Master of Technology (M. Tech)

In

Electrical Engineering (Specialization in Renewable Energy Technologies and Management)

(As Per AICTE Model Curriculum)

CBCS Course Matrix for

I to IV Semesters

Faculty of Engineering and Technology

2022 - Onwards

Date: **Head of the Department**

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2022 - Onwards

1a. Programme Structure

	Particulars								
Semester	**BS**	**ES**	**HSS**	**Core**	**Dept. Elective**	**Open Elective**	**MC**	**SEC**	**Total**
I	03	--	03	11	--	--	00	--	**17**
II	--	--	--	13	06	--	00	--	**19**
III	--	--	--	--	03	03	--	11	**17**
IV	--	--	--	--	--	--	--	16	**16**
Total	**03**	**00**	**03**	**24**	**09**	**03**	**00**	**27**	**69**

	BS	**ES**	**HSS**	**Core**	**Dept. Elective**	**Open Elective**	**MC**	**SEC**	**Total**
Total Credit distribution for batch 2021	**03**	**00**	**03**	**24**	**09**	**03**	**00**	**27**	**69**

1b. List of Courses

BS: Basic Science

1. Applied Mathematics for Electrical Engineers

HSS: Humanities and Social Science

1. Research Methodology & IPR

Core

1. Power Converters & Control
2. Advanced Control Theory
3. **Power Generation by Renewable Energy Sources (Specialization paper)**
4. Solar Photovoltaic Devices and Systems
5. Wind and Small Hydro Energy System
6. Analysis, Design and Grid Integration of Renewable Energy Systems
7. Electrical Simulation Laboratory
8. Solar Energy Laboratory
9. Renewable Energy Simulation Laboratory

DE: Department Electives

1. Energy Resource Economics and Environment

2. Embedded System Controllers for Renewable energy Systems
3. Energy and Climate
4. Bio Inspired Algorithms
5. Energy Management and Audit
6. Smart Grid Technologies and Application

OE: Open Electives

1. Emerging Technologies in Power Generation
2. Energy Storage Systems
3. Applications of Artificial Intelligence in Renewables Energy

MC: Mandatory Courses

1. English for Research Paper Writing
2. Pedagogy Studies
3. Value Education
4. Personality Development through Life Enhancement Skills
5. Constitution of India
6. Stress Management by Management by Yoga

Department of Electrical and Electronics Engineering

I Semester – M. Tech – Renewable Energy Technologies and Management

Course Matrix-CBCS

S.No.	Subject Code	Name of the Subject	Credit (Marks)	L–T–P	Internal Assessment		End Semester Examinations		Minimum Passing Marks
					Max. Marks	Min. Marks	Max. Marks	Min. Marks	
1		**Applied Mathematics for Electrical Engineers**	**3**	3–0–0	50	25	50	25	50
2		**Research Methodology & IPR**	**3**	3–0–0	50	25	50	25	50
3		**Power Converters & Control**	**3**	3–0–0	50	25	50	25	50
4		**Advanced Control Theory**	**3**	3–0–0	50	25	50	25	50
5		**Specialization Paper**	**3**	3–0–0	50	25	50	25	50
6		**Electrical Simulation Laboratory**	**2**	0–0–4	50	25	50	25	50
7		**Mandatory Course I**	**Non-Credit**	2–0–0					
Total Credit			**17**						

BS	ES	HSS	Core	DE	OE	MC	SEC	Total Credits
03	00	03	11	--	--	00	--	**17**

Department of Electrical and Electronics Engineering

II Semester – M. Tech – Renewable Energy Technologies and Management

Course Matrix-CBCS

S.No.	Subject Code	Name of the Subject	Credit (Marks)	L–T–P	Internal Assessment		End Semester Examinations		Minimum Passing Marks
					Max. Marks	Min. Marks	Max. Marks	Min. Marks	
1		**Solar Photovoltaic Devices and Systems**	3	3–0–0	50	25	50	25	50
2		**Wind And Small Hydro Energy Systems**	3	3–0–0	50	25	50	25	50
3		**Analysis, Design and Grid Integration of Renewable Energy Systems**	3	3–0–0	50	25	50	25	50
4		**DE-I**	3	3–0–0	50	25	50	25	50
5		**DE-II**	3	3–0–0	50	25	50	25	50
6		**Solar Energy Laboratory**	2	0–0–4	50	25	50	25	50
7		**Renewable Energy Simulation Laboratory**	2	0–0–4	50	25	50	25	50
8		**Mandatory Course - 2**	**Non-credit**	2-0-0					
Total Credit			**19**						

BS	ES	HSS	Core	DE	OE	MC	SEC	Total Credits
00	00	00	13	06	--	00	--	**19**

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Department of Electrical and Electronics Engineering

III Semester – M. Tech – Renewable Energy Technologies and Management

Course Matrix-CBCS

S.No.	Subject Code	Name of the Subject	Credit (Marks)	L–T–P	Internal Assessment		End Semester Examinations		Minimum Passing Marks
					Max. Marks	Min. Marks	Max. Marks	Min. Marks	
1		**DE-III**	**3**	3–0–0	50		50	25	50
2		**OE**	**3**	3–0–0	50		50	25	50
3		**Technical Seminar**	**1**	0–0–2	100*				50
4		**Project Phase -I**	**10**	0–0–20	100*				50
Total Credit			**17**						

BS	ES	HSS	Core	DE	OE	MC	SEC	Total Credits
00	00	00	00	03	03	00	11	**17**

*** -> Continuous Assessment (CA)**

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Department of Electrical and Electronics Engineering

IV Semester – M. Tech – Renewable Energy Technologies and Management

Course Matrix-CBCS

S.No.	Subject Code	Name of the Subject	Credit (Marks)	L–T–P	Internal Assessment		End Semester Examinations		Minimum Passing Marks
					Max. Marks	Min. Marks	Max. Marks	Min. Marks	
1		**Project Phase –II and Dissertation**	16	0–0–32	100	50	400	200	250
Total Credit			**16**						

BS	ES	HSS	Core	DE	OE	MC	SEC	Total Credits
00	00	00	00	00	00	00	16	**16**

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I Semester

Applied Mathematics for Electrical Engineers

Subject Code: **Credits: 03**

Hrs/week: 03 **Total hrs: 45**

Module – I: **9 Hours**

Probability and Statistics: Sampling distributions, Estimation of parameters (point estimation – unbiasedness & minimum variance, basics of interval estimation – confidence interval for mean), Testing of hypotheses (one and two sample tests for mean), Linear regression, Introduction to non-linear regression.

Module II: **9 Hours**

Stochastic process: Random processes, Random walk, Markov process with special emphasis on Markov chain

Module – III: **12 Hours**

Numerical Analysis: Introduction to Interpolation formulae [Bessel's & Sterling's], Roots of transcendental equations [Bisection, Regula-Falsi & Newton-Raphson] Solutions of simultaneous non-linear equations [Newton's method], Numerical solution of Ordinary Differential equation [Modified Euler's method, fourth order Runga-Kutta method], Matrix Eigen value and Eigen vector problems.

Module IV: **8 Hours**

Optimization Technique: Calculus of several variables, Implicit function theorem, Nature of singular points, Necessary and sufficient conditions for optimization, Constrained Optimization, Lagrange multipliers, Gradient method – steepest descent method.

Module V: **7 Hours**

Wavelet Transform: Resolution problems, Multi-resolution analysis, Continuous & discrete wavelet transform

Text books:

1. Kreyzig, 'Advanced Engineering Mathematics'

References:

1. Scarborough, J. B.- Numerical Mathematical Analysis, Oxford University Press
2. Cone, S. D.- Elementary Numerical Analysis, Mc. GrawHill.
3. Mukhopadhyay, P.-Mathematical Statistics, New Central Book Agency
4. Kapoor, V. K and Gupta, S.C.-Fundamental of Mathematical Statistics, Sultan Chand and Sons.
5. Rao, S. S.-Optimization Theory and Application, Wiley Eastern Ltd., New Delhi
6. S. S. Shastri, Numerical Methods
7. J. Medhi, Stochastic Processes
8. Jain & Iyenger, Numerical Analysis
9. Bopardikar & Rao, Wavelet Transform, Wiley

Course Outcome:

1. Outcome: Ability to analyze and solve problems related to digital communication.
2. Outcome: Ability to analyze and solve stochastic engineering & industrial problems
3. Outcome: Ability to optimize & solve real life problems
4. Outcome: Ability to apply in simple real life problems

Pre-requisite: Review of Basic Probability Theory, Basic Under graduate course in probability, Undergraduate Transformation theory

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Research Methodology and IPR

Subject Code: **Credits: 03**

Hrs/week: 03 **Total hrs: 45**

Course Outcomes:

At the end of this course, students will be able to

1. Understand research problem formulation.
2. Analyze research related information
3. Follow research ethics
4. Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.
5. Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.
6. Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.

Unit 1: **9 Hours**

Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

Unit 2: 9 Hours

Effective literature studies approaches, analysis Plagiarism , Research ethics, Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

Unit 3: **9 Hours**

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 4: **9 Hours**

Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

Unit 5: **9 Hours**

New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, PR and IITs.

References:

- Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students'"
- Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction"
- Ranjit Kumar, 2 nd Edition , "Research Methodology: A Step by Step Guide for beginners"
- Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007.
- Mayall , "Industrial Design", McGraw Hill, 1992.
- Niebel , "Product Design", McGraw Hill, 1974.
- Asimov , "Introduction to Design", Prentice Hall, 1962.
- Robert P. Merges, Peter S. Menell, Mark A. Lemley, " Intellectual Property in New Technological Age", 2016
- T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 20

ADVANCED CONTROL THEORY

COURSE OUTLINE

Subject code: **Total Hours: 45**

Credits: 03 **Hours per week: 03**

Unit I 9 Hours

Fields, Vectors, and vector spaces; State space representation, state equations for dynamic systems, solution of state equations; State transition matrix – Properties of state transition matrix; evaluation. Fadeeva algorithm for conversion from state space to transfer function, Linearization of non-linear models

Unit II 9 Hours

Non uniqueness of state model, Similarity transformation, Invariance of system properties. Controllability – necessary and sufficient condition - Pole assignment using State feedback – Ackerman's formula for feedback gain determination; Observability. Duality. Effect of state feedback on controllability and observability. Controllable subspace – decomposition of state into controllable and uncontrollable components.

Unit III 9 Hours

Design of full order observer – Bass Gura algorithm. The separation principle - Combined observer – controller compensator. Design of reduced order observer. Unobservable subspace – decomposition of state into observable and unobservable components – Canonical decomposition theorem.

Unit IV 9 Hours

Reducibility – realization of transfer function matrices. Model decomposition and decoupling by state feedback. Design of robust control system for asymptotic tracking and disturbance rejection using State variable equations. Transfer function interpretations – transfer function form of observer and state estimate feedback. State space interpretation of internal model principle.

Unit V 9 Hours

Discrete time linear state regulator – Algorithm for the solution, Use of observer in implementing the control law. Continuous time linear state regulator – Matrix Riccati equation. Time invariant linear state regulator – the reduced matrix Riccati equation - An iterative method to solve the reduced matrix Riccati equation. Suboptimal linear regulator.

Text Books:

1. Modern Control Engineering, Katsuhiko Ogata, 5th Edition, Prentice Hall India, 1997

2. Modern Control System Theory, M. Gopal, Revised 2nd Edition, New Age International Publishers, 2005.

References:

1. Linear Systems, Thomas Kailath, Perntice Hall, 1980.

2. Control System Design, Graham C. Goodwin, StefanF. Graebe and Mario E. Salgado, Pearson Education, 2000.

3. Linear System Theory and Design, Chi-Tsong Chen, OXFORD University Press.

4. Richard C. Dorf and Robert H. Bishop, Modern Control Systems, 11th Edition, Pearson Edu India, 2009.

POWER CONVERTERS AND CONTROL

COURSE OUTLINE

Subject code: **Total Hours: 45**

Credits: 03 **Hours per week: 03**

Prerequisite:
Power Electronics, Signal Generation, Control Systems.

Course Objective:

1. Analyze Power converters used in various types of Electric Vehicles.
2. Describe the line frequency phase-controlled rectifiers.
3. Describe the line frequency phase-controlled inverters.
4. Analyze the DC – DC converters used in EV applications.
5. Analyze the Switch-Mode dc-ac Inverters.
6. Discuss the Resonant Converters.

UNIT-1 **9 hours**

Application of Power Converter in Different Electric Vehicles:

Battery Electric Vehicles – Architecture of battery electric vehicle, Role of PECs in battery electric vehicle,

Fuel cell electric vehicle – Architecture of Fuel cell electric vehicle, Role of PECs in Fuel cell electric vehicle,

Hybrid electric vehicles (HEVS) – Series hybrid electric vehicle, Parallel hybrid electric vehicle, Series-Parallel hybrid electric vehicle, Role of PECs in Hybrid electric vehicles (HEVS)

Plug-In electric vehicles – Architecture of battery electric vehicle, Role of PECs in battery electric vehicle,

UNIT-2 **9 hours**

Line-Frequency Phase-Controlled Rectifiers and Inverters: Line-Frequency ac - Controlled dc: Introduction, Thyristor Circuits and Their Control, Single-Phase Converters, Three-Phase Converters, Other Three-Phase Converters.

UNIT-3 **9 hours**

dc-dc Switch-Mode Converters: Introduction, Control of dc-de Converters, Step-Down (Buck) Converter, Step-Up (Boost) Converter, Buck-Boost Converter, Cuk dc-dc Converter, Full Bridge dc-dc Converter, dc-dc Converter Comparison.

UNIT-4 **9 hours**

Switch-Mode dc-ac Inverters: dc ~ Sinusoidal ac: Introduction, Basic Concepts of Switch-Mode Inverters, Single-Phase Inverters, Three-Phase Inverters, Effect of Blanking Time on Output Voltage in PWM Inverters, Other Inverter Switching Schemes, Rectifier Mode of Operation.

UNIT-5 **9 hours**

Resonant Converters: Zero-Voltage and/or Zero-Current Switching: Introduction, Classification of Resonant Converters, Basic Resonant Circuit Concepts, Load-Resonant Converters, Resonant-Switch Converters, Zero-Voltage-Switching, Clamped-Voltage Topologies, Resonant-dc-Link Inverters with Zero-Voltage switching, High-Frequency-Link, Integral-Half-Cycle Converters.

Text Books:

1. Pandav Kiran Maroti, Sanjeevikumar Padmanaban, Mahajan Sagar Bhaskar, Vigna K. Ramachandaramurthy, Frede Blaabjerg, “The state-of-the-art of power electronics converters configurations in electric vehicle technologies”, Power Electronic Devices and Components,
Elsevier, Volume 1, 2022.
2. Ned Mohan, T.M. Undeland and William P. Robbins: Power Electronics: Converters, Applications, 3rd Edition, John Wiley & Sons, 2009

Reference Books:

1. Power Electronics-Md.H.Rashid –Pearson Education Third Edition- First IndianReprint-2008
2. Elements of Power Electronics – Philip T. Krein, Oxford University press, 2014

Course Outcomes:

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

CO1: Analyze the Power converters used in various types of Electric Vehicles.

CO2: Describe the line frequency phase-controlled rectifiers.

CO3: Describe the line frequency phase-controlled inverters.

CO4: Analyze the DC – DC converters used in EV applications.

CO5: Analyze the Switch-Mode dc-ac Inverters.

CO6: Discuss the Resonant Converters.

POWER GENERATION BY RENEWABLE ENERGY SOURCES

COURSE OUTLINE

Subject code: **Total Hours: 45**

Credits: 03 **Hours per week: 03**

Prerequisite:
NIL

Course Objective:

This course should serve as a basic course for M.Tech. students imparting the knowledge about various types of green and renewable energy sources, generators used for power generation.

UNIT-1 **9 hours**

Solar Radiation: Solar radiation outside the Earth's atmosphere and at the Earth's surface – Instruments for Solar radiation measurement, Solar radiation data – Solar radiation geometry – Empirical equations – Solar radiation on a tilted surface – Problems.

UNIT-2 **9 hours**

Solar Photovoltaic Systems – PV Cell fundamentals – equivalent circuit – cell characteristics – I-V equation-series parallel combination of P V Cells-classification of solar cell. Solar thermal energy collectors – types - Liquid flat plate collector -

concentrating collectors –parabolic collector - central receiver collector– applications – solar water heating systems. - Overview of Solar thermal electric power generation.

UNIT-3 **9 hours**

Wind Energy: Basic principles of wind energy conversion – wind speed measurement - classification of wind turbine – types of rotors – aerodynamic operation of wind turbine – wind power equation – Betz limit – Wind characteristics – Problems – types of generators – site selection.

UNIT-4 **9 hours**

Hydrogen energy: Introduction – hydrogen production – electrolysis – thermo chemical methods – hydrogen storage – utilization of hydrogen gas. Fuel cell: Principles of operation of fuel cell – classification – conversion efficiency and losses – types of electrodes – work output and emf – applications.

UNIT-5 **9 hours**

Ocean Energy: Methods of ocean thermal electric power generation –open cycle and closed cycle OTEC system - Environmental impacts. Wave Energy: Power in Waves – wave energy technology – Heaving float type – pitching type – Heaving and pitching type – oscillating water column type – surge devices - Environmental impacts - Tidal Energy: Limitations of tidal energy – tidal range powers – problems – tidal energy conversion scheme – single basin and double basin types.

Text Books:

3. Rai .G.D, “Non-Conventional Energy Sources”, 4th edition, Khanna Publishers, New Delhi, 2000.
4. Sukhatme. S.P, “Solar Energy”, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 1997.

5. Godfrey Boyle, “Renewable Energy, Power for a Sustainable Future”, Oxford University Press, U.K., 2012

Reference Books:

1. Khartchenko .N.V, “Advanced Energy Systems”, Taylor and Francis, Washington DC, 1998.
2. Chauhan .D.S, Srivastava .S.K, “Non-Conventional Energy Resources”, New Age, 2009.
3. Georgiadis M.C, “Energy Systems Engineering”, Wiley-VCH, 2008.

Course Outcomes:

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

CO1:

CO2:.

CO3:.

CO4:.

CO5:.

CO6:.

CO-PO/PSO Mapping:

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1														
CO2														
CO3														

CO4														
CO5														
CO6														
Total														

ELECTRICAL SIMULATION LABORATORY

COURSE OUTLINE

Sub Code: **Hours per Week: 03**

Credit: 01

Course objectives:

- To explain the use of MATLAB package to obtain the power angle characteristics of salient and non- salient pole alternator.
- To explain the use of MATLAB package to study transient stability of radial power systems under three phase fault conditions.
- To explain the use of MATLAB package to perform fault studies for simple radial power systems.

List of Experiments:

Use of MATLAB package

1. Determination of Power Angle Diagrams, Reluctance Power, Excitation, Emf and Regulation for Salient and Non-Salient Pole Synchronous Machines.
2. To obtain Swing Curve and to Determine Critical Clearing Time, Regulation, Inertia Constant/Line Parameters /Fault Location/Clearing Time/Pre-Fault Electrical Output for a Single Machine connected to Infinite Bus through a Pair of identical Transmission Lines Under 3-Phase Fault on One of the two Lines.
3. To Determine Fault Currents and Voltages in a Single Transmission Line System with Star-Delta Transformers at a Specified Location for LG and LLG faults by simulation.
4. Y Bus Formation for Power Systems with and without Mutual Coupling, by Singular Transformation and Inspection Method.
5. Simulation of Three-Phase Two-Level PWM Converters.

6. Simulation of AC/DC Three Level PWM Converters.
7. Simulation of Three-Phase Three Level PWM Converters.
8. Power flow study on a given power system network using Gauss – Siedal method for 5 bus system, IEEE 14 bus system and IEEE 30 bus system.
9. A Simulink model for a single area load frequency problem and simulate with and without controller.
10. Performance of solar photovoltaic Maximum Power Point Tracking based on Perturbation & Observation algorithm and charge lead acid battery using three stage charging algorithms.
11. Performance of photovoltaic panel Maximum Power Point Tracking based on Particle Swarm Optimization algorithm.
12. Dynamic PSO MPPT PV under Partial shading conditions with DC-DC boost converter.

Course Outcomes:

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

CO1: .

CO2:.

CO3:.

CO4:.

CO5:.

CO6:.

CO-PO/PSO Mapping:

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	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1														
CO2														
CO3														
CO4														
CO5														
CO6														
Total														

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Semester II

SOLAR PHOTOVOLTAIC DEVICES AND SYSTEMS

COURSE OUTLINE

Subject code: **Total Hours: 45**

Credits: 03 **Hours per week: 03**

Prerequisite:
Power Electronics

Course Objective:

The Course will be able to learn the fundamentals, design and application of solar photovoltaic systems for power generation on small- and large-scale electrification.

UNIT-1 **9 hours**

Introduction, Insolation and irradiance, Insolation variation with time of day, Earth centric viewpoint and declination, Solar geometry, Insolation on a horizontal flat plate, Energy on a horizontal flat plate, Sunrise and sunset hour angles.

UNIT-2 **9 hours**

A Historical Perspective, PV cell characteristics and equivalent circuit, I-V characteristics of a PV module, maximum power point, cell efficiency, fill factor, effect of irradiation and temperature, PV cell simulation.

UNIT-3 **9 hours**

PV cell simulation using PSPICE/MATLAB, Identical PV cells in series, Load line, non-identical cells in series, protecting cells in series, interconnecting cells in series, Simulation of cells in series, Identical cells in parallel, non-identical cells in parallel, protecting cells in parallel, interconnecting modules, Simulation of cells in parallel, Practical - Measuring I-V characteristics and Practical - PV source emulation.

UNIT-4 **9 hours**

Sizing PV for applications without batteries, introduction to batteries, Battery capacity, Battery C-rate, Battery efficiency, Battery energy and power densities, Battery comparison, Battery selection, other energy storage methods, PV system design - load profile, PV system design - days of autonomy, PV system design - battery sizing, PV system design - PV array sizing.

UNIT-5 **9 hours**

MPPT concept, Input impedance of Boost converter, Input impedance of Buck converter, Input impedance of Buck-Boost converter, PV module in SPICE/MATLAB, Simulation of PV and DC-DC converter interface. Impedance control methods, Reference cell - voltage scaling method, Reference cell - current scaling method, Sampling method, Power slope method 1, Power slope method 2, Hill climbing method, Practical points - Housekeeping power supply, Practical points - Gate driver, Practical points - MPPT for non-resistive loads, Simulation of MPPT.

Text Books:

1. Chetan Singh Solanki., Solar Photovoltaic: “Fundamentals, Technologies and Application”, PHI Learning Pvt., Ltd., 2009.
2. Jha .A.R, “Solar Cell Technology and Applications”, CRC Press, 2010.

3. John R. Balfour, Michael L. Shaw, Sharlave Jarosek., "Introduction to Photovoltaics", Jones & Bartlett Publishers, Burlington, 2011.

Reference Books:

4. Luque .A. L and Andreev .V.M, "Concentrator Photovoltaic", Springer, 2007.
5. Partain .L.D, Fraas L.M., "Solar Cells and Their Applications", 2nd ed., Wiley, 2010.
6. Sukhatme .S.P, Nayak .J.K, "Solar Energy", Tata McGraw Hill Education Private Limited, New Delhi, 2010.

Course Outcomes:

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

CO1:

CO2:.

CO3:.

CO4:.

CO5:.

CO6:.

CO-PO/PSO Mapping:

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1														
CO2														

CO3														
CO4														
CO5														
CO6														
Total														

ENERGY MANAGEMENT AND AUDIT

COURSE OUTLINE

Subject code: **Total Hours: 45**

Credits: 03 **Hours per week: 03**

Prerequisite:
Power Electronics

Course Objective:

To familiarize the students with energy conservation principles, energy conservation in thermal systems, energy conservation in electrical systems and basic concepts of energy management.

UNIT-1 **9 hours**

System approach and End use approach to efficient use of Electricity; Electricity tariff types; Energy auditing: Types and objectives-audit instruments- ECO assessment and Economic methods specific energy analysis-Minimum energy paths-consumption models-Case study.

UNIT-2 **9 hours**

Electric motors-Energy efficient controls and starting efficiency-Motor Efficiency and Load Analysis Energy efficient /highly efficient Motors-Case study. Transformer Loading/Efficiency analysis, Feeder/cable loss evaluation, case study. Reactive Power Management-Capacitor Sizing-Degree of Compensation-Capacitor Losses-Location-Placement- Maintenance, case study

UNIT-3 **9 hours**

Peak Demand controls- Methodologies-Types of Industrial Loads-Optimal Load scheduling-case study. Lighting- Energy efficient light sources-Energy conservation in Lighting Schemes Electronic Ballast-Power quality issues-Luminaries, case study.

UNIT-4 **9 hours**

Cogeneration-Types and Schemes-Optimal operation of cogeneration plants-case study; Electric loads of Air conditioning & Refrigeration-Energy conservation measures-Cool storage. Types-Optimal operation case study; Electric water heating-Geysers-Solar Water Heaters- Power Consumption in Compressors, Energy conservation measures; Electrolytic Process; Computer Controls-software-EMS.

UNIT-5 **9 hours**

Economic analysis methods-cash flow model, time value of money, evaluation of proposals, pay-back method, average rate of return method, internal rate of return method, present value method, life cycle costing approach, Case studies.

Text Books:

1. Reay .D.A, “Industrial Energy Conservation”, Pergamon Press, 1st edition, 2003.
2. White .L. C, “Industrial Energy Management and Utilization”, Hemisphere Publishers, 2002.

3. Beggs,Clive, “Energy – Management, Supply and Conservation”, Taylor and Francis, 2ndedition, 2009.

Reference Books:

1. Smith .C.B, “Energy “Management Principles”, Pergamon Press, 2006.
2. Hamies, “Energy Auditing and Conservation; Methods, Measurements, Management and Case study”, Hemisphere, 2003.
3. Trivedi .P.R and Jolka .K.R, “Energy Management”, Common Wealth Publication, 2002..

Course Outcomes:

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

CO1:

CO2:.

CO3:.

CO4:.

CO5:.

CO6:.

CO-PO/PSO Mapping:

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1														
CO2														
CO3														

CO4														
CO5														
CO6														
Total														

Scheme of Continuous Internal Evaluation (CIE): -

CIE consists of three tests each for a maximum of 45 marks. The performance of two best out of three tests is considered and is scaled for a maximum of 20 marks.3 MCQs carries 45 marks and is scaled down to 5 marks. Attendance 5 marks. Total 30 marks

Scheme of Semester End Examination (SEE):-

The question paper consists of one question from unit 1 and one question from unit 2, unit 3, 4 and 5 will be given with two questions of internal choice each for a maximum of 14 marks with two to three sub divisions. The students are required to answer five full questions (1 & 2 Compulsory, 3, 4, 5 with internal choice).

APPLICATIONS OF ARTIFICIAL INTELLIGENCE IN RENEWABLES ENERGY

COURSE OUTLINE

Subject code: **Total Hours: 45**

Credits: 03 **Hours per week: 03**

Prerequisite:
Power Electronics

Course Objective:

To familiarize the students with energy conservation principles, energy conservation in thermal systems, energy conservation in electrical systems and basic concepts of energy management.

UNIT-1 **9 hours**

Introduction to AI: Definition, Applications, Components of an AI program; production system. Problem Characteristics. Overview of searching techniques. Knowledge representation: Knowledge representation issues; and overview. Representing knowledge using rules; procedural versus declarative knowledge. Logic programming, forward versus backward reasoning, matching. Control knowledge.

UNIT-2 **9 hours**

Artificial Neural Networks: Biological Neuron, Neural Net, use of neural 'nets, applications, Perception, idea of single layer and multilayer neural nets, back propagation, Hopfield nets, supervised and unsupervised learning.

UNIT-3 **9 hours**

Fuzzy Logic: Introduction, Foundation of Fuzzy Systems, Representing Fuzzy Elements, Basic Terms and Operations, Properties of Fuzzy Sets, Fuzzification, Arithmetic Operations of Fuzzy Numbers, The alpha cut method, The extension method, Linguistic Descriptions and their Analytical Forms, Fuzzy Linguistic Descriptions, Fuzzy Relation Inferences, Fuzzy Implication and Algorithms, Defuzzification Methods, Centre of Area Defuzzification, Centre of Sums Defuzzification.

UNIT-4 **9 hours**

Genetic Algorithms and Evolutionary Programming: Introduction, Genetic Algorithms, Procedure of Genetic Algorithms, Genetic Representations, Initialization and Selection, Genetic Operators, Mutation, The Working of Genetic Algorithms, Evolutionary Programming, The Working of Evolutionary Programming.

UNIT-5 **9 hours**

Application of AI techniques: Solar Irradiance Forecasting, Grid-Connected Inverter Control, MPPT Control, Stand Alone Inverter Control, Condition Monitoring of Grid Connected PV System, Monitoring of PV Array Faults, Monitoring of Power Electronic Converter Faults, Monitoring of Faults in Filter, Monitoring of Battery Faults and Degradation, Reliability.

<u>Text Books:</u>

1. Reay .D.A, “Industrial Energy Conservation”, Pergamon Press, 1st edition, 2003.
2. White .L. C, “Industrial Energy Management and Utilization”, Hemisphere Publishers, 2002.
3. Beggs,Clive, “Energy – Management, Supply and Conservation”, Taylor and Francis, 2ndedition, 2009.

Reference Books:

1. Smith .C.B, “Energy “Management Principles”, Pergamon Press, 2006.
2. Hamies, “Energy Auditing and Conservation; Methods, Measurements, Management and Case study”, Hemisphere, 2003.
3. Trivedi .P.R and Jolka .K.R, “Energy Management”, Common Wealth Publication, 2002..

Course Outcomes:

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

CO1:

CO2:.

CO3:.

CO4:.

CO5:.

CO6:.

CO-PO/PSO Mapping:

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1														

CO2														
CO3														
CO4														
CO5														
CO6														
Total														

Scheme of Continuous Internal Evaluation (CIE):-

CIE consists of three tests each for a maximum of 45 marks. The performance of two best out of three tests is considered and is scaled for a maximum of 20 marks.3 MCQs carries 45 marks and is scaled down to 5 marks. Attendance 5 marks. Total 30 marks

Scheme of Semester End Examination (SEE): -

The question paper consists of one question from unit 1 and one question from unit 2, unit 3, 4 and 5 will be given with two questions of internal choice each for a maximum of 14 marks with two to three sub divisions. The students are required to answer five full questions (1 & 2 Compulsory, 3, 4, 5 with internal choice).

ENERGY RESOURCE ECONOMICS AND ENVIRONMENT

COURSE OUTLINE

Subject code: **Total Hours: 45**

Credits: 03 **Hours per week: 03**

Prerequisite:

Course Objective:

To familiarize the students with energy conservation principles, energy conservation in thermal systems, energy conservation in electrical systems and basic concepts of energy management.

UNIT-1 **9 hours**

Overview of World and India's energy scenario – energy reserves and security - Disaggregation by end-use and supply – country annual energy balances – examples – trends in energy use patterns – annual electrical energy usage pattern in India.

UNIT-2 **9 hours**

Energy chain - primary energy analysis – life cycle energy assessment – energy and development linkage – Energy Scenarios –need of scenarios – simple problems with development of energy use scenarios.

UNIT-3 **9 hours**

Energy Economics: Need for economic analysis - Simple payback period - advantages and limitations - Time value of money - Return on Investment – Internal Rate of Return – Capital Recovery Factor - Net Present Value.

UNIT-4 **9 hours**

Life cycle costing – cost of saved energy – cost of energy generated – simple problems about economics of renewable energy systems and energy conservation systems.

UNIT-5 **9 hours**

Climate change from greenhouse gases – CO2 emissions – Global warming - Greenhouse gases and Global warming potential, Radiative forcing of Climate change - mitigation and adaptation measures – IPCC Assessment –Stabilizing Greenhouse gases, Kyoto Protocol – Carbon credits.

Text Books:

1. Reay .D.A, "Industrial Energy Conservation", Pergamon Press, 1st edition, 2003.
2. White .L. C, "Industrial Energy Management and Utilization", Hemisphere Publishers, 2002.
3. Beggs,Clive, "Energy – Management, Supply and Conservation", Taylor and Francis, 2ndedition, 2009.

Reference Books:

4. .

5. .
6. .

Course Outcomes:

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

CO1:

CO2:.

CO3:.

CO4:.

CO5:.

CO6:.

CO-PO/PSO Mapping:

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1														
CO2														
CO3														
CO4														
CO5														
CO6														
Total														

Scheme of Continuous Internal Evaluation (CIE):-

CIE consists of three tests each for a maximum of 45 marks. The performance of two best out of three tests is considered and is scaled for a maximum of 20 marks.3 MCQs carries 45 marks and is scaled down to 5 marks. Attendance 5 marks. Total 30 marks

Scheme of Semester End Examination (SEE):-

The question paper consists of one question from unit 1 and one question from unit 2, unit 3, 4 and 5 will be given with two questions of internal choice each for a maximum of 14 marks with two to three sub divisions. The students are required to answer five full questions (1 & 2 Compulsory, 3, 4, 5 with internal choice).

ANALYSIS, DESIGN AND GRID INTEGRATION OF RENEWABLE ENERGY SYSTEMS

COURSE OUTLINE

Subject code: **Total Hours: 45**

Credits: 03 **Hours per week: 03**

Prerequisite:

Course Objective:

To familiarize the students with energy conservation principles, energy conservation in thermal systems, energy conservation in electrical systems and basic concepts of energy management.

UNIT-1 **9 hours**

Direct PV-battery connection, Charge controller, Battery charger - Understanding current control, Battery charger - slope compensation, Battery charger - simulation of current control, Batteries in series - charge equalization, Batteries in parallel. PV data, Grid connection principle, PV to grid topologies Part-I, PV to grid topologies Part-II, PV to grid topologies Part-III.

UNIT-2 **9 hours**

3 phase d-q controlled grid connection intro, d-q axis theory, d-q theory : AC to DC transformations, d-q theory : DC to AC transformations, 3 phase grid connection system, Single phase grid connection system, PV-Grid interface example, Point of common

coupling (PCC) - Comparison with Off grid systems. Anti-islanding and protection schemes. Power flow control in grid connected PV system- Active and reactive power control in α-β and d-q frame. Line of protective equipment in solar PV system – fuse, MCB, string combiner box and string monitoring box- Earthing scheme of PV installations.

UNIT-3 **9 hours**

Wind Energy Conversion System: Introduction, Fundamentals of wind turbine power contained in wind-types-tip speed ratio- power coefficient- specific rated capacity- Aerodynamics of wind rotor- power speed characteristics and torque speed characteristics wind turbine control system – pitch - stall- yaw and power electronic control Development of Wind Power Generation, Wind Power Conversion -Basic Control Variables for Wind Turbines-Wind Turbine Concepts.

UNIT-4 **9 hours**

Power Converters for Wind Turbines: Two-Level, Multilevel, Multi-cell Converter. Power Semiconductors for Wind Power Converter. Controls and Grid Requirements for Modern Wind Turbines: Active Power Control – Reactive Power Control- THD, Fault Ride-Through Capability. Emerging Reliability Issues for Wind Power System.

UNIT-5 **9 hours**

DFIG Based Grid Integrated Wind Energy Conversion System Properties and Control of a Doubly Fed Induction Machine: Introduction. Basic principles of DFIMStructure of the Machine and Electric configuration –Steady State Equivalent Circuit-Dynamic Modeling. Vector Control of DFIM Using an AC/DC/AC Converter – Grid Connection Operation-Rotor Position Observers- Stand-alone Operation DFIM-Based Wind Energy Conversion Systems:Wind Turbine Aerodynamic-Turbine Control Zones-Turbine

Control-Typical Dimensioning of DFIM-Based Wind Turbines - Steady-State Performance of the Wind Turbine Based on DFIM - Analysis of DFIM Based Wind Turbines during Voltage Dips.

Text Books:

1. .
2. .
3. .

Reference Books:

1. .
2. .
3. .

Course Outcomes:

At the end of the course students will be able to,
CO1:

CO2:.

CO3:.

CO4:.

CO5:.

JAIN DEEMED-TO-BE UNIVERSITY | FACULTY OF ENGINEERING AND TECHNOLOGY

CO6:.

CO-PO/PSO Mapping:

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1														
CO2														
CO3														
CO4														
CO5														
CO6														
Total														

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SOLAR ENERGY LABORATORY

COURSE OUTLINE

Sub Code: **Hours per Week: 03**

Credit: 01

List of Experiments:

Use of MATLAB package

1. Measuring the parameters of a solar PV cell in under controlled luminary.
2. Analyze the IV characteristics at different series/parallel combinations.
3. Measurement of IV characteristics at different temperature levels to extract temperature parameters of the modules (without fans).
4. Measurement of IV characteristics with change in illumination to analyze the deviation of operating points from Maximum power point.
5. Variation in the inclination angle of solar panel at different levels and measure the power generation of solar panel to find an optimal tilt.
6. To plot IV characteristic and find the variation of the power output with change in intensity of light fixed in the structure.
7. Study the change in module power with change in tilt and find out the optimum tilt.
8. Analysis in the change of power at different orientation angles of modules in the direction of sun’s movement to analyze the intraday variation.
9. Performance analysis of PWM and MPPT type charge controllers.

10. Change in operating point of modules with and without MPPT with variation in load.
11. Comparison between charging points of battery with and without MPPT.
12. To convert and observe various DC voltages 17.5, 35, 70 V to 24, 48 & 96 V respectively using DC step up converters.
13. To analyze the efficiency of step up and step-down converter and DC to AC converter at different power.

Course Outcomes:

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

CO1:.

CO2:.

CO3:.

CO4:.

CO5:.

CO6:.

CO-PO/PSO Mapping:

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1														
CO2														
CO3														
CO4														
CO5														

CO6														
Total														

RENEWABLE ENERGY SIMULATION LABORATORY

COURSE OUTLINE

Sub Code: **Hours per Week: 03**

Credit: 01

List of Experiments:

Use of MATLAB package

1. Simulation study on Solar PV Energy System.
2. Experiment on VI-Characteristics and Efficiency of 1kWp Solar PV System.
3. Experiment on Shadowing effect & diode-based solution in 1 kWp Solar PV System.
4. Experiment on Performance assessment of Grid connected and Standalone 1 kWp Solar Power System.
5. Simulation study on Wind Energy Generator.
6. Experiment on Performance assessment of micro–Wind Energy Generator.
7. Simulation study on Hybrid (Solar-Wind) Power System.
8. Experiment on Performance Assessment of Hybrid (Solar-Wind) Power System.
9. Simulation study on Hydel Power.
10. Experiment on Performance Assessment of 100W Fuel Cell.
11. Simulation study on Intelligent Controllers for Hybrid Systems.

Course Outcomes:

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

CO1:.

CO2:.

CO3:.

CO4:.

CO5:.

CO6:.

CO-PO/PSO Mapping:

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1														
CO2														
CO3														
CO4														
CO5														
CO6														

FACULTY OF ENGINEERING AND TECHNOLOGY

Semester III

EMBEDDED SYSTEM CONTROLLERS FOR RENEWABLE ENERGY SYSTEMS

COURSE OUTLINE

Subject code: **Total Hours: 45**

Credits: 03 **Hours per week: 03**

Prerequisite:

Course Objective:

To familiarize the students with energy conservation principles, energy conservation in thermal systems, energy conservation in electrical systems and basic concepts of energy management.

UNIT-1 **9 hours**

Introduction to Embedded System: An embedded system, processor, hardware unit, software embedded into a system, Example of an embedded system, Real time and embedded OS. Structural unit in a processor selection for embedded systems.

UNIT-2 **9 hours**

AVR system –AVR family processors, Architecture, Addressing modes, Instruction overview, Branch, Call, and Time Delay Loop, AVR I/O Port Programming. Assembly level programming.

UNIT-3 **9 hours**

Real world interfacing: Interfacing LED, push button, LCD and Keyboard, ADC, DAC, and different Sensor Interfacing, Relay, Opt isolator interface.

UNIT-4 **9 hours**

Stepper Motor Interfacing, Servo motor interfacing, PWM Programming, RTC, PC interface, data acquisition system. Case studies DC motor control, Induction Motor control (VSI and CSI fed), BLDC motor control.

UNIT-5 **9 hours**

Concept of smart card sized computers- Programming of smart card sized controllers- AVR based single board microcomputers for data acquisition and PWM signal generation.

Text Books:

1. .
2. .
3. .

Reference Books:

1. .
2. .
3. .

Course Outcomes:

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

CO1:

CO2:.

CO3:.

CO4:.

CO5:.

CO6:.

CO-PO/PSO Mapping:

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**
CO1														
CO2														
CO3														
CO4														
CO5														
CO6														
Total														

Scheme of Continuous Internal Evaluation (CIE):-

CIE consists of three tests each for a maximum of 45 marks. The performance of two best out of three tests is considered and is scaled for a maximum of 20 marks.3 MCQs carries 45 marks and is scaled down to 5 marks. Attendance 5 marks. Total 30 marks

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Scheme of Semester End Examination (SEE):-

The question paper consists of one question from unit 1 and one question from unit 2, unit 3, 4 and 5 will be given with two questions of internal choice each for a maximum of 14 marks with two to three sub divisions. The students are required to answer five full questions (1 & 2 Compulsory, 3, 4, 5 with internal choice).

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ENERGY AND CLIMATE

COURSE OUTLINE

Subject code: **Total Hours: 45**

Credits: 03 **Hours per week: 03**

Prerequisite:

Course Objective:

To familiarize the students with energy conservation principles, energy conservation in thermal systems, energy conservation in electrical systems and basic concepts of energy management.

UNIT-1 **9 hours**

Current energy scenario of World, USA and India – Energy terms – Fossil energy vs renewable sources – Electricity – Future projections Externalities of energy use. Cycles Water cycle – Oxygen cycle – Carbon cycle – Nitrogen cycle – Phosphorous cycle.

UNIT-2 **9 hours**

Climate Science Research: Climate history – Greenhouse gas effect – Anthropogenic climate change – role of different gases Impacts and adaptation – uncertainties – precautionary principle.

UNIT-3 **9 hours**

Global problems – Integrated assessment models Bio-diversity – Environmental aspects of energy utilization – Public health issues related to environmental pollution.

UNIT-4 **9 hours**

Transport– storage – monitoring – feasibility – economics and public perceptions, Case studies.

UNIT-5 **9 hours**

Climate Policy: Kyoto protocol – UNFCCC – IPCC – Geopolitics of GHG control, Carbon market – CDM and other emission trading mechanisms –Non-CO GHGs - Relevance for India.

<u>Text Books:</u>

1. .
2. .
3. .

<u>Reference Books:</u>

1. .
2. .
3. .

<u>Course Outcomes:</u>

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

CO1:

CO2:.

CO3:.

CO4:.

CO5:.

CO6:.

CO-PO/PSO Mapping:

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**
CO1														
CO2														
CO3														
CO4														
CO5														
CO6														
Total														

Scheme of Continuous Internal Evaluation (CIE):-

CIE consists of three tests each for a maximum of 45 marks. The performance of two best out of three tests is considered and is scaled for a maximum of 20 marks.3 MCQs carries 45 marks and is scaled down to 5 marks. Attendance 5 marks. Total 30 marks

Scheme of Semester End Examination (SEE):-

The question paper consists of one question from unit 1 and one question from unit 2, unit 3, 4 and 5 will be given with two questions of internal choice each for a maximum of 14 marks with two to three sub divisions. The students are required to answer five full questions (1 & 2 Compulsory, 3, 4, 5 with internal choice).

SMART GRID TECHNOLOGIES AND APPLICATION

COURSE OUTLINE

Subject code: **Total Hours: 45**

Credits: 03 **Hours per week: 03**

Prerequisite:

Course Objective:

To familiarize the students with energy conservation principles, energy conservation in thermal systems, energy conservation in electrical systems and basic concepts of energy management.

UNIT-1 **9 hours**

Evolution of Electric Grid, Concept, Definitions and Need for Smart Grid, Smart grid drivers, functions, opportunities, challenges and Benefits. Present development & International policies in Smart Grid. Indian Smart Grid. Components and Architecture of Smart Grid Design.

UNIT-2 **9 hours**

Introduction to Smart Meters, Real Time Pricing- Models, Smart Appliances, Automatic Meter Reading(AMR), Plug in Hybrid Electric Vehicles (PHEV), Vehicle to Grid, Smart Sensors, Home & Building Automation.

UNIT-3 **9 hours**

Smart Substations, Substation Automation, Introduction to IEC 61850, Feeder Automation. Geographic Information System (GIS). Intelligent Electronic Devices (IED) & their application for monitoring & protection, Wide Area Measurement System (WAMS). Phase Measurement Units (PMU).

UNIT-4 **9 hours**

Smart energy efficient end use devices-Smart distributed energy resources- Energy Management-Role of technology in demand response- Demand Side Management. Load Curves -Load Shaping Objectives-Methodologies-Barriers. Peak load saving- Constraints-Problem formulation- Case study.

UNIT-5 **9 hours**

Advanced Metering Infrastructure (AMI), Home Area Network (HAN), Bluetooth, Zig-Bee, GPS, Wi-Fi, Wi-Max based communication. Cloud computing in smart grid. Private, public and Hybrid cloud. Cloud architecture of smart grid.

Text Books:

1. .
2. .
3. .

Reference Books:

1. .

2. .
3. .

Course Outcomes:

At the end of the course students will be able to,
CO1:

CO2:.

CO3:.

CO4:.

CO5:.

CO6:.

CO-PO/PSO Mapping:

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1														
CO2														
CO3														
CO4														
CO5														
CO6														
Total														

<u>Scheme of Continuous Internal Evaluation (CIE):-</u>

CIE consists of three tests each for a maximum of 45 marks. The performance of two best out of three tests is considered and is scaled for a maximum of 20 marks.3 MCQs carries 45 marks and is scaled down to 5 marks. Attendance 5 marks. Total 30 marks

<u>Scheme of Semester End Examination (SEE):-</u>

The question paper consists of one question from unit 1 and one question from unit 2, unit 3, 4 and 5 will be given with two questions of internal choice each for a maximum of 14 marks with two to three sub divisions. The students are required to answer five full questions (1 & 2 Compulsory, 3, 4, 5 with internal choice).

BIO INSPIRED ALGORITHMS

COURSE OUTLINE

Subject code: **Total Hours: 45**

Credits: 03 **Hours per week: 03**

Prerequisite:

Course Objective:

.

UNIT-1 **9 hours**

Fuzzy Logic-concepts-set theory, -operations-membership function-fuzzy, rules-fuzzy reasoning-fuzzy inference systems Mamdani and Sugeno type- defuzzification- fuzzy controllers- -applications in electric drives, power system.

UNIT-2 **9 hours**

Genetic Algorithm Application: Modern Heuristic Search Techniques, Genetic Algorithm-Introduction- -Encoding-Fitness Function, Premature Convergence, Slow Finishing, Basic Operators, Selection-Tournament Selection, Truncation Selection, Linear Ranking Selection, Exponential

Ranking Selection, Elitist Selection, Proportional Selection-Crossover, Mutation, Control Parameters Estimation, Niching Methods, Parallel Genetic Algorithms-Application in Drives Tuning of membership function using genetic algorithm. Application of GA to neural network. Tuning of controllers.

UNIT-3 **9 hours**

Swarm intelligence general characteristics, Ant Colony Optimization: Basic Concepts- The Ant Colony System- Ants' Foraging Behavior and Optimization, - The Max-Min Ant System Minimum Cost Paths, Combinatorial Optimization.

UNIT-4 **9 hours**

Major Characteristics of Ant Colony Search Algorithms- Positive Feedback- Rapid Discovery of Good Solution - Use of Greedy Search and Constructive Heuristic Information- Ant Colony Optimization Algorithms Applications.

UNIT-5 **9 hours**

Particle swarm optimization: -Fundamentals- Concepts of PSO-Comparison with Genetic Algorithm-Application and Implementation. Firefly Algorithm –Basic Concepts-Application in optimization, power electronics and power system problems.

Text Books:

1. .
2. .
3. .

Reference Books:

1. .
2. .
3. .

Course Outcomes:

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

CO1:

CO2:.

CO3:.

CO4:.

CO5:.

CO6:.

CO-PO/PSO Mapping:

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1														
CO2														
CO3														
CO4														
CO5														
CO6														
Total														

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Scheme of Continuous Internal Evaluation (CIE):-

CIE consists of three tests each for a maximum of 45 marks. The performance of two best out of three tests is considered and is scaled for a maximum of 20 marks.3 MCQs carries 45 marks and is scaled down to 5 marks. Attendance 5 marks. Total 30 marks

Scheme of Semester End Examination (SEE):-

The question paper consists of one question from unit 1 and one question from unit 2, unit 3, 4 and 5 will be given with two questions of internal choice each for a maximum of 14 marks with two to three sub divisions. The students are required to answer five full questions (1 & 2 Compulsory, 3, 4, 5 with internal choice).

ENERGY STORAGE SYSTEMS

COURSE OUTLINE

Subject code: **Total Hours: 45**

Credits: 03 **Hours per week: 03**

Prerequisite:

Course Objective:

To enable the student to understand the need for energy storage, devices and technologies available and their applications.

UNIT-1 **9 hours**

Introduction: Types of new technologies of power generation – potential of efficient and clean energy generation.

Fuel cells- Potential application- classification based on electrolytes-based on types of fuel & oxidants based on operating temperature-application- phosphoric acid fuel cells, alkaline fuel cells.

UNIT-2 **9 hours**

Polymer electrolyte membrane fuel cells- Molten carbonate fuel cells-sold oxide fuel cells recent developments and relative performance of various fuel cells. Fuels for fuel cells-efficiency of fuel cells- VI characteristics of fuel cells-Fuel cell power plants.

UNIT-3 **9 hours**

Hydro energy- Production of hydrogen- Thermo-chemical methods-electrolysis of water thermolysis of water-Bio photolysis. Hydrogen storage- Hydrogen delivery-energy conversion methods and usage-safety issues.

UNIT-4 **9 hours**

Mini & Micro hydroelectric generation- Advantages of very small hydro-plants- Progress of small hydro power world over, in India & China- Advantages of small hydro generation- Details of power plant & civil works- Diversion weir & channel – Desilting tank-Forebay, penstock & tailrace, Power house- \types of turbines used- Grid connection.

UNIT-5 **9 hours**

Principles & MHP power generation – MHD design problems & developments – Advantages of MHD system- electrical conditions. Voltage and power output- Materials for MHD generators-Magnetic fields – Super conductivity – International status of MHD power generation & Future prospects- Developments in Thermo nuclear Fusion energy- Present status and future outlook.

Text Books:

1. Rai G.D, "Non-Conventional Sources of Energy", Khanna Publishers, 4th Edition, New Delhi, 2007.
2. D.P. Kothari, K.C. Singal and Rakesh Ranjan "Renewable Energy Sources and Emerging Technologies", PHI Learning private limited, Second Edition, New Delhi, 2005.

Reference Books:

1. Godfrey Boyle, "Renewable Energy – Power for a Sustainable Future", Oxford University Press, 2012.

2. Mukherjee, D., and Chakrabarti S, "Fundamentals of Renewable Energy Systems", New Age International Publishers, 2005.
3. Khan, B. H, "Non-Conventional Energy Resources", TMH, New Delhi, 2006.

Course Outcomes:

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

CO1:

CO2:.

CO3:.

CO4:.

CO5:.

CO6:.

CO-PO/PSO Mapping:

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1														
CO2														
CO3														
CO4														
CO5														
CO6														
Total														

Scheme of Continuous Internal Evaluation (CIE):-

CIE consists of three tests each for a maximum of 45 marks. The performance of two best out of three tests is considered and is scaled for a maximum of 20 marks.3 MCQs carries 45 marks and is scaled down to 5 marks. Attendance 5 marks. Total 30 marks

Scheme of Semester End Examination (SEE):-

The question paper consists of one question from unit 1 and one question from unit 2, unit 3, 4 and 5 will be given with two questions of internal choice each for a maximum of 14 marks with two to three sub divisions. The students are required to answer five full questions (1 & 2 Compulsory, 3, 4, 5 with internal choice).

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WIND AND SMALL HYDRO ENERGY SYSTEM

COURSE OUTLINE

Subject code: **Total Hours: 45**

Credits: 03 **Hours per week: 03**

Prerequisite:
Basic knowledge of Renewable Energy

Course Objective:

To impart understanding of various basic aspects related to wind energy power generation systems and technology.

UNIT-1 **9 hours**

Wind Energy Basics, Wind Speeds and scales, Terrain, Roughness, Wind Mechanics, Power Content, Class of wind turbines, Atmospheric Boundary Layers, Turbulence. Instrumentation for wind measurements, Wind data analysis, tabulation, Wind resource estimation, Betz's Limit, Turbulence Analysis.

UNIT-2 **9 hours**

Airfoil terminology, Blade element theory, Blade design, Rotor performance and dynamics, Balancing technique (Rotor & Blade), Types of loads; Sources of loads.

UNIT-3 **9 hours**

Wind turbines types, Description and performance of the horizontal–axis wind machines, Description and performance of the vertical–axis wind machines, Direct drive and Gear coupled Generator Wind turbine, Modern Wind Turbine and concept of wind farm and Micro-siting, Environmental concerns.

UNIT-4 **9 hours**

Introduction – Overview and Analysis of Small, mini and micro hydro turbines – Site selection and civil works, Penstocks and turbines, Speed and voltage regulation, Economical and Electrical Aspects of Small, mini and micro hydro turbines- potential developments – Design and reliability of Small, mini and micro hydro turbines – Case Study. Wind and hydro based stand-alone / hybrid power systems.

UNIT-5 **9 hours**

Types of generators: synchronous and induction, sizing and specification of single and three phase generators, power factor and its correction methodologies, excitation systems; electro-mechanical and digital governor, electronic load controller, types of relays, contactors and control schemes for small hydro power stations.

Text Books:

1. Rai G.D, "Non-Conventional Sources of Energy", Khanna Publishers, 4th Edition, New Delhi, 2007.
2. D.P. Kothari, K.C. Singal and Rakesh Ranjan "Renewable Energy Sources and Emerging Technologies", PHI Learning private limited, Second Edition, New Delhi, 2005.

Reference Books:

1. Godfrey Boyle, "Renewable Energy – Power for a Sustainable Future", Oxford University Press, 2012.
2. Mukherjee, D., and Chakrabarti S, "Fundamentals of Renewable Energy Systems", New Age International Publishers, 2005.
3. Khan, B. H, "Non-Conventional Energy Resources", TMH, New Delhi, 2006.

Course Outcomes:

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

CO1: Ability to differentiate types of wind energy conversion systems.

CO2: Know the status of wind energy in India.

CO3: Various aspects of selection of wind energy sites.

CO4: Understand the design of wind mills and applications.

CO5: Understand the overall development of small hydro power plant.

CO6: Know the application of generators, excitation systems, load controllers, relays for small hydro power plant.

CO-PO/PSO Mapping:

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1														
CO2														
CO3														
CO4														
CO5														
CO6														

Total														

Master of Technology (M.Tech)

In

Electrical Engineering (Specialization in Electric Vehicle Technology)

(As Per AICTE Model Curriculum)

CBCS Course Matrix for

I to IV Semesters

Faculty of Engineering and Technology

2022 - Onwards

Date: **Head of the Department**

1a. Programme Structure

	Particulars								
Semester	**BS**	**ES**	**HSS**	**Core**	**Dept. Elective**	**Open Elective**	**MC**	**SEC**	**Total**
I	03	--	03	11	--	--	00	--	**17**
II	--	--	--	13	06	--	00	--	**19**
III	--	--	--	--	03	03	--	11	**17**
IV	--	--	--	--	--	--	--	16	**16**
Total	**03**	**00**	**03**	**24**	**09**	**03**	**00**	**27**	**69**

	BS	**ES**	**HSS**	**Core**	**Dept. Elective**	**Open Elective**	**MC**	**SEC**	**Total**
Total Credit distribution for batch 2021	**03**	**00**	**03**	**24**	**09**	**03**	**00**	**27**	**69**

1b. List of Courses

BS: Basic Science

1. Applied Mathematics for Electrical Engineers

HSS: Humanities and Social Science

1. Research Methodology & IPR

Core

1. Power Converters & Control
2. Advanced Control Theory
3. **Hybrid Electric Vehicles (Specialization paper)**
4. EV Batteries & Charging Systems
5. IC Engines
6. Electric Drive Train & Control
7. Electrical Simulation Laboratory
8. Electric Vehicle Simulation Laboratory
9. IC Engines Laboratory

DE: Department Electives

1. Vehicle Dynamics & Control
2. Automotive Technology
3. Automotive Safety
4. In-Vehicle Networking

5. Embedded OS and RTOS
6. Computer Aided Design of Electric Apparatus
7. Sensors & Controls in EVs
8. Reconfigurable Computing for EV

OE: Open Electives

1. Electric and Hybrid Vehicle
2. Optimization Techniques

MC: Mandatory Courses

1. English for Research Paper Writing
2. Pedagogy Studies
3. Value Education
4. Personality Development through Life Enhancement Skills
5. Constitution of India
6. Stress Management by Management by Yoga

2022 - Onwards

Department of Electrical and Electronics Engineering

I Semester – M.Tech – Electrical Engineering (Specialization in Electric Vehicle Technology)

Course Matrix-CBCS

S.No.	Subject Code	Name of the Subject	Credit (Marks)	L–T–P	Internal Assessment		End Semester Examinations		Minimum Passing Marks
					Max. Marks	Min. Marks	Max. Marks	Min. Marks	
1		**Applied Mathematics for Electrical Engineers**	**3**	3-0-0	50	25	50	25	50
2		**Research Methodology & IPR**	**3**	3-0-0	50	25	50	25	50
3		**Power Converters & Control**	**3**	3-0-0	50	25	50	25	50
4		**Advanced Control Theory**	**3**	3-0-0	50	25	50	25	50
5		**Specialization paper**	**3**	3-0-0	50	25	50	25	50
6		**Electrical Simulation Laboratory**	**2**	0-0-4	50	25	50	25	50
7		**Mandatory Course - 1**	**Non-credit**	2-0-0					
		Total	**17**						

BS	ES	HSS	Core	DE	OE	MC	SEC	Total Credits
03	00	03	11	--	--	00	--	**17**

JAIN DEEMED-TO-BE UNIVERSITY | FACULTY OF ENGINEERING AND TECHNOLOGY

2022 - Onwards

Department of Electrical and Electronics Engineering

II Semester – M.Tech – Electrical Engineering (Specialization in Electric Vehicle Technology)

Course Matrix-CBCS

S.No.	Subject Code	Name of the Subject	Credit (Marks)	L–T–P	Internal Assessment		End Semester Examinations		Minimum Passing Marks
					Max. Marks	Min. Marks	Max. Marks	Min. Marks	
1		**EV Batteries & Charging Systems**	**3**	3-0-0	50	25	50	25	50
2		**IC Engines**	**3**	3-0-0	50	25	50	25	50
3		**Electric Drive Train & Control**	**3**	3-0-0	50	25	50	25	50
4		**DE -1**	**3**	3-0-0	50	25	50	25	50
5		**DE -2**	**3**	3-0-0	50	25	50	25	50
6		**Electric Vehicle Simulation Laboratory**	**2**	0-0-4	50	25	50	25	50
7		**IC Engines Laboratory**	**2**	0-0-4	50	25	50	25	50
8		**Mandatory Course - 2**	**Non-credit**	2-0-0					
		Total	**19**						

BS	ES	HSS	Core	DE	OE	MC	SEC	Total Credits
00	00	00	13	06	--	00	--	**19**

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2022 - Onwards

Department of Electrical and Electronics Engineering

III Semester – M.Tech – Electrical Engineering (Specialization in Electric Vehicle Technology)

Course Matrix-CBCS

S.No.	Subject Code	Name of the Subject	Credit (Marks)	L–T–P	Internal Assessment		End Semester Examinations		Minimum Passing Marks
					Max. Marks	Min. Marks	Max. Marks	Min. Marks	
1		**DE -3**	**3**	3-0-0	50	25	50	25	50
2		**OE**	**3**	3-0-0	50	25	50	25	50
3		**Technical Seminar**	**1**	0-0-2	100*				50
4		**Project Phase - I**	**10**	0-0-20	100*				50
		Total	**17**						

BS	ES	HSS	Core	DE	OE	MC	SEC	Total Credits
00	00	00	00	03	03	00	11	**17**

*** -> Continuous Assessment (CA)**

2022 - Onwards

Department of Electrical and Electronics Engineering

IV Semester – M.Tech – Electrical Engineering (Specialization in Electric Vehicle Technology)

Course Matrix-CBCS

S.No.	Subject Code	Name of the Subject	Credit (Marks)	L–T–P	Internal Assessment		End Semester Examinations		Minimum Passing Marks
					Max. Marks	Min. Marks	Max. Marks	Min. Marks	
1		**Project Phase – II and Dissertation**	**16**	0-0-32	100	50	400	200	250
		Total	**16**						

BS	ES	HSS	Core	DE	OE	MC	SEC	Total Credits
00	00	00	00	00	00	00	16	**16**

Semester I

JGi JAIN DEEMED-TO-BE UNIVERSITY | FACULTY OF ENGINEERING AND TECHNOLOGY

Applied Mathematics for Electrical Engineers

Subject Code: **Credits: 03**

Hrs/week: 03 **Total hrs: 45**

Module – I: **9 Hours**

Probability and Statistics: Sampling distributions, Estimation of parameters (point estimation – unbiasedness & minimum variance, basics of interval estimation – confidence interval for mean), Testing of hypotheses (one and two sample tests for mean), Linear regression, Introduction to non-linear regression.

Module II: **9 Hours**

Stochastic process: Random processes, Random walk, Markov process with special emphasis on Markov chain

Module – III: **12 Hours**

Numerical Analysis: Introduction to Interpolation formulae [Bessel's & Sterling's], Roots of transcendental equations [Bisection, Regula-Falsi & Newton-Raphson] Solutions of simultaneous non-linear equations [Newton's method], Numerical solution of Ordinary Differential equation [Modified Euler's method, fourth order Runga-Kutta method], Matrix Eigen value and Eigen vector problems.

Module IV: **8 Hours**

Optimization Technique: Calculus of several variables, Implicit function theorem, Nature of singular points, Necessary and sufficient conditions for optimization, Constrained Optimization, Lagrange multipliers, Gradient method – steepest descent method.

Module V: **7 Hours**

Wavelet Transform: Resolution problems, Multi-resolution analysis, Continuous & discrete wavelet transform

Text books:

1. Kreyzig, 'Advanced Engineering Mathematics'

References:

1. Scarborough, J. B.- Numerical Mathematical Analysis, Oxford University Press
2. Cone, S. D.- Elementary Numerical Analysis, Mc. GrawHill.
3. Mukhopadhyay, P.-Mathematical Statistics, New Central Book Agency
4. Kapoor, V. K and Gupta, S.C.-Fundamental of Mathematical Statistics, Sultan Chand and Sons.
5. Rao, S. S.-Optimization Theory and Application, Wiley Eastern Ltd., New Delhi
6. S. S. Shastri, Numerical Methods
7. J. Medhi, Stochastic Processes
8. Jain & Iyenger, Numerical Analysis
9. Bopardikar & Rao, Wavelet Transform, Wiley

Course Outcome:

1. Outcome: Ability to analyze and solve problems related to digital communication.
2. Outcome: Ability to analyze and solve stochastic engineering & industrial problems
3. Outcome: Ability to optimize & solve real life problems
4. Outcome: Ability to apply in simple real life problems

Pre-requisite: Review of Basic Probability Theory, Basic Under graduate course in probability, Undergraduate Transformation theory

FACULTY OF ENGINEERING AND TECHNOLOGY

Research Methodology and IPR

Subject Code: **Credits: 03**

Hrs/week: 03 **Total hrs: 45**

Course Outcomes:

At the end of this course, students will be able to

1. Understand research problem formulation.
2. Analyze research related information
3. Follow research ethics
4. Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.
5. Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.
6. Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.

Unit 1: **9 Hours**

Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

Unit 2: 9 Hours

Effective literature studies approaches, analysis Plagiarism , Research ethics, Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

Unit 3: **9 Hours**

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 4: **9 Hours**

Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

Unit 5: **9 Hours**

New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, PR and IITs.

References:

- Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students'"
- Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction"
- Ranjit Kumar, 2 nd Edition , "Research Methodology: A Step by Step Guide for beginners"
- Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007.
- Mayall , "Industrial Design", McGraw Hill, 1992.
- Niebel , "Product Design", McGraw Hill, 1974.
- Asimov , "Introduction to Design", Prentice Hall, 1962.
- Robert P. Merges, Peter S. Menell, Mark A. Lemley, " Intellectual Property in New Technological Age", 2016
- T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 20

ADVANCED CONTROL THEORY

COURSE OUTLINE

Subject code: **Total Hours: 45**

Credits: 03 **Hours per week: 03**

Unit I 9 Hours

Fields, Vectors, and vector spaces; State space representation, state equations for dynamic systems, solution of state equations; State transition matrix – Properties of state transition matrix; evaluation. Fadeeva algorithm for conversion from state space to transfer function, Linearization of non-linear models

Unit II 9 Hours

Non uniqueness of state model, Similarity transformation, Invariance of system properties. Controllability – necessary and sufficient condition - Pole assignment using State feedback – Ackerman's formula for feedback gain determination; Observability. Duality. Effect of state feedback on controllability and observability. Controllable subspace – decomposition of state into controllable and uncontrollable components.

Unit III 9 Hours

Design of full order observer – Bass Gura algorithm. The separation principle - Combined observer – controller compensator. Design of reduced order observer. Unobservable subspace – decomposition of state into observable and unobservable components – Canonical decomposition theorem.

Unit IV 9 Hours

Reducibility – realization of transfer function matrices. Model decomposition and decoupling by state feedback. Design of robust control system for asymptotic tracking and disturbance rejection using State variable equations. Transfer function interpretations – transfer function form of observer and state estimate feedback. State space interpretation of internal model principle.

Unit V 9 Hours

Discrete time linear state regulator – Algorithm for the solution, Use of observer in implementing the control law. Continuous time linear state regulator – Matrix Riccati equation. Time invariant linear state regulator – the reduced matrix Riccati equation - An iterative method to solve the reduced matrix Riccati equation. Suboptimal linear regulator.

Text Books:

1. Modern Control Engineering, Katsuhiko Ogata, 5th Edition, Prentice Hall India, 1997

2. Modern Control System Theory, M. Gopal, Revised 2nd Edition, New Age International Publishers, 2005.

References:

1. Linear Systems, Thomas Kailath, Perntice Hall, 1980.

2. Control System Design, Graham C. Goodwin, StefanF. Graebe and Mario E. Salgado, Pearson Education, 2000.

3. Linear System Theory and Design, Chi-Tsong Chen, OXFORD University Press.

4. Richard C. Dorf and Robert H. Bishop, Modern Control Systems, 11th Edition, Pearson Edu India, 2009.

POWER CONVERTERS AND CONTROL

COURSE OUTLINE

Subject code: **Total Hours: 45**

Credits: 03 **Hours per week: 03**

Prerequisite:
Power Electronics, Signal Generation, Control Systems.

Course Objective:

1. Analyze Power converters used in various types of Electric Vehicles.
2. Describe the line frequency phase-controlled rectifiers.
3. Describe the line frequency phase-controlled inverters.
4. Analyze the DC – DC converters used in EV applications.
5. Analyze the Switch-Mode dc-ac Inverters.
6. Discuss the Resonant Converters.

UNIT-1 **9 hours**

Application of Power Converter in Different Electric Vehicles:

Battery Electric Vehicles – Architecture of battery electric vehicle, Role of PECs in battery electric vehicle,

Fuel cell electric vehicle – Architecture of Fuel cell electric vehicle, Role of PECs in Fuel cell electric vehicle,

Hybrid electric vehicles (HEVS) – Series hybrid electric vehicle, Parallel hybrid electric vehicle, Series-Parallel hybrid electric vehicle, Role of PECs in Hybrid electric vehicles (HEVS)

Plug-In electric vehicles – Architecture of battery electric vehicle, Role of PECs in battery electric vehicle,

UNIT-2 **9 hours**

Line-Frequency Phase-Controlled Rectifiers and Inverters: Line-Frequency ac - Controlled dc: Introduction, Thyristor Circuits and Their Control, Single-Phase Converters, Three-Phase Converters, Other Three-Phase Converters.

UNIT-3 **9 hours**

dc-dc Switch-Mode Converters: Introduction, Control of dc-de Converters, Step-Down (Buck) Converter, Step-Up (Boost) Converter, Buck-Boost Converter, Cuk dc-dc Converter, Full Bridge dc-dc Converter, dc-dc Converter Comparison.

UNIT-4 **9 hours**

Switch-Mode dc-ac Inverters: dc ~ Sinusoidal ac: Introduction, Basic Concepts of Switch-Mode Inverters, Single-Phase Inverters, Three-Phase Inverters, Effect of Blanking Time on Output Voltage in PWM Inverters, Other Inverter Switching Schemes, Rectifier Mode of Operation.

UNIT-5 **9 hours**

Resonant Converters: Zero-Voltage and/or Zero-Current Switching: Introduction, Classification of Resonant Converters, Basic Resonant Circuit Concepts, Load-Resonant Converters, Resonant-Switch Converters, Zero-Voltage-Switching, Clamped-Voltage Topologies, Resonant-dc-Link Inverters with Zero-Voltage switching, High-Frequency-Link, Integral-Half-Cycle Converters.

Text Books:

1. Pandav Kiran Maroti, Sanjeevikumar Padmanaban, Mahajan Sagar Bhaskar, Vigna K. Ramachandaramurthy, Frede Blaabjerg, "The state-of-the-art of power electronics converters configurations in electric vehicle technologies", Power Electronic Devices and Components,
   Elsevier, Volume 1, 2022.
2. Ned Mohan, T.M. Undeland and William P. Robbins: Power Electronics: Converters, Applications, 3rd Edition, John Wiley & Sons, 2009

Reference Books:

1. Power Electronics-Md.H.Rashid –Pearson Education Third Edition- First IndianReprint-2008
2. Elements of Power Electronics – Philip T. Krein, Oxford University press, 2014

Course Outcomes:

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

CO1: Analyze the Power converters used in various types of Electric Vehicles.

CO2: Describe the line frequency phase-controlled rectifiers.

CO3: Describe the line frequency phase-controlled inverters.

CO4: Analyze the DC – DC converters used in EV applications.

CO5: Analyze the Switch-Mode dc-ac Inverters.

CO6: Discuss the Resonant Converters.

HYBRID ELECTRIC VEHICLE

COURSE OUTLINE

Subject Code: **Total Hours : 45**

Credits : 03 **Hours per week: 03**

Pre requisites: Machines, Industrial Drives

Course Objectives:

1. To Introduce the basic concepts of Hybrid Electric Vehicles
2. To study the Concepts of Electric Drive trains and it topologies
3. To study the concepts of Electric Propulsion system in Hybrid Electric Vehicle
4. To explore the types and usage of Energy Storage devices in HEV
5. To Introduce the Energy Management strategies used in HEV

UNIT –1 **9 Hours**

Introduction to Hybrid Electric Vehicles: History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies. Conventional Vehicles: Basics of vehicle performance, vehicle power source characterization, transmission characteristics, mathematical models to describe vehicle performance

UNIT – 2 **9 Hours**

Hybrid Electric Drive-trains: Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis. 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

UNIT – 3 **9 Hours**

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

UNIT – 4 **9 Hours**

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, Hybridization of different energy storage devices.

UNIT – 5 **9 Hours**

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. Case Studies: Design of a Hybrid Electric Vehicle (HEV), Design of a Battery Electric Vehicle (BEV).

Text Books:

1. Larminie, James, and John Lowry, "Electric Vehicle Technology Explained" John Wiley and Sons, 2012.

2. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003

3. Sheldon S. Williamson, "Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles", Springer, 2013.

Reference Books:

1. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003
2. Mehrdad Ehsani, YimiGao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2000
3. Emadi, A. (Ed.), Miller, J., Ehsani, M., "Vehicular Electric Power Systems" Boca
4. Raton, CRC Press, 2003.
5. Husain, I. "Electric and Hybrid Vehicles" Boca Raton, CRC Press, 2010
6. Tariq Muneer and Irene Illescas García, "The automobile, In Electric Vehicles: Prospects and Challenges", Elsevier, 2017.

Course Outcomes:

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

CO1: Understand the performance of Hybrid Electric Vehicle

CO2: Derive the Mathematical Model for Hybrid Electric Vehicle

CO3: Evaluate the different types of Electric train topologies for HEV

CO4: Illustrate the Propulsion System for HEV

CO5: Identify the different Energy Storage systems for HEV

CO6: Apply the various Energy Management Strategies for HEV

ELECTRICAL SIMULATION LABORATORY

COURSE OUTLINE

Sub Code: **Hours per Week: 03**

Credit: 01

Course objectives:

- To explain the use of MATLAB package to obtain the power angle characteristics of salient and non- salient pole alternator.
- To explain the use of MATLAB package to study transient stability of radial power systems under three phase fault conditions.
- To explain the use of MATLAB package to perform fault studies for simple radial power systems.

List of Experiments:

Use of MATLAB package

1. Determination of Power Angle Diagrams, Reluctance Power, Excitation, Emf and Regulation for Salient and Non-Salient Pole Synchronous Machines.
2. To obtain Swing Curve and to Determine Critical Clearing Time, Regulation, Inertia Constant/Line Parameters /Fault Location/Clearing Time/Pre-Fault Electrical Output for a Single Machine connected to Infinite Bus through a Pair of identical Transmission Lines Under 3-Phase Fault on One of the two Lines.
3. To Determine Fault Currents and Voltages in a Single Transmission Line System with Star-Delta Transformers at a Specified Location for LG and LLG faults by simulation.
4. Y Bus Formation for Power Systems with and without Mutual Coupling, by Singular Transformation and Inspection Method.
5. Simulation of Three-Phase Two-Level PWM Converters.
6. Simulation of AC/DC Three Level PWM Converters.
7. Simulation of Three-Phase Three Level PWM Converters.
8. Power flow study on a given power system network using Gauss – Siedal method for 5 bus system, IEEE 14 bus system and IEEE 30 bus system.

9. A Simulink model for a single area load frequency problem and simulate with and without controller.
10. Performance of solar photovoltaic Maximum Power Point Tracking based on Perturbation & Observation algorithm and charge lead acid battery using three stage charging algorithms.
11. Performance of photovoltaic panel Maximum Power Point Tracking based on Particle Swarm Optimization algorithm.
12. Dynamic PSO MPPT PV under Partial shading conditions with DC-DC boost converter.

JAIN DEEMED-TO-BE UNIVERSITY
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Semester II

EV BATTERIES AND CHARGING STATION

COURSE OUTLINE

Subject code: **Total Hours: 45**

Credits: 03 **Hours per week: 03**

Prerequisite:

Basics of Electrical Engineering.

Course Objective:

1. Understand the parameters of the battery.
2. Understand the EV batteries.
3. Classify the various types of Batteries.
4. Analyze the charging stations.
5. Understand charging infrastructures.
6. Develop EV charging stations.

UNIT-1 **9 hours**

Battery parameters

Cell and battery voltages, Charge (or Amphour) capacity, Energy stored, Energy density, Specific power, Amphour (or charge) efficiency, Energy efficiency, Self-discharge rates, Battery geometry, Battery temperature, heating and cooling needs, Battery life and number of deep cycles.

UNIT-2 **9 hours**

EV Batteries

Lead Acid Batteries Lead acid battery basics, Special characteristics of lead acid batteries, Battery life and maintenance, Battery charging, Summary Nickel-based Batteries Introduction, Nickel cadmium, Nickel metal hydride batteries.

UNIT-3 **9 hours**

Sodium, Lithium and Metal air batteries:

Sodium-based Batteries

Introduction, Sodium sulphur batteries, Sodium metal chloride (Zebra) batteries

Lithium Batteries

Introduction, The lithium polymer battery, The lithium-ion battery

Metal Air Batteries

Introduction, The aluminium air battery, The zinc air battery.

UNIT-4 **9 hours**

Charging Infrastructure:

Domestic Charging Infrastructure, Public Charging Infrastructure, Normal Charging Station, Occasional Charging Station, Fast Charging Station, Battery Swapping Station, Move-and-charge zone.

UNIT-5 **9 hours**

EV Charging:

Battery Chargers: Charge equalization, Conductive (Basic charger circuits, Microprocessor based charger circuit. Arrangement of an off-board conductive charger, Standard power levels of conductive chargers, Inductive (Principle of inductive charging, Soft-switching power converter for inductive charging), Battery indication methods.

Text Books:

3. James Larminie Oxford Brookes University, Oxford, UK John Lowry Acenti Designs Ltd., UK, Electric Vehicle Technology Explained.
4. C.C Chan, K.T Chau: Modern Electric Vehicle Technology, Oxford University Press Inc., New York 2001.
5. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.

Reference Books:

1. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.

2. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.

Course Outcomes:

At the end of the course students will be able to,
CO1: Understand the various parameters of the battery.

CO2: Understand the EV batteries like lead and nickel-based batteries.

CO3: Analyze the Sodium, Lithium and Metal air batteries.

CO4: Analyze the charging stations.

CO5: Understand charging infrastructures.

CO6: Develop EV charging stations.

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IC ENGINES

COURSE OUTLINE

Subject code: **Total Hours: 45**

Credits: 03 **Hours per week: 03**

Course Objective:

This course provides the knowledge, operation and performance of internal combustion engines.

UNIT-1 **9 hours**

Basic characteristics of engines : Compression ratio – energy supply to an engine – power developed by engine – specific weight and specific volume – cylinder pressures – IMEP determination – torque characteristics – cylinder arrangement and their relative merits. Engine cooling systems: types of cooling – cooling of critical engine components – recooling the coolant – comparison of air cooled and liquid cooled engines.

UNIT-2 **9 hours**

Fuel delivery in SI engines: Classification of fuel delivery systems – fuel transfer pumps – fixed jet carburetor – computer controlled carburetor – gasoline injection systems. Ignition systems in SI engines: Battery ignition system – requirements for satisfactory operation of the ignition system – ignition timing and advancing mechanisms – magneto ignition system – electronic ignition system.

UNIT-3 **9 hours**

Combustion and combustion systems in CI engines: Air motion in CI engines – delay period in CI engines – types of diesel combustion systems. Scavenging and super charging in CI engines : types of scavenging systems in two stroke SI engines – improved and modified scavenging systems – super charging and engine performance – methods of super charging.

UNIT-4 **9 hours**

Engine emissions, control systems and engine developments: SI engine pollutants – exhaust gas analyzer – SI engine emission control systems – particulate emissions – diesel pollution control methods – low heat rejection engines.

UNIT-5 **9 hours**

Conventional and alternate fuels for IC engines: desirable characteristics of gasoline – desirable characteristics of diesel fuel – alternative fuels for SI engines and CI engines.

Text Books:

1. John B. "Internal combustion engines fundamentals" McGraw – Hill international editions. 1st edition2017
2. V. Ganesan, "Internal combustion engines" Tata McGraw Hill book cop. 4th edition, 2012.

Reference Books:

1. Edward F. Obert, "Internal combustion engines and air pollutions" Intext education publishers, 3rd edition 1973.
2. Richard stone, "Introduction to internal combustion engines" society of automotive engineers, 3rd edition 1999.

ELECTRIC DRIVE TRAIN AND CONTROLS

COURSE OUTLINE

Subject code: **Total Hours: 45**

Credits: 03 **Hours per week: 03**

Prerequisite:

Course Objective:

This course provides the knowledge, principle of operation and performance control of various components in electric drive train systems.

UNIT-1 **9 hours**

Introduction to Hybrid Electric Vehicles: History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies

UNIT-2 **9 hours**

Hybrid Electric Drive-trains: Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis.

UNIT-3 **9 hours**

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.

UNIT-4 **9 hours**

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

UNIT-5 **9 hours**

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

Case Studies: Design of a Hybrid Electric Vehicle (HEV), Design of a Battery Electric Vehicle (BEV).

Text Books:

1. Peatman & John B, "Design with PIC Microcontrollers", 1st Edition, Pearson Education, New Delhi, 2009.
2. Ajay V Deshmukh, "Microcontrollers: Theory and Applications, Tata McGraw Hill, New Delhi, 2007.
3. Raj Kamal, "Embedded Systems Architecture, Programming and Design", Tata McGraw-Hill, New Delhi, 2007

Reference Books:

1. Myke Predko, "Programming and customizing the PIC Microcontroller", 3rd Edition, Tata Mcgraw Hill, Delhi, 2008.
2. http://ww1.microchip.com/downloads/en/DeviceDoc/39582C.
3. Vahid, Frank and Givargi, Tony, "Embedded System Design: A Unified hardware/Software Introductions", John Wiley & Sons, New York, 2001

Course Outcomes:

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

CO1: comprehend the environmental and social impacts of Electric vehicles

CO2: Analyse the different train topologies of Hybrid Electric vehicles.

CO3: Illustrate the power flow control and drive train topologies for Electric vehicles

CO4: Configure and Control different types of drives used in Electric vehicles.

CO5: elaborate the sizing of different components in Electric vehicles

CO6: design a Hybrid Electric vehicle and Battery Hybrid Electric vehicle

Department Elective I

VEHICLE DYNAMICS AND CONTROL

COURSE OUTLINE

Subject code: **Total Hours: 45**

Credits: 03 **Hours per week: 03**

Course Objective:

This course provides the knowledge and performance control of various dynamics in vehicles

UNIT-1 **10 hours**

Introduction to vehicle dynamics - Dynamics of the motor vehicle, Vehicle fixed coordinates system, Earth fixed coordinates system, Details of vehicle systems, wheel angles, Typical data of vehicles.

Tires - Types, axis system, mechanics of pneumatic tires-tire forces Tire forces and moments, Tire structure, Longitudinal and Lateral force at various slip angles, rolling resistance, Tractive and cornering property of tire.

UNIT-2 **8 hours**

Longitudinal dynamics - Forces and moments on vehicle, Equation of motion, Tire forces, rolling resistance, weight distribution, Tractive effort and Power available from the engine, Calculation of Maximum acceleration Braking torque, Braking Force, Brake Proportioning, Braking Efficiency, Stopping Distance, Prediction of Vehicle performance. ABS, stability control, Traction control.

UNIT-3 **9 hours**

Lateral Dynamics - Steering geometry, Types of steering systems, Fundamental condition for true Rolling, Development of lateral forces. Steady state handling characteristics. Yaw velocity, Lateral Acceleration, Curvature response & directional stability.

UNIT-4 **9 hours**

Vertical Dynamics - Human response to vibrations, Sources of Vibration, Suspension systems, Functions of suspension system. Body vibrations: Bouncing and pitching. Doubly conjugate points. Body rolling. Roll centre and roll axis, Stability against body rolling.

UNIT-5 **9 hours**

Mathematical Modelling of Vehicle - Quarter car suspension model; Half car suspension model; Full car suspension model for ride and road holding performance considering two degree freedom model for sprung & un-sprung mass, two degree freedom model for pitch & bounce and motion of vehicle on undulating road.

Text Books:

1. Thomas D. Gillespie, "Fundamentals of Vehicle Dynamics", 2013, Society of Automobile Engineers Inc., ISBN: 978-1560911999
2. J. Y. Woung , "Theory of Ground Vehicles", John Willey & Sons, NY., 2001
3. Rajesh Rajamani , "Vehicle dynamics and control", Springer publication, 2012

Reference Books:

1. W. Steed , "Mechanics of Road Vehicles", Ilete Books Ltd. London. , 1990
2. Reza N Jazar , "Vehicle Dynamics : Theory and Application", Springer publication, 2009

Course Outcomes:

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

CO1: Understand the dynamics of the automotive systems and its performance parameters.

CO2: Identify the driving/ braking resistances and their influences on vehicle dynamics.

CO3: Analyze dynamics systems such as suspension systems, body vibrations, steering mechanisms.

CO4: Understand ride characteristic of vehicle.

CO5: Formulate, and solve engineering problems.

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AUTOMOTIVE TECHNOLOGY

COURSE OUTLINE

Subject code: **Total Hours: 45**

Credits: 03 **Hours per week: 03**

Prerequisite:
Control Systems, Mechanical Engineering.

Course Objective:

1. Understand the system modeling of automotive system.
2. Analyze the mechanical system modeling.
3. Describe the controller components.
4. Discuss the designing aspects of automotive system.
5. Analyze the system stability.
6. Design the complete vehicle.

UNIT-1 **9 hours**

System model representation: Configuration form, State-space representation, input output equation, Transfer function, State-space representation from the input-output equation. Linearization, Determination of operating point, Numerical solution of Nonlinear model.

UNIT-2 **9 hours**

Mechanical system modeling: Translational systems, Rotational systems, Mixed rotational and translational systems and Gear train systems. Modeling of Electromechanical systems, Thermal systems, Pneumatic systems and Hydraulic systems. Transient response of First order systems and Second-order systems. Open loop and close loop control systems, Block diagrams. Signal flow graph, Mason's gain formula. Feedback characteristic of control systems.

UNIT-3 **9 hours**

Controller components: Sensors, Differencing and amplification, Actuators. Electrical components, Hydraulic components and Pneumatics components. Time resonance of Second-order systems, Time response specifications. Steady state error for Unit step input, Unit ramp input and Unit parabolic input. Types of feedback control systems. Type-0 system, Type-1 system and Type-2 system.

UNIT-4 **9 hours**

Designing Aspects: Design specifications of second order system, Derivative error compensation, Derivative output compensation, Integral error compensation, Proportional plus Integral plus Derivative compensation.

UNIT-5 **9 hours**

System stability: Algebraic criterion, Hurwitz stability criterion, Routh stability criterion. Automobile vehicle Driveline model. ABS Control systems. Complete vehicle model.

Text Books:

1. Dynamic Systems – Hung V. Vu , Ramin S. Esfandiari
2. Control Theory – I. J. Nagrath
3. Automotive Control Systems –U. Kiencke, L. Nielsen
4. Vehicle Dynamics – Ellis

Course Outcomes:

At the end of the course students will be able to,
CO1: Understand the system modeling of automotive system.

CO2: Analyze the mechanical system modeling

CO3: Describe the controller components.

CO4: Discuss the designing aspects of automotive system.

CO5: Analyze the system stability.

CO6: Design the complete vehicle.

SENSORS AND CONTROL

COURSE OUTLINE

Subject code: **Total Hours: 45**

Credits: 03 **Hours per week: 03**

Prerequisite:
Power Electronics, Signal Generation, Control Systems.

Course Objective:

1. To understand the concepts of measurement technology.
2. To learn the various sensors used to measure various physical parameters.
3. To learn the fundamentals of signal conditioning, data acquisition and communication systems used in mechatronics system development.

UNIT-1 **9 hours**

Introduction: Basics of Measurement – Classification of errors – Error analysis – Static and dynamic characteristics of transducers – Performance measures of sensors – Classification of sensors – Sensor calibration techniques – Sensor Output Signal Types

UNIT-2 **9 hours**

MOTION, PROXIMITY AND RANGING SENSORS

Motion Sensors – Potentiometers, Resolver, Encoders – Optical, Magnetic, Inductive, Capacitive, LVDT – RVDT – Synchro – Microsyn, Accelerometer – GPS, Bluetooth, Range Sensors – RF beacons, Ultrasonic Ranging, Reflective beacons, Laser Range Sensor (LIDAR).

UNIT-3 **9 hours**

FORCE, MAGNETIC AND HEADING SENSORS

Strain Gage, Load Cell, Magnetic Sensors –types, principle, requirement and advantages: Magneto resistive – Hall Effect – Current sensor Heading Sensors – Compass, Gyroscope, Inclinometers

UNIT-4 **9 hours**

OPTICAL, PRESSURE AND TEMPERATURE SENSORS

Photo conductive cell, photo voltaic, Photo resistive, LDR – Fiber optic sensors – Pressure – Diaphragm, Bellows, Piezoelectric – Tactile sensors, Temperature – IC, Thermistor, RTD, Thermocouple. Acoustic Sensors – flow and level measurement, Radiation Sensors - Smart Sensors - Film sensor, MEMS & Nano Sensors, LASER sensors**.**

UNIT-5 **9 hours**

SIGNAL CONDITIONING AND DAQ SYSTEMS

Amplification – Filtering – Sample and Hold circuits – Data Acquisition: Single channel and multi-channel data acquisition – Data logging - applications - Automobile, Aerospace, Home appliances, Manufacturing, Environmental monitoring.

Text Books:

1. Ernest O Doebelin, "Measurement Systems – Applications and Design", Tata McGraw-Hill, 2009.
2. Sawney A K and PuneetSawney, "A Course in Mechanical Measurements and Instrumentation and Control", 12th edition, DhanpatRai& Co, New Delhi, 2013.

Reference Books:

1. C. Sujatha Dyer, S.A., Survey of Instrumentation and Measurement, John Wiley & Sons, Canada, 2001
2. Hans Kurt Tönshoff (Editor), Ichiro , "Sensors in Manufacturing" Volume 1, Wiley-VCH April 2001.
3. John Turner and Martyn Hill, "Instrumentation for Engineers and Scientists", Oxford Science Publications, 1999.

4. Patranabis D, “Sensors and Transducers”, 2nd Edition, PHI, New Delhi, 2011.
5. Richard Zurawski, “Industrial Communication Technology Handbook” 2nd edition, CRC Press, 2015

Course Outcomes:

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

CO1: Familiarize with various calibration techniques and signal types for sensors.

CO2: Apply the various sensors in the Automotive and Mechatronics applications.

CO3: Describe the working principle and characteristics of force, magnetic and heading sensors.

CO4: Understand the basic principles of various pressure and temperature, smart sensors.

CO5: To implement the DAQ systems with different sensors for real time applications

Department Elective 2

COMPUTER AIDED DESIGN OF ELECTRICAL APPARATUS

COURSE OUTLINE

Subject code: **Total Hours: 45**

Credits: 03 **Hours per week: 03**

Prerequisite:

Course Objective:

This course provides the knowledge of computer aided design and finite element method for design of various electrical apparatus.

UNIT-1 **9 hours**

Introduction: Conventional design procedures, Limitations, Need for field analysis based design, Review of Basic principles of energy conversion, Development of Torque/Force.

UNIT-2 **9 hours**

Mathematical Formulation of Field Problems: Electromagnetic Field Equations, Magnetic Vector/Scalar potential, Electrical vector /Scalar potential, Stored energy in Electric and Magnetic fields, Capacitance, Inductance, Laplace and Poisson's Equations, Energy functional.

UNIT-3 **9 hours**

Philosophy of FEM: Mathematical models, Differential/Integral equations, Finite Difference method, Finite element method, Energy minimization, Variational method- 2D field problems, Discretization, Shape functions, Stiffness matrix, Solution techniques.

UNIT-4 **9 hours**

CAD Packages: Elements of a CAD System, Pre-processing, Modelling, Meshing, Material properties, Boundary Conditions, Setting up solution, Post processing.

UNIT-5 **9 hours**

Design Applications: Voltage Stress in Insulators, Capacitance calculation, Design of Solenoid Actuator, Inductance and force calculation, Torque calculation in Switched Reluctance Motor.

Text Books:

1. S.J Salon, 'Finite Element Analysis of Electrical Machines', Springer, Yes DEE publishers, Indian reprint, 2007.
2. Nicola Bianchi, 'Electrical Machine Analysis using Finite Elements', CRC Taylor & Francis, 2005.

Reference Books:

1. Joao Pedro, A. Bastos and Nelson Sadowski, 'Electromagnetic Modeling by Finite Element Methods', Marcell Dekker Inc., 2003.
2. P.P.Silvester and Ferrari, 'Finite Elements for Electrical Engineers', Cambridge University Press, 1983.
3. D.A.Lowther and P.P Silvester, 'Computer Aided Design in Magnetics', Springer Verlag, New York, 1986..

FACULTY OF ENGINEERING AND TECHNOLOGY

EMBEDDED OS AND RTOS

Subject code: **No. of Hours per week: 4**
Credits: 3 **Total no. of Hours: 45**

Course Objectives:

1. The objective of the subject is to provide understanding of the techniques essential to the design and implementation of device drivers and kernel internals of embedded operating systems.
2. This syllabus provides the students with an understanding of the aspects of the Real-time systems and Real-time Operating Systems and to provide an understanding of the techniques essential to the design and implementation of real-time embedded systems

Module I **9Hrs**
Introduction and Operating-System Structures
Defining Operating Systems, Operating-System Structure, Operating-System Operations, Process, Memory and Storage Management, Open-Source Operating Systems, Operating-System Services, User and Operating-System Interface, System Calls, Types of System Calls, System Programs, Operating-System Design and Implementation.

Module II **9Hrs**
Introduction to Real-Time Operating Systems
Real Life Examples of Embedded Systems, Real-Time Embedded Systems, Brief History of OS, Defining RTOS, The Scheduler, Objects, Services, Characteristics of RTOS, Defining a Task, Tasks States and Scheduling, Task Operations, Structure, Synchronization, Communication and Concurrency.

Module III **9Hrs**
Semaphores, Objects, Services and I/O
Defining Semaphores, Operations and Use, Defining Message Queue, States, Content, Storage, Operations and Use, Pipes, Event Registers, Signals, Other Building Blocks, Component Configuration, Basic I/O Concepts, I/O Subsystem

Module IV **9Hrs**
Exceptions, Interrupts and Timers
Exceptions, Interrupts, Applications, Processing of Exceptions and Spurious Interrupts, Real Time Clocks, Programmable Timers, Timer Interrupt Service Routines (ISR), Soft Timers, Operations.

Module V **9Hrs**
Case Studies of RTOS

RT Linux, Micro C/OS-II, POSIX standards, Vx Works, Embedded Linux, Tiny OS, and Basic Concepts of Android OS, Free-RTOS architecture

Course Outcome:

1. To acquire knowledge about concepts related to RTOS such as Scheduling techniques, threads, inter-thread communications and memory management.
2. Develop Real Time software programs for real time services, multithreaded applications using advanced RTOS tool.
3. Build real-time embedded systems using freeRTOS and VxWorks RTOSes

Text Books:

1. Operating System Concepts: Abraham Silberschatz & Peter B. Galvin & Greg Gagne, John Wiley & Sons, 2013
2. Real Time Concepts for Embedded Systems – Qing Li, Elsevier, 2011

Reference Books:

1. Embedded Systems- Architecture, Programming and Design by Rajkamal, 2007, TMH.
2. Advanced UNIX Programming, Richard Stevens
3. Embedded Linux: Hardware, Software and Interfacing – Dr. Craig Hollabaugh
4. Hermann Kopetz, "*Real–Time systems – Design Principles for distributed Embedded Applications*", Second Edition, Springer 2011.
5. Micro C OS II reference manual.
6. VX works Programmers manual.
7. Keil Real Time library documentation.
8. Doug Abbott, "*Linux for embedded and real time applications*", Elsevier Science, 2003.
9. "Getting started with RT-Linux", FSM Labs., Inc.,
10. MicroC/OS-II : The Real-Time Kernel by J. J. Labrosse
11. Real-Time and Embedded Guide by Herman B.
12. Real-Time System Design and Analysis by Philips A. Laplante

AUTOMOTIVE SAFETY

COURSE OUTLINE

Subject code: **Total Hours: 45**

Credits: 03 **Hours per week: 03**

Course Objective:

This course provides the knowledge and understanding of various safety measures in vehicles

UNIT-1 **9 hours**

Introduction to Vehicle Safety: Automotive Safety - Active and passive safety, Driver assistance systems in automobiles, Definitions and terminology. Balance of stiffness and toughness characteristics and energy absorption characteristics of vehicle structures, Design of crash crumple zones, Modeling and simulation studies, Optimization of vehicle structures for crash worthiness, Types of impacts, and Impact with rebound, movable barrier tests, Analysis and simulation of vehicle in barrier impacts, Roll over crash tests, Behavior of specific body structures in crash testing, Photographic analysis of impact tests.

UNIT-2 **9 hours**

Ergonomics and Human Importance to Impact: Importance of Ergonomics in Automotive safety, Locations of controls, Anthropometry, Human impact tolerance Determination of Injury thresholds, Severity Index, Study of comparative tolerance, Application of Trauma for analysis of crash injuries. Injury criteria's and relation with crash and modeling and simulation studies in dummy.

UNIT-3 **9 hours**

Vehicle Safety Systems: Survival space requirements, Restraints systems used automobiles, Types of safety belts, Head restraints, Air bags used in automobiles, Use of energy absorbing systems in automobiles, Impact protection from steering controls, Design of seats for safety, types of seats used in automobiles. Importance of Bumpers in automobiles, Damageability criteria in bumper designs. Introduction to the types of safety glass and their requirements and rearward field of vision in automobiles, Types of rear view mirrors and their assessment. Warning devices, Hinges and latches etc. Active safety.

UNIT-4 **9 hours**

Fundamentals of Light, Vision and Colour: Electromagnetic radiation and light, Propagation of light, Spectral sensitivity of light, Measures of radiation and light, standard elements for optical control. Illuminant calculations, Derivation of luminous flux from luminous intensity, flux transfer and inter reflection, luminance calculations, discomfort glare, eyes as an optical system visual processing, lighting for results, modes of appearance, Pointers for lighting devices. Nature of the color Trichromatic Colorimetry, Surface color, color spaces and color solids, color rendering.

UNIT-5 **9 hours**

Testing Equipment, Calibration and Photometric Practice: Basics of standards and detectors, spectral measurements and Colorimetry, illuminant meters and luminance meters, colorimeters. Fundamentals of equipment used for light measurement in Automotive field; Gonio- Photometer, Reflecto-meter, Colorimeter, Integrating sphere, types, application, coordinates system, Types of sensors and working principle, construction, characteristics etc. used in different equipment. National and international Regulations, test requirements and testing procedure.

Text Books:

1. Jullian Happian-Smith ‘An Introduction to Modern Vehicle Design" SAE, 2002
2. Johnson, W., and Mamalis, A.G., "Crashworthiness of Vehicles", MEP, London, 1995
3. Edward .A, "Lamps and Lighting", Hodder & Stoughton, London, 1993.

Reference Books:

1. Bosch, "automotive Handbook", 5 edition, SAE Publication-2000
2. Rollover Prevention, Crash Avoidance, Crashworthiness, "Ergonomics and Human Factors”, SAE Special Publication, November 2003.

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ELECTRIC HYBRID VEHICLES SIMULATION LABORATORY

COURSE OUTLINE

Subject Code: **Total Hours: 45**

Credits: 02 **Hours per week: 03**

Course Objectives:

This course will provide the detailed simulation study of Electric Hybrid Vehicles

List of Experiments

1. Design hybrid vehicle configuration and its components, performance analysis
2. Model and Simulate the battery
3. Simulation of electric vehicle drive systems.
4. Modeling and Design of hybrid electric vehicles.
5. Simulation of Electric Vehicle Drive Train
6. Fault diagnosis & repair / replacement of Battery, DC & AC Electrical Machines, and Hybrid Electric Vehicles in Simulation.

IC ENGINES LABORATORY

COURSE OUTLINE

Subject Code: **Total Hours: 45**

Credits: 02 **Hours per week: 03**

Course Objectives:

This course will provide the detailed study and performance of IC engines

List of Experiments

7. Drawing valve and port timing diagram for 4-stroke diesel and 2-stroke petrol engine respectively.
8. Performance test for 4-stroke SI engine and draw performance curves
9. Performance Test on 4-stroke CI engine and to draw the performance curves
10. Volumetric Efficiency of Reciprocating Air compressor unit
11. Performance Test on CI engine when the compression ratio is changing.
12. To Study the Cut Models of I.C. Engine.
13. To Study the Actual Valve Timing Diagram of 4-Stroke Petrol Engine.
14. To Study the Actual Valve Timing Diagram of 4-Stroke Diesel Engine.

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III Semester

Department Elective III

IN-VEHICLE NETWORKING

COURSE OUTLINE

Subject code: **Total Hours: 45**

Credits: 03 **Hours per week: 03**

Prerequisite:

Basics of Electrical Engineering, Automobile engineering and Mechanical engineering.

Course Objective:

1. Understand the in –vehicle networking.
2. Explain the different networks
3. Explain the communication protocols
4. Describe the higher layer protocol.
5. Describe the flex ray protocol.
6. Describe the latest trends in in–vehicle networking.

UNIT-1 **9 hours**

Basics of In-Vehicle Networking

Overview of Data communication and networking –need for In-Vehicle networking – layers of OSI reference model –multiplexing and de-multiplexing concepts –vehicle buses.

UNIT-2 **9 hours**

Networks and Protocols

Overview of general-purpose networks and protocols -Ethernet, TCP, UDP, IP, ARP, RARP - LIN standard overview –workflow concept-applications –LIN protocol specification –signals - Frame transfer –Frame types –Schedule tables –Task behaviour model –Network management –

status management - overview of CAN –fundamentals –Message transfer – frame types-Error handling –fault confinement-Bit time requirements.

UNIT-3 **9 hours**

Higher Layer Protocol:

Introduction to CAN open –TTCAN –Device net -SAE J1939 - overview of data channels – Control channel-synchronous channel – asynchronous channel –Logical device model – functions-methods-properties-protocol basics- Network section-data transport –Blocks – frames –Preamble-boundary descriptor.

UNIT-4 **9 hours**

Flex Ray Protocol:

Introduction –network topology –ECUs and bus interfaces –controller host interface and protocol operation controls –media access control and frame and symbol processing – coding/decoding unit –Flex Ray scheduling.

UNIT-5 **9 hours**

Latest Trends:

Car networking protocols – Networking future trends – Roadmaps – Competitive advantage.

<u>Text Books:</u>

1. J.Gabrielleen, "Automotive In-Vehicle Networks", John Wiley & Sons, Limited, 2008
2. Robert Bosch, "Bosch Automotive Networking", Bentley publishers, 2007
3. Society of Automotive Engineers, "In-Vehicle Networks", 2002.

<u>Reference Books:</u>

1. Ronald K Jurgen, "Automotive Electronics Handbook", McGraw-Hill Inc. 1999
2. Indra Widjaja, Alberto Leon-Garcia, "Communication Networks: Fundamental Concepts and Key Architectures", McGraw-Hill College; 1st edition, 2000

3. Konrad Etschberger, “Controller Area Network, IXXAT Automation”, August 22, 2001

4. Olaf Pfeiffer, Andrew Ayre, Christian Keydel, “Embedded Networking with CAN and CAN open”, Anna books/ Rtc Books, 2003.

Course Outcomes:

At the end of the course students will be able to,
CO1: Describe about in –vehicle networking.

CO2: Explain the different networks.

CO3: Explain the different communication protocols.

CO4: Describe the higher layer protocol.

CO5: Describe the flex ray protocol.

CO6: Describe the latest trends in in–vehicle networking.

RECONFIGURABLE COMPUTING

Subject code: **No. of Hours per week: 4**
Credits: 3 **Total no. of Hours: 45**

Course Objectives:

1. Acquire fundamental knowledge and understanding of principles and practice in reconfigurable architecture.
2. Understand the FPGA design principles, and logic synthesis.
3. Integrate hardware and software technologies for reconfiguration computing focusing on partial reconfiguration design.
4. Focus on different domains of applications on reconfigurable computing.

UNIT I **09 Hrs**

Introduction: History, Reconfigurable Vs Processor based system, RC Architecture. Reconfigurable Logic Devices: Field Programmable Gate Array, Coarse Grained Reconfigurable Arrays. Reconfigurable Computing System: Parallel Processing on Reconfigurable Computers, A survey of Reconfigurable Computing System.

UNIT II **09 Hrs**

Languages and Compilation: Design Cycle, Languages, HDL, High Level Compilation, Low level Design flow, Debugging Reconfigurable Computing Applications

UNIT III **09 Hrs**

Implementation: Integration, FPGA Design flow, Logic Synthesis. High Level Synthesis for Reconfigurable Devices: Modelling, Temporal Partitioning Algorithms.

UNIT IV **09 Hrs**

Partial Reconfiguration Design: Partial Reconfiguration Design, Bitstream Manipulation with JBits, The modular Design flow, The Early Access Design Flow, Creating Partially Reconfigurable Designs, Partial Reconfiguration using Hansel-C Designs, Platform Design.

UNIT V **09 Hrs**

Digital Designs on FPGA: Introduction to Xilinx VIVADO, basic building blocks of Nexys-4 ARTIX-7 FPGA board, creating a new project, simulating the project, synthesizing the project, implementing the synthesized project, bit-stream generation.

Text Books:

1. M. Gokhale and P. Graham, ―Reconfigurable Computing: Accelerating Computation with Field-Programmable Gate Arrays‖, Springer, 2005.
2. C. Bobda, ―Introduction to Reconfigurable Computing: Architectures, Algorithms and Applications‖, Springer, 2007.

Reference Books:

1. D. Pellerin and S. Thibault, ―Practical FPGA Programming in C‖, PrenticeHall, 2005.
2. W. Wolf, ―FPGA Based System Design‖, Prentice-Hall, 2004.
3. R. Cofer and B. Harding, ―Rapid System Prototyping with FPGAs: Accelerating the Design Process‖, Newnes, 2005.
4. Digital System Design with FPGA: Implementation Using Verilog and VHDL by Cem Unsalan and Bora Tar, McGraw Hill Education (India) Private Limited

Course Outcomes:

After studying this course, students will be able to:

1. Understand the difference between reconfigurability & processor/controller-based system.
2. Gain expertise on Hardware Description Language (HDL).
3. Synthesize the reconfigurable computing architectures.
4. Use the reconfigurable architectures for the design of a digital system.
5. Design of digital systems for a variety of applications on signal processing and system on chip configurations

Open Elective

ELECTRIC HYBRID VEHICLE

COURSE OUTLINE

Subject Code: **Total Hours: 45**

Credits: 03 **Hours per week: 03**

Prerequisite:

Chemistry, Electrical Machines

Unit -1 **9 hours**

Introduction to Electrical Vehicles:

Introduction, Components, vehicle mechanics, Roadway fundamentals, vehicle kinetics, Dynamics of vehicle motion - Propulsion System Design

Unit-2 **9 hours**

Batteries: Introduction, Different batteries for EV, Battery Characterization, Comparison of Different Energy Storage Technologies for HEVs, Battery Charging Control, Charge Management of Storage Devices, Flywheel Energy Storage System, Hydraulic Energy Storage System, Fuel Cells and Hybrid Fuel Cell Energy Storage System and Battery Management System.

Unit 3 **9 hours**

DC and AC Machines in Electrical Vehicles:

Motor and Engine rating, Requirements, DC machines, Three phase A/c machines, Induction machines, permanent magnet machines, switched reluctance machines.

Unit- 4 **9 hours**

Electrical Vehicle Drive Train

Transmission configuration, Components – gears, differential, clutch, brakes regenerative braking, motor sizing

Unit -5 **9 hours**

Hybrid Electrical Vehicles

Types – series, parallel and series, parallel configuration – Design – Drive train, sizing of components.

TEXT BOOKS:

1. Iqbal Hussain, **"Electric & Hybrid Vehicles – Design Fundamentals",** Second Edition, CRC Press, 2011. T2.

2. James Larminie, **"Electric Vehicle Technology Explained"**, John Wiley & Sons, 2003..

REFERENCE BOOKS:

1.Mehrdad Ehsani, Yimin Gao, Ali Emadi, **"Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals"**, CRC Press, 2010.

2. Sandeep Dhameja, **"Electric Vehicle Battery Systems",** Newnes publishers, 2000.

Course Outcomes:
At the end of this course,the students will be able to

CO1: Determine the characteristics of Electrical Vehicles

CO2: Categorize the various types and technical characteristic of Batteries

CO3: Illustrate the electrical drives used in Electrical Vehicles

CO4: Summarize the components used in Electrical Vehicle

CO5: Design and Demonstrate the different configuration of Hybrid Electrical Vehicle.

Optimization Techniques

COURSE OUTLINE

Prerequisite:

Operations research employs techniques from other mathematical sciences, such as mathematical modeling, statistical analysis, and mathematical optimization. Management science and decision science are sometimes helpful to illuminate management issues and solve managerial problems, as well as designing and developing new and better models of organizational excellence.

Course Objective:

Operations research is a discipline that deals with the application of advanced analytical methods to help make better decisions. Operations research is often concerned with determining the maximum (of profit, performance, or yield) or minimum (of loss, risk, or cost) of some real-world objective.

Unit – 1 **9 hours**

Linear Programming

Linear Programming, Introduction, formulation of linear programming problem, Standard and matrix from, graphical solution, simplex method, Big-M method.

Unit – 2 **12 hours**

Transportation Model

Definition of transportation model, 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

Assignment Model

Introduction, Formulation, Hungarian method for optimal solution, special cases, Traveling salesman problem

Unit – 3 **10 hours**

Project Management

Network representation, critical path computation, construction of the time schedule, variation under probabilistic models, PERT calculations, crashing of simple network.

Unit – 4 **5 hours**

Sequencing

Introduction, Johnson's Alorithm, n jobs – m machines, CDS Heuristic, graphical solution

Unit – 5 **9 hours**

Forecasting

Introduction, objectives, Forecasting variables, Opinion and judgemental methods, time series methods, exponential smoothing, regression and correlation method, control of forecasts.

Text Books:

1. Hamdy A Thaha, **"Operation Research An Introduction"**, Pearson Education, 8th edition, 2007

2. Fredrick S Hillier and Lieverman **"Operations Research – Concept and Cases"**, TMH, 8th edition, 2007.

3. P. K. Gupta and D. S. Hira, **"Operations Research**", S. Chand & co., 2007.

Reference Books:

1. S.D Sharma, "**Operational Research**", , Kedar Nath Ram Nath Publishers, 2010.

2. Dr. K.R. Pranesh, "**Operations Research"**, Sudha Publications, Fourth Edition, 2013.

Course outcomes:

CO1: Understand the mathematical tools that are needed to solve optimisation problems.

CO2: Identify operational research models from the verbal description of the real system

CO3: analyze the results and propose recommendations in language understandable to the decision-making processes in Management Engineering.

CO4: solve the larger problems, communicate technical knowledge, partition a problem into smaller tasks, and complete tasks on time.

CO5: summarize the key management concepts, principles and contribution by different Management thinkers

CO6: design new simple models to improve decision –making and develop critical thinking and objective analysis of decision problems.

Master of Technology (M.Tech)

In

Electrical Engineering (Specialization in Industrial Automation and Robotics)

(As Per AICTE Model Curriculum)

CBCS Course Matrix for

I to IV Semesters

Faculty of Engineering and Technology

2022 - Onwards

Date: **Head of the Department**

1a. Programme Structure

	Particulars								
Semester	**BS**	**ES**	**HSS**	**Core**	**Dept. Elective**	**Open Elective**	**MC**	**SEC**	**Total**
I	03	--	03	11	--	--	00	--	**17**
II	--	--	--	13	06	--	00	--	**19**
III	--	--	--	--	03	03	--	11	**17**
IV	--	--	--	--	--	--	--	16	**16**
Total	**03**	**00**	**03**	**24**	**09**	**03**	**00**	**27**	**69**

	BS	**ES**	**HSS**	**Core**	**Dept. Elective**	**Open Elective**	**MC**	**SEC**	**Total**
Total Credit distribution for batch 2021	**03**	**00**	**03**	**24**	**09**	**03**	**00**	**27**	**69**

1b. List of Courses

BS: Basic Science

1. Applied Mathematics for Electrical Engineers

HSS: Humanities and Social Science

1. Research Methodology & IPR

Core

1. Power Converters & Control
2. Advanced Control Theory
3. **Industrial Drives (Specialization paper)**
4. Robotics for Industrial Automation
5. Computer integrated manufacturing
6. Flexible Manufacturing System
7. Sensors Applications in Manufacturing
8. Electrical Simulation Laboratory
9. Drives and Control systems Laboratory
10. Robotics and Automation Laboratory

DE: Department Electives

1. Modeling, Simulation and Analysis of Manufacturing Systems.
2. Computer Vision and Image Processing
3. Mechatronics and applications

4. Finite Element Analysis
5. Computer Vision and Image processing
6. Fluid power Automation
7. Artificial Intelligence and Expert Systems in Automation
8. Additive Manufacturing & Tooling
9. Auto motive electronics
10. Industry 4.0

OE: Open Electives

1. Entrepreneurship development
2. Micro and Smart systems
3. Industrial Internet of Things
4. Wireless Sensor Networks

MC: Mandatory Courses

1. English for Research Paper Writing
2. Pedagogy Studies
3. Value Education
4. Personality Development through Life Enhancement Skills
5. Constitution of India
6. Stress Management by Management by Yoga

JGI JAIN DEEMED-TO-BE UNIVERSITY | FACULTY OF ENGINEERING AND TECHNOLOGY

2022 - Onwards

Department of Electrical and Electronics Engineering

I Semester – M.Tech – Electrical Engineering (Specialization in Industrial Automation and Robotics)

Course Matrix-CBCS

S.No.	Subject Code	Name of the Subject	Credit (Marks)	L–T–P	Internal Assessment		End Semester Examinations		Minimum Passing Marks
					Max. Marks	Min. Marks	Max. Marks	Min. Marks	
1		**Applied Mathematics for Electrical Engineers**	**3**	3-0-0	50	25	50	25	50
2		**Research Methodology & IPR**	**3**	3-0-0	50	25	50	25	50
3		**Power Converters & Control**	**3**	3-0-0	50	25	50	25	50
4		**Advanced Control Theory**	**3**	3-0-0	50	25	50	25	50
5		**Specialization Paper**	**3**	3-0-0	50	25	50	25	50
6		**Electrical Simulation Laboratory**	**2**	0-0-4	50	25	50	25	50
7		**Mandatory Course - 1**	**Non-credit**	2-0-0					
		Total	**17**						

BS	ES	HSS	Core	DE	OE	MC	SEC	Total Credits
03	00	03	11	--	--	00	--	**17**

JGi JAIN DEEMED-TO-BE UNIVERSITY | FACULTY OF ENGINEERING AND TECHNOLOGY

2022 - Onwards

Department of Electrical and Electronics Engineering

II Semester – M.Tech – Electrical Engineering (Specialization in Industrial Automation and Robotics)

Course Matrix-CBCS

S.No.	Subject Code	Name of the Subject	Credit (Marks)	L–T–P	Internal Assessment		End Semester Examinations		Minimum Passing Marks
					Max. Marks	Min. Marks	Max. Marks	Min. Marks	
1		Computer integrated manufacturing	3	3-0-0	50	25	50	25	50
2		Sensors Applications in Manufacturing	3	3-0-0	50	25	50	25	50
3		Robotics for Industrial Automation	3	3-0-0	50	25	50	25	50
4		DE -1	3	3-0-0	50	25	50	25	50
5		DE -2	3	3-0-0	50	25	50	25	50
6		Drives and Control systems Laboratory	2	0-0-4	50	25	50	25	50
7		Robotics and Automation Laboratory	2	0-0-4	50	25	50	25	50
8		Mandatory Course - 2	Non-credit	2-0-0					
		Total	19						

BS	ES	HSS	Core	DE	OE	MC	SEC	Total Credits

00	00	00	13	06	--	00	--	**19**

2022 - Onwards

Department of Electrical and Electronics Engineering

III Semester – M.Tech – Electrical Engineering (Specialization in Industrial Automation and Robotics)

Course Matrix-CBCS

S.No.	Subject Code	Name of the Subject	Credit (Marks)	L–T–P	Internal Assessment		End Semester Examinations		Minimum Passing Marks
					Max. Marks	Min. Marks	Max. Marks	Min. Marks	
1		**DE -3**	**3**	3-0-0	50	25	50	25	50
2		**OE**	**3**	3-0-0	50	25	50	25	50
3		**Technical Seminar**	**1**	0-0-2	100*				50
4		**Project Phase - I**	**10**	0-0-20	100*				50
		Total	**17**						

BS	ES	HSS	Core	DE	OE	MC	SEC	Total Credits
00	00	00	00	03	03	00	11	**17**

*** -> Continuous Assessment (CA)**

2022 - Onwards

Department of Electrical and Electronics Engineering

IV Semester – M.Tech – Electrical Engineering (Specialization in Industrial Automation and Robotics)

Course Matrix-CBCS

S.No.	Subject Code	Name of the Subject	Credit (Marks)	L–T–P	Internal Assessment		End Semester Examinations		Minimum Passing Marks
					Max. Marks	Min. Marks	Max. Marks	Min. Marks	
1		**Project Phase – II and Dissertation**	**16**	0-0-32	100	50	400	200	250
		Total	**16**						

BS	ES	HSS	Core	DE	OE	MC	SEC	Total Credits
00	00	00	00	00	00	00	16	**16**

Master of Technology (M.Tech)

In

Electrical Engineering (Specialization in Power Electronics and Industrial Drives)

(As Per AICTE Model Curriculum)

CBCS Course Matrix for

I to IV Semesters

Faculty of Engineering and Technology

2022 - Onwards

Date: **Head of the Department**

1a. Programme Structure

	Particulars								
Semester	**BS**	**ES**	**HSS**	**Core**	**Dept. Elective**	**Open Elective**	**MC**	**SEC**	**Total**
I	03	--	03	11	--	--	00	--	**17**
II	--	--	--	13	06	--	00	--	**19**
III	--	--	--	--	03	03	--	11	**17**
IV	--	--	--	--	--	--	--	16	**16**
Total	**03**	**00**	**03**	**24**	**09**	**03**	**00**	**27**	**69**

	BS	**ES**	**HSS**	**Core**	**Dept. Elective**	**Open Elective**	**MC**	**SEC**	**Total**
Total Credit distribution for batch 2021	**03**	**00**	**03**	**24**	**09**	**03**	**00**	**27**	**69**

1b. List of Courses

BS: Basic Science

1. Applied Mathematics for Electrical Engineers

HSS: Humanities and Social Science

1. Research Methodology & IPR

Core

1. Power Converters & Control
2. Advanced Control Theory
3. Analysis of DC input converters
4. **Analysis of AC input converters (Specialization paper)**
5. Analysis of DC drives
6. Analysis of AC drives
7. Drives for non-conventional application

DE: Department Electives

1. Modelling of conventional and modern Electrical Machinery
2. Power Electronics in Power Quality
3. Digital Design of Controllers for Power Electronic Converters
4. Intelligent Controllers
5. HVDC Power using Solid State Technology
6. Modern Power Semiconductor devices

7. Power Electronics and Smart Grid
8. Flexible AC transmission system
9. Simulation and software tools for power electronic converters
10. Application based Optimisation Techniques in Power Electronics

OE: Open Electives

1. Advanced Signal Processing Techniques
2. Special electrical machines and their controllers
3. Power Electronics for Electrical Vehicles

MC: Mandatory Courses

1. English for Research Paper Writing
2. Pedagogy Studies
3. Value Education
4. Personality Development through Life Enhancement Skills
5. Constitution of India
6. Stress Management by Management by Yoga

2022 - Onwards

Department of Electrical and Electronics Engineering

I Semester – M.Tech – Electrical Engineering (Specialization in Power Electronics & Industrial Drives)

Course Matrix-CBCS

S.No.	Subject Code	Name of the Subject	Credit (Marks)	L–T–P	Internal Assessment		End Semester Examinations		Minimum Passing Marks
					Max. Marks	Min. Marks	Max. Marks	Min. Marks	
1		**Applied Mathematics for Electrical Engineers**	**3**	3-0-0	50	25	50	25	50
2		**Research Methodology & IPR**	**3**	3-0-0	50	25	50	25	50
3		**Power Converters & Control**	**3**	3-0-0	50	25	50	25	50
4		**Advanced Control Theory**	**3**	3-0-0	50	25	50	25	50
5		**Specialization paper**	**3**	3-0-0	50	25	50	25	50
6		**Electrical Simulation Laboratory**	**2**	0-0-4	50	25	50	25	50
7		**Mandatory Course – 1**	**Non-credit**	2-0-0					
		Total	**17**						

BS	ES	HSS	Core	DE	OE	MC	SEC	Total Credits
03	00	03	11	--	--	00	--	**17**

2022 - Onwards

Department of Electrical and Electronics Engineering

II Semester – M.Tech – Electrical Engineering (Specialization in Power Electronics & Industrial Drives)

Course Matrix-CBCS

S.No.	Subject Code	Name of the Subject	Credit (Marks)	L–T–P	Internal Assessment		End Semester Examinations		Minimum Passing Marks
					Max. Marks	Min. Marks	Max. Marks	Min. Marks	
1		**Analysis of DC Input Converters**	**3**	3-0-0	50	25	50	25	50
2		**Analysis of DC Drive Systems**	**3**	3-0-0	50	25	50	25	50
3		**Analysis of AC Drive Systems**	**3**	3-0-0	50	25	50	25	50
4		**DE -1**	**3**	3-0-0	50	25	50	25	50
5		**DE -2**	**3**	3-0-0	50	25	50	25	50
6		**Advanced DC input converters Laboratory**	**2**	0-0-4	50	25	50	25	50
7		**Advanced AC input converters Laboratory**	**2**	0-0-4	50	25	50	25	50
8		**Mandatory Course - 2**	**Non-credit**	2-0-0					
		Total	**19**						

BS	ES	HSS	Core	DE	OE	MC	SEC	Total Credits
00	00	00	13	06	--	00	--	**19**

2022 - Onwards

Department of Electrical and Electronics Engineering

III Semester – M.Tech – Electrical Engineering (Specialization in Power Electronics & Industrial Drives)

Course Matrix-CBCS

S.No.	Subject Code	Name of the Subject	Credit (Marks)	L–T–P	Internal Assessment		End Semester Examinations		Minimum Passing Marks
					Max. Marks	Min. Marks	Max. Marks	Min. Marks	
1		**DE -3**	**3**	3-0-0	50	25	50	25	50
2		**OE**	**3**	3-0-0	50	25	50	25	50
3		**Technical Seminar**	**1**	0-0-2	100*				50
4		**Project Phase - I**	**10**	0-0-20	100*				50
		Total	**17**						

BS	ES	HSS	Core	DE	OE	MC	SEC	Total Credits
00	00	00	00	03	03	00	11	**17**

*** -> Continuous Assessment (CA)**

2022 - Onwards

Department of Electrical and Electronics Engineering

IV Semester – M.Tech – Electrical Engineering (Specialization in Power Electronics & Industrial Drives)

Course Matrix-CBCS

S.No.	Subject Code	Name of the Subject	Credit (Marks)	L–T–P	Internal Assessment		End Semester Examinations		Minimum Passing Marks
					Max. Marks	Min. Marks	Max. Marks	Min. Marks	
1		**Project Phase – II and Dissertation**	**16**	0-0-32	100	50	400	200	250
		Total	**16**						

BS	ES	HSS	Core	DE	OE	MC	SEC	Total Credits
00	00	00	00	00	00	00	16	**16**

FACULTY OF ENGINEERING AND TECHNOLOGY

I Semester

Applied Mathematics for Electrical Engineers

Subject Code: **Credits: 03**

Hrs/week: 03 **Total hrs: 45**

Module – I: **9 Hours**

Probability and Statistics: Sampling distributions, Estimation of parameters (point estimation – unbiasedness & minimum variance, basics of interval estimation – confidence interval for mean), Testing of hypotheses (one and two sample tests for mean), Linear regression, Introduction to non-linear regression.

Module II: **9 Hours**

Stochastic process: Random processes, Random walk, Markov process with special emphasis on Markov chain

Module – III: **12 Hours**

Numerical Analysis: Introduction to Interpolation formulae [Bessel's & Sterling's], Roots of transcendental equations [Bisection, Regula-Falsi & Newton-Raphson] Solutions of simultaneous non-linear equations [Newton's method], Numerical solution of Ordinary Differential equation [Modified Euler's method, fourth order Runga-Kutta method], Matrix Eigen value and Eigen vector problems.

Module IV: **8 Hours**

Optimization Technique: Calculus of several variables, Implicit function theorem, Nature of singular points, Necessary and sufficient conditions for optimization, Constrained Optimization, Lagrange multipliers, Gradient method – steepest descent method.

Module V: **7 Hours**

Wavelet Transform: Resolution problems, Multi-resolution analysis, Continuous & discrete wavelet transform

Text books:

1. Kreyzig, 'Advanced Engineering Mathematics'

References:

1. Scarborough, J. B.- Numerical Mathematical Analysis, Oxford University Press
2. Cone, S. D.- Elementary Numerical Analysis, Mc. GrawHill.
3. Mukhopadhyay, P.-Mathematical Statistics, New Central Book Agency
4. Kapoor, V. K and Gupta, S.C.-Fundamental of Mathematical Statistics, Sultan Chand and Sons.
5. Rao, S. S.-Optimization Theory and Application, Wiley Eastern Ltd., New Delhi
6. S. S. Shastri, Numerical Methods
7. J. Medhi, Stochastic Processes
8. Jain & Iyenger, Numerical Analysis
9. Bopardikar & Rao, Wavelet Transform, Wiley

Course Outcome:

1. Outcome: Ability to analyze and solve problems related to digital communication.
2. Outcome: Ability to analyze and solve stochastic engineering & industrial problems
3. Outcome: Ability to optimize & solve real life problems
4. Outcome: Ability to apply in simple real life problems

Pre-requisite: Review of Basic Probability Theory, Basic Under graduate course in probability, Undergraduate Transformation theory

Research Methodology and IPR

Subject Code: **Credits: 03**

Hrs/week: 03 **Total hrs: 45**

Course Outcomes:

At the end of this course, students will be able to

1. Understand research problem formulation.
2. Analyze research related information
3. Follow research ethics
4. Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.
5. Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.
6. Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.

Unit 1: **9 Hours**

Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

Unit 2: 9 Hours

Effective literature studies approaches, analysis Plagiarism , Research ethics, Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

Unit 3: **9 Hours**

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.

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Unit 4: **9 Hours**

Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

Unit 5: **9 Hours**

New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, PR and IITs.

References:

- Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students'"
- Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction"
- Ranjit Kumar, 2 nd Edition , "Research Methodology: A Step by Step Guide for beginners"
- Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007.
- Mayall , "Industrial Design", McGraw Hill, 1992.
- Niebel , "Product Design", McGraw Hill, 1974.
- Asimov , "Introduction to Design", Prentice Hall, 1962.
- Robert P. Merges, Peter S. Menell, Mark A. Lemley, " Intellectual Property in New Technological Age", 2016
- T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 20

ADVANCED CONTROL THEORY

COURSE OUTLINE

Subject code: **Total Hours: 45**

Credits: 03 **Hours per week: 03**

Unit I 9 Hours

Fields, Vectors, and vector spaces; State space representation, state equations for dynamic systems, solution of state equations; State transition matrix – Properties of state transition matrix; evaluation. Fadeeva algorithm for conversion from state space to transfer function, Linearization of non-linear models

Unit II 9 Hours

Non uniqueness of state model, Similarity transformation, Invariance of system properties. Controllability – necessary and sufficient condition - Pole assignment using State feedback – Ackerman's formula for feedback gain determination; Observability. Duality. Effect of state feedback on controllability and observability. Controllable subspace – decomposition of state into controllable and uncontrollable components.

Unit III 9 Hours

Design of full order observer – Bass Gura algorithm. The separation principle - Combined observer – controller compensator. Design of reduced order observer. Unobservable subspace – decomposition of state into observable and unobservable components – Canonical decomposition theorem.

Unit IV 9 Hours

Reducibility – realization of transfer function matrices. Model decomposition and decoupling by state feedback. Design of robust control system for asymptotic tracking and disturbance rejection using State variable equations. Transfer function interpretations – transfer function form of observer and state estimate feedback. State space interpretation of internal model principle.

Unit V 9 Hours

Discrete time linear state regulator – Algorithm for the solution, Use of observer in implementing the control law. Continuous time linear state regulator – Matrix Riccati equation. Time invariant linear state regulator – the reduced matrix Riccati equation - An iterative method to solve the reduced matrix Riccati equation. Suboptimal linear regulator.

Text Books:

1. Modern Control Engineering, Katsuhiko Ogata, 5th Edition, Prentice Hall India, 1997

2. Modern Control System Theory, M. Gopal, Revised 2nd Edition, New Age International Publishers, 2005.

References:

1. Linear Systems, Thomas Kailath, Perntice Hall, 1980.

2. Control System Design, Graham C. Goodwin, StefanF. Graebe and Mario E. Salgado, Pearson Education, 2000.

3. Linear System Theory and Design, Chi-Tsong Chen, OXFORD University Press.

4. Richard C. Dorf and Robert H. Bishop, Modern Control Systems, 11th Edition, Pearson Edu India, 2009.

POWER CONVERTERS AND CONTROL

COURSE OUTLINE

Subject code: **Total Hours: 45**

Credits: 03 **Hours per week: 03**

Prerequisite:
Power Electronics, Signal Generation, Control Systems.

Course Objective:

1. Analyze Power converters used in various types of Electric Vehicles.
2. Describe the line frequency phase-controlled rectifiers.
3. Describe the line frequency phase-controlled inverters.
4. Analyze the DC – DC converters used in EV applications.
5. Analyze the Switch-Mode dc-ac Inverters.
6. Discuss the Resonant Converters.

UNIT-1 **9 hours**

Application of Power Converter in Different Electric Vehicles:

Battery Electric Vehicles – Architecture of battery electric vehicle, Role of PECs in battery electric vehicle,

Fuel cell electric vehicle – Architecture of Fuel cell electric vehicle, Role of PECs in Fuel cell electric vehicle,

Hybrid electric vehicles (HEVS) – Series hybrid electric vehicle, Parallel hybrid electric vehicle, Series-Parallel hybrid electric vehicle, Role of PECs in Hybrid electric vehicles (HEVS)

Plug-In electric vehicles – Architecture of battery electric vehicle, Role of PECs in battery electric vehicle,

UNIT-2 **9 hours**

Line-Frequency Phase-Controlled Rectifiers and Inverters: Line-Frequency ac - Controlled dc: Introduction, Thyristor Circuits and Their Control, Single-Phase Converters, Three-Phase Converters, Other Three-Phase Converters.

UNIT-3 **9 hours**

dc-dc Switch-Mode Converters: Introduction, Control of dc-de Converters, Step-Down (Buck) Converter, Step-Up (Boost) Converter, Buck-Boost Converter, Cuk dc-dc Converter, Full Bridge dc-dc Converter, dc-dc Converter Comparison.

UNIT-4 **9 hours**

Switch-Mode dc-ac Inverters: dc ~ Sinusoidal ac: Introduction, Basic Concepts of Switch-Mode Inverters, Single-Phase Inverters, Three-Phase Inverters, Effect of Blanking Time on Output Voltage in PWM Inverters, Other Inverter Switching Schemes, Rectifier Mode of Operation.

UNIT-5 **9 hours**

Resonant Converters: Zero-Voltage and/or Zero-Current Switching: Introduction, Classification of Resonant Converters, Basic Resonant Circuit Concepts, Load-Resonant Converters, Resonant-Switch Converters, Zero-Voltage-Switching, Clamped-Voltage Topologies, Resonant-dc-Link Inverters with Zero-Voltage switching, High-Frequency-Link, Integral-Half-Cycle Converters.

Text Books:

1. Pandav Kiran Maroti, Sanjeevikumar Padmanaban, Mahajan Sagar Bhaskar, Vigna K. Ramachandaramurthy, Frede Blaabjerg, "The state-of-the-art of power electronics converters configurations in electric vehicle technologies", Power Electronic Devices and Components,
   Elsevier, Volume 1, 2022.
2. Ned Mohan, T.M. Undeland and William P. Robbins: Power Electronics: Converters, Applications, 3rd Edition, John Wiley & Sons, 2009

Reference Books:

1. Power Electronics-Md.H.Rashid –Pearson Education Third Edition- First IndianReprint-2008
2. Elements of Power Electronics – Philip T. Krein, Oxford University press, 2014

Course Outcomes:

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

CO1: Analyze the Power converters used in various types of Electric Vehicles.

CO2: Describe the line frequency phase-controlled rectifiers.

CO3: Describe the line frequency phase-controlled inverters.

CO4: Analyze the DC – DC converters used in EV applications.

CO5: Analyze the Switch-Mode dc-ac Inverters.

CO6: Discuss the Resonant Converters.

ANALYSIS OF AC INPUT CONVERTERS

COURSE OUTLINE

Subject code: **Total Hours: 45**

Credits: 03 **Hours per week: 03**

Unit I 9 Hours

SINGLE PHASE INVERTERS 9 Principle of operation of half and full bridge inverters – Performance parameters – Voltage control of single phase inverters using various PWM techniques – various harmonic elimination techniques.

Unit II 9 Hours

THREE PHASE VOLTAGE SOURCE INVERTERS 9 180 degree and 120 degree conduction mode inverters with star and delta connected loads – voltage control of three phase inverters: single, multi pulse, sinusoidal, space vector modulation techniques.

Unit III 9 Hours

CURRENT SOURCE INVERTERS 9 Single phase CSI - load commutated inverters – Auto sequential current source inverter (ASCI) - Operation of sixstep thyristors inverter – inverter operation modes – comparison of current source inverter and voltage source inverters.

Unit IV 9 Hours

MULTILEVEL INVERTERS 9 Multilevel concept – diode clamped – flying capacitor – cascade type multilevel inverters - Comparison of multilevel inverters - application of multilevel inverters.

Unit V 9 Hours

RESONANT INVERTERS 9 Series and parallel resonant inverters - voltage control of resonant inverters – Class E resonant inverter – resonant DC – link inverters.

Reference Book:

1. Rashid M.H., “Power Electronics Circuits, Devices and Applications ", Pearson Education, Fourth Edition. 2014.

2. Jai P.Agrawal, “Power Electronics Systems”, Pearson Education, Second Edition, 2002.

3. Bimal K.Bose “Modern Power Electronics and AC Drives”, Pearson Education, Second Edition, 2003.

4. Philip T. krein, “Elements of Power Electronics” Oxford University Press -2004.

ELECTRICAL SIMULATION LABORATORY

COURSE OUTLINE

Sub Code: **Hours per Week: 03**

Credit: 01

Course objectives:

- To explain the use of MATLAB package to obtain the power angle characteristics of salient and non- salient pole alternator.
- To explain the use of MATLAB package to study transient stability of radial power systems under three phase fault conditions.
- To explain the use of MATLAB package to perform fault studies for simple radial power systems.

List of Experiments:

Use of MATLAB package

1. Determination of Power Angle Diagrams, Reluctance Power, Excitation, Emf and Regulation for Salient and Non-Salient Pole Synchronous Machines.
2. To obtain Swing Curve and to Determine Critical Clearing Time, Regulation, Inertia Constant/Line Parameters /Fault Location/Clearing Time/Pre-Fault Electrical Output for a Single Machine connected to Infinite Bus through a Pair of identical Transmission Lines Under 3-Phase Fault on One of the two Lines.
3. To Determine Fault Currents and Voltages in a Single Transmission Line System with Star-Delta Transformers at a Specified Location for LG and LLG faults by simulation.
4. Y Bus Formation for Power Systems with and without Mutual Coupling, by Singular Transformation and Inspection Method.
5. Simulation of Three-Phase Two-Level PWM Converters.
6. Simulation of AC/DC Three Level PWM Converters.
7. Simulation of Three-Phase Three Level PWM Converters.

8. Power flow study on a given power system network using Gauss – Siedal method for 5 bus system, IEEE 14 bus system and IEEE 30 bus system.
9. A Simulink model for a single area load frequency problem and simulate with and without controller.
10. Performance of solar photovoltaic Maximum Power Point Tracking based on Perturbation & Observation algorithm and charge lead acid battery using three stage charging algorithms.
11. Performance of photovoltaic panel Maximum Power Point Tracking based on Particle Swarm Optimization algorithm.
12. Dynamic PSO MPPT PV under Partial shading conditions with DC-DC boost converter.

FACULTY OF ENGINEERING AND TECHNOLOGY

Semester II

ANALYSIS OF DC INPUT CONVERTERS

COURSE OUTLINE

Subject code: **Total Hours: 45**

Credits: 03 **Hours per week: 03**

UNIT 1 8 Hrs.

DC – DC Converters (Basic Converters): Linear voltage regulators (LVRs), a basic switching converter (SMPC), comparison between LVR & SMPC, principle of operation of step-down chopper, two-quadrant and four-quadrant choppers. principle of operation and analysis of buck converter, inductor current ripple and output voltage ripple, capacitor resistance effect, synchronous rectification, design considerations, buck converter for discontinuous current operation.

UNIT 2 8 Hrs.

Principle of operation and analysis of boost converter, inductor current ripple and output voltage ripple, inductor resistance effect, design considerations, boost converter for discontinuous current operation. Principle of operation and analysis of buck-boost converter analysis, inductors current ripple and output voltage ripple, design considerations, buck-boost converter for discontinuous current operation.

UNIT 3 9 Hrs.

Principle of operation and analysis of CUK converter , inductor current ripple and output voltage ripple, capacitor resistance effect, design considerations, single ended primary inductance converter(SEPIC). Derived Converters: Introduction, transformer models, principle of operation and analysis of fly back converter-continuous and discontinuous current mode of operation, design considerations

UNIT 4 9 Hrs

Principle of operation and analysis of forward converter, design considerations, double ended(Two switch) forward converter, principle of operation and analysis of push-pull converter, design considerations, principle of operation and analysis of full bridge and half-bridge DC-DC converters, design considerations, current fed converters, multiple outputs.

UNIT 5 10hrs

Resonant Converters: Introduction, resonant switch ZCS converter, principle of operation and analysis, resonant switch ZVS converter, principle of operation and analysis, Series resonant inverter, series resonant DC-DC converter, parallel resonant DC-DC converter, series- parallel resonant DCDC converter, resonant converters comparison.

REFERENCE BOOKS

1. Daniel W Hart, “Power Electronics”, Tata McGraw Hill, 2011.

2. Umanand L and Bhatt S R, “Design of Magnetic Components for Switched Mode Power Converters”, Wiley Eastern Publication, 2009.

3. Rashid M.H., “Power Electronics – Circuits Devices and Applications”, 3rd Edition, Pearson, 2011.

. D M Mitchel, “DC-DC Switching Regulator Analysis” McGraw-Hill Ltd, 1988.

ANALYSIS OF DC DRIVES

COURSE OUTLINE

Subject code: **Total Hours: 45**

Credits: 03 **Hours per week: 03**

OBJECTIVES

- To make the students analyze the operation of AC Voltage controller fed AC Drives.
- To make the students analyze the operation of VSI and CSI fed AC Drives.
- To make the students understand the operation of the speed control of induction motor drive from the rotor side.
- To make the students understand the field-oriented control of induction machines.
- To make the students understand the operation of synchronous motor drives

OUTCOMES

- Analyze the performance of stator voltage-controlled inductance motor drive.
- Analyze the operation of VSI & CSI fed induction motor speed control.
- Analyze the speed control of induction motor drive from the rotor side.
- Explain the field-oriented control of induction machine.
- Understand the control of synchronous motor drives.

Unit I STATOR VOLTAGE CONTROLLED INDUCTION MOTORS 9 Hours

Introduction - Rotating magnetic field – torque production, Equivalent circuit– Steady state performance equations, Variable voltage constant frequency operation - Conventional method - Variable voltage characteristics –- Control of induction motor by AC voltage controllers - Waveforms - speed torque characteristics - Four quadrant operation

– Closed loop speed control - different braking methods

Unit IISTATOR FREQUENCY CONTROLLED INDUCTION MOTORS 9 Hours

Constant voltage variable frequency operation - constant Volt/Hz operation - speed torque characteristics, Analysis -Drive operating regions, variable stator current operation and analysis, six step inverter voltage and frequency control - PWM inverter fed induction motor drives - CSI fed IM variable frequency drives -comparison - Closed loop speed control

Unit III ROTOR CONTROLLED INDUCTION MOTOR DRIVES 9 Hours

Review of rotor resistance control – Static rotor resistance control – Performance Analysis, Speed torque characteristics –Slip power recovery scheme - Conventional method, Static Kramer drives , Static Scherbius drives , Analysis

Unit IV FIELD ORIENTED CONTROL 9 Hours

Field oriented control of induction machines – Theory – DC drive analogy – Direct and Indirect methods – Flux vector estimation - Direct torque control of Induction Machines – Torque expression with stator and rotor fluxes, DTC control strategy

Unit V SYNCHRONOUS MOTOR DRIVES 9 Hours

Wound field cylindrical rotor motor – Equivalent circuits – performance equations of operation Power factor control and V curves – starting and braking of Synchronous motor drives – speed control of synchronous motors – adjustable frequency operation of synchronous motors – voltage source inverter drive with open loop control – self controlled and separate controlled synchronous motor – self controlled synchronous motor drive using load commutated thyristor inverter – Cycloconverter fed drive

Reference Book:

1. Bimal K Bose, “Modern Power Electronics and AC Drives”, Pearson Education 2002.
2. Vedam Subramanyam, “Electric Drives – Concepts and Applications”, McGraw Hill, Second Edition, 2010.
3. Gobal K.Dubey, “Fundamentals of Electrical Drives”, Narosal Publishing House, New Delhi, Second Edition

,2009

4. R.Krishnan, “Electric Motor Drives – Modeling, Analysis and Control”, Prentice-Hall of India Pvt. Ltd., New Delhi, 2003.

ANALYSIS OF AC DRIVES

COURSE OUTLINE

Subject code: **Total Hours: 45**

Credits: 03 **Hours per week: 03**

OBJECTIVES

- To impart knowledge on the operation and analysis of DC Motors.
- To make the students analyze the operation of controlled rectifier fed DC Drives.
- To make the students analyze the operation of Chopper fed DC Drives.
- To make the students understand the current and speed controllers for closed loop solid state DC motor drives.

OUTCOMES

- Explain the basic concept of steady state operation and transient dynamics of a motor load system
- Study and analyze the operation of the various controlled rectifier fed DC drives.
- Study and analyze the operation of the various choppers fed DC drives.
- Understand the modelling of various elements and digital control of DC drives.
- Study and analyze the current and speed controllers for closed loop solid state DC motor drives

Unit I DC MOTORS FUNDAMENTALS AND MECHANICAL SYSTEMS 9 Houes

DC motor- Types, induced emf, speed-torque relations; Speed control – Armature and field speed control; Ward Leonard control – Braking methods- Constant torque and constant horse power operation. Characteristics of mechanical system – dynamic equations, components of torque, types of load; Requirements of drives characteristics - stability of drives – multi-quadrant operation; Drive elements, types of motor duty and selection of motor rating.

Unit II CONVERTER FED DC DRIVES 9 Hours

Principle of phase control – Fundamental relations; Analysis of series and separately excited DC motor with single- phase and three-phase converters – waveforms, performance parameters, performance characteristics. Continuous and discontinuous mode, Current ripple and its effect on performance; Operation with freewheeling diode, Dual converter fed DC drives-related problems.

Unit III CHOPPER FED DC DRIVES 9 Hours

Introduction about chopper, control strategy, Class A, B, C, D and E chopper controlled DC motor drive –performance analysis, Chopper based implementation of braking methods, Multi-phase chopper; Related problems.

Unit IV CLOSED LOOP CONTROL 9 Hours

Modeling of drive elements – Equivalent circuit, transfer function of separately excited DC motors, model of power converters; Sensing and feedback elements. Closed loop control of armature and field control- PLL and microcomputer control of dc drives.

Unit V DESIGN OF CLOSED LOOP CONTROL 9 Hours

Closed loop speed control – current and speed loops, P, PI and PID controllers – response comparison. Case study of converter and chopper fed dc drive

Reference Book:

1. Bimal K Bose, “Modern Power Electronics and AC Drives”, Pearson Education Asia 2002.
2. Vedam Subramanyam, “Electric Drives – Concepts and Applications”, McGraw Hill, Second Edition, 2010.
3. Gobal K.Dubey, “Fundamentals of Electrical Drives”, Narosal Publishing House, New Delhi, Second Edition ,2009
4. R.Krishnan, “Electric Motor Drives – Modeling, Analysis and Control”, Prentice-Hall of India Pvt. Ltd., New Delhi, 2003.
5. Gopal K Dubey, “Power Semiconductor controlled Drives”, Prentice Hall Inc., New Jersy, 1989.
6. Buxbaum, A.Schierau, K.and Staughen, "A Design of control System for DC Drives”, Springer-Verlag,

Department Elective

MODELLING OF CONVENTIONAL AND MODERN ELECTRICAL MACHINERY

COURSE OUTLINE

Subject code: **Total Hours: 45**

Credits: 03 **Hours per week: 03**

UNIT I **9 Hours**

Electromagnetic Energy Conversion and Reference Frame Theory: General expression of stored magnetic energy, co-energy and force/torque, example using single and doubly excited system; Calculation of air gap mmf and per phase machine inductance using physical machine data; Voltage and torque equation of dc machine, three phase symmetrical induction machine and salient pole synchronous machines in phase variable form. Concept of two pole generalized machine, Rotating & transformer voltage, principle of Kron's primitive machine, transformation of three-phase to two-phase variables and it's vice versa, physical concept of park transformation,

UNIT II DC Machine Modelling: **9 hours**

Mathematical model of separately excited DC motor-steady state and transient state analysis, sudden application of inertia load, transfer function of separately excited DC motor, mathematical model of dc series motor, shunt motor, linearization techniques for small perturbations.

UNIT III Dynamic Modelling of Three Phase Induction Machine: **9 Hours**

Generalized model in arbitrary frame, electromagnetic torque, deviation of commonly used induction motor models-stator reference frames model, rotor reference frames model, synchronously rotating reference frames model, equations in flux linkages, per unit model, dynamic simulation.

Derivation of small signal equations of induction machine, space phasor model, DQ flux linkages model derivation, control principle of the induction motor.

UNIT IV Modelling of Synchronous Machines: **9 Hours**

Introduction, voltage equations and torque equation in machine variables, stator voltage equations in arbitrary and rotor reference frame variables, Park's equations, torque equations in substitute variables, rotor angle and angle between rotors, per unit system, analysis of steady state operation.

UNIT V Modelling of Special Electrical Machines **9 Hours**

Special Machines: Surface permanent magnet (square and sinusoidal back emf type) and interior permanent magnet machines, construction, operating principle and true synchronous characteristics, dynamic modelling and self-controlled operation: construction and operation of BLDC Motor, mathematical model of BLDC motor, commutation torque ripples, Impact of motor inductance on the dynamic performance. Stepper motors operation, classification, features of stepper motor, operation of switched reluctance motor, expressions of torque

Text Book

1. P.S. Bimbra, Generalised Theory of Electric Machines, Khanna Publications, 7thEdition, Delhi, 2010.
2. D.P. Kothari &I.J.Nagrath, Electric Machines.
3. A.R. Fitzgrald Electric Machinery.
4. Chee- Mun Ong, Dynamic Simulation of Electric Machinery using Matlab/Simulink
5. B.K. Bose, Modern Power Electronics and AC drives.

Reference Book

1. Analysis of Electrical Machinery and drive systems- Paul C. Krause, OlegWasynczuk&Scott D. Sudhoff.
2. B. Adkins & R.G. Harley Generalized Theory of AC Machines.
3. Electric Drive- G.K. Dubey.

POWER ELECTRONICS IN POWER QUALITY

Subject code: **Total Hours: 45**

Credits: 03 **Hours per week: 03**

OBJECTIVES

- The concept of the Power Quality Issues.
- The concept of the Single phase linear and non linear loads.
- The concept of load compensation and voltage regulation using DVR and analysis of classical load balancing problem.
- The concept of instantaneous PQ theory and control of DSTATCOM..

OUTCOMES

- List and classify the various power quality issues.
- Elucidate the concept of power and power factor in supplying non-linear loads.
- Explain and Design the conventional compensation techniques used for power factor correction and load voltage regulation.
- Describe about active shunt compensation techniques used for power factor correction and load voltage regulation
- Describe about active series compensation techniques used for load voltage regulation

Unit I INTRODUCTION 9

Introduction – Characterisation of Electric Power Quality and its impact: Transients, short duration and long duration voltage variations, Voltage imbalance, waveform distortion, Voltage fluctuations, Power frequency variation, Power acceptability curves- Power quality standards. Harmonic Indices: Total Harmonic Distortion, Total Demand Distortion

Unit II ANALYSIS OF SINGLE PHASE AND THREE PHASE SYSTEM 9

Single phase linear and non linear loads –single phase sinusoidal voltage supplying linear and non linear load, non sinusoidal source supplying linear and nonlinear load- True Power Factor-Three-phase Sinusoidal Balanced System- Instantaneous Active and Reactive Powers for Three-phase Circuits- Three-Phase Unbalance System: Concept of vector apparent power and arithmetic apparent power

Unit III CONVENTIONAL LOAD COMPENSATION METHODS 9

Principle of load compensation and voltage regulation for single phase loads using passive compensator- classical load balancing problem : open loop balancing of delta connected unbalanced load – closed loop balancing- Analysis and Design of Three-Phase Four-Wire Passive Shunt Compensators - Extraction of fundamental sequence component

Unit IV LOAD COMPENSATION USING DSTATCOM 9

Introduction to Custom Power Devices and its classification- Compensating single phase loads- Ideal three phase shunt compensator structure- generating reference currents using instantaneous PQ theory – Instantaneous symmetrical components theory – Generating reference currents when the source is unbalanced- Realization and control of DSTATCOM

Unit V SERIES COMPENSATOR AND UPQC 9

Classification of Active Series Compensators-Rectifier supported DVR – DC Capacitor supported DVR- Series Compensator Rating- Design of Active Series Compensators components-UPQC- UPQC Configurations: Right-Shunt UPQC and Left shunt UPQC- Harmonic filters: passive, Active and hybrid filters

Reference Book:

1. Roger.C.Dugan, Mark.F.McGranagham, Surya Santoso, H.Wayne Beaty, “Electrical Power Systems Quality: 3rd Edition” McGraw Hill Publication, 2012.
2. Arindam Ghosh and Gerard Ledwich, “Power Quality Enhancement Using Custom Power Devices”, Springer

International Edition, 2002

3. Bhim Singh, Ambrish Chandra and Kamal Al-Haddad, “Power Quality: Problems and Mitigation Techniques”

Wiley Publications, 2014

Digital Design of Controllers for Power Electronic Converters

Subject code: **Total Hours: 45**

Credits: 03 **Hours per week: 03**

UNIT 1 10 Hrs.

Introduction: Measurement techniques for voltages, current, power, power factor in power electronic circuits, recording and analysis of waveforms, sensing of speed.

UNIT2 8 Hrs.

Switching Regulator Control Circuits: Introduction, Isolation techniques of switching regulator systems, PWM systems.

UNIT 3 8 Hrs.

Commercial PWM Control ICs and their Applications: TL 494 PWM Control IC, UC 1840 Programmable off line PWM controller, UC 1524 PWM control IC, UC 1846 current mode control IC, UC 1852 resonant mode power supply controller.

UNIT 4 9 Hrs.

Switching Power Supply Ancillary, Supervisory & Peripheral Circuits and Components: Introduction, Opto-couplers, self-biased techniques used in primary side of reference power supplies, Soft/Start in switching power supplies, current limit circuits, over voltage protection, AC line loss detection.

UNIT 5 10hrs

Phase – Locked Loops (PLL) & Applications: PLL Design using ICs, 555 timer & its applications, analog to digital converter using IC‟s, digital to analog converters using ICs, implementation of different gating circuits.

REFERENCE BOOKS

1. G. K. Dubey, S. R. Doradla, A. Johsi, and R. M. K. Sinha, “Thyristorised Power Controllers”, 2nd Edition, New Age International, 2010.

2. Chryssis “High Frequency Switching Power Supplies”, 2nd Edition, MGH, 1989

INTELLIGENT CONTROLLERS

Subject code: **Total Hours: 45**

Credits: 03 **Hours per week: 03**

Objectives:

- Gaining an understanding of the functional operation of a variety of intelligent control techniques and their bio-foundations
- the study of control-theoretic foundations
- learning analytical approaches to study properties

Outcomes:

- Develop Neural Networks, Fuzzy Logic, and Genetic algorithms.
- Implement soft computing to solve real-world problems mainly pertaining to control system applications

Unit-I :Introduction and motivation. Approaches to intelligent control. Architecture for intelligent control. Symbolic reasoning system, rule-based systems, the AI approach. Knowledge representation. Expert systems.

Unit-II :Concept of Artificial Neural Networks and its basic mathematical model, McCulloch-Pitts neuron model, simple perceptron, Adaline and Madaline, Feedforward Multilayer Perceptron. Learning and Training the neural network. Data Processing: Scaling, Fourier transformation, principal-component analysis.

Unit-III : Networks: Hopfield network, Self-organizing network and Recurrent network. Neural Network based controller Case studies: Identification and control of linear and nonlinear dynamic systems using Matlab-Neural Network toolbox. Stability analysis of Neural-Network interconnection systems.

Unit-IV :Genetic Algorithm: Basic concept of Genetic algorithm and detail algorithmic steps, adjustment of free parameters. Solution of typical control problems using genetic algorithm. Concept on some other search techniques like tabu search and ant-colony search techniques for solving optimization problems.

Unit-V :Introduction to crisp sets and fuzzy sets, basic fuzzy set operation and approximate reasoning. Introduction to fuzzy logic modeling and control. Fuzzification, inferencing and defuzzification. Fuzzy knowledge and rule bases. Fuzzy modeling and control schemes for nonlinear systems. Fuzzy logic control for nonlinear time-delay system. Implementation of fuzzy logic controller using Matlab fuzzylogic toolbox. Stability analysis of fuzzy control systems.

TEXT BOOKS:

- Simon Haykins, Neural Networks: A comprehensive Foundation, Pearson Edition, 2003.
- T.J. Ross, Fuzzy logic with Fuzzy Applications, Mc Graw Hill Inc, 1997.
- David E Goldberg, Genetic Algorithms.
- John Yen and Reza Langari, Fuzzy logic Intelligence, Control, and Information, Pearson Education, Indian Edition, 2003.

REFERENCES:

- M.T. Hagan, H. B. Demuth and M. Beale, Neural Network Design, Indian reprint, 2008.
- Fredric M. Ham and Ivica Kostanic, Principles of Neuro computing for science and Engineering, McGraw Hill, 2001.
- N. K. Bose and P. Liang, Neural Network Fundamentals with Graphs, Algorithms, and Applications, Mc – Graw Hill, Inc. 1996.
- Yung C. Shin and Chengying Xu, Intelligent System – Modeling, Optimization and Control, CRC Press, 2009.

Department Elective 2

HVDC Power using Solid State Technology

Subject code: **Total Hours: 45**

Credits: 03 **Hours per week: 03**

Unit I **10hrs**

DC MOTORS FUNDAMENTALS AND MECHANICAL SYSTEMS 12 DC motor- Types, induced emf, speed-torque relations; Speed control – Armature and field speed control; Ward Leonard control – Braking methods- Constant torque and constant horse power operation. Characteristics of mechanical system – dynamic equations, components of torque, types of load; Requirements of drives characteristics - stability of drives – multi-quadrant operation; Drive elements, types of motor duty and selection of motor rating.

Unit II **08hrs**

CONVERTER FED DC DRIVES 12 Principle of phase control – Fundamental relations; Analysis of series and separately excited DC motor with singlephase and three-phase converters – waveforms, performance parameters, performance characteristics. Continuous and discontinuous mode, Current ripple and its effect on performance; Operation with freewheeling diode, Dual converter fed DC drives-related problems.

Unit III **09hrs**

CHOPPER FED DC DRIVES 12 Introduction about chopper, control strategy, Class A, B, C, D and E chopper controlled DC motor drive – performance analysis, Chopper based implementation of braking methods, Multi-phase chopper; Related problems.

Unit IV **09hrs**

CLOSED LOOP CONTROL 12 Modeling of drive elements – Equivalent circuit, transfer function of separately excited DC motors, model of power converters; Sensing and feedback elements. Closed loop control of armature and field control- PLL and microcomputer control of dc drives.

Unit V **09hrs**

DESIGN OF CLOSED LOOP CONTROL 12 Closed loop speed control – current and speed loops, P, PI and PID controllers – response comparison. Case study of converter and chopper fed dc drive

Reference Book:

1. Bimal K Bose, “Modern Power Electronics and AC Drives”, Pearson Education Asia 2002.

2. Vedam Subramanyam, “Electric Drives – Concepts and Applications”, McGraw Hill, Second Edition, 2010.

3. Gobal K.Dubey, “Fundamentals of Electrical Drives”, Narosal Publishing House, New Delhi, Second Edition ,2009

4. R.Krishnan, “Electric Motor Drives – Modeling, Analysis and Control”, Prentice-Hall of India Pvt. Ltd., New Delhi, 2003.

5. Gopal K Dubey, “Power Semiconductor controlled Drives”, Prentice Hall Inc., New Jersy, 1989.

6. Buxbaum, A.Schierau, K.and Staughen, "A Design of control System for DC Drives”, Springer-Verlag, berlin, 1990.

Modern Power Semiconductor devices

Subject code: **Total Hours: 45**

Credits: 03 **Hours per week: 03**

Unit I **10hrs**

Introduction to Power switching devices overview – Attributes of an ideal switch, application requirements, circuit symbols; Power handling capability – SOA - Device selection strategy – On-state and switching losses – EMI due to switching - Power diodes - Types, forward and reverse characteristics, switching characteristics – rating.

Unit II **9hrs**

Thyristors – Physical and electrical principle underlying operating mode, Two transistor analogy – concept of latching- Gate and switching characteristics- commutation of Thyristors - converter grade and inverter grade; series and parallel operation- Models of Thyristors

Unit III **9hrs**

Current Controlled Transistors: Power BJTs – Construction, static characteristics, switching characteristics; Negative temperature co-efficient and secondary breakdown - comparison of BJT and Thyristor – steady state and dynamic models of BJT.

Unit IV **9hrs**

Voltage Controlled Devices: Power MOSFETs and IGBTs – Principle of voltage controlled devices, construction, types, static and switching characteristics, steady state and dynamic models of MOSFET and IGBTs - Basics of GTO, MCT, RCT and IGCT.

Unit V **8hrs**

Firing And Protecting Circuits : Necessity of isolation, pulse transformer, opto-coupler – Gate drives circuit: SCR, MOSFET, IGBTs and base driving for power BJT. - Over voltage, over current and gate protections; Design of snubbers. Heat transfer – conduction, convection and radiation, Electrical analogy of thermal components- Thermal resistance and impedance, Guidance for heat sink selection –Mounting types.

REFERENCE BOOK:

1. Rashid M.H., “Power Electronics Circuits, Devices and Applications ", Pearson Education, Fourth Edition. 2014.

2. MD Singh and K.B Khanchandani, “Power Electronics”, McGraw Hill, third edition, 2008.

3. Ned Mohan, Undeland and Robbin, "Power Electronics: converters, Application and design" John Wiley and sons, 2003.

4. Philip T. krein, "Elements of Power Electronics", Oxford University Press – second edition, 2016.

5. M.S.Jamil Asghar, "Power Electronics", Prentice Hall of India private Ltd -2011.

6. Joseph Vithayathil, Power Electronics: Principles and Applications, Delhi, McGrawHill, 2010

POWER ELECTRONICS AND SMART GRID

Subject code: **Total Hours: 45**

Credits: 03 **Hours per week: 03**

OBJECTIVES

- Smart Grid technologies, different smart meters and advanced metering infrastructure.
- Power quality management issues in Smart Grid.
- High performance computing techniques for Smart Grid application

OUTCOMES

- Explicate the need of smart grid technology.
- Describe the concept of smart grid technologies
- Exemplify the smart meters and their role
- Analyze the power quality issues in smart grid
- Apply high performance computing for smart grid

Unit I INTRODUCTION TO SMART GRID 9

Evolution of Electric Grid, Concept, Definitions and Need for Smart Grid, Smart grid drivers, functions, opportunities, challenges and benefits, Difference between conventional & Smart Grid, Concept of Resilient &Self Healing Grid, Present development & International policies in Smart Grid, Diverse perspectives from experts and global Smart Grid initiatives.

Unit II SMART GRID TECHNOLOGIES 9

Technology Drivers, Smart energy resources, Smart substations, Substation Automation, Feeder Automation ,Transmission systems: EMS, FACTS and HVDC, Wide area monitoring, Protection and control, Distribution systems: DMS, Volt/VAr control, Fault Detection, Isolation and service restoration, Outage management, High-Efficiency Distribution Transformers, Phase Shifting Transformers, Plug in Hybrid Electric Vehicles (PHEV).

Unit III SMART METERS AND ADVANCED METERING INFRASTRUCTURE 9

Introduction to Smart Meters, Advanced Metering infrastructure (AMI) drivers and benefits, AMI protocols, standards and initiatives, AMI needs in the smart grid, Phasor Measurement Unit(PMU), Intelligent Electronic Devices(IED) & their application for monitoring & protection.

Unit IV POWER QUALITY MANAGEMENT IN SMART GRID 9

Power Quality & EMC in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid, Web based Power Quality monitoring, Power Quality Audit.

Unit V HIGH PERFORMANCE COMPUTING FOR SMART GRID APPLICATIONS 9

Local Area Network (LAN), House Area Network (HAN), Wide Area Network (WAN), Broadband over Power line (BPL), IP based Protocols, Basics of Web Service and CLOUD Computing to make Smart Grids smarter, Cyber Security for Smart Grid

Reference Book:

1. Stuart Borlase "Smart Grid: Infrastructure, Technology and Solutions", CRC Press, 2012.
2. Janaka Ekanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama, "Smart Grid: Technology and Applications", John Wiley & Sons, March 2012.
3. Lars T. Berger and Krzysztof Iniewski, "Smart Grid Applications, Communications, and Security", John Wiley & Sons, March 2012.
4. Vehbi C. Güngör, DilanSahin, TaskinKocak, Salih Ergüt, Concettina Buccella, Carlo Cecati, and Gerhard P. Hancke, "Smart Grid Technologies: Communication Technologies and Standards IEEE Transactions On Industrial Informatics", Vol. 7, No. 4, November 2011.

FLEXIBLE AC TRANSMISSION SYSTEMS

Subject code: **Total Hours: 45**

Credits: 03 **Hours per week: 03**

OBJECTIVES

- To impart knowledge on the basics of compensation techniques used in transmission system.
- To educate the students on the working of voltage source converters.
- To make the students understand the benefits and the applications of FACTS devices.
- To introduce the concept of coordinating various controllers.

OUTCOMES

- Illustrate the effect of series and shunt compensation on power system.
- Demonstrate the use of SVC to mitigate power system problems.
- Demonstrate the use of TCSC to mitigate power system problems.
- Model the FACTS devices for load flow and stability studies.
- Suggest suitable techniques for coordinating various FACTS devices.

Unit I INTRODUCTION 9

Review of basics of power transmission networks-control of power flow in AC transmission line- Analysis of uncompensated AC Transmission line- Passive reactive power compensation: Effect of series and shunt compensation on power transfer capacity- Possible benefits from FACTS controllers- types of FACTS controllers

Unit IISTATIC VAR COMPENSATOR (SVC) 9

Voltage control - voltage control by SVC – Advantages of slope in the SVC dynamic characteristics – Influence of SVC on system voltage - Modeling of SVC for load flow studies- Applications: Transient stability enhancement, Augmentation of Power System damping and Mitigation of SSR

Unit III THYRISTOR CONTROLLED SERIES CAPACITOR (TCSC) 9

Concepts of Controlled Series Compensation – Operation of TCSC - Analysis of TCSC – Modelling of TCSC for load flow studies and stability studies – Brief overview of world’s first

TCSC installation - Applications of TCSC – Enhancement of system damping - SSR mitigation and Operational concept of GCSC

Unit IV VOLTAGE SOURCE CONVERTER BASED FACTS CONTROLLERS 9

STATCOM-: Principle of operation, V-I curve and SSR mitigation application, SSSC – Principle of operation, control system and power flow control application, UPFC- principle of operation, modes of operation and power flow control and oscillation damping application and IPFC-operational concept. Modeling of STATCOM, SSSC, UPFC and IPFC for power flow and stability studies

Unit V CONTROLLERS AND THEIR COORDINATION 9

FACTS Controller interactions – SVC–SVC interaction, SVC-TCSC interaction and TCSC-TCSC interaction - co- ordination of multiple controllers using linear control techniques – Quantitative treatment of control coordination.

Reference Book:

1. Narain G.Hingorani, Laszio. Gyugyl, "Understanding FACTS Concepts and Technology of Flexible AC Transmission System", Standard Publishers, Delhi 2001.
2. Mohan Mathur, R., Rajiv. K. Varma, "Thyristor Based FACTS Controllers for Electrical Transmission Systems",IEEE press and John Wiley & Sons, 2002
3. K.R.Padiyar, "FACTS Controllers in Power Transmission and Distribution", New Age International(P) Ltd.,

Publishers, New Delhi, Reprint 2008,

4. A.T.John, "Flexible AC Transmission System", Institution of Electrical and Electronic Engineers (IEEE), 1999.
5. V.K.Sood, "HVDC and FACTS controllers- Applications of Static Converters in Power System", Kluwer Academic Publisher, 2004.

JAIN DEEMED-TO-BE UNIVERSITY | FACULTY OF ENGINEERING AND TECHNOLOGY

III Semester

SIMULATION AND SOFTWARE TOOLS FOR POWER ELECTRONIC CONVERTERS

COURSE OUTLINE

Subject Code: **Total Hours: 45**

Credits: 03 **Hours per week: 04**

UNIT 1 **10 Hrs.**

Introduction to soft computing, soft computing Vs. hard computing: introduction to soft computing, various types of soft computing techniques, applications of soft computing techniques, Expert system architecture and applications such as Fault diagnosis, P-I control tuning of a drive.

UNIT 2 **7 Hrs.**

Fuzzy Logic-I (Introduction) Basic concepts of fuzzy logic, Fuzzy sets and Crisp sets, Fuzzy set theory and operations, Properties of fuzzy sets, Fuzzy and Crisp relations, Fuzzy to Crisp conversion.

UNIT 3 **10 Hrs.**

Fuzzy Logic –II (Fuzzy Membership, Rules) Membership functions, interference in fuzzy logic, fuzzy if-then rules, Fuzzy implications and Fuzzy algorithms, Fuzzyfications & Defuzzificataions, Fuzzy Controller, Induction Motor Speed control, Speed control system of BLDC Motor.

UNIT 4 **8 Hrs.**

Neural Networks- (Introduction & Architecture) Neuron, Nerve structure and synapse, Artificial Neuron and its model, activation functions, Neural network architecture: single layer and multilayer feed forward networks, recurrent networks. Various learning techniques; perception and convergence rule.

UNIT 5 **10 Hrs.**

Back propagation Neural Networks: perceptron model, solution, single layer artificial neural network, multilayer perception model; back propogation learning methods, effect of learning rule co-efficient ;back propagation algorithm, factors affecting backpropagation training, Neural adaptive P-I DC motor drive controller.

REFERENCE BOOKS

1. S. N. Sivanandam & S. N. Deepa, Principles of Soft Computing, Wiley - India, 2007.

2. S. Rajasekaran & G. A. Vijayalakshmi Pai, Neural Networks, Fuzzy Logic and Genetic Algorithms: Synthesis & Applications, PHI, 2003.

3. V. Kartalopoulos, Understanding Neural Networks and Fuzzy Logic: Basic Concepts and Applications, IEEE Press - PHI, 2004.

4. M. Mitchell, An Introduction to Genetic Algorithms, Prentice-Hall, 1998.

5. D. E. Goldberg, Genetic Algorithms in Search, Optimization, and Machine Learning, Addison-Wesley, 1989.

6. C.D. Manning, P. Raghvan & H. Schutze, "Introduction to Information Retrieval", Cambridge University Press, 2008.

FACULTY OF ENGINEERING AND TECHNOLOGY

OPTIMISATION SYSTEMS FOR POWER ELECTRONICS

COURSE OUTLINE

Subject Code: **Total Hours: 45**

Credits: 03 **Hours per week: 04**

Course Outcomes:

CO1: Formulate and solve LP Problem

CO2: Solve Nonlinear Programming Problems

CO3: Apply search methods to solve constrained and unconstrained optimization Problems.

CO4: Solve optimization problems using evolutionary techniques like Genetic Algorithms and Particle Swarm Optimization.

UNIT I

INTRODUCTION

Introduction to various optimization techniques and their application to power systems and power electronics

UNIT-II

Linear Programming: Introduction and formulation of models, Standard and canonical forms of LPP, assumptions in LPP, simplex method, simplex method using Artificial Variables, duality in L.P., dual simplex method, sensitivity analysis: change in coefficients of objective function.

UNIT-III

Non-linear Programming: Unconstrained problems of Maxima and Minima, Constrained problems of Maxima and Minima: Equality and inequality constraints, Lagrangian Method, Kuhn Tucker conditions. Quadratic programming: Wolfe's Modified simplex method.

UNIT-IV

Dynamic Programming: Solution of linear programming problem, simple problems. One-dimensional search methods: Sequential search, Interval Halving Method, Fibonacci search.

Multi-dimensional search methods: Univariate search, gradient methods- steepest descent / ascent methods, conjugate gradient method: Fletcher – Reeves method, penalty function approach.

UNIT-V

Evolutionary Optimization Techniques: Evolution in Nature-Fundamentals of Evolutionary Algorithms-Working Principles of Genetic Algorithm, Genetic Operators: Selection, Crossover and Mutation, Issues in GA implementation, anatomy of a particleequations based on velocity and positions -PSO topologies - control parameters – GA and PSO algorithms for solving ELD problem.

References:

[1] S.S.Rao, "Engineering Optimization: Theory and Practice", 3rd Ed., New Age International.

[2] D. Sharma, "Operations Research12th edition", Kedar Nath Ram Nath & Co.

[3] Kalyanmoy Deb, "Optimization for Engineering Design: Algorithms and Examples", PHI

[4] Xin-She Yang, "Recent Advances in Swarm Intelligence and Evolutionary Computation", Springer International Publishing, Switzerland.

[5] Kalyanmoy Deb, "Multi-Objective Optimization using Evolutionary Algorithms", John Wiley & Sons.

[6] Rajasekaran S, Pai, G.A. Vijaya Lakshmi., "Neural networks, Fuzzy logic and Genetic Algorihms: Synthesis and Applications", PHI.

Applied Mathematics for Electrical Engineers

Subject Code: **Credits: 03**

Hrs/week: 03 **Total hrs: 45**

Module – I: **9 Hours**

Probability and Statistics: Sampling distributions, Estimation of parameters (point estimation – unbiasedness & minimum variance, basics of interval estimation – confidence interval for mean), Testing of hypotheses (one and two sample tests for mean), Linear regression, Introduction to non-linear regression.

Module II: **9 Hours**

Stochastic process: Random processes, Random walk, Markov process with special emphasis on Markov chain

Module – III: **12 Hours**

Numerical Analysis: Introduction to Interpolation formulae [Bessel's & Sterling's], Roots of transcendental equations [Bisection, Regula-Falsi & Newton-Raphson] Solutions of simultaneous non-linear equations [Newton's method], Numerical solution of Ordinary Differential equation [Modified Euler's method, fourth order Runga-Kutta method], Matrix Eigen value and Eigen vector problems.

Module IV: **8 Hours**

Optimization Technique: Calculus of several variables, Implicit function theorem, Nature of singular points, Necessary and sufficient conditions for optimization, Constrained Optimization, Lagrange multipliers, Gradient method – steepest descent method.

Module V: **7 Hours**

Wavelet Transform: Resolution problems, Multi-resolution analysis, Continuous & discrete wavelet transform

Text books:

1. Kreyzig, 'Advanced Engineering Mathematics'

References:

1. Scarborough, J. B.- Numerical Mathematical Analysis, Oxford University Press
2. Cone, S. D.- Elementary Numerical Analysis, Mc. GrawHill.
3. Mukhopadhyay, P.-Mathematical Statistics, New Central Book Agency
4. Kapoor, V. K and Gupta, S.C.-Fundamental of Mathematical Statistics, Sultan Chand and Sons.
5. Rao, S. S.-Optimization Theory and Application, Wiley Eastern Ltd., New Delhi
6. S. S. Shastri, Numerical Methods
7. J. Medhi, Stochastic Processes
8. Jain & Iyenger, Numerical Analysis
9. Bopardikar & Rao, Wavelet Transform, Wiley

Course Outcome:

1. Outcome: Ability to analyze and solve problems related to digital communication.

2. Outcome: Ability to analyze and solve stochastic engineering & industrial problems

3. Outcome: Ability to optimize & solve real life problems

4. Outcome: Ability to apply in simple real life problems

Pre-requisite: Review of Basic Probability Theory, Basic Under graduate course in probability, Undergraduate Transformation theory

Research Methodology and IPR

Subject Code: **Credits: 03**

Hrs/week: 03 **Total hrs: 45**

Course Outcomes:

At the end of this course, students will be able to

1. Understand research problem formulation.
2. Analyze research related information
3. Follow research ethics
4. Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.
5. Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.
6. Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.

Unit 1: **9 Hours**

Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

Unit 2: 9 Hours

Effective literature studies approaches, analysis Plagiarism , Research ethics, Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

Unit 3: **9 Hours**

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 4: 9 Hours

Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

Unit 5: 9 Hours

New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, PR and IITs.

References:

- Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students'"
- Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction"
- Ranjit Kumar, 2 nd Edition , "Research Methodology: A Step by Step Guide for beginners"
- Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007.
- Mayall , "Industrial Design", McGraw Hill, 1992.
- Niebel , "Product Design", McGraw Hill, 1974.
- Asimov , "Introduction to Design", Prentice Hall, 1962.
- Robert P. Merges, Peter S. Menell, Mark A. Lemley, " Intellectual Property in New Technological Age", 2016
- T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 20

ADVANCED CONTROL THEORY

COURSE OUTLINE

Subject code: **Total Hours: 45**

Credits: 03 **Hours per week: 03**

Unit I 9 Hours

Fields, Vectors, and vector spaces; State space representation, state equations for dynamic systems, solution of state equations; State transition matrix – Properties of state transition matrix; evaluation. Fadeeva algorithm for conversion from state space to transfer function, Linearization of non-linear models

Unit II 9 Hours

Non uniqueness of state model, Similarity transformation, Invariance of system properties. Controllability – necessary and sufficient condition - Pole assignment using State feedback – Ackerman's formula for feedback gain determination; Observability. Duality. Effect of state feedback on controllability and observability. Controllable subspace – decomposition of state into controllable and uncontrollable components.

Unit III 9 Hours

Design of full order observer – Bass Gura algorithm. The separation principle - Combined observer – controller compensator. Design of reduced order observer. Unobservable subspace – decomposition of state into observable and unobservable components – Canonical decomposition theorem.

Unit IV 9 Hours

Reducibility – realization of transfer function matrices. Model decomposition and decoupling by state feedback. Design of robust control system for asymptotic tracking and disturbance rejection using State variable equations. Transfer function interpretations – transfer function form of observer and state estimate feedback. State space interpretation of internal model principle.

Unit V 9 Hours

Discrete time linear state regulator – Algorithm for the solution, Use of observer in implementing the control law. Continuous time linear state regulator – Matrix Riccati equation. Time invariant linear state regulator – the reduced matrix Riccati equation - An iterative method to solve the reduced matrix Riccati equation. Suboptimal linear regulator.

Text Books:

1. Modern Control Engineering, Katsuhiko Ogata, 5th Edition, Prentice Hall India, 1997

2. Modern Control System Theory, M. Gopal, Revised 2nd Edition, New Age International Publishers, 2005.

References:

1. Linear Systems, Thomas Kailath, Perntice Hall, 1980.

2. Control System Design, Graham C. Goodwin, StefanF. Graebe and Mario E. Salgado, Pearson Education, 2000.

3. Linear System Theory and Design, Chi-Tsong Chen, OXFORD University Press.

4. Richard C. Dorf and Robert H. Bishop, Modern Control Systems, 11th Edition, Pearson Edu India, 2009.

POWER CONVERTERS AND CONTROL

COURSE OUTLINE

Subject code: **Total Hours: 45**

Credits: 03 **Hours per week: 03**

Prerequisite:

Power Electronics, Signal Generation, Control Systems.

Course Objective:

1. Analyze Power converters used in various types of Electric Vehicles.
2. Describe the line frequency phase-controlled rectifiers.
3. Describe the line frequency phase-controlled inverters.
4. Analyze the DC – DC converters used in EV applications.
5. Analyze the Switch-Mode dc-ac Inverters.
6. Discuss the Resonant Converters.

UNIT-1 **9 hours**

Application of Power Converter in Different Electric Vehicles:

Battery Electric Vehicles – Architecture of battery electric vehicle, Role of PECs in battery electric vehicle,

Fuel cell electric vehicle – Architecture of Fuel cell electric vehicle, Role of PECs in Fuel cell electric vehicle,

Hybrid electric vehicles (HEVS) – Series hybrid electric vehicle, Parallel hybrid electric vehicle, Series-Parallel hybrid electric vehicle, Role of PECs in Hybrid electric vehicles (HEVS)

Plug-In electric vehicles – Architecture of battery electric vehicle, Role of PECs in battery electric vehicle,

UNIT-2 **9 hours**

Line-Frequency Phase-Controlled Rectifiers and Inverters: Line-Frequency ac - Controlled dc: Introduction, Thyristor Circuits and Their Control, Single-Phase Converters, Three-Phase Converters, Other Three-Phase Converters.

UNIT-3 **9 hours**

dc-dc Switch-Mode Converters: Introduction, Control of dc-de Converters, Step-Down (Buck) Converter, Step-Up (Boost) Converter, Buck-Boost Converter, Cuk dc-dc Converter, Full Bridge dc-dc Converter, dc-dc Converter Comparison.

UNIT-4 **9 hours**

Switch-Mode dc-ac Inverters: dc ~ Sinusoidal ac: Introduction, Basic Concepts of Switch-Mode Inverters, Single-Phase Inverters, Three-Phase Inverters, Effect of Blanking Time on Output Voltage in PWM Inverters, Other Inverter Switching Schemes, Rectifier Mode of Operation.

UNIT-5 **9 hours**

Resonant Converters: Zero-Voltage and/or Zero-Current Switching: Introduction, Classification of Resonant Converters, Basic Resonant Circuit Concepts, Load-Resonant Converters, Resonant-Switch Converters, Zero-Voltage-Switching, Clamped-Voltage Topologies, Resonant-dc-Link Inverters with Zero-Voltage switching, High-Frequency-Link, Integral-Half-Cycle Converters.

<u>Text Books:</u>

1. Pandav Kiran Maroti, Sanjeevikumar Padmanaban, Mahajan Sagar Bhaskar, Vigna K. Ramachandaramurthy, Frede Blaabjerg, “The state-of-the-art of power electronics converters configurations in electric vehicle technologies”, Power Electronic Devices and Components,

Elsevier, Volume 1, 2022.

2. Ned Mohan, T.M. Undeland and William P. Robbins: Power Electronics: Converters, Applications, 3rd Edition, John Wiley & Sons, 2009

Reference Books:

1. Power Electronics-Md.H.Rashid –Pearson Education Third Edition- First IndianReprint-2008
2. Elements of Power Electronics – Philip T. Krein, Oxford University press, 2014

Course Outcomes:

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

CO1: Analyze the Power converters used in various types of Electric Vehicles.

CO2: Describe the line frequency phase-controlled rectifiers.

CO3: Describe the line frequency phase-controlled inverters.

CO4: Analyze the DC – DC converters used in EV applications.

CO5: Analyze the Switch-Mode dc-ac Inverters.

CO6: Discuss the Resonant Converters.

INDUSTRIAL DRIVES

COURSE OUTLINE

Subject Code: **Total Hours :45**

Credits : 03 **Hours per week: 03**

Pre requisites: knowledge of Electrical Machines, mathematical concepts.

Course Objectives:

1. Introduction of basic concepts of Electrical Drives as industrial drives
2. Study the suitability of DC machines for Electrical drives application
3. Understand the suitability of AC machines for Electrical Drives application
4. Explore the control methods used for electrical drives
5. Expose the industrial application of electrical drives

UNIT –1 **9 Hours**

Basics of Industrial Drives: Basic classification and comparison of mechanical and electrical drives, - constituents of an electrical drive, motor-load system, quadrants of operation of a motor load system, Classification of load torque, motor duty classification, calculation of motor rating.

UNIT – 2 **9 Hours**

DC Machines for drives – DC motors and their characteristics –characteristics matching with load requirements - speed control methods in DC motors- Electrical braking in DC motors – recent developments in DC motors for drive applications

UNIT – 3 **9 Hours**

AC Machines for Drives Induction motor types and characteristics –speed control methods - braking in induction motors – synchronous motor drives- speed control methods – braking in synchronous motors - recent developments in ac machines for drive applications.

UNIT – 4 **9 Hours**

Control of Industrial drives – Transition between braking and motoring –closed loop control – current limit control-torque control –speed control- multi-motor drives in closed loop – speed sensing – current sensing –PLL Control – closed loop position control

UNIT – 5 **9 Hours**

Industrial application of Drives - Selection of drives for paper mill, cement mill, sugar mill, steel mill, Hoists and cranes, drives for pumping in reverse osmosis plant – drives for industrial compressors solar powered pump drives, drive system for electrical vehicles – recent advances in AC and DC drives for industrial applications

Text Books:

1. , Gopal K Dubey, "Fundamentals of Electrical Drives",Narosa Publishing House, 2020, ISBN: 978-81-7319-428-3

2. Pillai.S.K "A First Course on Electric Drives", Wiley Eastern Limited, 2012 , ISBN: 978-04-7021-399-5

3. M A Elsharkawi, Fundamentals of Electrical Drives, Thomson Learning, 2000

Reference Books:

1. Nagrath .I.J. & Kothari .D.P, "Electrical Machines", Tata McGraw-Hill, 2006
2. Partab. H., "Art and Science and Utilisation of Electrical Energy", DhanpatRai and Sons, 2017
3. S A Nasar, Boldea. Electrical Drives, Second edition CRC Press, 2006.

Course Outcomes:

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

CO1: Compare and classify electrical drives and determine the ratings based on loads

CO2: Understand the necessity of DC motors for drive applications.

CO3: Use of AC motors in Drive applications

CO4: Appraise the various types of control methodology used in Electrical Drives

CO5: Select drives for various industrial applications

CO6: Describe the recent improvements in electrical drives as industrial drives

ELECTRICAL SIMULATION LABORATORY

COURSE OUTLINE

Sub Code: **Hours per Week: 03**

Credit: 01

Course objectives:

- To explain the use of MATLAB package to obtain the power angle characteristics of salient and non- salient pole alternator.
- To explain the use of MATLAB package to study transient stability of radial power systems under three phase fault conditions.
- To explain the use of MATLAB package to perform fault studies for simple radial power systems.

List of Experiments:

Use of MATLAB package

1. Determination of Power Angle Diagrams, Reluctance Power, Excitation, Emf and Regulation for Salient and Non-Salient Pole Synchronous Machines.
2. To obtain Swing Curve and to Determine Critical Clearing Time, Regulation, Inertia Constant/Line Parameters /Fault Location/Clearing Time/Pre-Fault Electrical Output for a Single Machine connected to Infinite Bus through a Pair of identical Transmission Lines Under 3-Phase Fault on One of the two Lines.
3. To Determine Fault Currents and Voltages in a Single Transmission Line System with Star-Delta Transformers at a Specified Location for LG and LLG faults by simulation.
4. Y Bus Formation for Power Systems with and without Mutual Coupling, by Singular Transformation and Inspection Method.
5. Simulation of Three-Phase Two-Level PWM Converters.
6. Simulation of AC/DC Three Level PWM Converters.
7. Simulation of Three-Phase Three Level PWM Converters.
8. Power flow study on a given power system network using Gauss – Siedal method for 5 bus system, IEEE 14 bus system and IEEE 30 bus system.

9. A Simulink model for a single area load frequency problem and simulate with and without controller.
10. Performance of solar photovoltaic Maximum Power Point Tracking based on Perturbation & Observation algorithm and charge lead acid battery using three stage charging algorithms.
11. Performance of photovoltaic panel Maximum Power Point Tracking based on Particle Swarm Optimization algorithm.
12. Dynamic PSO MPPT PV under Partial shading conditions with DC-DC boost converter.

COMPUTER INTEGRATED MANUFACTURING SYSTEM

Course Code :

Credits 04

Module-1 Introduction to Computer integrated Manufacturing Systems 9 hour

Manufacturing Systems, Types of Manufacturing Systems, , Machine Tools and related equipment‟s, Material Handling Systems, Computer monitoring and control, Manufacturing support systems, The Product Cycle and CAD/CAM, Functions of computers in CIMS: CIMS Data Files, System Reports, Benefits of Computer integrated Manufacturing Systems. Fundamentals of Numerical Control: Basic concepts of NC, Classification of NC- Point to Point and contouring, Incremental and absolute system, Open loop and closed loop system, Advantages of NC.

Module-2 NC/ CNC Machine Tools 9 hour

General architecture of CNC Machine, Components of the CNC Systems: Machine Control Unit, CNC Driving system components: Hydraulic, Servo Motors, Stepper Motors, Feedback Devices: Encoder, Resolver, Inductosyn, Tachometers, Counting devices.

Module-3 Constructional Features of CNC Machines 9 hour

Design considerations of CNC machines for improving machining accuracy, Structural Members, Slide ways, bearings, Re-circulating ball Screws, Spindle drives, Work holding devices and tool holding devices, Automatic tool changers.

Module-4 N.C Part Programming 9 hour

Introduction, NC/ CNC programming methods: Manual part programming for turning and milling centers, G codes, M codes, canned cycles, Programming with CAD/CAM integration, CAM packages for CNC part program generation, Practical Exercises on CNC part programming. Computer Controls in NC: CNC Technology: Functions of CNC Control in Machine Tools, Advantages of CNC, Direct Numerical Control (DNC Systems): Configuration of DNC system, Functions of DNC, Communication between DNC computer & MCU, Advantages of DNC.

Module-5 Adaptive Control machining systems 9 hour

. Adaptive control optimization system, adaptive control constraint system, applications to machining processes, Benefits of Adaptive control Machining. Computerized Manufacturing Planning and Control Systems: Computer aided process planning, Variant and Generative approaches, Computer integrated production planning and control systems, Typical production planning and control system, Material planning systems, Capacity planning, Shop Floor Control, Automatic identification, Automated data collection systems.

Textbook/ Textbooks

(1) Groover, M. P. and Zimmers, E. W., CAD/CAM:Computer Aided Design & Manufacturing, 2006, Pearson Education India

(2) Mikell P. Groover and Emory W. Zimmer, Jr., CAD/CAM Computer Aided Design and Manufacturing, Prentice Hall India (P) Ltd, 1992.

(3) M. Koren―Computer Controls of Manufacturing Systems, McGrawHill, 1983

Reference Books

(1) Martin J. ―Numerical control of machine tools".

(2) P.N. Rao – CAD/CAM Principles and Applications McGrawhill 2002

(3) Y. Koren&J.Benuri -"Numerical control of machine to ols -Khanna, 1992

(4) Hood-Daniel P., and Kelly J.F., Build Your Own CNC Machine, 2009, Springer-Verlag New York

Course Outcomes:

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

CO1: Apply the concepts of machining for the purpose of selection of appropriate machining centers, machining parameters

CO2: Create and demonstrate the technical documentation for design/ selection of suitable drive technologies, precision components and an overall CNC machine tool system for automation of machining operations

CO3: Part model/ part drawings using Computer Aided Manufacturing technology through programming, setup, and ensuring safe operation of Computer Numerical Control (CNC) machine tools.

CO4: Create and validate NC part program data using manual data input (MDI) and automatically using standard commercial CAM package for manufacturing of required component.

CO5: Design automated material handling and storage systems for a typical production system and control the process

Sensors Applications in Manufacturing

Sub Code: CIE: 50%

Marks Hrs/Week: 03 Marks SEE Hrs: 3Hrs

Course Content

Module I Fundamentals of Sensors and Transducers 9 hours

Performance terminology, static and dynamic characteristics of transducers, classification of sensors and transducers, signal processing and signal conditioning. Operational amplifiers, filters, protection devices, analog to digital converter, digital to analog converter. Sensors and their applications: Inductive, capacitive, magnetic, various types of photo sensors, detection methods, through-beam detection, reflex detection & proximity detection, ultrasonic and microwave sensors. Applications and understanding of the above sensors, limit switches , multiplexers and data acquisition systems.

Module II: Advanced Sensor Technologies 9 hours

Laser production, characteristics of lasers, types of laser sensors, bar code sensors, benefits of bar coding, transponder, RFID (Radio Frequency Identification), electromagnetic identifier, optical encoders ,.color sensors, sensing principles, color theory, unit color measurement, color comparator, color sensing algorithm, fuzzy logic color sensor, fuzzy logic for optoelectronic color sensor in manufacturing. Advantages and disadvantages of optical encoders.

Module III: Flexible Manufacturing Systems 8 hours

Introduction of FMS, types , sensors used in FMS, integration sensorsVision sensors(image capturing, image transformations and analysis), detecting partially visible objects, overlap and defects using vision sensors. Edge detection and extraction.

Module IV Sensors for Special Applications 10 hours

Cryogenic manufacturing applications, semiconductor absorption sensors, semiconductor temperature detector using photoluminescence temperature detectors using pointcontact, sensors in process manufacturing plants, measurement of high temperature, robot control through sensors, other sensors(predictive monitoring serving the CIM strategy, optical sensor quantifying acidity of solution, reflective strip imaging camera sensor, ultrasonic stress sensor for measuring dynamic changes in materials, acousto optical synthetic aperture radar, sensors for vibration measurement of structures), collection and generation of process signals in decentralized manufacturing system. SLE: Non-contact Sensors (pyrometers) multi sensor applications

Module V: Networking 9 hours

Networking of sensors, control of manufacturing process- tracking- the mean time between operations interventions, tracking the yield , mean process time, detection of machining faults, diagnostic systems, resonance vibration analyzer, sensing motor current for signature analysis, temperature sensing(RTD, thermocouple).

Text Books

1. Sabnesoloman, sensors & control systems in manufacturing. Mc-Graw Hill book Company Network, 1994.

2. Mechatronics by W.Bolton,

References

1. Sensor Technology Handbook by Jon S. Wilson

2. N.L.Buck&T.G.Buckwith, Mechanical measurement.

3. Sensors and Transducers by Ian Sinclair

Course outcome:

After the successful completion of this course, the student will be able to:

1. Explain various signal condition devices used in electronic devises and use of appropriatemethod in signal conditions in various applications.

2. Describe impact of an RFID system on manufacturing, defense, distribution, retail and health sectors &abstract ("filter") information in RFID.

3. Summaries the future advances to the quality and integrity of manufacturing and related sectors resulting from the use of RFID and other sensor technologies

4. Analyze and choose appropriate sensors in different industrial applications

Robotics for Industrial Automation

Sub Code: Hrs/Week: 04

SEE Hrs: 3Hrs Max.Marks:100

Course Content

Module I: Introduction **9 hours**

Definitions, Types of Robots, Application of Robots, Representing Position and Orientation, Representing Pose in 2-Dimensions, Representing Pose in 3-Dimensions, Representing Orientation in 3-Dimensions, Combining Translation and Orientation. Matlab program for translation and orientation

Module II: Time and Motion **9 hours**

Trajectories, Smooth One-Dimensional Trajectories, Multi-Dimensional Case, Multi-Segment Trajectories, Interpolation of Orientation in 3D, Cartesian Motion, Time Varying Coordinate Frames, Rotating Coordinate Frame, Incremental Motion, Inertial Navigation Systems. Mobile Robot Vehicles, Mobility, Car-like Mobile Robots, Moving to a Point, Following a Line, Following a Path, Moving to a Pose. Flying Robots

Module III: Navigation **9 hours**

Reactive Navigation, Braitenberg Vehicles, Simple Automata, Map-Based Planning, Distance Transform, Voronoi Roadmap Method, Probabilistic Roadmap Method, Localization, Dead Reckoning, Modeling the Vehicle, Estimating Pose, Using a Map, Creating a Map, Localization and Mapping, Monte-Carlo Localization. Matlab programming of localization

Module- IV Robot Arm Kinematics **9 hours**

Describing a Robot Arm, Forward Kinematics, A 2-Link Robot, A 6- Axis Robot, Inverse Kinematics, Closed-Form Solution, Numerical Solution, Under-Actuated Manipulator, Redundant Manipulator, Trajectories, Joint-Space Motion, Cartesian Motion, Motion through a Singularity.

Module- V Robot Programming

Using Sensors and Actuators with ROS, SCORBOT structure, joint movements, work envelop, motors, encoders, microswitch, transmission, gripper, SCORBOT programming, IS-14533 : 2005 Manipulating industrial robots - Performance criteria related test methods, Mobile Robot Programming, Industrial Robot Programming

Text Books

1. Robotics, Vision and Control: Fundamental Algorithms in MATLAB® - Peter Corke, Springer Tracts in Advanced Robotics, Volume 73, 2011

2. Learning ROS for Robotics Programming - Aaron Martinez & Enrique Fernández, Packt Publishing, September 2013

References

1. Robotics for Engineers -YoramKoren, McGraw Hill International, 1st edition, 1985.

2. Industrial Robotics-Groover, Weiss, Nagel, McGraw Hill International, 2nd edition, 2012.

3. Robotics, control vision and intelligence-Fu, Lee and Gonzalez. McGraw Hill International, 2nd edition, 2007.

4. Introduction to Robotics- John J. Craig, Addison Wesley Publishing, 3rd edition, 2010

Course Outcome

1. Explain 3D translation and orientation representation & illustrate the robot arm kinematics and use of Robot Operating System usage.

2. Design / simulate a robot which meets kinematic requirements.

3. Apply localization and mapping aspects of mobile robotics.

4. To understand robot programming.

5. Apply the Programing skills to develop Industrial robots using Sensors and Actuators.

Artificial Intelligence and Expert System in Automation

Sub Code: Hrs/Week: 04

SEE Hrs: 3Hrs Max.Marks:100

Course content

Module-1 **9 hours**

Introduction: artificial intelligence in cad, applications of artificial intelligence in design. Scope and history of AI. Structure of an expert system, building an expert system. Strategies for knowledge acquisition, components of knowledge. Knowledge representation, production systems, decision tables, frame systems.

Module-2 **9 hours**

Knowledge Representations: knowledge representations process, purposes, contexts and agents, knowledge soup, knowledge acquisition and sharing. Knowledge representation languages, issues in knowledge representation. A network representation language. LISP: Introduction to LISP. Search strategies in LISP, a recursive unification function. Interpreters and embedded languages. Logic programming in LISP. An expert system shell in LISP.

Module-3 **9 hours**

Decision Support Systems: introduction. Basis of decision making. Typical progressive models. Intelligent models, life-cycle values. Total life-cycle cost. Compatibility analysis. Sensitivity analysis. Life-cycle ranking or rating scheme.

Module-4 **9 hours**

Learning Processes and AI Algorithms: the general problem solver and difference tables. Resolution theorem proving. Machine learning, perceptron learning, back propagation learning, and competitive learning. The genetic algorithm: the genetic programming. Artificial life and society based learning. Methods of inference, inexact reasoning.

Module-5 **9 hours**

Knowledge Based Design Aids: inference process, backward chaining, forward chaining, hybrid chaining. Expert system shells, feature based modeling, feature recognition, design by features, and application of feature based models. Design of expert systems and applications: benefits and examples of expert systems. Design of expert systems, introduction to clips, pattern matching, modular design and execution control fuzzy logic, typical expert system MYCIN, DENDRAL, PROSPECTOR.

Textbook/ Textbooks

(1) A guide to Expert Systems – Donald A Waterman, Addison Wesley, 1st edition, 2002.
(2) Principles of Artificial Intelligence – Springer-Verlag, Berlin, 1982.
(3) Introduction to Artificial Intelligence and Expert Systems – DAN.W.Patterson, PHI, 2nd edition, 2009.

Reference Books

(1) Understanding Decision Support System and Expert Systems-McGraw Hill, 2nd edition, 1993.
(2) Artificial Intelligence – Elain Rich, McGraw Hill, 3rd edition, 2010.
(3) Artificial Intelligence- George.F.Luger, Pearson Education, Asia, 3rd Edition,2009.

Course outcomes:

CO1: Understand problem solving methods, state space problems and search methods.
CO2: Understand knowledge acquisition and representation methods.
CO3: Apply knowledge on decision making.
CO4: Assess critically the techniques presented and apply them to real world problems.
CO5: Develop knowledge of decision making and learning methods

Modeling, simulation and analysis of Manufacturing Systems.

Sub Code: Hrs/Week: 04

SEE Hrs: 3Hrs Max.Marks:100

Course content

Module I **9 hours**

Principles of Modeling & Simulation: Basic Simulation Modeling, When simulation is appropriate, When simulation is not appropriate, Advantages and disadvantages and pit falls of Simulation, Monte - Carlo Simulation, Areas of Applications, Discrete and Continuous Systems, Modeling of a system, Types of Models, Discrete event simulation.

Module II **9 hours**

Modeling Approaches: List processing in simulation, Simple simulation language, Single server queuing systems, Time shared computer model, Multiteller banking with jockeying, Job shop model.

Module III **9 hours**

Random Number Generation : Basic Probability and Statistics-Random variables and their properties, Properties of random numbers, generation of Pseudo random numbers, techniques for generating random numbers, Various tests for random numbers-frequency test, and test for Autocorrelation.

Module IV **9 hours**

Random Variate Generation: Introduction, different techniques to generate random variate: Inverse transform technique,-exponential, Normal, uniform, acceptance rejection techniquesPoisson distribution. Output Data Analysis for a single system: Types of simulation with respect to output analysis, transient and steady state behavior of a stochastic process.

Module V **9 hours**

Statistical Techniques: Comparison of two system design, Comparison of several system design – Bonferroni approaches to multiple comparisons for selecting best fit, for screening, Variance reduction Techniques such as simple linear regression, multiple linear regression. Simulation Studies: Simulation of Inventory Problems, Discrete Event Simulation problems

Text Books:

1. Simulation, Modeling and Analysis –Averill Law & David M.Kelton, TMH, 4th Edition, 2007.

2. Discrete event and Simulation Systems – Banks & Carson, Prentice Hall Inc, 4th edition, 2011.

Reference Books:

1. System Simulation- Gordon, PHI, 2nd edition, 2009

2. Probability and statistics for engineers – Richard A. Johnson, Prentice hall, 7th edition, 2006.

Course Outcome:

After the successful completion of this course, the student will be able to:
1. Describe and explain model and analyze typical queuing scenarios
2. Develop and apply appropriate random number, random variable generation techniques &appropriate simulation statistical output techniques
3. Analyze appropriate input distributions and to explain simulation time advance mechanisms. Use the Arena simulation language to model and analyze problems found in industrial engineering practice and to design and analyze a simulation experiment.
4. Comparisons of systems and optimization techniques.

Computer Vision and Image Processing

Sub Code: Hrs/Week: 04

SEE Hrs: 3Hrs Max.Marks:100

Course Content

Module I: 9 hours

Introduction: Computer Vision,Brief History, Image formation, Geometric primitives and transformations, Geometric primitives, 2D transformation, 3D transformation, 3D rotation, 3D to 2D projection, Lens distortion, Photometric image formation, Lighting, the digital camera, sampling and aliasing, color.

Module II: 9 hours

Image processing: Point operators, Pixel transforms, color transforms, compositing and matting, histogram equalization, Linear filtering, separable filtering, examples of linear filtering, band pass and steerable filter, More neighborhood operators , non -linear filtering, morphology, distance transform, Fourier transforms , Fourier transform pairs, two dimensional Fourier transforms, wiener filtering, Geometric transformations , parametric transformation, mesh based warping, Global optimization, regularization, Markov random fields.

Module III: 9 hours

Feature detection and matching : Points and patches , Feature detectors , Feature descriptors, Feature matching , Feature tracking , Edge detection , Edge linking , Lines, Successive approximation, Hough transforms, Vanishing points

Module IV: 9 hours

Segmentation: Active contours , snakes, dynamic snake and condensation, scissors, level sets, Split and merge , watershed, region splitting, region merging, graph based segmentation, probabilistic aggregation, Mean shift and mode finding , K-means and mixtures of Gaussians , mean shift, Normalized cuts , Graph cuts and energybased methods

Module V: 9 hours

Stereo correspondence: Epipolar geometry, rectification , plane sweep, Sparse correspondence , 3D profiles and curves, Dense correspondence , similarity measures, Local methods , sub – pixel estimation and uncertainty, Global optimization, dynamic programming, segmentation based techniques, Multi-view stereo.

Text Books:

1. Computer Vision: Algorithms and Applications, Richard Szeliski , 2010 Springer.

Reference Books:

1. ComputerVision - A modern approach by D. Forsyth and J. Ponce, Prentice Hall
2. Robot Vision by B. K. P. Horn, McGraw-Hill.

Course Outcomes:

After the successful completion of this course, the student will be able to:

1. Understand the applications of computer vision in automation
2. Describe image processing techniques, feature detection and matching techniques.
3. Describe image segmentation and stereo correspondence techniques.
4. Demonstrate the use of multi view stereo.

Finite Element Analysis

Sub Code: Hrs/Week: 04

SEE Hrs: 3Hrs Max.Marks:100

Course Content

Module I: 9 hours

Calculus of Variation: Introduction to Calculus of Variations, Introduction to Equilibrium Equations in Elasticity, Euler's Langrange's Equations, Principal of Virtual Work, Virtual Displacements, Principles of Minimum Potential Energy, Boundary Value, Initial Value Problems, Flexibility Approach, Different Problems in Structural Analysis.

Module II: 9 hours

FEM Procedure: Derivation of FEM Equations by Variation Principle Polynomials, Concept of Shape Functions, and Derivation for Linear Simplex Element, Interpolation Polynomials in Global and Local Coordinates. Need for Integral Forms

Module III: 9 hours

Weighted Residual Methods: Concept of Weighted Residual Method, Derivation of FEMEquations by Galerkin's Method, Solving Cantilever Beam Problem by Galerkin's Approach, Derivation of Shape Functions for CST Triangular Elements, Shape Functions for Rectangular Elements, Shape Functions for Quadrilateral Elements. Higher Order Elements: Concept of Iso-Parametric Elements, Concept of Sub-Parametric andSuper –Parametric Elements.

Module IV: 9 hours

Numerical Integration: Numerical Integration, One Point Formula and Two Point Formula for2D,Different Problems of Numerical Integration Evaluation of Element Stiffness Matrix, Automatic Mesh Generation Schemes.

Module V: 9 hours

Pascal's Triangle Law For 2D Shape Functions Polynomial, Pascal's Triangle Law for 3DShape Function Polynomials, Shape Function for Beam Elements, Hermitian Shape Functions. Convergence: Convergence Criteria, Compatibility Requirements, Geometric Isotropy Invariance, Shape Functions for Iso-Parametric Elements, , Direct Method for Deriving Shape Functions using Langrage's Formula, Plane Stress Problems

Text Books:

1.Finite Element Procedure- Bathe, PHI (EEE), 1st edition, 2009.
2.Finite Elements in Engineering – Chandrupatla, and Belagundu, Prentice Hall of India Pvt. Ltd., New Delhi, 3rd edition, 2009.

References:

1. The Finite Element Method – O. C. Zienkiewicz, R. L. Taylor. , TMHl, New Delhi, 5th edition, 2009
2. Concepts and Applications of Finite Element Analysis:- Cook.D Robert, Malus.S.David, Plesha E. Michel , John Wilely& sons 3rdEdn., New York, 2000
3. Finite Element Analysis – C.S.Krishnamoorthy, TMH, New Delhi, 1995

MECHATRONICS AND APPLICATIONS

Sub Code: CIE: 50%

Marks Hrs/Week: 03 Marks SEE Hrs: 3Hrs

Module I **9 Hours**

Mechatronics systems, elements, levels of mechatronics system, Mechatronics design process, system, measurement systems, control systems, microprocessor-based controllers, advantages and disadvantages of mechatronics systems. Sensors and transducers, types, displacement, position, proximity, temperature and light sensors.

Module II **9 Hours**

Introduction to Micro Controllers: Introduction, Comparing Microprocessors and Micro Controllers, Z-80, 8051, PIC Micro Controllers, PIC Development Tools. The Micro Controller Survey, 4Bit, 8Bit, 16Bit and 32 Bit Micro Controllers. Develop Systems for Micro Controllers. Micro Controllers Architecture: 8051 Architecture, PIC Architecture, 8051 Micro Controller Hardware, Input/ Output Pins, Ports and Circuits, External Memory, Counter and Timers, Serial Data Input/Output, (SLE: Interrupts).

Module III **10 Hours**

Basic Assembly Language Programming Concepts in Micro Controllers: The Mechanics of Programming, the Assembly Language Programming Process, PAL Instructions, Programming Tools and Techniques. Addressing Modes, Data Exchanges, Code Memory Read-Only Data Moves, Push Pop Op Codes, Logical Operators, Arithmetic Operators, Jump and Call Instructions. (SLE: Programming Concepts for 8051 and PIC.) Micro Controller Applications: Introduction, Key Boards, Displays, Pulse Measurement, D/A and A/D Conversions, Multiple Interrupts. (SLE: Programming the 8255).

Module IV **9 Hours**

Input/output Systems: Interfacing, Input/output Addressing, Interface Requirements. Communication Systems: Digital Communications, Centralised, Hierarchical and Distributed Control, Networks, Protocols, Open System Interconnection Communication Model, Serial Communication Interfaces, Parallel Communication Interfaces, Wireless Protocols

Module V **8 Hours**

Mechatronics System design: Mechatronics Designs, Timed Switch, Windscreen-wiper Motion, Case Studies: Car Park Barriers, Digital Camera, Car Engine Management, Bar Code Reader, Hard Disk Drive

Course Outcomes:

At the end of the course the student will be able to:
CO1: Identify and explain the architectures of 8085 and 8086 microprocessors. Describe the concept of segmentation
CO2: Interfacing with respect to memory and I/O. Discuss the application examples of stepper motor.
CO3: Understand the concept of Microcontroller and microprocessor and PIC architectures and core concepts
CO4: Discuss about various assembly programming mechanics and explain various instructions used for Microcontroller assembly programing.
CO5: Integrate mechanical, electronics, control and computer engineering in the design of mechatronics systems
CO6: Design, building, interfacing and actuation of a mechatronic system for a set of specifications.

Industry 4.0

Course Learning Objectives

1. This course is designed to offer learners an introduction to Industry 4.0 and its applications.
2. Learners will gain deep insights into how smartness is being harnessed from data.
3. Learners will understand what needs to be done in order to overcome the challenges.
4. To familiarize in Industry 4.0 in healthcare services.

Course Content

Module 1

Introduction to Industry 4.0- The Various Industrial Revolutions, Digitalization and the Networked Economy, Drivers, Enablers, Compelling Forces and Challenges for Industry 4.0, Comparison of Industry 4.0 Factory and Today's Factory, Trends of Industrial Big Data and Predictive Analytics for Smart Business Transformation

Module 2

Internet of Things (IoT) & Industrial Internet of Things (IIoT) & Internet of Services, Smart Manufacturing, Smart Devices and Products, Smart Logistics, Smart Cities, Predictive Analytics.

Module 3

Technologies for enabling Industry 4.0 - Cyber Physical Systems, Robotic Automation and Collaborative Robots, Support System for Industry 4.0, Mobile Computing, Cyber Security.

Module 4

3D printing technologies, selection of material and equipment, develop a product using 3D printing in Industry 4.0 environment. IIoT case studies, Industry 4.0 in healthcare services, Strategies for competing in an Industry 4.0 world.

Module 5

Obstacles and Framework Conditions for Industry 4.0

Lack of A Digital Strategy alongside Resource Scarcity, Lack of standards and poor data security, Financing conditions, availability of skilled workers, comprehensive broadband infra- structure, state support, legal framework, protection of corporate data, liability, handling personal data.

Text Books

1. Alasdair Gilchrist, “Industry 4.0: The Industrial Internet of Things”, Apress, 2016.
2. Lan Gibson, David W. Rosen and Brent Stucker, “Additive Manufacturing Technologies Rapid Prototyping to Direct Digital Manufacturing”, Springer, 2010.

Reference Books

1. Andreas Gebhardt, “Understanding Additive Manufacturing: Rapid Prototyping, Rapid Tooling, Rapid Manufacturing”, Hanser Publisher, 2011.

2. J. Chanchaichujit, A.Tan, Meng, F., Eaimkhong, S. "Healthcare 4.0 Next Generation Processes with the Latest Technologies", Palgrave Pivot, 2019.

Course Outcomes

On completion of this course, the students will be able to

1. understand the drivers and enablers of Industry 4.0.
2. appreciate the smartness in Smart Factories, Smart cities, smart products and smart services.
3. outline the various systems used in a manufacturing plant and their role in an Industry 4.0 world.
4. outlines a strategic framework to exploit new technologies to enable Healthcare 4.0.

FLUID POWER AUTOMATION

Sub Code: CIE: 50%

Marks Hrs/Week: 03 Marks SEE Hrs: 3Hrs

Course Content

MODULE 1 **9 hours**

Fluid Power Generating/Utilizing Elements: Hydraulic pumps and motor gears, vane, piston pumps-motors-selection and specification-drive characteristics-Linear actuator- Types, mounting details, cushioning-power packs-construction, reservoir capacity, heat dissipation, accumulators standard circuit symbols, circuit (flow) analysis.

Control and regulation elements: Direction flow and pressure control valves-method of actuation, types, sizing of ports-pressure and temperature compensation, overlapped and under lapped spool valves

MODULE 2 **9 hours**

Comparison of Hydraulics and Pneumatics: need for Automation, Hydraulic and Pneumatic comparison-ISO symbols for fluid power elements, Hydraulic, pneumatics- Selection criteria and examples related to selection criteria. Advanced Hydraulics: Types of proportional control devices-pressure relief, flow control, directional control, Hydraulic symbols, Spool configurations, solenoid design, comparison between conventional and proportional valves.

MODULE 3 **9 hours**

Method of control : Comparison between analogue and digital control, Proportional attributes, Ramp, Gain, dead band, Dither, Pulse width modulation, Amplifier cards, Principles of operation, Design and application, Analogue and digital, Closed loop, Internal and external feedback devices, Operation and application of closed loop system, Integrated electronics option frequency Response, Principles of operation, Bode diagrams and their use in manufacturer's data, PID control.

MODULE 4 **9 hours**

Electrical Control of Fluid power: Electrical control of Hydraulics and Pneumatics, use of relays, Timers, counters, PLC ladder diagram for various circuits, motion controllers, use of field busses in circuits, Electronic circuits for various open loop control and closed loop (Servo) control of Hydraulics and Pneumatics.

Circuit Design: Typical industrial hydraulic circuit design methodology- Ladder diagram- sequencing circuits- combinational and logic circuits.

MODULE 5 **9 hours**

Application of Propositional and Servo Valves : Velocity control, Position control and Directional control and applications example: paper industry, process industry, printing sawmill, wood working, extrusion press, power metallurgical press, continuous casting, Food and packaging, Injection moulding, Solar energy and automobile

Course outcomes:

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

CO1: Analyze and identify the functional requirements of a fluid power.

CO2: Identify the various applications of fluid power

CO3: Differentiate between fluid power and transport systems.

CO4: Apply concept of fluid power for the industrial applications of fluid power

CO5: Analyze and design hydraulic and pneumatic circuits

Textbook/ Textbooks

(1) Pnematic System, S.R.Majumdar,TMH, 1995

(2) Fluid Power Systems and Control, Antony Esposito, Prentice Hall,1998

(3) Hydraulic and Pneumatics control, R.Srinivasan, Vijay Nicole Imprints Private Ltd.

(4) Hydraulic and Pneumatics, Andrew Parr, Butterworth-Heinemann

Reference Books

(1) Hydraulic control systems, Herbert R Merritt, John Wiely& Sons, Newyork,1967.

(2) Basic fluid power, Dudbey A Peace, Prentice hall Inc,1967.

(3) Fluid power logic circuit design, Peter Rohner,Macmillan press Ltd, London,1979.

(4) Fluid Power logic circuit design, Peter Rohner, Mcmelan prem,1994.

Automotive Electronics

Sub Code: CIE: 70%

Marks Hrs/Week: 03 Marks SEE Hrs: 3Hrs

Course Content

MODULE 1 **9 hours**

Automotive fundamentals overview – four stroke cycle, engine control, ignition system, spark plug, spark pulse generation, ignition timing, drive train, transmission, brakes, steering system, starting system. Actuators – fuel metering actuators, fuel injector, ignition actuator.

Exhaust After – Treatment System –AIR, catalytic converter, exhaust gas recirculation n (EGR), Evaporative emission systems

MODULE 2 **9 hours**

Air/ fuel system – fuel handling, air intake system, air/ fuel management Sensors: Oxygen (02/EGO) sensors, throttle position sensor (TPS), engine crankshaft angular position (CKP)sensor, magnetic reluctance position sensor, engine speed sensor, ignition timing sensor, hall effect position sensor, shield field sensor, optical crankshaft position sensor, manifold absolute pressure(MAP) sensor-strain gauge and capacitor capsule, Engine coolant temperature(ECT) sensor, intake air temperature (AIT) sensor, knock sensor, airflow rate sensor, throttle angle sensor

MODULE 3 **9 hours**

Electronic Engine Control – engine parameters, variables, engine performance terms, electronic fuel control system, electronic ignition control, idle speed control, EGR control. Vehicle motion control – cruise control, chassis, power brakes, antilock brake system (ABS), electronic steering control, power steering, traction control, electronically controlled suspension

MODULE 4 **9 hours**

Communication-serial data, communication systems, protection, body and chassis electrical systems, remote keyless entry, GPS Automotive Instrumentation– sampling, measurement & signal conversion of various parameters. Radar warning system, low tire pressure warning system, radio navigation, advance driver information system.

MODULE 5 **9 hours**

Integrated body- climate control systems, electronic HVAC system, Safety systems- SIR, interior safety, lighting, entertainment systems. Automotive diagnostics – Timing light, engine analyzer, on-board diagnostic off- board diagnostics, expert systems.

Course outcomes:

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

CO1: Obtain an overview of automotive components, subsystems, design cycles, communication protocols and safety systems employed in today's automotive industry.

CO2: Differentiate electronic and mechanical components used in automobile systems

CO3: Apply concept of integration of system components

CO4: Analyze and measure signal conversion parameters

CO5: Obtain an overview of automotive diagnostics

Textbook/ Textbooks

(1) "Automobile Electrical and Electronic Systems" Tom Denton, Routledge,5 edition,2017.

Reference Books

(1) understanding automotive electronics, Willian b. Ribbens, SAMS/Elsevier publishing 6th edition,2002 (2) Automotive electrics automotive electronics systems and components, Robert Bosch Gmbh, john wiley & sons ltd., 5th sedition, 2007

Product Design and Development

Sub Code: IAR2C02 CIE: 70%

Marks Hrs/Week: 03 Marks SEE Hrs: 3Hrs

Course Content

Module I **9 hours**

Introduction: Characteristics of successful product development, Design and development of products, duration and cost of product development, the challenges of product development. Development Processes and Organizations: A generic development process, concept development: the front-end process, adopting the generic product development process, product development organizations.

Module II **9 hours**

Product Planning: The product planning process, identify opportunities. Evaluate and prioritize projects, allocate resources and plan timing, complete pre project planning, reflect all the results and the process. Identifying Customer Needs: Gather raw data from customers, interpret raw data in terms of customer needs, organize the needs into a hierarchy, establish the relative importance of the needs and reflect on the results and the process

Module III **9 hours**

Concept Generation: The activities of concept generation clarify the problem, search externally, search internally, explore systematically, and reflect on the results and the process. Concept Selection: Overview of methodology, concept screening, and concept scoring. Pugh Selection for one problem solution

Module IV **9 hours**

Concept Testing: Define the purpose of concept test, choose a survey population, choose a survey format, communicate the concept, measure customer response, interpret the result, reflect on the results and the process. Product Architecture: What is product architecture, implications of the architecture, establishing the architecture, variety and supply chain considerations, platform planning, related system level design issues

Module V **9 hours**

Design for Manufacturing: Definition, estimation of manufacturing cost, reducing the cost of components, assembly, supporting production, impact of DFM on other factors. Prototyping: Prototyping basics, principles of prototyping, technologies, planning for prototypes. Industrial design: Importance of industrial design, industrial design process, assessing the quality of industrial design.

Text books:

1. Product Design and Development- Karl.T.Ulrich, Steven D Eppinger, Irwin McGrawHill, 5th edition, 2011.

References:

1. Product Design and Manufacturing- A C Chitale and R C Gupta, PHI 3rd Edition, 2003.

2. New Product Development- Timjones. Butterworth Heinmann, Oxford. UCI. 1997 3. Product Design for Manufacture and Assembly-GeofferyBoothroyd, Peter Dewhurst and Winston Knight, 3 rd edition, 2010

Open Electives

Entrepreneurship development

Sub Code: CIE: 70%

Marks Hrs/Week: 03 Marks SEE Hrs: 3Hrs

Module I: **9 hours**

The Entrepreneurial revolution: Entrepreneurs- challenging the unknown, Entrepreneurs/small business owners: A Distinction Entrepreneurship: A mind set, our entrepreneurial economy- The environment for entrepreneurship, the age of the gazelles, Emerging trends: the internet and E-Commerce, Entrepreneurial opportunities. The Evolution of Entrepreneurship: The Evolution of Entrepreneurship, the Myths of entrepreneurship, Approaches to entrepreneurship Process approaches, entrepreneurship (Corporate entrepreneurship) Corporate entrepreneurship: The nature of corporate entrepreneurship, conceptualizing corporate entrepreneurship strategy.

Module II: **9 hours**

The Entrepreneurial individual: The entrepreneurial mindset, the dark side of entrepreneurship, entrepreneurial motivation.. Developing individual innovation: Entrepreneurs: Imagination and creativity, the role of creativity, arenas in which people are creative, innovation and the entrepreneur, the innovation process. Ethics and Entrepreneurship: The ethical side of enterprise, defining ethics, ethics and laws, establishing a strategy for ethical responsibility, ethics and business decisions, the social responsibility challenge, ethical considerations in corporate entrepreneurship.

Module III: **9 hours**

Opportunity Assessment in Entrepreneurship: The Challenge of New-Venture Start-Ups, Pitfalls in Selecting New Ventures, Critical Factors for New-Venture Development, Why New Ventures Fail, the Evaluation Process. Environmental Assessment in Entrepreneurship: Sustainable Competitive Advantage, the environment for New Ventures, A Macro view: The economic and industry environments, A Micro view: The community perspective. Entrepreneurial Ventures and Marketing Research: Marketing Research, Inhibitors to marketing research, developing the marketing concept, marketing stages for growing ventures, marketing planning, telemarketing, internet marketing, pricing strategies.

Module IV: **9 hours**

The legal Forms of Entrepreneurial Organizations: Identifying legal structures, sole proprietorships, partnerships, corporations, specific forms of partnerships and corporations, franchising, final thoughts: The legal environment and Entrepreneurship: Patents, copyrights, trademarks, bankruptcy, keeping legal expenses down.

Module V: **9 hours**

Strategic Planning and Entrepreneurship: The nature of planning in emerging firms, strategic planning, the lack of strategic planning, the value of strategic planning, implementing a strategic plan, the nature of operational planning, The Challenge of Entrepreneurial Growth: Venture development stages, the entrepreneurial company in the 21st Century, building the adaptive firm, the transition from an entrepreneurial style to a managerial approach, understanding the growth stage, the international environment: global opportunities, achieving entrepreneurial leadership in the new millennium.

Course Out comes:

After the successful completion of this course, the student will be able to:

1. Describe the entrepreneurship process, requirements for motivation, opportunity assessment, critical factors for venture development.

2. Estimate financial requirements using sample project.

3. Demonstrate the knowledge of process involved in establishing an SME.

4. To understand strategic planning in entrepreneurship

Text Books:

1. “Entrepreneurship in the New Millennium”, Kuratko, Hodgetts, CENGAGE Learning, India Edition 2007.

2. “Entrepreneurship Development”, S Anil Kumar, S C Poornima, New Age International Publisher 2008

References:

1. “Entrepreneurship” Hisrich, 6th Edition, Tata McGraw-Hill Education, 2011.

2.“The New Business Road Test” John Mullins, Pearson Education Limited, Third Edition, 2010

Rapid Prototyping

Course Learning Objectives

1. To introduce about different classes of Rapid Prototyping (RP) systems.

2. To impart knowledge about applications of various RP processes.

3. To introduce about rapid tooling.

4. Understand about RP Technology selection.

MODULE 1 **9 Hours**

Introduction- Need for the compression in product development, History of Rapid Prototyping (RP) systems, Survey of applications, Growth of RP industry, Classification of RP systems.

MODULE 2 **9 Hours**

Principle, process parameters, process details and applications of various RP processes - Stereo lithography systems, Laser Sintering, Fused Deposition Modeling, Laminated Object.

MODULE 3 **8 Hours**

Manufacturing, Solid Ground Curing, Laser Engineered Net Shaping, 3D Printing, Laser Melting, Cladding.

MODULE 4 **10 Hours**

Rapid Tooling - Indirect rapid tooling, Direct rapid tooling, soft tooling Vs hard tooling, Rapid Manufacturing Process Optimization- Factors influencing accuracy, data preparation errors, part building errors, errors in finishing, influence of part build orientation.

MODULE 5 **9 Hours**

Software for RP - STL files, Overview of solid view, Magics, mimics, magics communicator, etc., internet-based software, collaboration tools. RP Technology selection, Decision Making, Life Cycle Assessment of RP processes, Sustainability issues

Text Books

1. Prasad H and Badrinarayanan, K S, “Rapid Prototyping and Tooling”, SPIPageturners, Bangalore, India, 2013.
2. Hilton P, Jacobs P F, “Rapid Tooling: Technologies and Industrial Applications”, 1st Edition CRC press, 2000.

Reference Books

1. Pham D T and Dimov S S, "Rapid Manufacturing", SpringerVerlag,2001.
2. Paul F Jacobs, "Stereo lithography and other RP&M Technologies", SME,1996.
3. Terry Wohlers, "Wohlers Report 2001", Wohlers Associates,2008

Course Outcomes

On completion of this course, the students will be able to

1. understand the importance of time compression technologies
2. select of appropriate technology for particular application.
3. apply RP software packages
4. recognize various types of rapid tooling

Industrial Internet of Things

Course Learning Objectives

1. To provide a good understanding of Internet of Things (IoT) and its envisioned deployment domains.
2. To provide an understanding of smart sensors/actuators with their internet connectivity for experimentation and designing systems.
3. To provide a overview about the various protocol standards deployed in the Internet of Things (IoT) domain and to make informed choices.
4. To impart knowledge in the design and development of IoT systems with enablement ensuring security and assimilated privacy

Course Content

Introduction to Internet of Things - Overview of Internet of Things- the Edge, Cloud and the Application Development, Anatomy of the Thing, Industrial Internet of Things (IIoT - Industry 4.0), Quality Assurance, Predictive Maintenance, Real Time Diagnostics, Design and Development for IoT, Understanding System Design for IoT, Design Model for IoT.

System Design of Connected Devices - Embedded Devices, Embedded Hardware, Connected Sensors and Actuators, Controllers, Battery Life Conservation and designing with Energy Efficient Devices, SoCs, CC3200, Architecture, CC3200 Launchpad for Rapid Internet Connectivity with Cloud Service Providers.

Understanding Internet Protocols - Simplified OSI Model, Network Topologies, Standards, Types of Internet Networking – Ethernet, WiFi, Local Networking, Bluetooth, Bluetooth Low Energy (BLE), Zigbee,6LoWPAN, Sub 1 GHz, RFID, NFC, Proprietary Protocols, SimpliciTI, Networking Design – Push,Pull and Polling, Network APIs.

System Design Perspective for IoT – Products vs Services, Value Propositions for IoT, Services in IoT, Design views of Good Products, Understanding Context, IoT Specific Challenges and Opportunities.

Advances Design Concepts for IoT – Software UX Design Considerations, Machine Learning and Predictive Analysis, Interactions, Interusability and Interoperability considerations, Understanding Security in IoT Design, Design requirements of IoT Security Issues and challenges, Privacy, Overview of Social Engineering.

Text Books:

1. Joe Biron& Jonathan Follett, Foundational Elements of an IoT Solution – The Edge, The Cloud and Application Development, Oreilly,1st Edition, 2016

2. 2. Elizabeth Goodman, Alfred Lui, Martin Charlier, Ann Light, Claire Rowland, "Designing Connected Products UX for the Consumer Internet of Things", 2nd Edition,2013.

3. The Internet of Things (A Look at Real World Use Cases and Concerns), Kindle Edition, Lucas Darnell, 2016

Reference Books

1. Alasdair Gilchrist, "Industry 4.0: The Industrial Internet of Things", Apress 1st ed. Edition, 2017.

2. Olivier Hersent, "The Internet of Things: Key Applications and Protocols", Wiley 2nd Edition, 2012.

3. The Internet of Things – Opportunities and Challenges http://www.ti.com/ww/en/internet_of_things/pdf/14-09-17-IoTforCap.pdf

Course Outcomes

On the completion of this course, the students will be able to

1. understand the design architecture of IoT.
2. make choice of protocols and deployment in solutions.
3. comprehend the design perspective of IoT based products /services.
4. basic understanding of various Industrial IoT platforms

Wireless Sensor Networks

Course Learning Objectives

1. To overview the various design issues and challenges in the layered architecture of Wireless sensor networks.
2. Analyze various protocols used in wireless sensor networks.
3. To familiarize localization and tracking in networks
4. Learn about data handling in wireless sensor networks

Course Content

Module 1 **9 Hours**

Introduction to Sensor Networks - Unique constraints and challenges, Advantage and Applications of Sensor Networks, Enabling technologies for Wireless Sensor Networks. Sensor Node Hardware and Network Architecture: Single-node architecture, Hardware components & design constraints, Operating systems and execution environments, Network architecture, Optimization goals and figures of merit, Design principles for WSNs.

Module 2 **9 Hours**

Physical layer- Introduction, wireless channel and communication fundamentals – frequency allocation, modulation and demodulation, wave propagation effects and noise, channels models, spread spectrum communication, packet transmission and synchronization, quality of wireless channels and measures for improvement, physical layer and transceiver design consideration in wireless sensor networks.

Module 3 **9 Hours**

Data link layer- Fundamentals of wireless MAC protocols, Characteristics of MAC protocol in wireless sensor networks contention-based protocols, Contention free MAC protocols, Hybrid MAC protocols Network layer-routing metrics -Flooding and gossiping.

Module 4 **9 Hours**

Localization and tracking – A tracking scenario, tracking multiple objects, sensor models, performance comparison and metrics, Networking sensors – MAC, general issues, geographic energy – aware routing, Attribute – Based routing. Deployment and Configuration: Localization and positioning, Coverage and connectivity, Single-hop and multi-hop localization, self-configuring localization systems, sensor management.

Module 5 **9 Hours**

Data Storage and Manipulation: Data centric and content based routing, storage and retrieval in network, compression technologies for WSN, Data aggregation technique. Case study Detecting unauthorized activity using a sensor network, Target detection tracking, Habitat monitoring, Environmental disaster monitoring, Practical implementation issues.

Text Books

1. W. Dargie, C. Poellabauer, “Fundamentals of Wireless sensor networks -Theory and Practice”, John Wiley & Sons Publication, 2010.
2. K. Sohraby, D.Minoli and T.Znati, “Wireless Sensor Network Technology Protocols and Applications”, John Wiley & Sons, 2007.
3. HolgerKerl, Andreas Willig, “Protocols and Architectures for Wireless Sensor Network”, John Wiley and Sons, 2005.
4. Feng Zhao, Leonidas Guibas, “Wireless Sensor Network”, 1st Ed., Elsevier, 2004.

Reference Books

1. F.Zhao, L.Guibas, “Wireless Sensor Networks: an information processing approach”, Elsevier publication, 2004.
2. C.S.Raghavendra Krishna, M.Sivalingam and Taribznati, “Wireless Sensor Networks”, Springer publication, 2004.
3. H. Karl, A.willig, “Protocol and Architecture for Wireless Sensor Networks”, John Wiley publication, Jan 2006

Course Outcomes

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

1. analyze the challenges and constraints of wireless sensor network and its subsystems.
2. examine the physical layer specification, modulation and transceiver design considerations.
3. compare and analyze the types of routing protocols and data aggregation techniques.
4. identify the application areas and practical implementation issues.