ACADEMIC REGULATIONS
COURSE STRUCTURE
AND
DETAILED SYLLABUS

ELECTRICAL AND ELECTRONICS ENGINEERING

for

M.Tech. – POWER ELECTRONICS AND DRIVES

(Applicable from 2019-2020 Batches)

UNIVERSITY COLLEGE OF ENGINEERING KAKINADA *(Autonomous)*

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY: KAKINADA

KAKINADA - 533 003, ANDHRA PRADESH, INDIA

Vision and Mission of the Institute:

Vision:

To be a premier institute of excellence developing highly talented holistic human capital that contributes to the nation through leadership in technology and innovation through engineering education.

Mission:

1. To impart Personnel Skills and Ethical Values for Sustainable Development of the Nation.
2. To create Research & Industry oriented centers of excellence in all engineering disciplines.
3. To be a renowned IPR generator and repository for innovative technologies.
4. To develop Research and Industry oriented technical talent.
5. To benchmark globally the academic & research output.

Vision and Mission of the Department:

Vision:

To be in the forefront in advanced research in emerging areas of Electrical & Electronics Engineering, be proactive with industry in technology development and mould the department into a centre of academic excellence.

Mission:

1. To produce high quality Electrical and Electronics Engineering graduates with the requisite theoretical and practical knowledge.

2. To undertake research & development and extension activities in the field of Electrical and Electronics Engineering in the area of relevance for immediate application as well as for establishing and strengthening the fundamental knowledge.

3. To create social awareness and ethical values in the graduates so as to contribute in the progress of the society.

Programme Education Objectives (PEOs):

PEO1:	Design and develop innovative products and services in the field of Power Electronics & Drives.
PEO2:	Communicate effectively to propagate ideas and promote teamwork and keep abreast with the latest technology and toolset.
PEO3:	Attain intellectual leadership skills to cater to the changing needs of power industry, academia, society and environment.
PEO4:	To become socially and ethically responsible and pursue life-long learning.

Mapping of Mission statements to PEOs:

Mission of the Department	**Programme Education Objectives (PEOs)**			
	PEO1	**PEO2**	**PEO3**	**PEO4**
To produce high quality Electrical and Electronics Engineering graduates with the requisite theoretical and practical knowledge.				
To undertake research & development and extension activities in the field of Electrical and Electronics Engineering in the area of relevance for immediate application as well as for establishing and strengthening the fundamental knowledge.				
To create social awareness and ethical values in the graduates so as to contribute in the progress of the society.				

Rubrics:

L-Low**, M-**Medium**, H-**High

Programme Outcomes (POs):

PO1:	The graduate will be able to acquire in depth knowledge in the area of Power electronics and Drives.
PO2:	The graduate will attain the lateral thinking and problem solving capabilities in the area of Power Electronics and Drives.
PO3:	The graduate will obtain the capabilities of critical thinking, analyzing real world problems and handling the complexities to arrive feasible and optimal solutions considering societal and environmental factors.
PO4:	The graduate will be able to extract information through literature survey and apply appropriate research methodologies, techniques and tools to solve Power Electronics and Drives problems.
PO5:	The graduate will be able to use the state-of-the-art tools for modelling, simulation and analysis of problems related to Power Electronics and Drives.
PO6:	The graduate will be trained to assess social, health, safety, legal, cultural issues and She/he will also be trained on the consequent responsibilities relevant to the professional engineering practices.
PO7:	To sensitize the graduate about the impact of professional engineering solutions in social and environmental contents and demonstrates the knowledge of, and need for sustainable developments.
PO8:	The graduate will become socially responsible and follow ethical practices to contribute to the community for sustainable development of society.
PO9:	The graduate will be able to independently observe and examine critically the outcomes of his actions and reflect on to make corrective measures subsequently and move forward positively by learning through mistakes.
PO10:	The graduate will be able to communicate confidently, make effective presentations and write good reports to engineering community and society.
PO11:	The graduate will demonstrate knowledge and understanding of Power Electronics and Drives and management principles and apply the same for efficiently carrying out projects with due consideration to economical and financial factors.
PO12:	The graduate will recognize the need for life-long learning and have the ability to do it independently.

Programme Specific Outcomes (PSOs):

PSO1:	Able to apply the knowledge during the course of the program from basic computing and social science in general and all electrical courses in particular to identify, formulate and solve real life problems faced in industries and/or during research work.
PSO2:	Development of environment-conscious, new technologies to enhance the quality of human life.

Mapping of POs, PSOs to PEOs

Programme Outcomes (PO's)	Programme Education Objectives (PEOs)			
	PEO1	PEO2	PEO3	PEO4
PO1				
PO2				
PO3				
PO4				
PO5				
PO6				
PO7				
PO8				
PO9				
PO10				
PO11				
PO12				

Programme Specific Outcomes (PSOs)	Programme Education Objectives (PEOs)			
	PEO1	PEO2	PEO3	PEO4
PSO1				
PSO2				

Rubrics:

L-Low**, M-**Medium**, H-**High

COURSE STRUCTURE

I-M.Tech. I-Semester

S.No	Course No	Course Name	P.Os	Category	L	T	P	Credits	Marks
1	PC	Electrical Machine Modeling and Analysis			3	0	0	3	100
2	PC	Analysis of Power Electronic Converters			3	0	0	3	100
3	PE	Elective – I i. Modern Control Theory ii. Power Quality and Custom Power Devices iii. Programmable Logic Controllers & Applications			3	0	0	3	100
4	PE	Elective – II i. Artificial Intelligence Techniques ii. Renewable Energy Technologies iii. HVDC Transmission and Flexible AC Transmission Systems			3	0	0	3	100
5		Research Methodology and IPR			2	0	0	2	100
6		Power Electronics Simulation Laboratory			0	0	4	2	100
7		Power Converters Laboratory			0	0	4	2	100
8		Audit Course – 1			2	0	0	0	100
				Total	16	0	8	18	800

I-M.Tech. II Semester

S.No	Course No	Course Name	P.Os	Category	L	T	P	Credits	Marks
1	PC	Switched Mode Power Conversion			3	0	0	3	100
2	PC	Power Electronic Control of Electrical Drives			3	0	0	3	100
3	PE	Elective – III i. Energy Auditing, Conservation and Management ii. Hybrid Electric Vehicles iii. Advanced Digital Control Systems			3	0	0	3	100
4	PE	Elective – IV i. Advanced Digital Signal Processing ii. Evolutionary Algorithms and Applications iii. Microcontrollers			3	0	0	3	100
5		Electric Drives Simulation Laboratory			0		4	2	100
6		Electric Drives Laboratory			0	0	4	2	100
7		Mini Project with Seminar			0	0	4	2	100
8		Audit Course – 2			2	0	0	0	100
				Total	14	0	12	18	800

II-M.Tech. III Semester*

S.No	Course No	Course Name	P.Os	Category	L	T	P	Credits	Marks
1	PE	Program Elective – V i. Smart Grid Technologies. ii. Industrial Applications to Power Electronics Systems. iii. Optimization Techniques. iv. Swayam Courses			3	0	0	3	100
2	OE	Open Elective** i. Renewable Energy Technologies. ii. Hybrid Electric Vehicles. iii. Swayam Courses			3	0	0	3	100
3		Dissertation Phase - I **(to be continued and evaluated next semester)**			0	0	20	10	---
				Total	6	6	20	16	200

*Students can complete these courses through MOOCs (Swayam).

*Chairman in consultation with the local BoS members will float the list of allowed MOOC electives, each academic year.

* The student shall be encouraged to conduct the Project in the industry.

** Open Elective subjects are offered to other branches by EEE Department (except for EEE Branch).

II-M.Tech, IV Semester

S.No	Course No	Course Name	P.Os	Category	L	T	P	Credits	Marks
1		Dissertation Phase - II **(continued from III semester)**			0	0	32	16	100
				Total	0	0	32	16	

I-M.Tech I-Semester

COURSE CODE –	Electrical Machine Modeling and Analysis	PC	3-0-0	3

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

		Knowledge Level (K)#
CO1	Analyse the characteristics of different types of DC motors to design suitable controllers for different applications.	
CO2	Apply the knowledge of reference frame theory for AC machines to model the induction and Synchronous machines.	
CO3	Evaluate the steady state and transient behavior of induction and synchronous machines to Propose the suitability of drives for different industrial applications	
CO4	Analyse the behavior of induction machines using voltage and torque equations.	

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	Contact Hours
UNIT– 1	**Basic concepts of Modeling** Basic two-pole machine representation of Commutator machines, representations of 3-phase synchronous machine with and without damper bars and 3-phase induction machine, Kron’s primitive Machine voltage, current and torque equations.	
UNIT– 2	**DC Machine Modeling** Mathematical model of separately excited D.C motor – Steady state analysis-transient State analysis-sudden application of inertia load-transfer function of separately excited D.C motor- Mathematical model of D.C Series motor, Shunt motor-Linearization techniques for small perturbations	
UNIT– 3	**Reference frame theory & Modeling of single phase Induction Machines** Linear transformation-Phase transformation - three phase to two phase transformation (abc to $\alpha\ \beta\ 0$) and vice-versa, transformation to rotating reference frame, ($\alpha\ \beta\ 0$ to dqo) and vice versa -Power equivalence- Mathematical modeling of single phase induction machines.	
UNIT– 4	**Modeling of three phase Induction Machine** Generalized model in arbitrary reference frame-Derivation of commonly used induction machine models- Synchronously rotating reference frame model, Stator reference frame model-Rotor reference frame model--power equation, electromagnetic torque equation, state space model in induction motor with flux linkages as variables	
UNIT– 5	**Modeling of Synchronous Machine** Synchronous machine inductances –derivation of voltage equations in the rotor’s dq0 reference frame electromagnetic torque-current in terms of flux linkages-	

	three phase synchronous motor. State space models with flux linkages as variables.	
	Total	**48 Hrs**

Text Books

1. Analysis of Electric Machinery and Drive Systems, 3rd Edition-Wiley-IEEE Press- Paul Krause, Oleg Wasynczuk, Scott D. Sudhoff, Steven Pekarek, Junr 2013.
2. Electric Motor Drives - Modeling, Analysis& control -R.Krishnan- Pearson Publications- 1st edition -2002.

Reference Books:

1. Generalised theory of Electrical Machines - Fifth edition, Khanna Publishers P. S. Bimbhra, 1985.
2. Dynamic simulation of Electric machinery using Matlab / Simulink –CheeMunOng- Prentice Hall, 2003.
3. Magneto electric devices transducers, transformers and machines- G. R. Slemon- Wiley in New York, London, 1966.

I-M.Tech I-Semester

COURSE CODE –	Analysis of Power Electronic Converters	PC	3-0-0	3

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

		Knowledge Level (K)#
CO1	Describe and analyze the operation of AC-DC, DC-AC and AC-AC power converters.	
CO2	Analyze the operation of power factor correction converters.	
CO3	Analyze the operation of three phase inverters with PWM control.	
CO4	Study the principles of operation of multi level inverters and their applications.	

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	Contact Hours
UNIT– 1	**Overview of Switching Devices:** Power MOSFET, IGBT, GTO, GaN devices-static and dynamic characteristics, gate drive circuits for switching devices.	
UNIT– 2	**AC-DC converters:** Single phase fully controlled converters with RL load– Evaluation of input power factor and harmonic factor-Continuous and Discontinuous load current, Power factor improvements, Extinction angle control, symmetrical angle control, PWM control. Three Phase AC-DC Converters, fully controlled Converters with RL load, Evaluation of input power factor and harmonic factor, Continuous and Discontinuous load current-three phase dual converters.	
UNIT– 3	**Power Factor Correction Converters:** Single-phase single stage boost power factor corrected rectifier, power circuit principle of operation, and steady state-analysis, three phase boost PFC converter	
UNIT– 4	**PWM Inverters:** Principle of operation-Voltage control of single phase inverters - sinusoidal PWM – modified PWM – phase displacement Control – Trapezoidal, staircase, stepped, harmonic injection and delta modulation. Voltage Control of Three-Phase Inverters- Sinusoidal PWM- 60^0 PWM- Third Harmonic PWM- Space Vector Modulation- Comparison of PWM Techniques- Three phase current source inverters-Variable dc link inverter.	
UNIT– 5	**Multi level inverters:** Introduction, Multilevel Concept, Types of Multilevel Inverters- Diode-Clamped Multilevel Inverter, Principle of Operation, Features of Diode-Clamped Inverter, Improved Diode-Clamped Inverter- Flying-Capacitors Multilevel Inverter- Principle of Operation, Features of Flying- Capacitors Inverter- Cascaded Multilevel Inverter- Principle of Operation- Features of Cascaded Inverter- Switching Device Currents-DC-Link Capacitor Voltage	

	Balancing- Features of Multilevel Inverters- Comparisons of Multilevel Converters.	
	Total	**48 Hrs**

Text Books

1. Power Electronics-Md.H.Rashid –Pearson Education Third Edition- First IndianReprint-2008.
2. Power Electronics Daniel W. Hart - McGraw-Hill,2011.

Reference Books:

1. Elements of Power Electronics – Philip T. Krein, Oxford University press, 2014.
2. Power Electronics: Converters, Applications, and Design- Ned Mohan, Tore M. Undeland, William P. Robbins, John Wiley& Sons, 2nd Edition, 2003.
3. Power Converter Circuits – William Shepherd & Li Zhang-Yes Dee CRC Press, 2004.

I-M.Tech I-Semester

COURSE CODE –	Modern Control Theory (Elective-I)	PE	3-0-0	3

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

		Knowledge Level (K)#
CO1	Formulate and solve the state equations of dynamic systems, analyze controllability and observability.	
CO2	Design a state feedback controller; design an observer.	
CO3	Linearize a nonlinear system model; analyze non linear systems through describing functions.	
CO4	Determine the stability of a given system; generate a Lyapunov function.	
CO5	Minimize a given functional, design an optimal feedback gain matrix.	

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	Contact Hours
UNIT– 1	**State Variable Analysis** The concept of state – State Equations for Dynamic systems– Solution of Linear Time Invariant Continuous-Time State Equations, State transition matrix and it’s properties. Controllability and Observability of state model in Jordan Canonical form - Controllability and Observability Canonical forms of State model	
UNIT– 2	**Design using state variable technique** Design of state feedback controller through pole placement technique-Necessary and sufficient condition- Ackermann’s formula. Concept of observer-Design of full order state observer-reduced order observer.	
UNIT– 3	**Non Linear Systems** Classification of Nonlinearities- common physical nonlinearities– Characteristics of nonlinear systems - Singular Points –Linearization of nonlinear systems–Describing function – describing function analysis of nonlinear systems- Stability analysis of Nonlinear systems through describing functions.	
UNIT– 4	**Stability Analysis** Stability in the sense of Lyapunov, Lyapunov’s stability and Lyapunov’s instability theorems – Stability Analysis of Linear Continuous time invariant systems by Lyapunov method – Generation of Lyapunov functions – Variable gradient method – Krasooviski’s method.	
UNIT– 5	**Introduction to Optimal Control** Minimization of functional of single function – Constrained minimization – Minimum principle – Control variable inequality constraints – Control and state variable inequality constraints – Euler lagrangine equation.	

	Typical optimal control performance measures-optimal control based on Quadratic performance measures- Quadratic optimal regulator systems- State regulator problems –Output regulator problems, tracking problems; Riccati equation-Infinite time regulator problem-Reduce matrix Reccati equation-determination of optimal feedback gain matrix	
	Total	**48 Hrs**

Text Books:

1. Modern Control Engineering – by K. Ogata, Prentice Hall of India, 3rd edition, 1998.
2. Automatic Control Systems by B.C. Kuo, Prentice Hall Publication.

Reference Books:

1. Modern Control System Theory – by M. Gopal, New Age International Publishers, 2nd edition,1996
2. Control Systems Engineering by I.J. Nagarath and M.Gopal, New Age International (P) Ltd.
3. Digital Control and State Variable Methods – by M. Gopal, Tata McGraw–Hill Companies, 1997.
4. Systems and Control by Stainslaw H. Zak , Oxford Press, 2003.
5. Optimal control theory: an Introduction by Donald E.Kirk by Dover publications.
6. Modern control systems, Richard C. Dorf and Robert H. Bishop, 11th Edition, Pearson Edu, India, 2009

I-M.Tech I-Semester

COURSE CODE –	Power Quality and Custom Power Devices (Elective-I)	PE	3-0-0	3

Pre-requisite:

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

		Knowledge Level (K)#
CO1	Identify the issues related to power quality in power systems.	
CO2	Address the problems of transient and long duration voltage variations in power systems.	
CO3	Analyze the effects of harmonics and study of different mitigation techniques.	
CO4	Identify the importance of custom power devices and their applications.	
CO5	Acquire knowledge on different compensation techniques to minimize power quality disturbances.	

 # Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												
CO6												

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	Contact Hours
UNIT– 1	**Introduction to power quality:** Overview of Power Quality, Concern about the Power Quality, General Classes of Power Quality Problems, Voltage Unbalance, Waveform Distortion, Voltage fluctuation, Power Frequency Variations, Power Quality Terms, Voltage Sags, swells, flicker and Interruptions - Sources of voltage and current interruptions, Nonlinear loads.	
UNIT– 2	**Transient and Long Duration Voltage Variations** Source of Transient Over Voltages - Principles of Over Voltage Protection, Devices for Over Voltage Protection, Utility Capacitor Switching Transients, Utility Lightning Protection, Load Switching Transient Problems. Principles of Regulating the Voltage, Device for Voltage Regulation, Utility Voltage Regulator Application, Capacitor for Voltage Regulation, End-user Capacitor Application, Regulating Utility Voltage with Distributed generation	
UNIT– 3	**Harmonic Distortion and solutions** Voltage vs. Current Distortion, Harmonics vs. Transients - Power System Quantities under Non-sinusoidal Conditions, Harmonic Indices, Sources of harmonics, Locating Sources of Harmonics, System Response Characteristics, Effects of Harmonic Distortion, Inter harmonics, Harmonic Solutions Harmonic Distortion Evaluation, Devices for Controlling Harmonic Distortion, Harmonic Filter Design, Standards on Harmonics	

UNIT– 4	**Custom Power Devices:** Custom power and custom power devices, voltage source inverters, reactive power and harmonic compensation devices, compensation of voltage interruptions and current interruptions, static series and shunt compensators, compensation in distribution systems, interaction with distribution equipment, installation considerations.	
UNIT– 5	**Application of custom power devices in power systems:** Static and hybrid Source Transfer Switches, Solid state current limiter - Solid state breaker. P-Q theory – Control of P and Q, Dynamic Voltage Restorer (DVR): Operation and control – Interline Power Flow Controller (IPFC): Operation and control of Unified Power Quality Conditioner (UPQC); Generalized power quality conditioner	
	Total	**48 Hrs**

Text Books:

1. Electrical Power Systems Quality, Dugan R C, McGranaghan M F, Santoso S, and Beaty H W, Second Edition, McGraw-Hill, 2002.
2. Understanding Power Quality Problems: Voltage Sags and Interruptions, Bollen M H J, First Edition, IEEE Press; 2000.
3. Guidebook on Custom Power Devices, Technical Report, Published by EPRI, Nov 2000
4. Power Quality Enhancement Using Custom Power Devices – Power Electronics and Power Systems, Gerard Ledwich, Arindam Ghosh, Kluwer Academic Publishers, 2002.

Reference Books:

1. Power Quality Primer, Kennedy B W, First Edition, McGraw-Hill, 2000.
2. Power System Harmonics, Arrillaga J and Watson N R, Second Edition, John Wiley & Sons, 2003.
3. Electric Power Quality control Techniques, W. E. Kazibwe and M. H. Sendaula, Van Nostrad Reinhold, New York.
4. Power Quality c.shankaran, CRC Press, 2001
5. Harmonics and Power Systems –Franciso C.DE LA Rosa-CRC Press (Taylor & Francis).
6. Power Quality in Power systems and Electrical Machines-EwaldF.fuchs, Mohammad A.S. Masoum-Elsevier
7. Power Quality, C. Shankaran, CRC Press, 2001
8. Instantaneous Power Theory and Application to Power Conditioning, H. Akagiet.al., IEEE Press, 2007.
9. Custom Power Devices - An Introduction, Arindam Ghosh and Gerard Ledwich, Springer, 2002
10. A Review of Compensating Type Custom Power Devices for Power Quality Improvement, Yash Pal et.al., Joint International Conference on Power System Technology and IEEE Power India Conference, 2008. POWERCON 2008.

I-M.Tech I-Semester

COURSE CODE –	**Programmable Logic Controllers & Applications (Elective-I)**	**PE**	**3-0-0**	**3**

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

		Knowledge Level (K)#
CO1	Understand the PLCs and their I/O modules.	
CO2	Develop control algorithms to PLC using ladder logic etc.	
CO3	Manage PLC registers for effective utilization in different applications.	
CO4	Handle data functions and control of two axis and their axis robots with PLC.	
CO5	Design PID controller with PLC.	

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	Contact Hours
UNIT– 1	**PLC Basics:** PLC system, I/O modules and interfacing, CPU processor, programming equipment, programming formats, construction of PLC ladder diagrams, devices connected to I/O modules.	
UNIT– 2	**PLC Programming:** Input instructions, outputs, operational procedures, programming examples using contacts and coils. Drill press operation. Digital logic gates, programming in the Boolean algebra system, conversion examples. Ladder diagrams for process control: Ladder diagrams and sequence listings, ladder diagram construction and flow chart for spray process system.	
UNIT– 3	**PLC Registers:** Characteristics of Registers, module addressing, holding registers, input registers, output registers. PLC Functions: Timer functions and Industrial applications, counters, counter function industrial applications, Arithmetic functions, Number comparison functions, number conversion functions.	
UNIT– 4	**Data Handling functions:** SKIP, Master control Relay, Jump, Move, FIFO, FAL, ONS, CLR and Sweep functions and their applications. Bit Pattern and changing a bit shift register, sequence functions and applications, controlling of two axis and three axis Robots with PLC, Matrix functions.	

UNIT– 5	**Analog PLC operation:** Analog modules and systems, Analog signal processing, multi bit data processing, analog output application examples, PID principles, position indicator with PID control, PID modules, PID tuning, PID functions.	
	Total	**48 Hrs**

Text Books:

1. Programmable Logic Controllers – Principle and Applications by John W. Webb and Ronald A. Reiss, Fifth Edition, PHI
2. Programmable Logic Controllers – Programming Method and Applications by JR. Hackworth and F.D Hackworth Jr. – Pearson, 2004.

Reference Books:

1. Introduction to Programmable Logic Controllers- Gary Dunning-Cengage Learning.
2. Programmable Logic Controllers –W.Bolton-Elsevier publisher.

I-M.Tech I-Semester

COURSE CODE –	Artificial Intelligence Techniques (Elective-II)	PE	3-0-0	3

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

		Knowledge Level (K)#
CO1	Differentiate between Algorithmic based methods and knowledge based methods.	
CO2	Use the soft computing techniques for power system problems.	
CO3	Use appropriate AI framework for solving power system problems.	
CO4	Apply GA to power system optimization problems.	

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	Contact Hours
UNIT– 1	**Introduction** Artificial Neural Networks (ANN) – definition and fundamental concepts – Biological neural networks – Artificial neuron – activation functions – setting of weights – typical architectures – biases and thresholds – learning/training laws and algorithms. Perceptron – architectures, ADALINE and MADLINE – linear separability- XOR function.	
UNIT– 2	**ANN Paradigms** ADALINE – feed forward networks – Back Propagation algorithm- number of hidden layers – gradient decent algorithm – Radial Basis Function (RBF) network. Kohonen's self organizing map (SOM), Learning Vector Quantization (LVQ) and its types – Functional Link Networks (FLN) – Bidirectional Associative Memory (BAM) – Hopfield Neural Network.	
UNIT– 3	**Classical and Fuzzy Sets** Introduction to classical sets- properties, Operations and relations; Fuzzy sets, Membership, Operations, Properties, Fuzzy relations, Cardinalities, Membership functions.	
UNIT– 4	**FUZZY LOGIC CONTROLLER (FLC)** Fuzzy logic system components: Fuzzification, Inference engine (development of rule base and decision making system), Defuzzification to crisp sets-Defuzzification methods.	
UNIT– 5	**Application of AI Techniques** Speed control of DC motors using fuzzy logic –load flow studies using back propagation algorithm, single area and two area load frequency control using fuzzy logic.	
	Total	**48 Hrs**

Text Books:

1. Introduction to Artificial Neural Systems - Jacek M. Zuarda, Jaico Publishing House, 1997.
2. Fuzzy logic with Fuzzy Applications – T.J Ross – Mc Graw Hill Inc, 1997.

Reference Books:

1. Neural Networks, Fuzzy logic, Genetic algorithms: synthesis and applications by RajasekharanandPai – PHI Publication.
2. Modern power Electronics and AC Drives – B.K.Bose -Prentice Hall, 2002
3. Genetic Algorithms- David E Goldberg. Pearson publications.
5. Introduction to Neural Networks using MATLAB 6.0 by S N Sivanandam,SSumathi,S N Deepa TMGH
6. Introduction to Fuzzy Logic using MATLAB by S N Sivanandam,SSumathi,S N Deepa Springer, 2007.

I-M.Tech I-Semester

COURSE CODE –	Renewable Energy Technologies (Elective-II)	PE	3-0-0	3

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

		Knowledge Level (K)#
CO1	Understand various general aspects of renewable energy systems.	
CO2	Analyze and design induction generator for power generation from wind.	
CO3	Design MPPT controller for solar power utilization.	
CO4	Utilize fuel cell systems for power generation.	

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	Contact Hours
UNIT– 1	**Introduction:** Renewable Sources of Energy; Distributed Generation; Renewable Energy Economics - Calculation of Electricity Generation Costs; Demand-Side Management Options; Supply-Side Management Options; Control of renewable energy based power Systems	
UNIT– 2	**Induction Generators:** Principles of Operation; Representation of Steady-State Operation; Power and Losses Generated - Self-Excited Induction Generator; Magnetizing Curves and Self-Excitation - Mathematical Description of the Self-Excitation Process; Interconnected and Stand-alone operation - Speed and Voltage Control.	
UNIT– 3	**Wind Power Plants:** Site Selection; Evaluation of Wind Intensity; Topography; Purpose of the Energy Generation- General Classification of Wind Turbines; Rotor Turbines; Multiple-Blade Turbines; Drag Turbines; Lifting Turbines - Generators and Speed Control Used in Wind Power Energy; Analysis of Small wind energy conversion system.	
UNIT– 4	**Photovoltaic Power Plants:** Solar Energy; Generation of Electricity by Photovoltaic Effect; Dependence of a PV Cell on Temperature and irradiance input-output Characteristics - Equivalent Models and Parameters for Photovoltaic Panels; MPPT schemes: P&O,INC, effect of partial shaded condition. Applications of Photovoltaic Solar Energy-Economical Analysis of Solar Energy	
UNIT– 5	**Fuel Cells:** The Fuel Cell; Low- and High-Temperature Fuel Cells; Commercial and Manufacturing Issues - Constructional Features of Proton Exchange-Membrane Fuel Cells; Reformers; Electrolyzer Systems; Advantages and Disadvantages of Fuel Cells - Fuel Cell Equivalent Circuit; Practical Determination of the Equivalent Model Parameters; Aspects of Hydrogen for storage	
	Total	**48 Hrs**

Text Books:

1. Felix A. Farret, M. Godoy Simo` es, Integration of Alternative Sources of Energy, John Wiley & Sons, 2006.
2. Remus Teodorescu, Marco Liserre, Pedro Rodríguez, Grid Converters for Photovoltaic and Wind Power Systems, John Wiley & Sons, 2011.

Reference Books:

1. Gilbert M. Masters, Renewable and Efficient Electric Power Systems, John Wiley & Sons, 2004

I-M.Tech I-Semester

COURSE CODE –	HVDC Transmission and Flexible AC Transmission Systems (Elective-II)	PE	3-0-0	3

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

		Knowledge Level (K)#
CO1	Compare HVDC and EHVAC transmission systems	
CO2	Analyze converter configurations used in HVDC and evaluate the performance metrics.	
CO3	Understand controllers for controlling the power flow through a dc link and compute filter Parameters.	
CO4	Apply impedance, phase angle and voltage control for real and reactive power flow in ac transmission systems with FACTS controller.	
CO5	Analyze and select a suitable FACTS controller for a given power flow condition.	

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												
CO6												

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	Contact Hours
UNIT– 1	**HVDC Transmission:** DC Power Transmission: Need for power system interconnections, Evolution of AC and DC transmission systems, Comparison of HVDC and HVAC Transmission systems, Types of DC links, relative merits, Components of a HVDC system, Modern trends in DC Transmission systems	
UNIT– 2	**Analysis of HVDC Converters:** Pulse number, choice of converter configurations, Analysis of Graetz circuit with and without overlap, voltage waveforms, Analysis of two and three valve conduction mode, Converter Bridge characteristics, Inverter mode of operation, voltage waveforms	
UNIT– 3	**HVDC Control:** Principles of DC link control, Converter Control characteristics, Control hierarchy Constant current Control, CEA Control, firing angle control of valves, starting and stopping of a dc link, Power control **Harmonics and Filters:** effects of Harmonics, sources of harmonic generation, Types of filters –Design examples	
UNIT– 4	**Power Flow Analysis in AC/DC Systems:** Modelling of DC links, solutions of AC-DC Power flow **Flexible AC Transmission Systems (FACTS):** FACTS concepts and general system conditions: Power flow in AC systems, Relative importance of controllable parameters, Basic types of FACTS controllers, shunt and series controllers, Current source and Voltage source converters	
UNIT– 5	**Static Shunt Compensators:** Objectives of shunt compensation, Methods of	

	controllable VAR generation, Static Var Compensator, its characteristics, TCR, TSC, STATCOM, basic operating principle, control approaches and characteristics **Static Series Compensators:** Objectives of series compensator, variable impedance type of series compensators, TCSC, TSSC-operating principles and control schemes, SSSC, Power Angle characteristics, Control range and VAR rating, Capability to provide reactive power compensation, external control Introduction to Unified Power Flow Controller, Basic operating principles, Conventional control capabilities, Independent control of real and reactive power	
	Total	**48 Hrs**

Text Books:

1. Narain G.Honorani, Laszlo Gyugyi: Understanding FACTS –Concepts and Technology of Flexible AC Transmission Systems, Wiley-IEEE Press, 2000.
2. K.R.Padiyar: HVDC Power Transmission Systems –Technology and System Interactions, New Age International Publishers, 2011.

Reference Books:

1. Kimbark: Direct Current Transmission, 1971.
2. Jos Arrillaga: High Voltage Direct Current Transmission, The Institution of electrical Engineers, 1998.
3. Yong Hua Song, Allan T Johns: Flexible AC Transmission Systems, The Institution of electrical Engineers, 1999.

I-M.Tech I-Semester

COURSE CODE –	Power Electronics Simulation Laboratory	PC	0-0-4	3

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

		Knowledge Level (K)#
CO1	Analyze single and three phase full and semi bridge controlled rectifiers.	
CO2	Analyze single and three phase bride inverters.	
CO3	Analyze three phase bride inverters in various PWM modulation strategies.	
CO4	Analyze Three and Five level multilevel inverters.	

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												

(Please fill the above with Levels of Correlation, viz., L, M, H)

List of Experiments

Any 10 of the following experiments are to be conducted

S.No.	CONTENTS
1.	Simulation of single phase full controlled bridge rectifier.
2.	Simulation of single phase half controlled bridge rectifier.
3.	Simulation of three phase full controlled bridge rectifier
4.	Simulation of three phase half controlled bridge rectifier.
5.	Simulation of single phase square wave inverter.
6.	Simulation of three phase inverter for 120º mode of conduction.
7.	Simulation of three phase inverter for 180º mode of conduction.
8.	Simulation of three phase inverter for Sine-PWM modulation method.
9.	Simulation of three phase inverter with SVPWM modulation.
10.	Simulation of Buck DC-DC converter.
11.	Simulation of Boost DC-DC converter.
12.	Simulation of Buck-Boost DC-DC converter.
13.	Simulation of 3-level NPC inverter.
14.	Simulation of 5-level cascaded H-bridge inverter.

I-M.Tech I-Semester

COURSE CODE –	Power Converters Laboratory	PC	0-0-4	3

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

		Knowledge Level (K)#
CO1	Analyze single and three phase full and semi bridge controlled rectifiers.	
CO2	Analyze single and three phase bride inverters.	
CO3	Analyze three phase bride inverters in various PWM modulation strategies.	
CO4	Analyze Three and Five level multilevel inverters.	

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												

(Please fill the above with Levels of Correlation, viz., L, M, H)

List of Experiments

Any 10 of the following experiments are to be conducted

S.No.	CONTENTS
1.	Analysis of single phase full controlled bridge rectifier.
2.	Analysis of single phase half controlled bridge rectifier.
3.	Analysis of three phase full controlled bridge rectifier
4.	Analysis of three phase half controlled bridge rectifier.
5.	Analysis of single phase square wave inverter.
6.	Analysis of three phase inverter for 120º mode of conduction.
7.	Analysis of three phase inverter for 180º mode of conduction.
8.	Analysis of three phase inverter for Sine-PWM modulation method.
9.	Analysis of three phase inverter with SVPWM modulation.
10.	Analysis of Buck DC-DC converter.
11.	Analysis of Boost DC-DC converter.
12.	Analysis of Buck-Boost DC-DC converter.
13.	Analysis of 3-level NPC inverter.
14.	Analysis of 5-level cascaded H-bridge inverter.

I-M.Tech II-Semester

COURSE CODE –	Switched Mode Power Conversion	PC	3-0-0	3

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

		Knowledge Level (K)#
CO1	Analyze operation and control of non-isolated and isolated switch mode converters.	
CO2	Design non-isolated and isolated switch mode converters.	
CO3	Analyze operation and control of resonant converters.	
CO4	Feedback design of switch mode converters based on linearized models.	

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	Contact Hours
UNIT– 1	**Non-isolated switch mode converters:** Control of DC-DC converters: Buck converters, Boost converters, Buck-Boost converter, CUK Converter, continuous and discontinuous operation, Converter realization with non-ideal components.	
UNIT– 2	**Isolated switched mode converters:** Forwarded converter, flyback converter, push-pull converter, half-bridge converter, full bridge converter.	
UNIT– 3	**Resonant converters:** Basic resonant circuit concepts, series resonant circuits, parallel resonant circuits, zero current switching quasi-resonant buck converter, zero current switching quasi-resonant boost converter, zero voltage switching quasi-resonant buck converter, zero voltage switching quasi-resonant boost converter.	
UNIT– 4	**Control schemes of switching converters:** Voltage control, Current mode control, control scheme for resonant converters. Magnetic design consideration: Transformer design, inductor and capacitor design.	
UNIT– 5	**Modeling and Controller design based on linearization:** Formulation of averaged models for buck and boost converters average circuits models, small – signal analysis and linearization-state space analysis, average switch modelling. Control design based on linearization: Transfer function of converters, control design, large signal issues in voltage-mode and current-mode control.	
	Total	**48 Hrs**

Reference Books:

1. Fundamentals of Power Electronics- Erickson, Robert W., Maksimovic, Dragan, Springer, 2011.
2. Power switching converters- Simon Ang, Alejandro Oliva, CRC Press, 2010.
3. Elements of Power Electronics – Philip T. Krein, Oxford University press, 2014.
4. Design of Magnetic Components for Switched Mode Power Converters- Z Umanand, S.P. Bhat, John Wiley & Sons Australia, 1992.

Reference Books:

1. Switching Power Supply Design- Abraham I. Pressman, McGraw-Hill Ryerson, Limited, 1991.
2. Power Electronics – Issa Batareseh, Jhon Wiley publications, 2004.
3. Power Electronics: converters Applications & Design – Mohan, Undeland, Robbins-Wiley publications.

I-M.Tech II-Semester

COURSE CODE –	Power Electronic Control of Electrical Drives	PC	3-0-0	3

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

		Knowledge Level (K)#
CO1	Study the concepts of scalar and vector control methods for drive systems.	
CO2	Analyze and design controllers and converters for induction motor and PMSM, BLDC drives.	
CO3	Select and implement proper control techniques for induction motor and PMSM for specific applications.	
CO4	Analyze and design control techniques and converters for SRM drives.	

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												
CO6												

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	Contact Hours
UNIT– 1	**Vector Control of Induction Motor Drive:** Principle of scalar and vector control, direct vector control, indirect vector control, rotor flux oriented control, stator flux oriented control, air gap flux oriented control, decoupling circuits.	
UNIT– 2	**Sensor less Control of induction Motor Drive:** Advantages of speed sensor less control, voltage current based speed sensor less control, MRAS-model reference adaptive systems, ExtendedKalman filter observers.	
UNIT– 3	**Direct Torque Control of Induction Motor Drive:** Principle of Direct torque control (DTC), concept of space vectors, DTC control strategy of induction motor, comparison between vector control and DTC, applications, space vector modulation based DTC of induction motors.	
UNIT– 4	**Control of Permanent Magnet Synchronous Machines (PMSM) and Brushless DC (BLDC) Motor Drives:** Advantages and limitations of Permanent magnet machines, operating principle of PMSM,modeling of PMSM, operating principle BLDC, modeling of BLDC, similarities and difference between PMSM and BLDC, need for position sensing in BLDC motors, control strategies for PMSM and BLDC, methods of reducing torque ripples of BLDC motor.	
UNIT– 5	**Control of Switched Reluctance Motor (SRM) Drive:** SRM structure, Merits and limitations, stator excitation, converter topologies, SRM waveforms, Torque control schemes, speed control of SRM, torque ripple minimization, instantaneous -torque control using current controllers and flux controllers	

		Total	**48 Hrs**

Text Books:

1. Bose B. K., "Power Electronics and Variable Frequency Drives",IEEE Press, Standard Publisher Distributors. 2001.
2. Power electronic converters applications and design-Mohan, Undeland, Robbins-Wiley publications

Reference Books:

1. Krishnan R., "Electric Motor Drives – Modeling, Analysis and Control", Prentice Hall of India Private Limited.
2. Switched Reluctance Motors and Their Control- T. J. E. Miller, Magna Physics, 1993.

I-M.Tech II-Semester

COURSE CODE –	Energy Auditing, Conservation and Management (Elective-III)	PE	3-0-0	3

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

		Knowledge Level (K)#
CO1	Understand the principle of energy audit and their economic aspects.	
CO2	Recommend energy efficient motors and design good lighting system.	
CO3	Understand advantages to improve the power factor.	
CO4	Evaluate the depreciation of equipment.	

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	Contact Hours
UNIT– 1	**Basic Principles of Energy Audit** Energy audit- definitions, concept , types of audit, energy index, cost index ,pie charts, Sankey diagrams and load profiles, Energy conservation schemes- Energy audit of industries- energy saving potential, energy audit of process industry, thermal power station, building energy audit.	
UNIT– 2	**Energy Management** Principles of energy management, organizing energy management program, initiating, planning, controlling, promoting, monitoring, reporting. Energy manager, qualities and functions, language, Questionnaire – check list for top management	
UNIT– 3	**Energy Efficient Motors and Lighting** Energy efficient motors, factors affecting efficiency, loss distribution, constructional details, characteristics – variable speed , variable duty cycle systems, RMS - voltage variation-voltage unbalance-over motoring-motor energy audit. lighting system design and practice, lighting control, lighting energy audit	
UNIT– 4	**Power Factor Improvement and energy instruments** Power factor – methods of improvement, location of capacitors, Power factor with non-linear loads, effect of harmonics on p.f, p.f motor controllers – Energy Instruments- watt meter, data loggers, thermocouples, pyrometers, lux meters, tongue testers,application of PLC's	
UNIT– 5	**Economic Aspects and their computation** Economics Analysis depreciation Methods, time value of money, rate of return, present worth method, replacement analysis, lifecycle costing analysis – Energy efficient motors. Calculation of simple payback method, net present value method- Power factor correction, lighting – Applications of life cycle costing analysis, return on investment.	
	Total	**48 Hrs**

Text Books:

1. Energy management by W.R.Murphy&G.Mckay Butter worth, Heinemann publications, 1982.
2. Energy management hand book by W.CTurner, John wiley and sons, 1982.

Reference Books:

1. Energy efficient electric motors by John.C.Andreas, Marcel Dekker Inc Ltd-2nd edition,1995
2. Energy management by Paul o' Callaghan, Mc-graw Hill Book company-1st edition, 1998
3. Energy management and good lighting practice : fuel efficiency- booklet12-EEO

I-M.Tech II-Semester

COURSE CODE –	Hybrid Electric Vehicles (Elective-III)	PE	3-0-0	3

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

		Knowledge Level (K)#
CO1	Know the concept of electric vehicles and hybrid electric vehicles.	
CO2	Familiar with different motors used for hybrid electric vehicles.	
CO3	Understand the power converters used in hybrid electric vehicles	
CO4	Know different batteries and other energy storage systems.	

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	Contact Hours
UNIT– 1	**Introduction:** History of hybrid vehicles, architectures of HEVs, series and parallel HEVs, complex HEVs.	
UNIT– 2	**Hybridization of Automobile:** Fundamentals of vehicle, components of conventional vehicle and propulsion load; Drive cycles and drive terrain; Concept of electric vehicle and hybrid electric vehicle; Plug-in hybrid vehicle, constituents of PHEV, comparison of HEV and PHEV; Fuel Cell vehicles and its constituents.	
UNIT– 3	**Plug-in Hybrid Electric Vehicle:** PHEVs and EREVs blended PHEVs, PHEV Architectures, equivalent electric range of blended PHEVs; Fuel economy of PHEVs, power management of PHEVs, end-of-life battery for electric power grid support, vehicle to grid technology, PHEV battery charging.	
UNIT– 4	**Power Electronics in HEVs:** Rectifiers used in HEVs, voltage ripples; Buck converter used in HEVs, non-isolated bidirectional DC-DC converter, regenerative braking, voltage source inverter, current source inverter, isolated bidirectional DC-DC converter, PWM rectifier in HEVs, EV and PHEV battery chargers.	
UNIT– 5	**Battery and Storage Systems** Energy Storage Parameters; Lead–Acid Batteries; Ultra capacitors; Flywheels - Superconducting Magnetic Storage System; Pumped Hydroelectric Energy Storage; Compressed Air Energy Storage - Storage Heat; Energy Storage as an Economic Resource	
	Total	**48 Hrs**

Text Books

1. Ali Emadi, Advanced Electric Drive Vehicles, CRC Press, 2014.
2. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.

Reference Books:

1. Mehrdad Ehsani, YimiGao, 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.
3. H. Partab: Modern Electric Traction - DhanpatRai& Co, 2007.

ResearchBooks:

1. Pistooa G., “Power Sources , Models, Sustanability, Infrstructure and the market”, Elsevier 2008
2. Mi Chris, Masrur A., and Gao D.W., “ Hybrid Electric Vehicle: Principles and Applications with Practical Perspectives” 1995.

I-M.Tech II-Semester

COURSE CODE –	Advanced Digital Control Systems (Elective-III)	PE	3-0-0	3

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

		Knowledge Level (K)#
CO1	Analyze digital control systems using Z-transforms and Inverse Z-Transforms.	
CO2	Evaluate the state transition matrix and solve state equation for discrete model for continuous time systems, investigate the controllability and observability.	
CO3	Determine the stability; design state feedback controller.	
CO4	Design an observer.	
CO5	Solve a given optimal control problem.	

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	Contact Hours
UNIT– 1	**Introduction** Introduction to analog and digital control systems – Advantages of digital systems – Typical examples– Sample and hold devices – Sampling theorem and data reconstruction-Transfer functions and frequency domain characteristics of zero order hold and first order hold. Review of Z–transforms and Inverse Z–transforms- solving differential equations. Mapping between the S–Plane and the Z–Plane – Primary strips and Complementary Strips	
UNIT– 2	**State space analysis and the concepts of Controllability and observability** State Space Representation of discrete time systems – State transition matrix properties and evaluation – Solution of state equations- Discretization of continuous-time state equations –controllability and observability – concepts, conditions and tests, Principle of duality.	
UNIT– 3	**Stability Analysis and Controller Design** Stability criterion – Modified Routh’s stability criterion and Jury’s stability test, Lyapunov’s stability analysis. Design of state feedback controller through pole placement techniques, Necessary and sufficient conditions, Ackermann’s formula, controller for deadbeat response, control system with reference input, Design of full order observer-reduced order observer.	
UNIT– 4	**State Observer** Necessary and sufficient condition for state observation-Full order state observer-error dynamics – design of prediction observers- Ackermann’s formula-effect of the addition of observer on closed loop system-Current observer- minimum order observer observed – state feedback control system with minimum order observer -	

	control system with reference input.	
UNIT– 5	**Quadratic Optimal Control Systems** Quadratic optimal control problems-Solution by minimization method using Lagrange multipliers-Evolution of the minimum performance index – discretize quadratic optimal control –Steady state Reccati equations-Lypnove approaches to the solution of the Steady state quadratic optimal regulator problem and optimal control problem - Quadratic optimal control of a servo system.	
	Total	**48 Hrs**

Text Book:

1. Discrete–Time Control systems – K. Ogata, Pearson Education/PHI, 2nd Edition.
2. B. C. Kuo, "Digital control systems"- Holt Saunder's International Edition, 1991.

Reference Books:

1. M. Gopal: Digital control engineering, New Age Int. Ltd., India, 1998.
2. K. Ogata, "Modern control engineering"- PHI, 1991.

I-M.Tech II-Semester

COURSE CODE –	Advanced Digital Signal Processing (Elective-IV)	PE	3-0-0	3

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

		Knowledge Level (K)#
CO1	Describe structure of digital filters.	
CO2	Design digital filters with different techniques.	
CO3	Understand the implementation aspects of signal processing algorithms.	
CO4	Know the effect of finite word length in signal processing.	
CO5	Analyze different power spectrum estimation techniques.	

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	Contact Hours
UNIT– 1	**Digital Filter Structure:** Block diagram representation-Equivalent Structures-FIR and IIR digital filter Structures All pass Filters-tunable IIR Digital Filters-IIR tapped cascaded Lattice Structures-FIR cascaded Lattice structures-Parallel-Digital Sine-cosine generator-Computational complexity of digital filter structures.	
UNIT– 2	**Digital filter design:** Preliminary considerations-Bilinear transformation method of IIR filter design-design of lowpass, high pass-band pass, and band stop- IIR digital filters-Spectral transformations of IIR filters, FIR filter design-based on windowed Fourier series- design of FIR digital filters with least –mean- square-error-constrained least-square design of FIR digital filters	
UNIT– 3	**DSP algorithm implementation:** Computation of the discrete Fourier transform-number representation-arithmetic operations handling of overflow-tunable digital filters-function approximation.	
UNIT– 4	**Analysis of finite Word length effects:** The quantization process and errors-quantization of fixed -point and floating -point Numbers-Analysis of coefficient quantization effects, Analysis of arithmetic round-off errors, dynamic range scaling-signal- to- noise ratio in low -order IIR filters-low-sensitivity digital filters-Reduction of Product round-off errors using error feedback-Limit cycles in IIR digital filters, Round-off errors in FFT Algorithms.	
UNIT– 5	**Power Spectrum Estimation:** Estimation of spectra from finite duration observations signals – Non-parametric methods for power spectrum estimation – parametric method for power spectrum estimation, estimation of spectral form-finite duration observation of signals-non-parametric methods for power spectrum estimation-Walsh methods-Blackman & torchy method.	
	Total	**48 Hrs**

Text Books:

1. Digital signal processing-Sanjit K. Mitra-TMH second edition, 2002.
2. Discrete Time Signal Processing – Alan V.Oppenheim, Ronald W.Shafer - PHI-1996 1st edition-9th reprint

Reference Books:

1. Digital Signal Processing and principles, algorithms and Applications – John G.Proakis -PHI – 3rd edition-2002.
2. Digital Signal Processing – S.Salivahanan, A.Vallavaraj, C. Gnanapriya – TMH - 2nd reprint-2001
3. Theory and Applications of Digital Signal Proceesing-Lourens R. Rebinar & Bernold.
4. Digital Filter Analysis and Design-Auntonian-TMH.

I-M.Tech II-Semester

COURSE CODE –	Evolutionary Algorithms and Applications (Elective-IV)	PE	3-0-0	3

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

		Knowledge Level (K)#
CO1	State and formulate the optimization problem, without and with constraints, by using design variables from an engineering design problem.	
CO2	Apply classical optimization techniques to minimize or maximize a multi-variable objective function, without or with constraints, and arrive at an optimal solution.	
CO3	Formulate a mathematical model and apply linear programming technique by using Simplex method. Also extend the concept of dual Simplex method for optimal solutions.	
CO4	Apply gradient and non-gradient methods to nonlinear optimization problems and use interior or exterior penalty functions for the constraints to derive the optimal solutions.	
CO5	Apply Genetic algorithms for simple electrical problems and able to solve practical problems using PSO.	

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	Contact Hours
UNIT– 1	**Fundamentals of Soft Computing Techniques** Definition-Classification of optimization problems- Unconstrained and Constrained optimization Optimality conditions- Introduction to intelligent systems- Soft computing techniques- Conventional Computing versus Swarm Computing - Classification of meta-heuristic techniques - Single solution based and population based algorithms – Exploitation and exploration in population based algorithms - Properties of Swarm intelligent Systems - Application domain - Discrete and continuous problems - Single objective and multi-objective problems.	
UNIT– 2	**Genetic Algorithm and Particle Swarm Optimization** Genetic algorithms- Genetic Algorithm versus Conventional Optimization Techniques - Genetic representations and selection mechanisms; Genetic operators- different types of crossover and mutation operators -Bird flocking and Fish Schooling – anatomy of a particle- equations based on velocity and positions -PSO topologies - control parameters – GA and PSO algorithms for solving ELD problem without loss, Selective Harmonic Elimination in inverters and PI controller tuning.	
UNIT– 3	**Ant Colony Optimization and Artificial Bee Colony Algorithms** Biological ant colony system - Artificial ants and assumptions - Stigmergic communications - Pheromone updating- local-global - Pheromone evaporation - ant colony system- ACO models-Touring ant colony system-max min ant system	

	- Concept of elistic ants-Task partitioning in honey bees - Balancing foragers and receivers - Artificial bee colony (ABC) algorithms-binary ABC algorithms – ACO and ABC algorithms for solving Economic Dispatch without loss and PI controller tuning.	
UNIT– 4	**Shuffled Frog-Leaping Algorithm and Bat Optimization Algorithm** Bat Algorithm- Echolocation of bats- Behaviour of microbats- Acoustics of Echolocation- Movement of Virtual Bats- Loudness and Pulse Emission- Shuffled frog algorithm-virtual population of frogscomparison of memes and genes - memeplex formation- memeplex updation- BA and SFLA algorithms for solving ELD without loss and PI controller tuning.	
UNIT– 5	**Multi Objective Optimization** Multi-Objective optimization Introduction- Concept of Pareto optimality - Non-dominant sorting technique-Pareto fronts-best compromise solution-min-max method-NSGA-II algorithm and application to general two objective optimization problem.	
	Total	**48 Hrs**

Text Books

1. Xin-She Yang, „Recent Advances in Swarm Intelligence and Evolutionary Computation", Springer International Publishing, Switzerland, 2015.
2. Kalyanmoy Deb „Multi-Objective Optimization using Evolutionary Algorithms", John Wiley & Sons, 2001.
3. James Kennedy and Russel E Eberheart, „Swarm Intelligence", The Morgan Kaufmann Series in Evolutionary Computation, 2001.

Reference Books:

1. Eric Bonabeau, Marco Dorigo and Guy Theraulaz, „Swarm Intelligence-From natural to Artificial Systems", Oxford university Press, 1999.
2. David Goldberg, „Genetic Algorithms in Search, Optimization and Machine Learning", Pearson Education, 2007.
3. Konstantinos E. Parsopoulos and Michael N. Vrahatis, „Particle Swarm Optimization and Intelligence: Advances and Applications", InformatIon scIence reference, IGI Global, , 2010.
4. N P Padhy, „Artificial Intelligence and Intelligent Systems", Oxford University Press, 2005.

Reference Papers:

1. “Shuffled frog-leaping algorithm: a memetic meta-heuristic for discrete optimization” by Muzaffar eusuff, Kevin lansey and Fayzul pasha, Engineering Optimization, Taylor & Francis, Vol. 38, No. pp.129–154, March 2006.
2. “A New Metaheuristic Bat-Inspired Algorithm” by Xin-She Yang, Nature Inspired Cooperative Strategies for Optimization (NISCO 2010) (Eds. J. R. Gonzalez et al.), Studies in Computational Intelligence, Springer Berlin, 284, Springer, 65-74 (2010).
3. “Firefly Algorithms for Multimodal Optimization” Xin-She Yang, O. Watanabe and T. Zeugmann (Eds.), Springer-Verlag Berlin Heidelberg, pp. 169–178, 2009.

I-M.Tech II-Semester

COURSE CODE –	Microcontrollers (Elective-IV)	PE	3-0-0	3

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

		Knowledge Level (K)#
CO1	Design the interfacing circuits for input and output to PIC micro controllers and DSP processors.	
CO2	Write ALP for DSP processors.	
CO3	Design PWM controller for power electronic circuits using FPGA.	

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	Contact Hours
UNIT– 1	**PIC Microcontrollers** PIC Microcontrollers: Overview and Features, PIC 16C6X/7X, FSR(File Selection Register) [Indirect Data Memory Address Pointer], PIC Reset Actions, PIC Oscillator Connections, PIC Memory Organizations, PIC PIC 16C6X/7X Instructions, Addressing Modes, I/O Ports, Interrupts in PIC 16C61/71, PIC 16C61/71 Timers, PIC 16C71 Analog-to-Digital Converter (ADC)	
UNIT– 2	**Introduction to DSP** Introduction to the C2xx DSP core and code generation, The components of the C2xx DSP core, Mapping external devices to the C2xx core , peripherals and Peripheral Interface , System configuration registers , Memory , Types of Physical Memory , memory Addressing Modes , Assembly Programming using C2xx DSP, Instruction Set, Software Tools.	
UNIT– 3	**I/O & Control Registers** Pin Multiplexing (MUX) and General Purpose I/O Overview, Multiplexing and General Purpose I/O Control Registers .Introduction to Interrupts, Interrupt Hierarchy, Interrupt Control Registers, Initializing and Servicing Interrupts in Software.	
UNIT– 4	**ADC & Event Manager** ADC Overview , Operation of the ADC in the DSP , Overview of the Event manager (EV), Event Manager Interrupts , General Purpose (GP) Timers , Compare UNITs, Capture UNITs And Quadrature Enclosed Pulse (QEP) Circuitry , General Event Manager Information	
UNIT– 5	**Introduction to Field Programmable Gate Arrays** – CPLD Vs FPGA – Types of FPGA , Xilinx XC3000 series , Configurable logic Blocks (CLB), Input/Output Block (IOB) – Programmable Interconnect Point (PIP) – Xilinx 4000 series – HDL programming – overview of Spartan 3E and Virtex II pro FPGA boards-case study.	
	Total	**48 Hrs**

Text Books:

1. Microcontrollers-Theory and Applications - Ajay V Deshmukh, McGraw Hills, 2005.
2. DSP Based Electro Mechanical Motion Control -Hamid.A.Toliyat and Steven G.Campbell, CRC Press New York, 2004.

Reference Books:

1. The 8051 Microcontroller- Kennith J ayala, Thomson publishers,2005.
2. Microprocessor and Microcontrollers by Prof C.R.Sarma.
3. XC 3000 series datasheets (version 3.1). Xilinx,Inc.,USA, 1998.
4. Wayne Wolf," FPGA based system design ", Prentice hall, 2004

I-M.Tech II-Semester

COURSE CODE –	Electric Drives Simulation Laboratory	PC	0-0-4	3

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

		Knowledge Level (K)#
CO1	The student will be able to Combine the use of computer based simulation tools relevant to electrical Drives with practical laboratory experimentation	
CO2	The student will be able to analyze the performance of D.C electrical machines and drives	
CO3	The student will be able to analyze the performance of D.C electrical machines and drives	
CO4	The student will be able to analyze the performance of A.C electrical machines and drives	

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												

(Please fill the above with Levels of Correlation, viz., L, M, H)

List of Experiments

S.No.	CONTENTS
1.	Simulation of DC shunt machine as motor & generator.
2.	Simulate the speed control of DC motor using chopper converter.
3.	Simulation of induction motor modes using d-q model.
4.	Simulate the speed control of induction motor by using V/f control.
5.	Simulate the BLDC motor and observe the speed transients.
6.	Simulate speed control of induction motor by using vector control.
7.	Compare the transient performance of induction motor controlled by v/f control & vector control methods.
8.	Simulate PMSM motor by using d-q model.
9.	Simulate the multi-level inverter fed induction motor drive.
10.	Simulate the re-generative braking of inverter fed induction motor.
11.	Simulate the PWM controlled inverter fed PMSM drive.
12.	Evaluation of switching frequency effect on electric drive

I-M.Tech II-Semester

COURSE CODE –	**Electric Drives Laboratory**	**PC**	**0-0-4**	**3**

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

		Knowledge Level (K)#
CO1		
CO2		
CO3		
CO4		

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1												
CO2												
CO3												
CO4												

(Please fill the above with Levels of Correlation, viz., L, M, H)

List of Experiments

I-M.Tech II-Semester

COURSE CODE –	Mini Project with Seminar	PC	0-0-4	2

Syllabus Contents:

Mini Project will have mid semester presentation and end semester presentation. Mid semester presentation will include identification of the problem based on the literature review on the topic referring to latest literature available.

End semester presentation should be done along with the report on identification of topic for the work and the methodology adopted involving scientific research, collection and analysis of data, determining solutions highlighting individuals' contribution.

Continuous assessment of Mini Project at Mid semester and End semester will be monitored by the departmental committee.

II-M.Tech. I-Semester

COURSE CODE –	SMART GRID TECHNOLOGIES (ELECTIVE -V)	CATEGORY	L-T-P 3 -0-0	CREDITS 3

Pre-requisite: Basic knowledge on smart concept communication protocols, renewable energy systems and electronic circuits.

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

		Knowledge Level (K)#
CO1	Understand smart grids and analyze the smart grid policies and developments in smart grids.	
CO2	Develop concepts of smart grid technologies in hybrid electrical vehicles etc.	
CO3	Understand smart substations, feeder automation, GIS etc.	
CO4	Analyze micro grids and distributed generation systems.	
CO5	Analyze the effect of power quality in smart grid and to understand latest developments in ICT for smart grid.	

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	**Contact Hours**
UNIT – 1	**Introduction to Smart Grid:** Evolution of Electric Grid, Concept of Smart Grid, Definitions, Need of Smart Grid, Functions of Smart Grid, Opportunities & Barriers of Smart Grid, Difference between conventional & smart grid, Concept of Resilient &Self Healing Grid, Present development & International policies on Smart Grid. Case study of Smart Grid.	
UNIT – 2	**Smart Grid Technologies: Part 1:** Introduction to Smart Meters, Real Time Prizing, Smart Appliances, Automatic Meter Reading(AMR), Outage Management System(OMS), Plug in Hybrid Electric Vehicles(PHEV), Vehicle to Grid, Smart Sensors, Home & Building Automation, Phase Shifting Transformers.	
UNIT – 3	**Smart Grid Technologies: Part 2:** Smart Substations, Substation Automation, Feeder Automation. Geographic Information System(GIS), Intelligent Electronic Devices(IED) & their application for monitoring &	

	protection, Smart storage like Battery, SMES, Pumped Hydro, Compressed Air Energy Storage, Wide Area Measurement System(WAMS), Phase Measurement Unit(PMU).	
UNIT – 4	**Microgrids and Distributed Energy Resources:** Concept of micro grid, need & applications of microgrid, formation of microgrid, Issues of interconnection, protection & control of microgrid. Plastic & Organic solar cells, Thin film solar cells, Variable speed wind generators, fuelcells, microturbines, Captive power plants, Integration of renewable energy sources.	
UNIT – 5	**Power Quality Management in Smart Grid:** 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. **Information and Communication Technology for Smart Grid:** Advanced Metering Infrastructure (AMI), Home Area Network (HAN), Neighborhood Area Network (NAN), Wide Area Network (WAN).	
	Total	**48 Hrs**

Text Books:

1. Ali Keyhani, Mohammad N. Marwali, Min Dai “Integration of Green and Renewable Energy in Electric Power Systems”, Wiley
2. Clark W. Gellings, “The Smart Grid: Enabling Energy Efficiency and Demand Response”, CRC Press

Reference Books:

1. JanakaEkanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama,“Smart Grid: Technology and Applications”, Wiley
2. Jean Claude Sabonnadière, NouredineHadjsaïd, “Smart Grids”, Wiley Blackwell 19
3. Peter S. Fox Penner, “Smart Power: Climate Changes, the Smart Grid, and the Future of Electric Utilities”, Island Press; 1 edition 8 Jun 2010
4. S. Chowdhury, S. P. Chowdhury, P. Crossley, “Microgrids and Active Distribution Networks.” Institution of Engineering and Technology, 30 Jun 2009
5. Stuart Borlase, “Smart Grids (Power Engineering)”, CRC Press
6. Andres Carvallo, John Cooper, “The Advanced Smart Grid: Edge Power Driving Sustainability: 1”, Artech House Publishers July 2011

II-M.Tech. I-Semester

COURSE CODE –	INDUSTRIAL APPLICATIONS OF POWER ELECTRONIC SYSTEMS (Elective-V)	CATEGORY	L-T-P 3 -0-0	CREDITS 3

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

		Knowledge Level (K)#
CO1	Design power converters for LED lightning systems	
CO2	Analyze uninterrupted power supplies	
CO3	Select different electrical drives for electric traction systems	
CO4	Differentiate linear machines and rotating machines	

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	Contact Hours
UNIT– 1	**LED Lightning Systems:** LED lightning systems, types of industrial LED lightning systems, LED characteristics, converters for LED lightning systems, Illumination control of LEDs for different applications.	
UNIT– 2	**UPS and SMPS:** Components of UPS, operation and applications of UPS, basic operation and applications of SMPS, difference between UPS and SMPS. Servo stabilizers: Principle and operation of Servo stabilizers, applications of Servo stabilizers.	
UNIT– 3	**Electrical Traction Systems:** Selection of motor for traction applications, advantages of electric traction, characteristics of traction motors, electric braking of traction motors, power supply management in traction system.	
UNIT– 4	**Stepper motors and control:** Construction of Stepper motor, types of Stepper motor, operation of Stepper motor, characteristics of Stepper motor, applications of Stepper motor, open loop and closed loop control of stepper motors.	
UNIT– 5	**Linear machines and control:** Linear Induction Motor: Principle of operation of Linear Induction Motor, types of Linear Induction Motor, Characteristics and applications of Linear Induction Motor, control of linear induction motor for magnetic levitation. Linear Synchronous Motor: Principle of operation of Linear Synchronous Motor, types of Linear Synchronous Motor, Characteristics and applications of Linear Synchronous Motor.	
	Total	**48 Hrs**

Reference Books:

1. Michael Jacob, "Industrial Control Electronics – Applications and Design", Prentice Hall, 1988.
2. Thomas, E. Kissel, "Industrial Electronics" PHI, 2003.
3. James Maas, "Industrial Electronics", Prentice Hall, 1995.

II-M.Tech. I-Semester

COURSE CODE –	OPTIMIZATION TECHNIQUES (Elective-V)	CATEGORY	L-T-P 3 -0-0	CREDITS 3

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

		Knowledge Level (K)#
CO1	State and formulate the optimization problem, without and with constraints, by using design variables from an engineering design problem.	
CO2	Apply classical optimization techniques to minimize or maximize a multi-variable objective function, without or with constraints, and arrive at an optimal solution.	
CO3	Formulate a mathematical model and apply linear programming technique by using Simplex method. Also extend the concept of dual Simplex method for optimal solutions.	
CO4	Apply gradient and non-gradient methods to nonlinear optimization problems and use interior or exterior penalty functions for the constraints to derive the optimal solutions.	
CO5	Able to apply Genetic algorithms for simple electrical problems and to solve practical problems using PSO.	

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1												
CO2												
CO3												
CO4												

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	Contact Hours
UNIT– 1	**Introduction and Classical Optimization Techniques:** Statement of an Optimization problem – design vector – design constraints – constraint surface – objective function – objective function surfaces – classification of Optimization problems. Single variable Optimization – multi variable Optimization without constraints – necessary and sufficient conditions for minimum/maximum – multivariable Optimization with equality constraints.Solution by method of Lagrange multipliers – multivariable Optimization with inequality constraints – Kuhn – Tucker conditions.	
UNIT– 2	**Linear Programming** Standard form of a linear programming problem – geometry of linear programming problems – definitions and theorems – solution of a system	

	of linear simultaneous equations – pivotal reduction of a general system of equations – motivation to the simplex method – simplex algorithm - Duality in Linear Programming – Dual Simplex method.	
UNIT– 3	**Nonlinear Programming:** **Unconstrained cases -** One – dimensional minimization methods: Classification, Fibonacci method and Quadratic interpolation method - Univariate method, Powell's method and steepest descent method. **Constrained cases -** Characteristics of a constrained problem, Classification, Basic approach of Penalty Function method; Basic approaches of Interior and Exterior penalty function methods.Introduction to convex Programming Problem.	
UNIT– 4	**Introduction to Evolutionary Methods:** Evolutionary programming methods - Introduction to Genetic Algorithms (GA)– Control parameters –Number of generation, population size, selection, reproduction, crossover and mutation – Operator selection criteria – Simple mapping of objective function to fitness function – constraints – Genetic algorithm steps – Stopping criteria –Simple examples.	
UNIT– 5	**Introduction to Swarm Intelligence Systems:** Swarm intelligence programming methods - Basic Partial Swarm Optimization – Method – Characteristic features of PSO procedure of the global version – Parameters of PSO (Simple PSO algorithm – Operators selection criteria – Fitness function constraints) – Comparison with other evolutionary techniques – Engineering applications of PSO.	
	Total	**48 Hrs**

Text Books

1. "Engineering optimization: Theory and practice"-by S. S.Rao, New Age International (P) Limited, 3rd edition, 1998.
2. Soft Computing with Matlab Programming by N.P.Padhy&S.P.Simson, Oxford University Press – 2015

Reference Books:

1. **"**Optimization methods in operations Research and Systems Analysis" by K.V.Mital and C.Mohan, New Age International (P) Limited, Publishers, 3rd edition, 1996.
2. Genetic Algorithms in search, optimization, and Machine Learning by David E.Goldberg,ISBN:978-81-7758-829-3, Pearsonby Dorling Kindersley (India) Pvt. Ltd.
3. "Operations Research: An Introduction" by H.A.Taha, PHI pvt. Ltd., 6th edition.
4. Linear Programming by G.Hadley.,Narosa Publishers.

II M.Tech I-Semester

COURSE CODE –	RENEWABLE ENERGY TECHNOLOGIES (Open Elective)	CATEGORY	L-T-P 3 -0-0	CREDITS 3

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

		Knowledge Level (K)#
CO1	Analyze solar radiation data, extraterrestrial radiation, radiation on earth's surface and solar Energy Storage.	
CO2	Design the of Wind Energy Systems.	
CO3	Design of biomass digesters, Geothermal plants and its working characteristics	
CO4	Know the Energy production from OTEC, Tidal and Waves.	
CO5	Evaluate the concept and working of Fuel cells & MHD power generation.	

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	Contact Hours
UNIT– 1	**Solar Energy:** Introduction, Renewable Sources, prospects, Solar radiation at the Earth Surface, Solar Energy Collectors-Flat plate Collectors, concentrating collectors, advantages and dis advantages, Solar Energy storage systems – Solar Pond. Applications of Solar Energy-Solar water heating, Solar Green house.	
UNIT– 2	**Wind Energy:** Introduction, basic Principles of Wind Energy Conversion, the nature of Wind, the power in the wind, Wind Energy Conversion, Site selection considerations, basic components of a WECS(Wind Energy Conversion Systems),Classification of WEC Systems, Advantages and Disadvantages of WECS, Applications of Wind Energy	
UNIT– 3	**Biomass and Geothermal Energy:** Introduction, Biomass conversion technologies, Photosynthesis, factors affecting Bio digestion, classification of biogas plants, advantages and their disadvantages, Types of biogas plants, selection of site for a biogas plant **Geothermal Energy**: Introduction, Geothermal Sources, Applications of geothermal Energy, Advantages and Disadvantages, operational and Environmental problems.	
UNIT– 4	**Energy From oceans, Waves & Tides:** **Oceans:** Introduction, Ocean Thermal Electric Conversion (OTEC), methods, Advantages and Disadvantages, prospects of OTEC in India. **Waves :** Introduction, Energy and Power from the waves, Wave Energy conversion devices, Advantages and Disadvantages **Tides**: Basic principle of Tide Energy, Components of Tidal Energy, Advantages and limitations of Tidal power Generation.	

UNIT– 5	**Chemical Energy Sources:** **Fuel Cells:** Introduction, Fuel Cell Equivalent Circuit, operation of Fuel cell, types of Fuel Cells, Advantages and Disadvantages of Fuel Cells, Applications of Fuel Cells. **Hydrogen Energy**: Introduction, Methods of Hydrogen production, Storage and Applications **Magneto Hydro Dynamic (MHD) Power generation**: Principle of Operation, Types, advantages and disadvantages.	
	Total	**48 Hrs**

Text Books:

1. G.D.Rai, Non-Conventional Energy Sources, khanna Publications, 2011.
2. John Twidell & Tony Weir, Renewable Energy Sources, Taylor & francis, 2013.

Reference Books:

1 .S.P.Sukhatme & J.K.Nayak, Solar Energy-Principles of Thermal Collection and Storage,TMH, 2011

2.John Andrews & Nick Jelly, Energy Science- principles, technologies and Impacts,Oxford.

II M.Tech. I-Semester

COURSE CODE –	HYBRID ELECTRIC VEHICLES (OPEN ELECTIVE)	CATEGORY	L-T-P 3 -0-0	CREDITS 3

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

		Knowledge Level (K)#
CO1	Know the concept of electric vehicles and hybrid electric vehicles.	
CO2	Familiar with different motors used for hybrid electric vehicles.	
CO3	Understand the power converters used in hybrid electric vehicles	
CO4	Know different batteries and other energy storage systems.	

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	Contact Hours
UNIT– 1	**Introduction:** History of hybrid vehicles, architectures of HEVs, series and parallel HEVs, complex HEVs.	
UNIT– 2	**Hybridization of Automobile:** Fundamentals of vehicle, components of conventional vehicle and propulsion load; Drive cycles and drive terrain; Concept of electric vehicle and hybrid electric vehicle; Plug-in hybrid vehicle, constituents of PHEV, comparison of HEV and PHEV; Fuel Cell vehicles and its constituents.	
UNIT– 3	**Plug-in Hybrid Electric Vehicle:** PHEVs and EREVs blended PHEVs, PHEV Architectures, equivalent electric range of blended PHEVs; Fuel economy of PHEVs, power management of PHEVs, end-of-life battery for electric power grid support, vehicle to grid technology, PHEV battery charging.	
UNIT– 4	**Power Electronics in HEVs:** Rectifiers used in HEVs, voltage ripples; Buck converter used in HEVs, non-isolated bidirectional DC-DC converter, regenerative braking, voltage source inverter, current source inverter, isolated bidirectional DC-DC converter, PWM rectifier in HEVs, EV and PHEV battery chargers.	
UNIT– 5	**Battery and Storage Systems** Energy Storage Parameters; Lead–Acid Batteries; Ultra capacitors; Flywheels - Superconducting Magnetic Storage System; Pumped Hydroelectric Energy Storage; Compressed Air Energy Storage - Storage Heat; Energy Storage as an Economic Resource	
	Total	**48 Hrs**

Text Books

1. Ali Emadi, Advanced Electric Drive Vehicles, CRC Press, 2014.
2. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.

Reference Books:

1. Mehrdad Ehsani, YimiGao, 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.
3. H. Partab: Modern Electric Traction - DhanpatRai& Co, 2007.

Research Books:

1. Pistooa G., “Power Sources , Models, Sustanability, Infrstructure and the market”, Elsevier 2008
2. Mi Chris, Masrur A., and Gao D.W., “ Hybrid Electric Vehicle: Principles and Applications with Practical Perspectives” 1995.