Programme Outcomes

PO1: An ability to independently carry out research /investigation and development work to solve practical problems

PO2: An ability to write and present a substantial technical report/document

PO3: Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program

Programme Specific Outcomes

PSO1: Analyze, Design and Develop Power Electronic Systems

PSO2: Analyze and Design modern electric machines, drives, power converters, and control circuits related to industrial and renewable energy applications

I Semester Syllabus

APPLIED MATHEMATICS

Contact Hours/ Week	: 3	Credits:	3
Total Lecture Hours	: 50	CIE Marks:	50
Lab work	: -	SEE Marks:	50
Sub. Code	: N1PGMAT		

UNIT 1

Numerical Methods: Solution of algebraic and transcendental equations iterative methods based on second degree equation – Muller method, (no derivation) Chebyshev method, general iteration method (first order), acceleration of convergence, system of non-linear equations, and complex roots – Newton-Raphson method, polynomial equations – Birge –Vieta method and Bairstow's method. **Interpolation:** Hermite interpolation, spline interpolation, numerical solution of differential equations – Numerov method. **10 hrs**

UNIT 2

Numerical Solution of Partial Differential Equations: Classification of second order equations, parabolic equations- solution of one-dimensional heat equation, explicit method, Crank-Nicolson method and Du Fort-Frankel method, hyperbolic equations- solution of one-dimensional wave equation. **10 hrs**

UNIT 3

System of Linear Algebraic Equations and Eigen Value Problems: Iterative methods - Gauss-Seidal method, SOR method, Eigen value problems – Gerschgorian circle, Eigen values and Eigen vectors of real symmetric matrices -Jacobi method, Givens method. **10 hrs**

UNIT 4

Optimization: **Linear programming**- formulation of the problem, graphical method, general linear programming problem, simplex method, artificial variable technique - M-method. **10 hrs**

UNIT 5

Optimization: Nonlinear programming: single variable optimization-local and global optima, searching techniques, convex functions. Multivariable optimization without constraints-local and global maxima, Gradient vector and Hessian matrix, the method of steepest ascent, Newton-Raphson method, Fletcher-powell method, searching techniques, choice of an initial approximation, concave function. Multivariable optimization with constraints-standard forms, Lagrange multipliers, Newton Raphson method, penalty functions, Kuhn-Tucker conditions, method of feasible directions. **10 hrs**

Reference Books:

1. M K Jain, S R K Iyengar and R K Jain, "Numerical Methods for Scientific and Engineering Computations", 6th edition, New Age International, 2004.
2. M K Jain, "Numerical Solution of Differential Equations", 2nd Edition, New Age International, 2008.
3. Dr. B.S. Grewal, "Numerical Methods in Engineering and Science", Khanna Publishers, 2012.
4. Dr. B.S. Grewal, "Higher Engineering Mathematics", 43rd Edition, Khanna Publishers, 2015.
5. Richard Bronson and Govindasami Naadimuthu, "Schaum's outlines Operations Research", 2nd edition, Tata McGraw-Hill Publishers, 1997.
6. Kenneth Hoffman and Ray Kunze, "Linear Algebra", 2nd Edition, PHI, 2011.

CONTROLLED RECTIFIERS AND INVERTERS

Contact Hours/ Week	: 3+0+2(L+T+P)	Credits:	4.0
Total Lecture Hours	:40	CIE Marks:	50
Tutorial/ Practical	:26(P)	SEE Marks:	50
Sub. Code	: N1EPE01		

Course Objectives:

1. To expose students to analyse the construction and operation of Power semiconductor devices
2. To expose students to analyse the operation and control techniques of Phase controlled rectifiers
3. To expose students to analyse the operation and control techniques of Inverters
4. To expose students to analyse the operation and features of different multilevel inverter topologies and Matrix converters.

Course Outcomes:

Upon completion of this course the student will be able to:

CO1: Understand various characteristics of power devices, data sheet for proper selection of power devices for defined application

CO2: Design and analyse single phase line commutated converters and three phase line commutated converters and evaluate the performance of 1-ph converter under the effect of source inductance.

CO3: Design and analyse of switch mode inverters in linear modulation and over modulation. Analysis of harmonic components.

CO4: Analyse different Inverter control methods and Inverter Topologies

UNIT 1

Power Devices: Thyristor, MOSFET and IGBT- V-I characteristics, switching transient- turn-on transient, turn-off transient.

Power Devices Continued: FBSOA and RBSOA curve of MOSFET and IGBT, optocoupler isolated drive circuit for MOSFET and IGBT. **08Hrs.**

UNIT 2

Controlled Rectifier: Operation and analysis of single phase fully controlled converter, effect of source inductance (1-phase converters), and discontinuous current conduction. Dual Converter (1-phase), three phase fully controlled converter, effect of source inductance (3-phase converters) **Power Factor Improvements:** Extinction angle control, symmetric angle control, PWM control.

08 Hrs.

UNIT 3

Switch-Mode Inverters: Half-Bridge inverter PWM switching scheme-linear modulation, over modulation, square wave operation. Full-bridge inverter-PWM bipolar and unipolar voltage switching. Three-phase inverter PWM switching scheme-linear modulation, over modulation, square wave operation, **Control of Single-Phase Inverters:** Modified SPWM methods, SVPWM. **08 Hrs.**

UNIT 4

Harmonic Reductions. **Current Source Inverter**: ASCI, comparison between VSI & CSI. **Boost Inverter, Matrix Converters**: Single Phase Matrix Converter, Three Phase Matrix Converter, and Commutation Methods in Matrix Converter. **08 Hrs.**

UNIT 5

Multilevel Inverters: Introduction, types, diode clamped multi-level inverters, cascaded H-bridge inverter, flying capacitor clamped inverter & applications, Switching Device Currents, DC-Link Capacitor Voltage Balancing, Features of Multilevel Inverters, Comparisons of Multilevel Converters. **08 Hrs.**

REFERENCE BOOKS

Sl. No.	**Authors/s**	**Title, Publisher, Edition, Year, ISBN**
1.	Rashid M.H	Power Electronics: Circuits Devices and Applications,Pearson Publishers,3rd edition,2011, ISBN-10: 0131011405
2.	Ned Mohan, Tore M. Undeland, William P. Robbins	Power Electronics Converters, Applications, and Design, Wiley India Pvt Ltd,3rd edition,2011, ISBN: 978-0-471-22693-2

3.	B. K. Bose	Modern Power Electronics & AC Drives, PHI,1st edition,2012, ISBN: 0-13-016743-6
4.	Powel Szczesniak	Three-phase AC-AC Power Converters based on Matrix Converter Topology, Springer Verilog, London,1st edition,2013, 2013, ISBN 978-1-4471-4896-8

List of Experiments:

1. Design and Simulation of Single phase semi controlled rectifier feeding R and RL load
2. Design and Simulation of Single phase Fully controlled rectifier feeding R and RL load
3. Design and Simulation of Single-phase Dual converter with circulating and noncirculating modes of current
4. Design and Simulation of Three phase Fully controlled rectifier feeding R and RL load
5. Design and Simulation of Three phase Dual converter with circulating and Non circulating modes of current
6. Design and Simulation of Single-phase Half bridge Inverter feeding R and RL load
7. Design and Simulation of Single-phase Full bridge Inverter feeding R and RL load
8. Design and Simulation of Three phase Inverter
9. Conduction and Analysis of Single phase Fully controlled rectifier feeding R and RL load
10. Conduction and Analysis of Three phase Fully controlled rectifier feeding R and RL load
11. Conduction and Analysis of Single-phase Inverter
12. Conduction and Analysis of Three phase Inverter

MODELLING & ANALYSIS OF ELECTRICAL MACHINES

Contact Hours/ Week	: 3+2+0(L+T+P)	Credits:	4.0
Total Lecture Hours	:40	CIE Marks:	50
Tutorial/ Practical	:26(T)	SEE Marks:	50
Sub. Code	: N1EPE02		

Course Objectives:

1. To expose students to the modeling techniques of Electrical Machines.
2. To expose students to the dynamic and steady-state analysis of Electrical Machines.

Course Outcomes:

Upon completion of this course the student will be able to:

CO1: Understand energy storage and electromechanical energy transfer in electromechanical systems

CO2: Transform circuit variables into an arbitrary reference frame

CO3: Model and Analyse the performance of Induction machines

CO4: Model and Analyse the performance of Synchronous machines

CO5: Model and Analyse the performance of Brushless dc machines

UNIT 1

Basic Principles for Electric machine analysis: Magnetically coupled circuits-leakage flux, linear magnetic system, non-linear magnetic system, electromechanical energy conversion – Energy relationships, Energy in coupling fields, Electromagnetic forces, Machine windings and air-gap MMF, Winding inductances. **(08+05) Hrs.**

UNIT 2

Theory of Direct-current machines: Voltage and torque equations - Mathematical model of separately excited DC motor, transfer function of separately excited DC motor Separately excited DC motor: steady state and transient state analysis (simulation only).

Reference – Frame Theory: Introduction, equations of transformation – change of variables, stationary circuit variables transformed to the arbitrary reference frame, commonly used reference frames, transformation between reference frames. Transformation of a balanced set. Balanced steady state phasor relationships, balanced steady-state voltage equations variables observed from several frames of reference (simulation only**).** **(08+05) Hrs.**

UNIT 3

Symmetrical Induction Machines: Introduction, voltage equations in machine variables, Torque equation in machine variables, equation of transformation for rotor circuits, voltage equations in arbitrary reference – frame variables, Torque equation in arbitrary reference – frame variables, commonly used reference frames, per unit system, Steady state analysis, Dynamic performance during sudden changes in load torque and three phase fault at the machine terminals (simulation only) **Industrial visit** **(08+05) Hrs.**

UNIT 4

Theory of Synchronous Machines: Introduction, voltage equations in machine variables, Torque equation in machine variables, stator voltage equations in arbitrary reference – frame variables, voltage equations in rotor reference – frame variables-Park equations, Torque equation in substitute variables, Rotor angle and angle between rotors, per unit system, analysis of steady state operation. Dynamic performance during sudden change in input torque and during a 3-phase/Single Line-to ground/Double Line-to-ground fault at the machine terminals (simulation only). **(08+06) Hrs.**

UNIT 5

Theory of Brushless dc Machines: Introduction, Voltage and Torque equations in machine variables, voltage and torque equations in Rotor-reference frame variables, Analysis of Steady state operation. Dynamic performance (simulation only). **(08+05) Hrs.**

REFERENCE BOOKS

1. P.C.Krause, Oleg Wasynczuk, Scott D.Sudhoff, “Analysis of Electrical Machinery and Drive Systems”, 2nd Edition, Wiley India, 2010.
2. R. Krishnan, “Electric Motor Drives - Modeling, Analysis & Control”, PHI Learning Private Ltd, 2009.
3. P.S.Bimbra, “Generalized Theory of Electrical Machines” Khanna Publications, 5th Edition, 1995.
4. Chee-Mun Ong, “Dynamic Simulation of Electric Machinery using Matlab / Simulink”, Prentice Hall, 1998.

SWITCHED MODE AND RESONANT CONVERTERS

Contact Hours/ Week	:2+2+0(L+T+P)	Credits:	3.0
Total Lecture Hours	:26	CIE Marks:	50
Tutorial/ Practical	:26(T)	SEE Marks:	50
Sub. Code	: N1EPE03		

Course Objectives:

1. To expose students to the analysis and design of DC-DC power converters
2. To expose students to the analysis and design of the resonant converters
3. To expose students to the selection and design of magnetic components of converters

Course Outcomes:

Upon completion of this course the student will be able to:

CO1: Analyse and design Buck, Boost and Buck-boost converters

CO2: Analyse and design SEPIC, CUK and derived converter

CO3: Analyse and design forward, push-pull and bridge converters

CO4: Analyse and design resonant converters

CO5: Design magnetic components for DC-DC converters

UNIT 1

DC – DC Converters (Basic Converters): A basic switching converter (SMPC), principle of operation and analysis of buck converter, inductor current ripple and output voltage ripple, capacitor resistance effect, design considerations, buck converter for discontinuous current operation. 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. (**06+06) Hrs.**

UNIT 2

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. Principle of operation and analysis of CUK converter, inductor current ripple and output voltage ripple, capacitor resistance effect, design considerations, Principle of operation and analysis of SEPIC converter. **(05+05) Hrs.**

UNIT 3

Derived Converters: Introduction, transformer models, principle of operation and analysis of fly back converter-continuous, design considerations. Principle of operation & analysis of forward converter, design considerations, principle of operation & 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. **(05+05) Hrs.**

UNIT 4

Resonant Converters: Introduction, resonant switch ZCS converter, principle of operation and analysis, resonant switch ZVS converter, principle of operation and analysis, series resonant DC-DC converter, parallel resonant DC-DC converter, Series, Parallel resonant converters comparison. **(05+05) Hrs.**

UNIT 5

Design of magnetic components-design of transformer, Design of Inductor, Selection of filter capacitors, Selection of ratings for devices, input filter design, Thermal design. **(05+05) Hrs.**

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.

4. D M Mitchel, "DC-DC Switching Regulator Analysis" McGraw-Hill Ltd, 1988.

5. Ned Mohan, Tore M. Undeland, William P. Robbins, "Power Electronics Converters, Applications, and Design", 3rd Edition, Wiley India Pvt Ltd, 2010.

ADVANCED CONTROL SYSTEMS

Contact Hours/ Week	: 2+2+0(L+T+P)	Credits:	3.0
Total Lecture Hours	: 26	CIE Marks:	50
Tutorial/Practical	: 26	SEE Marks:	50
Sub. Code	: N1EPE04		

Course objectives:

1. To impart basic knowledge about state-space models, state regulator design, controllable and observable systems.
2. Understand and implement PID controllers and various practical considerations.
3. To expose students to methods of analyzing non-linear control systems.
4. To impart knowledge of sliding mode control
5. To impart knowledge of implementation of PID, state-feedback controller, and sliding mode controller on converters.

Course Outcomes:

Upon completion of this course the student will be able to:

CO1: Understand the concepts and significance of controllability and observability, design of state feedback control, and observer in the design of feedback control systems.

CO2: Analyze the importance and design of PID controllers.

CO3: Analyze non-linear systems and its stability.

CO4: Understanding fundamentals of sliding mode control, chattering phenomenon and its reduction.

CO5: Implementation of PID, state-feedback, and sliding mode control on converters.

UNIT 1

State-space: Overview of state-space, concepts of controllability and observability, Kalman test to check controllability and observability, design of servo-systems, pole placement by state feedback, design of servo-systems, full order and reduced order observer. **(06+06) Hrs.**

UNIT 2

PID controller: Proportional controllers, PI and PID controllers, Derivative overrun, integral windup, cascaded control, Feed forward control. PID controllers-Ziegler-Nichols tuning method. Modifications in PID control: PID, PI-D, I-PD controller. Two-Degree-of-Freedom Control.

(05+05) Hrs.

UNIT 3

Analysis of Non-Linear Control Systems: Introduction, Common nonlinearities, singular points, stability of nonlinear systems – linearization, phase plane analysis, Lyapunov's stability analysis – examples. **(05+05) Hrs.**

Unit-4

Nonlinear Design tools (Sliding Mode Control): Concept of variable structure control, implementation of switching control laws. Reduction of chattering in sliding mode, Lyapunov's redesign Stabilization – nonlinear damping. **(05+05) Hrs.**

Unit-5

Controller Design: Design of PI, PD, PID controller for buck, boost, and buck-boost converter. State Feedback Controller design for buck, boost, & buck-boost converter. Design of Sliding Mode Controller with PI type sliding surface for buck converter. (Note: select some standard models of converters). **(05+05) Hrs.**

REFRENCE BOOKS

Sl. No.	**Author/s**	**Title, Publisher, Edition, Year, ISBN**
1	Ogata. K	"Modern Control Engineering", 5th Edition, PHI, 2010.ISBN:0-13-615673-8.
2	Nagarath and Gopal,	"Control Systems Engineering", New Age International Publishers, 2007.3rd Edition, ISBN: 81-224-1192-4.
3	Hassan K Khalil,	"Nonlinear Systems", Prentice Hall, 2002, 3rd edition, ISBN: 0-13-067389-7.

4	D. Roy Choudhury	"Modern Control Engineering" Prentice Hall India Learning Private Limited, Edition-1, 2005. ISBN: 9788120321960.
5	Christopher Edwards & Sarah K. Spurgeon	Sliding Mode Control-Theory & Applications, CRC Press, Taylor & Francis Group, 1998. ISBN: 978-0-7484-0601-2-4
6	Axay kumar Mehta & Brijesh Naik	Sliding Mode Controllers for Power Electronic Converters" Springer series-2019. ISBN: 978-981-13- 3151-0.
7	Aidan O' Dwyer,	"Handbook of PI & PID Controllers tuning rules", second edition, Imperial College Press, 2006. ISBN: 1-86094-622.
8	Yuri Shtessel, Christopher Edwards, Leonid Fridman, & Arie Levant	"Sliding Mode Control and Observation" Springer, Edition-1, 2014. eBook ISBN: 978-0-8176-4893-0.

PROFESSIONAL ELECTIVE-I

EMBEDDED SYSTEM DESIGN

Contact Hours/ Week	: 2+0+2(L+P+T/SDA)	Credits:	3.0
Total Lecture Hours	: 26	CIE Marks:	50
Tutorial/ Practical	: 26	SEE Marks:	50
Sub. Code	: N1EPEE11		

Course objectives:

1. To introduce the Building Blocks of Embedded System and various development strategies
2. To Introduce Bus Communication in processors, Input/output interfacing.
3. To impart knowledge in various processor scheduling algorithms.
4. To introduce Basics of Real time operating system and example tutorials to discuss on one real time operating system tool

Course Outcomes:

Upon completion of this course the student will be able to:

CO1: Explain design process in embedded system and formulation of system design.

CO2: Acquire knowledge about processor and memory organization in embedded systems design.

CO3: Acquire knowledge about ARM system architecture and high-performance processors.

CO4: Explain real time programming and modelling concepts during single and multi-processor system software development process.

CO5: Describe real time operating systems concepts.

UNIT 1

Introduction to Embedded System: An embedded system, processor, hardware unit, software embedded into a system, example of an embedded system, OS services, I/O, N/W, O/S, real time and embedded OS. Classification of Embedded Systems, Skill required for an Embedded System Designer. **(5+5) Hrs.**

UNIT 2

Processor and Memory Organization: Structural unit in a processor, processor selection for an embedded system, memory devices, memory selection for an embedded system, allocation of memory to program statements and blocks and memory map of a system, direct memory accesses.

(5+5) Hrs.

UNIT 3

ARM various system architecture, high performance processors - strong ARM processors; addressing modes, instruction set, basic alp programs, interrupts structure. **(5+5) Hrs.**

UNIT 4

Real Time System: Types, real time computing, design issues, sample systems, hardware requirements- processors introduction. **RTOS Based Embedded System:** Operating System Basics, Types of Operating Systems, Tasks, Process and Threads, Multiprocessing and Multitasking, Task Scheduling. Tasks, state transition diagram, task control block. Inter-task communication and synchronization of tasks, building real time applications. **(5+5) Hrs.**

UNIT 5

RTOS programming fundamentals: Tasks and Task states – Semaphores – Shared data – Message queues, Mail boxes and pipes – Memory management – Interrupt routines – Encapsulating semaphore and queues. **(6+6) Hrs.**

TEXT BOOKS

Sl. No.	**Author/s**	**Title, Publisher, Edition, Year, ISBN**
1	Rajkamal	"Embedded System Architecture: Programming & Design", TMH, 2010. ISBN-13: 978-933290149
2	David E. Simon	"An Embedded Software Primer", Pearson Education, 1999. ISBN-13: 978-8177581546
3	Philip. A. Laplante	"Real-Time Systems Design and Analysis- An Engineer's Handbook"- 2nd Edition, Pearson. ASIN: B000QCS6WQ
REFERENCE BOOKS		
1	Jane W.S. Liu	"Real-Time Systems", Pearson Education Inc, 2012. ISBN-13: 978-9382993490
2	K.V.K.K Prasad	"Embedded Real Time Systems: Concepts Design and Programming", Dreamtech Press New Delhi, 2003. ISBN-13: 978-8177224610

ELECTRIC POWER QUALITY

Contact Hours/ Week	: 2+0+2(L+T+P)	Credits:	4.0
Total Lecture Hours	:26	CIE Marks:	50
Tutorial/ Practical	:26	SEE Marks:	50
Sub. Code	: N1EPEE12		

Course objectives:

1. To expose students to power quality disturbances, classification, and relevant standards
2. To expose students to harmonics and to design and analysis of filters for mitigation of harmonics.
3. To expose students to Voltage variations and to design and analysis of compensators for suppression of Voltage variations.

Course Outcomes:

Upon completion of this course the student will be able to:

CO1: Acquire knowledge about the various power quality disturbance and Power Quality Standards and Monitoring

CO2: understand the various sources of harmonics and design and analysis of Passive filter for mitigation of harmonics.

CO3: design and analysis of Active filter for mitigation of harmonics.

CO4: Acquire knowledge about the Voltage sag and short interruptions and its consequences.

CO5: analysis of different mitigation methods for suppression of Voltage sag and short interruptions.

UNIT 1

Power Quality: Introduction, Classification of Power Quality Problems, Causes of Power Quality Problems, Effects of Power Quality Problems on Users, Classification of Mitigation Techniques for Power Quality Problems. **Power Quality Standards and Monitoring**: Introduction, Power Quality Terminologies, Power Quality Definitions, Power Quality Standards, Power Quality Monitoring, Numerical Examples. **(05+05)Hrs**

UNIT 2

Power Quality Disturbance Sources: Classification of Nonlinear Loads, Power Quality Problems Caused by Nonlinear Loads, Analysis of Nonlinear Loads, **Passive Power Filters** :

Introduction, Classification of Passive Filters , Principle of Operation of Passive Power Filters, Analysis and Design of Passive Power Filters, Limitations of Passive Filters, Parallel Resonance of Passive Filters with the Supply System and Its Mitigation , Numerical Examples.

(06+06) Hrs.

UNIT 3

Active Power Filters: Shunt Active Power Filters: Introduction , Classification of Shunt Active Power Filters, Principle of Operation and Control of Shunt Active Power Filters ,Analysis and Design of Shunt Active Power Filters, **Series Active Power Filters:** Introduction, Classification of Series Active Power Filters, Principle of Operation and Control of Series Active Power Filters, Analysis and Design of Series Active Power Filters, **Hybrid Power Filters :** Introduction, Classification of Hybrid Power Filters, Principle of Operation and Control of Hybrid Power Filters, Analysis and Design of Hybrid Power Filters ,Numerical Examples. **(05+05) Hrs.**

UNIT 4

Short Interruptions: Origin of Short Interruptions, Basic Principle, Fuse Saving, Voltage Magnitude Events due to Reclosing, Voltage During the Interruption, Monitoring of Short Interruptions, Influence on Equipment. **Voltage Sags-Characterization:** Introduction, Voltage Sag Magnitude, Monitoring, Voltage Sag Duration, Fault-Clearing Time, Magnitude-Duration Plots, Measurement of Sag Duration. Load Influence on Voltage Sags, Induction Motors and Three-Phase Faults, Power Electronics Load. **(05+05) Hrs.**

UNIT 5

Mitigation of Interruptions and Voltage Sags: Overview of Mitigation Methods, From Fault to Trip, Reducing the Number of Faults, Reducing the Fault-Clearing Time, Changing the Power System, Installing Mitigation Equipment, Improving Equipment Immunity, The System-Equipment Interface, Voltage-Source Converter, Series Voltage Controllers-DVR, Shunt Voltage Controllers-Stacom. (**05+05)Hrs**.

REFERRENCE BOOKS

Sl. No.	**Authors/s**	**Title, Publisher, Edition, Year, ISBN**
1	Bhim Singh, Ambrish Chandra and Kamal Al-Haddad	Power Quality Problems and Mitigation Techniques" John Wiley & Sons ,1st t Edition, 2015. ISBN: 9781118922057

2	Math H. Bollen	Understanding Power Quality Problems", IEEE Press,1st edition, 2000, Online ISBN: 9780470546840, Print ISBN: 9780780347137

SOFT COMPUTING

Contact Hours/ Week	: 2+2+0(L+T+P)	Credits:	3
Total Lecture Hours	: 26	CIE Marks:	50
Tutorial/ Practical	: 26	SEE Marks:	50
Sub. Code	: N1EPEE13		

Course objectives:

1. Understanding the fundamental theory and concepts of computational intelligence methods, in particular neural networks, fuzzy systems, genetic algorithms and their applications in the area of machine intelligence.
2. To understand the concepts of fuzzy sets, knowledge representation using fuzzy rules, approximate reasoning, fuzzy inference systems, and fuzzy logic control and other machine intelligence applications of fuzzy logic.
3. To understand the fundamental theory and concepts of neural networks, neuro-modeling, several neural network paradigms and its applications.
4. To understand the basics of an evolutionary computing paradigm known as genetic algorithms and its application to engineering optimization problems.

Course Outcomes: Upon completion of this course the student will be able to:

CO1: Identify and describe soft computing techniques and their roles in building intelligent machines such as expert system.

CO2: Apply fuzzy logic reasoning algorithms to handle uncertainty and solve simple engineering problems

CO3: Design and effectively Apply the usage of fuzzy logic software tool to solve real world problems. Identify and Apply neural network models and learning tools for simple engineering applications

CO4: Design and Apply neural networks models to practical problems

CO5: Apply genetic algorithms to real world control and probabilistic reasoning problems

UNIT 1

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, Python programming. **(05+05)Hrs**.

UNIT 2

Fuzzy Logic (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. (Fuzzy Membership, Rules) Membership functions, interference in fuzzy logic, fuzzy if-then rules. **(06+06)Hrs**.

UNIT 3

Fuzzy implications and Fuzzy algorithms, Fuzzyfication & Defuzzificataion, Fuzzy Controller, Implementation of fuzzy controller using python programming. Introduction to Neural Networks (Introduction & Architecture) Neuron, Nerve structure and synapse, Artificial Neuron and its model, activation functions. **(05+05)Hrs**.

UNIT 4

Neural network architecture: single layer and multilayer feed forward networks, recurrent networks. Various learning techniques; perception and convergence rule. Back propagation Neural Networks: perceptron model, solution, single layer artificial neural network, multilayer perception model; back propagation learning methods, effect of learning rule co-efficient; Radial basis function, implementation of RBF network. Back propagation algorithm, factors affecting backpropagation training. Implementation of BP network algorithm using python programming.

(05+05)Hrs.

UNIT 5

Genetic Algorithm (GA) Basic concepts, working principle, procedures of GA, flow chart of GA, Genetic representations, (encoding) Initialization and selection, Genetic operators, Mutation, Generational Cycle. Implementation of GA using python programming. Hybrid systems, Types and Implementation of Neuro-Fuzzy system. **(05+05)Hrs**.

TEXT BOOKS

Sl. No.	**Authors/s**	**Title, Publisher, Edition, Year, ISBN**
1.	D. E. Goldberg	Genetic Algorithms in Search, Optimization, and Machine Learning, Addison-Wesley Pub. Co.,13th ed., 1989, ISBN: 0201157675 9780201157673
3.	N.P.Padhy	Artificial Intelligence and Intelligent Systems, Oxford University Press, 4th ed., 2005, ISBN: ISBN 10: 0195671546 ISBN 13: 9780195671544
4.	Siman Haykin	Neural Networks, Prentice-Hall Of India Pvt. Limited, 2nd ed., 1999, ISBN-13: 978-0132733502, ISBN-10: 0132733501

5.	Timothy J. Ross	Fuzzy Logic with Engineering Applications, John Wiley & Sons, Ltd.,3rd ed., 2010 ISBN: 978-0-470-74376-8
6.	Kumar Satish	Neural Networks, Tata McGraw-Hill Education, 2nd ed., 2013, ISBN: 0070482926 9780070482920 007124672X 9780071246729
7.	Yashavant Kanetkar & Aditya Kanetkar	Let Us Python, BPB Publishers, 2nd Revised & Updated Edition, ISBN: 9789389845006

REFERENCE BOOKS

Sl. No.	Authors/s	Title, Publisher, Edition, Year, ISBN
1.	S.N. Sivanandam & S. N. Deepa	Principles of Soft Computing, John Wiley & Sons India, 3rd Ed., 2007, ISBN: 9788126577132
2.	S.Rajasekaran&G.A. Vijayalakshmi Pai	Neural Networks, Fuzzy Logic and Genetic Algorithms: Synthesis and Applications, PHI Learning, 2nd Ed., 2003, ISBN: 8120321863, 9788120321861
3.	V. Kartalopoulos	Understanding Neural Networks and Fuzzy Logic: Basic Concepts and Applications, IEEE Press - PHI, 4th Ed., 2004, ISBN-13 : 978-0780311282
4.	M. Mitchell	An Introduction to Genetic Algorithms, Prentice-Hall, 5th Ed., 1999, ISBN 0−262−13316−4 (HB), 0−262−63185−7 (PB)

ADVANCED DIGITAL SIGNAL PROCESSING

Contact Hours/ Week	: 2+2+0(L+T+P)	Credits:	3
Total Lecture Hours	: 26	CIE Marks:	50
Tutorial/ Practical	: 26	SEE Marks:	50
Sub. Code	: N1EPEE14		

Course objectives:

1. Understand the modern digital signal processing algorithms and applications.
2. To have an in-depth knowledge of use of digital systems in real time applications

Course Outcomes: Upon completion of this course the student will be able to

CO1: Differentiate between the time domain and frequency domain representations as well carryout analysis of discrete time signals and systems

CO2: Study the design techniques for IIR and FIR filters and their realization structures.

CO3: Acquire knowledge about the finite word length effects in implementation of digital filters.

CO4: Acquire Knowledge about the various linear signal models and estimation of power spectrum of stationary random signals

CO5: Design optimum FIR and IIR filters

UNIT 1

Discrete time signals, Linear shift invariant systems-Stability and causality, Sampling of continuous time signals, Discrete time Fourier transform, Discrete Fourier series, Discrete Fourier transform, Z-Transform-Properties of different transforms. **(6+6) Hrs.**

UNIT 2

Linear convolution using DFT, Computation of DFT, Design of IIR digital filters from analog filters - Impulse invariance method, Bilinear transformation method **(5+5) Hrs.**

UNIT 3

FIR filter design using window functions, Comparison of IIR and FIR digital filters, Basic IIR and FIR filter realization structures, Signal flow graph representations Quantization process and errors, Coefficient quantization effects in IIR and FIR filters **(5+5) Hrs.**

UNIT 4

A/D conversion noise- Arithmetic round-off errors, Dynamic range scaling, Overflow oscillations and zero Input limit cycles in IIR filters, Linear Signal Models. All pole, All zero and Pole-zero models, Power spectrum estimation- Spectral analysis of deterministic signals, Estimation of power spectrum of stationary random signals. **(5+5) Hrs.**

UNIT 5

Optimum linear filters, Optimum signal estimation, Mean square error estimation, Optimum FIR and IIR Filters **(5+5) Hrs.**

TEXT BOOKS

Sl. No.	Author/s	Title, Publisher, Edition, Year, ISBN
1	Sanjit K Mitra	"Digital Signal Processing: A computer-based approach ", TataMc Grow-Hill Edition 1998. ISBN:9781259098581
2	Dimitris G. Manolakis, Vinay K Ingle and Stephen M. Kogon	"Statistical and Adaptive Signal Processing", Mc. Grow Hill international editions. -2000, ISBN-13: 978-8131710005

POWER ELECTRONICS LABORATORY – I

Contact Hours/ Week	: 1+2+0(L+T+P)	Credits: 3
Total Lecture Hours	: 13	CIE Marks: 50
Tutorial/ Practical	: 26(P)	SEE Marks: 50
Sub. Code	: N1EPEL01	

Course Objectives:

1. Students must be able to design the circuit for the given problem / system using MATLAB software
2. Students must be able to analyze the characteristic of Semiconductor devices.
3. Students must be able to model the given problem / system using Semikron converter and DSPIC Controller.
4. To observe the difference of the conventional and power electronic control of drives.

Course Outcomes: Upon completion of this course the student will be able to:

CO1: To analyze, design and study DC-DC converters.

CO2: To analyze and study the characteristic of Semiconductor devices

CO3: To analyze and program the DSPIC controller for converter applications.

CO4: To analyze and study different converters using Semikron converter

List of Experiments:

1. Analysis of static and dynamic characteristic of MOSFET and IGBT
2. Performance analysis of two & four quadrant chopper
3. Simulation study of buck, boost and buck- boost, SEPIC converter (basic topologies)and analysis of wave forms for continuous & discontinuous current mode current mode in MATLAB.
4. Basic coding of DSPIC CONTROLLER. (PWM signal with variable frequency and duty cycle)
5. Design of buck converter using DSPIC(TMS320F2790D) controller.
6. Study of Semikron converter operation using DSPIC

7. Study of Diode clamped multilevel inverter simulation in MATLAB.
8. Simulation study of V/F Control of Induction motor.
9. Simulation study of closed loop operation of DC-DC converters.
10. Simulation study of Resonant converters.

II Semester Syllabus

DIGITAL CONTROLLERS FOR POWER ELECTRONIC APPLICATIONS

Contact Hours/ Week	: 3+0+2(L+T+P)	Credits:	4
Total Lecture Hours	: 40	CIE Marks:	50
Practical	: 13(P)	SEE Marks:	50
Sub. Code	: N2EPE01		

Course Objectives:

1. To deal with interfacing of different peripheral devices with Microprocessor
2. To study fundamentals of microcontroller systems with Assembly Language Programming
3. To describe signals mathematically and understand how to perform mathematical
4. operations on signals.
5. To covers the advanced design and analysis of digital circuits with HDL. The primary goal is to provide in depth understanding of system design.

Course Outcomes: Upon completion of this course the student will be able to:

CO1: Learn the concept of digital principles.

CO2: Digital instrumentation setup to control various power electronics-based drives.

CO3: Design the power electronic circuits using Digital logic.

CO4: Analyse the power electronic circuits using Digital logic.

CO5: Design simple filters circuits for particular application.

UNIT 1

MICROCONTROLLERs FOR CONTROL OF POWER ELECTRONIC SYSTEMS: Types, real time computing, design issues, Microcontrollers architecture, addressing modes, instruction set, and few basic assembly language programs Microcomputer control of Power Electronic Systems, Digital vs Analog control, Real time control using Microcomputer, Advanced Microprocessor, power electronic systems, Application examples. **8Hrs.**

UNIT 2

DIGITAL SIGNAL PROCESSORS: Introduction to the TMSLF2407 DSP Controller, Peripherals, Types of Physical Memory, Software Tools, C2xx DSP Core and Code Generation, Components of the C2xx DSP Core, Mapping External Devices to the C2xx Core and the Peripheral Interface, Registers, Memory, Memory Addressing Modes, Programming Using the C2xx DSP Instruction Set. **8Hrs.**

UNIT 3

DIGITAL SIGNAL PROCESSORS INTERFACING: General Purpose Input/Output (GPIO) Functionality, Pin Multiplexing (MUX) and General Purpose I/O Overview, Multiplexing and General Purpose I/O Control Registers, Using the General Purpose I/O Ports, Interrupts on the TMS320LF2407, Interrupt Hierarchy, Initializing and Servicing Interrupts in Software, Interrupt Usage Exercise, The Analog-to-Digital Converter (ADC). **8Hrs.**

UNIT 4

APPLICATION DSP IN POWER ELECTRONICS: The Event Managers (EVA, EVB), Overview of the Event Manager (EV), General Purpose (GP) Timers, PWM Signal Generation, DSP-Based Implementation of DC-DC Buck-Boost Converters, Converter Structure, Continuous Conduction Mode, Discontinuous Conduction Mode, Connecting the DSP to the Buck-Boost Converter, Controlling the Buck-Boost Converter, DSP-Based Control of Stepper Motors. **8 Hrs.**

UNIT 5

FIELD PROGRAMMABLE GATE ARRAYS: RTL Design – simulation and synthesis - Combinational logic – Types – Operators –Packages – Sequential circuit – Sub-programs – Test benches. (Examples: adders, counters, flipflops, FSM, Multiplexers / Demultiplexers). Overview of Field Programmable Gate Arrays – CPLD Vs FPGA – Types of FPGA, Xilinx XC3000 series, Configurable logic Blocks (CLB), Input/Output Block (IOB) , overview of Spartan 3E and Virtex III pro FPGA boards- case study Controlled Rectifier, Switched Mode Power Converters, PWM Inverters, DC motor control, Induction Motor Control using Virtex III pro FPGA boards. **8Hrs.**

TEXT BOOKS

Sl. No.	**Author/s**	**Title, Publisher, Edition, Year, ISBN**
1	Hamid A., Toliyat and Steven Campbell G	DSP Based Electro Mechanical Motion Control", CRC Press New York, 2004.ISBN-13: 978-0849319181
2	Wayne Wolf	FPGA based system design", Prentice Hall, 2004. ISBN-13: 978-8131724651

REFERENCE BOOKS

1	Dogan Ibrahim,	Microcontroller Based Applied Digital Control, Released April 2006 Publisher(s): Wiley ISBN: 9780470863350

Integrated lab

1. Programs to generate delay, Programs using serial port and on-chip timer/counters
2. Stepper motor interface
3. DC motor interface for direction and speed control using PWM
4. Interfacing of 8-bit DAC 0800 with 8051 Microcontroller and Waveform generation using DAC

LIST OF EXPERIMENTS USING DSP PROCESSOR

1. Architecture and Instruction Set of DSPCHIP- TMS
2. Introduction to Code Composer Studio
3. Computation of N- Point DFT of a Given Sequence
4. Implementation of FFT of Given Sequence
5. Controlling the Buck-Boost Converter
6. DSP-Based Control of Stepper Motors.

LIST OF EXPERIMENTS USING Virtex III pro FPGA boards

1. DC motor control using Virtex III pro FPGA boards

2. Induction Motor Control using Virtex III pro FPGA boards

ELECTRIC DRIVES

Contact Hours/ Week	: 3+2+0(L+T+P)	Credits:	4.0
Total Lecture Hours	:40	CIE Marks:	50
Tutorial/ Practical	:26(T)	SEE Marks:	50
Sub. Code	: N2EPE02		

Course Objectives:

1. To expose students to the Electric drive requirements of different applications.
2. To expose students to the operation and control of DC and AC drives.

Course Outcomes:

Upon completion of this course the student will be able to:

CO1: Analyze the Elements of a drive system and characteristics of different Electro Mechanical systems

CO2: Analyze the operation of slip power recovery drives and scalar control of induction motor drives

CO3: Analyze the operation of vector control and DTC of induction motor drives

CO4: Analyze the operation of Permanent magnet synchronous machine drives

CO5: Analyze the operation of wound field synchronous and reluctance machine drives

UNIT 1

Introduction: Elements of a drive system, The mechanical system-components of load torque, load toque characteristics of compressor, centrifugal pump, constant power drive, transportation drive, winch drive, crane hoist, required drive characteristics–speed changes, fundamental torque equation, steady state stability D**C MOTOR DRIVER** 3-ph fully controlled rectifier control of dc separately excited motor, chopper control of separately excited dc motor. **(08+06) Hrs.**

UNIT 2

Induction Motor Slip-Power Recovery Drives: Introduction, Static Kramer drive, Static Scherbius Drive. **Induction Motor Drives:** Induction motor control with small signal model**,** Scalar control – Voltage-fed Inverter control, Scalar control - Current-fed Inverter Control.

(08+05) Hrs.

UNIT 3

Field-oriented control: DC Drive analogy, Principles of vector control, Direct or feedback vector control, Flux vector estimation, Indirect vector control, Stator flux-oriented vector control

Sensorless vector control-slip calculation, direct synthesis from state equation **Direct Torque and Flux Control:** Torque expression with stator and rotor fluxes, control strategy of DTC.

(08+05) Hrs.

UNIT 4

Synchronous machine drives: Sinusoidal SPM machine drives – Open loop Volts/hertz control, self-control model, vector control, Synchronous Reluctance machine drives, Sinusoidal IPM machine drives, Trapezoidal SPM machine drives. **(08+05) Hrs.**

UNIT 5

Wound-Field Synchronous Machine Drives – Brush and Brushless DC Excitation, Load-Commutated Inverter Drive, sensorless control of BLDC motor, Switched reluctance motor drives.

(08+05) Hrs.

REFERENCE BOOKS

1. Bose B. K, "Modern Power Electronics & AC Drives" PHI, 2011.
2. R.Krishnan "Electric Motor Drives", EEE, PHI, 2010.
3. Hamid Toliyat and Steven Campbell, "DSP-Based Electromechanical Motion Control", CRC Press, 2019.
4. G K Dubey, "Fundamentals of Electrical Drives", second edition, Narosa Publishing House, 2001
5. S.B.Dewan, G.R.Slemon, A.Straughen, "Power Semiconductor Drives", John Wiley and Sons, Inc, 1984
6. Mehrdad Ehsani, Yimin Gao, Alin Emadi, "Modern Electric, Hybrid Electric and Fuel Cell Vehicle Fundamentals, Theory and Design" Special Indian Edition, CRC Press 2011.

MODELING AND CONTROL OF POWER ELECTRONIC SYSTEMS

Contact Hours/ Week	: 2+2+0(L+T+P)	Credits:	3
Total Lecture Hours	: 26	CIE Marks:	50
Tutorial/ Practical	: 26	SEE Marks:	50
Sub. Code	: N2EPE03		

Course objective: The objective of this course is learning the modelling of electrical system and thereby analyzing the operation of different types of power converters, course also emphasizes on analysis of advanced control techniques for control of power modulators.

Course Outcomes: Upon completion of this course the student will be able to:

CO1: Understand the modeling techniques of electrical systems and Analyze the operation of DC/DC (boost, buck and buck boost, cuk, sepic) converter.

CO2: Analyze the Dynamic Performance of DC-DC Converter and Modeling of DC-DC Converter

CO3: Analyze and evaluate the performance of the Closed Loop Control of Power Converter

CO4: Analyze the performance of Current Programmed Control for DC-DC Converter

CO5: Analyze the operation of Soft Switching Converters

UNIT 1

Modeling of Systems: Input-Output relations, differential equations and linearization, state space representation, transfer function representation of a simple RC, RL circuit, DC shunt motor. Review of DC/DC (boost, buck, buck-boost, cuk and SEPIC) converter in continuous and discontinuous mode of operation. **(5+5) Hrs.**

UNIT 2

Dynamic Performance of DC-DC Converter: Introduction, dynamic and output equation of a converter, modeling of non-ideal flyback converter, average model and steady state solution, small signal model, generalized state space model of converter with buck, boost and buck-boost converters as examples. **(6+6) Hrs.**

UNIT 3

Closed Loop Control of Power Converter: Introduction, control requirements, structure and design of compensators, close loop performance function, Effect of input filters on converter performance (audio susceptibility, input admittance, output impedance, control voltage gain, control current gain). **(5+5) Hrs.**

UNIT 4

Current Programmed Control: Introduction, Sub-harmonics instability in current-z programmed control, determination of duty ratio for current programmed control (buck, boost and buck- boost converter), Current programmed control transfer function (buck, boost and buck-boost converter).

(5+5) Hrs.

UNIT 5

Soft Switching Converters: Introduction, Resonant load converter, SMPS using resonant circuit, steady state modeling of SMPS, Approximate design procedure, Buck converter using zero current switching, Boost converter with zero voltage switching. Resonant switching circuit with active clamp (analysis only for buck converter). **(5+5) Hrs.**

REFERENCE BOOKS

Sl. No.	**Authors/s**	**Title, Publisher, Edition, Year, ISBN**
1.	M.B.Patil, V.Ramanarayanan, V.T.Ranganathan	Simulation of Power Electronic Circuits, Narosa Publishing House,1st edition,2013, ISBN: 978-81- 7319-989-9.
2	V. Ramanarayanan	Course Material on Switched Mode Power Conversion, Department of Electrical Engineering, Indian Institute of Science, Bangalore 560012.
3	Ned Mohan, Tore M. Undeland, William P. Robbins	Power Electronics Converters, Applications, and Design, Wiley India Pvt Ltd,3rd edition,2011, ISBN: 978-0-471-22693-2.
4	L.Umanand	Power Electronics Essentials and Applications, John Wiley & Sons,1st Edition,2009. ISBN: 9788126519453.
5	Antoneta Iuliana Bratcu and Seddik Bacha	Power Electronic Converters Modeling and Control: With Case Studies, Springer Publication,1st edition, 2013, ISBN 978-1-4471-5478-5.

PROFESSIONAL ELECTIVE-II

PWM CONVERTERS AND APPLICATIONS

Contact Hours/ Week	:2+2+0 (L+T+P)	Credits:	3
Total Lecture Hours	: 26	CIE Marks:	50
Tutorial/ Practical	: 26	SEE Marks:	50
Sub. Code	: N2EPEE21		

Course Objectives:

1. Understand pulse width modulation techniques for1-phase and 3-phase bridge converters, sine-triangle PWM, bus clamping PWM, space vector based PWM, advanced PWM techniques
2. Understand the calculation of switching and conduction losses; compensation for dead time and DC voltage regulation.
3. Understand the estimation of current ripple and torque ripple in inverter fed drives.
4. Understand over modulation; extension of modulation methods to multilevel inverters.

Course Outcomes: Upon completion of this course the student will be able to:

CO1: Analyze basic concepts of PWM control method.

CO2: Analyze basic and explore advance PWM methods for inverters and converters.

CO3: Evaluate performance parameters like current ripple, torque ripple and losses

CO4: Design a PWM controller for a given application.

UNIT 1

Introduction to pulse width modulation (PWM)- Overview of converters and control methods. Purpose of PWM control of converters, Fourier series, Harmonic voltages and their effects. Basic PWM techniques: Triangle-comparison based PWM: single pulse. Multiple pulse, SPWM, modified SPWM and phase displacement techniques, Third harmonic injection PWM (THIPWM), Bus-clamping PWM. **(05+05) Hrs.**

UNIT 2

Advanced PWM Techniques: Hysteresis band current control PWM, Harmonic Cancellation techniques Concept of space vector, Conventional space vector PWM and bus-clamping PWM, Advanced bus-clamping PWM, Comparison of PWM techniques, Voltage and frequency control of single phase and three-phase inverters. **(06+06) Hrs.**

UNIT 3

Analysis of line current ripple: Transformation from stationary reference frame to synchronously revolving dq reference frame, Volt-second balance and instantaneous error voltage, Calculation of

RMS line current ripple, Space vector-based hybrid PWM for reduced line current ripple. Analysis of dc link current, Average and RMS values of dc link current. Analysis of torque ripple: Calculation of harmonic torques and RMS torque ripple, Hybrid PWM techniques to reduce ripple torque. **(05+05) Hrs.**

UNIT 4

Loss Calculations: Practical devices in converters, calculation of switching and conduction loss, PWM techniques for reduced switching loss compensation for dead time and DC voltage regulation. Effect of inverter dead-time: Effect of dead-time with continuous modulation and discontinuous modulation. **(05+05) Hrs.**

UNIT 5

Over modulation- Per-phase approach to over modulation, Space vector approach to over modulation, A perspective from the synchronously revolving d-q reference frame. PWM for multilevel inverters, Extension of sine-triangle modulation to three-level inverters, Extension of conventional space vector modulation to three-level inverters. **(05+05) Hrs.**

REFERENCE BOOKS

1	Mohan, Undeland and Robbins,	Power Electronics: Converter, Applications and Design, 3rdEdition, 2011, Wiley India, ISBN-13: 9781848003170
2	Erickson R W, Chapman Hall	Fundamentals of Power Electronics, 1st Edition, 1997, Springer Publisher, ISBN 0-412-08541-0
3	Joseph Vithyahil,	Power electronics-Principles and Applications, 2017, McGraw Hill Education, ISBN 9780070702394
4	NPTEL materials on	‘Pulse width Modulation for Power Electronic Converters’

DISTRIBUTED GENERATION AND MICROGRIDS

Contact Hours/ Week	: 2+0+2(L+T+P)	Credits:	4.0
Total Lecture Hours	:26	CIE Marks:	50
Tutorial/ Practical	:26	SEE Marks:	50
Sub. Code	: N2EPEE22		

Course objectives:

1. To illustrate the concept of distributed generation
2. To analyze the impact of grid integration.

3. To study concept of Micro grid and its configuration
4. To find optimal size, placement and control aspects of DGs

Course Outcomes: After the completion of the course, the student will be able to

CO1: Identify the size and optimal placement of DG.

CO2: Analyze the impact of grid integration and control aspects of DGs.

CO3: Model and analyze a micro grid taking into consideration the planning and operational issues of the DGs to be connected in the system.

CO4: Classify the technical impacts of DGs in power systems.

UNIT 1

Need for Distributed generation. Renewable sources in distributed generation and current scenario in Distributed Generation. **(05+05) Hrs**

UNIT 2

Planning of DGs. Sitting and sizing of DGs optimal placement of DG sources in distribution systems. Grid integration of DGs Different types of interfaces, Inverter based DGs and rotating machine-based interfaces. Aggregation of multiple DG units. **(06+06) Hrs**

UNIT 3

Technical impacts of DGs. Transmission systems Distribution Systems Deregulation Impact of DGs upon protective relaying. Impact of DGs upon transient and dynamic stability of existing distribution systems, Steady-state and Dynamic analysis. **(05+05) Hrs**

UNIT 4

Economic and control aspects of DGs Market facts. Issues and challenges, Limitations of DGs, Voltage control techniques. Reactive power control, Harmonics Power quality issues, Reliability of DG based systems**.** **(05+05) Hrs.**

UNIT 5

Introduction to micro-grids. Types of micro-grids: autonomous and non-autonomous grids Sizing of micro-grids. Modeling & analysis of Micro-grids with multiple DGs. Micro-grids with power electronic interfacing units**.** **(05+05)Hrs**.

Text Books:

1. H. Lee Willis, Walter G. Scott, "Distributed Power Generation – Planning and Evaluation", Marcel Decker Press.
2. S. Chowdhury .S. P. Chowdhury, P. Crossley ,'Micro Grid and Active Distribution Networks'IET Publication, 2009.
3. Gevorg Gharehpetian Mohammad Mousav,' Distributed Generation Systems' Butter-worth - Heinemann, 2017.

ELECTROMAGNETIC COMPATIBILITY

Contact Hours/ Week	: 2+0+2(L+P+T/SDA)	Credits:	3.0
Total Lecture Hours	: 26	CIE Marks:	50
Tutorial/ Practical	: 26	SEE Marks:	50
Sub. Code	: N2EPEE23		

Course objective:

1. To familiarize with the problems of EMI and various EMC standards.
2. To design systems complying with EMC guidelines.

Course Outcomes:

Upon completion of this course the student will be able to:

CO1: Analyse the real-world EMC design constraints and make appropriate trade-offs to achieve the most cost-effective design that meets all requirements.

CO2: Design electronic systems that function without errors or problems related to electromagnetic compatibility.

CO3: Diagnose and solve basic electromagnetic compatibility problems and design the cable routing & connection and understand the interconnection techniques.

UNIT 1

Review of EMI Theory: Introduction to EMI, Noise and Interference, Designing for Electromagnetic Compatibility, EMC Regulations, The Regulatory Process, Typical Noise Path, Methods of Noise Coupling, Conductively Coupled Noise, Common Impedance Coupling, Electric and Magnetic Field Coupling, Miscellaneous Noise Sources, Use of Network Theory.

(05+05) Hrs.

UNIT 2

Cabling: Capacitive coupling, effect of shield on magnetic coupling, mutual inductance calculations, magnetic coupling between shield and inner conductor, shielding to prevent magnetic radiation, shielding a receptor against magnetic fields, shield transfer impedance, example of selective shielding, co-axial cable versus shielded twisted pair braided shields, Grounding of Cable Shields. **(05+05) Hrs.**

UNIT 3

Shielding: Near Fields and Far Fields, Characteristic and Wave Impedances, Shielding Effectiveness, Absorption Loss, Reflection Loss, Reflection Loss to Plane Waves, Reflection Loss in the Near Field, Electric Field Reflection Loss, Magnetic Field Reflection Loss, General Equations for Reflection Loss, Multiple Reflections in Thin Shields. **(06+06) Hrs.**

UNIT 4

EMC Requirements for Electronic Systems: Governmental Requirements, Requirements for Commercial Products, Requirements for Military Products Marketed, Measurement of Emissions for Verification of Compliance, A Simple Example to Illustrate the Difficulty in Meeting the Regulatory Limits, Requirements for Commercial Aircraft, Requirements for Commercial Vehicles, Design Constraints for Products, Advantages of EMC Design. **(05+05) Hrs.**

UNIT 5

EMC Applications: Digital Circuit Power Distribution, Power Supply Decoupling, Transient Power Supply Currents, Transient Load Current, Dynamic Internal Current, Total Transient Current, Decoupling Capacitors, Effective Decoupling Strategies, Multiple Decoupling Capacitors, Multiple Capacitors of the Same Value. Target Impedance, Embedded PCB Capacitance, Power Supply Isolation. Power Entry Filters. **(05+05) Hrs.**

REFERENCE BOOKS:

Sl. No.	**Author/s**	**Title, Publisher, Edition, Year, ISBN**
1	Ott H. W.,	"Noise Reduction Techniques in Electronic Systems", John Wiley and Sons, 2nd Edition, 1988, ISBN-13: 978-0471850687
2	Paul Clayton,	"Introduction to Electromagnetic Compatibility", Wiley Interscience, 2nd Edition,2006, ISBN-13: 978-8126528752
3	William B. Greason	"Electrostatic Damage in Electronics: Devices and Systems", Research Studies Press, 1987
4	Joseph Di Giacomo,	"Digital Bus Hand Book", McGraw Hill Publishing Company, 1990, ISBN-13: 978-0070169234
5	White, R. J.,	"Handbook Series of Electromagnetic Interference and Compatibility", Don White consultants Inc. 1980 (Ott H. W UNIT-1,2,4,5-chapter-1,2,6,11 UNIT-2 Paul Clayton chapter-2)

DESIGN OF POWER ELECTRONIC CONVERTERS

Contact Hours/ Week	: 2+2+0(L+T+P)	Credits: 3
Total Lecture Hours	: 26	CIE Marks: 50
Tutorial/ Practical	: 26	SEE Marks: 50
Sub. Code	: N2EPEE24	

Course Objectives: This course will enable students to:

1. understand the theory and applications of Power semiconductor devices.
2. understand the switching characteristics of different power electronics switches and different types of gate drive control.
3. understand the design of snubber for power electronics circuits and their applications.
4. understand various losses in power converter circuits.
5. understand the EMI and solutions for EMI.

Course Outcomes:

CO1: Apply the knowledge of Power semiconductor devices to study the switching characteristics

CO2: Understand and design of gate driver circuits

CO3: Identify and analyze the snubbers for different damping conditions

CO4: Analyze different types of losses in Power converters

CO5: Identify the EMI in converter design and design the solution for EMI

UNIT 1

Power semiconductor devices and Analysis of power electronic converters: Introduction, Different types of power diode, Diode characteristics, Choosing Diode based on data sheet, MOSFET, switching characteristics of MOSFET, Choosing MOSFET based on data sheet, IGBT, switching characteristics of IGBT, Choosing IGBT based on data sheet, Analysis of Buck Converter, Choosing L and C, Design Example of Buck Converter, Analysis of H Bridge, Bipolar PWM, Unipolar PWM, Bipolar vs Unipolar PWM. **(06+06)Hrs.**

UNIT 2

Gate drivers: Introduction to Gate Drivers, Gate Driver requirements, Optocouplers based Gate Drivers and it types, Desat Protection, Bootstrapping, Pulse Transformer based Gate Drivers

(05+05) Hrs.

UNIT 3

Snubber design: Introduction to Snubbers, RC Snubber Analysis, RC Snubber Analysis for Underdamped, **overdamped &** Case, RC Snubber Design, RCD Snubber Design. **(05+05) Hrs.**

UNIT 4

Thermal design: Power Loss and it types, Different types of Thermal Modelling, Choosing Heat Sinks. Magnetics Design: Magnetic Losses, Magnetic Materials, Magnetic cores, Inductor Design and Transformer Design. **(05+05) Hrs.**

UNIT 5

Electromagnetic interference in power electronic converters: Introduction to EMI, EMI Measurement, EMI in power electronics, CM & DM Noise, EMI filters, Design solution for EMI**.**

(05+05) Hrs.

TEXT BOOKS

Sl. No.	**Author/s**	**Title, Publisher, Edition, Year, ISBN**
1	Ned Mohan, Tore M. Undeland, William P. Robbins	"Power Electronics: Converters, Applications, and Design", 3rd Ed. Wiley, 2007.
2	Muhammad H. Rashid	"Power Electronics: Circuits, Devices and Applications", 4th Ed. Pearson Education, 2017

PROFESSIONAL ELECTIVE-III

HVDC AND FACTS

Contact Hours/ Week	: 2+2	Credits:	3
Total Lecture Hours	: 26	CIE Marks:	50
Tutorial/ Practical	: 26	SEE Marks:	50
Sub. Code	: N2EPEE31		

Course Objectives:

1. To comprehend the conversion principles of HVDC Transmission
2. Analysis of 6 pulse converters, rectifier, and inverter operations of HVDC converters
3. To comprehend the fundamentals of FACTS Controllers, Importance of controllable parameters and types of FACTS controllers & their benefits
4. To outline Objectives of Shunt and Series compensation
5. To relate to the Control of STATCOM and SVC and their comparison & the regulation of STATCOM.
6. To explain Functioning and control of GCSC, TSSC and TCSC

Course Outcomes:

Upon completion of this course the student will be able to:

CO1: Interpret the basic concepts & analytical knowledge of HVDC convert circuits

CO2: Describe the concept of control & protection aspects of HVDC link

CO3: Interpret the basic concepts of FACTS devises & Design of SVC controller

CO4: Interpret the basics of Thyristor and GTO Controlled Series Capacitor

CO5: Describe the concept of Static Synchronous Compensator (STATCOM)

UNIT 1

Line commutated converters: Introduction, Analysis of LCC, choice of converter configuration, Analysis of HVDC Converters: Effects of source inductance for u<60, equivalent circuits and characteristics of 6 pulse converter. **(06+06) Hrs.**

UNIT 2

Control and Protection Methods: DC link control principles, converter control characteristics, firing angle control, fault development and protection schemes. DC Protection devices, DC reactor and its design Consideration, Review of basics of power transmission networks. **(05+05) Hrs.**

UNIT 3

Introduction to FACTS Devices. Effect of series and shunt compensation at the mid-point of the line on power transfer- types of FACTS controllers. Static Var Compensator: Analysis of SVC - Configuration of SVC- SVC Controller –applications of SVC. **(05+05) Hrs.**

UNIT 4

Thyristor and GTO Controlled Series Capacitor: Introduction – basic concepts of controlled series compensation -operation of TCSC - analysis of TCSC- control of TCSC - Introduction of GTO thyristor-controlled series capacitor (GCSC) - applications of TCSC & GCSC. **(05+05) Hrs.**

UNIT 5

Static Synchronous Compensator (STATCOM): Introduction – principle of operation of STATCOM - a simplified analysis of a three phase six pulse STATCOM - applications of STATCOM. **(05+05) Hrs.**

REFERENCE BOOKS

Sl. No.	**Author/s**	**Title, Publisher, Edition, Year, ISBN**
1	K. R. Padiyar	"HVDC Power Transmission Systems: Technology and System Interactions", New Age International, 2ndEdition, 2017, ISBN 10: 1781831076
2	K.R Padiyar	"FACTS Controllers in Power Transmission and Distribution", New Age International, 2007, ISBN8122421423, 9788122421422
3	E.W.Kimbark	"Direct Current Transmission", Wiley Inter-Science, London, Vol.1, 2006, **ISBN:** 0-470-21706- 5
4	Narain G Hingorani and L. Gyugyi	"Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems", Wiley India, 2011. **ISBN:** 0-7803-3455-8
5	Y. H. Song and A. T. Johns	"Flexible AC Transmission System", Institution of Engineering and Technology, 2009, ISBN: 978-1-62870-460-0

Hybrid Electric Vehicles

Contact Hours/ Week	: 2+2+0(L+T+P)	Credits:3
Total Lecture Hours	: 26	CIE Marks:50
Tutorial/ Practical	: 26	SEE Marks:50
Sub. Code	: N2EPEE32	

Course objectives: After completing the course, the students will be able to:

1. Understand the fundamental concepts and principles of electric vehicles.
2. Explore the working principle of electric vehicles.
3. understand key roles played by motors as propulsion systems and requirements for battery and it management systems.
4. emphasizes the EV business and the future trends in the development of electric vehicles.

Course outcomes: After completing the course, the students will be able to:
CO1: Apply the basics of electric and hybrid electric vehicles, their architecture, technologies and fundamentals.

CO2: Analyze the use of different power electronics converters and electrical machines in hybrid electric vehicles.

CO3: Able to interpret the working of different configurations of electric vehicles and its components, hybrid vehicle configurations.

CO4: Explain the use of different energy storage systems used for hybrid electric vehicles, their control techniques, and select appropriate energy balancing technology.

CO5: Ability to understand the control and configurations of HEV charging stations.

UNIT 1

Introduction to Electric Vehicle: Introduction, EV Historical Background, Benefits of Using Evs, Overview of types of Evs and its Challenges, Overview of Electric Vehicles in India, EV Motor Drive Technologies, Energy Source Technologies. **(05+05) Hrs.**

UNIT 2

Vehicle Dynamics and system configurations: Vehicle Dynamics intro and tractive effort, Vehicle Dynamics and dynamic equation, EV Subsystems and Configurations, HEV Subsystems and Configurations, HEV modes of operation **(05+05) Hrs.**

UNIT 3

EV Motors and Controllers: Fundamentals and Design. Electric vehicle motors, flow of energy, understanding torque, motor dynamics, electric vehicle controllers, field-oriented control, Thermal design. **(05+05) Hrs.**

UNIT 4

Electric Propulsion Systems: Basic Principles of BLDC Motor Drives, BLDC Machine Construction and Classification, application to Electric Vehicles. Switched Reluctance Motor Drives, Basic Magnetic Structure, Torque Production, SRM Drive Converter, Modes of Operation, Generating Mode of Operation, application to Electric Vehicles. **(05+05) Hrs.**

UNIT 5

Introduction to Energy Storage Requirements: Requirements for Battery Systems in Electric Vehicles, Types of Batteries, Key Battery Management Technologies, Typical Structure of Battery Management Systems. **(06+06) Hrs.**

Text Books:

1. Emadi, A. (Ed.), Miller, J., Ehsani, M., "Vehicular Electric Power Systems" Boca Raton, CRC Press, 2003.

2. Iqbal Husain, "ELECTRIC and HYBRID VEHICLES: Design Fundamentals", CRC PRESS Boca Raton London New York Washington, D.C., 2003.

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

Reference Books:

1. Mehrdad Ehsani, Yimin Gao, Sebastien E. Gay, Ali Emadi, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design", CRC PRESS Boca Raton London New York Washington, D.C., 2009.

2. Shen, Weixiang Xiong, Rui," Advanced battery management technologies for electric vehicles" 2019, John Wiley & Sons.

SPECIAL ELECTRICAL MACHINES

Contact Hours/ Week	: 2+0+2	Credits:	3.0
Total Lecture Hours	: 26	CIE Marks:	50
Tutorial/ Practical	: 26	SEE Marks:	50
Sub. Code	: N2EPEE33		

Course Objectives:

1. To impart knowledge of construction and principle of operation of various special electrical machines.
2. To expose students to the various applications of Special Electrical Machines.

Course Outcomes:

Upon completion of this course the student will be able to:

CO1: Analyze the construction, working and applications of permanent magnet synchronous motors

CO2: Analyze the construction, working and applications of permanent magnet DC motors and permanent magnet synchronous motors and Synchronous Reluctance Motor.

CO3: Analyze the construction, working and applications of switched reluctance motor.

CO4: Analyze the control schemes of Stepper Motors.

CO5: Analyze the working of Linear Induction Motor, Hysteresis Motor and Repulsion Motor.

UNIT 1

Permanent Magnet Synchronous Motor (PMSM): Construction, Principle of Operation, EMF Equation, Torque Equation, Phasor Diagram, Circle Diagram, Comparison of Conventional and PMSM, Applications **(05+05) Hrs.**

UNIT 2

Permanent Magnet DC Motor and Brushless Permanent Magnet DC Motor: Permanent Magnet DC (PMDC) motor, Brushless Permanent Magnet DC (BLDC) Motors.

Synchronous Reluctance Motor (SyRM): Construction of SyRM, Working, Phasor Diagram and Torque Equation, Advantages and Applications. **(06+06) Hrs.**

UNIT 3

Switched Reluctance Motor (SRM): Construction, Principle of Working, Basics of SRM Analysis, Constraints on Pole Arc and Tooth Arc, Torque Equation and Characteristics, Power Converter Circuits, Rotor Position Sensors, Current Regulators. **(05+05) Hrs.**

UNIT 4

Stepper Motors: Constructional features –Principle of operation –Types – Torque predictions – Linear Analysis – Characteristics – Drive circuits – Closed loop control – Concept of lead angle - Applications. **(05+05) Hrs.**

UNIT 5

Other Special Machines: Constructional features – Principle of operation and Characteristics of Hysteresis motor-Linear Induction motor-Repulsion motor- Applications. **(05+05) Hrs.**

REFERENCE BOOKS

1. Special Electrical Machines, E.G. Janardanan, PHI, 1st Edition, 2014.
2. Special Electrical Machines, K Venkataratham, University Press, 2009.
3. Bose B. K, "Modern Power Electronics & AC Drives" PHI, 2011.
4. R.Krishnan "Electric Motor Drives", EEE, PHI, 2010.
5. Hamid Toliyat and Steven Campbell, "DSP-Based Electromechanical Motion Control", CRC Press, 2019.
6. G K Dubey, "Fundamentals of Electrical Drives", second edition, Narosa Publishing House, 2001
7. S.B.Dewan, G.R.Slemon, A.Straughen, "Power Semiconductor Drives", John Wiley and Sons, Inc, 1984
8. Mehrdad Ehsani, Yimin Gao, Alin Emadi, "Modern Electric, Hybrid Electric and Fuel Cell Vehicle Fundamentals, Theory and Design" Special Indian Edition, CRC Press 2011.

POWER ELECTRONICS IN SMART GRID

Contact Hours/ Week	:2+2+0(L+T+P)	Credits:	3
Total Lecture Hours	:26	CIE Marks:	50
Tutorial/ Practical	:26	SEE Marks:	50
Sub. Code	: N2EPEE34		

Course Objective:

1. Introduction to Smart Grid and an understanding of the relevance of it in global perspective.
2. To learn the Technology needed and Reforms and restructuring in Indian power sector.

3. To understand the Knowledge about intelligent and Strategic issues related to growth & development of Power Sector.

Course Outcomes:

Upon completion of this course the student will be able to:

CO1: To distinguish the difference between smart grid & conventional grid and identify fundamental problems in conventional grid

CO2: Formulate solutions in the areas of smart substations, distributed generation and wide area measurements

CO3: To understand the planning and operational issues related to Distributed Generation.

UNIT 1

Introduction: Introduction to smart grid, electricity network, local energy networks, electric transportation, low carbon central generation, fundamental problems of electrical power systems, power flow control, distributed generation and energy storage, attributes of the smart grid.

(06+06) Hrs.

UNIT 2

Power Control and Quality Problems: Introduction, general problems and solutions of power control, power quality and EMC, power quality issues, monitoring, legal and organizational regulations, mitigation methods, and EMC related phenomena in smart system, EMC cases in distributed power system. **High frequency AC Power Distribution Platform**: Introduction, high frequency in space applications, automotive and motor drives, micro grids. **(05+05) Hrs.**

UNIT 3

Integration of Distributed Generation with Power System and Active Power Controllers: Distributed generation past and future, interconnection with a hosting grid, integration and interconnection concerns, power injection principle, injection using static compensators and advanced static devices, distributed generation contribution to power quality problems and current challenges. Dynamic static synchronous controllers, D – STATCOM, Dynamic static synchronous series controllers, dynamic voltage restorer, AC/AC voltage regulators. **(05+05) Hrs.**

UNIT 4

Energy Storage Systems: Introduction, structure of power storage devices, pumped – storage hydroelectricity, compressed air energy storage system, battery storage, hydrogen storage, super conducting magnet energy storage, super capacitors, applications of energy storage devices.

(05+05) Hrs.

UNIT 5

COMPUTATIONAL TOOLS FOR SMART GRID DESIGN: Introduction to Computational Tools, Decision Support Tools, Optimization Techniques, Classical Optimization Method, Heuristic Optimization, Evolutionary Computational Techniques, Adaptive Dynamic Programming Techniques, Pareto methods, Hybridizing Optimization Techniques and Applications to the Smart Grid, Computational Challenges. Pathway for Designing Smart Grid: Introduction to Smart Grid Pathway Design, Barriers and Solutions to Smart Grid Development, Solution Pathways for Designing Smart Grid Using Advanced Optimization and Control Techniques for Selection Functions, General Level Automation, Bulk Power Systems Automation of the Smart Grid at Transmission Level, Distribution System Automation Requirement of the Power Grid, End User/Appliance Level of the Smart Grid, Applications for Adaptive Control and Optimization. **(05+05) Hrs.**

TEXT BOOKS

Sl.No	**Author/s**	**Title, Publisher, Edition, Year, ISBN**
1	Strzelecki Benysek	Power Electronics in Smart Electrical Energy Networks", Springer, 2008. ISBN 978-1-84800-318-7
2	Clark W Gellings	The Smart Grid: Enabling Energy Efficiency and Demand Side Response", CRC Press, 2009. 13: 978-1439815748
REFERENCE BOOKS		
1	James Momoh	Smart Grid: Fundamentals of Design and Analysis", IEEE Press, 2012. ASIN: B007KGE58K

POWER ELECTRONICS LABORATORY – II

Contact Hours/ Week	: 1+2+0(L+T+P)	Credits:	1.0
Total Lecture Hours	:13	CIE Marks:	50
Tutorial/ Practical	:13	SEE Marks:	50
Sub. Code	: N2EPEL01		

Course Objectives: student will be able to:

1. Show awareness of the impact of power electronic circuits on motor control
2. Understand hardware and simulation models of PV systems.
3. Familiarize with the battery charging and discharging application.

Course Outcomes:

CO1: To analyze, design and study motor control
CO2: To analyze, design and study PV systems
CO3: To analyze, design and study Wind turbine systems
CO4: To analyze, design converter for battery charging and discharging application

List of Experiments

1. Cycloconverter based AC Induction motor control equipment.
2. Performance study of Li-ion battery characteristics
3. Simulation of bi-directional DC-DC converter for Battery applications.
4. Wind Turbine Modeling and Simulation using Matlab -simulink.
5. Solar Panel Modeling and Simulation using Matlab –simulink.
6. Performance evaluation of solar PV collector for series and parallel connection.
7. Power flow calculations of stand-alone PV system with DC load and battery
8. Power flow calculations of stand-alone PV system with AC load and battery
9. Power flow calculations of stand-alone PV system with DC and AC load and battery
10. Study of charging and discharging characteristics of battery.

NANO SCIENCE AND NANO TECHNOLOGY

Contact Hours/ Week	: 3+0+0(L+T+P)	Credits:	3
Total Lecture Hours	: 40	CIE Marks:	50
Total Tutorial Hours	: -	SEE Marks:	50
Course Code	: N2OE01		

Course Objectives: This course will enable students to:

1. To understand the foundational knowledge of the Nanoscience and related fields.
2. To understand the Nanoscience and Applications.
3. To understand the synthesis of nanomaterials and their application and the impact of nanomaterials on environment.

Course Outcomes: Upon completion of this course the student will be able to:

CO1: Learn basic material science with special, emphasize on nanomaterials
CO2: Explain and comprehend the physio-chemical methods for synthesis of nanoparticles.
CO3: Describe the various characterization techniques of nano materials.
CO4: Understand basic properties of nanoparticles.
CO5: Understand accurate description of optical properties of material at nanoscale.

Unit I

Introduction: Definition of Nano, Scientific Revolution-Atomic Structure & atomic size, emergence & challenges of nanoscience, carbon age-new form of carbon (CNT- Graphene), influence of nano over micro/macro, size effects and crystals, large surface to volume ration, surface effects on the properties. **8 Hrs**

Unit II

PHYSICO-CHEMICAL METHODS OF NANOSTRUCTURED MATERIALS: Solution growth techniques of 1D-2D nano structures:- Synthesis of metallic, semiconducting and oxide nanoparticles – homo- and hetero-nucleation growth methods – template-based synthesis (electrochemical, electrophoretic, Melt and solution, CVD, ALD) – Gas Phase Synthesis of Nanopowders: – Vapor (or solution) – liquid – solid (VLS or SLS) growth – the Need for Gas/vapor State Processing – Main Stages of Gas Phase Synthesis – Applicability of the methods.

8 Hrs

Unit III

CHARACTERIZATION OF NANOPHASE MATERIALS: Fundamentals of the techniques – experimental approaches and data interpretation – applications/limitations of Xray characterization: – X-ray sources – wide angle, extended x-ray absorption technique – Electron microscopy: SEM/TEM – high resolution imaging – defects in nanomaterials – Spectroscopy: – electron energy-loss mechanisms – electron filtered imaging – prospects of scanning probe microscopes – optical spectroscopy of metal/semiconductor nanoparticles **8 Hrs**

Unit IV

NANOSCALE PROPERTIES: Magnetism:- Magnetic Moment in clusters/Nanoparticles – Magnetic Order – coercivity – Magnetocrystalline Anisotropy – thermal activation and Superparamagnetic effects – Electronics and Optoelectronics:- Quantum Confinement of Superlattices and Quantum Wells – Dielectric Constant of Nanoscale Silicon – Doping of a Nanoparticle – Excitonic Binding and Recombination Energies – Capacitance in a Nanoparticle – Diffusion in Nanocrystalline Materials –Diffusion In Grain Boundaries Of Metals. **8 Hrs**

Unit V

Optical Properties, Photoconductivity, Optical absorption & transmission, Photoluminescence, Fluorescence, Phosphorescence, Electroluminescence. Magnetic Materials: Basic Magnetic Phenomena; Diamagnetism, Paramagnetism, Ferromagnetism, Anti-ferromagnetism, Application of Nanomaterial molecular electronics, biological and environmental, membrane-based application, polymer-based applications in electrical engineering **8 Hrs**

TEXTBOOKS:

1.	Ajoy K. Ghatak, S. Lokanathan	Quantum Mechanics: Theory and Applications
2.	Chriss Bins	Introduction to Nanoscience and Nanotechnology 2nd ed., Wiley, A John Wiley & Sons, INC., Publication, 2010
3.	T. Pradeep	Nano The essentials, Understanding Nano science and Naotechnology, Tata McGraw-Hill Publishing Company Limited, NEW DELHI, 2007, DOI: 10.1036/0071548297, ISBN:9780071548298
4.	Wesley Crowell Sanders	Basic Principles of Nanotechnology, CRC Press; Taylor & Francis, 2018, 1351054406, ISBN 13: 9781351054409

REFERENCE BOOKS:

1.	G. Schmidt	Nanoparticles: From theory to applications 2nd ed., Wiley-VCH Verlag, Weinheim, 2010, ISBN: 978-3-527-32589-4
2.	Geoffrey A Ozin, André Arsenault, Ludovico Cademartiri	Nanochemistry: A Chemical Approach to Nanomaterials, Royal Society of Chemistry, Cambridge UK 2005.

BoS Recommended online course

Sl. No.	Course	Course Offering Institute
1	Power Electronics and Distributed Generation	IISc Bangalore
2	High Power Multilevel Converters- Analysis, design and operational issues	IIT Delhi
3	Energy Management Systems and SCADA	IIT Madras
4	Power Quality in Power Distribution Systems	IIT Madras
5	Advanced Electric Drives	IIT Kanpur
6	Introduction to Hybrid and Electric Vehicles	IIT Guwahati
7	Industrial Automation and Control	IIT Kharagpur
8	Introduction to Smart Grid	IIT Roorkee
9	Advance power electronics and Control	IIT Roorkee
10	Design and Simulation of Power conversion using open-source tools	IISc Bangalore
11	Fundamentals of Electric vehicles: Technology & Economics	IIT Madras
12	Electric vehicles and Renewable energy	IIT Madras
13	Fuzzy Sets, Logic and Systems & Applications	IIT Kanpur
14	Digital Control in Switched Mode Power Converters and FPGA-based Prototyping	IIT Kharagpur
15	Dc Microgrid and control systems	IIT Roorkee