# ACE
# Engineering College

Ankushapur(V), Ghatkesar(M), R.R.Dist - 501 301

(An Autonomous Institution)

**B.TECH. FOURTH YEAR DEGREE COURSE**

**ELECTRICAL AND ELECTRONICS ENGINEERING**

**COURSE STRUCTURE**

**(R20 Regulation)**

| IV Year | | | | I Semester | | | |
|---|---|---|---|---|---|---|---|
| S. No. | Course type | Course Code | Course Title | Periods per week | | | Credits |
| | | | | L | T | P | |
| 01 | PCC | EE701PC | Power Semiconductor Drives | 2 | 0 | 0 | 2 |
| 02 | HSMC | SM702MS | Fundamentals of Management for Engineers | 3 | 0 | 0 | 3 |
| 03 | PEC | | Professional Elective-III | 3 | 0 | 0 | 3 |
| 04 | PEC | | Professional Elective-IV | 3 | 0 | 0 | 3 |
| 05 | OEC | | Open Elective-II | 3 | 0 | 0 | 3 |
| 06 | PCC | EE703PC | Electrical and Electronics Design Lab | 0 | 0 | 2 | 1 |
| 07 | PROJ | EE704PC | Project Phase-I | 0 | 0 | 6 | 3 |
| 08 | PROJ | EE705PC | Industry Oriented Mini Project | 0 | 0 | 0 | 2 |
| 09 | PROJ | EE706PC | Technical Seminar | 0 | 0 | 2 | 1 |
| 10 | MC | MC707EC | Introduction to ARDUINO | 0 | 0 | 2 | 0 |
| **Total** | | | | **14** | **0** | **12** | **21** |

**NOTE: Industry Oriented Mini Project is to be carried out during the summer vacation between 6$^{th}$ and 7$^{th}$ semesters. Students should submit report of Industrial Oriented Mini Project for evaluation.**

***Open Elective – Students should take Open Electives from List of Open Electives Offered by Other Departments/Branches Only.**

## EE701PC: POWER SEMICONDUCTOR DRIVES

**B.TECH. IV YEAR I SEMESTER**

| Course Code | Category | Hours/Week | | | Credits | Maximum Marks | | |
|---|---|---|---|---|---|---|---|---|
| | | L | T | P | C | CIA | SEE | Total |
| EE701PC | PCC | 2 | 0 | 0 | 2 | 30 | 70 | 100 |

**Prerequisite:** Power Electronics(EE501PC),Electrical Machines–I(EE304PC), Electrical Machines -II(EE402PC)

**Course Objectives:**

1. To introduce the drive system and operating modes of drive and its characteristics
2. To understand Speed – Torque characteristics of different motor drives by various power converter topologies
3. To appreciate the motoring and braking operations of drive
4. To differentiate DC and AC drives

**Course Outcomes:** After completion of this course the student is able to

1. Identify the drawbacks of speed control of motor by conventional methods.
2. Differentiate Phase controlled and chopper-controlled DC drives speed-torque characteristics merits and demerits
3. Understand 3-phase Induction motor drive speed–torque characteristics using different control strategies its merits and demerits
4. Apply Slip power recovery scheme
5. Understand speed control of 3-phase synchronous motor drive

### UNIT: I CONTROL OF DC MOTORS BY SINGLE PHASE AND THREE PHASE CONVERTERS

Thyristor controlled Drives, Single Phase semi and fully controlled converters connected to d.c separately excited and d.c series motors – continuous current operation – output voltage and current waveforms – Speed and Torque expressions – Speed – Torque Characteristics Problems on Converter fed d.c motors. Three phase semi and fully controlled converters connected to d.c separately excited and d.c series motors – output voltage and current waveforms – Speed and Torque expressions – Speed – Torque characteristics – Problems.

### UNIT: II FOUR QUADRANT OPERATION OF DC DRIVES & CONTROL OF DC MOTORS BY CHOPPERS

Four quadrant operation of DC drives: Introduction to Four quadrant operation – Motoring operations, Electric Braking – Plugging, Dynamic, and Regenerative Braking operations. Four quadrant operations of D.C motors by single phase and three phase dual converters – Closed loop operation of DC motor (Block Diagram Only) Control of DC Motors by Choppers: Single quadrant, two quadrant and four quadrant chopper fed dc separately excited and series motors – Continuous current operation – Output voltage and current wave forms – Speed and torque expressions – speed-torque characteristics – Problems on Chopper fed D.C Motors – Closed Loop operation (Block Diagram Only)

### UNIT: III CONTROL OF INDUCTION MOTORS

Variable voltage characteristics-Control of Induction Motor by Ac Voltage Controllers – Waveforms – speed torque characteristics. Variable frequency characteristics-Variable frequency control of induction motor by Voltage source and current source inverter and cyclo converters-

PWM control – Comparison of VSI and CSI operations – Speed torque characteristics – numerical problems on induction motor drives – Closed loop operation of induction motor drives

| UNIT: IV | ROTOR SIDE CONTROL OF INDUCTION MOTOR |
|---|---|

Static rotor resistance control – Slip power recovery – Static Scherbius drive – Static Kramer Drive – their performance and speed torque characteristics – advantages, applications, problems.

| UNIT: V | CONTROL OF SYNCHRONOUS MOTORS |
|---|---|

Separate control and self-control of synchronous motors – Operation of self-controlled synchronous motors by VSI, CSI and cyclo converters. Load commutated CSI fed Synchronous Motor – Operation – Waveforms – speed torque characteristics – Applications – Advantages and Numerical Problems – Closed Loop control operation of synchronous motor drives ,variable frequency control - Cyclo converter, PWM based VSI& CSI.

**TEXT BOOKS:**


1. "G K Dubey", Fundamentals of Electric Drives, CRC Press, 2020
2. "Vedam Subramanyam", Thyristor Control of Electric drives, Tata McGraw Hill Publications, 2004.


**REFERENCE BOOKS:**


1. "S K Pillai", A First course on Electrical Drives, New Age International (P) Ltd. 2nd Edition. January 2012.
2. "P. C. Sen", Thyristor DC Drives, Wiley-Blackwell, 1981
3. "B. K. Bose", Modern Power Electronics, and AC Drives, Pearson 2015.


**WEB REFERENCES:**

1. https://nptel.ac.in/courses/108/104/108104140/

## SM702MS: FUNDAMENTALS OF MANAGEMENT FOR ENGINEERS

B.Tech. IV Year I Sem. L T P C

3 0 0 3

**Course Objective:**

- To understand the Management Concepts, applications of Concepts in Practical aspects of business and development of Managerial Skills for Engineers.

**Course Outcome:**

- The students understand the significance of Management in their Profession. The various Management Functions like Planning, Organizing, Staffing, Leading, Motivation and Control aspects are learnt in this course. The students can explore the Management Practices in their domain area.

**UNIT- I:**

**Introduction to Management:** Definition, Nature and Scope, Functions, Managerial Roles, Levels of Management, Managerial Skills, Challenges of Management; Evolution of Management- Classical Approach- Scientific and Administrative Management; The Behavioral approach; The Quantitative approach; The Systems Approach; Contingency Approach, IT Approach.

**UNIT – II:**

**Planning and Decision Making:** General Framework for Planning - Planning Process, Types of Plans, Management by Objectives; Production Planning and Control. Decision making and Problem Solving - Programmed and Non Programmed Decisions, Steps in Problem Solving and Decision Making; Bounded Rationality and Influences on Decision Making; Group Problem Solving and Decision Making, Creativity and Innovation in Managerial Work.

**UNIT- III:**

**Organization and HRM:** Principles of Organization: Organizational Design & Organizational Structures; Departmentalization, Delegation; Empowerment, Centralization, Decentralization, Recentralization; Organizational Culture; Organizational Climate and Organizational Change. Human Resource Management & Business Strategy: Job Satisfaction, Job Enrichment, Job Enlargement, Talent Management, Strategic Human Resource Planning; Recruitment and Selection; Training and Development; Performance Appraisal.

**UNIT- IV:**

**Leading and Motivation:** Leadership, Power and Authority, Leadership Styles; Behavioral Leadership, Situational Leadership, Leadership Skills, Leader as Mentor and Coach, Leadership during adversity and Crisis; Handling Employee and Customer Complaints, Team Leadership. Motivation - Types of Motivation; Relationship between

Motivation, Performance and Engagement, Content Motivational Theories - Needs Hierarchy Theory, Two Factor Theory, Theory X and Theory Y.

**UNIT- V:**

**Controlling:** Control, Types and Strategies for Control, Steps in Control Process, Budgetary and Non Budgetary Controls. Characteristics of Effective Controls, Establishing control systems, Control frequency and Methods.

**TEXT BOOKS:**

1. Management Essentials, Andrew DuBrin, 9e, Cengage Learning, 2012.

2. Fundamentals of Management, Stephen P. Robbins, Pearson Education, 2009.

**REFERENCE BOOKS:**

1. Essentials of Management, Koontz Kleihrich, Tata Mc - Graw Hill.

2. Management Fundamentals, Robert N Lussier, 5e, Cengage Learning, 2013.

3. Industrial Engineering and Management: Including Production Management, T.R. Banga, S.C. Sharma, Khanna Publishers.

## EE711PE- FLEXIBLE A.C. TRANSMISSION SYSTEMS
## (Professional Elective - III)

**B.TECH. IV YEAR I SEMESTER**

| Course Code | Category | Hours/Week | | | Credits | Maximum Marks | | |
|---|---|---|---|---|---|---|---|---|
| | | L | T | P | C | CIA | SEE | Total |
| EE711PE | PEC | 3 | 0 | 0 | 3 | 30 | 70 | 100 |

**Prerequisite:** Power Electronics(EE501PC), Power System-I(EE405PC), Power System-II(EE502PC)

**Course Objectives:**

1. To understand the fundamentals of FACTS Controllers.
2. To know the importance of controllable parameters and types of FACTS controllers & their benefits.
3. To study the objectives of Shunt and Series compensation.
4. To Control STATCOM and SVC and their comparison

**Course Outcomes:** At the end of this course, students will demonstrate the ability to

1. Choose proper controller for the specific application based on system requirements.
2. Analyze various systems thoroughly and their requirements.
3. Apply SVC & STATCOM for power quality improvement
4. Analyze the Power and control circuits of Series Controllers GCSC, TSSC and TCSC.
5. Design the thyristor switched series capacitor (TSSC)

| UNIT: I | FACTS CONCEPTS |
|---|---|

Transmission interconnections power flow in an AC system, loading capability limits, Dynamic stability considerations, importance of controllable parameters, basic types of FACTS controllers, and benefits from FACTS controllers.

| UNIT: II | VOLTAGE SOURCE CONVERTERS |
|---|---|

Single phase, three phase full wave bridge converters transformer connections for 12 pulse operation. Three level voltage source converter, pulse width modulation converter, basic concept of current source Converters, and comparison of current source converters with voltage source converters.

| UNIT: III | STATIC SHUNT COMPENSATION |
|---|---|

Objectives of shunt compensation, midpoint voltage regulation, voltage instability prevention, improvement of transient stability, Power oscillation damping, Methods of controllable var generation, variable impedance type static var generators, switching converter type var generators and hybrid var generators.

| UNIT: IV | SVC AND STATCOM |
|---|---|

FC-TCR and TSC-TCR. STATCOM. The regulation and slope. Comparison between SVC and STATCOM

| UNIT: V | STATIC SERIES COMPENSATORS |
|---|---|

Objectives of Series compensation, concept of series capacitive compensation, GTO thyristor-controlled series capacitor (GSC), thyristor switched series capacitor (TSSC), and thyristor-controlled series capacitor (TCSC) control schemes for GSC TSSC and TCSC.

**TEXT BOOKS:**

1. "N.G. Hingorani","L. Guygi", Understanding Facts: Concepts and Technology of Flexible AC Transmission Systems, Wiley India Pvt Ltd, 2011
2. "Yong- Hua Song, Allan Johns", Flexible AC Transmission System, Laxmi Publications, 2009

**REFERENCE BOOKS:**

1. "Kalyan K. Sen","Meylingsen", Introduction to FACTS Controllers, John wiley& sons, Inc., Mohamed E.EI – Hawary Series editor, 2016.
2. "K. R Padiyar", "Motilal", FACTS controllers in power transmission and distribution, New Age International Pvt Ltd; Second edition, 2016

**WEB REFERENCES:**

1. https://nptel.ac.in/courses/108/107/108107114/

**EE712PE: POWER SYSTEM DE-REGULATION**
**(PROFESSIONAL ELECTIVE III)**

| **B. Tech. IV Year I Semester** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Course Code** | **Category** | **Hours/Week** | | | **Credits** | **Maximum Marks** | | |
| EE712PE | **PEC** | L | T | P | C | CIA | SEE | Total |
| | | 3 | 0 | 0 | 3 | 30 | 70 | 100 |

Prerequisite: Power System Operation and Control(EE604PC)

Course Objectives:
1. To understand restructuring of electricity market.
2. To understand the need of deregulation in electricity market.
3. To apply the concept of deregulation and ATC
4. To understand money, power & information flow in a deregulated power system.

Course Outcomes:
1. Understand the Developments of restructuring worldwide.
2. Identify the roles and responsibilities of different entities in power market.
3. Explore issues like Congestion management, Transmission pricing, Ancillary Services Management.
4. Understand operational planning activities of ISO
5. Apply Synchronous Generators as Ancillary service.

| **UNIT – I** | **OVER VIEW OF KEY ISSUES IN ELECTRIC UTILITIES** |
|---|---|

Introduction- restructuring models- Independent system operator (ISO)-power Exchange-Market operations-Market power -standard cost -Transmission Pricing-Congestion Pricing -Management of Inter Zonal/Intra Zonal Congestion.

| **UNIT – II** | **OASIS (OPEN ACCESS SAME-TIME INFORMATION SYSTEM)** |
|---|---|

Structure of OASIS-posting of Information-Transfer capability on OASIS-Definitions Transfer capabilities -ATC-TTC-TRM-CBM calculations-Methodologies to calculate ATC.

| **UNIT – III** | **ELECTRICITY PRICING** |
|---|---|

Introduction -Electricity price volatility-Electricity price Indexes-Challenges to electricity pricing-Construction of forward price curves-short time price forecasting.

| **UNIT – IV** | **POWER SYSTEM OPERATION IN A COMPETITIVE ENVIRONMENT** |
|---|---|

Introduction -operational planning activities of ISO-The ISO in Pool Markets-The ISO in Bilateral Markets -Operational Planning Activities of GENCO.

| **UNIT – V** | **ANCILLARY SERVICES** |
|---|---|

Introduction- Reactive power as an Ancillary service-a review based on present research-Synchronous Generators as Ancillary service Providers.

**Text Books:**

1. "Dr.P.V.Ramakrishna","G.Srinivas",Dr.S.V.Padmavathi", Power System Deregulation(Unit Commitment Problem),Namya Press Publication,1st edition -2020.
2. "Pawan Chandrakant Tapre", Generation Rescheduling In Deregulated Power System ,Wizard Publisher; 1st edition -2019

**Reference Books:**


1. "Krishna P.V. Rama", POWER SYSTEM DEREGULATION (Unit Commitment Problem) ,Namya Press-2020
2. "S.K.Gupta", Power System Operation Control & Restructuring, I K International PublishingHouse Pvt. Ltd – 2015


**Web Reference:**

1. https://nptel.ac.in/courses/108/101/108101005/
2. https://shodhganga.inflibnet.ac.in/bitstream/10603/17295/13/13_chapter3.pdf
3. https://onlinelibrary.wiley.com/doi/pdf/10.1002/0470846119.fmatter_indsub
4. https://ieeexplore.ieee.org/iel5/2224/21343/00990185.pdf

**EE713PE: COMPUTER METHODS IN POWER SYSTEM**
**(Professional Elective - III)**

**B.TECH. IV YEAR I SEMESTER**

| Course Code | Category | Hours/Week | | | Credits | Maximum Marks | | |
|---|---|---|---|---|---|---|---|---|
| | | L | T | P | C | CIA | SEE | Total |
| EE713PE | PEC | 3 | 0 | 0 | 3 | 30 | 70 | 100 |

**Prerequisite:** Power System–I(EE405PC), Power system–II(EE502PC**)** & Electrical Circuits (EE302PC)

**Course Objectives:**

1. To understand formation of Z bus of a transmission line.
2. To discuss power flow studies by various methods.
3. To determine short circuit analysis.
4. To analyze the power system for steady state and transient stability

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

1. Analyze power system network matrices through graph theory.
2. Discuss about the power flow studies (load-flow) through various computer methods.
3. Analyze the short-circuit analysis & per unit representation.
4. Compare symmetrical and unsymmetrical fault analysis.
5. Analyze steady-state and transient state stability in power system.

**UNIT: I** **POWER SYSTEM NETWORK MATRICES**

Graph Theory: Definitions, Bus Incidence Matrix, Y bus formation by Direct and Singular Transformation Methods, Numerical Problems.

Formation of Z Bus: Partial network, Algorithm for the Modification of Z Bus Matrix for addition element for the following cases: Addition of element from a new bus to reference, Addition of element from a new bus to an old bus, Addition of element between an old bus to reference and Addition of element between two old busses (Derivations and Numerical Problems). - Modification of ZBus for the changes in network (Problems).

**UNIT: II** **POWER FLOW STUDIES**

**Load Flows:**

Necessity of Power Flow Studies – Data for Power Flow Studies – Derivation of Static load flow equations. **Load flow solutions using Gauss Seidel Method**:

Acceleration Factor, Load flow solution with and without P-V buses, Algorithm and Flowchart. Numerical Load flow Solution for Simple Power Systems (Max. 3-Buses): Determination of Bus Voltages, Injected Active and Reactive Powers (Sample One Iteration only) and finding Line Flows/Losses for the given Bus Voltages.

**Newton-Raphson Method in Rectangular and Polar Co-Ordinates Form:**

Load Flow Solution with or without PV Busses- Derivation of Jacobian Elements, Algorithm and Flowchart.

**Decoupled and Fast Decoupled Methods:**
Comparison of Different Methods – DC load Flow.

| UNIT: III | SHORT CIRCUIT ANALYSIS |
|---|---|

**Per-Unit System of Representation:**
Per-Unit equivalent reactance network of a three phase Power System, Numerical Problems.

**Symmetrical fault Analysis:**
Short Circuit Current and MVA Calculations, Fault levels, Application of Series Reactors, Numerical Problems.

**Symmetrical Component Theory:**
Symmetrical Component Transformation, Positive, Negative and Zero sequence components: Voltages, Currents and Impedances. Sequence Networks: Positive, Negative and Zero sequence Networks, Numerical Problems.

**Unsymmetrical Fault Analysis:**
LG, LL, LLG faults with and without fault impedance, Numerical Problems.

| UNIT: IV | STEADY STATE STABILITY ANALYSIS |
|---|---|

Elementary concepts of Steady State, Dynamic and Transient Stabilities. Description of: Steady State Stability Power Limit, Transfer Reactance, Synchronizing Power Coefficient, Power Angle Curve and Determination of Steady State Stability and Methods to improve steady state stability.

| UNIT: V | TRANSIENT STABILITY ANALYSIS |
|---|---|

Derivation of Swing Equation. Determination of Transient Stability by Equal Area Criterion. Application of Equal Area Criterion, Critical Clearing Angle Calculation. - Solution of Swing Equation: Point-by-Point Method. Methods to improve Stability - Application of Auto Reclosing and Fast Operating Circuit Breakers.

**TEXT BOOKS:**


1. "M.A.Pai", Computer Techniques in Power System Analysis, TMH Publications 3rd Edition July 2017.
2. "K.Umarao", Computer techniques and models in power systems, , I.K.International 1st edition, September 2014.


**REFERENCE BOOKS:**


1. "PSR Murty", Power System Analysis, BS Publications, January 2018
2. "HadiSaadat", Power System Analysis, , TMH, 3rd edition, 2018
3. "TuranGonen",Modern Power System Analysis, CRC Press, 2nd edition February 2013


**WEB REFERENCES:**

1. https://nptel.ac.in/courses/108/107/108107127/
2. https://nptel.ac.in/courses/108/105/108105067/

**EE714PE: POWER SYSTEM AUTOMATION**
**(Professional Elective - III)**

| **B.TECH. IV YEAR I SEMESTER** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Course Code** | **Category** | **Hours/Week** | | | **Credits** | **Maximum Marks** | | |
| | | **L** | **T** | **P** | **C** | **CIA** | **SEE** | **Total** |
| **EE714PE** | **PEC** | 3 | 0 | 0 | 3 | 30 | 70 | 100 |

**Prerequisite:** Power System – I (EE405PC), Power System – II(EE502PC)

**Course Objectives:**

1. To explain the basics of MIMO systems and calculation of system norms
2. To design the hardware and programming of programmable logic controllers
3. To understand the real time systems and inter task communication.
4. To discuss the fundamentals of PLC and its architecture.
5. To develop the PLC programming fundamentals, process logic and human machine interface.

**Course Outcomes:** At the end of this course, students will demonstrate the ability to

1. Understand the need of structure and operation of power system automation.
2. Discuss the Energy Management System and its role in programmable logic controller.
3. Explain the fundamentals of SCADA.
4. Illustrate the substation automation structure and its applications.
5. Describethe various control schemes of distribution automation and its technical benefits.

| **UNIT: I** | **INTRODUCTION** |
|---|---|

Evolution of automation system – Benefits of power system automation, Structure of power system automation, Electrical Protection, Control, Measurement, Monitoring- Architecture for power system automation – Classification of power system automation – Substation automation and Distribution automation – Problems with Data acquisition - implementation of power system automation and protection using SCADA.

| **UNIT: II** | **ENERGY MANAGEMENT SYSTEMS & PLC** |
|---|---|

Introduction- EMS in Power Systems, Objectives of EMS, Evolution of EMS, Functions and Benefits of EMS, EMS Architecture, Working of EMS, Evolution of EMS.
Introduction – Basic Operation – PLC architecture and components – Programming Languages – PLC"s Applications to Power System Automation.

| **UNIT: III** | **SCADA FUNDAMENTALS** |
|---|---|

Introduction – Building Blocks of SCADA - SCADA in power systems – Its application functions in Generation, Transmission and Distribution – Advantages of SCADA - SCADA Communication systems - RTUs – Components of RTUs –Communication Protocols – Advanced RTU functionalities, IEDs, Data concentrators and merging units, Human Machine Interface, Classification of SCADA systems Single master–single remote, Single master–multiple RTU, Multiple master–multiple RTUs, Single master, multiple submaster, multiple remote.

| UNIT: IV | SUBSTATION AUTOMATION |
|---|---|
| Need for Substation automation, Role of IEDs in SA, Conventional substations: Islands of automation, Substation automation issues, SA architectures, application functions, Enterprise-level application functions, Benefits of data analysis to utilities | |
| **UNIT: V** | **DISTRIBUTION AUTOMATION** |
| Introduction to Distribution Automation (DA), control system interfaces, control and data requirements, centralized (Vs) decentralized control, DA System (DAS), DA Hardware, DAS software, Distribution Automation Functions-Information management, system reliability management, system efficiency management, voltage management, Load management, Communication systems used in DA - DA communication requirements, Communication reliability, Cost effectiveness, Data rate Requirements, Two way capability, Technical Benefits of DA. | |

**TEXT BOOKS:**

1. "Mini S Thomas", "John D McDonald",Power system SCADA and smart grids, CRC Press, 2015.
2. "James. Northcote", "Green Robert Wilson", Control and Automation of Electrical Distribution Systems, , CRC Press 1st edition 2007

**REFERENCE BOOKS:**

1. "Rajesh Mehra", "Vikrant Vij", PLCs and SCADA- Theory and Practice, LaxmiPublications, First edition, 2016.
2. "Dr. M. K. Khedkar", "Dr. G.M.Dhole", Electric Power Distribution Automation, University Science press,2010

**WEB REFERENCES:**

1. https://www.electricalindia.in/power-system-automation/
2. https://nptel.ac.in/courses/108/105/108105063/

## EE721PE: HVDC TRANSMISSION

**(Professional Elective-IV)**

**B.TECH. IV YEAR I SEMESTER**

| Course Code | Category | Hours/Week | | | Credits | Maximum Marks | | |
|---|---|---|---|---|---|---|---|---|
| | | L | T | P | C | CIA | SEE | Total |
| EE721PE | PEC | 3 | 0 | 0 | 3 | 30 | 70 | 100 |

**Prerequisite:** Power System-I(EE405PC), Power System-II(EE502PC), Power System Protection(EE603PC), Power System Operation and Control(EE604PC), Power Electronics(EE501PC)

**Course Objectives:**

1. To compare EHV AC and HVDC systems
2. To analyze Graetz circuit and also explain 6 and 12 pulse converters
3. To control HVDC systems with various methods and to perform power flow analysis inAC/DC systems.
4. To describe various protection methods for HVDC systems and Harmonics

**Course Outcomes:** After completion of this course the student is able to

1. Compare EHV AC and HVDC system and to describe various types of DC links
2. Analyze Graetz circuit for rectifier and inverter mode of operation
3. Describe various methods for the control of HVDC systems and to perform power flow analysis in AC/DC systems
4. Discuss various protection methods for HVDC systems
5. Analyze the classification of Harmonics and design different types of filters.

### UNIT: I CONVERTERS FOR HVDC TRANSMISSION

**Basic Concepts** Necessity of HVDC systems, Economics and Terminal equipment of HVDC transmission systems, Types of HVDC Links, Apparatus required for HVDC Systems, Comparison of AC and DC Transmission, Application of DC Transmission System, Planning and Modern trends in D.C. Transmission.

**Analysis of HVDC Converters**: Choice of Converter Configuration, Analysis of Graetz circuit, Characteristics of 6 Pulse and 12 Pulse converters, Cases of two 3 phase converters in Y/Y mode – their performance.

### UNIT: II CONTROL OF HVDC SYSTEM

**Converter and HVDC System Control**: Principle of DC Link Control, Converters Control Characteristics, firing angle control, Current and extinction angle control, Effect of source inductance on the system, Starting and stopping of DC link, Power Control.

**Reactive Power Control in HVDC**: Introduction, Reactive Power Requirements in steady state, sources of reactive power- Static VAR Compensators, Reactive power control during transients.

### UNIT: III POWER FLOW ANALYSIS IN HVDC SYSTEMS

Modelling of DC Links, DC Network, DC Converter, Controller Equations, Solution of DC load flow, P.U. System for DC quantities, solution of AC-DC Power flow-Simultaneous method-Sequential method.

| UNIT: IV | PROTECTION OF CONVERTERS |
|---|---|

**Converter Faults and Protection**: Converter faults, protection against over current and over voltage in converter station, surge arresters, smoothing reactors, DC breakers, Audible noise, space charge field, corona effects on DC lines, Radio interference.

| UNIT: V | HARMONIC ANALYSIS |
|---|---|

Characteristics of harmonics, calculation of AC Harmonics, Non harmonics Characteristics, adverse effects of harmonics, Calculation of voltage and Current harmonics, Effect of Pulse number on harmonics

**Filters**: Types of AC filters, Design of Single tuned filters –Design of High pass filters.

**TEXT BOOKS:**


1. "K. R. Padiyar", HVDC Power Transmission Systems, New Age International Publishers, 2017
2. "S K Kamakshaiah, V Kamaraju", HVDC Transmission, Mc Graw Hill Publishers, 2020


**REFERENCE BOOKS:**


1. "S. Rao", EHVAC and HVDC Transmission Engineering and Practice, Khanna publications, 3rd Edition 2016.
2. "Jos Arrillaga", HVDC Transmission, The institution of electrical engineers, IEE power & energy series 29, 2nd edition 2008.
3. "E. W. Kimbark", Direct Current Transmission, John Wiley and Sons, volume 1, 1971.


**WEB REFERENCES:**

1. https://nptel.ac.in/courses/108/104/108104013/
2. https://nptel.ac.in/courses/108/106/108106160/

## EE722PE: POWER QUALITY

**(Professional Elective IV)**

**B.TECH. IV YEAR I SEMESTER**

| Course Code | Category | Hours/Week | | | Credits | Maximum Marks | | |
|---|---|---|---|---|---|---|---|---|
| | | L | T | P | C | CIA | SEE | Total |
| EE722PE | PEC | 3 | 0 | 0 | 3 | 30 | 70 | 100 |

**Prerequisite:** Power systems – II(EE502PC)

**Course Objectives:**

1. To understand the power quality and different terms of power quality.
2. To compare short and long interruption.
3. To study about voltage sag and its effects.
4. To know the behavior of power electronics loads.

**Course Outcomes:** Upon completing this course, the student will be able to

1. Discuss the severity of power quality problems in distribution system.
2. Understand the concept of voltage sag transformation from up-stream (higher voltages) to down-stream (lower voltage)
3. Explain the concept of improving the power quality.
4. Discuss various methods of mitigation in DC drives.
5. Analyze power quality issues by the VSI converters.

| 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 | 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 ISSUES IN INDUSTRIES |
|---|---|

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.

**TEXT BOOKS:**

1. "Roger C. Dugan" , "Mark F. Mcgranaghan", "Surya Santoso" , "H. Wayne Beaty",ElectricalPower Systems Quality, McGraw Hill Education; 3rd edition -2017
2. "Math H J Bollen", Understanding Power Quality Problems by Bollen, Wiley India-2011

**REFERENCE BOOKS:**

1. "P. Sanjeevikumar", "C. Sharmeela", "Jens Bo Holm-Nielsen", "P. Sivaraman", Power Quality in Modern Power Systems, Academic Press-2020
2. "Bhim Singh","AmbrishChandra","Kamal", "Al-Haddad",Power Quality: Problems and Mitigation Techniques, John Wiley & Sons, Inc.- 2015

**WEB REFERENCES:**

1. https://nptel.ac.in/courses/108/102/108102179/
2. https://nptel.ac.in/courses/108/107/108107157/

## EE723PE: ADVANCED CONTROL SYSTEMS
## (Professional Elective IV)

**B.TECH. IV YEAR I SEMESTER**

| Course Code | Category | Hours/Week | | | Credits | Maximum Marks | | |
|---|---|---|---|---|---|---|---|---|
| | | L | T | P | C | CIA | SEE | Total |
| EE723PE | PEC | 3 | 0 | 0 | 3 | 30 | 70 | 100 |

**Prerequisite:** Control Systems(EE404PC)

**Course Objectives:**

1. To discuss about stability analysis
2. To understand about phase plane analysis
3. To explain describing function analysis
4. To understand observability and controllability

**Course Outcomes:** Upon completing this course, the student will be able to

1. Understand the basics of advanced control systems.
2. Analyze stability analysis of control systems in frequency domain through polar &nyquist plots
3. Design of lag, lead, lag-lead compensators in frequency domain,
4. Analyze the stability of continuous systems.
5. Apply concept of controllability and observabilty.

| UNIT: I | FREQUENCY BASED STABILITY ANALYSIS AND CONTROLLERS DESIGN |
|---|---|

Frequency Domain: Polar Plots-Nyquist Plots-Stability Analysis. Lag, Lead, Lead-Lag Controllers design in frequency Domain.

| UNIT: II | STABILITY ANALYSIS THROUGH LYAPUNOV METHODS |
|---|---|

Stability in the sense of Lyapunov. Lyapunov"s stability and Lypanov"s instability theorems. Direct method of Lypanov for the Linear and Nonlinear continuous time autonomous systems.

| UNIT: III | PHASE-PLANE ANALYSIS |
|---|---|

Introduction to phase-plane analysis, Method of Isoclines for Constructing Trajectories, singular points,phase-plane analysis of nonlinear control systems

| UNIT: IV | DESCRIBING FUNCTION ANALYSIS |
|---|---|

Introduction to nonlinear systems, Types of nonlinearities, describing functions, describing function analysis of nonlinear control systems.

| UNIT: V | STATE SPACE ANALYSIS OF CONTINUOUS SYSTEMS |
|---|---|

Concepts of state, state variables and state model, derivation of state models from block diagrams, Diagonalization- Solving the Time invariant state Equations- State Transition Matrix and it"s Properties – Concepts of Controllability and Observability.

**TEXT BOOKS:**


1. "B. N. Sarkar", Advanced Control Systems, PHI Learning Private Limited, 2013
2. "Somanath Majhi", Advanced Control Theory, Cengage Learning, 2nd Edition June 2009

**REFERENCE BOOKS:**


1. "S.Palani", Control Systems Engineering, Tata-McGraw-Hill, 2nd Edition 2010
2. "I. J. Nagrath and M. Gopal" Control Systems Engineering, , New Age International (P) Limited, Publishers,6th Edition,2017
3. "K. Ogata", Modern Control Engineering,Prentice Hall of India, 5th Edition,2015.
4. M. Gopal, Modern Control System Theory, New Age International Publishers,4th Edition, 2014


**WEB REFERENCES:**

1. https://nptel.ac.in/courses/108/103/108103007/
2. https://nptel.ac.in/courses/108/107/108107115/

**EE724PE: ELECTRICAL MACHINE DESIGN**
**(Professional Elective - IV)**

**B.TECH. IV YEAR I SEMESTER**

| Course Code | Category | Hours/Week | | | Credits | Maximum Marks | | |
|---|---|---|---|---|---|---|---|---|
| | | L | T | P | C | CIA | SEE | Total |
| EE724PE | PEC | 3 | 0 | 0 | 3 | 30 | 70 | 100 |

**Prerequisite:** Electrical Machines-I(EE304PC), Electrical Machines-II(EE402PC)

**Course Objectives:**

1. To know the major considerations in electrical machine design, electrical engineering materials, space factor, choice of specific electrical and magnetic loadings.
2. To analyze the thermal considerations, heat flow, temperature rise, rating of machines.
3. To understand the design of transformers.
4. To study the design of induction motors.
5. To know the design of synchronous machines.
6. To understand the CAD design concepts.

**Course Outcomes:** Upon completing this course, the student will be able to

1. Design the construction and performance characteristics of electrical machines.
2. Analyze the various factors which influence the design of electrical, magnetic and thermal loading of electrical machines.
3. Apply the principles of electrical machine design and carry out a basic design of an ac machine.
4. Use software tools to do design calculations.
5. Analyze the design considerations of induction motors.

**UNIT: I** **INTRODUCTION**

Major considerations in electrical machine design, space factor, choice of specific electrical and magnetic loadings, thermal considerations, heat flow, temperature rise, rating of machines. Introduction to design aspects of modern machines PMDC,PMAC,PMSMs, BLDCs, and claw-pole machines.

**UNIT: II** **SWITCHED RELUCTANCE MOTORS**

Design aspects of stator and rotor pole arcs, design of stator and rotor and pole arcs in SR motor-determination of L(θ)--- θ profile – power converter for SR motor-A numerical example –Rotor sensing mechanism and logic control, drive and power circuits, position sensing of rotor with Hall problems—derivation of torque expression, general linear case.

**UNIT: III** **INDUCTION MOTORS**

Sizing of an induction motor, main dimensions, length of air gap, rules for selecting rotor slots of squirrel cage machines, design of rotor bars & slots, design of end rings, design of wound rotor, magnetic leakage calculations, leakage reactance of poly-phase machines, magnetizing current, short circuit current, circle diagram, operating characteristics.

| UNIT: IV | SYNCHRONOUS MACHINES |
|---|---|

Sizing of a synchronous machine, main dimensions, design of salient pole machines, short circuit ratio, shape of pole face, armature design, armature parameters, estimation of airgap length, design of rotor, design of damper winding, determination of full load field mmf, design of field winding, design of turbo alternators, rotor design.

| UNIT: V | COMPUTER AIDED DESIGN (CAD) |
|---|---|

Limitations (assumptions) of traditional designs need for CAD analysis, synthesis and hybrid methods, design optimization methods, variables, constraints and objective function, problem formulation. Introduction to FEM based machine design.

**TEXT BOOKS:**


1. "A. K. Sawhney", A Course in Electrical Machine Design, Dhanpat Rai and Sons, 2016.
2. "M.G. Say", Theory & Performance & Design of A.C. Machines, ELBS London.


**REFERENCE BOOKS:**


1. "S. K. Sen", Principles of Electrical Machine Design with computer programmes, Oxford and IBH Publishing, 2006.
2. "K. L. Narang", A Text Book of Electrical Engineering Drawings, Satya Prakashan, 1969.
3. "A. Shanmugasundaram", "G. Gangadharan"," R. Palani", Electrical Machine Design Data Book, New Age International, 1979.
4. "M. V. Murthy",Computer Aided Design of Electrical Machines, B.S. Publications, 2008.
5. "Electrical machines and equipment design exercise examples using Ansoft"s Maxwell 2D machine design package.


**WEB REFERENCES:**

1. https://nptel.ac.in/courses/108/106/108106023/
2. https://nptel.ac.in/courses/108/105/108105131/

## EE703PC: ELECTRICAL AND ELECTRONICS DESIGN LAB

**B.TECH. IV YEAR I SEMESTER**

| Course Code | Category | Hours/Week | | | Credits | Maximum Marks | | |
|---|---|---|---|---|---|---|---|---|
| | | L | T | P | C | CIA | SEE | Total |
| EE703PC | PCC | 0 | 0 | 2 | 1 | 30 | 70 | 100 |

**Prerequisite**: Basic Electrical Engineering(EE103ES)

**Course Objectives:**

1. To enhance practical knowledge related to different subjects
2. To develop hardware skills such as soldering, winding etc.
3. To develop debugging skills.
4. To increase ability for analysis and testing of circuits.
5. To fabricate basic electrical circuit elements/networks

**Course Outcomes:** Upon completing this course, the student will be able to

1. Get practical knowledge related to electrical
2. Trouble shoot the electrical circuits
3. Design filter circuit for application
4. Get hardware skills such as soldering, winding etc.
5. Get debugging skills.

**List of Experiments:**

**Group A:**

1. Design and fabrication of reactor/ electromagnet for different inductance values.
2. Design and fabrication of single-phase Induction/three phase motor stator.
3. Start delta starter wiring for automatic and manual operation.
4. Wiring of distribution box with MCB, ELCB, RCCB and MCCB.
5. Wiring of 40 W tube, T-5, LED, Metal Halide lamps and available latest luminaries.
6. Assembly of various types of contactors with wiring.
7. Assembly of DOL and 3-point starter with NVC connections and overload operation.

**Group B:**

This group consists of electronic circuits which must be assembled and tested on general purpose PCB or bread boards.

1. Design and development of 5 V regulated power supply.
2. Design and development of precision rectifier.
3. Design and development of first order/ second order low pass/high pass filters with an application.
4. Microcontroller Interface circuit for temperature/level/speed/current/voltage measurement.
5. Peak detector using op-amplifiers.
6. Zero crossing detector using op-amplifiers.
7. PCB design and layout.

**WEB REFERENCES:**

1. http://vlabs.iitkgp.ernet.in/be/index.html#
2. https://vem-iitg.vlabs.ac.in/Star%20Delta%20Starting(intro).html

# MC707: INTRODUCTION TO ARDUINO

Arduino is a prototype platform (open-source) based on an easy-to-use hardware and software. It consists of a circuit board, which can be programed (referred to as a microcontroller) and a readymade software called Arduino IDE (Integrated Development Environment), which is used to write and upload the computer code to the physical board. Arduino provides a standard form factor that breaks the functions of the micro-controller into a more accessible package.

This course is intended for enthusiastic students or hobbyists. With Arduino, one can get to know the basics of micro-controllers and sensors very quickly and can start building prototype with very little investment. This course is intended to make you comfortable in getting started with Arduino.

**B.TECH. IV YEAR I SEMESTER**

| Course Code | Category | Hours/Week | | | Credits | Maximum Marks | | |
|---|---|---|---|---|---|---|---|---|
| | | L | T | P | C | CIA | SEE | Total |
| MC707 | Mandatory course | | | | | 30 | 70 | 100 |

**Prerequisite:** Basics of C and C++. Knowledge in other programming language. A basic understanding of digital electronics , microcontrollers and electronic components is also expected.

**Course Objectives:**

5. Understand the basics of an embedded system.
6. Understand the typical components of an embedded system.
7. To understand different communication interfaces used in Arduino.
8. To learn the design process of Arduino based embedded system applications.

**Course Outcomes:** Upon completing this course, the student will be able to

1. Learn the basics of electronics, including reading schematics (electronics diagrams)
2. Learn how to prototype circuits with a breadboard and Arduino programming language and IDE
3. Program basic Arduino examples and Prototype circuits and connect them to the Arduino
4. Program the Arduino microcontroller to make the circuits work
5. Connect the Arduino microcontroller to a serial terminal to understand communication and stand-alone use
6. Explore the provided example code and online resources for extending knowledge about the capabilities of the Arduino microcontroller.

| Unit: I | Introduction | |
|---|---|---|

Introduction to Embedded system, Understanding Embedded System, Overview of basic electronics and digital electronics, Representation of data in hexadecimal number system, advantages and applications of hexadecimal number system, Microcontroller vs. Microprocessor, Common features of Microcontroller. Different types of microcontrollers. Pin diagram of 8051,AT 89C52, PIC microcontrollers.

| Unit: II | Getting Started with Arduino&Embedded C | |
|---|---|---|

Introduction to Arduino, Pin configuration and architecture, Device and platform features, Concept of digital and analog ports, familiarizing with Arduino Interfacing Board. Types of Arduino boards.
Introduction to Embedded C and Arduino platform, Review of Basic Concepts, data types ,Variables and constants, Operators , Control Statements , Arrays Functions.

| **Unit: III** | **Arduino Sensors& Relays** | |
|---|---|---|

**Sensors**: Purpose of sensor, **Types**: Humidity Sensor, Temperature Sensor, Water Detector / Sensor, PIR Sensor, Ultrasonic Sensor, LDR. Obstacle sensors, Accelerometer and gyro. Fingerprint sensor. Photoelectric Sensors, Motion Sensors, Gas and Chemical Sensors. Electrical sensor and its types (Voltage and Current sensors).
**Relays**: Controlling Electrical appliances with electromagnetic relays, Types of Relay.

| **Unit: IV** | **Arduino Communications** | |
|---|---|---|

Wired and Wireless Communication (Bluetooth, WiFi, Zigbee), Communication Protocols, Interfacing Communication Modules with Arduino, (Serial Communication Modules) , Types of Serial Communications Arduino UART , GSM/GPRS Arduino Interfacing.

| **Unit: V** | **Making it a reality (Arduino Projects)** | |
|---|---|---|

This will involve designing, developing, coding and implement Arduino project. Projects will include but not limited to :

- Intelligent home locking system.
- Intelligent water level management system
- Measuring Room Temperature
- Intelligent Automatic Irrigation System
- How To Control a DC Motor with an Arduino
- IoT based Smart Grid System using Arduino

**TEXT BOOKS:**


1. Arduino for beginners : Essential Skills Every Maker Needs, John Baichtal, Person Education, Inc., 1st edition.
2. Intro to Embedded Systems by ShibuKv
3. Sensors and Transducers Second edition by D. Patranabis


**REFERENCE BOOKS:**


1. Arduino Cookbook by Michael Margolis, O'Reilly Media, Inc., 1st edition
2. Digital design by Marris Mano
3. A.K.Ray, K.M.Bhurchandi,"Advanced Microprocessors and Peripherals",


**WEB REFERENCES:**

1. Beginning C for Arduino by Jack Purdum (ebook)
2. https://www.electronicshub.org/different-types-sensors/
3. https://learn.sparkfun.com/tutorials/what-is-an-arduino/all
4. https://create.arduino.cc/projecthub
5. https://www.instructables.com/Arduino-Projects/
6. https://www.allaboutcircuits.com/projects/control-a-motor-with-an-arduino/