



**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD**  
**M. TECH. (ELECTRICAL POWER SYSTEMS/POWER ENGINEERING AND ENERGY SYSTEMS/**  
**POWER SYSTEM CONTROL AND AUTOMATION/ ELECTRICAL POWER ENGINEERING)**  
**COURSE STRUCTURE AND SYLLABUS**

**I Year – I Semester**

| Category             | Course Title  | Int. marks | Ext. marks | L         | P        | C         |
|----------------------|---|------------|------------|-----------|----------|-----------|
| Core Course I        | Advanced Power System Analysis  | 25         | 75         | 4         | --       | 4         |
| Core Course II       | Advanced Power System Protection  | 25         | 75         | 4         | --       | 4         |
| Core Course III      | Modern Control Theory   | 25         | 75         | 4         | --       | 4         |
| Core Elective I      | 1. EHV AC Transmission<br>2. High Voltage Engineering<br>3. Advanced Digital Signal Processing  | 25         | 75         | 4         | --       | 4         |
| Core Elective II     | 1. Power Quality<br>2. Microcontrollers and applications<br>3. Distribution Automation  | 25         | 75         | 4         | --       | 4         |
| Open Elective I      | 1. Optimization Techniques<br>2. Digital control systems<br>3. Renewable energy systems<br>4. HVDC Transmission<br>5. Analysis of power converters<br>6. Embedded Systems | 25         | 75         | 4         | --       | 4         |
| Laboratory I         | Power Systems Lab-I   | 25         | 75         | --        | 4        | 2         |
| Seminar I            | Seminar-I   | 50         | --         | --        | 4        | 2         |
| <b>Total Credits</b> |   |            |            | <b>24</b> | <b>8</b> | <b>28</b> |

**I Year – II Semester**

| Category             | Course Title  | Int. marks | Ext. marks | L         | P        | C         |
|----------------------|---|------------|------------|-----------|----------|-----------|
| Core Course IV       | Power System Dynamics   | 25         | 75         | 4         | --       | 4         |
| Core Course V        | Flexible AC Transmission Systems (FACTS)  | 25         | 75         | 4         | --       | 4         |
| Core Course VI       | Power System Operation and Deregulation   | 25         | 75         | 4         | --       | 4         |
| Core Elective III    | 1. Gas Insulated Systems(GIS)<br>2. Programmable Logic Controllers and their applications<br>3. High frequency magnetic components  | 25         | 75         | 4         | --       | 4         |
| Core Elective IV     | 1. Reactive Power Compensation and Management<br>2. Power System Reliability<br>3. Voltage Stability  | 25         | 75         | 4         | --       | 4         |
| Open Elective II     | 1. Instrumentation & Control<br>2. Intelligent Control<br>3. Smart grid technologies<br>4. AI Techniques in Electrical Engineering<br>5. Reliability Engineering<br>6. Energy Auditing, Conservation & Management | 25         | 75         | 4         | --       | 4         |
| Laboratory II        | Power Systems Lab-II  | 25         | 75         | --        | 4        | 2         |
| Seminar II           | Seminar-II  | 50         | --         | --        | 4        | 2         |
| <b>Total Credits</b> |   |            |            | <b>24</b> | <b>8</b> | <b>28</b> |

**II Year - I Semester**

| Course Title            | Int. marks | Ext. marks | L  | P         | C         |
|-------------------------|------------|------------|----|-----------|-----------|
| Comprehensive Viva-Voce | --         | 100        | -- | --        | 4         |
| Project work Review I   | 50         | --         | -- | 24        | 12        |
| <b>Total Credits</b>    |            |            | -- | <b>24</b> | <b>16</b> |

**II Year - II Semester**

| Course Title                   | Int. marks | Ext. marks | L  | P         | C         |
|--------------------------------|------------|------------|----|-----------|-----------|
| Project work Review II         | 50         | --         | -- | 8         | 4         |
| Project Evaluation (Viva-Voce) | --         | 150        | -- | 16        | 12        |
| <b>Total Credits</b>           |            |            | -- | <b>24</b> | <b>16</b> |

**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD**



**M. TECH – I YEAR – I SEM. (EPE/EPs/PEES/PSC&A)**

**ADVANCED POWER SYSTEM ANALYSIS  
(Core Course I)**

**Prerequisite: Computer Methods in Power Systems**

**Course Objectives:**

- To analyze a Power System Network using graph theory.
- To interpret the formation of Network matrices.
- To construct the necessity of load flow studies and various methods of Analysis.
- To examine short circuit analysis using  $Z_{BUS}$ .

**Course Outcomes:**

Upon the completion of the subject, the student will be able to

- Remember proper mathematical models for analysis.
- Conclude methodologies of load flow studies for the power network.
- Apply contingency Analysis.
- Analyze power system studies.

**UNIT-I:**

Admittance Model and Network Calculations, Branch and Node Admittances, Mutually Coupled Branches in  $Y_{BUS}$ , An Equivalent Admittance Network, Modification of  $Y_{BUS}$ , Network Incidence Matrix and  $Y_{BUS}$ , Method of Successive Elimination, Node Elimination, Triangular Factorization, Sparsity and Near Optimal Ordering.

**UNIT-II:**

Impedance Model and Network Calculations, the  $BUS$  Admittance and Impedance Matrices, Thevenin's Theorem and  $Z_{BUS}$ , Algorithms for building  $Z_{BUS}$ , Modification of existing  $Z_{BUS}$ , Calculation of  $Z_{BUS}$  elements from  $Y_{BUS}$ , Power Invariant Transformations, Mutually Coupled Branches in  $Z_{BUS}$ .

**UNIT-III:**

Gauss Seidel method, N-R Method, Decoupled method, fast decoupled method, comparison between power flow solutions. DC load flow.

**UNIT-IV:**

$Z_{BUS}$  Method in Contingency Analysis, Adding and Removing Multiple Lines, Piecewise Solution of Interconnected Systems, Analysis of Single Contingencies, Analysis of Multiple Contingencies, Contingency Analysis of DC Model, System Reduction for Contingency and Fault Studies.

**UNIT-V:**

Fault Analysis: Symmetrical faults-Fault calculations using  $Z_{BUS}$ - Fault calculations using  $Z_{BUS}$  equivalent circuits –Selection of circuit breakers- Unsymmetrical faults-Problems on various types of faults.

**TEXT BOOKS:**

1. John J.Grainger and W.D. Stevenson, "Power System Analysis"- T.M.H.Edition.
2. Modern Power System Analysis – by I.J.Nagrath & D.P.Kothari Tata M Graw – Hi Publishing Company Ltd, 2<sup>nd</sup> edition.

**REFERENCE:**

1. Power System Analysis and Design by J.Duncan Glover and M.S.Sarma., cengage 3<sup>rd</sup> Edition.
2. Olle. L.Elgaard, "Electrical Energy Systems Theory"-T.M.H.Edition.
3. Power systems stability and control, Prabha Kundur, The Mc Graw – Hill companies.
4. Power System Operation and Control, Dr. K. Uma Rao, Wiley India Pvt. Ltd.
5. Operation and Control in Power Systems, PSR Murthy, Bs Publications.
6. Power System Operation, Robert H. Miller, James H. Malinowski, The Mc Graw – Hill companies.
7. Power Systems Analysis, operation and control by Abhijit Chakrabarti, Sunitha Halder, PHI 3/e, 2010



**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD**  
**M. TECH – I YEAR – I SEM. (EPE/EPS/PEES/PSC&A)**

**ADVANCED POWER SYSTEM PROTECTION**  
**(Core Course II)**

**Prerequisite: Switch Gear and Protection**

**Course Objectives:**

- To distinguish all kinds of circuit breakers and relays for protection of Generators, Transformers and feeder bus bars from Over voltages and other hazards.
- To generalize neutral grounding for overall protection.
- To illustrate the phenomenon of Over Voltages and its classification.

**Course Outcomes:**

Upon the completion of the subject, the student will be able to

- Understand the basic function of a circuit breaker, all kinds of circuit breakers and differentiate fuse and circuit breakers under fault condition.
- Describe the necessity for the protection of alternators, transformers and feeder bus bars from over voltages and other hazards
- Illustrate neutral grounding, and how over voltages can be generated and how system can be protected against lightning and switching transient over voltages with various protective means
- Identify operation and control of microprocessor based relays.

**UNIT-I:**

**Static Relays:** Advantages of static relays-Basic construction of static relays-Level detectors-Replica impedance –Mixing circuits-General equation for two input phase and amplitude comparators-Duality between amplitude and phase comparators.

**Amplitude Comparators:** Circulating current type and opposed voltage type- rectifier bridge comparators, Direct and Instantaneous comparators.

**UNIT-II:**

**Phase Comparators:** Coincidence circuit type- block spike phase comparator, techniques to measure the period of coincidence-Integrating type-Rectifier and Vector product type- Phase comparators.

**Static Over Current Relays:** Instantaneous over-current relay-Time over-current relays-basic principles –definite time and Inverse definite time over-current relays.

**UNIT-III:**

**Static Differential Relays:** Analysis of Static Differential Relays –Static Relay schemes –Duo bias transformer differential protection –Harmonic restraint relay.

**Static Distance Relays:** Static impedance-reactance-MHO and angle impedance relay-sampling comparator –realization of reactance and MHO relay using sampling comparator.

**UNIT-IV:**

**Multi-Input Comparators:** Conic section characteristics-Three input amplitude comparator –Hybrid comparator-switched distance schemes –Poly phase distance schemes- phase fault scheme –three phase scheme – combined and ground fault scheme.

**Power Swings:** Effect of power swings on the performance of distance relays –Power swing analysis-Principle of out of step tripping and blocking relays-effect of line and length and source impedance on distance relays.

**UNIT-V:**

**Microprocessor based Protective Relays:** (Block diagram and flowchart approach only)-Over current relays-impedance relays-directional relay-reactance relay .Generalized mathematical expressions for distance relays-measurement of resistance and reactance –MHO and offset MHO relays-Realization of MHO characteristics- Realization of offset MHO characteristics -Basic principle of Digital computer relaying.

**TEXT BOOKS:**

1. Badri Ram and D.N.Vishwakarma, "Power system protection and Switch gear ", TMH publication New Delhi 1995.



2. T.S.Madhava Rao , “Static relays”, TMH publication, second edition 1989.

**REFERENCE:**

1. Protection and Switchgear, Bhavesh Bhalja, R. P. Mahesheari, Nilesh G. Chothani, Oxford University Press.
2. Electrical Power System Protection, C. Christopoulos and A. Wright, Springer International.



**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD**  
**M. TECH – I YEAR – I SEM. (EPE/EPS/PEES/PSC&A)**

**MODERN CONTROL THEORY**  
**(Core Course III)**

**Prerequisite: Control Systems**

**Course Objectives**

- To explain the concepts of basic and modern control system for the real time analysis and design of control systems.
- To Explain and apply concepts of state variables analysis.
- To study and analyze non linear systems.
- To analyze the concept of stability of nonlinear systems and categorization.
- To apply the comprehensive knowledge of optimal theory for Control Systems.

**Course Outcomes**

Upon completion of this course, students should be able to:

- Apply the knowledge of basic and modern control system for the real time analysis and design of control systems.
- Understand the concepts of state variables analysis.
- Analyze the concept of stability of nonlinear systems and optimal control.

**UNIT-I:**

**Mathematical Preliminaries:** Fields, Vectors and Vector Spaces – Linear combinations and Bases – Linear Transformations and Matrices – Scalar Product and Norms – Eigen-values, Eigen Vectors and a Canonical form representation of Linear operators – The concept of state – State Equations for Dynamic systems – Time invariance and Linearity – Non-uniqueness of state model – State diagrams for Continuous-Time State models.

**UNIT-II:**

**State Variable Analysis:** Linear Continuous time models for Physical systems– Existence and Uniqueness of Solutions to Continuous-Time State Equations – Solutions of Linear Time Invariant Continuous-Time State Equations – State transition matrix and its properties. General concept of controllability – General concept of Observability – Controllability tests for Continuous-Time Invariant Systems – Observability tests for Continuous-Time Invariant Systems – Controllability and Observability of State Model in Jordan Canonical form – Controllability and Observability Canonical forms of State model.

**UNIT-III:**

**Non Linear Systems:** Introduction – Non Linear Systems - Types of Non-Linearities – Saturation – Dead-Zone - Backlash – Jump Phenomenon etc;– Singular Points – Introduction to Linearization of nonlinear systems, Properties of Non-Linear systems – Describing function–describing function analysis of nonlinear systems – Stability analysis of Non-Linear systems through describing functions. Introduction to phase-plane analysis, Method of Isoclines for Constructing Trajectories, singular points, phase-plane analysis of nonlinear control systems.

**UNIT-IV:**

**Stability Analysis:** Stability in the sense of Lyapunov, Lyapunov's stability and Lyapunov's instability theorems - Stability Analysis of the Linear continuous time invariant systems by Lyapunov second method – Generation of Lyapunov functions – Variable gradient method – Krasovskii's method. State feedback controller design through Pole Assignment – State observers: Full order and Reduced order.

**UNIT-V:**

**Optimal Control:** Introduction to optimal control - Formulation of optimal control problems – calculus of variations – fundamental concepts, functional, variation of functional – fundamental theorem of theorem of Calculus of variations – boundary conditions – constrained minimization – formulation using Hamiltonian method – Linear Quadratic regulator.

**TEXT BOOKS:**

1. modern control system theory by m.gopal – new age international -1984
2. Control System Engineering, Nagrath and Gopal - New Age International – Fourth Edition

**REFERENCES:**

1. Optimal control by Kirck , Dover Publications
2. Advanced Control Theory A. Nagoor Kani, RBA Publications, 1999
3. Modern Control Engineering by Ogata.K – Prentice Hall - 1997



**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD**  
**M. TECH – I YEAR – I SEM. (EPE/EPSP/PEES/PSC&A)**

**EHV AC TRANSMISSION**  
**(Core Elective- I)**

**Prerequisite: Power Systems -II**

**Course objectives:**

- To identify the different aspects of Extra High Voltage A.C and D.C Transmission design and Analysis
- To understand the importance of modern developments of E.H.V and U.H.V transmission systems.
- To demonstrate EHV ac transmission system components, protection and insulation level for over voltages.

**Course Outcomes:**

Upon the completion of the subject, the student will be able to

- List the necessity of EHV AC transmission, choice of voltage for transmission, line losses and power handling capability.
- Estimate the Statistical procedures for line designs, scientific and engineering principles in power systems.

**Construct commercial transmission system**

**UNIT- I:**

E.H.V.A.C. Transmission line trends and preliminary aspect standard transmission voltages – Estimation at line and ground parameters-Bundle conductor systems-Inductance and Capacitance of E.H.V. lines – positive, negative and zero sequence impedance – Line Parameters for Modes of Propagation.

**UNIT- II:**

Electrostatic field and voltage gradients – calculations of electrostatic field of AC lines – effect of high electrostatic field on biological organisms and human beings - surface voltage gradients and maximum gradients of actual transmission lines – voltage gradients on sub conductor.

**UNIT- III:**

Electrostatic induction in unenergized lines – measurement of field and voltage gradients for three phase single and double circuit lines – un energized lines. Power Frequency Voltage control and over-voltages in EHV lines: No load voltage – charging currents at power frequency-voltage control – shunt and series compensation – static VAR compensation.

**UNIT - IV:**

Corona in E.H.V. lines – Corona loss formulae- attention of traveling waves due to Corona – Audio noise due to Corona, its generation, characteristic and limits. Measurements of audio noise radio interference due to Corona - properties of radio noise – frequency spectrum of RI fields – Measurements of RI and RIV.

**UNIT- V:**

Design of EHV lines based on steady state and transient limits - EHV cables and their characteristics.

**TEXT BOOKS:**

1. R. D. Begamudre, "EHVAC Transmission Engineering", New Age International (p) Ltd. 3<sup>rd</sup> Edition.
2. K.R. Padiyar, "HVDC Power Transmission Systems" New Age International (p) Ltd. 2<sup>nd</sup> revised Edition, 2012.

**REFERENCES:**

1. S. Rao "EHVAC and HVDC Transmission Engg. Practice" Khanna publishers.
2. Arrillaga.J " High Voltage Direct Current Transmission" 2<sup>nd</sup> Edition (London) peter Peregrines, IEE, 1998.
3. Padiyar.K.R, " FACTS Controllers in Power Transmission and Distribution" New Age Int. Publishers, 2007.
4. Hingorani H G and Gyugyi. L " Understanding FACTS-Concepts and Technology of Flexible AC Transmission Systems" New York, IEEE Press, 2000.



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**M. TECH – I YEAR – I SEM. (EPE/EPS/PEES/PSC&A)**

**HIGH VOLTAGE ENGINEERING**  
**(Core Elective I)**

**Prerequisite: Power Systems and Electrical & Electronics Instrumentation**

**Course Objectives:**

- To distinguish the Gaseous, liquid and solid dielectric behavior under High Voltage.
- To understand the generation methods of High A.C, DC & Impulse Voltages required for various application.
- To apply the measuring techniques of High A.C., D.C & Impulse voltages and currents.
- To identify the testing techniques for High Voltage Equipment.

**Course Outcomes:**

Upon the completion of the subject, the student will be able to

- Know conduction and breakdown will occur in gases, liquids and solids dielectrics and different applications of the insulating materials in electrical power apparatus.
- Explain the insulation testing of various components in power systems for different types of voltages, namely power frequency A.C, high frequency, switching or lightning impulses, for which generation of high voltages in laboratories is essential
- Interpret the necessity to measure the voltages and currents accurately, ensuring perfect safety to the personnel and equipment.
- Detect the necessary condition for all the electrical equipment which are capable of withstanding the over voltages which met in service like natural causes lightning or system originated ones switching or power frequency transient voltages.

**UNIT- I:**

**Introduction To High Voltage Engineering:** Electric Field Stresses, Gas / Vacuum as Insulator, Liquid Dielectrics, Solids and Composites, Estimation and Control of Electric Stress, Numerical methods for electric field computation, Surge voltages, their distribution and control, Applications of insulating materials in transformers, rotating machines, circuit breakers, cable power capacitors and bushings.

**UNIT- II:**

**Break Down In Dielectric Materials:** Gases as insulating media, collision process, Ionization process, Townsend's criteria of breakdown in gases, Paschen's law. Liquid as Insulator, pure and commercial liquids, breakdown in pure and commercial liquids. Intrinsic breakdown, electromechanical breakdown, thermal breakdown, breakdown of solid dielectrics in practice, Breakdown in composite dielectrics, solid dielectrics used in practice.

**UNIT-III:**

**Generation & Measurement of High Voltages & Currents :** Generation of High Direct Current Voltages, Generation of High alternating voltages, Generation of Impulse Voltages, Generation of Impulse currents, Tripping and control of impulse generators. Measurement of High Direct Current voltages, Measurement of High Voltages alternating and impulse, Measurement of High Currents- direct, alternating and Impulse, Oscilloscope for impulse voltage and current measurements.

**UNIT-IV:**

**Over Voltages & Insulation Co-Ordination:** Natural causes for over voltages – Lightning phenomenon, Overvoltage due to switching surges, system faults and other abnormal conditions, Principles of Insulation Coordination on High voltage and Extra High Voltage power systems.

**UNIT- V:**

**Testing of Materials & Electrical Apparatus:** Measurement of D.C Resistivity, Measurement of Dielectric Constant and loss factor, Partial discharge measurements. Testing of Insulators and bushings, Testing of Isolators and circuit breakers, testing of cables, Testing of Transformers, Testing of Surge Arresters, and Radio Interference measurements.

**TEXT BOOKS:**

1. High Voltage Engineering by M.S.Naidu and V. Kamaraju – TMH Publications, 3<sup>rd</sup> Edition





2. High Voltage Engineering: Fundamentals by E.Kuffel, W.S.Zaengl, J.Kuffel by Elsevier, 2<sup>nd</sup> Edition.

**REFERENCES:**

1. High Voltage Engineering by C.L.Wadhwa, New Age International (P) Limited, 1997.
2. High Voltage Insulation Engineering by Ravindra Arora, Wolfgang Mosch, New Age International (P) Limited, 1995.
3. High Voltage Engineering, Theory and Practice by Mazen Abdel Salam, Hussein Anis, Ahdan El-Morshedy, Roshdy Radwan, Marcel Dekker



**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD**  
**M. Tech – I Year – I Sem. (PE/PEED/PID)**

**ADVANCED DIGITAL SIGNAL PROCESSING**  
**(Core Elective-I)**

**Prerequisite: Digital Signal Processing**

**Course Learning Objectives**

- To Comprehend characteristics of discrete time signals and systems
- To analyze and process signals using various transform techniques
- To identify various factors involved in design of digital filters
- To illustrate the effects of finite word length implementation.

**Course Outcomes**

- Analyze and process signals in the discrete domain
- Design filters to suit specific requirements for specific applications
- Perform statistical analysis and inferences on various types of signals
- Design multi rate signal processing of signals through systems.

Analyze binary fixed point and floating-point representation of numbers and arithmetic operations

**UNIT-I:**

**Digital Filter Structures:** Block diagram representation – Equivalent Structures – FIR and IIR digital filter Structures All pass Filters-tunable IIR Digital Sine-cosine generator- Computational complexity of digital filter structures.

**UNIT-II:**

**Digital Filter Design :**

Preliminary considerations- Bilinear transformation method of IIR filter design –design of Low pass 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-III:**

**DSP Algorithm Implementation :** Computation of the discrete Fourier transform- Number representation – Arithmetic operations – handling of overflow – Tunable digital filters – function approximation.

**UNIT-IV:**

**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 in Low –order IIR filters- Low – Sensitivity Digital filter – Reduction of Product round-off errors feedback – Limit cycles in IIR digital filter – Round – off errors in FFT Algorithms.

**UNIT-V:**

**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 and torchy method.

**TEXT BOOKS:**

1. Digital Signal Processing principles –algorithms and Applications- John G. Proakis –PHI – 3<sup>rd</sup> edition 2002.
2. Digital Time Signal Processing: Alan V.Oppenheim,Ronald W ,Shafer – PHI 1996 1<sup>st</sup> Edition reprint
3. Advanced Digital Signal Processing – Theory and Applications – Glenn Zelniker, Fred J. Taylor.

**REFERENCE BOOKS**

1. Digital Signal Processing – S Salivahanan . A Vallavaraj C. Gnanapriya –TMH – 2<sup>nd</sup> reprint 2001.



2. Digital Signal Processing – sanjit K.Mitra – TMH second edition.
- 3 Theory and Applications of Digital Signal Processing – Lourens R RebinarandBernold.
4. Digital Filter Analysis and Design Auntoniam - TMH
5. Digital Signal Processing – J.S.Chitode – First Edition, 2008, Technical Publications.



**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD**  
**M. TECH – I YEAR – I SEM. (EPE/EPS/PEES/PSC&A)**

**POWER QUALITY**  
**(Core Elective II)**

**Prerequisite: Power Systems and Power Electronics**

**Course Objectives**

- To know different terms of power quality.
- To Illustrate of voltage power quality issue - short and long interruption
- To construct study of characterization of voltage sag magnitude and three phase unbalanced voltage sag.
- To know the behavior of power electronics loads; induction motors, synchronous motor etc by the power quality issues
- To prepare mitigation of power quality issues by the VSI converters.

**Course Outcomes:**

Upon the completion of the subject, the student will be able to

- Know the severity of power quality problems in distribution system;
- Understand the concept of voltage sag transformation from up-stream (higher voltages) to down-stream (lower voltage)
- compute the concept of improving the power quality to sensitive load by various mitigating custom power devices

**UNIT-I:**

**Introduction :** Introduction of the Power Quality (PQ) problem, Terms used in PQ: Voltage, Sag, Swell, Surges, Harmonics, over voltages, spikes, Voltage fluctuations, Transients, Interruption, overview of power quality phenomenon, Remedies to improve power quality, power quality monitoring.

**UNIT-II:**

**Long & Short Interruptions:** Interruptions – Definition – Difference between failures, outage, Interruptions – causes of Long Interruptions – Origin of Interruptions – Limits for the Interruption frequency – Limits for the interruption duration – costs of Interruption – Overview of Reliability evaluation to power quality, comparison of observations and reliability evaluation.

**Short interruptions:** definition, origin of short interruptions, basic principle, fuse saving, voltage magnitude events due to re-closing, voltage during the interruption, monitoring of short interruptions, difference between medium and low voltage systems. Multiple events, single phase tripping – voltage and current during fault period, voltage and current at post fault period, stochastic prediction of short interruptions.

**UNIT III:**

**1 & 3-Phase Voltage SAG Characterization :** Voltage sag – definition, causes of voltage sag, voltage sag magnitude, and monitoring, theoretical calculation of voltage sag magnitude, voltage sag calculation in non-radial systems, meshed systems, and voltage sag duration.

Three phase faults, phase angle jumps, magnitude and phase angle jumps for three phase unbalanced sags, load influence on voltage sags.

**UNIT-IV:**

**Power Quality Considerations in Industrial Power Systems:** Voltage sag – equipment behavior of Power electronic loads, induction motors, synchronous motors, computers, consumer electronics, adjustable speed AC drives and its operation. Mitigation of AC Drives, adjustable speed DC drives and its operation, mitigation methods of DC drives.

**UNIT-V:**

**Mitigation of Interruptions & Voltage Sags:** Overview of mitigation methods – from fault to trip, reducing the number of faults, reducing the fault clearing time changing the power system, installing mitigation equipment, improving equipment immunity, different events and mitigation methods. System equipment interface – voltage source converter, series voltage controller, shunt controller, combined shunt and series controller.



**Power Quality and EMC Standards:** Introduction to standardization, IEC Electromagnetic compatibility standards, European voltage characteristics standards, PQ surveys.

**TEXTBOOKS:**

1. Math H J Bollen "Understanding Power Quality Problems", IEEE Press.
2. R.C. Dugan, M.F. McGranaghan and H.W. Beaty, "Electric Power Systems Quality." New York: McGraw-Hill.1996

**REFERENCES:**

1. G.T. Heydt, 'Electric Power Quality', 2nd Edition. (West Lafayette, IN, Stars in a Circle Publications, 1994).
2. Power Quality VAR Compensation in Power Systems, R. SastryVedamMulukutla S. Sarma,CRC Press.
3. A Ghosh, G. Ledwich, Power Quality Enhancement Using Custom Power Devices. Kluwer Academic, 2002



**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD**  
**M. TECH – I YEAR – I SEM. (EPE/EPS/PEES/PSC&A)**

**MICROCONTROLLERS AND APPLICATIONS**  
**(Core Elective II)**

**Prerequisite: Microprocessors and Interfacing Devices**

**Course Objectives:**

- To relate the basic architecture and addressing modes of a microcontroller.
- To summarize the principles of top down design to microcontroller software development
- To demonstrate assembly language programs for the advanced Microcontroller , assembly language code for high-level language structures such as IF-THEN-ELSE and DO-WHILE
- To analyze a typical I/O interface and to discuss timing issues
- To identify different types of memory used in microcontroller systems

**Course Outcomes:**

Upon the completion of the subject, the student will be able to

- Distinguish Types of computers & microcontrollers,
- Generalize 8-Bit, 16- Bit & 32 Bit advanced Microcontrollers.
- Construct Real time Applications of Microcontrollers.
- Demonstrate RTOS for Microcontrollers.
- Translate Hardware applications using Microcontrollers.

**UNIT-I:**

**Overview of Architecture & Microcontroller Resources:** Architecture of a microcontroller – Microcontroller resources – Resources in advanced and next generation microcontrollers – 8051 microcontroller – Internal and External memories – Counters and Timers – Synchronous serial-cum asynchronous serial communication - Interrupts.

**UNIT-II:**

**8051- Microcontrollers Instruction Set :** Basic assembly language programming – Data transfer instructions – Data and Bit-manipulation instructions – Arithmetic instructions – Instructions for Logical operations on the test among the Registers, Internal RAM, and SFRs – Program flow control instructions – Interrupt control flow.

**UNIT-III:**

**Real Time Control: Interrupts:** Interrupt handling structure of an MCU – Interrupt Latency and Interrupt deadline – Multiple sources of the interrupts – Non-maskable interrupt sources – Enabling or disabling of the sources – Polling to determine the interrupt source and assignment of the priorities among them – Interrupt structure in Intel 8051.

**Timers:** Programmable Timers in the MCU's – Free running counter and real time control – Interrupt interval and density constraints.

**UNIT-IV:**

**Systems Design: Digital and Analog Interfacing Methods:** Switch, Keypad and Keyboard interfacing – LED and Array of LEDs – Keyboard-cum-Display controller (8279) – Alphanumeric Devices – Display Systems and its interfaces – Printer interfaces – Programmable instruments interface using IEEE 488 Bus – Interfacing with the Flash Memory – Interfaces – Interfacing to High Power Devices – Analog input interfacing – Analog output interfacing – Optical motor shaft encoders – Industrial control – Industrial process control system – Prototype MCU based Measuring instruments – Robotics and Embedded control – Digital Signal Processing and digital filters.

**UNIT-V:**

**Real Time Operating System for Microcontrollers:** Real Time operating system – RTOS of Keil (RTX51) – Use of RTOS in Design – Software development tools for Microcontrollers.

**16-Bit Microcontrollers:** Hardware – Memory map in Intel 80196 family MCU system – IO ports – Programmable Timers and High-speed outputs and input captures – Interrupts – instructions. ARM 32 Bit MCUs: Introduction to 16/32 Bit processors – ARM architecture and organization – ARM / Thumb programming model – ARM / Thumb instruction set – Development tools.

**TEXT BOOKS:**

1. Raj Kamal," Microcontrollers Architecture, Programming, Interfacing and System Design"– Pearson Education, 2005.
2. Mazidi and Mazidi, "The 8051 Microcontroller and Embedded Systems" – PHI, 2000.

**REFERENCES:**

1. A.V. Deshmuk, "Microcontrollers (Theory & Applications)" – WTMH, 2005.
2. John B. Peatman, "Design with PIC Microcontrollers" – Pearson Education, 2005.
3. Microcontroller Programming, Julio Sanchez, Maria P. Canton, CRC Press.
4. The 8051 Microcontroller, Ayala, Cengage Learning.
5. Microprocessors and Microcontrollers, Architecture, Programming and System Design, Krishna Kant, PHI Learning PVT. Ltd.
6. Microprocessors, Nilesh B. Bahadure, PHI Learning PVT. Ltd.



**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD**  
**M. TECH – I YEAR – I SEM. (EPE/EPS/PEES/PSC&A)**

**DISTRIBUTION AUTOMATION**  
**(Core Elective II)**

**Prerequisite: Electrical Distribution Systems**

**Course objectives:**

- To list the distribution systems for load modeling
- To understand the design & working of substations.
- To compute system protection
- To give a comprehensive idea on communication systems.

**Course Outcomes:**

Upon the completion of the subject, the student will be able to

- Find the transfer of electrical data in distribution system through Digital Communication.
- Predict load forecasting and reliability in economic point of view
- Apply Distribution Automation objectives and SCADA
- To have a knowledge on management of different electrical parameters.

**UNIT-I:**

**Distribution Automation and The Utility System:** Introduction to Distribution Automation (DA), control system interfaces, control and data requirements, centralized (Vs) decentralized control, DA System (DAS), DA Hardware, DAS software.

**UNIT-II:**

**Distribution Automation Functions :** DA capabilities, Automation system computer facilities, management processes, Information management, system reliability management, system efficiency management, voltage management, Load management.

**UNIT-III:**

**Communication Systems for DA:** DA communication requirements, Communication reliability, Cost effectiveness, Data rate Requirements, Two way capability, Ability to communicate during outages and faults, Ease of operation and maintenance, Conforming to the architecture of data flow

**Communication systems used in DA :** Distribution line carrier (Power line carrier), Ripple control, Zero crossing technique, telephone, cable TV, Radio, AM broadcast, FM SCA, VHF Radio, UHF Radio, Microwave satellite. Fiber optics, Hybrid Communication systems, Communication systems used in field tests.

**UNIT-IV:**

**Technical Benefits:** DA benefit categories, Capital deferred savings, Operation and Maintenance savings, Interruption related savings, Customer related savings, Operational savings, improved operation, Function benefits, Potential benefits for functions, and function shared benefits, Guidelines for formulation of estimating equations Parameters required, economic impact areas, Resources for determining benefits impact on distribution system, integration of benefits into economic evaluation.

**UNIT-V:**

**Economic Evaluation Methods:** Development and evaluation of alternate plans, Select study area, Select study period, Project load growth, Develop Alternatives, Calculate operating and maintenance costs, Evaluate alternatives. Economic comparison of alternate plans, Classification of expenses and capital expenditures, Comparison of revenue requirements of alternative plans, Book Life and Continuing plant analysis, Year by year revenue requirement analysis, short term analysis, end of study adjustment, Break even analysis, Sensitivity analysis computational aids.

**TEXT BOOKS:**

1. Control and Automation of Electrical Distribution Systems, James. Northcote – Green Robert Wilson, CRC Press.
2. Electric Power Distribution Automation, Dr. M. K. Khedkar, Dr. G.M.Dhole, University Science press.

**REFERENCES:**

1. IEEE Tutorial Course "Distribution Automation"
2. IEEE Working Group on "Distribution Automation"





**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD**  
**M. TECH – I YEAR – I SEM. (EPE/EPS/PEES/PSC&A)**

**OPTIMIZATION TECHNIQUES**  
**(Open Elective I)**

**Course Objectives**

- To understand the theory of optimization methods and algorithms developed for solving various types of optimization problems.
- To develop an interest in applying optimization techniques in problems of Engineering and Technology
- To apply the mathematical results and numerical techniques of optimization theory to concrete Engineering problems.

**Course Outcomes**

Upon the completion of the subject, the student will be able to

- Know basic theoretical principles in optimization
- formulation of optimization models
- solution methods in optimization;
- methods of sensitivity analysis and post processing of results
- applications to a wide range of engineering problems

**UNIT – I**

**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.

**Classical Optimization Techniques:** 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 – II**

**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.

**UNIT – III**

**Transportation Problem:** Finding initial basic feasible solution by north – west corner rule, least cost method and Vogel's approximation method – testing for optimality of balanced transportation problems.

**Unconstrained Nonlinear Programming:** One – dimensional minimization methods: Classification, Fibonacci method and Quadratic interpolation method

**UNIT – IV**

**Unconstrained Optimization Techniques:** Univariate method, Powell's method and steepest descent method.

**Constrained Nonlinear Programming:** Characteristics of a constrained problem, Classification, Basic approach of Penalty Function method; Basic approach of Penalty Function method; Basic approaches of Interior and Exterior penalty function methods. Introduction to convex Programming Problem.

**UNIT – V**

**Dynamic Programming:** Dynamic programming multistage decision processes – types – concept of sub optimization and the principle of optimality – computational procedure in dynamic programming – examples illustrating the calculus method of solution - examples illustrating the tabular method of solution.

**TEXT BOOKS:**

1. "Engineering optimization: Theory and practice"-by S. S.Rao, New Age International (P) Limited, 3<sup>rd</sup> edition, 1998.
2. "Introductory Operations Research" by H.S. Kasene & K.D. Kumar, Springer(India), Pvt .LTd.

**REFERENCE BOOKS:**

- 1 “ Optimization Methods in Operations Research and systems Analysis” – by K.V. Mital and C. Mohan, New Age International (P) Limited, Publishers, 3<sup>rd</sup> edition, 1996.
2. Operations Research – by Dr. S.D.Sharma.
3. “Operations Research : An Introduction” – by H.A. Taha, PHI Pvt. Ltd., 6<sup>th</sup> edition
4. Linear Programming – by G. Hadley



**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD**  
**M. TECH – I YEAR – I SEM. (EPE/EPS/PEES/PSC&A)**

**DIGITAL CONTROL SYSTEMS**  
**(Open Elective I)**

**Prerequisite: Control Systems**

**Course Objectives**

- To explain basic and digital control system for the real time analysis and design of control systems.
- To apply the knowledge state variable analysis in the design of discrete systems.
  - To explain the concept of stability analysis and design of discrete time systems.

**Course Outcomes**

Upon the completion of the subject, the student will be able to

- To illustrate the concepts of Digital control systems.
- Analysis and design of discrete systems in state variable analysis.
- To relate the concepts of stability analysis and design of discrete time systems.

**UNIT – I:**

**Concept & Representation of Discrete time Systems:** Block Diagram of typical control system- advantages of sampling in control systems – examples of discrete data and digital systems – data conversion and quantization – sample and hold devices – D/A and A/D conversion – sampling theorem – reconstruction of sampled signals.

**Z-transform:** Definition of Z-transforms – mapping between s-plane and z-plane –inverse z- transform – properties of z-transforms - ROC of z-transforms –pulse transfer function –relation between  $G(s)$  and  $G(z)$  – signal flow graph method applied to digital control systems.

**UNIT- II:**

**State Space Analysis:** State space modeling of discrete time systems – state transition equation of discrete time invariant systems – solution of time invariant discrete state equations: recursive method and the Z-Transformation method – conversion of pulse transfer function to the state model & vice-versa – Eigen values – Eigen vectors of discrete time system-matrix (A) – Realization of pulse transformation in state space form, discretization of continuous time systems, Computation of state transition matrix and its properties. Response of sample data system between sampling instants.

**UNIT – III :**

**Controllability, Observability & Stability Tests:** Concept of controllability, stabilizability, observability and reachability - Controllability and observability tests, Transformation of discrete time systems into controllable and observable forms.

Stability: Definition of stability – stability tests – The second method of Liapunov.

**UNIT- IV:**

**Design of Discrete Time Controllers and Observers:** Design of discrete time controller with bilinear transformation – Realization of digital PID controller-Design of deadbeat controller; Pole placement through state feedback.

**UNIT-V:**

**State Observers:** Design of - Full order and reduced order observers. Study of observer based control design

**TEXT BOOKS:**

1. K. Ogata , Discrete-Time Control systems, Pearson Education/PHI, 2nd Edition.
2. V. I. George, C. P. Kurian, Digital Control Systems, Cengage Learning.
3. M.Gopal, Digital Control Engineering, New Age Int. Pvt. Ltd., 2014

**REFERENCE BOOKS:**

1. Kuo, Digital Control Systems, Oxford University Press, 2nd Edition, 2003.
2. M.Gopal , Digital Control and State Variable Methods, TMH.
3. M. Sami Fadali Antonio Visioli, Digital Control Engineering Analysis and Design, Academic Press



**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD**  
**M. TECH – I YEAR – I SEM. (EPE/EPS/PEES/PSC&A)**

**RENEWABLE ENERGY SYSTEMS**  
**(Open Elective I)**

**Prerequisite: No Prerequisite**

**Course Objectives:**

- To recognize the awareness of energy conservation in students
- To identify the use of renewable energy sources for electrical power generation
- To collect different energy storage methods
- To detect about environmental effects of energy conversion

**Course Outcomes:**

Upon the completion of the subject, the student will be able to

- find different renewable energy sources to produce electrical power
- estimate the use of conventional energy sources to produce electrical energy
- role-play the fact that the conventional energy resources are depleted
- arrange Store energy and to avoid the environmental pollution

**UNIT-I:**

Photo voltaic power generation ,spectral distribution of energy in solar radiation, solar cell configurations, voltage developed by solar cell, photo current and load current, practical solar cell performance, commercial photo voltaic systems, test specifications for PV systems, applications of super conducting materials in electrical equipment systems.

**UNIT-II:**

Principles of MHD power generation, ideal MHD generator performance, practical MHD generator, MHD technology.

**Wind Energy conversion:** Power from wind, properties of air and wind, types of wind Turbines, operating characteristics.

**UNIT-III:**

Tides and tidal power stations, modes of operation, tidal project examples, turbines and generators for tidal power generation.

**Wave energy conversion:** properties of waves and power content, vertex motion of Waves, device applications. Types of ocean thermal energy conversion systems Application of OTEC systems examples,

**UNIT-IV:**

**Miscellaneous energy conversion systems:** coal gasification and liquefaction, biomass conversion, geothermal energy, thermo electric energy conversion, principles of EMF generation, description of fuel cells, Co-generation and energy storage, combined cycle co-generation, energy storage.

**Global energy position and environmental effects:** energy units, global energy position.

**UNIT-V:**

Types of fuel cells,  $H_2$ - $O_2$  Fuel cells, Application of fuel cells – Batteries, Description of batteries, Battery application for large power. Environmental effects of energy conversion systems, pollution from coal and preventive measures steam stations and pollution, pollution free energy systems.

**TEXT BOOKS:**

1. "Energy conversion systems" by Rakosh das Begamudre, New age International publishers, New Delhi - 2000.
2. "Renewable Energy Resources" by John Twidell and Tony Weir, 2<sup>nd</sup> Edition, Fspan & Co.

**REFERENCES:**

1. "Understanding Renewable Energy Systems" by Volker Quaschning, 2005, UK.
2. "Renewable Energy Systems-Advanced Conversion, Technologies & Applications" by Faner Lin Luo Honer Ye, CRC press, Taylor & Francies group.



**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD**  
**M. TECH – I YEAR – I SEM. (EPE/EPS/PEES/PSC&A)**

**HVDC TRANSMISSION**  
**(Open Elective I)**

**Prerequisite: Power Systems-II**

**Course Objectives:**

- To Comprehend the conversion principles of HVDC Transmission
- Analysis of 3,6 , 12 pulse converters, rectifier and inverter operations of HVDC converters
- To identify the different types of Harmonics and reduction by using Filters
- To Comprehend Interaction between HVAC and DC systems in various aspects
- To appreciate the reliable MTDC systems and protection of HVDC system

**Course Outcomes:**

Upon the completion of the subject, the student will be able to

- To find the applications of HVDC transmission in the power system with the acquired knowledge.
- To analyze different converter topologies viz. 3,6 and 12 Pulse converters and understand it's control aspects.
- To understand the filter configuration for Harmonics in HVDC systems.
- To appreciate the reliable Multi terminal HVDC system.
- To have knowledge on the Protection of HVDC systems against Transient over voltages and over currents.

**UNIT-I:**

**Introduction:** General consideration, Power Handling Capabilities of HVDC Lines Basic Conversion principles, static converter configuration.

**UNIT-II:**

**Static Power Converters:** 3-pulse, 6-pulse, and 12-pulse converters, converter station and Terminal equipment, commutation process, Rectifier and inverter operation, equivalent circuit for converter – special features of converter transformers. Harmonics in HVDC Systems, Harmonic elimination, AC and DC filters.

**UNIT-III:**

**Control of HVDC Converters and Systems:** Constant current, constant extinction angle and constant ignition angle control Individual phase control and equidistant firing angle control DC power flow control. Interaction between HV AC and DC systems – Voltage interaction Harmonic instability problems and DC power modulation.

**UNIT-IV:**

**MTDC Systems & Over Voltages:** Series parallel and series parallel systems their operation and control. Over voltages due to disturbances on DC side, over voltages due to DC and AC side line faults.

**UNIT-V:**

**Converter Faults & Protection:** Converter faults, over current protection – valve group, and DC line protection over voltage protection of converters, surge arresters.

**TEXT BOOKS:**

1. E.W. Kimbark: Direct current Transmission, Wiley Inter Science – New York
2. KR Padiyar : High Voltage Direct current Transmission Wiley Eastern Ltd New Delhi – 1992.

**REFERENCES:**

- J. Arillaga HVDC Transmission Peter Peregrinus Ltd. London UK 1983
1. E. Uhlman : Power Transmission by Direct Current , Springer Verlag, Berlin Helberg. 1985.
  2. S. Rao "EHVAC and HVDC Transmission Engg. Practice" Khanna publishers.



**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD**  
**M. TECH – I YEAR – I SEM. (EPE/EPSP/PEES/PSC&A)**

**ANALYSIS OF POWER ELECTRONIC CONVERTERS**  
**(Open Elective I)**

**Prerequisite: Power Electronics**

**Course Objectives**

- To comprehend the concepts of converters
- Students will be able to relate to the applications of phase controlled rectifiers
- Students will be able to describe the importance of AC voltage controllers and cyclo converters for various industrial applications
- Students will be able to analyze and design switch mode power electronic converters for various applications including microprocessor power supplies, renewable energy systems, and motor drives.
- Students will be able to analyze pulse width modulated inverters which are used in variable speed drives

**Course Outcomes**

- Students will have good understanding of the basic principles of switch mode power conversion
- Students will understand the operating principles and models of different types of power electronic converters including dc-dc converters, PWM rectifiers and inverters
- Students will be able to choose appropriate power converter topologies and design the power stage and feedback controllers for various applications
- Students will be able to use power electronic simulation packages for analyzing and designing power converters

**Unit I**

**Single Phase AC Voltage Controllers:** Single phase AC voltage controllers with Resistive, Resistive-inductive and Resistive-inductive-induced e.m.f. loads - ac voltage controllers with PW Control - Effects of source and load inductances - Synchronous tap changers-Applications - numerical problems.

**Unit II**

**Three Phase AC Voltage Controllers:** Three phase AC voltage controllers - Analysis of controllers with star and delta Connected Resistive, Resistive-inductive loads - Effects of source and load Inductances - applications - numerical problems.

**Cycloconverters:** Single phase to single phase cycloconverters - analysis of midpoint and bridge Configurations - Three phase to three phase cycloconverters - analysis of Midpoint and bridge configurations - Limitations - Advantages - Applications- numerical problems.

**Unit III**

**Single Phase Converters:** Single phase converters - Half controlled and Fully controlled converters -Evaluation of input power factor and harmonic factor - continuous and Discontinuous load current - single phase dual converters - power factor Improvements - Extinction angle control - symmetrical angle control - PWM -single phase sinusoidal PWM - single phase series converters - Applications -Numerical problems.

**Three Phase Converters:** Three phase converters - Half controlled and fully controlled converters - Evaluation of input power factor and harmonic factor - continuous and Discontinuous load current - three phase dual converters - power factor Improvements - three phase PWM - twelve pulse converters - applications -Numerical problems.

**Unit VI**

**D.C. to D.C. Converters:** Analysis of step-down and step-up dc to dc converters with resistive and Resistive-inductive loads - Switched mode regulators - Analysis of Buck Regulators - Boost regulators - buck and boost regulators - Cuk regulators - Condition for continuous inductor current and capacitor voltage - comparison of regulators -Multioutput boost converters - advantages - applications - Numerical problems.



## Unit V

**Pulse Width Modulated Inverters(single phase):** Principle of operation - performance parameters - single phase bridge inverter -evaluation of output voltage and current with resistive, inductive and Capacitive loads - Voltage control of single phase inverters - single PWM - Multiple PWM - sinusoidal PWM - modified PWM - phase displacement Control - Advanced modulation techniques for improved performance - Trapezoidal, staircase, stepped, harmonic injection and delta modulation - Advantage - application - numerical problems.

**Pulse Width Modulated Inverters(three phase):** Three phase inverters - analysis of 180 degree condition for output voltage And current with resistive, inductive loads - analysis of 120 degree Conduction - voltage control of three phase inverters - sinusoidal PWM - Third Harmonic PWM – 60 degree PWM - space vector modulation - Comparison of PWM techniques  
- harmonic reductions - Current Source Inverter - variable d.c. link inverter - boost inverter - buck and boost inverter - inverter circuit design - advantages -applications - numerical problems.

### TEXT BOOKS:

1. Power Electronics - Mohammed H. Rashid - Pearson Education -Third Edition - First Indian reprint 2004.
2. Power Electronics - Ned Mohan, Tore M. Undeland and William P. Robbins –John Wiley and Sons - Second Edition

### REFERENCES:

1. Power Electronics Daniel W. Hart
2. Fundamentals of Power Electronics, 2<sup>nd</sup> Edition. R.W. Erickson
3. The power electronics Hand Book Timothy, L. Skvarenina, Purdue University



**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD**  
**M. TECH – I YEAR – I SEM. (EPE/EPs/PEES/PSC&A)**

**EMBEDDED SYSTEMS**  
**(Open Elective I)**

**Prerequisite: Microprocessors and Interfacing Devices**

**Course Learning Objectives**

- To Comprehend the general embedded system concepts , design of embedded hardware and software development tools
- To explain the basics of real time operating and embedded systems
- To Describe key issues such as CPU scheduling, memory management, task synchronization, and file system in the context of real-time embedded systems.

**Course Outcomes:**

- To analyze and design embedded systems and real-time systems
- Define the unique design problems and challenges of real-time systems
- Identify the unique characteristics of real-time operating systems and evaluate the need for real-time operating system
- Explain the general structure of a real-time system and Understand and use RTOS to build an embedded real-time system
- Gain knowledge and skills necessary to design and develop embedded applications based on real-time operating systems.

**UNIT- I:**

**Overview of Embedded System:** Embedded System, types of Embedded System, Requirements of Embedded System, and Issues in Embedded software development, Applications.

**UNIT-II:**

**Processor & Memory Organization:** Structural units in a processor, Processor selection, Memory devices, Memory selection, Memory Allocation & Map, Interfacing.

**UNIT-III:**

**Devices, Device Drivers & Buses for Device Networks:** I/O devices, Timer & Counter devices, Serial Communication, Communication between devices using different buses. Device drives, Parallel and serial port device drives in a system, Interrupt servicing mechanism, context and periods for context switching, Deadline and Interrupt Latency.

**UNIT-IV:**

**Programming & Modeling Concepts :** Program elements, Modeling Processes for Software Analysis, Programming Models, Modeling of Multiprocessor Systems, Software algorithm Concepts, design, implementation, testing, validating, debugging, Management and maintenance, Necessity of RTOS.

**UNIT-V:**

**Hardware and Software Co-Design:** Embedded system design and co design issues in software development, design cycle in development phase for Embedded System, Use of ICE & Software tools for development of ES, Issues in embedded system design.

**TEXTBOOK**

1. Embedded systems: Architecture, programming and design by Rajkamal, TMH
2. Embedded system design by Arnold S Burger, CMP

**REFERENCES**

1. An embedded software primer by David Simon, PEA
2. Embedded systems design:Real world design be Steve Heath; Butterworth Heinenann, Newton mass USA 2002
3. Data communication by Hayt.





**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD**  
**M. TECH – I YEAR – I SEM. (EPE/EPS/PEES/PSC&A)**

**POWER SYSTEM LAB – I**

1. Develop Program for  $Y_{BUS}$  formation.
2. Develop Program for G-S Load Flow Analysis.
3. Develop Program for N-R Load Flow Analysis.
4. Develop Program for FDLF Load Flow Analysis.
5. Develop Program for Short Circuit Analysis.
6. Develop Program for Transient Stability Analysis for Single Machine connected to Infinite Bus by Point by Point Method.
7. Develop Program for Generation System Reliability Analysis.
8. Develop Program for Distribution System Reliability Analysis.
9. Develop Simulation of RLC Circuit
10. Develop Simulation of Single Phase Full Converter with RLE Load
11. Develop Program model for Closed Loop Speed Control of Separately Excited D.C Motor.
12. Develop Program model for Sinusoidal Pulse Width Modulation.

**Note:** From the above list minimum 10 experiments are to be conducted using suitable software.