M S Ramaiah University of Applied Sciences

Program Structure and Course Details

of

M.Tech (Power Electronics and Drives)

Program Code: 117

Batch: 2019 Onwards

Department of Electrical Engineering

Faculty of Engineering and Technology

M S Ramaiah University of Applied Sciences

Registrar
M.S. Ramaiah University of Applied Sciences
Bangalore - 560 054

Dean-Academics
M.S. Ramaiah University of Applied Sciences
Bangalore-560054

Faculty	Engineering and Technology
Department	Electrical Engineering
Name of the Programme	M.Tech in Power Electronics and Drives
Programme Code	117
Mode of Study	Full Time
Date of Commencement of the Programme	May 2019
Date of Programme Approval by the Academic Council of MSRUAS	Agenda No.1, Thursday, 12-September-2019

1. Programme Objective

The aim of the programme is to enhance the professional competency of postgraduates by imparting advanced knowledge and understanding of Power Electronics and Drives (PED); critical thinking, problem solving techniques, analytical and transferable skills. The programme emphasises on modelling, analysis, synthesis and development of power electronics and drives. The students will be able to acquire skills in designing, developing, testing of power electronic systems and their interaction with externally connected components or systems using advanced simulation tools.

2. Programme Outcomes (POs) / Graduate Attributes

PO 1. Explicate the operation of power electronic converters, electric machines and variable speed drives

PO 2. Analyze, model, design, and develop power converter based energy conversion systems

PO 3. Design, simulate and synthesis controllers for PED systems using simulation tools

PO 4. Implement, test and validate designed power electronic converters and drives

PO 5. Analyze Electromagnetic interference and compatibility issues in power electronic converters

PO 6. Develop competency to test and validate power electronic systems for real-time application

PO 7. Pursue opportunities and build a career in industries

3. Programme Specific Outcomes (PSOs)

The programme specific outcomes are listed under four headings:

1. Knowledge and Understanding
2. Cognitive skills
3. Practical skills and
4. Capability/Transferable skills

Knowledge and Understanding: After undergoing this programme, a student will be able to:

PSO1: Explain various power electronic converter topologies

PSO2: Describe various design aspects of power electronic drive systems

PSO3: Describe the importance of electromagnetic compatibility in power electronic systems

PSO4: Explain the power system for aerospace, marine and automotive applications

Cognitive Skills: After undergoing this programme, a student will be able to:

PSO5: Design and analyze various topologies for electric drives

PSO6: Arrive at design specifications of solar and wind energy conversion systems

PSO7: Apply finite element analysis to a given electric drive system

PSO8: Model and analyze power electronic systems used in smart grid

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Practical Skills: After undergoing this programme, a student will be able to:

PSO9: Use software tools for simulation of motors and drives

PSO10: Use finite element tools to design and analyze electrical drives

PSO11: Critical analysis for the choice of power semiconductor devices for an application

PSO12: Test the performance of designed power converters for a given application

Capability Skills / Transferrable Skills: After undergoing the programme, a student will be able to:

PSO13: Manage information, develop technical reports and make presentations

PSO14: Build, Manage and Lead a team to successfully complete a project and communicate across teams and organizations to achieve professional objectives

PSO15: Work under various constraints to meet project targets

PSO16: Adopt to the chosen profession by continuously upgrading his/her knowledge and understanding through Life-long Learning philosophy

4. Eligibility for Admission:

4.1. Eligibility for students seeking admission under Government of Karnataka quota (for 40% seats):

i. A candidate seeking admission to postgraduate programme must have passed graduate level in Engineering and Technology in a related discipline with at least 50% marks in aggregate or equivalent CGPA.

ii. A candidate belonging to SC/ST category will be entitled to a relaxation in the qualifying marks in accordance with the related government notification in this regard.

4.2. Eligibility for Indian students seeking admission under the university quota:

Students seeking admission under University quota must have passed graduate level degree in Engineering in a related discipline with at least 50% marks in aggregate or equivalent CGPA.

4.3. Eligibility for foreign students seeking admission under University quota:

i. Foreign students should have Association of Indian Universities recognized first degree qualification in the Engineering related discipline of equivalent

ii. Should have proof of proficiency in English.

4.4: Selection of Students

Selection of students for admission under Government of Karnataka will be based on Karnataka

Government notified admission tests.

Selection of students for admission to University quota of seats is based on admission policy of the University notified from time to time.

Selection of foreign students for admission to University quota of seats is based on the admission policy of the University notified from time to time.

4.4.1: Admission to Programme

Selected candidates shall complete the admission procedure within the prescribed date by paying the prescribed fees and completing all other admission formalities notified by the University. Failure to do so may lead to cancellation of the selection.

4.4.2: Annual Programme Fee

Details of the fees payable for each Programme will be notified well in advance to the commencement of the programme.

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The fees, once paid, will not be refunded under any circumstances.
The continuation of a student's registration in subsequent academic years is subject to payment of the prescribed programme and registration fees for each of those years.

4.4.3: Free-ship and scholarships
The Board of Management, in consultation with the Board of Governors, may consider offering free ships / scholarships to deserving students who maintain a minimum level of academic performance on a yearly basis.

5. Programme Duration

5.1. Normal Duration: The normal duration of the M.Tech. postgraduate programme is:

a. Two years in the Full-Time Route
b. Three years in the Part-Time Route

5.2. Maximum Duration: The maximum period a student is allowed to complete the M.Tech Programme shall be double the normal duration of the programme, i.e., Four Years for Full-Time students and Six years for Part-Time students.

5.3. Duration for Lateral Entry Scheme: N/A

6. Medium of Instruction

English is the medium of instruction for the programme.

7. Programme Structure

The programme structure is presented in **Appendix A**.

8. Programme Curriculum

The programme structure is presented in **Appendix B**.

9. Attendance Requirement

A student is required to have a minimum attendance of 85% to be eligible to appear for the examination and for assignment submission. Students who fail to achieve the minimum attendance will be declared as "FAIL". A failed student is required to re-register, attend the module and take up all the components of assessment at the next offering.

10. Assessment

10.1. Achievement Testing: The Faculty Dean constitutes a Board of Examiners (BoE) for the purpose of assessment of students' performance. The BoE, comprising Internal and External examiners, is headed by a Chairman. Normally, the Head of the Department, offering the programme, is the Chairman of BoE or any Professor of the Department nominated by the Dean. The Board of Examiners (BoE) is responsible for:

- Setting and review of question papers and evaluation of answer scripts
- Setting and review of Assignments and evaluation
- Laboratory/Workshop/Studio/Project/Internship assessment
- Supervision of Written Examinations and Conducting Laboratory Examinations

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10.1.1: Module Assessment

Performance in every module will be assessed on the following two components:
Component - 1
Assignment (50% weight)
Component -2
Examination (50% weight)

The **Module Specifications (MS)** provide the details of Components-1 and 2.

A student is required to score a minimum of 40% in each of the components and 40% overall for successful completion of a module and for earning the corresponding credit(s).

10.1.2: Second Assessment and External Review

Each student's work is first assessed by the module teaching team. All the answer scripts of a given module are to be assessed by a second examiner. 10% of the evaluated scripts will be further reviewed by an examiner who is external to the University. An External examiner will have tenure of 2 years which can be renewed for a further period of 2 years. The first assessor or assessing team is required to fill in the evaluation data and write the Post Module Assessment Report (PMAR).

10.1.2.2: Feedback on Assessed work

The awarded marks and distribution pattern will be reviewed by the Dean of the Faculty before scheduling a face-to-face feedback session with the student. After completing assessment of the module, the module teaching team along with the concerned Head of the Department should provide face-to-face feedback to the student regarding his/her performance after handing over the assessed documents on a prescheduled day. After the feedback, the assessed documents are collected and deposited with the Examination and Assessment Unit of the Faculty.

10.3. Credits not earned in a Course and Opportunities for Make-up:

A minimum of 40 % marks in the assignment and a minimum of 40% marks in the written examination are required for successful completion of a module. A student failing in any one of the components will be declared 'FAILED' in the module. A failed student who has fulfilled the attendance criterion is eligible to re-sit under the fast track scheme.

There is no provision for a re-examination or re-submission of any of the assessment components for a failed module.

A maximum of 3 attempts, including the first attempt, are permitted for successful completion of a module.

10.3.1: Fast Track Scheme

- Background:

The Fast Track Scheme has been devised to provide a re-sit opportunity for failed students who have met the attendance requirement.

- Details of Fast Track Scheme:

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The details of the scheme are as under:

a. The scheme is available for those students who are carrying out their dissertation but have a backlog of module(s).

b. A schedule for the Fast Track scheme will be notified, well in advance, by the Academic

Registrar (Faculty).

c. A student can register for a maximum of TWO modules excluding the following:

i. Elective module

ii. Group project

d. A failed student need not attend the classes and lab sessions but will have to appear for all components of the module assessment, viz., written test, assignment, laboratory/field work as the case may be.

e. The assessment method is the same as that for regular modules. However, the marks awarded in any module that is attempted under the Fast Track scheme will be capped at 40% (pass class).

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11. Academic Awards

Award of Grades: The basis for awarding Grades is shown in Table below:

Grade Definition and Grade Point			
Sl. No.	**Marks Scored**	**Grading**	**GPA Grade Points**
1.	90.1 – 100	O (Outstanding)	10
2.	80.1 – 90	A+ (Excellent)	9
3.	70.1 – 80	A (Very Good)	8
4.	60.1 – 70	B+ (Good)	7
5.	55.1 – 60	B (Above Average)	6
6.	50.1 – 55	C (Average)	5
7.	40 – 50	P (Pass)	4
8.	Below 40	F/Ab (Fail/Absent)	0

GPA= Grade Point Average

∑_1^n (Grade Points scored in a given module* Number of Credits of that Module)/(Total Number of Credits)

(n – total number of modules)

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Appendix A

Programme Structure

The following are the courses a student is required to successfully complete for the award of the degree. The Programme is delivered as per the Time-Table for every batch.

SEMESTER 1

Sl. No.	Code	Course Title	Theory (h/W/S)	Tutorials (h/W/S)	Practical (h/W/S)	Total Credits	Max. Marks
1	19PEC501	Modern Power Semi conductor Devices	3	2	--	5	100
2	19PEC502	Electric Drive Systems	3	2	--	5	100
3	19PEC503	Power Converters Analysis and Design	3	1	1	5	100
4	19PEC504	Power Electronic Control of Drives	3	1	1	5	100
5	19FET509A	Research Methodology & IPR	2	--	--	2	50
6	19FET510A	Audit Course	1	--	--	0	
		Total	**15**	**06**	**02**	**22**	**550**
	Total number of contact hours per week		**23 hours**				
	Number of credits can be registered		**Minimum**	**18**		**Maximum**	**22**

SEMESTER 2

Sl. No.	Code	Course Title	Theory (h/W/S)	Tutorials (h/W/S)	Practical (h/W/S)	Total Credits	Max. Marks
1	19PEC505	Power Electronics in Renewable Energy Systems	3	1	1	5	100
2	19PEC506	Finite Element Analysis of Electric Drives	3	1	1	5	100
3	19PEE51X	Digital Control of Power Electronic Systems/ Electric Drive Vehicle Engineering	3	--	--	3	100
4	19PEE51X	Smart Grid Technologies/ Intelligent Control	3	--	--	3	100

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		Systems in Electric Vehicles					
5	19PEE52X	Power Systems for Aerospace, Marine and Automotive Applications/ Embedded Systems for EV	3	--	--	3	100
6	19PEE52X	Power Quality/ Energy Storage Systems	3	--	--	3	100
9	19FET520A	Audit Course	1			0	
		Total	**19**	**02**	**02**	**22**	**600**
		Total number of contact hours per week	**23 hours**				
		Number of credits can be registered	**Minimum**	**18**		**Maximum**	**22**

SEMESTER 3

Sl.No.	Code	Course Title	Theory (h/W/S)	Tutorials (h/W/S)	Practical (h/W/S)	Total Credits	Max. Marks
X	19PEP521A	*Internship*			10	4	100
	19PEP522A	Group project			**15**	8	200
		Total			**25**	**12**	**300**
Total number of contact hours per week			**XX hours**				
Number of credits can be registered			**Minimum**	**XX**		**Maximum**	**XX**

SEMESTER 4

Sl.No.	Code	Course Title	Theory (h/W/S)	Tutorials (h/W/S)	Practical (h/W/S)	Total Credits	Max. Marks
	19PEP523A	Dissertation and Publication			24	24	400
Total					**24**	**24**	**400**
Total number of contact hours per week			**24 hours**				
Number of credits can be registered			**Minimum**	**24**		**Maximum**	**24**

Appendix B

Course Title	Modern Power Semiconductor Devices
Course Code	19PEC501
Department	Electrical Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

The aim of the course is to enlighten the students with recent developments in power semiconductor devices. Students are familiarized with switching and operational characteristics of advanced power semiconductor devices like GTO, IGBT and emerging devices like GaN/SiC MOSFET, IGCT etc. Selection of appropriate devices for various power electronic circuit topology is emphasized. The students are able to design triggering and protection circuits for various power semiconductor devices.

Course Outcomes

After undergoing this course students will be able to:

- **CO 1.** Discuss the operation, characteristics and application of modern power semiconductor devices
- **CO 2.** Discuss thermal management of power semiconductor devices
- **CO 3.** Choose an appropriate power semiconductor device for a given application
- **CO 4.** Design and analyze the firing and protection circuit for a given power semiconductor device
- **CO 5.** Design the heat sink for a given power semiconductor device

Course Contents

Unit 1: Power diodes:
Construction, principle of operation, voltage-current, turn-on and turn-off characteristics of pn fast-recovery diode, silicon carbide Schottky barrier diode

Unit 2: Power Transistor:
Construction, principle of operation voltage-current, turn-on and turn-off characteristics of MOSFET and IGBT, PT and NPT IGBT, super junction and SiC/GaN devices, trade off, cosmic-ray induced failure

Unit 3: Thyristor:
Converter grade and inverter grade thyristors, Asymmetrical Silicon-Controlled Rectifier (ASCR), Reverse-Conducting Thyristor (RCT), MOS Turn Off Thyristors (MTOs), Emitter Turn Off thyristors (ETOs), Gate Turn-Off Thyristor (GTO), Integrated Gate Commutated Thyristor (IGCT)

Unit 4: Firing and Protection Circuits:
Necessity of isolation, pulse transformer, opto-coupler, and gate drive circuits: SCR, MOSFET, IGBTs. Over voltage, over current and gate protections; design of snubber circuits

Unit 5: Thermal Protection:
Modes of heat transfer, cooling methods: liquid, vapour–phase cooling; heat sink types, heat sink selection: thermal resistance and impedance, electrical analogy of thermal parameters, mounting types, design of heat sink

Course Resources

a. Essential Reading

1. 1. Course Notes
2. Williams, B.W., Principles and Elements of Power Electronics. Devices, Drivers, Applications and Passive Components, 2006
3. Mohan, Undeland, Robins, Power Electronics – Concepts, Applications and Design, John Wiley and Sons, 2015

b. Recommended Reading

1. H.R. Zeller., Cosmic Ray Induced Failures in High Power Semiconductor Devices, ABB Semiconductors AG, Lenzburg, Switzerland
2. Kassakian J G et al, Principles of Power Electronics, Pearson Education, 2010
3. Branko L. Dokić, Branko Blanuša, 2015, Power Electronics: Converters and Regulators, Springer International Publishing

c. Other Electronic Resources

1. http://nptel.ac.in/

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Course Title	Electric Drive Systems
Course Code	19PEC502
Department	Electrical Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

The aim of the course is to emphasize electric drives and sensors based on their characteristics and thermal aspects. Students are taught the requirements to setup an electric drive based on the behavior, specifications and characterization of transmission, parametric expressions, dynamic and thermal equations of rotating machines. They are also enabled to design electric drive system with suitable sensors.

Course Outcomes

After undergoing this course students will be able to:

- **CO 1.** Elucidate electric drive characteristics and various sensors
- **CO 2.** Explicate electric drive components with specifications and their transient behavior
- **CO 3.** Analyze motor characteristics and associated expressions in designing electric drives
- **CO 4.** Model electric drive based on its static and dynamic behavior
- **CO 5.** Design motor drive system for a given application

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Bangalore - 560 054

Course Contents

Unit 1: Electric drive design aspects:

Selection of motor based on characteristics; selection of devices and sensors

Components: Electric drive components; Driven bodies: function of the driven body, reference or rated running, transient behavior, specifications

Transmission: Types and characterization, resolution, speed adaptation, dynamic behavior, oscillatory torque, position transfer

Unit 2: Motors:

Characteristics, scaling laws, parametric expression, rotating and linear motors,

Global Design of an Electric Drive: Dynamic equations, case studies

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Bangalore-560054

Heating and Thermal Limits: Importance of heating in drives, thermal equations for modes of heat transfer, global phenomenon, resolution, measurement and behaviour of heating

Energy dissipation, modes of cooling: air, water

Unit 3: Sensors:

Optical position sensors, Hall sensors, inductive position sensors, resolver-type rotating sensors, inductive sensors, and contactless sensors, sensor positioning, current sensors and protection sensors

Devices for drives: Voltage adjustment and current adjustment devices, switching devices and configurations

Direct Drives: Performance limits, motor with external rotor, case studies

Integrated drives: Principle, realization

Course Resources

a. Essential Reading

1. Course Notes
2. Marcel Jufer, Electric Drives: Design Methodology, Wiley Publications, 2010
3. S. B. Dewan, Gordon R. Slemon, A. Straughen, Power Semiconductor Drives, Wiley Publications, 2009

b. Recommended Reading

1. Bose, B.K., Modern Power Electronics and AC Drives. Pearson, 2015
2. Bogdan M. Wilamowski, J. David Irwin Power Electronics and Motor Drives, CRC Press,2011
3. Stefanos Manias, Power Electronics and Motor Drive Systems, Academic Press, 2016

c. Other Electronic Resources

1. http://nptel.ac.in/

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Course Title	Power Converter Analysis and Design
Course Code	19PEC503
Department	Electrical Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

The aim of the course is to analyze advanced power converters and pulse width modulation techniques. Students are taught various operation and analysis of three phase inverters, PWM techniques, multilevel inverters, DC and AC switched mode power supplies, resonant converters and their applications in power conversion systems. Students are enabled to design, model and analyze power electronic converters for various applications using standard simulation tool.

Course Outcomes

After undergoing this course students will be able to:

- **CO 1.** Discuss the operation of modern power converters
- **CO 2.** Discuss and analyze the various PWM techniques for power converters
- **CO 3.** Design and analyze DC and AC power supplies for various applications
- **CO 4.** Develop an appropriate power converter for a given application
- **CO 5.** Model and analyze multilevel inverters for industrial applications
- **CO 6.** Model, simulate and analyze power electronic systems using standard software tools

Course Contents

Unit 1 : Overview: Fourier series, Laplace transform

Three Phase Voltage Inverters: Analysis of 180° and 120° conduction modes, evaluation of output voltage and current: resistive and resistive-inductive loads

Unit 2 : PWM Techniques:

Sine PWM, 3rd harmonic PWM, delayed PWM (60°), Space Vector Modulation (SVM), PWM techniques comparison, suppression of harmonics

Current source inverters: Variable DC link inverter, applications

Unit 3 : Multi-Level Inverters (MLI):

Concept, classification, principle of operation and main features of diode clamped MLI, improved diode clamped MLI, flying capacitors MLI, cascaded MLI; comparisons of MLIs, applications

Unit 4 : AC voltage controllers:

Single phase and three phase AC voltage controllers with R and RL loads, PWM control, effects of source and load inductances, synchronous tap changers, applications

Unit 5 : DC power converters:

Classification, buck, boost, buck-boost, fly back, push-pull, half bridge and full bridge converters

Unit 6 : Uninterruptible Power Supplies (UPS):

Classification, on-line UPS, off-line, line-interactive UPS

Course Resources

a. Essential Reading

1. Course Notes

2. Umanand, L., Power electronics essentials and applications. 1sted. New York, NY, Wiley Publishers, 2009

3. Muhammad H. Rashid, Power Electronics: Circuits, Devices & Applications, Fourth Edition 2014

b. Recommended Reading

1. Dragan Jovcic, Khaled Ahmed, High Voltage Direct Current Transmission: Converters, Systems and DC Grids, 2015, Wiley

2. M.D.Singh and K.B. Khanchandani, Power Electronics, Second Edition, Tata McGraw Hill, 2017

3. P.S.Bimbhra, Power Electronics, Khanna publishers, 2004

4. Ned Mohan, Tore M. Undeland, William P. Robbins, Power Electronics: Converters, Applications, and Design, Third Edition, 2015

c. Other Electronic Resources

1. http://nptel.ac.in/

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Course Title	Power Electronic Control of Drives
Course Code	19PEC504
Department	Electrical Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

The aim of the course is to elucidate speed control of AC and DC motors using power electronic converters. Students are trained to design various power electronic circuits for speed control of AC and DC motors. They will be able to select appropriate speed control methodology for various applications and analyze various induction motor drives. Students are able to design closed loop controllers for AC and DC drives.

Course Outcomes

After undergoing this course students will be able to:

CO 1. Explicate various speed control methods of AC and DC motors
CO 2. Elucidate various methods of controlling induction motor drives, SRM and BLDC
CO 3. Discuss closed loop control of various AC and DC drives
CO 4. Discuss scalar controlled induction motor drives
CO 5. Model and analyze various power electronic converters used in AC and DC drives
CO 6. Use standard software tool to model, simulate and analyze various speed control methodologies

Course Contents

Unit 1: Overview:

Vector algebra, transformations: Parks transformation, abc to d-q and d-q to abc

Unit 2: Control of DC Drives:

Principle of DC motor speed control, phase-controlled converters, steady state analysis of three phase converter-controlled DC motor Drive

Chopper Fed DC Drives: Principle of operation of the chopper, chopper-controlled drives, duty-ratio control, current-limit control, steady state analysis, four quadrant chopper circuit

Unit 3: Switched Reluctance Motor (SRM):

Torque expression, converters for SRM drives, control of SRM drives

Brushless DC Motor: Torque expression, converters for BLDC drives, control of BLDC drives

Unit 4: Control of AC Drives:

Scalar control of induction motor drive: Open loop voltage/frequency control, closed-loop voltage/frequency control, stator current control and slip frequency control

Modelling and simulation of AC and DC drives using standard software tools

Course Resources

a. Essential Reading

1. 1. Course Notes
2. Bose, B.K., 2015. Modern Power Electronics and AC Drives. Pearson
3. Krishnan, 2015, Electric Motor Drives: Modelling Analysis and Control, Pearson

b. Recommended Reading

1. Mohan, Undeland, Robins, 2015, Power Electronics – Concepts, Applications and Design, John Wiley and Sons, Singapore
2. Gopal K. Dubey, 2015, Fundamentals of Electrical Drives, Narosa Publishing House

c. Other Electronic Resources

1. http://nptel.ac.in/

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Course Title	Research methodology and IPR
Course Code	19FET508A
Department	Electrical Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

This course deals with the principles of research, research methodology, significant phases of research, Intellectual property and its rights. Students are taught the realistic guidelines to be followed in the choice of field of research, topic of research and formulation of research problem. Key and careful considerations in the choice of tools for the solution of research problem are covered in this module. The module emphasizes the desirable close-knit relation between innovation and concept of out of the box thinking. The principles of effective research and the need for a Proactive approach in a successful research programme are also explained. The course discusses the significant role of Literature Review in a research cycle and the expectations from good literature review as well as procedure for systematic literature review. Students will get an insight into the privilege, honour and the associated responsibilities of a researcher. This course gives insight of the intellectual property rights and over view of the benefits.

Course Outcomes

After undergoing this course students will be able to:

- **CO 1.** Describe the value, scope, relevance and mandatory steps of research as well as principles of effective research, Nature of Intellectual Property
- **CO 2.** Discuss the guidelines to progress from the choice of broad field of research to specific topic of research, patent rights, process of patenting at National and International level, New Developments in IPR
- **CO 3.** Demonstrate the application and utility of the Systematic approach and out of box thinking concepts for research to be effective
- **CO 4.** Adapt, Analyse and prepare well-structured research proposal and research paper invoking clearly outlined principles

Course Contents

Unit 1: Foundations of Research – Definitions of Research, Mandatory Steps in Research, Types of Research, Relevance of Research for Innovation and Technology Development, Effective Research and Self Discipline.

Unit 2: Formulation of Research Problem: Identification of problems, Narrowing down the problem, Factors to be considered for problem selection. History and Evolution of Science & Technology

Unit 3: Out Of the Box Thinking and Systematic approach in Research – Transformation to Impossible Thinking, Convergent and Divergent Thinking, Generation, Evaluation and Selection of Ideas, Critical Thinking

Literature Review – Importance of Literature Review, Constituents of Good Literature Review, Strategies for Literature Search, Referencing, Paraphrasing, and Summarizing Academic Standards and Ethics

Research Proposal – Structure of a Good Research Proposal, Getting Started, Tips for Compilation of Good Research Proposal.

Unit 4: Nature of Intellectual Property: Patents, Designs, Trade and Copyright, Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

Unit 6: Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases, Geographical Indicators

Unit 7: New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Copy rights for Software's

Traditional knowledge Case Studies.

Course Resources

a. Essential Reading

1. Class Notes

2. Dr. Chakroborty, S.K. "ValuStuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students'"

3. Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction"

4. Ranjit Kumar, 2nd Edition, "Research Methodology: A Step by Step Guide for beginners"

5. Halbert, (2007) "Resisting Intellectual Property", Taylor & Francis Ltd .

b. Recommended Reading

1. Mayall, (1192),"Industrial Design", McGraw Hill.

2. Niebel, (1972), "Product Design", McGraw Hill.

3. Asimov, (1962), "Introduction to Design", Prentice Hall.

4. Robert P. Merges, Peter S. Menell, Mark A. Lemley, (2016)," Intellectual Property

in New Technological Age".

9. T. Ramappa, (2008)"Intellectual Property Rights Under WTO", S. Chand.**c.Other Electronic Resources**

1. http://nptel.ac.in/

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Course Title	Professional Communication
Course Code	19FET509A
Department	Electrical Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

This course aims at sensitising students to the essentials of professional communication. Professional Communication is essential to achieve the objectives of an organisation.

Course Outcomes

After undergoing this course students will be able to:

CO 1. Compose effective written business communication
CO 2. Practice the techniques of presentation

Course Contents

Uint 1: Introduction to Professional Communication, Conversation and Listening

Uint 2: Reading Skills for Effective Professional Communication: Introduction, SQ3R (Survey, Question, Read, Retrieve, and Review) Technique of Reading

Uint 3: Written Business Communication: Writing Memos, Letters, Circulars and Notices, Communicating through Email

Uint 4: Presentation Skills: Message development, content, projection, inflection, and delivery

Course Resources

a. Essential Reading

1. Class Notes
2. Dr. C.S.G. Krishnamacharyulu (2016) Business Communication, Himalaya Publishing House

b. Recommended Reading

1. V. Lesikar, John D. Pettit, Jr., Marie E. Flatley. (1999), Basic Business Communication, 8th Edition, Tata McGraw Hill

c.Other Electronic Resources

1. http://nptel.ac.in/

Course Title	Power Electronics in Renewable Energy Systems
Course Code	19PEC505
Department	Electrical Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

The aim of the course is to design power converters for solar and wind energy systems. Various converter topologies used in wind and solar photovoltaic systems with maximum power point tracking are discussed. The students are able to analyze the grid integration issues, develop phase locked loop systems and synchronization techniques. Students are able to model and analyze solar and wind power conversion systems using standard software tool.

Course Outcomes

Course Contents

Unit 1: Solar Energy:

Solar photovoltaic cell: fundamentals, characteristics, classification; configuration: cell, module, array; maximizing solar PV output, maximum power point tracking algorithm, load matching

Unit 2: Switched Mode Power Conversion:

Reactive elements, design of inductor, design of transformer, capacitors for power electronic applications, analysis and design of dc to dc converters: control of dc-dc converters, buck converters, boost converters, buck-boost converters, overview of resonant converters

Unit 3: Inverters for PV:

Single phase, three phase inverters with and without transformer; inverter topologies: Current Source Inverter; control schemes: unipolar, bipolar, PLL and synchronization, power balancing/bypass

Grid integration issues: leakage current, islanding, harmonics, active/reactive power feeding

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Bangalore-54

Unit 4: Wind Energy:

Classification, advantages, disadvantages, characteristics, maximum power point tracking algorithm, environmental aspects

Unit 5: Adaptive control: Deterministic and predictive self-tuning regulators, Model-reference adaptive systems and their properties

Types of Wind Energy Conversion Systems: Power conversion system with induction generators, doubly fed induction generators, permanent magnet synchronous generators

Grid integration issues: Wind farm and its accessories, grid connectors, challenges related to grid integration of wind turbines

Course Resources

a. Essential Reading

1. Course Notes

2. Muhammad H. Rashid., 2017. Power electronics: devices, circuits and applications. 4thed, Pearson Education.

3. Umanand, L., 2009. Power electronics essentials and applications. 1sted. New York, NY, Wiley Publishers.

b. Recommended Reading

1. Nicola Femia, Giovanni Petrone, Giovanni Spagnuolo, Massimo Vitelli, 2013, Power Electronics and control for maximum Energy Harvesting in Photovoltaic Systems, CRC Press.

2. Marco H. Balderas, Renewable Energy Grid Integration, Nova Science publishers, New York, 2009

3. Sudipta Chakraborty, Marcelo G. Simes, and William E. Kramer, Power Electronics for Renewable and Distributed Energy Systems: A Sourcebook of Topologies, Control and Integration. Springer Science & Business, 2013

4. Ned Mohan, Tore M. Undeland and William P. Robbins, 2007 "Power Electronics: Converters, Applications and Design", Third Edition, John Wiley & Sons

c.Other Electronic Resources

1. http://nptel.ac.in/

Course Title	Finite Element Analysis of Electric Drives
Course Code	19PEC506
Department	Electrical Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

The aim of the course is to enable the students to comprehend analysis of magnetic fields and electric potentials in sub-systems of electrical machines and drives using finite element analysis. Students are taught the principles of geometric modelling and engineering analysis with exposure to 3D modelling and discretization using software tools.

Course Outcomes

Course Contents

Unit 1: Electromagnetics:

Requirements for electromagnetic devices, procedure for analyzing electromagnetic devices, components and modules for Computer Aided Engineering (CAE), classification of electromagnetic field, computer aided design in magnetics

Unit 2: Electromagnetic Fields:

Quasi stationary fields, boundary value problem, field equations in partial differential form

Potentials and Formulations: Magnetic vector potential, electric vector potential for conducting current, electro-static vector potential, magnetic scalar potential, Aϕ and Av formulation, Maxwell equations

Unit 3: Field Computation and Numerical Techniques:

Magnetic equivalent circuit, point mirroring method, computation of field quantities, numerical solution of partial differential equations, finite difference method.

Geometric Modelling: Finite Element Method (FEM), material modelling, numerical implementation of the FEM

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Unit 4: Adaptive Refinement for 2D Triangular Meshes:

Type of element refinement, priori error estimation, reconstruction of the original geometry, posteriori error estimation, energy, magnetic flux and magnetic flux density

Post Processing: Potentials, energies, local field quantities, forces and torques, inductances in magneto static problems

Unit 5: Modelling of Electrostatic and Magnetic Devices

Modelling with parametric sweep, geometry modelling, boundary conditions, transformations

Case Study: AC and DC drives

Course Resources

a. Essential Reading

1. Course Notes

2. Dubey, G.K., Fundamentals of electrical drives, CRC Press, 2018

3 .Hameyer, K. and Belmans, R., Numerical Modelling and Design of Electrical Machines and Devices, WIT Press, Southampton, 2001

b. Recommended Reading

1. Salon, S. Finite element analysis of electrical machines. Boston: Kluwer Academic Publishers, 1995

2. Bianchi, N., Electrical machine analysis using finite elements, CRC press, 2017

c. Other Electronic Resources

1. http://nptel.ac.in/

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Course Title	Value Education
Course Code	19FET510A
Department	Electrical Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

This course aims at sensitising students to learn the importance of value education. It gives an insight about the Universal Brotherhood.

Course Outcomes

After undergoing this course students will be able to:

CO 1. Discuss the role of Values and Ethics in Self-Development
CO 2. Appreciate the importance of Universal Brotherhood

Course Contents

- Values, Ethics and Self-Development; Awareness of self-destructive habits, Power of faith, Positive Thinking
- Value judgements – Stereotypes, prejudices and biases
- Sense of duty, Self-reliance, Confidence, Concentration, Discipline, Honesty, Truthfulness
- National Unity, Patriotism, Love for nature
- Universal brotherhood and religious tolerance
- Character and Competence –Rational Thinking vs Blind faith

Course Resources

a. Essential Reading

1. Class Notes

b. Recommended Reading

c. Other Electronic Resources

1. http://nptel.ac.in/

Course Title	Digital Control of Power Electronic Systems
Course Code	19PEE511
Department	Electrical Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

The aim of the course is to emphasize on digital control techniques for power electronic converters. Students are given an exposure to various digital control techniques like hysteresis control, predictive current control and digital pulse width modulation. They are also updated on various modern digital control paradigms. Students are able to design a digital controller for a particular power electronic system.

Course Outcomes

After undergoing this course students will be able to:

CO 1. Explicate various digital control techniques used in power electronic converters
CO 2. Discuss VSI and CSI controllers used in power electronic systems
CO 3. Analyze various architectures for digital control of distributed generation systems
CO 4. Model different current controllers for power electronic applications
CO 5. Design and analyse digital controllers for a power electronic system using standard software

Course Contents

Digital Control Application to Power Electronic Circuits:

Modern power electronic systems, trends and perspectives, Single-Phase Voltage Source Inverter: Voltage Source Inverter (VSI), low-level control of the voltage source inverter: PWM modulation, analog control approaches

Digital Current Mode Control:

Requirements: signal conditioning and sampling, synchronization between sampling and PWM, implementation of digital current controller: large bandwidth controller, narrow bandwidth controller, applications

Multi-Sampled Current Controllers:

Oversampled PI current controller and predictive current controller, digital and fixed frequency hysteresis current controller, large-signal response test, Extension to Three-phase Inverters: αβ-transformation, space vector modulation, rotating reference frame current controller, external control loops

New Digital Control Paradigms

Flexibility and performance, distributed generation control architectures, Case

Course Resources

a. Essential Reading

1. Course Notes

2. Buso, S. and Mattavelli, P., Digital control in power electronics. Synthesis Lectures on Power Electronics, 2015

3. Frede Blaabjerg, Control of Power Electronic Converters and Systems, Volume 1, Academic Press, 2018

b. Recommended Reading

1. Khaligh, A., Nie, Z., Lee, Y.J. and Emadi, A., Integrated power electronic converters and digital control. CRC Press, 2009

c. Other Electronic Resources

1. http://nptel.ac.in/

Course Title	Power Quality
Course Code	19PEE512
Department	Electrical Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

The aim of the course is to analyse and mitigate power quality issues in power systems. Students are taught various mitigation techniques using SVC, STATCOM, and DSTATCOM etc... They are also given an exposure to Electro Magnetic Interference (EMI), Electromagnetic compatibility and various Harmonic filtering techniques .The students will be able to suggest suitable power quality conditioners for power quality improvement using standard software tool.

Course Outcomes

After undergoing this course students will be able to:

- **CO 1.** Elucidate various power quality issues and effect of harmonics on power system components
- **CO 2.** Discuss sources of electromagnetic interference and various harmonic mitigation techniques
- **CO 3.** Analyze effect of various power quality issues and choose appropriate power quality conditioner to improve the reliability of the system
- **CO 4.** Discuss various harmonic filtering techniques and Electromagnetic compatibility enhancement techniques
- **CO 5.** Simulate various power quality conditioners for a given application using a standard software tool.

Course Contents

Unit 1: Issues:

Transients, voltage variations, voltage imbalance, waveform distortion, voltage fluctuations: voltage sags, causes of voltage sags, magnitude, duration of voltage sags, effect on drives and peripherals; power frequency variations: interruptions, origin of long and short interruptions, influence on various equipment; harmonics, harmonic introducing devices: SMPS, three phase power converters, arcing devices, storable devices; effect of harmonics on power system equipment and loads; power factor, electromagnetic interference

Unit 2: Mitigation:

Power factor improvement, passive compensation, passive filtering, harmonic resonance, impedance scan analysis, Active Power Factor Correction (APFC): single phase front end, control methods: single phase, three phase; PFC based on bilateral single phase and three phase converter, Static VAR Compensators (SVC) and STATCOM, load compensation using DSTATCOM, realization and control of

DSTATCOM, series compensation of power distribution system, Unified Power Quality Conditioner (UPFC), future directions and opportunities for power quality enhancement

Unit 3: Harmonic Filtering:

Shunt injection filter for single phase, three-phase three-wire and three-phase four-wire systems; d-q domain control of three phase shunt active filters, UPS, constant voltage transformers, series active power filtering techniques for harmonic cancellation and isolation, dynamic voltage restorers for sag, swell and flicker problems; electromagnetic compatibility enhancement

Course Resources

a. Essential Reading

1 Course notes

2. Eswald.F.Fudis and M.A.S.Masoum, "Power Quality in Power System and Electrical Machines," Elseviar Academic Press, 2013

3. Robert Smolenski, Conducted Electromagnetic Interference (EMI) in Smart Grid, Springer, 2012

b. Recommended Reading

1. Ali Keyhani, Design of smart power grid renewable energy systems, Wiley IEEE, 2011

2. A.G.Phadke, "Synchronized Phasor Measurement and their Applications", Springer.

3. Roger. C. Dugan, Mark. F. McGranagham, Surya Santoso, H.Wayne Beaty, 'Electrical Power Systems Quality' McGraw Hill, 2003.

4. J. Arrillaga, Power System Quality Assessment, John Wiley, 2000

5. Arindam Ghosh, Gerard Ledwich, Power Quality Enhancement Using Custom Power Devices, springer 2002

c. Other Electronic Resources

1. http://nptel.ac.in/

Course Title	Power Systems for Aerospace, Marine and Automotive Applications
Course Code	19PEE513
Department	Electrical Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

The aim of the course is to enlighten the students with basic concepts of power system and electric drives in aerospace, marine and automotive applications. Power generation schemes, distribution systems, various drives, electric propulsion, regenerative braking systems, tractive effort and transmission characteristics are discussed. Students are able to model drive systems for various applications using standard software tool.

Course Outcomes

After undergoing this course students will be able to:

- **CO 1.** Elucidate power generation scheme, types of propulsion, energy conversion in ships, aircrafts and automobiles
- **CO 2.** Illustrate power distribution system, various drives in aircrafts, ships, propeller and automobiles
- **CO 3.** Develop power converter control strategies for aerospace, automobile and marine applications
- **CO 4.** Model and analyze power converter circuits for energy storage system in aerospace, marine and automotive applications
- **CO 5.** Simulate the individual components used in drives with power converter circuit for aerospace, marine and automotive applications using standard software tool

Course Contents

Aircraft Electrical Systems: **(00 Hours)** Power generation, power conversion, emergency power sources, typical aircraft DC system, typical civil transport electrical system, electrical loads, emergency power generation, recent trends in electrical load management systems, Aircraft Electric Propulsion: Types of propulsion
Drives in Aircrafts: **(00 Hours)** Variable speed induction motor drives, variable speed constant frequency drives, power distribution system, Marine Electrical Power System: Systems and major components, power management systems, power generation, load analysis, electrical system in ships
Marine Electric Propulsion: **(00 Hours)** Layout and general features, excitation systems, types of propulsion: basic turbo electric propulsion, advanced diesel-electric propulsion system, general distribution scheme on-board in a ship

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Electric Drives:	**(00 Hours)**
AC single-speed drive and AC induction motor drive with a controllable pitch propeller; fixed-speed alternators with variable-speed synchronous motors, cycloconverter method of speed control; SIMAR drive cyclo: drive with the cycloconverter; SIMAR drive PWM: drive with IGBTs, Motor Drives for Vehicular Applications: Cell balancing converters; DC drives, AC drives, brushless DC motor drives, SRM drives, self-tuning techniques of SRM Drives	

Course Resources

a. Essential Reading

1.Course notes

2.Ian Moir and Allan Seabridge,' Aircraft Systems: Mechanical, Electrical and Avionics- Subsystem Integration',Wiley India Pvt Ltd 2008

3.Elstan A. Fernandez Kholi.P.L, 'Marine Electrical Technology' Fifth Edition, Shroff publishers & distributors pvt. Ltd, 2010

b. Recommended Reading

1.Mehrdad Ehsani, Yimin Gao,Sebastien E. Gay, Ali Emadi, 'Modern Electric ,Hybrid Electric and fuel cell vehicles Fundamentals ,Theory and Design', CRC press Taylor and Francis group, 2005

2.Iqbal Hussain , 'Electric and hybrid vehicles design fundamentals' second edition, CRC press Taylor and Francis group, 2013

c. Other Electronic Resources

1. http://nptel.ac.in/

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Course Title	Smart Grid Technologies
Course Code	19PEE514
Department	Electrical Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

The aim of the course is to emphasize the need for smart grid in current power system scenario. Students are taught components and architecture of smart grid design; role of automation in distributed generation and measurement. They are also given an exposure to power quality issues, concepts of smart grid communication and control technologies.

Course Outcomes

After undergoing this course students will be able to:

CO 1. Elucidate the need for Smart Grid and their features in the context of Indian grid
CO 2. Explicate the operation and importance of PMUs, PDCs, WAMS, voltage and frequency control in micro grids
CO 3. Discuss the role of automation in distributed generation
CO 4. Develop and analyze various algorithms for the smart grid/distributed generation
CO 5. Model and analyze appropriate power quality conditioners to improve the performance of the smart grid

Course Contents

Unit I (Smart Grid): Concept of smart grid, functions, new technologies, advantages, key challenges comparison between traditional power grid and smart grid, Indian smart grid, environmental impact, climate change, economic issues

Unit II (Smart Grid Architecture): Architecture and components of smart grid design; transmission automation, distribution automation, renewable integration, Renewable energy technologies, micro grids, storage technologies, Electric Vehicles (EV)

Unit III (Communication Technologies and Smart Grid): Communication technology, Phasor Measurement Units (PMUs), Wide Area Measurement Systems (WAMS)

Unit IV (Control of Smart Grid System): Load Frequency Control (LFC) in micro grid system, voltage control in micro grid system, reactive power control in smart grid, case studies

Unit V (Power Quality in Smart Grid): Power quality issues of grid connected renewable energy sources, EMI issues in smart grid, power quality conditioners for smart grid. Tools and Techniques for Smart Grid: Artificial intelligence techniques.

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Course Resources

a. Essential Reading

1. Course notes
2. Stuart Borlase, Smart Grids, Infrastructure, Technology and Solutions, CRC Press, 2013
3. Gil Masters, Renewable and Efficient Electric Power System, Wiley–IEEE Press, 2004.

b. Recommended Reading

1. A.G. Phadke and J.S. Thorp, "Synchronized Phasor Measurements and their Applications", Springer Edition, 2010.
2. T. Ackermann, Wind Power in Power Systems, Hoboken, NJ, USA, John Wiley, 2005

c. Other Electronic Resources

1. http://nptel.ac.in/

Course Title	Electric Drive Vehicle Engineering
Course Code	19PEE521
Department	Electrical Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

The aim of the course is to emphasize on automotive electrification and controllers for different motors in Electric Vehicles (EV). Students are taught conventional vehicle power train, architecture and control of plug in electric vehicles. They are also given an exposure to EV charging infrastructure, Vehicle to Grid (V2G) interface and range extended vehicles.

Course Outcomes

After undergoing this course students will be able to:

- **CO 1.** Explicate vehicle electrification and conventional vehicle power trains
- **CO 2.** Elucidate various electric drive control techniques and hybrid electric power trains
- **CO 3.** Discuss charging infrastructure for EV and PHEV powered by grid and Renewable Energy system
- **CO 4.** Modelling of DSP controllers for electric vehicles
- **CO 5.** Model and synthesize vehicle drive systems using standard software tool

Course Contents

Unit I (Automotive Electrification): Enabling technologies for transportation electrification, electrical grid systems, transportation electrification a paradigm shift

Unit II (Conventional Vehicles and Power Trains): Longitudinal vehicle model, longitudinal resistance, total tractive force, maximum tractive effort and powertrain tractive effort, vehicle performance, braking performance and distribution, vehicle power plant and transmission characteristics

Unit III (Electric Motor Control): DC motor: torque production and control, fundamentals of AC motor control, fundamentals of BLDC machine torque control, fundamentals of BLAC machine torque control, switched reluctance machine control, speed control in machines

Unit IV (All Electric Vehicle and Range Extended Electric Vehicles): EV configuration and main components, EV performance, range extended electric vehicle, fuel cell electric vehicle, solar electric vehicle and electric bicycle.

Unit V (Vehicle to Grid Interface and Electrical Infrastructure): EV and PEV charging infrastructure, Power electronics for EV and PEV charging infrastructure, concepts of V2G and Vehicle to Home (V2H), impact of EV charging and V2G power flow on the grid, renewable energy and EV/PEV blend in a smart grid.

Course Resources

a. Essential Reading

1. Course notes
2. Emadi, A., 2014. Advanced electric drive vehicles. CRC Press
3. Hayes, J.G. and Goodarzi, G.A., 2017. Electric Powertrain: Energy Systems, Power Electronics and Drives for Hybrid, Electric and Fuel Cell Vehicles. John Wiley & Sons

b. Recommended Reading

1. Husain, I., 2003. Electric and hybrid vehicles: design fundamentals. CRC press.
2. Larminie, J. and Lowry, J., 2012. Electric vehicle technology explained. John Wiley & Sons

c. Other Electronic Resources

2. http://nptel.ac.in/

Course Title	Energy Storage Systems
Course Code	19PEE522
Department	Electrical Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

The aim of the course is to provide an understanding of energy storage systems associated with electric vehicle and smart grid. Students are taught different energy storage devices and technologies. They are also enabled to estimate the storage sizing, State of Charge (SoC) and State of Health (SoH) of batteries.

Course Outcomes

After undergoing this course students will be able to:

- **CO 1.** Explicate construction and working principle of various types of energy storage devices
- **CO 2.** Discuss the various technical specifications of energy storage technologies
- **CO 3.** Elucidate the electrical performance and safety aspects of batteries
- **CO 4.** Analyze the characteristics and performance of various energy storage systems for Electrical Vehicle
- **CO 5.** Estimate the storage sizing and state parameters for various batteries

Course Contents

Unit I (Energy Storage Systems): Significance, need, components, application and technical benefits; Techno – economic characteristics, classification

Unit II (Energy Storage Technologies): Batteries, fuel cells, supercapacitors: electric double layer capacitors, electrochemical pseudo capacitors, hybrid supercapacitors; flow battery, and superconducting magnetic energy storage, Assessment and comparison: Technical maturity, power rating, discharge time, storage duration, capital cost, cycle efficiency, energy, power density, life time and cycle life

Unit III (Battery Storage: Classification of batteries): Standard, modern, special, flow and high temperature batteries; composition, estimation of storage for grid connected solar PV, wind power and hybrid systems. Energy Storage for Electric Vehicles (EV): Lithium ion batteries: parameters, limits and potential future developments; supercapacitors, lithium air batteries

Unit IV (Fuel cells): Proton exchange membrane, alkaline electrolyte, direct methanol, medium and high temperature Batteries: Types, technical description, design, electrical performance, environmental and safety aspects Battery State Estimation: Cell balancing, determination of state parameters: State of Charge (SoC), State of Health (SoH) and State of Function (SoF)

Course Resources

a. Essential Reading

1. Course notes
2. Zobaa, A.F., 2013. Energy storage-technologies and applications, intechopen.com.
3. Scrosati, B., Garche, J. and Tillmetz, W. eds., 2015. Advances in battery technologies for electric vehicles. Woodhead Publishing.

b. Recommended Reading

1. Larminie, J., Dicks, A. and McDonald, M.S., 2003. Fuel cell systems explained (Vol. 2, pp. 207-225). Chichester, UK: J. Wiley.
2. Brodd, R.J. ed., 2012. Batteries for sustainability: selected entries from the encyclopedia of sustainability science and technology. Springer Science & Business Media.

c. Other Electronic Resources

1. http://nptel.ac.in/

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Course Title	Embedded Systems for EV
Course Code	19PEE523
Department	Electrical Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

The aim of the course is to emphasize on the basic concepts of embedded systems in electric vehicles. Students are taught vehicle functional domains and embedded systems requirements. They are given an exposure to levels of automation and intelligent vehicle technologies.

Course Outcomes

After undergoing this course students will be able to:

- **CO 1.** Understand basics of embedded systems and vehicle domains
- **CO 2.** Explain architecture of ARM and concepts of their programming
- **CO 3.** Discuss embedded system requirements, software and communication
- **CO 4.** Program the real time embedded system, execute and verify its functionality.
- **CO 5.** Analyze various examples of embedded systems based on ARM processor
- **CO 6.** Realize the functionalities of various intelligent vehicular techniques used in electric vehicles

Course Contents

Unit I (Embedded Systems and Vehicle Functional Domains): Typical embedded system, microcontrollers and microprocessors, review of embedded automotive protocols: automotive communication systems: characteristics and constraints, in-car embedded networks, multimedia networks, ARM architecture, power train domain, chassis domain, body domain, multimedia telematics and HMI domain, active/passive safety, diagnostic.

Unit II (Embedded system requirements for EV): Standardized component models and processes, in-vehicle networks and protocols, operating systems, middleware, architecture description languages for automotive application.

Unit III (Automation Level in the Automotive Environment): Reducing or eliminating the human factor in driving, level of car automation; driverless cars: data acquisition, data treatment, Internet of Things technology (IoT), predictive maintenance.

Unit IV (Intelligent Vehicle Technologies): Evolution of intelligent vehicle technologies, sensor technologies, Sensor fusion, wireless network technologies, intelligent vehicle control applications, driving assistance

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Course Resources

a. Essential Reading

1. Denton T, "Automobile Electrical and Electronic Systems", Elsevier Jordan Hill, Oxford, 2010.
2. Iqbal Husain, "Electric and Hybrid Vehicles: Design Fundamentals", Second Edition, Aug 2010.
3. S. Van Themsche, "The advent of unmanned electric vehicles", springer, 2016.

b. Recommended Reading

1. Asier Perallos, Unai Hernandez Jayo, Enrique Onieva, Ignacio Garcia Zuazola, "Intelligent transport systems", First edition, Wiley, 2016.
2. Larminie, J. and Lowry, J., 2012. Electric vehicle technology explained. John Wiley & Sons.
3. Chan, C.C. and Chau, K.T., 2001. Modern electric vehicle technology (Vol. 47). Oxford University Press on Demand.

c. Other Electronic Resources

1. http://nptel.ac.in/

Course Title	Intelligent Control Systems in Electric Vehicles
Course Code	19PEE524
Department	Electrical Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

This aim of the course gives an overview of various control schemes for Electric Vehicles (EV). Various electronic control units and control strategies in EVs are discussed. Students are taught concepts of fuzzy sets and relations. They are given an exposure to model, simulate and analyze fuzzy logic controller in EV.

Course Outcomes

After undergoing this course students will be able to:

- **CO 1.** Elucidate the functions of control system in electric vehicles
- **CO 2.** Discuss various types of control units and their control strategies in electric vehicles
- **CO 3.** Identify, evaluate and choose appropriate membership functions and fuzzy rule base for a given application
- **CO 4.** Develop a schematic diagram for design of Fuzzy Logic Controllers (FLC)
- **CO 5.** Analyze adaptive control theories, their properties, and applications to autonomous vehicles
- **CO 6.** Model, simulate and analyze fuzzy logic controller for EV

Course Contents

Unit I (Control Systems in EVs): Benefits of control system, design sequence, algorithm development; various operational modes to be controlled; elements of control system in EV, robustness of control system. Electronic Control Units (ECU): Engine ECU, motor-generator ECU, power electronics ECU, battery ECU

Unit II (Control Variables): Variables connecting the ECUs, energy management, control complexities Control Strategies: Adaptive control, fuzzy systems Fuzzy Sets and Fuzzy Systems: Fuzzy set operations, properties of fuzzy sets, fuzzy relations: cardinality, operations, and properties

Unit III (Membership Functions): Features of membership function, classification of fuzzy sets Fuzzification: Membership value assignments: intuition, inference rank ordering, angular fuzzy sets neural networks, inductive reasoning

Unit IV (Defuzzification): Lambda cuts for fuzzy sets, lambda cuts for fuzzy relations, defuzzification methods Fuzzy Rule-Based System: Formation of rules, decomposition of rules, and aggregation of fuzzy rules, properties of set of rules, fuzzy inference system, construction and working of inference system Fuzzy inference methods: Mamdani fuzzy inference method, Takagi–Sugeno fuzzy method (TS method), advantages of Sugeno and Mamdani methodsFuzzy Logic Control (FLC): Mamdani Type Fuzzy Control, fuzzy PID control, structure of FLC for EV

Course Resources

a. Essential Reading

1. Course Notes
2. M. Ehsani, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2005
3. A. E. Fuhs, Hybrid Vehicles and the Future of Personal Transportation, CRC Press, 2009
4. Ross, T. J. (2009). Fuzzy Logic with Engineering Applications: Wiley.

b. Recommended Reading

1. Fuzzy Logic: A Pratical approach, F. Martin, , Mc neill, and Ellen Thro, AP Professional, 2000.
2. Fuzzy Logic with Engineering Applications (3rd Edn.), Timothy J. Ross, Willey, 2010.
3. Zhihua Qu, Cooperative Control of Dynamical Systems: Applications to Autonomous Vehicles, Springer 2009.

c. Other Electronic Resources

1. http://nptel.ac.in/

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Course Title	Internship
Course Code	19PEP521A
Department	Electrical Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

The aim of this course is to make a student experience an industrial or business environment. The student will visit various departments of an industry/business and observe the activities in each department for a certain duration of time and try to relate his/her experience with the theory practiced back at the faculty. The student should develop a report and make a presentation on his/her experience at the industry/business.

Course Outcomes

Course Contents

Industry Internship in the relevant organization

Course Resources

a. Essential Reading

1. Organization Website
2. Discussions with Managers/Mentor/Supervisor of different departments of the organization

Course Title	Group Project
Course Code	19PEP5522A
Department	Electrical Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

This course is intended to provide student an opportunity to synergise their learning from the earlier courses through working in a team, sharing responsibilities, to conceiving, designing and fabricating a working prototype of a system related to an automotive application. The students will learn skills related to project identification, planning, management and execution, working in teams and verbal and written communication. During design, analysis and synthesis stage, they will get an opportunity to apply theoretical knowledge to develop real life product and prototyping stage will provide them experience of converting a design into a working system through use of various fabrication techniques available.

Course Outcomes

After undergoing this course students will be able to:

- **CO 1.** Define aim and objectives of the chosen project idea and explain its applications
- **CO 2.** Arrive at various technical specifications to be targeted while executing the project
- **CO 3.** Specify the methodologies/procedure/methods for the design and implementation of the project
- **CO 4.** Demonstrate /present a prototype of the implemented project
- **CO 5.** Work as team, develop leadership and project management skills

Course Contents

Team building, Team work and Leadership skills

Preparing design specifications, design, analysis and synthesis, design evaluation

Costing, Finance Management, Project management

Procurement, prototype building and related manufacturing methods

Preparing and presenting audio-visual and verbal presentations and preparing written documents

Course Resources

a. Essential Reading

1. Assigned reading relevant to the group project

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Course Title	Dissertation and Publication
Course Code	19PEP523A
Department	Electrical Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

This course is intended to give an insight to the students on application of principles of research methodology, preparation of research project proposal, research project management, execution of research project and effective technical communication and presentation. It also emphasizes the need and the relevance of a structured approach to identify a research topic and undertake research. This course provides an opportunity for students to apply theories and techniques learnt during programme work. It involves in-depth work in the chosen area of study.

Course Outcomes

After undergoing this course students will be able to:

- **CO 1.** Critically review scholarly literature collected from various sources for the project purpose and formulate a research problem
- **CO 2.** Prepare and present a research proposal
- **CO 3.** Conduct research to achieve research objectives
- **CO 4.** Propose new ideas/methodologies or procedures for further improvement of the research undertaken
- **CO 5.** Create research document and write research papers for publications
- **CO 6.** Defend the research findings in front of scholarly audience

Course Contents

Research Methodology

Information search, retrieval and review

Project definition and project planning

Use of conceptual models and frameworks Problem solving and Evaluation Interpretations and drawing conclusions Proposing ideas or methods for further work Thesis writing

Oral presentation

Authoring Research paper

Course Resources

a. Essential Reading

1. Lecture Sessions on individual project, Thesis Preparation delivered by the concerned Head of Dept

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