# Shri Vaishnav Vidyapeeth Vishwavidyalaya

## Master of Technology (Power System)

## SEMESTER II

| COURSE CODE | CATEGORY | COURSE NAME | L | T | P | CREDITS | TEACHING & EVALUATION SCHEME | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | THEORY | | | PRACTICAL | |
| | | | | | | | END SEM University Exam | Two Term Exam | Teachers Assessment* | END SEM University Exam | Teachers Assessment* |
| **MTPS 201** | | **ADVANCED POWER SYSTEM PROTECTION** | 2 | 1 | 2 | 4 | 60 | 20 | 20 | 30 | 20 |

**Legends**: **L** - Lecture; **T** - Tutorial/Teacher Guided Student Activity; **P** – Practical; **C** - Credit;
***Teacher Assessment** shall be based following components: Quiz/Assignment/ Project/Participation in Class, given that no component shall exceed more than 10 marks.

**Course Objectives:**

1. To facilitate the students understand the basic concepts and recent trends in power system protection.
2. To enable the students design and work with the concepts of digital and numerical relaying.

**Course Outcomes:**

After completion of this course the students are expected to be able to demonstrate following knowledge, skills and attitudes

The students will be able to:

1. Skilled enough to work with various type of relaying schemes used for different apparatus protection.
2. **Express** the concept of static distance protection and pilot relaying schemes.
3. Express the concept of digital protection used in transmission line, synchronous generator and power transformers.
4. **Elucidate** the concepts of microprocessor based protective relays and digital relaying algorithms

**Syllabus:**

**UNIT I**

**Numerical Protection**

Introduction, block diagram of numerical relay, sampling theorem, correlation with a reference Wave, least error squared (LES) technique, digital filtering, and numerical over- current protection. Vector surge and df/dt digital relays.

**UNIT II**

**Digital Protection of Transmission line**

Introduction, Protection scheme of transmission line, distance relays, traveling wave relays, digital protection scheme based upon fundamental signal, hardware design, software design, digital protection of EHV/UHV transmission line based upon traveling wave phenomenon, new relaying scheme using amplitude comparison.

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**UNIT III**

**Digital protection of Synchronous generator**

Introduction, faults in synchronous generator, protection schemes for synchronous generator, digital protection of synchronous generator.

**UNIT IV**

**Digital Protection of Power Transformer**

Introduction, faults in a transformer, schemes used for transformer protection, digital protection of transformer

**UNIT V**

**Distance and over current relay setting and co-ordination**

Directional instantaneous IDMT over current relay, directional multi-zone instantaneous relay, distance relay setting, co-ordination of distance relays, co-ordination of over current relays, computer graphics display, man-machine interface subsystem, integrated operation of national power system, application of computer graphics. Short circuit studies in designing relaying scheme Types of faults, assumptions, development of algorithm for S.C. studies, PC based integrated software for S.C. studies, transformation to component quantities, S.C. studies of multiphase systems. Ultra high speed protective relays for high voltage long transmission line.

**Text Books:**

1. Digital Protection - L. P. Singh, (New Age International (P) Limited Publishers, New Delhi, 2nd Edition)
2. Fundamentals of Power System Protection Paithankar & Bhide (Prentice Hall of India Pvt. Ltd.,New Delhi)
3. Digital Relay / Numerical relays – T.S.M. Rao, Tata Mc Graw Hill, New Delhi
4. Digital Protection IEE Monograph, John and Salman, Peter Teregruins Publishers, London

**List of Practical's:** (If Practical Credit Shown in Syllabus)

1. Ratio Test of a C.T and determination of error.
2. Determination of knee point voltage of a CT. 3 Summation Transformer characteristics.
3. Study of CT Connection for E/F protection.
4. Study of Open delta PT Connection for earth fault indication.
5. Protection of 3 ph. Alternater (simulation study).
6. Protection of 3 ph. Induction Motor (simulation study).
7. Over current / under voltage / Negative seq Relay Characteristics (simulation study).
8. Simulation of Transmission line protection.
9. Study of differential protection of transformer (simulation study).

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### Common for Power System / Power Electronics

| COURSE CODE | CATEGORY | COURSE NAME | L | T | P | CREDITS | TEACHING & EVALUATION SCHEME | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | THEORY | | | PRACTICAL | |
| | | | | | | | END SEM University Exam | Two Term Exam | Teachers Assessment* | END SEM University Exam | Teachers Assessment* |
| MTPE 201 | EE | POWER QUALITY | 2 | 1 | 2 | 4 | 60 | 20 | 20 | 30 | 20 |

**Legends**: **L** - Lecture; **T** - Tutorial/Teacher Guided Student Activity; **P** – Practical; **C** - Credit;
***Teacher Assessment** shall be based following components: Quiz/Assignment/ Project/Participation in Class, given that no component shall exceed more than 10 marks.

**Course Objectives:**

The Students (A) Will Be Able to familiarize with different power quality issues (B) with emphasis on their analysis and application to practical engineering problems(C) efficiently & effectively (D)

**Course Outcomes:**

After completion of this course the students are expected to be able to demonstrate following knowledge, skills and attitudes

The students will be able to

1. Identify various power quality disturbances in engineering.
2. Identify, formulate, and solve harmonics in electrical engineering.
3. Demonstrate and analyze the active power filters.
4. Demonstrate the knowledge of various solution of power quality improvement.
5. Demonstrate the knowledge of grounding and wiring.

**Syllabus**

**UNIT - I**

Introduction - power quality, voltage quality, overview of power quality phenomena, Classification of power quality issues, power quality measures and standards, THD -TIF-DINC-message weights-flicker factor-transient phenomena, occurrence of power quality problems, power acceptability curves, IEEE guides, standards and recommended practices.

**UNIT - II**

Harmonics, individual and total harmonic distortion, RMS value of a harmonic waveform, triplex harmonics, important harmonic introducing devices, SMPS, Three phase power converters, arcing devices, saturable devices, harmonic distortion of fluorescent lamps, effect of power system harmonics on power system equipment and loads. Modeling of networks and components under non-sinusoidal conditions, transmission and distribution systems, shunt capacitors, transformers, electric machines, ground systems, loads that cause power quality problems, power quality problems created by drives and its impact on drives

**UNIT - III**

Power factor improvement, Passive Compensation, Passive Filtering, Harmonic Resonance, Impedance Scan Analysis, Active Power Factor Corrected Single Phase Front End, Control Methods for Single Phase APFC, Three Phase APFC and Control Techniques, PFC Based on Bilateral Single Phase and Three Phase Converter. Static VAR compensators, SVC and

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**UNIT - IV**
Active Harmonic Filtering, Shunt Injection Filter for single phase, three -phase three -wire and three-phase four-wire systems, d-q domain control of three phase shunt active filters uninterruptible power supplies-constant voltage transformers, series active power filtering techniques for harmonic cancellation and isolation . Dynamic Voltage Restorers for sag, swell and flicker problems.

**UNIT - V**
Grounding and wiring, introduction, NEC grounding requirements, reasons for grounding, typical grounding and wiring problems, solutions to grounding, and wiring problems

**Reference Books:**

1. J. Arrillaga, .Power System Quality Assessment., John wiley, 2000
2. J. Arrillaga, B.C. Smith, N.R. Watson & A. R.Wood ,.Power system Harmonic .Analysis, Wiley, 1997 'Selected Topics in Power Quality and Custom Power', Course book for STTP, 2004, Ashok S.Surya Santoso, H. Wayne Beaty, Roger C. Dugan, Mark F. McGranaghan, Electrical Power System Quality , MC Graw
3. Electric power quality by G.T.heydt
4. Understanding Power Quality Problems by Math H. Bollen

**List of Practical's:** (If Practical Credit Shown in Syllabus)

1. Simulation of Power quality disturbance using MATLAB/SIMULATION.
2. To measure the performance like THD. PF of a three phase fully controlled converter feeding a resistive load.
3. To measure the performance like DF & CF of a single phase fully controlled converter feeding a RL load.
4. To measure and analyze the harmonic contents of a three phase inverter fed non line load.
5. To study and simulate power filter.
6. To study and simulate active power filter.
7. Application of FFT/wavelet techniques for power quality analysis using MATLAB/ SIMULATION.

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## SEMESTER II

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|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | THEORY | | | PRACTICAL | |
| | | | | | | | END SEM University Exam | Two Term Exam | Teachers Assessment* | END SEM University Exam | Teachers Assessment* |
| MTPS 203 | EE | ADVANCED POWER SYSTEM ANALYSIS | 3 | 1 | 0 | 4 | 60 | 20 | 20 | 0 | 0 |

**Legends**: **L** - Lecture; **T** - Tutorial/Teacher Guided Student Activity; **P** – Practical; **C** - Credit;
***Teacher Assessment** shall be based following components: Quiz/Assignment/ Project/Participation in Class, given that no component shall exceed more than 10 marks.

**Course Objectives:**
The Students will be able to familiarize (A)with the power network matrix (admittance and impedance matrices) and (B)impart in-depth knowledge on different methods of power flow solutions. (C) They will be able to understand the fundamental concepts of power system stability and its classificationand factors influencing stability(D).

**Course Outcomes:**
After completion of this course the students are expected to be able to demonstrate following knowledge, skills and attitudes
The students will be able to

1. To analyze multi-node power networks using an admittance matrix or impedance matrix representation of the power system and develop admittance matrix using singular transformation.
2. To perform optimal power flow solutions in detail and impart in-depth knowledge on different methods of power flow solutions (Gauss Seidal, Newton Raphson and FDLF methods).
3. To gain knowledge on solution techniques of power system stability and develop solution of swing equation and equal area criteria.
4. To understand the basic knowledge about the dynamic mechanisms behind power system stability (angle and voltage stability) problems in electric power systems, including physical phenomena and modeling issues.

**Syllabus**
**UNIT -I**
**Network matrix:** Physical interpretation of bus admittance and impedance matrices, introduction to admittance matrix formulation, formation of admittance matrix due to inclusion of regulating transformer, development of admittance matrix using singular transformation, modification of admittance matrix for branch addition/ deletion.
**UNIT -II**
**Complex power flow:** Analytical formulation of complex power flow solution, Gauss-Seidal method of power flow, Newton Raphson method of power flow, algorithm for solving power flow problem using N-R method in rectangular form, algorithm forsolving power flow problem using N-R method in polar form, fast decoupled load flow method.

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**UNIT -III**

**Power System Stability:** Definitions, classification of stability-rotor angle and voltage stability, synchronous machine representation for stability study.

**UNIT - IV**

**Transient stability**: Assumptions for transient stability, derivation of swing equation, swing equation for synchronous machine connected to infinite bus, swing equation for a two machine system, solution of swing equation by Euler and Runge Kutta method, equal area criterion, critical clearing angle, application of critical clearing angle to transient stability of synchronous machine. Methods of improving transient stability: reducing fault clearance time, automatic reclosing, single phase reclosing, electric braking, voltage regulators, fast governor action, high speed excitation system.

**UNIT - V**

**Voltage stability**: Definition and classification of voltage stability, mechanism of voltage collapse, analytical concept of voltage stability for a two bus system, expression for critical receiving end voltage and critical power angle at voltage stability limit for at wo bus power system, PV and QV curves, L index for the assessment of voltage stability.

**Reference Books:**

1. A. Chakrabarti,M.L. Soni, P. V. Gupta, U. S. Bhatnagar "A text book on Power System Engineering", DhanpatRai and Co.
2. Power system Analysis by HadiSaadat: Tata McGraw-Hill Publishing Company Limited.
3. Power system Analysis by Charles A. Gross: John Wiley & Sons.
4. Power system Analysis by John J. Grainger & William D. Stevenson, JR: Tata McGraw-Hill Edition

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## SEMESTER II

### Common for Power System / Power Electronics

| COURSE CODE | CATEGORY | COURSE NAME | L | T | P | CREDITS | TEACHING & EVALUATION SCHEME | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | THEORY | | | PRACTICAL | |
| | | | | | | | END SEM University Exam | Two Term Exam | Teachers Assessment* | END SEM University Exam | Teachers Assessment* |
| MTPS 215 | | POWER SYSTEM STABILITY AND CONTROL | 2 | 0 | 0 | 2 | 60 | 20 | 20 | 0 | 0 |

**Legends**: **L** - Lecture; **T** - Tutorial/Teacher Guided Student Activity; **P** – Practical; **C** - Credit;
***Teacher Assessment** shall be based following components: Quiz/Assignment/ Project/Participation in Class, given that no component shall exceed more than 10 marks.

**Course Objectives:**
This course aims to give basic knowledge about the dynamic mechanisms behind angle and voltage stability problems in electric power systems, including physical phenomena and modelling issues.

**Course Outcomes:**
After completion of this course the students are expected to be able to demonstrate following knowledge, skills and attitudes
The students will be able to
1. Analyze various types of stability properties of power systems
2. Develop mathematical models of power system for dynamic studies
3. Analyze the performance of single and multi-machine systems under transient, steady state and dynamic conditions.
4. Demonstrate how the transient stability of a power system can be analyzed by using Equal Area Criterion.

**Syllabus**
**UNIT I**
**Power System Structure**: Operating states, control problem, control loops. Power System Stability – classification, terms and definitions.
**Power system components:** Hydraulic and steam turbine, Effect of exciter and governor. Excitation system – requirements, functions, types and modeling of excitation systems, IEEE standards and models.

**UNIT II**
**Control of Power and Frequency:** Power, Frequency characteristics, Division of load, Load frequency control, Generator, load and Prime mover models, Governor models, AGC in a two area system, AGC in a multi area system parameter setting constants, Tie- line bias control, AGC with optimal dispatch of Generation, AGC including Excitation system, Conventional PI and PID controllers for AGC, AI applications automatic generation control.

**UNIT III**
**Control of voltage and Reactive Power:** Relation between voltage, power and reactive

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power, Generation and absorption of reactive power, voltage control and voltage stability analysis, V-Q curves and sensitivity analysis, Voltage stability indices, Factors affecting voltage instability and voltage collapse.

**UNIT IV**

**Stability Studies:** Concepts, steady state and transient stability, small signal stability analysis, excitation system, Dynamic and transient stability analysis of single machine and multi -machine systems, power system stabilizer design and analysis for stability problem. Transient Stability: Solution of swing equations, swing curves, stability criterion.

**UNIT V**

**Techniques for the improvement of stability:** operation under abnormal and distressed condition, Enhancement of small signal stability: use of power system stabilizers, supplementary control of Static VAr compensators, supplementary control of HVDC links, Techniques for improvement of transient stability, Integrated analysis of Voltage and Angle stability, Control of voltage instability, concepts of load shedding.

**Text Books:**

1. Prabha Kundur, "Power System Stability and Control" Mc-Graw Hill Inc, New York, 1993.
2. Taylor C.W.," Power System Voltage Stability" Mc-Graw Hill Inc, New York, 1993.
3. K.R.Padiyar,.Power System Dynamic . Stability and Control., Inter Publishing (P) Ltd., Bangalore, 1999 .
4. P.S.R. Murthy , " Power System Operation and Control," Tata Mc-Graw ,New Delhi 1984.
5. Nagrath IJ, Kothari ., " Power System Engineering ," Tata Mc-Graw ,New Delhi 1994.
6. Weedy B.M. " Electric Power System" John Wiley and Sons ,3 rd edition .
7. Elgerd," Electric Energy System Theory : an Introduction ," Mc-Graw Hill, NX, 1983.

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| COURSE CODE | CATEGORY | COURSE NAME | L | T | P | CREDITS | TEACHING & EVALUATION SCHEME | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | THEORY | | | PRACTICAL | |
| | | | | | | | END SEM University Exam | Two Term Exam | Teachers Assessment* | END SEM University Exam | Teachers Assessment* |
| MTPS 225 | EE | ADVANCED CONTROL THEORY | 2 | 0 | 0 | 2 | 60 | 20 | 20 | 0 | 0 |

**Legends: L** - Lecture; **T** - Tutorial/Teacher Guided Student Activity; **P** – Practical; **C** - Credit;
***Teacher Assessment** shall be based following components: Quiz/Assignment/ Project/Participation in Class, given that no component shall exceed more than 10 marks.

**Course Objectives:**

The Students (A) will be able to design mathematical modelling and control systems (B) Understanding PID controller design and implementation issues (C) Control system design using state space models(D) State feedback controller design. Observer design. State estimate feedback control system design.

**Course Outcomes:**

After completion of this course the students are expected to be able to demonstrate following knowledge, skills and attitudes

The students will be able to

1. Develop mathematical models and understand the mathematical relationships between the sensitivity functions and how they govern the fundamentals in control systems.
2. design and fine tune PID controllers and understand the roles of P, I and D in feedback control
3. design pole-assignment controller and the specific design procedures
4. develop state-space models
5. design state feedback controller and state observer

**Syllabus**

**UNIT I**

Review of classical and modern control concepts: PID control and tuning approaches, State space method, analysis and design of control system in state space, pole placement, state observer, design of control system with Luenberger observer.

**UNIT II**

**Optimal control:**

Parameter optimization and optimal control problems, quadratic performance index, analysis and design of finite and infinite time Linear Quadratic Regulators, Introduction to Linear Quadratic Gaussian approach.

**UNIT III**

**Robust Control:**

Concept of robust control, description and categorization of system uncertainities. System and signal norms, small gain theorem, robust stability, design of robust control, Introduction to H-$\infty$ control.

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**UNIT IV**

**Nonlinear Control:**

Nonlinear Systems and Equilibrium Points , Concepts of Stability, Linearization, Stability analysis of nonlinear systems, Feedback Linearization, Input-output linearization, Input-State Linearization.

**UNIT V**

**Sliding mode control**

Notion of variable structure system and variable structure control, Introduction to sliding mode control, features of sliding mode control, sliding mode control design, concept of sliding surface,control design using reaching laws, stability analysis. Applications to power system/power electronics:Transfer functions of various power electronic devices like converters (switching model, averaging model), Applications of control theory for control of converters, renewable systems, distribution generation, power quality devices.

**Text Books:**


1. 'Control of Power Inverters in Renewable Energy and Smart Grid Integration', Qing-Chang Zhong, Tomas Hornik, Wiley Publication, 2013
2. 'Sliding-mode Control: Theory and applications' by Sarah K. Spurgeon, Taylor & Francis, 1998
3. 'Digital Control and State Variable Methods' by M. Gopal, Tata-McGraw-Hill Publishing
4. Company Limited
5. 'Optimal Control: Linear Quadratic Methods' Brian D. O. Anderson, John Barratt Moore, Dover Publications, 2007
6. 'Modern Control Engineering'- Katsuhiko Ogata, Prentice Hall India, 5th edition 2010.
7. 'Applied Non Linear Control', Jean-Jacques E. Slotine, Prentice Hall Englewood Cliffs, New Jersey.
8. 'Non-linear Systems', by Hassan Khalil, Prentice Hall.


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|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | THEORY | | | PRACTICAL | |
| | | | | | | | END SEM University Exam | Two Term Exam | Teachers Assessment* | END SEM University Exam | Teachers Assessment* |
| **MTPS 235** | | **ADVANCED PROCESSORS AND APPLICATION** | 2 | 0 | 0 | 2 | 60 | 20 | 20 | 0 | 0 |

**Legends**: **L** - Lecture; **T** - Tutorial/Teacher Guided Student Activity; **P** – Practical; **C** - Credit;
***Teacher Assessment** shall be based following components: Quiz/Assignment/ Project/Participation in Class, given that no component shall exceed more than 10 marks.

**Course Objectives:**
The Students (A) will be able to learn the generalized architecture of digital signal processors/controllers (B) develop algorithm/program of the digital signal controllers for a particular task (C) interface digital signal controllers with external peripherals.

**Course Outcomes:**
After completion of this course the students are expected to be able to demonstrate following knowledge, skills and attitudes. The students will be able to

1. Understand different processor architectures and system-level design processes.
2. Understand the principles of I/O in computer systems, including viable mechanisms for I/O and secondary storage organisation.
3. Develop systems programming skills in the content of computer system design and organisation
4. Understand various ADC modules.

**Syllabus**
**UNIT-I**
Introduction to the concept of digital signal processor, digital signal controller, basic architectures, essential features of digital signal processor/controller, Texas families of processors C2000, C5000, C6000, their features and applications.

**UNIT -II**
Evolution of C2000 family, TMS 320F2812 block diagram, math units, data memory access,internal bus structure, ALU, instruction pipeline, memory map, code security module, interrupt response.

**UNIT -III**
Digital input/output interface: GPIO register structure, digital I/O registers, clock module, watchdog timer, system control and status register.

**UNIT -IV**
Interrupt system: Interrupt lines, reset boot-loader, interrupt sources, maskable interrupt processing,peripheral interrupt expansion, C28x CPU timers, applications.

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**UNIT -V**

Event manager: Block diagram, timer operating modes, interrupt sources, GP timer registers, GP timer interrupts, event manager compare units, capture units, QEP unit, and applications.
Analog Digital Converter: ADC module overview, ADC in cascaded mode, ADC in dual sequencer mode, ADC conversion time, ADC register block, applications.

**Reference Books:**


1. 'Programming and Use of TMS320F2812 DSP to Control and Regulate Power Electronic Converters'by Baris Bagci, Grin Verlag, 2007.
2. 'Digital Signal Processing' by Avatar Singh, S. Srinivassan, Cengage Learning, 2004.
3. 'TMS320F2812 Digital Signal Processor: Implementation Tutorial' by Texas Instruments.
4. 'TMS320x281x DSP Event Manager (EV) Reference Guide' by Texas Instruments.


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|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | THEORY | | | PRACTICAL | |
| | | | | | | | END SEM University Exam | Two Term Exam | Teachers Assessment* | END SEM University Exam | Teachers Assessment* |
| **MTPS 216** | **EE** | **DISTRIBUTION SYSTEM AUTOMATION** | 2 | 0 | 0 | 2 | 60 | 20 | 20 | 0 | 0 |

**Legends: L** - Lecture; **T** - Tutorial/Teacher Guided Student Activity; **P** – Practical; **C** - Credit;
***Teacher Assessment** shall be based following components: Quiz/Assignment/ Project/Participation in Class, given that no component shall exceed more than 10 marks.

**Course Objectives:**

The Students (A) will be able to gain the awareness of the problems and challenges of the existing distribution system and understand the need for Distribution Automation (DA) and appreciate its role in overcoming existing problems of distribution system. They will able to understand the distribution system expansion planning and reliability analysis procedures (B) and also get the idea about various power quality issues (C) and concept of deregulated systems.

**Course Outcomes:**

After completion of this course the students are expected to be able to demonstrate following knowledge, skills and attitudes

The students will be able to

1. Understand the concepts of Distribution Automation and become familiar in the emerging areas of distribution systems brought about by integrating advanced technology and communication with distribution components.
2. Comprehend advanced concepts of distribution planning, design, engineering and reliability assessment.
3. Have the wider knowledge on power quality issues, earthing and safety.
4. Describe the analysis of load management, demand side management (DSM) and reactive power control.
5. Understand how the Power Market operates in a deregulated Electrical Power Industry.
6. Understand general principles of project planning for Distribution Automation (DA) and various aspects of Distribution Automation (SCADA, CIS, GIS).

**Syllabus**

**UNIT-I**

Distribution System Automation and Planning, Factors Affecting System Planning, Present Distribution Planning, Techniques, Planning in the Future, Power System reliability, Basic Reliability Concepts and Series, Parallel, Series -Parallel Systems, Development of State Transition Model to Determine the Steady State Probabilities.

**UNIT-II**

Electrical System Design, Distribution System Design, Electrical Design Aspects of Industrial, Commercials Buildings, Electrical Safety and Earthing Practices at various voltage levels, IS Codes

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**UNIT-III**

Power Quality: Sags, Swells, Unbalance, Flicker, Distortion, Current Harmonics, Sources of Harmonics in Distribution Systems and its Effects, Energy Management, Energy Conservation Through Energy Management Demand Side Management, Load Management, Reactive Power Control. Custom Power: Concept, Custom Power Devices, Operation and Applications.

**UNIT-IV**

Deregulated Systems: Reconfiguring Power systems, Unbundling of Electric Utilities, Competition and Direct access.

**UNIT-V**

Project planning for distribution automation-communication, sensors, supervisory control and data acquisition, consumer information system (CIS), geographical information system (GIS).

**Reference Books:**


1. IEEE recommended practice for electric power distribution for industrial plants, - December 1993.
2. M.V Deshpande: .Electrical Power System Design. - Tata -McGraw Hill.
3. Pabla H S.: .Electrical Power Distribution Systems..Tata McGraw Hill.
4. IEEE Slandered 739 . 1984 Recommended Practice for Energy Conservation and Cost
5. Effective Planning in Industrial Facilities.
6. Lakervi& E J Holmes .Electricity distribution Network Design., 2nd Edition Peter
7. TuranGonen: .Electric Power Distribution System Engineering. - McGraw Hill Company.
8. Pansini: .Electrical Distribution Engineering


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|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | THEORY | | | PRACTICAL | |
| | | | | | | | END SEM University Exam | Two Term Exam | Teachers Assessment* | END SEM University Exam | Teachers Assessment* |
| MTPS 226 | | SMART GRID TECHNOLOGIES AND APPLICATION | 2 | 0 | 0 | 2 | 60 | 20 | 20 | 0 | 0 |

**Legends**: **L** - Lecture; **T** - Tutorial/Teacher Guided Student Activity; **P** – Practical; **C** - Credit;
***Teacher Assessment** shall be based following components: Quiz/Assignment/ Project/Participation in Class, given that no component shall exceed more than 10 marks.

**Course Objectives:**
Students would get acquainted with the smart technologies, smart meters and power quality issues in smart grids.

**Course Outcomes:**
After completion of this course the students are expected to be able to demonstrate following knowledge, skills and attitudes
The students will be able to
1. Study about Smart Grid technologies, different smart meters and advanced metering infrastructure.
2. Familiarize the power quality management issues in Smart Grid.
3. Familiarize the high performance computing for Smart Grid applications.
4. Understand various Smart grid control elements required to monitor and control the grid, such as smart meters, sensors and phasor measurement units.

**Syllabus**
**UNIT I**
Introduction to Smart Grid: Evolution of Electric Grid, Concept of Smart Grid, Definitions, Need of Smart Grid, Functions of Smart Grid, Opportunities & Barriers of Smart Grid, Difference between conventional & smart grid, Concept of Resilient & Self-Healing Grid, Present development & International policies in Smart Grid. Case study of Smart Grid. CDM opportunities in Smart Grid.

**UNIT II**
Smart Grid Technologies:
Part 1:Introduction to Smart Meters, Real Time Pricing, Smart Appliances, Automatic Meter Reading(AMR), Outage Management System(OMS), Plug in Hybrid Electric Vehicles(PHEV), Vehicle to Grid, Smart Sensors, Home & Building Automation. Phase Shifting Transformers.

**UNIT III**
Smart Grid Technologies:
Part 2: Smart Substations, Substation Automation, Feeder Automation. Geographic Information System (GIS), Intelligent Electronic Devices(IED) & their application for monitoring & protection, Smart storage like Battery, SMES, Pumped Hydro, Compressed Air Energy Storage,

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Wide Area Measurement System(WAMS), Phase Measurement Unit(PMU).

**UNIT IV**

**Micro grids and Distributed Energy Resources:**

Concept of micro grid, need & applications of micro grid, formation of micro grid, Issues of interconnection, protection & control of micro grid. Plastic & Organic solar cells, thin film solar cells, Variable speed wind generators, fuel cells, micro turbines, Captive power plants, Integration of renewable energy sources.

**UNIT V**

**Power Quality Management in Smart Grid:**

Power Quality & EMC in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid, Web based Power Quality monitoring, Power Quality Audit. Information and Communication Technology for Smart Grid: Advanced Metering Infrastructure (AMI), Home Area Network (HAN), Neighbourhood Area Network (NAN), Wide Area Network (WAN). Bluetooth, Zig-Bee, GPS, Wi-Fi, Wi-Max based communication, Wireless Mesh Network, Cyber Security for Smart Grid. Broadband over Power line (BPL). IP based protocols.

**Text Books:**

1. Ali Keyhani, Mohammad N. Marwali, Min Dai "Integration of Green and Renewable Energy in Electric Power Systems", Wiley
2. Clark W. Gellings, "The Smart Grid: Enabling Energy Efficiency and Demand Response",CRC Press
   JanakaEkanayake, Nick Jenkins, Kithsiri Liyanage, Jian zhong Wu, Akihiko Yokoyama," Smart Grid: Technology and Applications", Wiley
3. Jean Claude Sabonnadiere, Nouredine Hadjsaid, "Smart Grids", Wiley Blackwell 4 Tony Flick and Justin More house, "Securing the Smart Grid", Elsevier Inc. (ISBN: 978-1-59749-570-7)
4. Peter S. Fox-Penner, "Smart Power: Climate Change, the Smart Grid, and the Future of Electric Utilities"

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## Master of Technology (Power System)

## SEMESTER II

| COURSE CODE | CATEGORY | COURSE NAME | L | T | P | CREDITS | TEACHING & EVALUATION SCHEME | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | THEORY | | | PRACTICAL | |
| | | | | | | | END SEM University Exam | Two Term Exam | Teachers Assessment* | END SEM University Exam | Teachers Assessment* |
| MTPS 236 | EE | EHVAC AND DC TRANSMISSION | 2 | 0 | 0 | 2 | 60 | 20 | 20 | 0 | 0 |

**Legends**: **L** - Lecture; **T** - Tutorial/Teacher Guided Student Activity; **P** – Practical; **C** - Credit;
***Teacher Assessment** shall be based following components: Quiz/Assignment/ Project/Participation in Class, given that no component shall exceed more than 10 marks.

**Course Objectives:**

1. Elicit the advantages of EHV AC transmission systems.
2. Mould students to acquire knowledge about HVDC Transmission systems.
3. Complete analysis of harmonics and basis of protection for HVDC Systems.

**Course Outcomes:**

After completion of this course the students are expected to be able to demonstrate following knowledge, skills and attitudes

The students will be able to

1. Critically evaluate AC and DC transmission system with all aspects
2. Work and analyze modern and classical EHVAC/HVDC systems
3. **Know** the necessity, merits and demerits of EHVAC transmission and mechanical aspects
4. Perform in depth converter analysis, faults, protections, harmonic considerations, grounding system.

**Syllabus:**

**UNIT I**

Sequential impedances of AC systems EHVAC transmission over voltages, insulation design of lightning and switching over voltages, High voltage testing of AC equipments, Reactive Power compensation of EHV AC lines.

**UNIT II**

**DC Power Transmission Technology:** Application of DC Transmission, Description of DC Transmission System, Planning for HVDC Transmission, Modern Trends in DC Transmission, Thyristor Device, Thyristor Valve, Valve Tests, Recent Trends in valves. Comparison of EHV AC & DC transmission.

**UNIT III**

**HVDC Converters:** Pulse Number, Choice of Converter Configuration, Simplified Analysis of Graetz Circuit, Converter Bridge Characteristics. Characteristics of a Twelve Pulse Converter, Detailed Analysis of Converters

**HVDC System Control:** Principal of DC Link Control, Converter Control Characteristics, System Control Hierarchy, Firing Angle Control, Current and Extinction Angle Control, Starting and Stopping of DC Link, Power Control, Higher Level Controllers, Telecommunication

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Requirements

**UNIT IV**

**Converter Faults and Protection:** Converter Faults , Protection Against Overcurrents, Over voltages in a Converter Station , Surge Arresters, Protection Against Over voltages. **Smoothing Reactor and DC Line**: Smoothing Reactors, DC Line, Transient over Voltages In DC Line, Protection of DC Line, DC Breakers, Monopolar Operation, Effects of Proximity of AC and DC Transmission Lines

**UNIT V**

**Reactive Power Control:** Reactive Power Requirements in Steady State, Sources of Reactive Power, Static Var Systems, Reactive Power Control during Transients

**Harmonics and Filters:** Generation of Harmonics, Design of AC Filters, DC Filters, Carrier Frequency and RI Noise

**Text Books:**

1. HVDC Power Transmission System: K.R. Padiyar , Wiley Eastern Limited.
2. Power System Stability and Control by Prabha Kundur- EPRI. Mc Graw Hill Inc.

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