credit Course –II**

The learner shall opt for the course recommended by Faculty Advisor/ Project Supervisor from the institute. The opted course shall be of 3 credits of equivalent number of weeks.

## Semester IV

| Course Code | Course Name | Teaching Scheme (Contact Hours) | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|
| | | Theory | Pract. | Tut. | Theory | Pract. | Tut. | Total |
| PEDMP401 | Major Project: Dissertation -II | -- | 32 | -- | -- | 16 | -- | 16 |
| **Total** | | **--** | **32** | **--** | **--** | **16** | **--** | **16** |

| Course Code | Course Name | Examination Scheme | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Theory | | | | | Term Work | Pract/ Oral | Total |
| | | Internal Assessment | | | End Sem. Exam | Exam. Duration (in Hrs) | | | |
| | | Test-1 | Test-2 | Avg | | | | | |
| PEDMP401 | Major Project: Dissertation -II | -- | -- | -- | -- | -- | 100 | 100 | 200 |
| **Total** | | **--** | **--** | **--** | **--** | -- | **100** | **100** | **200** |

**Note 3:** The Dissertation-II submission shall not be permitted till the learner completes all the requirements of M. Tech course.

**Note 4:** The contact hours for the calculation of load of the teacher for Major Project are as follows:
Major Project Dissertation I and II - 02 Hour / week / student

# D. Syllabi
# First & Second Year

| M. Tech. in Electrical Engineering (Power Electronics and Drives)- Sem-I | | | | | | |
|---|---|---|---|---|---|---|
| **Subject code** | **Subject Name** | **Teaching scheme (Contact Hours)** | | **Credits Assigned** | | |
| **PEDC101** | **Electrical Drives and Application** | **Theory** | **Pract./Tut.** | **Theory** | **Pract./Tut.** | **Total** |
| | | 3 | -- | 3 | | 3 |

| **Subject code** | **Subject Name** | **Examination Scheme** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **Theory** | | | | | **Term Work** | **Pract/ Oral** | **Total** |
| | | **Internal Assessment** | | | **End Sem. Exam** | **Exam Duration (in Hrs)** | | | |
| | | **Test 1** | **Test 2** | **Avg** | | | | | |
| **PEDC101** | **Electrical Drives and Application** | 20 | 20 | 20 | 80 | 3 | - | - | 100 |

| | |
|---|---|
| **Course Objectives** | **To impart knowledge on**<br>1. Modelling and control of various machines<br>2. Drives in various applications |
| **Course Outcomes** | **Upon successful completion of this course, the learner will be able:**<br>1. To develop mathematical model of an electrical machine.<br>2. To analyse scalar control schemes of induction motor.<br>3. To analyse vector control schemes of induction motor.<br>4. To analyse the control of PMSM, SyRM and BLDC motors.<br>5. To identify the motors, power modulators and the control schemes used in various applications. |

| **Module** | **Details** | **Hours** |
|---|---|---|
| Module I | **Electrical Machine Modelling:**<br>Modelling of DC Machine: Voltage and Torque equations, Time domain block diagram of DC shunt Machine, Modelling of AC Machine: Three Phase to Two Phase Transformation, Inverse Transformation, commonly used Reference Frames. Voltage and Torque equations, Dynamic model of Induction Machine. | 08 |
| Module II | **Scalar Control of Induction Motor:**<br>Variable voltage and Variable Frequency Operation of Three Phase Symmetrical Induction Machine, Drive Operating Regions, Different Scalar Control Schemes with block diagrams (Voltage fed Inverter Control and Current fed Inverter Control) | 06 |
| Module III | **Vector Control and Direct Torque Control of Induction Motor:**<br>Introduction, Direct or Feedback Vector Control, Flux Vector Estimation, Indirect or Feed Forward Vector Control, Stator Flux Oriented Vector Control, Sensorless Vector Control, Direct Torque and Flux Control (DTC), Adaptive Control: MRAC, Fuzzy logic control | 08 |
| Module IV | **Control of PMSM, BLDC Motor and Synchronous Reluctance Motor (SyRM):**<br>PMSM: V/Hz control, Self-Control Model, Vector control, Speed Control of BLDC Motor. Construction details and speed control of SyRM | 06 |
| Module V | **Domestic and Industrial Applications:**<br>Domestic applications of Drives and Control: Ceiling fan with single phase induction motor/BLDC motor, Refrigerator, Washing Machine, Air Conditioner, Mixer grinder.<br>Industrial Application: Drives in Cement factory, Steel Industry, Rolling Mills, Pumps, Blower Fans, Conveyors, Cranes and Lifts | 06 |
| Module VI | **Electrical Drives in Electric Vehicle Applications:** | 05 |

| | | |
|---|---|---|
| | Block Diagram of a typical EV powertrain. Power/Energy Supply Requirements for EV applications, Machines used for Propulsion Applications and Basic Control Schemes - Induction Motor, PMSM, BLDC motor, SyRM, SRM. | |

**Text Books:-**


1. Modern Power Electronics and A.C. Drives, B. K. Bose, Prentice Hall PTR.
2. Electric Motor Drives: Modeling, Analysis and Control, Krishnan.R, PHI.
3. First Course on Electrical Drives by S. K. Pillai, New Age International
4. Electrical Drives: Concepts and Applications by Vedam Subramanyam, T.M.H


**Reference Books:-**


1. Analysis of Electric Machinery P.C. Krause, McGraw Hill, New York
2. Power Semiconductor Controlled Drives, G. K. Dubey, Prentice-Hall International.
3. D. W. Novotny and T. A. Lipo, Vector Control and Dynamics of AC Drives, Oxford University Press, 1996.
4. Power Electronics by Muhammad H. Rashid, Pearson
5. Control of Electrical drives, W. Leonhard, Springer-Verlag.
6. John Chiasson, Modelling and High Performance Control of Electric Machines, Wiley- IEEE Press, 2005.
7. I. Boldea, S. A. Nasar, Vector Control of AC Drives, CRC Press, 1992.


**Assessment:**
Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

**Theory Examination:**
1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining questions will be randomly selected from all the modules.

| M. Tech. in Electrical Engineering (Power Electronics and Drives)- Sem-I | | | | | | |
|---|---|---|---|---|---|---|
| **Subject code** | **Subject Name** | **Teaching scheme (Contact Hours)** | | **Credits Assigned** | | |
| **PEDC102** | **Power Electronic Converters** | **Theory** | **Pract./Tut.** | **Theory** | **Pract./Tut.** | **Total** |
| | | 3 | -- | 3 | | 3 |

| **Subject code** | **Subject Name** | **Examination Scheme** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **Theory** | | | | | **Term Work** | **Pract/ Oral** | **Total** |
| | | **Internal Assessment** | | | **End Sem. Exam** | **Exam Duration (in Hrs)** | | | |
| | | **Test 1** | **Test 2** | **Avg** | | | | | |
| **PEDC102** | **Power Electronic Converters** | 20 | 20 | 20 | 80 | 3 | - | - | 100 |

| | |
|---|---|
| **Course Objectives** | **To impart knowledge on**<br>1. To understand and acquire knowledge about various power semiconductor devices related to its characteristics, ratings, protection and to select semiconductor devices for various applications.<br>2. To introduce different methods of power conversion such as ac to dc, dc to dc, dc to ac the underlying principles of converter operation and hence to analyze different converter circuits for power conversion.<br>3. To keep abreast with the latest technologies and research going on in different areas related to power electronics.<br>4. To enhance the capability of problem solving skills. |
| **Course Outcomes** | **Upon successful completion of this course, the learner will be able to**<br>1. Select and design power electronic converter topologies for a broad range of energy conversion applications.<br>2. Ability to analyze various single phase and three phase power converter circuits and understand their applications.<br>3. Apply the basic concepts of power electronics to design the circuits in the fields of AC and DC drives, power generation and transmission and energy conversion, industrial applications, extraction of energy from renewable sources.<br>4. Determine the drive circuit requirements in terms of electrical isolation and design heat sink, snubber circuit for protection |

| **Module** | **Details** | **Hrs** |
|---|---|---|
| Module I | **Power semiconductor Devices**<br>Review of Power Devices: SCR, BJT, MOSFET, IGBT, Safe operating Limits, selection of devices for various applications, Conduction and Switching losses, numericals, Wide band gap devices (WBC): SiC, GaN devices. | 07 |
| Module II | **Drive circuits and Protection:**<br>Gate drive requirements, Types of driver circuits, Driver ICs, Driver circuit requirements for WBC devices. Protection circuits: Snubber circuits and its design, temperature control and heat-sinks, numericals. | 06 |
| Module III | **DC to DC converters**<br>Analysis of various conduction modes of $2^{nd}$ order converters: Buck, Boost, Buck-Boost converters, Introduction to $4^{th}$ order converters: Cuk and SEPIC converters in CCM, waveforms, output voltage derivation, comparison of dc to dc converters, numericals, Introduction to interleaved dc-dc converters. | 08 |
| Module IV | **Power factor and power decoupling in Rectifiers** | 06 |

| | | |
|---|---|---|
| | Causes for poor power factor in diode rectifiers, effect of power factor on firing angle in thyristor rectifiers, Single phase PWM rectifiers and its applications, Power factor improvement using DC-DC converters.<br>Need for power decoupling in single phase rectifiers, single phase power decoupling techniques in rectifiers. | |
| Module V | **DC to AC converters and modulation strategies:**<br>Output waveforms of single and Three phase VSI, blanking/dead time requirement, harmonic analysis of load voltage, Current source inverters, comparison of VSI and CSI, numericals. | 06 |
| Module VI | **PWM modulation strategies**:<br>Single phase Sinusoidal PWM (unipolar, bipolar), effect of amplitude and frequency modulation index, Hysterisis PWM, Three phase SPWM, Space vector modulation. | 06 |

**Text Books**:


1. N. Mohan, T. M. Undeland, W.P Robbins, Power Electronics, Converters, Applications & Design, Wiley India Pvt. Ltd.
2. M. H. Rashid, Hand book of Power Electronics", Academic Press,2001.
3. Daniel.W.Hart, "Power Electronics", Mc GrawHill Publications 2010.
4. Joseph Vithayathil, Power Electronics, Tata McGraw Hill.
5. P.S Bhimbra, "Power Electronics", Khanna Publishers.
6. Simon Ang, Alejandro Oliva, "Power-Switching Converters" Taylor and Francis group
7. R W Erickson and D Maksimovic, Fundamental of Power Electronics Springer, 2nd Edition.


**Other References/Journals**


1. P. T. Krein, Elements of Power Electronics, Oxford University Press.
2. L. Umanad, "Power Electronics: Essentials & Applications," Wiley.
3. IEEE Transaction journals, IECON, APEC and other power electronic related Conference Proceedings etc.


**Assessment:**

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

**Theory Examination**:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining questions will be randomly selected from all the modules.

| M. Tech. in Electrical Engineering (Power Electronics and Drives)- Sem-I | | | | | | |
|---|---|---|---|---|---|---|
| **Subject code** | **Subject Name** | **Teaching scheme (Contact Hours)** | | **Credits Assigned** | | |
| **PEDPE1011** | **Machine Learning Techniques in Power System** | **Theory** | **Pract./Tut.** | **Theory** | **Pract./Tut.** | **Total** |
| | | 3 | -- | 3 | | 3 |

| **Subject code** | **Subject Name** | **Examination Scheme** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **Theory** | | | | | | | |
| | | **Internal Assessment** | | | **End Sem. Exam** | **Exam Duration (in Hrs)** | **Term Work** | **Pract/ Oral** | **Total** |
| | | **Test 1** | **Test 2** | **Avg** | | | | | |
| **PEDPE1011** | **Machine Learning Techniques in Power System** | 20 | 20 | 20 | 80 | 3 | - | - | 100 |

| | |
|---|---|
| **Course Objectives** | **To impart knowledge on**<br>1. Understand the motivation for different machine learning algorithms and select the appropriate algorithm for a given problem<br>2. Use the backpropagation algorithm to calculate weight gradients in a feed forward neural network by hand<br>3. Write a machine learning algorithm from scratch using Python libraries, and analyse its performance. |
| **Course Outcomes** | **Upon successful completion of this course, the learner will be able to:**<br>1. To compare and contrast pros and cons of various machine learning techniques and to get an insight of when to apply a particular machine learning approach.<br>2. To understand the importance of Decision tree algorithms in machine learning<br>3. To analyse and implement various machine learning approaches and paradigms using python libraries.<br>4. Extract features that can be used for a particular machine learning approach in various applications in electrical engineering. |

| **Module** | **Details** | **Hrs** |
|---|---|---|
| Module I | **Introduction to machine learning:** Impact in daily lives. Brief history of Machin learning. Machine learning techniques: Supervised, Unsupervised, Reinforcement, Neural Network. Train and test methodology, Issues in Machine Learning, Overfitting, Machine learning versus Artificial Intelligence , Ethics in AI, Introduction to Python, Libraries for Machine learning. | 04 |
| Module II | **Decision Tree:** Introduction, Decision tree representation, appropriate problems for decision tree learning, basic decision tree algorithm, hyperspace search in decision tree learning, issues in decision tree learning. | 06 |
| Module III | **Supervised Learning:** Regression, Linear Regression, Multilinear Regression, Logistic Regression, Best fit line, Decision Line, Regression model in Python. | 06 |
| Module IV | **Clustering & Unsupervised Learning:** Learning from unclassified data. Clustering, Hierarchical Agglomerative Clustering. K-means clustering. Expectation maximization (EM) for soft clustering. Semi-supervised learning with EM using labelled and unlabelled data, clustering model in Python. | 08 |
| Module V | **Artificial Neural Network:** Introduction, Feed Forward Neural Networks, basic neural network structure, The Perceptron, forward propagation, cost functions, nonlinear function, Multilayer network. | 09 |

| | | |
|---|---|---|
| Module VI | **Back propagation Algorithm and Applications:** backpropagation, error, training by gradient descent, bias/variance and under/overfitting, regularization, ANN model in Python, Applications of machine learning in electrical engineering: smart grid, renewable energy generation, Forecasting. | 06 |

**Text Books:**


1. Introduction to Machine Learning with Python: A Guide for Data Scientists by Andreas C. Mueller, Sarah Guido, Published by O'Reilly Media, Inc.
2. Introduction to Artificial Neural Systems Jacek M. Zurada, JAICO Publishing House Ed. 2006.
3. Neural Network Design, Second Edition, Martin T. Hagan, Howard B. Demuth, Mark Hudson Beale, and Orlando De Jesús, 2014.


**Reference Books:**


1. Introduction to Machine Learning, By Ethem Alpaydin
2. Neural Networks a Comprehensive Foundations, Simon S Haykin, PHI Edition,


**Assessment:**
Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

**Theory Examination**:
1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining questions will be randomly selected from all the modules.

| M. Tech. in Electrical Engineering (Power Electronics and Drives)- Sem-I | | | | | | |
|---|---|---|---|---|---|---|
| **Subject code** | **Subject Name** | **Teaching scheme (Contact Hours)** | | **Credits Assigned** | | |
| **PEDPE1012** | **Power Quality in Power System** | **Theory** | **Pract./Tut.** | **Theory** | **Pract./Tut.** | **Total** |
| | | 3 | -- | 3 | | 3 |

| **Subject code** | **Subject Name** | **Examination Scheme** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **Theory** | | | | | | | |
| | | **Internal Assessment** | | | **End Sem. Exam** | **Exam Duration (in Hrs)** | **Term Work** | **Pract/ Oral** | **Total** |
| | | **Test 1** | **Test 2** | **Avg** | | | | | |
| **PEDPE1012** | **Power Quality in Power System** | 20 | 20 | 20 | 80 | 3 | - | - | 100 |

| | |
|---|---|
| **Course Objectives** | **To impart knowledge on**<br>1. To know various power quality issues, it causes and effects<br>2. To understand effects of harmonics due to non-linear load<br>3. To learn mitigation methods for harmonics |
| **Course Outcomes** | **Upon successful completion of this course, the learner will be able to**<br>1. To identify the problems in power system due to harmonics<br>2. To suggest solutions to the problems due to power quality |

| **Module** | **Contents** | **Hours** |
|---|---|---|
| Module I | **Introduction:**<br>Sources and Effects of power quality problems, types of power quality disturbances - Voltage sag (or dip), Swell, Transients, short duration voltage variation, long duration voltage variation, voltage imbalance, waveform distortion, and voltage flicker. | 06 |
| Module II | **Fundamentals of Harmonics:**<br>Harmonic Distortion, Voltage versus Current Distortion, Harmonics versus Transients, Harmonic Sources from Commercial Loads, Harmonic Sources from Industrial Loads, Locating Harmonic Sources, System Response Characteristics, Effects of Harmonic Distortion, Inter-harmonics | 06 |
| Module III | **Power Quality Evaluation:**<br>IEEE guide lines, Standards and recommended practices, Harmonics mechanism of harmonic generation, harmonic indices (THD, TIF, DIN, C – message weights) Power Quality Costs Evaluation, Harmonic sources, Switching devices, arcing devices, saturable devices. Effects of Power System, harmonics on Power System equipment and loads. | 06 |
| Module IV | **Power Factor Compensation in linear circuits:**<br>Linear circuits with Sinusoidal Supply-Basic relationship, complex power, apparent power, power factor and power factorcompensation<br>Linear circuits with non-Sinusoidal Supply-Basic relationship, complex power, apparent power, power factor and power factorcompensation. | 06 |
| Module V | **Power Factor Compensation in non-linear circuits:**<br>Non-Linear circuits with Sinusoidal Supply-Basic relationship, complex power, apparent power, power factor and power factor compensation.<br>Non-Linear circuits with non-Sinusoidal Supply-Basic relationship, complex power, apparent power, power factor and power factor compensation. | 07 |

| | | |
|---|---|---|
| Module VI | **Power Quality Mitigation Techniques:**<br>Passive Filters, Shunt Active Filters, Series Active Filters, Unified Power Quality Compensators | 08 |

**Text Books:**


1. Roger C. Dugan, Mark F. McGranaghan and H.Wayne Beaty, ―Electrical Power System Quality, MC Graw Hill
2. G.T. Heydt , Electric Power Quality, Stars in a Circle Publications
3. J. Arrillaga, N.R. Watson and S. Chen, Power System Quality Assessment, John Wiley & Sons
4. W. Shepherd and P. Zand, Energy flow and power factor in non-sinusoidal circuits, Cambridge University Press
5. IEEE-519: 1992, IEEE Recommended Practices and Requirements for Harmonic Control in Electric Power Systems
6. Bhim Singh, Ambrish Chandra, Kamal Al-Haddad, Power Quality: Problems and Mitigation Techniques, John Wiley & Sons, First Edition 2015


**Reference Book/Journals:**


1. Jos Arrillaga, B.C. Smith, Neville R Watson and A.R. Wood, Power System Harmonics Analysis, Wiley 1997
2. Math H.J. Bollen, Understanding Power Quality Problems, Voltage Sag and Interruptions, Wiley-IEEE Press
3. Selected research papers in IEEE Transactions on Power Systems, IEEE Transactions on Power Delivery, and IEEE Transaction on Power Quality


**Assessment:**

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

**Theory Examination**:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining questions will be randomly selected from all the modules.

| M. Tech. in Electrical Engineering (Power Electronics and Drives)- Sem-I | | | | | | |
|---|---|---|---|---|---|---|
| **Subject code** | **Subject Name** | **Teaching scheme (Contact Hours)** | | **Credits Assigned** | | |
| **PEDPE1013** | **Electric Vehicle Technology** | **Theory** | **Pract./Tut.** | **Theory** | **Pract./Tut.** | **Total** |
| | | 3 | -- | 3 | | 3 |

| **Subject code** | **Subject Name** | **Examination Scheme** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **Theory** | | | | | | | |
| | | **Internal Assessment** | | | **End Sem. Exam** | **Exam Duration (in Hrs)** | **Term Work** | **Pract/ Oral** | **Total** |
| | | **Test 1** | **Test 2** | **Avg** | | | | | |
| **PEDPE1013** | **Electric Vehicle Technology** | 20 | 20 | 20 | 80 | 3 | - | - | 100 |

| | |
|---|---|
| **Course Objectives** | **To impart knowledge on**<br>1. Know the history of electric hybrid electric vehicles (EV & HEV) and emphasize the need and importance of EV-HEV for sustainable future.<br>2. Introduce the fundamental concepts and principles of electric and hybrid electric vehicles drive train topologies.<br>3. Develop a thorough understanding of the key elements of EV/HEV: Electric Machines for Propulsion Applications and Energy Sources<br>4. Model, analyze and design electric and hybrid electric vehicles drive train and to understand energy management strategies |
| **Course Outcomes** | **Upon successful completion of this course, the learner will be able to**<br>1. To identify and describe the history and evolvement of electric & hybrid electric vehicles to emphasize on the need and importance of EV/HEV for sustainable future.<br>2. To identify and describe the principles of various EV/HEVs drive train topologies along with their power flow control and fuel efficiency estimation. \<br>3. To design and select electric propulsion system components for EV/HEV drives suitability for the desirable performance and control.<br>4. To compare and evaluate various energy sources and energy storage components for EV and HEV applications.<br>5. To model, analyze and design EV/HEV drive train with energy management strategies.<br>6. To recognize the need to adapt and engage in operations EV/HEV with the absolute technological change in the transportation system for sustainable future. |

| **Module** | **Contents** | **Hours** |
|---|---|---|
| Module I | Introduction:<br>Conventional Vehicles: Basics of vehicle performance, vehicle power source characterization, transmission characteristics, mathematical models to describe vehicle performance. Historical background of EV/HEV. Current state of the art in EV/HEV technology. | 05 |
| Module II | **Hybrid Electric Vehicles:**<br>History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies. Hybrid Electric Drive-trains: Basic concept of hybrid traction, introduction to various hybrid drivetrain topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis. | 07 |

| | | |
|---|---|---|
| Module III | **Electric Drive Trains:**<br>Electric Drive-trains: Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis. Electric Propulsion unit: Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives, configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives, drive system efficiency. | 08 |
| Module IV | **Energy Storage:**<br>Energy Storage: Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Super Capacitor based energy storage and its analysis, Flywheel based energy storage and its analysis, Hybridization of different energy storage devices. Sizing the drive system: Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology, Communications, supporting subsystems | 08 |
| Module V | **Energy Management Strategies:**<br>Energy Management Strategies: Introduction to energy management strategies used in hybrid and electric vehicles, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy management strategies. | 06 |
| Module VI | **Design of EV/HEV:**<br>Design considerations for a Hybrid Electric Vehicle (HEV), Design considerations for Battery Electric Vehicle (BEV). | 04 |

**Text Books:**


1. C. Mi, M. A. Masrur and D. W. Gao, Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives, John Wiley & Sons, 2011.
2. S. Onori, L. Serrao and G. Rizzoni, Hybrid Electric Vehicles: Energy Management Strategies, Springer, 2015.
4. M. Ehsani, Y. Gao, S. E. Gay and A. Emadi, Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design, CRC Press, 2004.
5. T. Denton, ―Electric and Hybrid Vehicles, Routledge, 2016


**Assessment:**

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

**Theory Examination**:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining questions will be randomly selected from all the modules.

| M. Tech. in Electrical Engineering (Power Electronics and Drives)- Sem-I | | | | | | |
|---|---|---|---|---|---|---|
| **Subject code** | **Subject Name** | **Teaching scheme (Contact Hours)** | | **Credits Assigned** | | |
| **PEDPE1021** | **Digital Signal Controller** | **Theory** | **Pract./Tut.** | **Theory** | **Pract./Tut.** | **Total** |
| | | 3 | -- | 3 | | 3 |

| **Subject code** | **Subject Name** | **Examination Scheme** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **Theory** | | | | | | | |
| | | **Internal Assessment** | | | **End Sem. Exam** | **Exam Duration (in Hrs)** | **Term Work** | **Pract/ Oral** | **Total** |
| | | **Test 1** | **Test 2** | **Avg** | | | | | |
| **PEDPE1021** | **Digital Signal Controller** | 20 | 20 | 20 | 80 | 3 | - | - | 100 |

| | |
|---|---|
| **Course Objectives** | • To impart knowledge of digital signal controllers with in depth understanding of various on-chip peripherals<br>• To impart knowledge of peripheral interfaces and programming of DSC |
| **Course Outcomes** | **Upon successful completion of this course, the learner will be able to:**<br>1. Illustrate the need for DSC in power and control applications<br>2. Describe the architectural features and details of DSC<br>3. Design the DSC analog interface for real world measurements<br>4. Use the DSC digital interface for power and control applications<br>5. Compare and recommend the use of on-chip communication for various applications |

| **Module** | **Details** | **Hours** |
|---|---|---|
| Module I | **Introduction**<br>Review of microprocessor, microcontroller and digital signal processors (DSP) architecture, Fixed and floating-point processors Number formats and operations: Fixed point 16 bit numbers representations of signed integers and fraction, Floating Point Numbers. Review of commonly used DSP processors and their applications, introduction to TMS320C2000 digital signal controller (DSC) | 06 |
| Module II | **DSC Architecture**<br>Overview of TMS320C2000 Digital signal controller family – Features, Architecture, Interrupt and Reset, Memory map - On-chip memories: Flash, RAM, and Boot ROM, Clock system | 06 |
| Module III | **DSC Programming**<br>Code development process, Assembly language programming, Linker, C Compiler, Code Composer Studio (CCS) and online debugging tools | 05 |
| Module IV | **Analog Interface for DSC**<br>Analog to Digital Converter (ADC): operating principal block diagram, modes of operation, configuration of ADC sensing voltage, current and other analog signal, programming for analog interface. Design aspects for real world measurements. | 07 |
| Module V | **Digital Interface for DSC:**<br>Block diagram, operation and configuration details of-Digital I/O -CPU Timers –Pulse Width Modulator (PWM), High Resolution PWM, Capture Module, Quadrature Encoder Pulse (QEP); use of these peripherals for real time power and control applications | 08 |

| | | |
|---|---|---|
| Module VI | **DSC Communication Interface and Protocols:**<br>On chip communication interface, configuration and use- Controller Area Network, SPI/SCI, I2C. Physical layer interface, programming for data transfer. | 07 |

**Reference Books:**


1. Digital Signal Processing in Power Electronics Control Circuits by Krzysztof Sozanski, Springer
2. Digital Signal Processing in Power System Protection and Control by Waldemar Rebizant, Janusz Szafran, and Andrzej Wiszniewski, Springer.
3. Digital Power Electronics and Applications by *Fang Lin Luo, Hong Ye and Muhammad Rashid,* Elsevier Academic Press.
4. Digital Signal Processing in Power Electronics Control Circuits by Krzysztof Sozanski, Springer
5. DSP Based Electromechanical Motion Control by Hamid Toliyat and Steven Campbell, CRC Press


**Web References:**


1. https://training.ti.com/c2000-f2837xd-microcontroller-one-day-workshop-series
2. https://software-dl.ti.com/trainingTTO/trainingTTO_public_sw/c28x28379/F2837xD_Microcontroller_M
3. https://www.ti.com/microcontrollers-mcus-processors/microcontrollers/c2000-real-time-control-mcus/overview.html
4. The Essential Guide for Developing with C2000™RealTime Microcontrollers: Texas Instruments


**Assessment:**

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

**Theory Examination**:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining questions will be randomly selected from all the modules.

| M. Tech. in Electrical Engineering (Power Electronics and Drives)- Sem-I | | | | | | |
|---|---|---|---|---|---|---|
| **Subject code** | **Subject Name** | **Teaching scheme (Contact Hours)** | | **Credits Assigned** | | |
| **PEDPE1022** | **Microgrid Technology** | **Theory** | **Pract./Tut.** | **Theory** | **Pract./Tut.** | **Total** |
| | | 3 | -- | 3 | | 3 |

| **Subject code** | **Subject Name** | **Examination Scheme** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **Theory** | | | | | **Term Work** | **Pract/ Oral** | **Total** |
| | | **Internal Assessment** | | | **End Sem. Exam** | **Exam Duration (in Hrs)** | | | |
| | | **Test 1** | **Test 2** | **Avg** | | | | | |
| **PEDPE1022** | **Microgrid Technology** | 20 | 20 | 20 | 80 | 3 | - | - | 100 |

| | |
|---|---|
| **Course Objectives** | 1. To introduce the fundamental concept, various power architectures and control of distributed generation and microgrids.<br>2. To review various regulatory standards and state of the art of microgrids<br>3. To understand the microgrid and Smart Grid deployments for large scale integration of clean energy sources, various technologies, automation and ICT infrastructure requirements. |
| **Course Outcomes** | **Upon successful completion of this course, the learner will be able to:**<br>1. To identify and describe the impact of renewable energy integration for mitigating energy crises and sustainable future.<br>2. To identify and describe the concept of Microgrid and its various topologies, modes of operation control and communication architecture.<br>3. To identify and describe the concept of Smart Grid, its features and the state of the art.<br>4. To understand various Smart Grid technologies, automation, resiliency and its adoption in current power system. |

| **Module** | **Details** | **Hours** |
|---|---|---|
| Module I | **Introduction:**<br>Present Energy Scenario, Review of various renewable technologies: Impact of grid integration of renewable energy resources on existing power system, Energy storage system and their role in enhancement of performance. | 02 |
| Module II | **Introduction to Microgrid:**<br>Concept of distributed generation, regulatory standard IEE 1547, DG installation classes, requirement for grid interconnection, security issue in DG, implementation and limitation, islanding issue; Concept of microgrid, review of sources of microgrids, typical structure and configuration of a microgrid, AC and DC microgrids, Power Electronics interfaces in DC and AC microgrids, modes of operation and control of microgrid: grid connected and islanded mode, Active and reactive power control, protection issues, anti-islanding schemes. | 12 |
| Module III | **Introduction to Smart Grid:** Evolution of Electric Grid, Concept of Smart Grid, Definitions, Need of Smart Grid, Functions of Smart Grid, Opportunities & Barriers of Smart Grid, Difference between conventional & smart grid, Concept of Resilient & Self-Healing Grid, Present development & International policies in Smart Grid. Case study of Smart Grid. CDM opportunities in Smart Grid | 06 |

| | | |
|---|---|---|
| Module IV | **Smart Grid Technologies:** Introduction to Smart Meters, Real Time Prizing, Smart Appliances, Automatic Meter Reading(AMR), Outage Management System(OMS), Plug in Hybrid Electric Vehicles(PHEV), Vehicle to Grid, Smart Sensors, Home & Building Automation | 04 |
| Module V | **Smart Grid Operations and Automation:** Smart Substations, Substation Automation, Feeder Automation. Geographic Information System (GIS), Intelligent Electronic Devices (IED) & their application for monitoring & protection, Wide Area Measurement System (WAMS), Phasor Measurement Unit (PMU) | 06 |
| Module VI | **Communication Technology for Microgrids & Smart Grid:** Advanced Metering Infrastructure (AMI), Home Area Network (HAN), Neighborhood Area Network (NAN), Wide Area Network (WAN). Bluetooth, ZigBee, GPS, Wi-Fi, Wi-Max based communication, Wireless Mesh Network, Basics of CLOUD Computing & Cyber Security for Smart Grid. | 06 |

**Books Recommended:**

*Reference Books:*


1. A. Yezdani, and Reza Iravani, Voltage *Source Converters in Power Systems: Modeling, Control and Applications*, John Wiley Publications, 2010
2. Dorin Neacsu, *Power Switching Converters: Medium and High Power*, CRC Press, 2006
3. A. Keyhani, M. N. Marwali, M. Dai, *Integration of Green and Renewable Energy in Electric Power Systems*, Wiley, 2009
4. B. M. Buchholz and Z. Styczynski, *Smart Grids – Fundamentals and Technologies in Electricity Networks,* Springer, 2014
5. C. W. Gellings, *The Smart Grid: Enabling Energy Efficiency and Demand Response*, CRC Press, 2009
6. J. Ekanayake, N. Jenkins, K. Liyanage, J. Wu, A. Yokoyama, *Smart Grid: Technology and Applications*, Wiley, 2012
7. J. C. Sabonnadière and N. Hadjsaïd, *Smart Grids*, John Wiley & Sons and ISTE, 2012
8. IEEE standards ―IEEE-1547-2003: IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems‖ IEEE standards 2003
9. IEEE standards ―IEEE 1547-4-2011: IEEE Guide for Design Operation & Integration of Distributed Resources Island System with Electric Power System,
10. Consortium for Electric Reliability Technology Solutions (CERTS) white paper on Integration of Distributed Energy Resources: _The CERTS Microgrid Concept‘ 2002


**Assessment:**

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

**Theory Examination**:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining questions will be randomly selected from all the modules.

| M. Tech. in Electrical Engineering (Power Electronics and Drives)- Sem-I | | | | | | |
|---|---|---|---|---|---|---|
| **Subject code** | **Subject Name** | **Teaching scheme (Contact Hours)** | | **Credits Assigned** | | |
| **PEDPE1023** | **IoT Application in Electrical Engineering** | **Theory** | **Pract./Tut.** | **Theory** | **Pract./Tut.** | **Total** |
| | | 3 | -- | 3 | | 3 |

| **Subject code** | **Subject Name** | **Examination Scheme** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **Theory** | | | | | **Term Work** | **Pract/ Oral** | **Total** |
| | | **Internal Assessment** | | | **End Sem. Exam** | **Exam Duration (in Hrs)** | | | |
| | | **Test 1** | **Test 2** | **Avg** | | | | | |
| **PEDPE1023** | **IoT Application in Electrical Engineering** | 20 | 20 | 20 | 80 | 3 | - | - | 100 |

| | |
|---|---|
| **Course Objectives** | 1. To learn the concepts of IOT.<br>2. To identify the different IoT technology.<br>3. To learn different protocols used in IOT.<br>4. To learn how to analyse the data in IOT.<br>5. To learn different applications in IOT |
| **Course Outcomes** | **Upon successful completion of this course, the learner will be able to:**<br>1. Apply the concepts of IOT.<br>2. Identify the different technology.<br>3. Analysis and evaluate protocols used in IOT<br>4. Analysis and evaluate the data received through sensors in IOT.<br>5. Apply IOT to different applications. |

| **Module** | **Details** | **Hours** |
|---|---|---|
| Module I | **Introduction to Internet of Things**:<br>Definition and characteristics of IoT, Physical design of IoT- Things in IoT, IoT protocol, Logical design of IoT – IoT functional blocks, IoT Communication Models, IoT communication APIs. | 04 |
| Module II | **Various Technologies for Implementations of IOT:**<br>Defining Specifications About - Purpose & requirements, process, domain model, information model, service, IoT level, Functional view, Operational view, Device and Component Integration, Application Development, Case Study | 06 |
| Module III | **Communication Technologies:**<br>Introduction to Communication Technologies 802.15.4, ZigBee, BLE, WiFi, LORA, GSM basic protocol, topologies, data rate, range, power, computations/bandwidth, QoS | 06 |
| Module IV | **Communication Model and Protocols:**<br>Communication Model and Protocols M2M vs IOT, Resource Management, Registration, Discovery Data Exchange Formats – XML & JSON, MQTT Protocol, RESTFul Architecture, HTTP REST Model , CoAP Protocol, Anti collisa protocol | 08 |
| Module V | **RFID Technology:**<br>Introduction, principle of RFID, components of RFID system: RFID tag, Reader, RFID middleware, issues, RFID, transponder, RFID architecture, | 09 |
| Module VI | **IOT Application**: | 06 |

| | | |
|---|---|---|
| | Case Studies of IOT Home (Smart Lighting and Intrusion detection), Cities (Smart Parking, Garbage collection), Environment (Pollution detection, Forest Fire Detection), Power (Smart Grid), Retail (Inventory Management), Health ( Monitoring and detection) | |

**Text Books:**


1. Francis DaCosta, Rethinking the Internet of Things: A Scalable Approach to Connecting Everything, 1st Edition, Apress Publications, 2013
2. Wimer Hazenberg, Menno Huisman and Sara Cordoba Rubino, Meta Products: Building the Internet of Things, BIS publishers.
3. Internet of Things connecting objects to the web, by Hakima Chaouchi, Wiley.
4. Internet of Things (A Hands-on-Approach) by Arshdeep Bhaga and Vijay Madisetti.


**Reference Books:**


1. The Internet of Things (MIT Press) by Samuel Greengard.
2. The Internet of Things (Connecting objects to the web) by Hakima Chaouchi (Wiley Publications).
3. RFID and the Internet of Things, by Herve chabanne, Wiley


**Assessment:**

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

**Theory Examination**:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining questions will be randomly selected from all the modules.

| M. Tech. in Electrical Engineering (Power Electronics and Drives)- Sem-I | | | | | | |
|---|---|---|---|---|---|---|
| **Course Code** | **Course Name** | **Teaching scheme (Contact Hours)** | | **Credits Assigned** | | |
| **PEDIE1011** | **Reliability Engineering** | **Theory** | **Pract./Tut.** | **Theory** | **Pract./Tut.** | **Total** |
| | | **3** | **--** | **3** | **--** | **3** |

| **Course code** | **Course Name** | **Examination Scheme** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **Theory** | | | | | **Term Work** | **Oral** | **Total** |
| | | **Internal Assessment** | | | **End Sem. Exam** | **Exam Duration (in Hrs)** | | | |
| | | **Test 1** | **Test 2** | **Avg** | | | | | |
| **PEDIE1011** | **Reliability Engineering** | **20** | **20** | **20** | **80** | **3** | **--** | **--** | **100** |

| | |
|---|---|
| **Course Objectives** | 1. To familiarize the students with various aspects of probability theory<br>2. To acquaint the students with reliability and its concepts<br>3. To introduce the students to methods of estimating the system reliability of simple and complex systems<br>4. To understand the various aspects of Maintainability, Availability and FMEA procedure |
| **Course Outcomes** | **Upon successful completion of this course, the learner will be able to:**<br>1. Understand and apply the concept of Probability to engineering problems<br>2. Apply various reliability concepts to calculate different reliability parameters<br>3. Estimate the system reliability of simple and complex systems<br>4. Carry out a Failure Mode Effect and Criticality Analysis |

| **Module** | **Detailed Contents** | **Hours** |
|---|---|---|
| 1 | **Probability theory:** Probability: Standard definitions and concepts; Conditional Probability, Baye's Theorem.<br>**Probability Distributions:** Central tendency and Dispersion; Binomial, Normal, Poisson, Weibull, Exponential, relations between them and their significance.<br>**Measures of Dispersion:** Mean, Median, Mode, Range, Mean Deviation, Standard Deviation, Variance, Skewness and Kurtosis. | 08 |
| 2 | **Reliability Concepts:** Reliability definitions, Importance of Reliability, Quality Assuranceand Reliability, Bath Tub Curve.<br>**Failure Data Analysis:** Hazard rate, failure density, Failure Rate, Mean Time To Failure (MTTF), MTBF, Reliability Functions.<br>**Reliability Hazard Models:** Constant Failure Rate, Linearly increasing, Time Dependent Failure Rate, Weibull Model. Distribution functions and reliability analysis. | 08 |
| 3 | **System Reliability:**<br>System Configurations: Series, parallel, mixed configuration, k out of n structure, Complex systems. | 05 |
| 4 | **Reliability Improvement:**<br>Redundancy Techniques: Element redundancy, Unit redundancy, Standby redundancies. Markov analysis.<br>System Reliability Analysis – Enumeration method, Cut-set method, Success Path method, Decomposition method. | 08 |

| | | |
|---|---|---|
| 5 | **Maintainability and Availability:**<br>System downtime, Design for Maintainability: Maintenance requirements, Design methods: Fault Isolation and self-diagnostics, Parts standardization and Interchangeability, Modularization and Accessibility, Repair Vs Replacement.<br>Availability – qualitative aspects. | 05 |
| 6 | **Failure Mode, Effects and Criticality Analysis:**<br>Failure mode effects analysis, severity/criticality analysis, FMECA examples. Fault tree construction, basic symbols, development of functional reliability block diagram, Fau1t tree analysis and Event tree Analysis | 05 |

**References:**


1. L.S. Srinath, "Reliability Engineering", Affiliated East-Wast Press (P) Ltd., 1985.
2. Charles E. Ebeling, "Reliability and Maintainability Engineering", Tata McGraw Hill.
3. B.S. Dhillion, C. Singh, "Engineering Reliability", John Wiley & Sons, 1980.
4. P.D.T. Conor, "Practical Reliability Engg.", John Wiley & Sons, 1985.
5. K.C. Kapur, L.R. Lamberson, "Reliability in Engineering Design", John Wiley & Sons.
6. Murray R. Spiegel, "Probability and Statistics", Tata McGraw-Hill Publishing Co. Ltd


**Assessment:**
Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

**Theory Examination**:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining questions will be randomly selected from all the modules.

| M.Tech in Electrical Engineering (Power Electronics and Drives)- Sem-I | | | | | | |
|---|---|---|---|---|---|---|
| **Course Code** | **Course Name** | **Teaching scheme (Contact Hours)** | | **Credits Assigned** | | |
| **PEDIE1012** | **Cyber Security and Laws** | **Theory** | **Pract./Tut.** | **Theory** | **Pract./Tut.** | **Total** |
| | | **3** | **--** | **3** | **--** | **3** |

| **Course code** | **Course Name** | **Examination Scheme** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **Theory** | | | | | **Term Work** | **Oral** | **Total** |
| | | **Internal Assessment** | | | **End Sem. Exam** | **Exam Duration (in Hrs)** | | | |
| | | **Test 1** | **Test 2** | **Avg** | | | | | |
| **PEDIE1012** | **Cyber Security and Laws** | **20** | **20** | **20** | **80** | **3** | **--** | **--** | **100** |

| | |
|---|---|
| **Course Objectives** | 1. To understand and identify different types cybercrime and cyber law<br>2. To recognized Indian IT Act 2008 and its latest amendments<br>3. To learn various types of security standards compliances |
| **Course Outcomes** | Upon successful completion of this course, the learner will be able to:<br>1. Understand the concept of cybercrime and its effect on outside world<br>2. Interpret and apply IT law in various legal issues<br>3. Distinguish different aspects of cyber law<br>4. Apply Information Security Standards compliance during software design and development |

| Module | Contents | Hours |
|---|---|---|
| 1 | **Introduction to Cybercrime:**<br>Cybercrime definition and origins of the world, Cybercrime and information security, Classifications of cybercrime, Cybercrime and the Indian ITA 2000, A global Perspective on cybercrimes. | 4 |
| 2 | **Cyber offenses & Cybercrime:**<br>How criminal plan the attacks, Social Engg, Cyber stalking, Cyber café and Cybercrimes, Botnets, Attack vector, Cloud computing, Proliferation of Mobile and Wireless Devices, Trends in Mobility, Credit Card Frauds in Mobile and Wireless Computing Era, Security Challenges Posed by Mobile Devices, Registry Settings for Mobile Devices, Authentication Service Security, Attacks on Mobile/Cell Phones, Mobile Devices: Security Implications for Organizations, Organizational Measures for Handling Mobile, Devices-Related Security Issues, Organizational Security Policies and Measures in Mobile Computing Era, Laptops | 9 |
| 3 | **Tools and Methods Used in Cyberline:**<br>Phishing, Password Cracking, Key loggers and Spywares, Virus and Worms, Steganography, DoS and DDoS Attacks, SQL Injection, Buffer Over Flow, Attacks on Wireless Networks, Phishing, Identity Theft (ID Theft) | 6 |
| 4 | **The Concept of Cyberspace**:<br>E-Commerce, The Contract Aspects in Cyber Law ,The Security Aspect of Cyber Law, TheIntellectual Property Aspect in Cyber Law, The Evidence Aspect in Cyber Law , The Criminal Aspect in Cyber Law, Global Trends in Cyber Law , Legal Framework for Electronic Data Interchange Law Relating to Electronic Banking , The Need for an Indian Cyber Law | 8 |

| | | |
|---|---|---|
| 5 | **Indian IT Act:**<br>Cyber Crime and Criminal Justice: Penalties, Adjudication and Appeals Under the IT Act,<br>2000, IT Act. 2008 and its Amendments | 6 |
| 6 | **Information Security Standard compliances**<br>SOX, GLBA, HIPAA, ISO, FISMA, NERC, PCI. | 6 |

**References:**


1. Nina Godbole, Sunit Belapure, *Cyber Security*, Wiley India, New Delhi
2. The Indian Cyber Law by Suresh T. Vishwanathan; Bharat Law House New Delhi
3. The Information Technology Act, 2000; Bare Act- Professional Book Publishers, New Delhi.
4. Cyber Law & Cyber Crimes by Advocate Prashant Mali; Snow White Publications, Mumbai
5. Nina Godbole, *Information Systems Security,* Wiley India, New Delhi
6. Kennetch J. Knapp, *Cyber Security &Global Information Assurance* Information Science Publishing.
7. William Stallings*, Cryptography and Network Security,* Pearson Publication
8. Websites for more information is available on: The Information Technology ACT, 2008- TIFR:https://www.tifrh.res.in
9. Website for more information: A Compliance Primer for IT professional: https://www.sans.org/reading-room/whitepapers/compliance/compliance-primerprofessionals-33538


**Assessment:**
Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

**Theory Examination**:
1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining questions will be randomly selected from all the modules.

| M.Tech in Electrical Engineering (Power Electronics and Drives)- Sem-I | | | | | | |
|---|---|---|---|---|---|---|
| **Course Code** | **Course Name** | **Teaching scheme (Contact Hours)** | | **Credits Assigned** | | |
| **PEDIE1013** | **Energy Audit and Management** | **Theory** | **Pract./Tut.** | **Theory** | **Pract./Tut.** | **Total** |
| | | **3** | **--** | **3** | **--** | **3** |

| **Course code** | **Course Name** | **Examination Scheme** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **Theory** | | | | | **Term Work** | **Oral** | **Total** |
| | | **Internal Assessment** | | | **End Sem. Exam** | **Exam Duration (in Hrs)** | | | |
| | | **Test 1** | **Test 2** | **Avg** | | | | | |
| **PEDIE1013** | **Energy Audit and Management** | **20** | **20** | **20** | **80** | **3** | **--** | **--** | **100** |

| | |
|---|---|
| **Course Objectives** | 1. To understand the importance energy security for sustainable development and the fundamentals of energy conservation.<br>2. To introduce performance evaluation criteria of various electrical and thermal installations to facilitate the energy management<br>3. To relate the data collected during performance evaluation of systems for identification of energy saving opportunities. |
| **Course Outcomes** | **Upon successful completion of this course, the learner will be able to:**<br>1. To identify and describe present state of energy security and its importance.<br>2. To identify and describe the basic principles and methodologies adopted in energy audit of a utility.<br>3. To describe the energy performance evaluation of some common electrical installations and identify the energy saving opportunities.<br>4. To describe the energy performance evaluation of some common thermal installations and identify the energy saving opportunities<br>5. To analyze the data collected during performance evaluation and recommend energy saving measures |

| **Module** | **Contents** | **Hours** |
|---|---|---|
| 1 | **Energy Scenario:**<br>Present Energy Scenario, Energy Pricing, Energy Sector Reforms, Energy Security, EnergyConservation and its Importance, Energy Conservation Act-2001 and its Features.<br>Basics of<br>Energy and its various forms, Material and Energy balance | 04 |
| 2 | **Energy Audit Principles:**<br>Definition, Energy audit- need, Types of energy audit, Energy management (audit) approach-understanding energy costs, Bench marking, Energy performance, Matching energy use to requirement, Maximizing system efficiencies, Optimizing the input energy requirements, Fuel and energy substitution. Elements of monitoring& targeting; Energy audit Instruments; Data and information-analysis.<br>Financial analysis techniques: Simple payback period, NPV, Return on investment (ROI), Internal rate of return (IRR) | 08 |
| 3 | **Energy Management and Energy Conservation in Electrical System:**<br>Electricity billing, Electrical load management and maximum demand Control; Power factor improvement, Energy efficient equipments and appliances, star ratings.<br>**Energy efficiency measures in lighting system, lighting control:** Occupancy sensors, daylight integration, and use of intelligent controllers. | 10 |

| | | |
|---|---|---|
| | Energy conservation opportunities in: water pumps, industrial drives, induction motors, motor retrofitting, soft starters, variable speed drives. | |
| 4 | **Energy Management and Energy Conservation in Thermal Systems:**<br>Review of different thermal loads; Energy conservation opportunities in: Steamdistribution system, Assessment of steam distribution losses, Steam leakages, Steam trapping, Condensate and flash steam recovery system.<br>General fuel economy measures in Boilers and furnaces, Waste heat recovery, use of insulation- types and application. HVAC system: Coefficient of performance, Capacity, factors affecting Refrigeration and Air Conditioning system performance and savings opportunities. | 10 |
| 5 | **Energy Performance Assessment:**<br>On site Performance evaluation techniques, Case studies based on: Motors and variable speed drive, pumps, HVAC system calculations; Lighting System: Installed Load Efficacy<br>Ratio (ILER) method, Financial Analysis. | 04 |
| 6 | **Energy conservation in Buildings:**<br>Energy Conservation Building Codes (ECBC): Green Building, LEED rating, Application ofNon-Conventional and Renewable Energy Sources | 03 |

**References:**


1. Handbook of Electrical Installation Practice, Geofry Stokes, Blackwell Science
2. Designing with light: Lighting Handbook, By Anil Valia, Lighting System
3. Energy Management Handbook, By W.C. Turner, John Wiley and Sons
4. Handbook on Energy Audits and Management, edited by A. K. Tyagi, Tata Energy ResearchInstitute (TERI).
5. Energy Management Principles, C.B.Smith, Pergamon Press
6. Energy Conservation Guidebook, Dale R. Patrick, S. Fardo, Ray E. Richardson, Fairmont Press
7. Handbook of Energy Audits, Albert Thumann, W. J. Younger, T. Niehus, CRC Press
8. www.energymanagertraining.com
9. www.bee-india.nic.in


**Assessment:**
Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

**Theory Examination**:
1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining questions will be randomly selected from all the modules.

| M.Tech. in Electrical Engineering (Power Electronics and Drives)- Sem-I | | | | | | |
|---|---|---|---|---|---|---|
| **Course Code** | **Course Name** | **Teaching scheme (Contact Hours)** | | **Credits Assigned** | | |
| **PEDIE1014** | **Operations Research** | **Theory** | **Pract./Tut.** | **Theory** | **Pract./Tut.** | **Total** |
| | | **3** | **--** | **3** | **--** | **3** |

| **Subject code** | **Subject Name** | **Examination Scheme** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **Theory** | | | | | **Term Work** | **Pract/ Oral** | **Total** |
| | | **Internal Assessment** | | | **End Sem. Exam** | **Exam Duration (in Hrs)** | | | |
| | | **Test 1** | **Test 2** | **Avg** | | | | | |
| **PEDPE1014** | **Operations Research** | 20 | 20 | 20 | 80 | 3 | - | - | 100 |

| | |
|---|---|
| **Course Objectives** | 1. Formulate a real-world problem as a mathematical programming model.<br>2. Understand the mathematical tools that are needed to solve optimization problems.<br>3. Use mathematical software to solve the proposed models. |
| **Course Outcomes** | Upon successful completion of this course, the learner will be able to:<br>1. Understand the theoretical workings of the simplex method, the relationship between a linear program and its dual, including strong duality and complementary slackness.<br>2. Perform sensitivity analysis to determine the direction and magnitude of change of a model's optimal solution as the data change.<br>3. Solve specialized linear programming problems like the transportation and assignment problems, solve network models like the shortest path, minimum spanning tree, and maximum flow problems.<br>4. Understand the applications of integer programming and a queuing model and compute important performance measures |

| **Module** | **Contents** | **Hours** |
|---|---|---|
| 1 | **Introduction to Operations Research**: Introduction, Structure of the Mathematical Model, Limitations of Operations Research<br>**Linear Programming**: Introduction, Linear Programming Problem, Requirements of LPP, Mathematical Formulation of LPP, Graphical method, Simplex Method Penalty Cost Method or Big M-method, Two Phase Method, Revised simplex method, **Duality**, Primal – Dual construction, Symmetric and Asymmetric Dual, Weak Duality Theorem, Complimentary Slackness Theorem, Main Duality Theorem, Dual Simplex Method, Sensitivity Analysis<br>**Transportation Problem**: Formulation, solution, unbalanced Transportation problem. Finding basic feasible solutions – Northwest corner rule, least cost method and Vogel's approximation method. Optimality test: the stepping stone method and MODI method.<br>**Assignment Problem**: Introduction, Mathematical Formulation of the Problem, Hungarian Method Algorithm, Processing of n Jobs Through Two Machines and m Machines, Graphical Method of Two Jobs m Machines Problem Routing Problem,Travelling Salesman Problem<br>**Integer Programming Problem**: Introduction, Types of Integer Programming Problems, Gomory's cutting plane Algorithm, Branch and Bound Technique. Introduction to Decomposition algorithms. | 14 |

| | | |
|---|---|---|
| 2 | **Queuing models**: queuing systems and structures, single server and multi-server models, Poisson input, exponential service, constant rate service, finite and infinite population | 05 |
| 3 | **Simulation**: Introduction, Methodology of Simulation, Basic Concepts, Simulation Procedure, Application of Simulation Monte-Carlo Method: Introduction, Monte-Carlo Simulation, Applications of Simulation, Advantages of Simulation, Limitations of Simulation | 05 |
| 4 | **Dynamic programming**. Characteristics of dynamic programming. Dynamic programming approach for Priority Management employment smoothening, capital budgeting, Stage Coach/Shortest Path, cargo loading and Reliability problems. | 05 |
| 5 | **Game Theory**. Competitive games, rectangular game, saddle point, minimax (maximin) method of optimal strategies, value of the game. Solution of games with saddle points, dominance principle. Rectangular games without saddle point – mixed strategy for 2 X 2 games. | 05 |
| 6 | **Inventory Models**: Classical EOQ Models, EOQ Model with Price Breaks, EOQ with Shortage, Probabilistic EOQ Model | 05 |

**REFERENCES:**


1. Taha, H.A. "Operations Research - An Introduction", Prentice Hall, (7th Edition), 2002.
2. Ravindran, A, Phillips, D. T and Solberg, J. J. "Operations Research: Principles and Practice", JohnWilley and Sons, 2nd Edition, 2009
3. Hiller, F. S. and Liebermann, G. J. "Introduction to Operations Research", Tata McGraw Hill,2002.
4. Operations Research, S. D. Sharma, KedarNath Ram Nath-Meerut
5. Operations Research, KantiSwarup, P. K. Gupta and Man Mohan, Sultan Chand & Sons


**Assessment:**
Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

**Theory Examination**:
1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining questions

| M. Tech. in Electrical Engineering (Power Electronics and Drives)- Sem-I | | | | | | |
|---|---|---|---|---|---|---|
| **Subject code** | **Subject Name** | **Teaching scheme (Contact Hours)** | | **Credits Assigned** | | |
| **PEDL101** | **Drives and Control Laboratory** | **Theory** | **Pract./Tut.** | **Theory** | **Pract./Tut.** | **Total** |
| | | -- | 2 | -- | 1 | 1 |

| **Subject code** | **Subject Name** | **Examination Scheme** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **Theory** | | | | | **Term Work** | **Oral** | **Total** |
| | | **Internal Assessment** | | | **End Sem. Exam** | **Exam Duration (in Hrs)** | | | |
| | | **Test 1** | **Test 2** | **Avg** | | | | | |
| **PEDL101** | **Drives and Control Laboratory** | -- | -- | -- | -- | -- | 25 | 25 | 50 |

| | |
|---|---|
| **Course Objectives** | To impart knowledge on electrical drives and control |
| **Course Outcomes** | **Upon successful completion of this course, the learner will be able to:**<br>1. Simulate drives and control applications.<br>2. Analyze the simulation results.<br>3. Identify the implementation methods of drives<br>4. Interface PLC with Drives for Automation |

**List of suggested experiments:**

1. Develop the model of DC Motor and analyze the performance (Simulation)
2. Develop the model of three phase Induction Motor and analyze the performance (Simulation)
3. Simulation of Half Controlled and Fully Controlled Converter fed DC Drives.
4. Four Quadrant Chopper fed DC Motor.
5. Simulation of PWM Inverter fed Three Phase Induction Motor Control: Compare stator voltage control and V/f control for a constant torque load.
6. Open loop V/f control of Three Phase Induction Motor.
7. Closed loop V/f control of Three Phase Induction Motor.
8. Vector Control of Three Phase Induction Motor.
9. Simulation of Sensorless Control of Three Phase Induction Motor.
10. Speed Control of BLDC Motor.
11. Speed Control of Permanent Magnet Synchronous Motor.
12. Electrical Braking of AC/DC Motor.
13. PLC with AC Drive for Automation - Control using digital / analog / Fieldbus Communication
14. PLC with AC Servo Drive for Position Control.

**Reference Books:-**


1. Analysis of Electric Machinery P.C. Krause, McGraw Hill, New York
2. Power Semiconductor Controlled Drives, G. K. Dubey, Prentice-Hall International.
3. D. W. Novotny and T. A. Lipo, Vector Control and Dynamics of AC Drives, Oxford University Press, 1996.
4. Power Electronics by Muhammad H. Rashid, Pearson
5. Control of Electrical drives, W. Leonhard, Springer-Verlag.
6. John Chiasson, Modelling and High Performance Control of Electric Machines, Wiley- IEEE Press, 2005.
7. I. Boldea, S. A. Nasar, Vector Control of AC Drives, CRC Press, 1992.

**Term work:**

Term work shall consist of **minimum eight experiments**.

| | |
|---|---|
| Experiments Performance | : 10 marks |
| Journal | : 10 marks |
| Attendance | : 05 marks |

The final certification and acceptance of term work ensures the minimum passing in the term work.

**Oral Examination:**

Oral examination will be based on entire lab work

| M. Tech. in Electrical Engineering (Power Electronics and Drives)- Sem-I | | | | | | |
|---|---|---|---|---|---|---|
| **Subject code** | **Subject Name** | **Teaching scheme (Contact Hours)** | | **Credits Assigned** | | |
| **PEDSBL101** | **Power Electronics System Design Laboratory** | **Theory** | **Pract./Tut.** | **Theory** | **Pract./Tut.** | **Total** |
| | | -- | **4** | **--** | **2** | **2** |

| **Subject code** | **Subject Name** | **Examination Scheme** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **Theory** | | | | | | | |
| | | **Internal Assessment** | | | **End Sem. Exam** | **Exam Duration (in Hrs)** | **Term Work** | **Oral** | **Total** |
| | | **Test 1** | **Test 2** | **Avg** | | | | | |
| **PEDSBL101** | **Power Electronics System Design Laboratory** | -- | -- | -- | -- | -- | **50** | **50** | **100** |

| | |
|---|---|
| **Course Objectives** | To impart knowledge on<br>1. Various auxiliary circuits required for power electronic converters<br>2. Hardware implementation aspects of converters |
| **Course Outcomes** | **Upon successful completion of this course, the learner will be able to:**<br>1. Design and implement auxiliary circuits of power electronic converters<br>2. Design and implement power electronic converters<br>3. Use controllers for power converter control |

**List of suggested experiments:**

1. Design of Gate driver circuits for Si devices like Power MOSFETS or IGBTs and its PCB fabrication.
2. Design of Gate driver circuits for Wide band gap devices like SiC or GaN and its PCB fabrication.
3. Design and Implementation of Snubber circuit and Heat sink
4. Design of transformer for isolated converter (flyback / full bridge / push pull / forward)
5. Design of PWM Controller IC based Closed loop controlled DC-DC Converter
6. Design of microcontroller based Closed loop controlled DC-DC Converter
7. Design and Implementation of a power electronic converter for drive application (BLDC motor/ any other motor)
8. Design of voltage or current controlled power electronic converter
9. Design of V/F controlled inverter for Induction motor

**Any other design exercise based on Power converters and their applications in various domains**

**References:**


1. Mohan Ned *et al.*, "Power Electronics Converters, Applications and Design", Wiley India Pvt. Ltd., New Delhi.
2. L. Umanand, Bhatt, "Design of Magnetic Components for Switched Mode Power Converters", John Wiley & Sons
3. NPTEL course on "Design of Power Electronic Converters", Prof. Shabari Nath, IIT Guwahati.
4. NPTEL course on "Advanced Power Electronics and Control", Prof. Avik Bhattacharya, IIT Roorkee.


**Term work:**

Term work shall consist of **minimum three experiments**.

Experiments Performance : 10 marks
Attendance : 05 marks
Journal : 10 marks

The final certification and acceptance of term work ensures the minimum passing in the term work.

**Oral Examination**:

Oral examination will be based on entire lab work

| M. Tech. in Electrical Engineering (Power Electronics and Drives)- Sem-II | | | | | | |
|---|---|---|---|---|---|---|
| **Subject code** | **Subject Name** | **Teaching scheme (Contact Hours)** | | **Credits Assigned** | | |
| **PEDC201** | **Advanced Power Electronics** | **Theory** | **Pract./Tut.** | **Theory** | **Pract./Tut.** | **Total** |
| | | 3 | -- | 3 | | 3 |

| **Subject code** | **Subject Name** | **Examination Scheme** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **Theory** | | | | | | | |
| | | **Internal Assessment** | | | **End Sem. Exam** | **Exam Duration (in Hrs)** | **Term Work** | **Pract/ Oral** | **Total** |
| | | **Test 1** | **Test 2** | **Avg** | | | | | |
| **PEDC201** | **Advanced Power Electronics** | 20 | 20 | 20 | 80 | 3 | - | - | 100 |

| | |
|---|---|
| **Course Objectives** | **To impart knowledge on**<br>1. Dc to dc conversion with isolation, the underlying principles of converter operation and hence to analyze different converter circuits for power conversion.<br>2. Design of magnetics such as high frequency transformers and inductors.<br>3. Modeling of converter and design the controller for deeper understanding and detailed analysis.<br>4. Latest technologies and research going on in different areas related to power electronics. |
| **Course Outcomes** | **Upon successful completion of this course, the learner will be able to**<br>1. Select and design magnetics and power electronic converters for a broad range of energy conversion applications.<br>2. Model and design controllers for the closed loop operation of power converters.<br>3. Apply the basic concepts of power electronics to design the circuits in the fields of AC and DC drives, power generation and transmission and energy conversion, industrial applications, extraction of energy from renewable sources.<br>4. Deliver technological solution in the field of power electronics. |

| **Module** | | |
|---|---|---|
| Module I | **Isolated dc to dc converters**<br>Advantages of switching power supplies, unidirectional and bidirectional core excitation, fly back, forward, push-pull and bridge converters, Selection of converters for various applications, numericals. | 08 |
| Module II | **Design of DC-DC converters:**<br>Selection of diode, controllable devices and capacitor of Buck, Boost, Buck-Boost converters and Flyback converters for various applications.<br>Design of Magnetics: Area product approach, design of high frequency inductor, design of high frequency transformer, numericals (No derivation in qu paper). | 05 |
| Module III | **Control Methods**<br>PWM duty ratio control, Voltage feed forward PWM control, current mode control, slope compensation, comparison of current mode and voltage mode control. | 04 |
| Module IV | **Modelling and Compensator design**<br>State space model of various ideal and non-ideal Buck, Boost and Buck-Boost and Flyback dc to dc converters, state space averaging techniques, small signal analysis, transfer function, feedback control, compensator design, State space model of VSI and compensator design. | 10 |
| Module V | **Multi-Level Inverter:**<br>Need for multilevel inverters, Diode clamped, flying capacitor and cascaded MLI, Phase shifted and level shifted PWM techniques, Applications of multilevel inverters. | 05 |

| | | |
|---|---|---|
| Module VI | **Applications of power electronic converters**<br>Comparison of hard switching and soft switching, ZVS & ZCS resonant converters in high frequency applications, Converters for extracting power from renewable sources like solar and wind, Converters for Uninterrupted power supplies. | 04 |

**Books Recommended:**

**Text Books:**


1. N. Mohan, T. M. Undeland, W.P Robbins, ―Power Electronics, Converters, Applications & Design, Wiley India Pvt. Ltd.
2. M. H. Rashid, ―Hand book of Power Electronics", Academic Press,2001.
3. Daniel Hart, "Power Electronics", McGraw Hill Publications 2010.
4. Joseph Vithayathil, ―Power Electronics, Tata McGraw Hill.
5. P.S Bhimbra, "Power Electronics", Khanna Publishers.
6. Simon Ang, Alejandro Oliva, "Power-Switching Converters" Taylor and Francis group
7. R W Erickson and D Maksimovic, Fundamental of Power Electronics‖ Springer, 2nd Edition.


**Other References/Journals**


1. P. T. Krein, Elements of Power Electronics‖, Oxford University Press.
2. L. Umanad, Power Electronics: Essentials & Applications, Wiley.
3. IEEE Transaction journals, IECON, APEC and other power electronic related Conference Proceedings etc.


**Assessment:**

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

**Theory Examination**:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining questions will be randomly selected from all the modules.

| M. Tech. in Electrical Engineering (Power Electronics and Drives)- Sem-II | | | | | | |
|---|---|---|---|---|---|---|
| **Subject code** | **Subject Name** | **Teaching scheme (Contact Hours)** | | **Credits Assigned** | | |
| **PEDC202** | **Digital Control of Electrical Drives** | **Theory** | **Pract./Tut.** | **Theory** | **Pract./Tut.** | **Total** |
| | | 3 | -- | 3 | -- | 3 |

| **Subject code** | **Subject Name** | **Examination Scheme** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **Theory** | | | | | **Term Work** | **Pract/ Oral** | **Total** |
| | | **Internal Assessment** | | | **End Sem. Exam** | **Exam Duration (in Hrs)** | | | |
| | | **Test 1** | **Test 2** | **Avg** | | | | | |
| **PEDC202** | **Digital Control of Electrical Drives** | 20 | 20 | 20 | 80 | 3 | -- | -- | 100 |

| | |
|---|---|
| **Course Objectives** | To impart knowledge on digital control of electrical drive |
| **Course Outcomes** | **Upon successful completion of this course, the learner will be able to:**<br>1. Design digital control scheme of DC-DC Converter<br>2. Design digital scalar control scheme of three phase induction motor<br>3. Design digital vector control scheme of three phase induction motor<br>4. Design digital control scheme of BLDC Motor |

| **Module** | **Details** | **Hours** |
|---|---|---|
| Module I | **Modelling and Analysis of Electrical Drive Components:**<br>Block diagram of DC drive, State space model of DC-DC converter (Buck/Boost), Small signal analysis of DC-DC converters. Modelling of DC Motors (Shunt motor). Block diagram of AC drive. Commonly used reference frames (d-q Stationary reference frame and synchronously rotating reference frame. State space Model of AC Motor (Induction motor), Large Signal Modelling of Inverter. Digital Data Acquisition system, Voltage Sensors, Current Sensors, Frequency Sensors and Speed Sensors. | 07 |
| Module II | **Digital control design:**<br>Practical Aspects of the Choice of Sampling Rate, Principles of Discretization, Digital controller with Bilinear Transformation, Inverse Z Transform to Derive Discrete Domain Equations, Frequency Response and Warping, Digital PID controller. Digital filter implementation. Anti-Wind Up Loop Implementation, ADC Delay Consideration. Selection of DSP according to the Requirement. | 06 |
| Module III | **Digital Control of DC-DC Converter:**<br>Open Loop Control of Buck/Boost Converter, Selection of Power switches. Current, Voltage and Dual Loop Closed Loop Digital Control of DC-DC Converter, Digital Control Loop Sampling Scheme, DC-DC Controller Design, Digital implementation of complete system. | 06 |
| Module IV | **Speed Controller:**<br>Basic Structure of the Speed-Controlled System, Open-loop and closed-loop Transfer Functions, Load Rejection of the Proportional Speed Controller, Proportional Speed Controller with Variable Reference, Proportional Speed Controller with Frictional Load, The Speed Controller with Proportional and Integral action, Transfer Functions of the system with a PI controller, Load Rejection with the PI Speed Controller, | 06 |

| | | |
|---|---|---|
| | Parameter Setting and the closed-loop Bandwidth, Discrete-time Implementation of Speed Controllers, Analysis of the System with a PI Discrete-time Speed Controller, High-frequency Disturbances and the Sampling Process. | |
| Module V | **Digital control of three phase Induction motor**:<br>Open loop Speed Control Implementation of Induction Motor using Sine PWM and Space Vector PWM controller or Third Harmonic Insertion technique, Speed Estimation Algorithm Using Encoder Signal, Closed Loop Scalar Control Implementation, Flux Estimation Algorithm, Indirect Vector Control Algorithm, Sine And Cosine Resolver for Direct Vector Control, Direct Vector Control Algorithm, Direct Torque Control Algorithm Implementation. | 08 |
| Module VI | **Digital Control of BLDC Motor, PMSM and Switched Reluctance Motor:**<br>Hall based Sensors, Look up Table Formation based on Hall Sensors Output, DSP Implementation: Speed and Torque Control using Voltage and Current Control Algorithms, Sensorless Control of BLDC Motor Drive, V/f Control of PMSM Motor, Vector control of PMSM Motor, Current Control of SRM with the help of Position Sensors, Digital ICs used for different types of motor control | 06 |

**Text Books:-**


1. Digital Control of Electrical Drives (Power Electronics and Power Systems) by Slobodan N. Vukosavic, Springer.
2. M. B. Patil, M. C. Chandorkar, V. Ramanarayanan, V. T. Ranganathan, Simulation of Power Electronic Circuits. Narosa Series in Power and Energy System, 2009.
3. Modern Power Electronics and AC Drives by B. K. Bose, Prentice Hall PTR
4. Advanced Electric Drives: Analysis, Control, and Modeling Using MATLAB / Simulink, Ned Mohan, Wiley, 2014.


**References:-**


1. Industrial Motion Control: Motor Selection, Drives, Controller Tuning, Applications, Hakan Gurocak, Wiley, 2016.
2. Electric Motor Drives: Modeling, Analysis and Control by Krishnan.R, PHI.
3. From Continuous-Times Domain to Microcontroller Code By Jonathan Dodge, P.E.
4. Designing a TMS320F280x Based Digitally Controlled DC-DC Switching Power Supply by Texas Instruments
5. Sensorless Field Oriented Control of 3-Phase Induction Motors Using F2833x by TI
6. Scalar (V/f) Control of 3-Phase Induction Motors by TI
7. BLDC Motor Control with Hall Sensors based on FRDM-KE02Z.


**Assessment:**
Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

**Theory Examination**:
1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining questions will be randomly selected from all the modules.

| M. Tech. in Electrical Engineering (Power Electronics and Drives)- Sem-II | | | | | | |
|---|---|---|---|---|---|---|
| **Subject code** | **Subject Name** | **Teaching scheme (Contact Hours)** | | **Credits Assigned** | | |
| **PEDPE2011** | **Power Electronics in Power System** | **Theory** | **Pract./Tut.** | **Theory** | **Pract./Tut.** | **Total** |
| | | 3 | -- | 3 | -- | 3 |

| **Subject code** | **Subject Name** | **Examination Scheme** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **Theory** | | | | | **Term Work** | **Pract/ Oral** | **Total** |
| | | **Internal Assessment** | | | **End Sem. Exam** | **Exam Duration (in Hrs)** | | | |
| | | **Test 1** | **Test 2** | **Avg** | | | | | |
| **PEDPE2011** | **Power Electronics in Power System** | 20 | 20 | 20 | 80 | 3 | -- | -- | 100 |

| | |
|---|---|
| **Course Objectives** | 1. To know the basic principle of conventional active and reactive power flow control in power systems and problems associated with long distance power transmission.<br>2. To make students aware how power electronics devices can be used to find solution to the problems in long distance power transmission |
| **Course Outcomes** | **Upon successful completion of this course, the learner will be able to:**<br>• Students should be able to select and implement proper compensator to solve the problems occurring in long distance power transmission |

| **Module** | **Details** | **Hours** |
|---|---|---|
| Module I | **Introduction:**<br>Steady state and dynamic problems in AC systems- Transmission interconnections- Flow of power in an AC system- Loading capability- Power flow and dynamic stability considerations of a transmission interconnection. Relative importance of controllable parameters. Basic types of FACTS controllers. | 08 |
| Module II | **Static shunt compensators:**<br>Objectives of shunt compensation, Methods of controllable Var generation. Variable impedance type static Var generators (TCR, TSR, TSC,FC-TCR), Switching converter type Var generators. | 08 |
| Module III | **Static series compensation:**<br>Objectives of series compensation- Variable impedance type series compensation- TSSC and TCSC. Switching converter type series compensators – SSSC. | 06 |
| Module IV | **Static voltage and phase angle regulators:**<br>Objectives of voltage and phase angle regulators, Approaches to TCVR and TCPAR, switching converter based voltage and phase angle regulators. | 06 |
| Module V | **Load Compensation:**<br>Objectives of load compensation. Compensating single phase loads using DSTATCOM, Ideal three phase shunt compensator structure, Series compensation of power distribution system using DVR. | 06 |
| Module VI | **Unified Power Flow Controller (UPFC):**<br>Basic operating principle, Conventional transmission control capabilities | 05 |

**Books Recommended:**

**Text Books:**

1. Hingorani N.G. & Gyugi L., Understanding FACTS :Concepts and Technology of Flexible AC Transmission Systems,‖ Wiley-IEEE Press
2. Timothy J. E. Miller, Reactive power control in Electric Systems, Wiley India Edition.

**Reference Books:**

1. Yong Hua Song ―Flexible AC Transmission System, Institution of Electrical Engineers, London
2. Arindam Ghosh and Gerard Ledwich, ― Power Quality Enhancement Using Custom Power Devices, Kluwer Academic Publishers

**Assessment:**

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

**Theory Examination**:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining questions will be randomly selected from all the modules.

| M. Tech. in Electrical Engineering (Power Electronics and Drives)- Sem-II | | | | | | |
|---|---|---|---|---|---|---|
| **Subject code** | **Subject Name** | **Teaching scheme (Contact Hours)** | | **Credits Assigned** | | |
| **PEDPE2012** | **Industrial Load Modelling and Control** | **Theory** | **Pract./Tut.** | **Theory** | **Pract./Tut.** | **Total** |
| | | 3 | -- | 3 | | 3 |

| **Subject code** | **Subject Name** | **Examination Scheme** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **Theory** | | | | | **Term Work** | **Pract/ Oral** | **Total** |
| | | **Internal Assessment** | | | **End Sem. Exam** | **Exam Duration (in Hrs)** | | | |
| | | **Test 1** | **Test 2** | **Avg** | | | | | |
| **PEDPE2012** | **Industrial Load Modelling and Control** | 20 | 20 | 20 | 80 | 3 | - | - | 100 |

| | |
|---|---|
| **Course Objectives** | 1. To understand the energy demand scenario<br>2. To understand the modelling of load and its ease to study load demand industrially<br>3. To know Electricity pricing models<br>4. 4. Study Reactive power management in Industries |
| **Course Outcomes** | **Upon successful completion of this course, the learner will be able to:**<br>1. Understand the role of Industrial load Management in present electrical energy scenario<br>2. Understand different load control techniques in industries and its application.<br>3. Understand reactive power management and its controls.<br>4. Understand various cooling and heating loads its control strategies<br>5. Understand captive power management and its control strategies<br>6. Understand and apply different optimal operation strategies to reduce demand of electricity during peak time. |

| **Module** | **Details** | **Hours** |
|---|---|---|
| Module I | **Introduction:**<br>Electric Energy Scenario-Demand Side Management-Industrial Load Management. Load Curves-Load Shaping Objectives-Methodologies. Barriers; Classification of Industrial Loads- Continuous and Batch processes -Load Modelling, Electricity pricing – Dynamic and spot pricing –Models. | 08 |
| Module II | **Load Control Methods:**<br>Direct load control- Interruptible load control. Bottom up approach- scheduling- Formulation of load models- Optimization and control algorithms - Case studies. | 07 |
| Module III | **Reactive Power Management**<br>Reactive power management in industries-controls-power quality impacts application of filters Energy saving in industries. | 06 |
| Module IV | **Cooling and Heating Loads:**<br>Load profiling- Modelling. Cold storage-Types- Control strategies. Optimal operation-Problem formulation- Case studies. | 06 |
| Module V | **Captive Power Management:**<br>Captive power units- Operating and control strategies- Power Pooling- Operation models. Energy banking-Industrial Cogeneration | 06 |

| | | |
|---|---|---|
| Module VI | **Optimal Operation Strategies:**<br>Selection of Schemes Optimal Operating Strategies. Peak load shaving-Constraints-Problem formulation- Case study. Integrated Load management for Industries | 06 |

**Books Recommended:**


1. C.O. Bjork “Industrial Load Management - Theory, Practice and Simulations", Elsevier, the Netherlands, 1989.
2. C.W. Gellings and S.N. Talukdar, “Load management concepts,” IEEE Press, New York, 1986, pp. 3-28.
3. Y. Manichaikul and F.C. Schweppe ," Physically based Industrial load", IEEE Trans. on PAS, April 1981.
4. H. G. Stoll, "Least cost Electricity Utility Planning”, Wiley Interscience Publication, USA, 1989.
5. I. J. Nagarath and D. P. Kothari, Modern Power System Engineering., Tata McGraw Hill publishers, New Delhi, 1995.
6. IEEE Bronze Book- “Recommended Practice for Energy Conservation and cost effective planning in Industrial facilities”, IEEE Inc, USA.


**Assessment:**

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

**Theory Examination**:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining questions will be randomly selected from all the modules

| M. Tech. in Electrical Engineering (Power Electronics and Drives)- Sem-II | | | | | | |
|---|---|---|---|---|---|---|
| **Subject code** | **Subject Name** | **Teaching scheme (Contact Hours)** | | **Credits Assigned** | | |
| **PEDPE2013** | **DSP Applications in Power Conversion Systems** | **Theory** | **Pract./Tut.** | **Theory** | **Pract./Tut.** | **Total** |
| | | 3 | -- | 3 | | 3 |

| **Subject code** | **Subject Name** | **Examination Scheme** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **Theory** | | | | | | | |
| | | **Internal Assessment** | | | **End Sem. Exam** | **Exam Duration (in Hrs)** | **Term Work** | **Pract/ Oral** | **Total** |
| | | **Test 1** | **Test 2** | **Avg** | | | | | |
| **PEDPE2013** | **DSP Applications in Power Conversion Systems** | 20 | 20 | 20 | 80 | 3 | - | - | 100 |

| | |
|---|---|
| **Course Objectives** | **To impart knowledge on**<br>1. Real time applications using DSP processors<br>2. Interfacing of DSP with various power converters<br>3. Programming DSP for Power and control applications |
| **Course Outcomes** | **Upon successful completion of this course, the learner will be able to:**<br>1. Use mathematical tools for DSP applications in real time power and control applications<br>2. Program the DSP for various building blocks of real time power and control applications<br>3. Design and implement DSP based control of power Electronic converters<br>4. Model and analyze the closed loop power Electronic system<br>5. Illustrate the use of DSP in various industrial applications |

| **Module** | **Details** | **Hours** |
|---|---|---|
| Module I | **Introduction:**<br>DSP/DSC for real time power and control applications, requirements, analog and digital interfaces.<br>Review of mathematical tools for DSP applications: numerical integration: Euler's implicit and explicit method, Heun's Method, Trapezoidal Method; Implementation of digital filters and transformations, PLL, Harmonic oscillator, Harmonic extraction. | 08 |
| Module II | **DSP based DC-DC Converter Control:**<br>Buck converter, Boost converter and Bidirectional Converter: closed loop control implementation: hardware and control program for current, voltage and power control.<br>Control implementation with PI, Type II and Type III controller | 08 |
| Module III | **DSP based DC-AC Converter Control:**<br>Standalone and Grid tied inverter (single and three phase) : closed loop control implementation: hardware and control program for current, voltage and power control. | 08 |
| Module IV | **DSP based AC-DC Converter Control:**<br>Active Front End (AFE) converter : closed loop control implementation: hardware and control programing | 07 |
| Module V | **DSP based multi-converter system:**<br>Multi-stage converter system control with DSP, requirement of analog / digital and communication interfaces | 04 |
| Module VI | **DSP applications in Industrial Domains:**<br>Overview of DSP applications in Traction converters, Electric Vehicles, UPS systems | 04 |

**Books Recommended:**

**Assessment:**
Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

**Theory Examination**:
1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining questions will be randomly selected from all the modules

| M. Tech. in Electrical Engineering (Power Electronics and Drives)- Sem-II | | | | | | |
|---|---|---|---|---|---|---|
| **Subject code** | **Subject Name** | **Teaching scheme (Contact Hours)** | | **Credits Assigned** | | |
| **PEDPE2021** | **Design of Electric Vehicles Systems** | **Theory** | **Pract./Tut.** | **Theory** | **Pract./Tut.** | **Total** |
| | | 3 | -- | 3 | | 3 |

| **Subject code** | **Subject Name** | **Examination Scheme** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **Theory** | | | | | **Term Work** | **Pract/ Oral** | **Total** |
| | | **Internal Assessment** | | | **End Sem. Exam** | **Exam Duration (in Hrs)** | | | |
| | | **Test 1** | **Test 2** | **Avg** | | | | | |
| **PEDPE2021** | **Design of Electric Vehicles Systems** | 20 | 20 | 20 | 80 | 3 | - | - | 100 |

| | |
|---|---|
| **Course Objectives** | 1. To illustrate the design philosophies used in the EV domain.<br>2. To explore the selection of power and control architecture of EV drives<br>3. To study the design aspects of EV battery packs and other auxiliary systems |
| **Course Outcomes** | **Upon successful completion of this course, the learner will be able:**<br>1. To select and size the electric motor for a particular EV application and performance criteria<br>2. To select and size the battery pack to meet desired EV performance and<br>3. To design the EV drive system with functional safety considerations.<br>4. To illustrate the use of hybrid energy source for EV performance improvement<br>5. To illustrate the design aspects of Automotive Subsystem<br>6. To design the EV chargers and charging infrastructure |

| **Module** | **Details** | **Hours** |
|---|---|---|
| Module I | **Selection/ Sizing of EV Electric Motors:**<br>Electric Vehicle modelling, Tractive force calculations, Design considerations for 2W, 3W and 4W EVs; Torque, power and Speed requirement, Traction Limit, Maximum Acceleration Limit, Maximum Grade Limit, Vehicle Power Demand Vehicle Performance Envelope, and Vehicle Power Envelope; Vehicle Power Demand during Driving Cycles.<br>Design considerations for EV motors and their cooling system. Application Examples of EV /HEV motors with vehicles and motor specifications. | 08 |
| Module II | **Selection/ Sizing of Battery pack and other Energy Resource:**<br>Selection of type of Battery pack for 2W, 3W and 4W EVs; Battery pack sizing: Design considerations: Range per charge, range anxiety, EV motor power requirement; Impact of road conditions, environmental conditions and traffic conditions.<br>High-Voltage Cabling and Disconnects, Safety in Battery Design, Testing for safety. Accelerated Reliability Testing of Electric Vehicles, Battery Cycle Life versus Peak Power and Rest Period.<br>Selection and sizing of Fuel cell for FCEV, design considerations; Battery-ultra-capacitor hybrid combination sizing, performance analysis.<br>Design considerations for Ultra-capacitor based EV, requirement of charging infra.<br>Flywheel selection and sizing for EV/HEV applications. | 12 |
| Module III | **Automotive Subsystem Design:** | 06 |

| | | |
|---|---|---|
| | Electronic Control Unit (ECU) and its Control Features, Communications between ECUs, Control Software Development: Software-in-the-Loop (SIL) Simulation and Hardware-in-the-Loop (HIL) Simulation.<br>Acceleration and braking control, regenerative braking; Automotive Steering Systems.<br>Design considerations of HVAC controller | |
| Module IV | **EV System integration:**<br>EMC design on ECU level, EMC design on system level and in special subsystems, Radiated emissions and Conducted emissions, EMI EMC measurements. | 06 |
| Module V | **Design of Charging Infrastructure:**<br>Design considerations for AC charger: vehicle interface and charging protocol design. applicable charging standards<br>Design of On-Board Charger (OBC)-Schematic, power topology and control, Power capacities, regenerative braking control.<br>Design considerations of DC fast charger: vehicle interface and charging protocol design. Connectivity and applicable charging standards<br>Installation guidelines and grid requirement for charger installations. | 12 |
| Module VI | **Design with Functional Safety of Automotive Electronics:**<br>Functional Safety requirements of Automotive Electronics; ASIL identification and safety goal finalization, ISO 26262.<br>Energy Storage integrity / protection: rupture and toxic gas management; low energy stranding, Unintended vehicle movement, shock protection, and Elimination of potential thermal/ explosive event.<br>Hazard and Risk Analysis (HARA) for different situations, Testing of vehicles for compliance of safety norms | 08 |

**Text/Reference Books:-**


1. Design and Control of Automotive Propulsion Systems by Zongxuan Sun and Guoming Zhu, CRC Press, 2015
2. Electric Vehicle Machines and Drives Design, Analysis and Application by K. T. Chau, IEEE Press, and Wiley, 2015
3. EMC and Functional Safety of Automotive Electronics by Kai Borgeest, IET, 2018


**Website Reference / Video Courses:**

1. **NPTEL Web Course:** Electric Vehicles - Part 1 by PROF. AMIT KUMAR JAIN Department of Electrical Engineering IIT Delhi; https://nptel.ac.in/courses/108/102/108102121/
2. **NPTEL Web Course:** Fundamentals of Electric vehicles: Technology & Economics**,** by Prof. Ashok Jhunjhunwala, Prof. Prabhjot Kaur, Prof. Kaushal Kumar Jha and Prof. L Kannan, IIT Madras, https://nptel.ac.in/courses/108/106/108106170/
3. **NPTEL Web Course:** Introduction to Hybrid and Electric Vehicles by Dr. Praveen Kumar and Prof. S. Majhi, IIT Guwahati, https://nptel.ac.in/courses/108/103/108103009/

**Assessment:**

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

**Theory Examination**:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining questions will be randomly selected from all the modules

| M. Tech. in Electrical Engineering (Power Electronics and Drives)- Sem-II | | | | | | |
|---|---|---|---|---|---|---|
| **Subject code** | **Subject Name** | **Teaching scheme (Contact Hours)** | | **Credits Assigned** | | |
| **PEDPE2022** | **Design of Power Converters** | **Theory** | **Pract./Tut.** | **Theory** | **Pract./Tut.** | **Total** |
| | | **3** | **--** | **3** | | **3** |

| **Subject code** | **Subject Name** | **Examination Scheme** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **Theory** | | | | | **Term Work** | **Pract/ Oral** | **Total** |
| | | **Internal Assessment** | | | **End Sem. Exam** | **Exam Duration (in Hrs)** | | | |
| | | **Test 1** | **Test 2** | **Avg** | | | | | |
| **PEDPE2022** | **Design of Power Converters** | **20** | **20** | **20** | **80** | **3** | **-** | **-** | **100** |

| | |
|---|---|
| **Course Objectives** | 1. To understand and select high power devices, gain knowledge about power modules, suitable packaging and latest market trends.<br>2. To understand and analyse high power converters and the protection needed for the converters.<br>3. To keep abreast with the latest technologies and research going on in different areas related to high power converters.<br>4. To enhance the knowledge of practical aspects in the design of Power Converters.<br>5. To deliver technological solution in the field of power electronics. |
| **Course Outcomes** | **Upon successful completion of this course, the learner will be able to**<br>1. Analyze and understand high power devices and practical issues in implementing high power converters.<br>2. Understand protection aspects and design considerations to build proper power electronics systems.<br>3. Design closed loop control and discretize controllers for using digital control methods.<br>4. Analyze and design converters in the fields of drives, power generation and energy conversion, industrial applications, extraction of energy from renewable sources. |

| **Module** | **Details** | **Hours** |
|---|---|---|
| Module I | **High power switching devices and drivers:**<br>Issues with conventional switches in high power applications, View of power device market trend, series connected devices, voltage equalization techniques-static and dynamic, **i**ntelligent power modules, packages for high power devices, drivers for wide band gap devices. | 04 |
| Module II | **High power converters and Protection:**<br>Review of Multi level inverters, Cascaded H bridge multilevel inverters, Modular Multi level converters.<br>Practical Aspects in building Three-Phase Power Converters- Motor drives, Grid applications.<br>Protection aspects-Over current, Over voltage, temperature, snubber design-component selection, basics of resonant snubber and regenerative snubber, numericals included. | 10 |
| Module III | **Design considerations:**<br>Electrical specifications, Mechanical specifications, Environmental specifications, EMI/EMC specifications, Hardware specifications, Thermal Management **,** Selection of switching frequency, Selection of switching device and topology, cost. | 06 |

| | | |
|---|---|---|
| Module IV | **Closed-Loop control:**<br>Analog PWM controllers**,** Digital control-advantages**,** Signal conditioning and sampling, digital implementation of PWM modulator-single update and double update mode, PI & PR controller discretization, effect of computational delay, Processors in converter control, Grid synchronization techniques, introduction to non-linear control methods. | 08 |
| Module V | **Design of High power converters for drives:**<br>Requirements and challenges**, s**witching device constraints, converter configurations, control aspects, case studies of design of drive application. | 05 |
| Module VI | **Design of Grid interfaced converters:**<br>Requirements and challenges, high power grid interfaced converters, current control, grid synchronization, filter design, dc link voltage control, case studies on grid interfacing of renewable energy sources. | 06 |

**Text Books:**


1. Dorin O. Neacsu, "Switching Power Converters, Medium and High Power", CRC press, Taylor & Francis group, second edition, 2017.
2. Bin Wu, "High Power Converters and AC drives", IEEE press, John Wiley & Sons.
3. N. Mohan and T. M. Undeland, "Power Electronics: Converters, Applications and Design", John Wiley & Sons, 2007.
4. Simon Ang, Alejandro Oliva, "Power-Switching Converters", Taylor and Francis group.
5. A Yazdani, R. Iravani, "Voltage- Sourced Converters in Power Systems", Wiley, IEEE press.
6. B. Jayant Baliga, "Silicon Carbide Power Devices", World Scientific, 2005.


**Reference Books:**


1. R. Teodoresco, M. Liserrie,P. Rodr´ıguez "Grid Converters for Photovoltaic and Wind Power Systems", John Wiley and Sons.
2. L. Umanad, "Power Electronics: Essentials & Applications", Wiley.
3. V. Ramanarayanan, "Course Material on Switched Mode Power Conversion", 2007.
4. M. Jamil, M. Rizwan, D.P Kothari, "Grid Integration of Solar Photovoltaic Systems", CRC press, Taylor & Francis.
5. Peter Friedrichs, T. Kimoto, L. Ley and G. Pensl, "Silicon Carbide, Volume 2: Power Devices and Sensors", Wiley Publications, 2011.
6. Relevant Papers published in reputed Journals, Conference/NPTEL lectures.


**Assessment:**

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project

**Theory Examination**:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining questions will be randomly selected from all the modules

| M. Tech. in Electrical Engineering (Power Electronics and Drives)- Sem-II | | | | | | |
|---|---|---|---|---|---|---|
| **Subject code** | **Subject Name** | **Teaching scheme (Contact Hours)** | | **Credits Assigned** | | |
| **PEDPE2023** | **Power Converters for Renewable Energy** | **Theory** | **Pract./Tut.** | **Theory** | **Pract./Tut.** | **Total** |
| | | 3 | -- | 3 | | 3 |

| **Subject code** | **Subject Name** | **Examination Scheme** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **Theory** | | | | | | | |
| | | **Internal Assessment** | | | **End Sem. Exam** | **Exam Duration (in Hrs)** | **Term Work** | **Pract/ Oral** | **Total** |
| | | **Test 1** | **Test 2** | **Avg.** | | | | | |
| **PEDPE2023** | **Power Converters for Renewable Energy** | 20 | 20 | 20 | 80 | 3 | - | - | 100 |

| | |
|---|---|
| **Course Objectives** | 1. To introduce the distributed generation system based on renewable energy resources.<br>2. To know the practical aspects of design of power converters for renewable energy sources.<br>3. To know the control implementation for power converters. |
| **Course Outcomes** | **Upon successful completion of this course, the learner will be able to:**<br>1. To understand operating principle and characteristics of various RES<br>2. To identify and describe various topologies of DGs based on use of various combinations of RES.<br>3. To design the power converters for solar PV applications.<br>4. To identify and describe the design considerations for the power converters for wind energy systems.<br>5. To identify and describe the design considerations for the power converters for fuel cell systems.<br>6. To model and design compensator for power converters operating in voltage and current control mode. |

| **Module** | **Details** | **Hours** |
|---|---|---|
| Module I | **Introduction to renewable sources:** Review of renewable energy sources, operating principles and characteristics of: Solar PV, Wind Energy Systems (WES), Fuel cells; Economics and statistics related to renewable energy. Review of energy storage systems with Batteries and ultra-capacitors. Categorization of energy sources | 4 |
| Module II | **Distributed generation system:** Basic concepts, various topologies and design considerations for standalone systems and grid connected systems, Power quality and protection issues, review of regulatory standards related to various aspects of renewable energy systems | 4 |
| Module III | **Design of power converters for Solar PV:** MPPT (maximum power point tracking), Design of DC-DC converters for MPPT, MPPT algorithms, Implementation of MPPT control through DSP controllers.<br>Topologies for grid connected and standalone applications: single phase and three phase systems, Design of multi stage solar PV grid connected and standalone systems. Low and high power Applications. Integration of ES-battery and ultra-capacitor for performance improvement, Converters for PV based charging stations for EV | 10 |
| Module IV | **Design of power converters for WES:** Topologies of WES, design considerations for WES with rectifier / inverter system, Power Converters for Doubly Fed Induction Generators (DFIG) in Wind Turbines, Matrix converter topology for grid connected system. | 06 |

| | | |
|---|---|---|
| Module V | **Design of power converters for Fuel Cell:** Review of fuel cell technology, Design of DC-DC converters for PEM fuel cell, MPPT in Fuel Cell, Design considerations for multi-stage converter / inverter system for grid connected operations. | 06 |
| Module VI | **Design of compensator for voltage and current control modes:** Modelling of the system, derivation of transfer function compensator for voltage and current control modes, design of PI and Type III controller in power conditioning system for renewable energy sources. | 06 |

**Books Recommended:**

**Text Books:**


1. Power Electronics, Converters, Applications & Design‖, N. Mohan, T. M. Undeland, W.P Robbins, Wiley India Pvt. Ltd.
2. Voltage Source Converters in Power Systems: Modeling, Control and Applications, Amirnaser Yezdani, and Reza Iravani, IEEE John Wiley Publications
3. Power Switching Converters: Medium and High Power, Dorin Neacsu, CRC press, Taylor &Francis, 2006
4. M.H. Rashid, ―Power Electronics Hand book‖, Academic Press, 2001


**References books /websites:**


1. DSP Based Electromechanical Motion Control, Hamid Toliyat and Steven Campbell, CRC Press
2. Digital Signal Processors - Architectures, Implementations, and Applications, Sen M. Kuoand Woon-SengGan Prentice Hall
3. Fuel Cell System, Leo J.M.J. Blomen and michael N. Mugerwa, New York, Plenum Press, 1993.
4. Wind Energy Explained, theory design and applications, J.F. Manwell, J.G. McGowan Wiley publication
5. Fuel Cell Systems Explained, James Larminie, Andrew Dicles, Wiley publication
6. Principles of Solar Engineering‖, D. Y. Goswami, F. Kreith and J. F. Kreider, Taylor and Francis, Philadelphia, 2000
7. Biomass Regenerable Energy, D. D. Hall and R. P. Grover, John Wiley, New York, 1987.


**Assessment:**

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

**Theory Examination**:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining questions will be randomly selected from all the modules

| M.E. Electrical Engineering (Power Electronics and Drives)- Sem-II | | | | | | |
|---|---|---|---|---|---|---|
| **Course Code** | **Course Name** | **Teaching scheme (Contact Hours)** | | **Credits Assigned** | | |
| **PEDIE2011** | **Environmental Management** | **Theory** | **Pract./Tut.** | **Theory** | **Pract./Tut.** | **Total** |
| | | **3** | **--** | **3** | **--** | **3** |

| **Course code** | **Course Name** | **Examination Scheme** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **Theory** | | | | | **Term Work** | **Oral** | **Total** |
| | | **Internal Assessment** | | | **End Sem. Exam** | **Exam Duration (in Hrs)** | | | |
| | | **Test 1** | **Test 2** | **Avg** | | | | | |
| **PEDIE2011** | **Environmental Management** | **20** | **20** | **20** | **80** | **3** | **--** | **--** | **100** |

| | |
|---|---|
| **Course Objectives** | 1 Understand and identify environmental issues relevant to India and global concerns<br>2 Learn concepts of ecology<br>3 Familiarise environment related legislations |
| **Course Outcomes** | Upon successful completion of this course, the learner will be able to:<br>1 Understand the concept of environmental management<br>2 Understand ecosystem and interdependence, food chain etc.<br>3 Understand and interpret environment related legislations |

| **Module** | **Detailed Contents** | **Hours** |
|---|---|---|
| 1 | Introduction and Definition of Environment: Significance of Environment Management for contemporary managers, Career opportunities, Environmental issues relevant to India, Sustainable Development, the Energy scenario | 10 |
| 2 | Global Environmental concerns : Global Warming, Acid Rain, Ozone Depletion, Hazardous Wastes, Endangered life-species, Loss of Biodiversity, Industrial/Man-made disasters, Atomic/Biomedical hazards, etc. | 06 |
| 3 | Concepts of Ecology: Ecosystems and interdependence between living organisms, habitats, limiting factors, carrying capacity, food chain, etc. | 05 |
| 4 | Scope of Environment Management, Role and functions of Government as a planning and regulating agency<br>Environment Quality Management and Corporate Environmental Responsibility | 10 |
| 5 | Total Quality Environmental Management, ISO-14000, EMS certification. | 05 |
| 6 | General overview of major legislations like Environment Protection Act, Air (P & CP) Act, Water (P & CP) Act, Wildlife Protection Act, Forest Act, Factories Act, etc. | 03 |

**References:**


1. Environmental Management: Principles and Practice, C J Barrow, Routledge Publishers London,1999
2. A Handbook of Environmental Management Edited by Jon C. Lovett and David G. Ockwell,Edward Elgar Publishing
3. Environmental Management,**T V Ramachandra and Vijay Kulkarni, TERI Press**
4. Indian Standard Environmental Management Systems — Requirements With Guidance For Use, Bureau Of Indian Standards, February 2005

5. Environmental Management: An Indian Perspective, S N Chary and Vinod Vyasulu, MaclillanIndia, 2000
6. Introduction to Environmental Management, Mary K Theodore and Louise Theodore, CRC PressEnvironment and Ecology, Majid Hussain, 3rd Ed. Access Publishing.2015

**Assessment:**
Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

**Theory Examination**:
1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining questions will be randomly selected from all the modules

| M.E. Electrical Engineering (Power Electronics and Drives)- Sem-II | | | | | | |
|---|---|---|---|---|---|---|
| **Course Code** | **Course Name** | **Teaching scheme (Contact Hours)** | | **Credits Assigned** | | |
| **PEDIE2012** | **Entrepreneurship Development** | **Theory** | **Pract./Tut.** | **Theory** | **Pract./Tut.** | **Total** |
| | | **3** | **--** | **3** | **--** | **3** |

| **Course code** | **Course Name** | **Examination Scheme** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **Theory** | | | | | **Term Work** | **Oral** | **Total** |
| | | **Internal Assessment** | | | **End Sem. Exam** | **Exam Duration (in Hrs)** | | | |
| | | **Test 1** | **Test 2** | **Avg** | | | | | |
| **PEDIE2012** | **Entrepreneurship Development** | **20** | **20** | **20** | **80** | **3** | **--** | **--** | **100** |

| | |
|---|---|
| **Course Objectives** | 1 To acquaint with entrepreneurship and management of business<br>2 Understand Indian environment for entrepreneurship<br>3 Idea of EDP, MSME |
| **Course Outcomes** | **Upon successful completion of this course, the learner will be able to:**<br>1 Understand the concept of business plan and ownerships<br>2 Interpret key regulations and legal aspects of entrepreneurship in India<br>3 Understand government policies for entrepreneurs |

| **Module** | **Detailed Contents** | **Hours** |
|---|---|---|
| 1 | **Overview of Entrepreneurship:** Definitions, Roles and Functions/Values of Entrepreneurship, History of Entrepreneurship Development, Role of Entrepreneurship in the National Economy, Functions of an Entrepreneur, Entrepreneurship and Forms of Business Ownership<br>Role of Money and Capital Markets in Entrepreneurial Development: Contribution of Government Agencies in Sourcing information for Entrepreneurship | 04 |
| 2 | **Business Plans and Importance of Capital to Entrepreneurship:** Preliminary and Marketing Plans, Management and Personnel, Start-up Costs and Financing as well as Projected Financial Statements, Legal Section, Insurance, Suppliers and Risks, Assumptions and Conclusion, Capital and its Importance to the Entrepreneur<br>**Entrepreneurship and Business Development:** Starting a New Business, Buying an Existing Business, New Product Development, Business Growth and the Entrepreneur Law and its Relevance to Business Operations | 09 |
| 3 | Women's Entrepreneurship Development, Social entrepreneurship-role and need, EDP cell, role of sustainability and sustainable development for SMEs, case studies, exercises | 05 |
| 4 | **Indian Environment for Entrepreneurship:** key regulations and legal aspects, MSMEDAct 2006 and its implications, schemes and policies of the Ministry of MSME, role andresponsibilities of various government organisations, departments, banks etc., Role ofState governments in terms of infrastructure developments and support etc., Public private partnerships, National Skill development Mission, Credit Guarantee Fund, PMEGP, discussions, group exercises etc. | 08 |
| 5 | **Effective Management of Business:** Issues and problems faced by micro and small enterprises and effective management of M and S enterprises (risk management, credit availability, technology innovation, supply chain management, linkage with large industries), exercises, e-Marketing | 08 |

| | | |
|---|---|---|
| 6 | **Achieving Success In The Small Business:** Stages of the small business life cycle, fourtypes of firm-level growth strategies, Options – harvesting or closing small business Critical Success factors of small business | 05 |

**References:**


1. Poornima Charantimath, Entrepreneurship development- Small Business Enterprise, Pearson
2. Education Robert D Hisrich, Michael P Peters, Dean A Shapherd, Entrepreneurship, latest edition, The McGrawHill Company
3. Dr TN Chhabra, Entrepreneurship Development, Sun India Publications, New Delhi
4. Dr CN Prasad, Small and Medium Enterprises in Global Perspective, New century Publications,New Delhi
5. Vasant Desai, Entrepreneurial development and management, Himalaya Publishing House
6. Maddhurima Lall, Shikah Sahai, Entrepreneurship, Excel Books
7. Rashmi Bansal, STAY hungry STAY foolish, CIIE, IIM Ahmedabad
8. Law and Practice relating to Micro, Small and Medium enterprises, Taxmann Publication Ltd.
9. Kurakto, Entrepreneurship- Principles and Practices, Thomson Publication
10. Laghu Udyog Samachar
11. www.msme.gov.in
12. www.dcmesme.gov.in
13. www.msmetraining.gov.in


**Assessment:**
Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

**Theory Examination**:
1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining questions will be randomly selected from all the modules

| M.E. Electrical Engineering (Power Electronics and Drives)- Sem-II | | | | | | |
|---|---|---|---|---|---|---|
| **Course Code** | **Course Name** | **Teaching scheme (Contact Hours)** | | **Credits Assigned** | | |
| **PEDIE2013** | **Finance Management** | **Theory** | **Pract./Tut.** | **Theory** | **Pract./Tut.** | **Total** |
| | | **3** | **--** | **3** | **--** | **3** |

| **Course code** | **Course Name** | **Examination Scheme** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **Theory** | | | | | **Term Work** | **Oral** | **Total** |
| | | **Internal Assessment** | | | **End Sem. Exam** | **Exam Duration (in Hrs)** | | | |
| | | **Test 1** | **Test 2** | **Avg** | | | | | |
| **PEDIE2013** | **Finance Management** | **20** | **20** | **20** | **80** | **3** | **--** | **--** | **100** |

| | |
|---|---|
| **Course Objectives** | 1. To familiarize the students with the use of a structured methodology/approach for each and every unique project undertaken, including utilizing project management concepts, tools and techniques.<br>2. To appraise the students with the project management life cycle and make them knowledgeable about the various phases from project initiation through closure. |
| **Course Outcomes** | **Upon successful completion of this course, the learner will be able to:**<br>1 Understand Indian finance system and corporate finance<br>2 Take investment, finance as well as dividend decisions |

| **Module** | **Detailed Contents** | **Hours** |
|---|---|---|
| 1 | **Overview of Indian Financial System:** Characteristics, Components and Functions ofFinancial System.<br>**Financial Instruments:** Meaning, Characteristics and Classification of Basic Financial Instruments — Equity Shares, Preference Shares, Bonds-Debentures, Certificates ofDeposit, and Treasury Bills.<br>**Financial Markets:** Meaning, Characteristics and Classification of Financial Markets —Capital Market, Money Market and Foreign Currency Market<br>**Financial Institutions:** Meaning, Characteristics and Classification of Financial Institutions — Commercial Banks, Investment-Merchant Banks and Stock Exchanges | 06 |
| 2 | **Concepts of Returns and Risks:** Measurement of Historical Returns and Expected Returns of a Single Security and a Two-security Portfolio; Measurement of Historical Risk and Expected Risk of a Single Security and a Two-security Portfolio.<br>**Time Value of Money:** Future Value of a Lump Sum, Ordinary Annuity, and Annuity Due; Present Value of a Lump Sum, Ordinary Annuity, and Annuity Due; Continuous Compounding and Continuous Discounting. | 06 |
| 3 | **Overview of Corporate Finance:** Objectives of Corporate Finance; Functions of Corporate Finance—Investment Decision, Financing Decision, and Dividend Decision.<br>**Financial Ratio Analysis:** Overview of Financial Statements—Balance Sheet, Profit and Loss Account, and Cash Flow Statement; Purpose of Financial Ratio Analysis; Liquidity Ratios; Efficiency or Activity Ratios; Profitability Ratios; Capital Structure Ratios; Stock<br>Market Ratios; Limitations of Ratio Analysis. | 09 |

| | | |
|---|---|---|
| 4 | **Capital Budgeting:** Meaning and Importance of Capital Budgeting; Inputs for Capital Budgeting Decisions; Investment Appraisal Criterion—Accounting Rate of Return, Payback Period, Discounted Payback Period, Net Present Value(NPV), Profitability Index, Internal Rate of Return (IRR), and Modified Internal Rate of Return (MIRR) **Working Capital Management:** Concepts of Meaning Working Capital; Importance ofWorking Capital Management; Factors Affecting an Entity's Working Capital Needs; Estimation of Working Capital Requirements; Management of Inventories;<br>Management of Receivables; and Management of Cash and Marketable Securities. | 10 |
| 5 | **Sources of Finance:** Long Term Sources—Equity, Debt, and Hybrids; Mezzanine Finance; Sources of Short Term Finance—Trade Credit, Bank Finance, Commercial Paper; Project Finance.<br>**Capital Structure:** Factors Affecting an Entity's Capital Structure; Overview of CapitalStructure Theories and Approaches— Net Income Approach, Net Operating Income Approach; Traditional Approach, and Modigliani-Miller Approach. Relation between<br>Capital Structure and Corporate Value; Concept of Optimal Capital Structure | 05 |
| 06 | **Dividend Policy:** Meaning and Importance of Dividend Policy; Factors Affecting an Entity's Dividend Decision; Overview of Dividend Policy Theories and Approaches—Gordon's Approach, Walter's Approach, and Modigliani-Miller Approach | 03 |

**References:**


1. Fundamentals of Financial Management, 13th Edition (2015) by Eugene F. Brigham and Joel F. Houston; Publisher: Cengage Publications, New Delhi.
2. Analysis for Financial Management, 10th Edition (2013) by Robert C. Higgins; Publishers: McGraw Hill Education, New Delhi.
3. Indian Financial System, 9th Edition (2015) by M. Y. Khan; Publisher: McGraw Hill Education, New Delhi.
4. Financial Management, 11th Edition (2015) by I. M. Pandey; Publisher: S. Chand (G/L) & Company Limited, New Delhi.


**Assessment:**
Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

**Theory Examination**:
1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining questions will be randomly selected from all the modules

| M.E. Electrical Engineering (Power Electronics and Drives)- Sem-II | | | | | | |
|---|---|---|---|---|---|---|
| **Course Code** | **Course Name** | **Teaching scheme (Contact Hours)** | | **Credits Assigned** | | |
| **PEDIE2014** | **Project Management** | **Theory** | **Pract./Tut.** | **Theory** | **Pract./Tut.** | **Total** |
| | | **3** | **--** | **3** | **--** | **3** |

| **Course code** | **Course Name** | **Examination Scheme** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **Theory** | | | | | **Term Work** | **Oral** | **Total** |
| | | **Internal Assessment** | | | **End Sem. Exam** | **Exam Duration (in Hrs)** | | | |
| | | **Test 1** | **Test 2** | **Avg** | | | | | |
| **PEDIE2014** | **Project Management** | **20** | **20** | **20** | **80** | **3** | **--** | **--** | **100** |

| | |
|---|---|
| **Course Objectives** | 1. To familiarize the students with the use of a structured methodology/approach for each and every unique project undertaken, including utilizing project management concepts, tools and techniques.<br>2. To appraise the students with the project management life cycle and make them knowledgeable about the various phases from project initiation through closure. |
| **Course Outcomes** | Upon successful completion of this course, the learner will be able to:<br>1. Apply selection criteria and select an appropriate project from different options.<br>2. Write work break down structure for a project and develop a schedule based on it.<br>3. Identify opportunities and threats to the project and decide an approach to deal with them strategically.<br>4. Use Earned value technique and determine & predict status of the project.<br>5. Capture lessons learned during project phases and document them for future reference |

| **Module** | **Detailed Contents** | **Hours** |
|---|---|---|
| 1 | **Project Management Foundation:**<br>Definition of a project, Project Vs Operations, Necessity of project management, Triple constraints, Project life cycles (typical & atypical) Project phases and stage gate process. Role of project manager, Negotiations and resolving conflicts, Project management in various organization structures, PM knowledge areas as per Project Management Institute (PMI) | 05 |
| 2 | **Initiating Projects:**<br>How to get a project started, selecting project strategically, Project selection models (Numeric /Scoring Models and Non-numeric models), Project portfolio process, Project sponsor and creating charter; Project proposal. Effective project team, Stages of team development & growth (forming, storming, norming &performing), team dynamics. | 06 |
| 3 | **Project Planning and Scheduling:**<br>Work Breakdown structure (WBS) and linear responsibility chart, Interface; Co-ordination and concurrent engineering, Project cost estimation and budgeting, Top down and bottoms up budgeting, Networking and Scheduling techniques. PERT, CPM, GANTT chart, Introduction to Project Management Information System (PMIS). | 08 |
| 4 | **Planning Projects:**<br>Crashing project time, Resource loading and levelling, Goldratt's critical chain, Project Stakeholders and Communication plan | 06 |

| | | |
|---|---|---|
| | Risk Management in projects: Risk management planning, Risk identification and risk register, Qualitative and quantitative risk assessment, Probability and impact matrix. Risk response strategies for positive and negative risks | |
| 5 | **5.1 Executing Projects:**<br>Planning monitoring and controlling cycle, Information needs and reporting, engaging with all stakeholders of the projects, Team management, communication and project meetings<br>**5.2 Monitoring and Controlling Projects:**<br>Earned Value Management techniques for measuring value of work completed; Using milestones for measurement; change requests and scope creep, Project audit<br>**5.3 Project Contracting**<br>Project procurement management, contracting and outsourcing, | 08 |
| 6 | **6.1 Project Leadership and Ethics:**<br>Introduction to project leadership, ethics in projects, Multicultural and virtual projects<br>**6.2 Closing the Project:**<br>Customer acceptance; Reasons of project termination, Various types of project terminations (Extinction, Addition, Integration, Starvation), Process of project termination, completing a final report; doing a lessons learned analysis; acknowledging successes and failures; Project management templates and other resources; Managing without authority; Areas of further study. | 06 |

**References:**


1. Project Management: A managerial approach, Jack Meredith & Samuel Mantel, 7th Edition,Wiley India
2. A Guide to the Project Management Body of Knowledge (PMBOK® Guide), 5th Ed, ProjectManagement Institute PA, USA
3. Project Management, Gido Clements, Cengage Learning
4. Project Management, Gopalan, Wiley India
5. Project Management, Dennis Lock, 9th Edition, Gower Publishing England


**Assessment:**
Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

**Theory Examination**:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining questions will be randomly selected from all the modules

| M. Tech. in Electrical Engineering (Power Electronics and Drives)- Sem-II | | | | | | |
|---|---|---|---|---|---|---|
| **Subject code** | **Subject Name** | **Teaching scheme (Contact Hours)** | | **Credits Assigned** | | |
| **PEDL201** | **DSP Applications Lab** | **Theory** | **Pract./Tut.** | **Theory** | **Pract./Tut.** | **Total** |
| | | -- | 2 | -- | 1 | 1 |

| **Subject code** | **Subject Name** | **Examination Scheme** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **Theory** | | | | | **Term Work** | **Oral** | **Total** |
| | | **Internal Assessment** | | | **End Sem. Exam** | **Exam Duration (in Hrs)** | | | |
| | | **Test 1** | **Test 2** | **Avg** | | | | | |
| **PEDL201** | **DSP Applications Lab** | -- | -- | -- | -- | -- | 25 | 25 | 50 |

| | |
|---|---|
| **Course Objectives** | To impart knowledge on<br>1. Use of DSP development boards and DSP programming platform<br>2. Program DSP for the use of various on board peripherals<br>3. Use of DSP for control of power electronic converters |
| **Course Outcomes** | **Upon successful completion of this course, the learner will be able to:**<br>1. Program in DSP for specific applications<br>2. Integrate DSP processor with external applications<br>3. Design and implement closed loop control of power electronic converters using DSP |

**Hardware and Software tools to be used**

- Students can use DSP development boards (Texas Instruments C2000 series like TMS320F28069 / TMS320F28335/ TMS 320F28379D or similar with software platform (Code Composer studio) to perform the suggested experiments. Use of training material (videos and lab manuals) available on Texas Instruments website is recommended.
- Use of emulation platforms with DSP target boards facility can also be done to conduct recommended lab experiments

**List of suggested experiments:**

**A. Use of DSP Peripherals: (minimum three)**

1. Mathematical calculations using DSP
2. Sine wave generation using DSP
3. Use of Graph utility and real time debugging interface with DSP
4. ADC application with DSP board
5. PWM (single phase and three phase) generation
6. Use of GPIO for status / indications
7. Use of communication protocols
8. Use of QEP / Capture module for Speed measurement

**B. DSP for Power Converter Application (minimum Two)**

1. DSP based Open loop operation of DC-DC converter
2. DSP based Closed Loop operation of DC-DC converter
3. DSP based Open loop operation of inverter
4. DSP based Closed loop operation of inverter
5. DSP based PWM rectifier

**C. DSP based Power Electronic System (minimum one)**

1. DSP based Electric drive: Induction motor with V/F control
2. DSP based BLDC motor drive

3. DSP based LED lamp control
4. DSP based data transfer between two systems with communication interface.

**Reference Books:**


1. Digital Signal Processing in Power Electronics Control Circuits by Krzysztof Sozanski, Springer
2. Digital Signal Processing in Power System Protection and Control by Waldemar Rebizant, Janusz Szafran, and Andrzej Wiszniewski, Springer.
3. Digital Power Electronics and Applications by *Fang Lin Luo, Hong Ye and Muhammad Rashid,* Elsevier Academic Press.
4. Digital Signal Processing in Power Electronics Control Circuits by Krzysztof Sozanski, Springer
5. DSP Based Electromechanical Motion Control by Hamid Toliyat and Steven Campbell, CRC Press


**Web References:**


1. https://training.ti.com/c2000-f2837xd-microcontroller-one-day-workshop-series
2. https://software-dl.ti.com/trainingTTO/trainingTTO_public_sw/c28x28379/F2837xD_Microcontroller_M
3. https://www.ti.com/microcontrollers-mcus-processors/microcontrollers/c2000-real-time-control-mcus/overview.html
4. The Essential Guide for Developing with C2000™RealTime Microcontrollers: Texas Instruments


**Term work:**

Term work shall consist of **minimum six experiments.**

| | |
|---|---|
| Experiments Performance | : 10 marks |
| Attendance | : 05 marks |
| Journal | : 10 marks |

The final certification and acceptance of term work ensures the minimum passing in the term work.

**Oral Examination**:

Oral examination will be based on entire lab work

| M. Tech. in Electrical Engineering (Power Electronics and Drives)- Sem-II | | | | | | |
|---|---|---|---|---|---|---|
| **Subject code** | **Subject Name** | **Teaching scheme (Contact Hours)** | | **Credits Assigned** | | |
| **PEDSBL201** | **Skill Based Lab-II Design of Large PED Systems** | **Theory** | **Pract./Tut.** | **Theory** | **Pract./Tut.** | **Total** |
| | | -- | 2 | -- | 1 | 1 |

| **Subject code** | **Subject Name** | **Examination Scheme** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **Theory** | | | | | **Term Work** | **Oral** | **Total** |
| | | **Internal Assessment** | | | **End Sem. Exam** | **Exam Duration (in Hrs)** | | | |
| | | **Test 1** | **Test 2** | **Avg** | | | | | |
| **PEDSBL201** | **Skill Based Lab-II Design of Large PED Systems** | -- | -- | -- | -- | -- | 50 | 50 | 100 |

| | |
|---|---|
| **Course Objectives** | To impart knowledge on<br>1. DSP programming<br>2. Design of magnetics in high frequency applications<br>3. Design of closed loop control of power electronic converters |
| **Course Outcomes** | **Upon successful completion of this course, the learner will be able to:**<br>1. Program in DSP for specific applications<br>2. Design magnetic components of power electronic converters<br>3. Design closed loop control of power electronic converters and implement it. |

**List of suggested experiments:**

1. Generate a DSP code for applications like MPPT / PLL/ SVM/ any other related to PE and Drives and its testing.
2. Inductor design and its fabrication for Buck or Boost or Buck-Boost DC-DC converter (any one converter)
3. Transformer Design and its Fabrication for any isolated DC-DC converter
4. Design and Implementation of closed loop control of Buck or Boost or Buck-Boost DC-DC converter for switched mode power supplies
5. Design and Implementation of any one isolated DC-DC converter in open loop

**References:**


1. Mohan, Ned. et.al, “Power Electronics Converters, Applications and Design”, Wiley India Pvt. Ltd., New Delhi.
2. L. Umanand, Bhatt, “Design of Magnetic Components for Switched Mode Power Converters”, John Wiley & Sons
3. NPTEL course on “Design of Power Electronic Converters”, Prof. Shabari Nath, IIT Guwahati.
4. NPTEL course on “Advanced Power Electronics and Control”, Prof. Avik Bhattacharya, IIT Roorkee.


**Term work:**

Term work shall consist of minimum Two experiments.

Experiments Performance : 10 marks
Attendance : 05 marks
Journal : 10 marks

The final certification and acceptance of term work ensures the minimum passing in the term work.

**Oral Examination**:

Oral examination will be based on entire lab work

| M. Tech. in Electrical Engineering (Power Electronics and Drives)- Sem-III | | | | | | |
|---|---|---|---|---|---|---|
| **Subject code** | **Subject Name** | **Teaching scheme (Contact Hours)** | | **Credits Assigned** | | |
| **PEDMP301** | **Major Project: Dissertation -I** | **Theory** | **Pract./Tut.** | **Theory** | **Pract./Tut.** | **Total** |
| | | -- | 20 | -- | 10 | 10 |

| **Subject code** | **Subject Name** | **Examination Scheme** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **Theory** | | | | | **Term Work** | **Pract/ Oral** | **Total** |
| | | **Internal Assessment** | | | **End Sem. Exam** | **Exam Duration (in Hrs)** | | | |
| | | **Test 1** | **Test 2** | **Avg** | | | | | |
| **PEDMP301** | **Major Project: Dissertation -I** | -- | -- | -- | -- | -- | 100 | -- | 100 |

**Guidelines for Dissertation-I**

Students should do literature survey and identify the problem for Dissertation and finalize in consultation with Guide/Supervisor. Students should use multiple literatures and understand the problem. Students should attempt solution to the problem by analytical/simulation/experimental methods. The solution to be validated with proper justification and compile the report in standard format. Guidelines for Assessment of Dissertation-I.

**Dissertation-I should be assessed based on following points**

- Quality of Literature survey and Novelty in the problem
- Clarity of Problem definition and Feasibility of problem solution
- Relevance to the specialization
- Clarity of objective and scope

**Dissertation-I should be assessed through a presentation by a panel of Internal examiners and external examiner appointed by the Head of the Department/Institute of respective Programme.**

| M. Tech. in Electrical Engineering (Power Electronics and Drives)- Sem-IV | | | | | | |
|---|---|---|---|---|---|---|
| **Subject code** | **Subject Name** | **Teaching scheme (Contact Hours)** | | **Credits Assigned** | | |
| **PEDMP401** | **Major Project: Dissertation -II** | **Theory** | **Pract./Tut.** | **Theory** | **Pract./Tut.** | **Total** |
| | | **--** | **32** | **--** | **16** | **16** |

| **Subject code** | **Subject Name** | **Examination Scheme** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **Theory** | | | | | **Term Work** | **Oral** | **Total** |
| | | **Internal Assessment** | | | **End Sem. Exam** | **Exam Duration (in Hrs)** | | | |
| | | **Test 1** | **Test 2** | **Avg** | | | | | |
| **PEDMP401** | **Major Project: Dissertation -II** | **--** | **--** | **--** | **--** | **--** | **100** | **100** | **200** |

**Guidelines for Assessment of Dissertation II**

**Dissertation II should be assessed based on following points:**

- Quality of Literature survey and Novelty in the problem
- Clarity of Problem definition and Feasibility of problem solution
- Relevance to the specialization or current Research / Industrial trends
- Clarity of objective and scope
- Quality of work attempted or learner contribution
- Validation of results
- Quality of Written and Oral Presentation

**Students should publish at least one paper based on the work in referred National/ International conference/Journal of repute.**

**Dissertation II should be assessed by internal and External Examiners appointed by the BOS of the program**