



**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA**  
**KAKINADA–533003, Andhra Pradesh, India**  
**DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING**

## **COURSE STRUCTURE AND SYLLABUS**

**For**

**B.TECH – ELECTRICAL AND ELECTRONICS ENGINEERING**

*(Applicable for batches admitted from 2020-2021)*



**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA**  
**KAKINADA-533003, Andhra Pradesh, India**



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**III B.Tech – I Semester**

Sl. No	Course Components	Subjects	L	T	P	Credits
1	PCC	Power Systems-II	3	0	0	3
2	PCC	Power Electronics	3	0	0	3
3	PCC	Control Systems	3	0	0	3
4	OEC	Open Elective- I/ Job Oriented Elective-I	3	0	0	3
5	PEC	Professional Elective - I	3	0	0	3
6	PCC	Control Systems Lab	0	0	3	1.5
7	PCC	Power Electronics Lab	0	0	3	1.5
8	SC	Soft Skill Course:Employability Skills	2	0	0	2
9	MC	Environmental Science	2	0	0	0
10	PROJ	Summer Internship 2 Months (Mandatory) after second year (to be evaluated during V semester)	0	0	0	1.5
<b>TotalCredits</b>			<b>21.5</b>			
		Minors Course*	4	0	0	4
		Honors Course*	4	0	0	4

**III B.Tech – II Semester**

Sl. No	Course Components	Subjects	L	T	P	Credits
1	PCC	Microprocessors and Microcontrollers	3	0	0	3
2	PCC	Electrical Measurements and Instrumentation	3	0	0	3
3	PCC	Power System Analysis	3	0	0	3
4	PEC	Professional Elective - II	3	0	0	3
5	OEC	Open Elective –II/ Job Oriented Elective-II	3	0	0	3
6	PCC	Electrical Measurements and Instrumentation Lab	0	0	3	1.5
7	PCC	Microprocessors and Microcontrollers Lab	0	0	3	1.5
8	PCC	Power Systems and Simulation Lab	0	0	3	1.5
9	SC	<b>Skill Advanced Course:</b> Machine Learning with Python	2	0	0	2
10	MC	Research Methodology	2	0	0	0
<b>Total Credits</b>			<b>21.5</b>			
		Minors Course*	4	0	0	4
		Honors Course*	4	0	0	4



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**IV B.Tech – I Semester**

Sl. No	Course Components	Subjects	L	T	P	Credits
1	PEC	Professional Elective – III	3	0	0	3
2	PEC	Professional Elective – IV	3	0	0	3
3	PEC	Professional Elective – V	3	0	0	3
4	OEC	Open Elective- III/Job Oriented Elective-III	3	0	0	3
5	OEC	Open Elective-IV /Job Oriented Elective-IV	3	0	0	3
6	HSMC	Universal Human Values-2: Understanding Harmony	3	0	0	3
7	SC	<b>Skill Advanced Course</b> Machine Learning with PythonLab	0	0	4	2
8	PROJ	Industrial / Research Internship 2 Months (Mandatory) after third year (to be evaluated during VII Semester)	0	0	3	3
<b>Total Credits</b>			<b>23</b>			
		Minors Course*	4	0	0	4
		Honors Course*	4	0	0	4

**IVB.TechIISemester**

Sl. No	Course Components	Subjects	L	T	P	Credits
1	Major Project	Project work, seminar and internship in industry (6 Months)	--	--	--	12
<b>Total Credits</b>			<b>12</b>			

**HSMC:** Humanities and Social Science  
Including Management Courses  
**BSC** : Basic Science Courses  
**ESC:** Engineering Science Courses  
**PCC:** Professional Core Courses

**PEC** : Professional Elective Courses  
**OEC** : Open Elective Courses  
**PROJ** : Internship, Seminar, Project Work  
**MC** : Mandatory Courses  
**SC** : Skill Oriented Courses



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**Professional Elective Subjects offered to EEE Branch Students:**

**Professional Elective – I:**

1. Linear IC Applications
2. Utilization of Electrical Energy
3. Computer Architecture and Organization
4. Optimization Techniques
5. Object Oriented Programming through Java

**Professional Elective – II:**

1. Signal and Systems
2. Electric Drives
3. Advanced Control Systems
4. Switchgear and Protection
5. Big Data Analytics

**Professional Elective –III:**

1. Digital Signal Processing
2. Renewable and Distributed Energy Technologies
3. Flexible Alternating Current Transmission Systems
4. Power Systems Deregulation
5. Data Base Management Systems

**Professional Elective – IV:**

1. Hybrid Electric Vehicles
2. High Voltage Engineering
3. Programmable Logic Controllers and Applications
4. Cloud Computing with AWS
5. Deep Learning Techniques

**Professional Elective – V:**

1. Power System Operation and Control
2. Switched Mode Power Conversion
3. AI Applications to Electrical Engineering
4. Data Science
5. MEAN Stack Technologies

**Open Electives offered by EEE Department for Other Branches (Except EEE Branch)**

**Open Elective-I:**

1. Renewable Energy Sources
2. Concepts of Optimization Techniques
3. Concepts of Control Systems

**Open Elective-II:**

1. Battery Management Systems and Charging Stations
2. Fundamentals of utilization of Electrical Energy
3. Indian Electricity Act

**Open Elective-III:**

1. Concepts of Microprocessors and Microcontrollers
2. Fundamentals of Electric Vehicles
3. Concepts of Internet of Things

**Open Elective-IV:**

1. Concepts of Power System Engineering
2. Concepts of Smart Grid Technologies



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**\*For Honor's/ Minor Course Fullfillments:**

- The 20 additional Credits need to be acquired, 16/15 credits can be earned by undergoing specified courses listed as pools, with 4/5 courses, each carrying 4/3 credits. The remaining 4/5 credits must be acquired through two online MOOCs (Swayam /NPTEL), which shall be domain specific, with 2/3 credits and with a minimum duration of 8/12weeks as recommended by the Board of Studies.
- Minor Engineering subjects are offered to other branches by EEE Department (except for EEE Students).
- Honors Engineering subjects are offered to EEE Students.
- The head of the department will float the list of allowed MOOC electives in each academic year, based on the list floated by MOOCs (Swayam/NPTEL).

**\*Honors Engineering Courses offered EEE Branch students**

**II B.Tech II Semester:**

1. Communication Systems
2. Electrical Wiring, Estimation and Costing
3. Electrical Distribution Systems

**III B.Tech I Semester:**

1. Advanced Computer Networks
2. Power Quality
3. Special Electrical Machines

**III B.Tech II Semester:**

1. Digital Control Systems
2. Analysis of Power Electronic Converters
3. HVDC Transmission

**IV B.Tech I Semester:**

1. EHV AC Transmission
2. Smart Grid Technologies
3. Power Electronic Control of Electrical Drives

**\*Minor Engineering Courses offered by EEE Department for Other Branches**  
**(Except EEE Branch)**

**II B.Tech II Semester:**

1. Fundamentals of Electrical Circuits
2. Concepts of Electrical Measurements

**III B.Tech I Semester:**

1. Analysis of Linear Systems
2. Energy Auditing, Conservation and Management

**III B.Tech II Semester:**

1. Evolutionary Algorithms
2. Fundamentals of Power Electronics

**IV B.Tech I Semester:**

1. Neural Networks and Fuzzy Logic
2. Concepts of Electric Drives and Its Applications



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<b>III Year – II SEMESTER</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>
<b>MICROPROCESSORS AND MICROCONTROLLERS</b>				

**Preamble:**

Microprocessor and Microcontroller have become important building blocks in digital electronics design. It is important for student to understand the architecture of a microprocessor and its interfacing with various modules. 8086 microprocessor architecture, programming, and interfacing is dealt in detail in this course. Interfacing, PIC, architecture, programming in C.

**Course objectives:**

- To understand the organization and architecture of Microprocessor
- To understand addressing modes to access memory
- To understand 8051 micro controller architecture
- To understand the programming principles for 8086 and 8051
- To understand the interfacing of Microprocessor with I/O as well as other devices
- To understand how to develop cyber physical systems

**UNIT - I****Introduction to Microprocessor Architecture**

Introduction and evolution of Microprocessors – Architecture of 8086 – Memory Organization of 8086 – Register Organization of 8086– Introduction to 80286 - 80386 - 80486 and Pentium (brief description about architectural advancements only).

**UNIT - II****Minimum and Maximum Mode Operations**

Instruction sets of 8086 - Addressing modes – Assembler directives - General bus operation of 8086 – Minimum and Maximum mode operations of 8086 – 8086 Control signal interfacing – Read and write cycle timing diagrams.

**UNIT - III****Microprocessors I/O interfacing**

8255 PPI– Architecture of 8255–Modes of operation– Interfacing I/O devices to 8086 using 8255– Interfacing A to D converters– Interfacing D to A converters– Stepper motor interfacing– Static memory interfacing with 8086.

Architecture and interfacing of 8251 USART – Architecture and interfacing of DMA controller (8257).

**UNIT - IV****8051 Microcontroller**

Overview of 8051 Microcontroller – Architecture– Memory Organization – Register set – I/O ports and Interrupts – Timers and Counters – Serial Communication – Interfacing of peripherals- Instruction set.

**UNIT - V****PIC Architecture**

Block diagram of basic PIC 18 micro controller – registers I/O ports – Programming in C for PIC: Data types - I/O programming - logical operations - data conversion.



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**Course Outcomes:**

After the completion of the course the student should be able to:

- Know the concepts of the Microprocessor capability in general and explore the evaluation of microprocessors.
- Analyse the instruction sets - addressing modes - minimum and maximum modes operations of 8086 Microprocessors
- Analyse the Microcontroller and interfacing capability
- Describe the architecture and interfacing of 8051 controller
- Know the concepts of PIC micro controller and its programming.

**Text Books:**

1. Ray and Burchandi - “Advanced Microprocessors and Interfacing” - Tata McGraw–Hill - 3<sup>rd</sup> edition - 2006.
2. Kenneth J Ayala - “The 8051 Microcontroller Architecture - Programming and Applications” - Thomson Publishers - 2nd Edition.
3. PIC Microcontroller and Embedded Systems using Assembly and C for PIC 18 - -Muhammad Ali Mazidi - RolindD.Mckinay - Danny causey -Pearson Publisher 21<sup>st</sup> Impression.

**Reference Books:**

1. Microprocessors and Interfacing - Douglas V Hall - Mc–Graw Hill - 2<sup>nd</sup> Edition.
2. R.S. Kaler - “A Text book of Microprocessors and Micro Controllers” - I.K. International Publishing House Pvt. Ltd.
3. Ajay V. Deshmukh - “Microcontrollers – Theory and Applications” - Tata McGraw–Hill Companies –2005.
4. Ajit Pal - “Microcontrollers – Principles and Applications” - PHI Learning Pvt Ltd - 2011.



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	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>
<b>ELECTRICAL MEASUREMENTS AND INSTRUMENTATION</b>				

**Preamble:**

This course gives an outset on principles of operation and construction of various basic instruments for measurement of different electrical quantities. Familiarization of modern digital measurement systems were also included here.

**Course Objectives:**

- To understand and analyze the factors that effect the various measuring units.
- To choose the appropriate meters for measuring of voltage, current, power, power factor and energy qualities & understand the concept of standardization.
- Describe the operating principle of AC & DC bridges for measurement of resistance, inductance and capacitance.
- To understand the concept of the transducer and their effectiveness in converting from one form to the other form for the ease of calculating and measuring purposes.
- To understand the operating principles of basic building blocks of digital systems, record and display units.

**UNIT - I****Analog Ammeter and Voltmeters**

Classification – deflecting - control and damping torques - – PMMC - moving iron type and electrostatic instruments - Construction - Torque equation - Range extension - Errors and compensations - advantages and disadvantages. Instrument transformers: Current Transformer and Potential Transformer-construction - theory - errors-Numerical Problems.

**UNIT - II****Analog Wattmeters and Power Factor Meters**

Electrodynamometer type wattmeter (LPF and UPF) - Power factor meters: Dynamometer and M.I type (Single phase and Three phase) - Construction - theory - torque equation - advantages and disadvantages.

Potentiometers: Introduction to DC and AC Potentiometers – Construction-working – Applications - Numerical Problems.

**UNIT - III****Measurements of Electrical parameters**

**DC Bridges:** Method of measuring low - medium and high resistance - sensitivity of Wheat stone's bridge - Kelvin's double bridge for measuring low resistance - Loss of charge method for measurement of high resistance - Megger – measurement of earth resistance - Numerical Problems.

**AC Bridges:** Measurement of inductance and quality factor - - Maxwell's bridge - - Hay's bridge - - Anderson's bridge. Measurement of capacitance and loss angle - - Desauty's bridge - Schering Bridge - Wien's bridge - Wagner's earthing device - - Numerical Problems.

**UNIT - IV****Transducers**

Definition - Classification - Resistive - Inductive and Capacitive Transducer - LVDT - Strain Gauge - Thermistors - Thermocouples - Piezo electric and Photo Diode Transducers - Hall effect sensors- Numerical Problems.





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**UNIT - V**

**Digital meters**

Digital Voltmeters – Successive approximation DVM - Ramp type DVM and Integrating type DVM – Digital frequency meter - Digital multimeter - Digital tachometer - Digital Energy Meter - Q meter - Power Analyzer. CRO- measurement of phase difference & Frequency using lissajious patterns - Numerical Problems.

**Course Outcomes:**

After the completion of the course the student should be able to:

- Know the construction and working of various types of analog instruments.
- Describe the construction and working of wattmeter and power factor meters
- Know the construction and working various bridges for the measurement resistance - inductance and capacitance
- Know the operational concepts of various transducers
- Know the construction and operation digital meters

**Text Books:**

1. Electrical Measurements and measuring Instruments by E.W. Golding and F.C.Widdis - 5<sup>th</sup> Edition - Wheeler Publishing.
2. Modern Electronic Instrumentation and Measurement Techniques by A.D. Helfrick and W.D. Cooper - PHI - 5<sup>th</sup> Edition - 2002.

**Reference Books:**

2. Electrical & Electronic Measurement & Instruments by A.K.Sawhney Dhanpat Rai & Co. Publications - 19<sup>th</sup> revised edition - 2011.
3. Electrical and Electronic Measurements and instrumentation by R.K.Rajput - S.Chand - 3<sup>rd</sup> edition.
3. Electrical Measurements by Buckingham and Price - Prentice – Hall
4. Electrical Measurements by Forest K. Harris. John Wiley and Sons



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		<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>
<b>POWER SYSTEM ANALYSIS</b>					

**Preamble:**

The course is designed to give students the required knowledge for the design and analysis of power flow studies and faults in electrical power systems. Calculation of power flow in a power system network using various techniques, formation of  $Z_{bus}$  and its importance are covered in this course. It also deals with short circuit analysis and analysis of power system for steady state and transient stability.

**Course Objectives:**

- To develop the impedance diagram (p.u) and formation of  $Y_{bus}$
- To learn the different load flow methods.
- To learn the  $Z_{bus}$  building algorithm.
- To learn short circuit calculation for symmetrical faults
- To learn the effect of unsymmetrical faults and their effects.
- To learn the stability of power systems and method to improve stability.

**UNIT - I****Circuit Topology & Per Unit Representation**

Graph theory definition – Formation of element node incidence and bus incidence matrices – Primitive network representation – Formation of  $Y_{bus}$  matrix by singular transformation and direct inspection methods – Per Unit Quantities–Single line diagram – Impedance diagram of a power system – Numerical Problems.

**UNIT - II****Power Flow Studies**

Necessity of power flow studies – Derivation of static power flow equations – Power flow solution using Gauss-Seidel Method – Newton Raphson Method (Rectangular and polar coordinates form) – Decoupled and Fast Decoupled methods – Algorithmic approach – Numerical Problems on 3–bus system only.

**UNIT - III****Z-Bus Algorithm & Symmetrical Fault Analysis**

Formation of  $Z_{bus}$ : Algorithm for the Modification of  $Z_{bus}$  Matrix (without mutual impedance) – Numerical Problems.

**Symmetrical Fault Analysis:**

Reactance's of Synchronous Machine – Three Phase Short Circuit Currents - Short circuit MVA calculations for Power Systems – Numerical Problems.

**UNIT - IV****Symmetrical Components**

Definition of symmetrical components – symmetrical components of unbalanced three phase systems – Power in symmetrical components – Sequence impedances and Sequence networks: Synchronous generator – Transmission line and transformers – Numerical Problems.

**Unsymmetrical Fault analysis**

Various types of faults: LG– LL– LLG and LLL on unloaded alternator-Numerical problems.

**UNIT - V****Power System Stability Analysis**

Elementary concepts of Steady state – Dynamic and Transient Stabilities – Swing equation – Steady state stability – Equal area criterion of stability – Applications of Equal area criterion – Factors affecting transient stability – Methods to improve steady state and transient stability – Numerical problems.



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**Course Outcomes:**

After the completion of the course the student should be able to:

- Draw impedance diagram for a power system network and calculate per unit quantities.
- Apply the load flow solution to a power system using different methods.
- Form  $Z_{bus}$  for a power system networks and analyse the effect of symmetrical faults.
- Find the sequence components for power system Components and analyse its effects of unsymmetrical faults.
- Analyse the stability concepts of a power system.

**Text Books:**

1. Power System Analysis by Grainger and Stevenson - Tata McGraw Hill.2003
2. Modern Power system Analysis – by I.J.Nagrath & D .P.Kothari: Tata McGraw–Hill Publishing Company - 3<sup>rd</sup> edition - 2007.

**Reference Books:**

1. Power System Analysis – by A.R.Bergen - Prentice Hall - 2<sup>nd</sup> edition - 2009.
2. Power System Analysis by HadiSaadat – Tata McGraw–Hill 3<sup>rd</sup> edition - 2010.
3. Power System Analysis by B.R.Gupta - A H Wheeler Publishing Company Limited - 1998.
4. Power System Analysis and Design by J.Duncan Glover - M.S.Sarma - T.J.Overbye – Cengage Learning publications - 5<sup>th</sup> edition - 2011.



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		<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>
<b>SIGNALS AND SYSTEMS</b> <b>(PROFESSIONAL ELECTIVE – II)</b>					

**Preamble:**

This course aims to lay the foundational aspects of signals and systems in both continuous time and discrete time, in preparation for more advanced subjects in digital signal processing, image processing, and communication theory & control systems.

**Course Objectives:**

- This gives the basics of signals and systems required for all electrical engineering related courses.
- To understand the behavior of signal in time and frequency domain.
- To understand the characteristics of Linear Time Invariant (LTI) systems.
- Concepts of the correlation and sampling process.
- This give concepts of signals and Systems along with its analysis using different transform techniques.

**UNIT – I****Introduction**

Definition of Signals and Systems - Classification of Signals - Classification of Systems - Operations on signals: time-shifting - time-scaling - amplitude-shifting - amplitude-scaling. Problems on classification and characteristics of Signals and Systems. Complex exponential and sinusoidal signals - Singularity functions and related functions: impulse function - step function signum function and ramp function. Analogy between vectors and signals - orthogonal signal space - Signal approximation using orthogonal functions - Mean square error - closed or complete set of orthogonal functions - Orthogonally in complex functions. Related Problems.

**UNIT – II****Fourier Series And Fourier Transform**

Fourier series representation of continuous time periodic signals - properties of Fourier series - Dirichlet's conditions - Trigonometric Fourier series and Exponential Fourier series - Relation between Trigonometric and Exponential Fourier series - Complex Fourier spectrum. Deriving Fourier transform from Fourier series - Fourier transform of arbitrary signal - Fourier transform of standard signals - Fourier transform of periodic signals - properties of Fourier transforms - Fourier transforms involving impulse function and Signum function. Introduction to Hilbert Transform. Related Problems.

**UNIT – III****Analysis of Linear Systems**

Introduction - Linear system - impulse response - Response of a linear system - Linear time invariant (LTI) system - Linear time variant (LTV) system - Concept of convolution in time domain and frequency domain - Graphical representation of convolution - Transfer function of a LTI system - Related problems. Filter characteristics of linear systems. Distortion less transmission through a system - Signal bandwidth - system bandwidth - Ideal LPF - HPF and BPF characteristics - Causality and Poly-Wiener criterion for physical realization - relationship between bandwidth and rise time.

**UNIT – IV****Correlation**

Auto-correlation and cross-correlation of functions - properties of correlation function - Energy density spectrum - Parseval's theorem - Power density spectrum - Relation between Convolution and correlation - Detection of periodic signals in the presence of noise by correlation - Extraction of signal from noise by filtering.



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### **Sampling Theorem**

Graphical and analytical proof for Band Limited Signals - impulse sampling - Natural and Flat top Sampling - Reconstruction of signal from its samples - effect of under sampling – Aliasing - Introduction to Band Pass sampling - Related problems.

### **UNIT - V**

#### **Laplace Transforms**

Introduction - Concept of region of convergence (ROC) for Laplace transforms - constraints on ROC for various classes of signals - Properties of L.T's - Inverse Laplace transform - Relation between L.T's - and F.T. of a signal. Laplace transform of certain signals using waveform synthesis.

#### **Z-Transforms**

Concept of Z- Transform of a discrete sequence. Region of convergence in Z-Transform - constraints on ROC for various classes of signals - Inverse Z-transform - properties of Z-transforms. Distinction between Laplace - Fourier and Z transforms.

#### **Course Outcomes:**

After the completion of the course the student should be able to:

- Apply the knowledge of various signals and operations.
- Analyze the spectral characteristics of periodic signals using Fourier Analysis.
- Classify the systems based on their properties and determine the response of LSI system using convolution.
- Understand the process of sampling and the effects of under sampling.
- Apply Laplace and z-transforms to analyze signals and Systems (continuous & discrete).

#### **Text Books:**

1. Signals - Systems & Communications - B.P. Lathi - BS Publications - 2003.
2. Signals and Systems - A.V. Oppenheim - A.S. Willsky and S.H. Nawab - PHI - 2nd Edition- 1997
3. Signals & Systems - Simon Haykin and Van Veen - Wiley - 2nd Edition - 2007

#### **Reference Books:**

1. Principles of Linear Systems and Signals – BP Lathi - Oxford University Press - 2015
2. Signals and Systems – T K Rawat - Oxford University press - 2011.



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		<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>
<b>ELECTRIC DRIVES</b> <b>(PROFESSIONAL ELECTIVE – II)</b>					

**Preamble:**

This course is an extension of power electronics applications to electric drives. This course covers in detail the application of power electronics converters for speed control of DC & AC motor drives.

**Course Objectives:**

- To learn the fundamentals of electric drive and different electric braking methods.
- To analyze the operation of three phase converter controlled dc motors and four quadrant operation of dc motors using dual converters.
- To discuss the DC-DC converter control of dc motors.
- To understand the concept of speed control of induction motor by using AC voltage controllers, voltage source inverters and slip power recovery scheme.
- To learn the speed control mechanism of synchronous motors

**UNIT - I****Fundamentals of Electric Drives**

Electric drive and its components– Fundamental torque equation – Load torque components – Nature and classification of load torques – Steady state stability – Load equalization– Four quadrant operation of drive (hoist control) – Braking methods: Dynamic – Plugging – Regenerative methods.

**UNIT - II****Controlled Converter Fed DC Motor Drives**

3-phase half and fully-controlled converter fed separately and self-excited DC motor drive – Output voltage and current waveforms – Speed-torque expressions – Speed-torque characteristics – Dual converter fed DC motor drives -Numerical problems.

**UNIT - III****DC–DC Converters Fed DC Motor Drives**

Single quadrant, two quadrant and four quadrant DC-DC converter fed separately excited and self-excited DC motors – Continuous current mode of operation - Output voltage and current waveforms – Speed–torque expressions and characteristics – Closed loop operation (qualitative treatment only).

**UNIT - IV****Stator and Rotor side control of 3-phase Induction motor Drive**

Stator voltage control using 3-phase AC voltage regulators – Waveforms –Speed torque characteristics– Variable Voltage Variable Frequency control of induction motor by PWM voltage source inverter – Closed loop V/f control of induction motor drives (qualitative treatment only). Static rotor resistance control – Slip power recovery schemes – Static Scherbius drive – Static Kramer drive – Performance and speed torque characteristics.

**UNIT - V****Control of Synchronous Motor Drives**

Separate control of synchronous motor – self-control of synchronous motor employing load commutated thyristor inverter - closed loop control of synchronous motor drive (qualitative treatment only)– PMSM (Basic operation only).



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**Course Outcomes:**

After the completion of the course the student should be able to:

- Explain the fundamentals of electric drive and different electric braking methods.
- Analyze the operation of three-phase converter fed dc motors and four quadrant operations of dc motors using dual converters.
- Describe the DC-DC converter fed control of dc motors in various quadrants of operation
- Know the concept of speed control of induction motor by using AC voltage controllers and voltage source inverters and differentiate the stator side control and rotor side control
- Learn the concepts of speed control of synchronous motor with different methods.

**Text Books:**

1. Fundamentals of Electric Drives – by G K Dubey - Narosa Publications - 2<sup>nd</sup> edition – 2002.
2. Power Semiconductor Drives - by S.B.Dewan - G.R.Slemon - A.Straughen - Wiley India - 1984.

**Reference Books:**

1. Electric Motors and Drives Fundamentals - Types and Applications - by Austin Hughes and Bill Drury - Newnes.4<sup>th</sup> edition - 2013.
2. Thyristor Control of Electric drives – Vedam Subramanyam Tata McGraw Hill Publications - 1987.
3. Power Electronic Circuits - Devices and applications by M.H.Rashid - PHI - 3<sup>rd</sup> edition - 2009.



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<b>III Year – II SEMESTER</b>		<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>
<b>ADVANCED CONTROL SYSTEMS</b> (PROFESSIONAL ELECTIVE – II)					

**Preamble:**

This subject aims to study state space, design of state feedback controllers and state observers, describing function and stability analysis including controllability and observability. It also deals with modern control and optimal control systems.

**Course Objectives:**

- To familiarize the state space representation in controllable, observable, diagonal and Jordan canonical forms.
- Introduce the concept of controllability and observability tests through canonical forms and design of state feedback controller by pole placement technique and State Observer design.
- Analysis of a nonlinear system using describing function approach.
- Illustrate the Lyapunov's method of stability analysis for linear and non-linear continuous time autonomous systems.
- Formulation of Euler Lagrange equation for the optimization of typical functional and solutions.

**UNIT - I****State Space Analysis**

State Space Representation – Canonical forms – Controllable canonical form – Observable canonical form - Jordan Canonical Form - Solution of state equation – State transition matrix.

**UNIT - II****Controllability - Observability and Design of Pole Placement**

Tests for controllability and observability for continuous time systems – Time varying case – Minimum energy control – Time invariant case – Principle of duality – Controllability and observability form Jordan canonical form and other canonical forms – Effect of state feedback on controllability and observability – Design of state feedback control through pole placement.

**UNIT - III****Nonlinear Systems**

Introduction to nonlinear systems - Types of nonlinearities. Introduction to phase–plane analysis - Singular points; Describing function - basic concepts - Describing functions of non- linearities.

**UNIT - IV****Stability analysis by Lyapunov Method**

Stability in the sense of Lyapunov – Lyapunov's stability and Lyapunov's instability theorems – Direct method of Lyapunov for the linear and nonlinear continuous time autonomous systems.

**UNIT - V****Calculus of Variations**

Minimization of functional of single function – Constrained minimization – Minimum principle – Control variable inequality constraints – Control and state variable inequality constraints –Euler lagrangine equation.





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**Course Outcomes:**

After the completion of the course the student should be able to:

- Analyse different canonical forms - solution of State equation.
- Design of control system using the pole placement technique is given after introducing the concept of controllability and observability.
- Analyze nonlinear system using describing function technique and phase plane analysis.
- Examine the stability analysis using Lyapunov method.
- Illustrate the Minimization of functional using calculus of variation - state and quadratic regulator problems.

**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 Mc Graw–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.



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<b>III Year – I SEMESTER</b>		<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>
<b>SWITCHGEAR AND PROTECTION</b> <b>(PROFESSIONAL ELECTIVE – II)</b>					

**Preamble:**

In order to supply power from generating end to receiving end several equipments are connected in to the system. In order to protect the equipments and components against various operating conditions and over voltages protective devices are required to be installed in the system. Topics specified in this subject deal with various types of protective equipments and their working principle including limitations etc.

**Course Objectives:**

- To provide the basic principles and operation of various types of circuit breakers.
- To know the classification, operation and application of different types of electromagnetic protective relays.
- To explain protective schemes for generator and transformers.
- To gain the knowledge of various protective schemes used for feeders and bus bars.
- To explain the principle and operation of different types of static relays.
- To understand different types of over voltages in a power system and principles of different neutral grounding methods.

**UNIT–I****Circuit Breakers**

Application oriented evolution of Switchgear - Miniature Circuit Breaker(MCB)– Elementary principles of arc interruption– Restriking Voltage and Recovery voltages– Restriking phenomenon - RRRV– Average and Max. RRRV– Current chopping and Resistance switching– Concept of oil circuit breakers– Description and operation of Air Blast– Vacuum and SF<sub>6</sub> circuit breakers– Circuit Breaker ratings and specifications– Concept of Auto reclosing – Application Spectrum Numerical examples

**UNIT–II****Electromagnetic Protection**

Relay connection – Balanced beam type attracted armature relay - induction disc and induction cup relays–Torque equation - Relays classification–Instantaneous– DMT and IDMT types– Applications of relays: Over current and under voltage relays– Directional relays– Differential relays and percentage differential relays– Universal torque equation– Distance relays: Impedance– Reactance– Mho and offset mho relays– Characteristics of distance relays and comparison.

**UNIT–III****Generator Protection**

Protection of generators against stator faults– Rotor faults and abnormal conditions– restricted earth fault and inter turn fault protection– Numerical examples.

**Transformer Protection**

Percentage differential protection– Design of CT's ratio– Buchholz relay protection–Numerical examples.

**UNIT–IV****Feeder and Bus bar Protection & Static Relays:**

Over current Protection schemes – PSM - TMS – Numerical examples – Carrier current and three zone distance relay using impedance relays.

Protection of bus bars by using Differential protection.

Static relays: Introduction – Classification of Static Relays – Basic Components of Static Relays.



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**UNIT–V**

**Protection against over voltage and grounding**

Generation of over voltages in power systems– Protection against lightning over voltages– Valve type and zinc oxide lightning arresters.

Grounded and ungrounded neutral systems – Effects of ungrounded neutral on system performance – Methods of neutral grounding: Solid–resistance–Reactance–Arcing grounds and grounding Practices.

**Course Outcomes:**

After the completion of the course the student should be able to:

- Illustrate the principles of arc interruption for application to high voltage circuit breakers of air - oil - vacuum - SF<sub>6</sub> gas type.
- Analyse the working principle and operation of different types of electromagnetic protective relays.
- Acquire knowledge of protective schemes for generator and transformers for different fault conditions.
- Classify various types of protective schemes used for feeders and bus bar protection and Types of static relays.
- Analyse the operation of different types of over voltages protective schemes required for insulation co-ordination and types of neutral grounding.

**Text Books:**

1. Power System Protection and Switchgear by Badri Ram and D.N Viswakarma - Tata McGraw Hill Publications - 2<sup>nd</sup> edition - 2011.
2. Power system protection- Static Relays with microprocessor applications by T.S.Madhava Rao - Tata McGraw Hill - 2<sup>nd</sup> edition.

**Reference Books:**

1. Fundamentals of Power System Protection by Paithankar and S.R.Bhide. - PHI - 2003.
2. Art & Science of Protective Relaying – by C R Mason - Wiley Eastern Ltd.
3. Protection and SwitchGear by BhaveshBhalja - R.P. Maheshwari - Nilesh G.Chothani - Oxford University Press - 2013.



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<b>III Year – II SEMESTER</b>		<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>
<b>BIG DATA ANALYTICS</b> <b>(PROFESSIONAL ELECTIVE – II)</b>					

**Course Objectives:**

- To understand the competitive advantages of big data analytics
- To understand the big data frameworks
- To learn data analysis methods
- To learn stream computing
- To gain knowledge on Hadoop related tools such as HBase, Cassandra, Pig, and Hive for big data analytics

**UNIT-I****Introduction To Big Data**

Big Data, Definition, Characteristic Features, Big Data Applications, Big Data vs Traditional Data, Risks of Big Data, Structure of Big Data, Challenges of Conventional Systems, Web Data, Evolution of Analytic Scalability.

**UNIT-II****Hadoop Framework**

Distributed File Systems, Large-Scale File System Organization, HDFS concepts, Map Reduce Execution, Algorithms using Map Reduce, Hadoop YARN.

**UNIT-III****Data Analysis**

Statistical Methods: Regression modelling, Multivariate Analysis, Classification: SVM & Kernel Methods, Rule Mining, Cluster Analysis, Types of Data in Cluster Analysis, Partitioning Methods, Predictive Analytics, Data analysis using R.

**UNIT-IV****Mining Data Streams**

Streams: Concepts, Stream Data Model and Architecture, Sampling data in a stream, Mining Data Streams and Mining Time-series data, Real Time Analytics Platform (RTAP) Applications, Case Studies, Real Time Sentiment Analysis.

**UNIT-V****Big Data Frameworks**

Introduction to NoSQL, Aggregate Data Models, Hbase: Data Model and Implementations, Hbase Clients, Examples, Cassandra: Data Model, Examples, Cassandra Clients, Hadoop Integration.

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

- Understand how to leverage the insights from big data analytics
- Analyze data by utilizing various statistical and data mining approaches
- Perform analytics on real-time streaming data
- Understand the various NoSql alternative database models



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**Software Links:**

1. Hadoop: <http://hadoop.apache.org/>
2. Hive: <https://cwiki.apache.org/confluence/display/Hive/Home>
3. Pig latin: <http://pig.apache.org/docs/r0.7.0/tutorial.html>

**Text Books:**

1. Big Java 4th Edition, Cay Horstmann, Wiley John Wiley & Sons, INC
2. Hadoop: The Definitive Guide by Tom White, 3rd Edition, O'reilly
3. Hadoop in Action by Chuck Lam, MANNING Publ.

**Reference Books:**

1. Hadoop in Practice by Alex Holmes, MANNING Publ.
2. Hadoop MapReduce Cookbook, SrinathPerera, ThilinaGunarathne
3. Michael Berthold, David J. Hand, —Intelligent Data Analysis, Springer, Second Edition, 2007.
4. Michael Minelli, Michelle Chambers, and Ambiga Dhiraj, "Big Data, Big Analytics: Emerging Business Intelligence and Analytic Trends for Today's Businesses", Wiley



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<b>III Year – II SEMESTER</b>		<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>
<b>BATTERY MANAGEMENT SYSTEMS AND CHARGING STATIONS</b>					
<b>(OPEN ELECTIVE – II)</b>					

**Preamble:**

The objective of this course is to introduce learner to batteries, its parameters, charging requirements and modelling. The course will help learner to understand the types of batteries and their charging methods, develop battery management and modelling algorithms for batteries.

**Course objectives:**

- Able to understand the working of different batteries for EV applications
- Able to know the fundamentals of battery charging methods and their advantages
- Able to know the different kinds of equipment in charging station
- Able to know the requirements of battery management.
- Able to know method of modelling batteries and their simulation studies.

**Unit - I:****EV Batteries**

Cells & Batteries, Nominal voltage and capacity, C rate, Energy and power, Cells connected in series, Cells connected in parallel. **Lead Acid Batteries:** Lead acid battery basics, special characteristics of lead acid batteries, battery life and maintenance, Li-ion batteries. **Nickel-based Batteries:** Nickel cadmium, Nickel metal hydride batteries. **Sodium-Based Batteries:**

Introduction, sodium sulphur batteries, sodium metal chloride (Zebra) batteries.

**Lithium Batteries:** Introduction, the lithium polymer battery, lithium ion battery.

**Unit - II:****Battery charging strategies**

Charging algorithms for a single battery: Basic terms for charging performance evaluation and characterization, CC charging for NiCd/NiMH batteries, CV charging for lead acid batteries, CC/CV charging for lead acid and Li-ion batteries, MSCC charging for lead acid, NiMH and Li-ion batteries, TSCC/CV charging for Li-ion batteries, CVCC/CV charging for Li-ion batteries, Pulse charging for lead acid, NiCd/NiMH and Li-ion batteries, Charging termination techniques, Comparisons of charging algorithms and new development; Balancing methods for battery pack charging: Battery sorting Overcharge for balancing, Passive balancing, Active balancing.

**Unit -III:****Charging Infrastructure**

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

**Unit - IV:****Battery-Management-System Requirements**

Battery-pack topology, BMS design requirements, Voltage sense, Temperature sense, Current sense, Contactor control, Isolation sense, Thermal control, Protection, Charger control, Communication via CAN bus, Log book, SOC estimation, Energy estimation, Power estimation, Diagnostics .

**Unit - V:****Battery Modelling**

General approach to modelling batteries, simulation model of rechargeable Li-ion battery, simulation model of a rechargeable NiCd battery, Parameterization of NiCd battery model, Simulation examples.



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**Course Outcomes:**

After the completion of the course the student should be able to:

- Describe the construction and operation of different batteries for EV applications
- Describe charging algorithms of different batteries and balancing methods of battery packs
- Describe the different kinds of infrastructure needed in the charging stations
- Describe the requirements of battery management and their maintenance.
- Obtain the modelling of batteries and develop their simulation models.

**Text Books**

1. Electric Vehicles Technology Explained by James Larminie Oxford Brookes University, Oxford, UK John Lowry Acenti Designs Ltd., Uk. (Unit-1)
2. Energy Systems for Electric and Hybrid Vehicles by K.T. Chau, IET Publications, First edition, 2016. (Unit-2)

**Reference Books:**

1. Modern Electric Vehicles Technology by C.C.Chan, K.T Chau, Oxford University Press Inc., New york , 2001. (Unit-3)
2. Battery Management Systems Vol. – II Equivalent Circuits and Methods, by Gregory L.Plett, Artech House publisher, First edition 2016. (Unit-4)
3. Battery Management Systems: design by Modelling by Henk Jan Bergveld, Wanda S. Kruijt, Springer Science & Business Media, 2002. (Unit-5)



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<b>III Year – II SEMESTER</b>		<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>
<b>FUNDAMENTALS OF UTILIZATION OF ELECTRICAL ENERGY</b> (OPEN ELECTIVE – II)					

**Preamble:**

In the modern society, every engineer is using electrical energy irrespective of their branch of specialization. To provide knowledge about the various electrical energy utilization technologies to non-electrical engineering students this course is developed. In this course, a detailed description about the illumination requirements and energy storage, various techniques used for heating & welding applications, and brief description about the electric traction are presented. At the end of the course, an insight in to the important techniques of various energy storage systems is also presented.

**Course Objectives:**

- To study the various types of Illumination equipment, measurement of Illumination, Illumination techniques.
- To know the various technologies used for heating applications using electrical energy.
- To understand the various welding techniques and operations of welding equipment and comparison.
- To know the various systems of traction, equipment used for traction.
- To understand the importance and operation of various Energy storage systems and comparison & applications.

**UNIT - I****Illumination fundamentals**

Introduction - terms used in illumination–Laws of illumination–Lux meter–Sources of light.

**Various Illumination Methods**

Tungsten filament lamps and fluorescent lamps - Comparison –Basic principles of light control– Types and design of lighting and flood lighting–LED lighting - Energy conservation.

**UNIT - II****Electric Heating**

Advantages and methods of electric heating–Resistance heating induction heating and dielectric heating.

**UNIT - III****Electric Welding**

Electric welding–Resistance and arc welding–Electric welding equipment–Comparison between AC and DC Welding

**UNIT - IV****Electric Traction**

System of electric traction and track electrification– Review of existing electric traction systems in India–Special features of traction motor– Mechanics of train movement–Speed–time curves for different services – Trapezoidal and quadrilateral speed time curves. Calculations of tractive effort– power – Specific energy consumption for given run–Effect of varying acceleration and braking retardation–Adhesive weight and braking retardation adhesive weight and coefficient of adhesion.

**UNIT - V****Introduction to Energy Storage Systems**

Need for energy storage - Types of energy storage-Thermal - electrical - magnetic and chemical storage systems - Comparison of energy storage technologies-Applications.





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**Course Outcomes:**

After the completion of the course the student should be able to:

- Know the concepts of illumination and various illumination methods.
- Know about the resistance - induction and dielectric heating.
- Learn about the resistance and arc welding and welding equipment
- Know about the mechanisms - equipment and technology used in the electric traction.
- Differentiate the importance of various energy storage systems

**Text Books:**

1. Electrical Power Systems(Generation, Transmission, Distribution, Protection and Utilization of Electrical Energy) – Dr. S.L.Uppal and Prof. Sunil S.Rao – Khanna Publisher, 15<sup>th</sup> edition, 1987.
2. Electric Power Distribution – A S Pabla – McGrawHill.

**Reference Books:**

1. Generation Distribution and Utilization of Electrical Energy – C.L.Wadhwa- New Age International Publishers- revised third edition.



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<b>III Year – II SEMESTER</b>		<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>
<b>INDIAN ELECTRICITY ACT</b> <b>(OPEN ELECTIVE – II)</b>					

**Preamble:**

This course helps the students to learn the electricity policies in generation, transmission and distribution networks. To understand the licensing process, regular commission, legal and special court issues and their solving capabilities.

**Course Objectives:**

- To acquire knowledge on national policy, plan and joint responsibilities of state and central governments.
- To understand the licensing procedures in transmission and distribution companies.
- To learn the regulatory body rules and protocols.
- To understand the offences and penalties related issues with respect to different tribunals.
- To learn the legal related issues and their resolutions.

**UNIT – I****National Electricity Policy and Plan - Generation of Electricity**

Electricity Act: commencement - definitions - comments; national policy on standalone systems - non-conventional energy systems - electrification and local distribution for rural areas; joint responsibilities of state and central governments in rural electrification - requirement for setting up of generating station - hydro-electric generation - captive generation; duties of generating companies.

**UNIT – II****Licensing -Transmission and Distribution Of Electricity**

Licensing: powers - procedures - conditions - amendments - revocation - provisions - directions - suspension and sale; inter-state and intra-state transmission; other provisions relating to transmission; provisions with respect to distribution licenses - electricity traders - supply generally; consumer protection: standard performance.

Electrical Wiring, Estimation & Costing

**UNIT – III****Tariff - CEA and Regulatory Commissions**

Works of licenses - provisions relating to overhead lines; Constitution and functions of Central Electricity Authority (CEA) - directions and certain powers; Constitution - powers and functions of state and central commissions - other provisions - proceedings and powers of Appropriate commission - Grants - Fund - Accounts Audit and Report.

**UNIT – IV****Appellate Tribunal - Reorganisation of Boards - Offences and Penalty**

Appellate Tribunal for electricity; investigation and assessment; reorganisation of boards; Offences and penalties.

**UNIT – V****Special Courts - Dispute Resolution - Other Provisions and Miscellaneous**

Constitution of special courts - procedures - powers - appeal - revision; arbitration; protective clauses; miscellaneous and enactments.



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**Course Outcomes:**

After the completion of the course the student should be able to:

- Learn the national policy and plan and the joint responsibilities of state and central governments.
- Analyze the licensing and the provisions related to transmission and distribution of electricity.
- Remember the composition and powers of Regulatory commissions and CEA.
- Learn the functions of Appellate Tribunal for electricity.
- Know the constitution procedure and provisions in Special courts and dispute resolutions.

**Text Books:**

1. The Electricity Act - 2003 {Act 36 of 2003 - dt.2-6-2003 - w.e.f. 10-6-2003 vide S.O. No. 669(E) - dt. 10-6-2003] published by Commercial Law Publishers (I) Pvt. Ltd.



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<b>III Year – II SEMESTER</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
	<b>0</b>	<b>0</b>	<b>3</b>	<b>1.5</b>
<b>ELECTRICAL MEASUREMENTS AND INSTRUMENTATION LABORATORY</b>				

**Course Objectives:**

- To understand students how different types of meters work and their construction.
- To make the students understand how to measure resistance, inductance and capacitance by AC & DC bridges.
- To understand the testing of CT and PT.
- To Understand and the characteristics of Thermo couples, LVDT, Capacitive transducer, piezoelectric transducer.
- To understand the measurement of strain and choke coil parameters.
- To study the procedure for standardization and calibration of various methods.

**Any 10 of the following experiments are to be conducted**

1. Calibration of dynamometer wattmeter using phantom loading
2. Measurement of resistance using Kelvin's double Bridge and Determination of its tolerance.
3. Measurement of Capacitance using Schering Bridge.
4. Measurement of Inductance using Anderson Bridge.
5. Calibration of LPF Wattmeter by direct loading.
6. Measurement of 3 phase reactive power using single wattmeter method for a balanced load.
7. Testing of C.T. using mutual inductor – Measurement of % ratio error and phase angle of given C.T. by Null deflection method.
8. P.T. testing by comparison – V.G as Null detector – Measurement of % ratio error and phase angle of the given P.T.
9. Determination of the characteristics of a Thermocouple.
10. Determination of the characteristics of a LVDT.
11. Determination of the characteristics for a capacitive transducer.
12. Measurement of strain for a bridge strain gauge.
13. Measurement of Choke coil parameters and single phase power using three voltmeter and three ammeter methods.
14. Calibration of single phase Energy Meter.
15. Dielectric oil Test using HV Kit.
16. Calibration of DC ammeter and voltmeter using Crompton DC Potentiometer.
17. AC Potentiometer: Polar Form / Cartesian Form - Calibration of AC voltmeter - Parameters of choke.

**Course Outcomes:**

After the completion of the course the student should be able to:

- Know about the phantom loading.
- Learn the calibration process.
- Measure the electrical parameters voltage - current - power - energy and electrical characteristics of resistance - inductance and capacitance.
- Gain the skill knowledge of various bridges and their applications.
- Learn the usage of CT's - PT's for measurement purpose.
- Know the characteristics of transducers.
- Measure the strains - frequency and phase difference.



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<b>III Year –II SEMESTER</b>		<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		<b>0</b>	<b>0</b>	<b>3</b>	<b>1.5</b>
<b>MICRO PROCESSORS AND MICRO CONTROLLERS LAB</b>					

**Course Objectives:**

- To study programming based on 8086 microprocessor and 8051 microcontroller.
- To study 8086 microprocessor based ALP using arithmetic, logical and shift operations.
- To study to interface 8086 with I/O and other devices.
- To study parallel and serial communication using 8051 & PIC 18 micro controllers.

**Any 10 of the following experiments are to be conducted:**

**8086 Microprocessor Programs:**

1. Arithmetic operations – Two 16-bit numbers and multibyte addition - subtraction - multiplication and division – Signed and unsigned arithmetic operations - ASCII – Arithmetic operations.
2. Logic operations – Shift and rotate – Converting packed BCD to unpacked BCD - BCD to ASCII conversion.
3. Arrange the given array in ascending and descending order
4. Determine the factorial of a given number
5. By using string operation and Instruction prefix: Move block - Reverse string Sorting - Inserting - Deleting - Length of the string - String comparison.
6. Find the first and n<sup>th</sup> number of ‘n’ natural numbers of a Fibonacci series.
7. Find the number and sum of even and odd numbers of a given array
8. Find the sum of ‘n’ natural numbers and squares of ‘n’ natural numbers
9. Arithmetic operations on 8051
10. Conversion of decimal number to hexa equivalent and hexa equivalent to decimal number
11. Find the Sum of elements in an array and also identify the largest & smallest number of a given array using 8051.

**Programs on Interfacing:**

12. Interfacing 8255–PPI with 8086.
13. Stepper motor control using 8253/8255.
14. Reading and Writing on a parallel port using 8051
15. Timer in different modes using 8051
16. Serial communication implementation using 8051
17. Understanding three memory areas of 00 – FF Using 8051 external interrupts.
18. Traffic Light Controller using 8051.

**Course Outcomes:**

After the completion of the course the student should be able to:

- Write assembly language program using 8086 microprocessor based on arithmetic - logical - number systems and shift operations.
- Write assembly language programs for numeric operations and array handling problems.
- Write a assembly program on string operations.
- Interface 8086 with I/O and other devices.
- Do parallel and serial communication using 8051 & PIC 18 micro controllers.
- Program microprocessors and microcontrollers for real world applications.



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<b>III Year – II SEMESTER</b>		<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		<b>0</b>	<b>0</b>	<b>3</b>	<b>1.5</b>
<b>POWER SYSTEMS AND SIMULATION LAB</b>					

**Course Objectives:**

To impart the practical knowledge of functioning of various power system components and determination of various parameters and simulation of load flows, transient stability, LFC and Economic dispatch.

**Any of 5 experiments are to be conducted from each section:****Section I: Power Systems Lab:**

1. Estimation of sequence impedances of 3-phase Transformer
2. Estimation of sequence impedances of 3-phase Alternator by Fault Analysis
3. Estimation of sequence impedances of 3-phase Alternator by Direct method
4. Estimation of ABCD parameters on transmission line model
5. Performance of long transmission line without compensation
6. Performance of long transmission line with shunt compensation
7. Analyze the Ferranti effect on long transmission line

**Section II: Simulation Lab**

8. Determination of  $Y_{bus}$  using direct inspection method
9. Load flow solution of a power system network using Gauss-Seidel method
10. Load flow solution of a power system network using Newton Raphson method.
11. Formation of  $Z_{bus}$  by building algorithm.
12. Economic load dispatch with & without losses
13. Load frequency control of a two area Power System without & with PI controller
14. Transient Stability analysis of single machine connected to an infinite bus (SMIB) using equal area criterion.

**Course Outcomes:**

After the completion of the course the student should be able to:

- Estimate the sequence impedances of 3-phase Transformer and Alternators
- Evaluate the performance of transmission lines
- Analyse and simulate power flow methods in power systems
- Analyse and simulate the performance of PI controller for load frequency control.
- Analyse and simulate stability studies of power systems



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**DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING**

<b>III Year – II SEMESTER</b>		<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		<b>2</b>	<b>0</b>	<b>0</b>	<b>2</b>
<b>SKILL ADVANCED COURSE</b> <b>MACHINE LEARNING WITH PYTHON</b>					

**Course Objectives:**

From the course the student will learn

- patterns and concepts from data without being explicitly programmed in various IOT nodes.
- to design and analyze various machine learning algorithms and techniques with a modern outlook focusing on recent advances.
- to explore supervised and unsupervised learning paradigms of machine learning, Deep learning technique and various feature extraction strategies.

**UNIT-I****Introduction to Machine Learning with Python**

Introduction to Machine Learning, basic terminology, Types of Machine Learning and Applications, Using Python for Machine Learning: Installing Python and packages from the Python Package Index, Introduction to NumPy, SciPy, matplotlib and scikitlearn, Tiny application of Machine Learning.

**UNIT-II****Supervised Learning**

Types of Supervised Learning, Supervised Machine Learning Algorithms: k-Nearest Neighbors, Linear Models, Naive Bayes Classifiers, Decision Trees, Ensembles of Decision Trees, Kernelized Support Vector Machines, Uncertainty Estimates from Classifiers.

**UNIT-III****Unsupervised Learning**

Types of Unsupervised Learning, challenges, Preprocessing and scaling, Dimensionality Reduction, Feature Extraction, Manifold Learning, Clustering: K-Means Clustering, Agglomerative Clustering, DBSCAN, Comparing and Evaluating Clustering Algorithms.

**UNIT-IV****Representing Data and Engineering Features**

Categorical Variables, Binning, Discretization, Linear Models, Trees, Interactions and Polynomials, Univariate Nonlinear Transformations, Automatic Feature Selection. Parameter Selection with Preprocessing, Building Pipelines, The General Pipeline Interface.

**UNIT-V****Working with Text Data (Data Visualization)**

Types of Data Represented as Strings, Example Application: Sentiment Analysis of Movie Reviews, Representing Text Data as a Bag of Words, Stop Words, Rescaling the Data with tf-idf, Investigating Model Coefficients, Approaching a Machine Learning Problem, Testing Production Systems, Ranking, Recommender Systems and Other kinds of Learning.

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

- Illustrate and comprehend the basics of Machine Learning with Python
- Demonstrate the algorithms of Supervised Learning and be able to differentiate linear and logistic regressions
- Demonstrate the algorithms of Unsupervised Learning and be able to understand the clustering algorithms
- Evaluate the concepts of binning, pipeline Interfaces with examples
- Apply the sentiment analysis for various case studies



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**Text Books:**

1. Introduction to Machine Learning with Python: A Guide for Data Scientists, Andreas C. Muller & Sarah Guido, Orielly Publications, 2019.
2. Python Machine Learning, Sebastian Raschka & Vahid Mirjalili, 3<sup>rd</sup> Edition, 2019.
3. Building Machine Learning Systems with Python, Luis Pedro Coelho, Willi Richert, 2nd Edition, 2015.

**Reference Books:**

1. Machine Learning, Tom M. Mitchell, Mc Graw-Hill Publication, 2017





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		<b>2</b>	<b>0</b>	<b>0</b>	<b>0</b>
<b>RESEARCH METHODOLOGY</b>					

**Course objectives:**

- To understand the objectives and characteristics of a research problem.
- To analyze research related information and to follow research ethics
- To understand the types of intellectual property rights.
- To learn about the scope of patent rights.
- To understand the new developments in IPR.

**UNIT - I**

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

**UNIT - II**

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

**UNIT - III**

**Nature of Intellectual Property:** Patents, Designs, Trade and Copyright.

**Process of Patenting and Development:** technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

**UNIT - IV**

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

**UNIT - V**

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

**Course Outcomes:**

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

- Understand objectives and characteristics of a research problem
- Analyze research related information and to follow research ethics.
- Understand the types of intellectual property rights.
- Learn about the scope of IPR.
- Understand the new developments in IPR.

**Text Books:**

1. Stuart Melville and Wayne Goddard, “Research methodology: an introduction for science & engineering students”
2. Wayne Goddard and Stuart Melville, “Research Methodology: An Introduction”
3. Ranjit Kumar, 2nd Edition, “Research Methodology: A Step by Step Guide for beginners”



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**References Books:**

1. Halbert, “Resisting Intellectual Property”, Taylor & Francis Ltd ,2007.
2. Mayall, “Industrial Design”, McGraw Hill, 1992.
3. Niebel, “Product Design”, McGraw Hill, 1974.
4. Asimov, “Introduction to Design”, Prentice Hall, 1962.
5. Robert P. Merges, Peter S. Menell, Mark A. Lemley, “ Intellectual Property in New Technological Age”, 2016.
6. T. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand, 2008



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		<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>
<b>DIGITAL CONTROL SYSTEMS</b>					
<b>(Honors Engineering Course)</b>					

**Preamble:**

In recent years digital controllers have become popular due to their capability of accurately performing complex computations at high speeds and versatility in leading nonlinear control systems. In this context, this course focuses on the analysis and design of digital control systems.

**Course objectives:**

- To understand the concepts of digital control systems and assemble various components associated with it. Advantages compared to the analog type.
- The theory of z–transformations and application for the mathematical analysis of digital control systems.
- To represent the discrete–time systems in state–space model and evaluation of state transition matrix, the design of state feedback control by “the pole placement method.”, design of state observers.
- To examine the stability of the system using different tests and study the conventional method of analyzing digital control systems in the w–plane.
- Design of state feedback controller through pole placement.

**UNIT - I****Introduction to Signal Processing**

Introduction to analog and digital control systems – Advantages of digital systems – Typical examples – Continuous and Discrete Time Signals – Sample and hold devices – Sampling theorem and data reconstruction – Frequency domain characteristics of zero order hold.

**UNIT - II****Z–Transformations**

Z–Transforms – Theorems – Finding inverse Z–transforms – Formulation of difference equations and solving – Block diagram representation – Pulse transfer functions and finding open loop and closed loop responses.

**UNIT - III****State Space Analysis and the Concepts of Controllability and Observability**

State space representation of discrete time systems – Solving Discrete Time state space equations – State transition matrix and its properties – Discretization of continuous time state equations – Concepts of controllability and observability – Tests(without proof).

**UNIT - IV****Stability Analysis**

Mapping between the S–Plane and the Z–Plane – Primary strips and Complementary strips – Stability criterion – Modified Routh’s stability criterion and Jury’s stability test.

**Design of Discrete–Time Control Systems By Conventional Methods**

Transient and steady state specifications – Design using frequency response in the w–plane for lag and lead compensators – Root locus technique in the z–plane.

**UNIT - V****State Feedback Controllers and State Observers**

Design of state feedback controller through pole placement – Necessary and sufficient conditions – Ackerman’s formula – Design of state observers (Full Order and Reduced Order).



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**Course Outcomes:**

After the completion of the course the student should be able to:

- Illustrate advantages of digital systems, sampling and data reconstruction.
- Calculate Z Transform and Inverse Z Transfer function, pulse transfer functions of open and closed loop response.
- Construct various canonical forms and concepts of controllability and observability.
- Compute the absolute and relative stability of discrete time systems using Routh Stability criterion and Root Locus, Design lag and lead compensators to improve system performance using bode diagrams.
- Design of state feedback controllers and state observers.

**Text Book:**

1. Discrete–Time Control systems – K. Ogata - Pearson Education/PHI - 2<sup>nd</sup> Edition.
2. Digital Control and State Variable Methods by M.Gopal - TMH - 4<sup>th</sup> Edition.

**Reference Books:**

1. Digital Control Systems - Kuo - Oxford University Press - 2nd Edition - 2003.



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		<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>
<b>ANALYSIS OF POWER ELECTRONIC CONVERTERS</b>					
<b>(Honors Engineering Course)</b>					

**Preamble:**

The usage of power electronics in day to day life has increased in recent years. It is important for students to analyze the power electronic converters in detail. This course covers characteristics of semiconductor devices and operation of AC-DC converters, PWM inverters & multilevel inverters.

**Course Objectives:**

- To learn the characteristics of switching devices & functionality of gate drive circuits.
- To illustrate the working of AC-DC converters.
- To learn functionality of PWM inverters in controlling the voltage and mitigating the harmonics.
- To understand the basic concepts of multi-level inverters.
- To learn PWM control of CHB and diode clamped multi-level inverters.

**UNIT – I****Overview of Switching Devices**

Power MOSFET, IGBT, GTO -static and dynamic characteristics, gate drive circuits for switching devices.

**UNIT – II****AC-DC Converters**

Single-phase fully-controlled converters with RL load– Continuous and Discontinuous load current operation-Evaluation of input power factor and harmonic factor Power factor improvements using extinction angle control, symmetrical angle control, PWM control. Three-Phase AC-DC fully-controlled Converters with RL load- Continuous and Discontinuous load current operation-Evaluation of input power factor and harmonic factor -three-phase dual converters.

**UNIT – III****PWM Inverters**

Operation of single-phase inverters -Voltage control of single-phase inverters - phase displacement Control –Bipolar PWM – Unipolar PWM- staircase PWM. Voltage Control of Three-Phase Inverters- Sinusoidal PWM- Third Harmonic PWM- Space Vector Modulation- Comparison of PWM Techniques- Three phase current source inverters-Variable dc link inverter.

**UNIT – IV****Multilevel Inverters**

Introduction, Multilevel Concept, Types of Multilevel Inverters- Diode-Clamped Multilevel Inverter, Principle of Operation, Features of Diode-Clamped Inverter- Flying-Capacitors Multilevel Inverter- Principle of Operation, Features of Flying-Capacitors Inverter- Cascaded H-bridge Multilevel Inverter, Principle of Operation, Features of Cascaded H-bridge Inverter- Comparisons of Multilevel inverters.

**UNIT – V****PWM Multilevel Inverters**

CHB Multilevel Inverter: SHE PWM- Phase shifted PWM-Level shifted PWM- Diode clamped Multilevel inverter: SHE PWM-Sinusoidal PWM- Space vector PWM-Capacitor voltage balancing.



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**Course Outcomes:**

After the completion of the course the student should be able to:

- Describe and analyze the characteristics of Switching devices
- Demonstrate the operation and perform harmonic analysis of AC-DC power converters.
- Analyze the operation of single-phase and three-phase inverters with PWM control.
- Illustrate the principles of operation of multilevel inverters.
- PWM Control of CHB and diode clamped multilevel inverters.

**Text Books**

1. Power Electronics: Converters, Applications, and Design- Ned Mohan, Tore M. Undeland, William P. Robbins, John Wiley& Sons, 2nd Edition, 2003.
2. Power Electronics-Md.H.Rashid –Pearson Education Third Edition- First IndianReprint-2008.
3. HIGH-POWER CONVERTERS AND AC DRIVES – Bin Wu, Wiley-IEEE Press, 2006.

**Reference Books:**

1. Elements of Power Electronics – Philip T. Krein, Oxford University press, 2014.
2. Power Converter Circuits – William Shepherd & Li Zhang-Yes Dee CRC Press, 2004.
3. Power Electronics Daniel W. Hart - McGraw-Hill, 2011.



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		<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>
<b>HVDC TRANSMISSION</b> (Honors Engineering Course)					

**Preamble:**

With the increasing power generation in the country and long distance power transmission, it is necessary that power should be transmitted at extra and ultra high voltage. The topics dealt in this subject relate to analysis of HVDC converters, control of HVDC converters and their protection.

**Course Objectives:**

- To analyse the operation of HVDC converters.
- To learn the principles of HVDC system control.
- To learn about converters faults and protection schemes of HVDC systems.
- To understand the requirements of reactive power control and filtering technique in HVDC system.
- To learn about MTDC systems and DC circuit breakers.

**UNIT - I****DC Power Transmission Technology**

Introduction - Historical Development - Comparison of AC and DC transmission - types of DC links - Existing HVDC Projects in INDIA. Modern Trends in HVDC Technology.

**Analysis of HVDC Converters**

Three Phase 6-Pulse bridge converter - simplified analysis - waveform with and without overlap - Current and voltage relationship - Equivalent circuits of converters - Analysis of a 12 pulse converters.

**UNIT - II****HVDC System Control**

Principles of DC link control - converter control characteristics - constant current and constant extinction angle control - constant ignition angle control - starting and stopping of HVDC link - power control & power reversal in HVDC link.

**UNIT - III****Converter Faults and Protection**

Over voltages in converter station - Surge arrestors - Protection against over voltages and over currents. Converter faults - Protection against faults in voltage source converter-Smoothing Reactor - Transient over voltages for DC line – Protection of DC lines.

**UNIT - IV****Reactive Power Control**

Sources of reactive power - Static VAR system – SVC and STATCOM - Reactive power control during transients.

**Harmonics & Filters**

Generation of harmonics – Types and design of various AC filters - DC filters – Active Filters.

**UNIT - V****Multi Terminal HVDC Systems & DC Circuit Breakers**

Types of MTDC systems - Control and Protection of MTDC system – HVDC insulation – DC line insulators – DC breakers – Characteristics and types of DC breakers.



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**Course Outcomes:**

After the completion of the course the student should be able to:

- Learn the basic concepts of HVDC Transmission & their converters.
- Understand the HVDC System Control Strategies with respect to protection.
- Understand the concepts of HVDC systems protection.
- Understand the various sources of reactive power
- Understand the Multi Terminal HVDC Systems.

**Text Book**

1. K. R. Padiyar - “HVDC Power Transmission Systems Technology and System Interactions” - New Age International (p) Limited - New Delhi - 2003.
2. Edward Wilson Kimbark - “Direct current Transmission” - Wiley Interscience - Vol. I - New York - 1971.

**Reference Books**

1. Vijay K. Sood - “HVDC and FACTS Controller: Application of Static Converters in power systems” - IEEE Power Electronics and Power Systems series - Kluwer Academic publishers - Boston - First edition January 2004.
2. C. Adamson and N.G. Hingorani - “High voltage DC power Transmission” - Garraway Limited - England - 1960.
3. Mohan - Undeland and Robbins - “Power Electronics Converters - Applications and Design - John Wiley & Son - Inc. - 2003.
4. J. Arrialga - “HVDC Transmission” - Peter Peregrinus Ltd. - London - 1983.





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		<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>
<b>EVOLUTIONARY ALGORITHMS</b>					
<b>(Minors Engineering Course)</b>					

**Preamble:**

Evolutionary algorithms use mechanisms inspired by nature and they can be used to solve optimization problems through process that emulate the behaviors of living organisms. In this course students learn different evolutionary algorithms and their applications to solve standard single-objective test problems.

**Course Objectives:**

- To classify optimization problems and learn the features of soft computing algorithms.
- To learn the steps of GA and PSO algorithms and their applications to solve Rosenbrock & Rastrigin function test problems.
- To learn HSA and ABC algorithms & their application to solve Rosenbrock & Rastrigin function test problems.
- To illustrate the steps of SFLA & Bat optimization algorithms & their application to solve standard single objective test problems.
- To learn the basic concepts of multi-objective optimization & steps of NSGA-II algorithm.

**UNIT - I****Fundamentals of Soft Computing Techniques**

Definition-Classification of optimization problems- Unconstrained and Constrained optimization  
 Optimality conditions- Soft computing techniques- Conventional Computing versus Soft Computing -  
 Classification of meta-heuristic techniques - Single solution based and population based algorithms –  
 Exploitation and exploration in population based algorithms - Discrete and continuous optimization  
 problems - Single objective and multi-objective problems.

**UNIT - II****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 standard  
 Rosenbrock, Rastrigin function test problems.

**UNIT - III****Harmony Search Optimization and Artificial Bee Colony Algorithms**

Harmony Search algorithm – steps – Harmony memory initialization, New harmony improvisation,  
 Harmony memory update – Improved Harmony search algorithm.

Task partitioning in honey bees - Balancing foragers and receivers - Artificial bee colony (ABC)  
 algorithms-HSA and ABC algorithms to solve Rosenbrock & Rastrigin function test problems.

**UNIT - IV****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 frogs-  
 comparison of memes and genes -memeplex formation- memeplex updation- BA and SFLA algorithms  
 to solve Rosenbrock & Rastrigin function test problems..



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**UNIT - V**

**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 solve general two objective optimization problem.

**Course Outcomes:**

After the completion of the course the student should be able to:

- State and formulate the optimization problem, without and with constraints, by using design variables.
- Apply GA and PSO algorithms to solve single objective optimization problems
- Apply HSA and ABC algorithms to solve single objective optimization problems
- Apply Bat and SFL algorithms to solve single objective optimization problems
- Formulate multi-objective optimization problem and use NSGA-II to solve two objective optimization problem

**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. K. Nekooei, M. M. Farsangi, H. Nezamabadi-Pour and K. Y. Lee, "An Improved Multi-Objective Harmony Search for Optimal Placement of DGs in Distribution Systems," in *IEEE Transactions on Smart Grid*, vol. 4, no. 1, pp. 557-567, March 2013, doi: 10.1109/TSG.2012.2237420.



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		<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>
<b>FUNDAMENTALS OF POWER ELECTRONICS</b>					
<b>(Minors Engineering Course)</b>					

**Preamble:**

The usage of power electronics in day to day life has increased in recent years. It is important for student to understand the fundamental principles behind all power electronic converters. This course covers characteristics of semiconductor devices and operation of ac/dc, dc/dc, ac/ac and dc/ac converters. The importance of using pulse width modulated techniques to obtain high quality power supply (dc/ac converter) is also discussed in detail in this course.

**Course Objectives:**

- To know the characteristics of various power semiconductor devices.
- To learn the operation of single phase full-wave converters and perform harmonic analysis of input current.
- To learn the operation of three phase full-wave converters and AC/AC converters.
- To learn the operation of different types of DC-DC converters.
- To learn the operation of PWM inverters for voltage control and harmonic mitigation.

**UNIT – I****Power Semi-Conductor Devices**

Silicon controlled rectifier (SCR) – Two transistor analogy - Static and Dynamic characteristics  
 Static and Dynamic Characteristics of Power MOSFET and Power IGBT– Gate Driver Circuits for Power MOSFET and IGBT - Numerical problems.

**UNIT – II****Single-phase AC-DC Converters**

Single-phase half wave controlled rectifiers - R load and RL load with and without freewheeling diode - Single-phase fully controlled bridge converter with R load - RL load and RLE load - Continuous and Discontinuous conduction - Expression for output voltages – Single-phase Semi-Converter with R load - RL load and RLE load – Continuous and Discontinuous conduction - Harmonic Analysis - Numerical Problems.

**UNIT – III****Three-phase AC-DC Converters & AC – AC Converters**

Three-phase fully controlled rectifier with R and RL load - Three-phase semi converter with R and RL load - Expression for Output Voltage - Harmonic Analysis - Numerical Problems.  
 AC-AC power control by phase control with R and RL loads - Expression for rms output voltage- Numerical problems.

**UNIT – IV****DC–DC Converters**

Analysis of Buck - Boost and Buck-Boost converters in Continuous Conduction Mode (CCM) and Discontinuous Conduction Modes (DCM) - Output voltage equations using volt-sec balance in CCM & DCM – Expressions for output voltage ripple and inductor current ripple- Numerical Problems.

**UNIT - V****DC–AC Converters**

Introduction - Single-phase half bridge and full bridge inverters with R and RL loads – Three-phase square wave inverters - 120<sup>0</sup> conduction and 180<sup>0</sup> conduction modes of operation - PWM inverters - Sinusoidal Pulse Width Modulation - Numerical Problems.



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**Course Outcomes:**

After the completion of the course the student should be able to:

- Illustrate the static and dynamic characteristics SCR - Power MOSFET and Power IGBT.
- Analyse the operation of phase controlled rectifiers.
- Analyse the operation of Three-phase full-wave converters - AC Voltage Controllers and Cyclo-converters.
- Examine the operation and design of different types of DC-DC converters.
- Analyse the operation of PWM inverters for voltage control and harmonic mitigation.

**Text Books:**

1. Power Electronics: Converters - Applications and Design by Ned Mohan - Tore M Undeland - William P Robbins - John Wiley & Sons.
2. Power Electronics: Circuits - Devices and Applications – by M. H. Rashid - Prentice Hall of India - 2<sup>nd</sup> edition - 1998
3. Power Electronics: Essentials & Applications by L. Umanand - Wiley - Pvt. Limited - India - 2009.

**Reference Books:**

1. Elements of Power Electronics–Philip T.Krein. Oxford University Press; Second edition
2. Power Electronics – by P.S.Bhimbra - Khanna Publishers.
3. Power Electronics: by Daniel W.Hart - Mc Graw Hill.