**YESHWANTRAO CHAVAN COLLEGE OF ENGINEERING**
**(An Autonomous Institution affiliated to R T M Nagpur University Nagpur)**
**Accredited by NAAC (1st Cycle) with 'A' Grade (Score 3.25 on 4 Point Scale)**
**Wanadongri, Hingna Road, Nagpur-441110**

# Department of Electrical Engineering
# (Honors in MGT)

# B.E. Honors in Micro Grid Technologies
# SoE & Syllabus 2021-22

# Information Brochure of Honor Program

1. Title of Program: **Micro grid Technologies**
2. Type of Program : Honor
3. Department offering the program: **Electrical Engineering**
4. Industry / Association / Collaboration: Skywing technology, Pune
   Kanta Height, First floor, Office No. 102
   Sr. No. 3/21, opp. Sawata Mali Mandir,
   Narhe, Pune, Maharashtra 411041
5. Departments eligible to opt for the program: Electrical Engineering Students
6. General information about courses in program:

**The theory course in the program includes**

**Renewable Energy System :** This Course deals with various Energy Sources such as solar, wind, energy from Biomass , Direct Energy Conversion Processes and Applications of Renewable energy)

**Distributed Generation and Micro Grid Technology-**This course deals with overview of Distribution Generation (DG) and Storage Technologies, Operational benefits of Grid connected Renewable DG systems, Technical impacts of DGs on Grid, Operation Control and Modeling of Micro grid, Protection of Micro Grid)

**Micro Grid Planning and Management**: In this course we study Micro Grid planning, Electricity Act 2003, Energy Conservation Act 2001, Indian Electricity Rule 2005, Grid code for Conventional grid and Micro Grid, Micro Grid Generation and Storage Planning, Micro Grid Economics, Impact of External Market Prices and Pricing Policies, Micro Grid Operation Management, Micro Grid Security and State Estimation.

**Advanced Power Electronics:** deals with various Semiconductor Power Devices, AC/DC Controlled

Rectifier, Non isolated DC/DC Converters, Isolated DC/DC converters, Multilevel Inverters, Soft switching Converters

**Power Quality:** In this course the main focus is to understand the different power quality problems, its causes, effects and various mitigating custom power devices. Further the subject is concentrated to analyze the different control strategies and algorithm.

The laboratory courses in the program includes Advanced Power Electronics, FACTS and Power Conditioning, Power System Simulation

Credits for theory courses are 15 and for laboratory courses are 3.

**7. Advance knowledge or research orientation of Program:**

After studying this honor program, students are ready to carry their research in various fields viz distributed active synchronization for micro grid under unbalance and harmonic distortions, DC micro grid operation and control, PV micro grids, shifting the energy paradigm, smart grid strategy, power quality enhancement, energy cost saving and high efficiency, system recovery under faults(selfheal), micro grid in rural area, Ac/DC micro grid for ships and aircrafts, AC/DC micro grids protection, DC micro grid and DC homes, micro grids based on wind/PV/storage hybrid system, energy storage system, energy management system, Design, modeling and control of micro grid, Coordination control schemes between micro grid elements including communication systems and energy management systems for DC micro grids

**8. Employability potential of program:**

A candidate with B.E. Electrical engineering and Major/Honor in Micro Grid technology is a most suitable person to get placement as micro grid design engineer (hardware), micro grid system modeler, senior energy and sustainability consultant, senior data scientist/ energy optimization, energy auditor/ energy consultant, micro grid application engineer, distributed energy services, solar energy project manager, Micro Grid Controls Engineer, Customer Service Manager for Commercial Power Generation, Electrical Engineer- Power Systems, embedded software engineer in Gram power Jaipur RJ, senior power system control engineer, system engineer, automation engineer, grid modernization consultant, smart grid engineer, project planning and control specialist

**9. Departmental Steering committee: For proper publicity / conduct of program**

| SN | Name of the Faculty Member | Post | Designation | e-mail ID | Contact Number |
|---|---|---|---|---|---|
| 1 | Dr. S. P. Gawande | Member | Assistant Professor | spgawande_18@yahoo.com | 9960328951 |
| 2 | Dr. A. P. Munshi | Publicity head | Assistant Professor | aniketmunshi@gmail.com | 9158000491<br>9422157818 |
| 3 | Dr.S. R. Gaigowal | Member | Assistant Professor | sandeep_rg5@rediffmail.com | 9423028761 |

**10. Program Coordinator:**

| SN | Name of the Faculty Member | Post | Designation | e-mail ID | Contact Number |
|---|---|---|---|---|---|
| 1 | Dr.P.M. Meshram | Program coordinator | Associate Professor | praful_1087@rediffmail.com | 9422826696<br>9156004936 |

# Scheme of Examinations
# Honors in Micro Grid Technologies

| SN | Sem | Sub. Code | Subject | T/P | Contact Hours | | | | Credits | % Weightage | | | ESE Duration Hours |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | L | T | P | Hrs | | MSEs* | TA** | ESE | |
| 1 | 5 | ELH131 | Renewable Energy System | **T** | 3 | 0 | 0 | 3 | 3 | 30 | 30 | 40 | 3 |
| 2 | 5 | ELH132 | Distributed Generation and Micro Grid Technologies | **T** | 3 | 0 | 0 | 3 | 3 | 30 | 30 | 40 | 3 |
| 3 | 6 | ELH141 | Micro Grid Planning and Management | **T** | 3 | 0 | 0 | 3 | 3 | 30 | 30 | 40 | 3 |
| 4 | 6 | ELH142 | Advanced Power Electronics | **T** | 3 | 0 | 0 | 3 | 3 | 30 | 30 | 40 | 3 |
| 5 | 6 | ELH143 | Lab: Advanced Power Electronics | **P** | 0 | 0 | 2 | 2 | 1 | | 60 | 40 | |
| 6 | 7 | ELH151 | Power Quality | **T** | 3 | 0 | 0 | 3 | 3 | 30 | 30 | 40 | 3 |
| 7 | 7 | ELH152 | Lab:FACTS and Power Conditioning | **P** | 0 | 0 | 2 | 2 | 1 | | 60 | 40 | |
| 8 | 7 | ELH153 | Lab:Power System Simulation | **P** | 0 | 0 | 2 | 2 | 1 | | 60 | 40 | |
| | | | **TOTAL** | | **15** | **0** | **6** | **21** | **18** | | | | |

**MSEs* = Three MSEs of 15 Marks each will conducted and marks of better 2 of these 3 MSEs will be considered for Continuous Assessment**

**TA ** = for Theory : 20 marks on lecture quizzes, 8 marks on assignments, 2 marks on class performance**

**TA** = for Practical : MSPA will be 15 marks each**

### V Semester

| ELH131 | Renewable Energy System | | | L= 3 | T = 0 | P = 0 | Credits = 3 |
|---|---|---|---|---|---|---|---|
| Evaluation Scheme *Best Two out of three MSE's would be considered | MSE-I* | MSE-II* | MSE-III* | TA | ESE | Total | ESE Duration |
| | 15 | 15 | 15 | 30 | 40 | 100 | 3 Hrs |
| **Prerequisites** | | | | | | | |

**Course Objective:**
This subject introduce the different renewable energy sources to the students. Students get knowledge of Electric Power generation by wind, solar, small hydro, Biomass, Fuel Cell and MHD

**Course Outcome**
Students will be able to

1. Summarize, classify and compare types of renewable energy sources, outline as per Global and Indian context.
2. Utilize solar energy for various applications, estimate solar radiation geometry and classify types of wind turbine generator.
3. Demonstrate, Classify and utilize fuel cell, MHD and biomass energy.
4. Study of grid interfacing of renewable energy sources.

**UNIT I : Introduction to Energy Sources**

World Energy Futures, Conventional Energy Sources, Renewable Energy Sources, Prospects of Renewable Energy Sources. Environmental aspects of Electrical Energy Generation.

**UNIT II : Solar Energy**

Introduction to Solar Radiation and its measurement, Introduction to Solar Energy Collectors and Storage.

Applications of Solar Energy: Solar Thermal Electric Conversion, Thermal Electric Conversion Systems, Solar Electric power Generation Solar Photo- Voltaic, Solar Cell Principle, Semiconductor Junctions, Conversion efficiency and power output, Basic Photo Voltaic System for Power Generation. Solar photovoltaic modules, maximum power point tracking and algorithms, Concentrating solar power, Thermo- PV (TPV)

**UNIT III : Wind Energy**

Introduction to wind energy Conversion, the nature of the wind, Power in the wind.
Wind Energy Conversion: Wind data and energy estimation, Site Selection Considerations, Basic Components of a Wind Energy Conversion System, Classification of WEC Systems, Schemes for Electric Generation using Synchronous Generator and Induction Generator, Wind energy Storage, Off shore wind power generation.

**UNIT IV : Direct Energy Conversion Processes (Overview)**

Information on Magneto Hydro Dynamic Power Generation:
Thermo-Electric Generation: Basic principles of thermo-electric power generation, Seebeck, Peltier, Thomson effects, Thermo-Electric power generator, Analysis, materials.
Thermionic Generation: Thermionic emission and work function, Basic thermionic generation.
Fuel Cells $H_2O_2$Cell, Classification of fuel Cells, Types, Advantages, Electrodes, Polarization.
Thermo Nuclear Fusion Energy: The basic Nuclear Function and Reactions Plasma Confinement, Thermo Nuclear function Reactions.

**UNIT V: Energy from Biomass**

Introduction: Biomass conversion technologies, photosynthesis, Bio-gas generation, types of bio-gas plants.
Biomass as a Source of Energy: Method for obtaining energy from Bio-mass, Biological Conversion of Solar Energy.

**UNIT VI: Applications of Renewable energy**

Wind Farms: Grid interfacing of wind farm, methods of grid connection, grid system and properties. Small hydro power, Hybrid systems: Wind- solar, etc,

**Text Books:**

| | Title | Edition | Author | Publisher |
|---|---|---|---|---|
| **1** | Non-Conventional Sources of Energy | 4th Edition, 2010 | G.D. Rai | Khanna Publishers |
| **2** | Non Conventional Energy Sources | 2nd Edition. 2009 | B. H. Khan | The McGraw Companies Hill |
| | Renewable energy sources and conversion technology | 1990 | N.K. Bansal, M. Kleemann, M. Heliss | Tata McGraw Hill |

| Reference Book: | | | | |
|---|---|---|---|---|
| | **Title** | **Edition** | **Author** | **Publisher** |
| **1** | Direct Energy Conversion | | R. A. Coombie | Pitman |
| **2** | Renewable energy sources and emerging technologies | 1st Edition, 2008 | D. P. Kothari ,K.C.Singal,Rakesh Ranjan | PHI Learning |
| | Related IEEE/IEE Publications | | | |

## V Semester

| ELH132 | Distributed Generation and Micro Grid Technologies | | | L= 3 | T = 0 | P = 0 | Credits = 3 |
|---|---|---|---|---|---|---|---|
| Evaluation Scheme *Best Two out of three MSE's would be considered | MSE-I* | MSE-II* | MSE-III* | TA | ESE | Total | ESE Duration |
| | 15 | 15 | 15 | 30 | 40 | 100 | 3 Hrs |
| **Prerequisites** | | | | | | | |

**Course Objective:**

1. To illustrate the concept of distributed generation
2. To analyze the impact of grid integration.
3. To study concept of Micro Grid and its configuration
4. To find optimal size, placement and control aspects of DGs

**Course Outcome**

Students will be able to

a) Find the type, size and optimal placement DG and storage systems.
b) Analyze the impact of DGs grid integration and its control aspects
c) Describe the operational impacts and performance analysis of DGs connected to integrated power systems
d) Analyze the Micro Grid taking into consideration the operational and control issues of the DGs

**UNIT I : Introduction:**

Introduction, Definition and Benefits of DG**,** Distributed generation (DG) overview and technology trend, Renewable and Non-renewable DG Technologies. Comparison amongst different DG technologies, Brief overview of various Distribution Generations.

**UNIT II : Distribution Generation (DG) and Storage Technologies**

Concept of distributed generations (DG) or distributed energy resources (DERs) topologies, Renewable DG Technologies: PV, Wind, Fuel Cell, micro hydro. Hybrid system. Classification and comparison of Energy Storage Systems (ESS), Battery, Super Capacitor, Flywheel, SMES, etc. Optimal placement of DG sources in distribution systems

**UNIT III : Operational benefits of Grid connected Renewable DG systems :**

Benefits of Renewable DG integration on : Reliability of Distribution System (Methods of improving reliability, reliability indices), Power loss reduction (optimal sizing of DG), Voltage profile improvement, Economic benefits, Emission reduction

UNIT IV : **Technical impacts of DGs on Grid :-**

Grid interconnection issues for grid connected operation of various types of DG systems.

Impact of DGs upon transient and dynamic stability, grid power quality, and protective relaying of existing distribution systems.

**UNIT V: Introduction and Operation Control and Modeling of Micro Grid :-**

Concept and definition of Micro Grid, Types of Micro Grid (AC, DC and Hybrid AC-DC), review of sources of Micro Grid, typical structure and configuration of a microgrid, Autonomous and non-autonomous grids, Sizing of Micro Grid, Micro grid with multiple DGs – Power Electronics interfaces in DC and AC microgrids, communication infrastructure, Micro Grid implementation in Indian and international scenario.

**UNIT VI: Controls & Protection of Micro Grid :-**

Control techniques for voltage, frequency, active and reactive power control of AC Micro Grid system, transients in Micro Grid, Protection of Micro Grid. DC Microgrid: Unipolar and Bipolar LVDC.

**Text Books:**

| | Title | Edition | Author | Publisher |
|---|---|---|---|---|
| **1** | Distributed Power Generation – Planning and Evaluation' | 2000 | H. Lee Willis, Walter G. Scott | Marcel Decker Press |
| **2** | Renewable Energy Systems – Design and Analysis with Induction Generators' | | M.Godoy Simoes, Felix A.Farret | CRC press |
| **3** | Micro Grid: A Conceptual Solution' | June 2004 | Robert Lasseter, Paolo Piagi | PESC 2004 |

**Reference Book:**

| | Title | Edition | Author | Publisher |
|---|---|---|---|---|
| **1** | Transients of a Micro-Grid System with Multiple Distributed Energy Resources' | 2005 | F. Katiraei, M.R. Iravani | International Conference on Power Systems Transients (IPST'05) in Montreal, Canada on June 19-23, 2005 |
| **2** | 'Facility Microgrids' | 2005 | Z. Ye, R. Walling, N. Miller, P. Du, K. Nelson | General Electric Global Research Center, Niskayuna, New York, Subcontract report, May 2005 |
| **3** | 'Microgrids and Active Distribution Networks' | 2009 | S. Chowdhury, S.P. Chowdhury and P. Crossley | The Institution of Engineering and Technology, London, U.K, |

## VI Semester

| ELH141 | Micro Grid Planning and Management | | | L= 3 | T = 0 | P = 0 | Credits = 3 |
|---|---|---|---|---|---|---|---|
| Evaluation Scheme<br>*Best Two out of three MSE's would be considered | MSE-I* | MSE-II* | MSE-III* | TA | ESE | Total | ESE Duration |
| | 15 | 15 | 15 | 30 | 40 | 100 | 3 Hrs |
| **Prerequisites** | | | | | | | |

**Course Objective**

To understand the concept of Micro Grid planning for generation and storage. Students will also understand the operational issues, economics, security assessment and state estimation

**Course Outcome**

Students will be able to

1. To identify and describe the evolvement Micro Grid, its features and different standards applicable for Micro Grid deployment.
2. To select and size the various Micro Grid resources.
3. To select and apply the various pricing policies and financial management of Micro Grid.
4. To identify factors affecting system security and state estimation.

**UNIT I : Introduction**

Introduction to Microgrid planning, planning tools, National and Regional Planning, Electricity Act 2003, Energy Conservation Act 2001, Indian Electricity Rule 2005, Grid code for Conventional grid and Microgrid.

**UNIT II : Microgrid Generation and Storage Planning**

Concept of Generation planning, power generation integration for microgrid, cogeneration/captive power, Power pooling and power trading, optimal storage calculation for microgrid.

**UNIT III : Microgrid Economics**

Power system Economics, Power sector finance, financial planning, private participation Rural Electrification investment, concept of Rational tariffs, Internal Markets and Business Models for Microgrids, External Market and Regulatory Settings for Microgrids.

**UNIT IV : Impact of External Market Prices and Pricing Policies**

Sensitivity analysis, sensitivity for Energy Balancing in response to external market prices, sensitivity of technical benefits in response to external market prices, sensitivity analysis of environmental and economical benefits for external market price variation.

**UNIT V: Microgrid Operation Management**

System operation planning, Performance tools of a Micro Grid: - Load forecasting, state estimation, load flow and real time simulation. Demand response and demand side management. Computerized management, power system simulator. Computer aided planning

**UNIT VI: Microgrid Security and State Estimation**

Operation in Microgrid Security:- Introduction, Factors affecting system security, Contingency analysis, ac power flow security analysis.

State Estimation: - Introduction, Method of least squares, Maximum likelihood weighted least square estimation, State estimation methods for microgrid, Detection and identification of bad measurements, network observability and pseudo-measurements.

Text books:

| | Title | Edition | Author | Publisher |
|---|---|---|---|---|
| 1 | Electrical Power System Planning | | A.S.Pabla | Macmillan India Ltd. |
| 2 | Energy Processing and Smart Grid | First | James A. Momoh | Wiley -IEEE Press |
| 3 | Microgrid : Architecture and Control | First | Edited By : Nikos Hatziargyriou | Wiley – IEEE Press |
| 4 | Electrical Power Systems – Analysis, Security and Deregulation | Third Printing | P.Venkatesh, B. V. Manikandan, S. Charles Raja, A. Srinivasan | PHI Learning Pvt. Ltd. |

## VI Semester

| ELH142 | Advanced Power Electronics | | | L= 3 | T = 0 | P = 0 | Credits = 3 |
|---|---|---|---|---|---|---|---|
| Evaluation Scheme | MSE-I* | MSE-II* | MSE-III* | TA | ESE | Total | ESE Duration |
| *Best Two out of three MSE's would be considered | 15 | 15 | 15 | 30 | 40 | 100 | 3 Hrs |
| **Prerequisites** | | | | | | | |

**Course Objective:**

1. To impart the knowledge of recent and advanced developments in the PE field.
2. To ensure the students having an in-depth understanding of the design and control of various converters.

**Course Outcome**

Students will be able to

1) Describe the working operation of conventional and advanced semiconductor devices
2) Demonstrate the skill of analyzing and design of controlled rectifiers.
3) Analyze and design of different types of converters.

UNIT I : **Semiconductor Power Devices**

Conventional semiconductor power devices:-Thyristor, Gate Turn Off thyristor(GTO),Metal Oxide Field Effect Transitor(MOSFET),Insulted Gate Bipolar Transistor(IGBT). Advanced semiconductor devices: MOS Turn Of Thyristor(MTO), Emitter Turn of Thyristor(ETO), Integrated Gate Commuted Thyristor(IGCT), MOS Controlled Thyristor(MCT), Static Induction Thyristor(SITH) - symbol, structure and equivalent circuit- comparison of their features. Significance of wide band gap materials (especially SiC and GaN).Introduction to SiC devices

UNIT II : **AC/DC Controlled Rectifier**

Single phase half controlled and full controlled converters continuous and discontinuous mode, Three phase controlled rectifier continuous mode, Single phase series converter, single and three phase dual converters, Effect of source inductance, Evaluation of input power factor and harmonic factor.

UNIT III : **Non isolated DC/DC Converters**

Principle of operation and analysis of buck, boost, buck-boost, Cuk and Single Ended Primary Inductance Converter (SEPIC) regulators in discontinuous and Continuous (DCM/CCM) mode, Input and output filter design.

**UNIT IV : Isolated DC/DC converters**

Introduction, transformer models, principle of operation and analysis of Flyback, Forward, double ended (Two Switch) forward, Push-Pull, half- bridge and full Bridge converters. Continuous and discontinuous mode operation and design consideration.

UNIT V: **Multilevel Inverters**

Single phase half and full bridge Voltage source Inverter(VSI),Three Phase Inverter, Evaluation of performance parameters. Multilevel inverter topologies- Neutral Point clamped (NPC), Flying capacitor (FC), Symmetrical and asymmetrical Cascaded Inverters etc., Other advanced inverters such as Multi-pulse, matrix inverter, Modulation techniques: Pulse Width Modulation (PWM), SHE, SHE PWM, Hysteresis, Space Vector modulation techniques for above inverters, Introduction to Current Source Inverter (CSI)

UNIT VI: **Soft switching Converters**

Resonant Converters- Classification of resonant converters, Basic resonant circuit concepts, Series parallel resonant converters, Zero voltage switching (ZVS) and Zero Current (ZCS) switching converters, steady state and dynamic analysis, modeling and control

**Text books:**

| | Title | Edition | Author | Publisher |
|---|---|---|---|---|
| 1 | Power Electronics Circuits Devices application | 2004 | M.H. Rashid | PHI third edition First Indian edition |
| 2 | Power Electronics: Converters, Application and Design | 1996 | Ned Mohan, Undeland and Robbin | John Wiley & Sons Third edition |
| 3 | High power converter and ac drives | 2006 | Bin Wu | Wiley-IEEE Press |

**Reference books:**

| | Title | Edition | Author | Publisher |
|---|---|---|---|---|
| 1 | Pulse width modulated DC-DC power converters | 1993 | Marian K Kazimierczuk | John Willey & Sons |
| 2 | Power electronics-principles and applications | 1995 | Joseph Vithayathil | McGraw hill Inc, New York |
| 3 | EEE/IET publications | | Various authors | On Internet site www.ieeexplore.ieee.org |

## VI Semester

| ELH143 | Lab : Advanced Power Electronics | | | L= 0 | | T = 0 | P = 2 | Credits = 1 |
|---|---|---|---|---|---|---|---|---|
| Evaluation Scheme | MSPA 1 | MSPA 2 | MSPA 3 | MSPA 4 | TA* | ESE | Total | ESE Duration |
| | -- | -- | -- | -- | 60 | 40 | 100 | 3 Hrs |
| **Prerequisites** | Power Electronics | | | | | | | |

| **Course Objective** | **Course Outcome** |
|---|---|
| 1. To impart the knowledge of recent and advanced developments in the PE field.<br>2.To ensure the students having an in-depth understanding of the design and control of various converter | Students will be able to<br>1. Describe the working operation of conventional and advanced semiconductor devices<br>2 Demonstrate the skill of analyzing and design of controlled rectifiers.<br>3. Analyze and design of various types of converters. |

The list of practicals will be according to the syllabi of Advanced power Electronics

## VII Semester

| ELH151 | Power Quality | | | L= 3 | T = 0 | P = 0 | Credits = 3 |
|---|---|---|---|---|---|---|---|
| Evaluation Scheme *Best Two out of three MSE's would be considered | MSE-I* | MSE-II* | MSE-III* | TA | ESE | Total | ESE Duration |
| | 15 | 15 | 15 | 30 | 40 | 100 | 3 Hrs |
| **Prerequisites** | Power System and Power Electronics | | | | | | |

**Course Objective:**

Understand the different power quality problems, its causes, effects and various mitigating custom power devices. Further the subject is concentrated to analyze the different control strategies and algorithm.

**Course Outcome**

Students will be able to

1. Define and discuss the various power quality problem, their causes and effects in distribution system
2. Identify and analyze the different voltage and current based power quality problems
3. Explain the various non-linear load, effects of harmonics on power system and apply conventional mitigation methods.
4. Describe and apply the various power quality conditioners, and their reference generation algorithms

**UNIT I : Introduction**

Introduction – Characterization of Electric Power Quality: Transients, short duration and long duration voltage variations, Voltage imbalance, waveform distortion, Voltage fluctuations, Power frequency variation, Power acceptability curves – power quality problems: poor load power factor, Non linear and unbalanced loads, DC offset in loads, Notching in load voltage, Disturbance in supply voltage – Power quality standards.

**UNIT II : Non Linear Loads**

Single phase / Three phase static converters, Battery chargers, Arc furnaces, Fluorescent lighting, pulse modulated devices, Adjustable speed drives.

**UNIT III : Measurement and Analysis Method**

Voltage, Current, Power and Energy measurements, power factor measurements and definitions, event recorders, Measurement Error – Analysis: Analysis in the periodic steady state, Time domain methods, Frequency domain methods: Laplace's, Fourier and Hartley transform
– The Walsh Transform – Wavelet Transform.

UNIT IV : **Analysis and Conventional Mitigation Methods**

Analysis of power outages, Analysis of unbalance: Symmetrical components of phasor quantities, Instantaneous symmetrical components, Instantaneous real and reactive powers, Analysis of distortion: On–line extraction of fundamental sequence components from measured samples – Harmonic indices.

**UNIT V: Voltage Sag**

Analysis of voltage sag: Detorit Edison sag score, Voltage sag energy, Voltage Sag Lost Energy Index (VSLEI)- Analysis of voltage flicker, Reduced duration and customer impact of outages, Classical load balancing problem: Open loop balancing, Closed loop balancing, current balancing, Harmonic reduction, Voltage sag reduction

**UNIT VI: Power Quality Improvement**

Utility-Customer interface –Harmonic filters: passive,–Custom power devices: Network reconfiguring Devices, Load compensation using

DSTATCOM, Voltage regulation using DSTATCOM, protecting sensitive loads using DVR, UPQC – control strategies: P-Q theory, Synchronous detection method – Custom power park – Status of application of custom power devices.

**Text Books:**

| | Title | Edition | Author | Publisher |
|---|---|---|---|---|
| **1** | Power Quality Enhancement Using Custom Power Devices | 2002 | Arindam Ghosh | Kluwer Academic Publishers |
| **2** | Electric Power Quality | 1994(2nd edition) | G.T.Heydt | Stars in a Circle Publications |
| | Electrical Power Systems Quality | 3rd edition | R.C. Duggan | McGraw Hill |

**Reference Book:**

| | Title | Edition | Author | Publisher |
|---|---|---|---|---|
| **1** | Power System Harmonics | 2003 | A.J. Arrillga | John Wiley and Sons |
| **2** | Power Electronic Converter Harmonics | 1999 | Derek A. Paice | Wiley IEEE Press |

## VII Semester

| ELH152 | Lab: FACTS and Power Conditioning | | | | L= 0 | T = 0 | P = 2 | Credits = 1 |
|---|---|---|---|---|---|---|---|---|
| Evaluation Scheme | MSPA 1 | MSPA 2 | MSPA 3 | MSPA 4 | TA* | ESE | Total | ESE Duration |
| | 15 | 15 | 15 | 15 | 60 | 40 | 100 | 3 Hrs |
| **Prerequisites** | Power System and Power Electronics | | | | | | | |

**Course Objective:**

To understand the problems and constraints related with stability of large interconnected systems and to study their solutions using different FACTS Controllers,Shunt SVC,STATCOM),Series (TCSC,GCSC,SSSC),Series Shunt(UPFC),Series Series(IPFC)

**Course Outcome**

Students will be able to

1) Study various FACTS Controllers, its classification and explain its applications in Transmission system.
2) Implement and design different shunt and series compensators
3) Extend, apply and analyze the FACTS concept using combine series-shunt and series-series controllers to evaluate the improved transmission system performance

| Sr N | Name of Experiment |
|---|---|
| 1. | To Study Modeling and Performance of Medium Transmission Line |
| 2. | To study complete analysis and performance of transmission line for symmetrical fault usin Power System Toolbox |
| 3. | To Study the performance of Thyristor Controlled Rectifier (TCR) for varying firing angle |
| 4. | To Study the performance of Fixed Capacitor-Thyristor Controlled Rectifier (FC-TCR) on transmission system |
| 5. | To Study Inductive and Capacitive Modes of Thyristor Controlled Series Capacitor (TCSC) Using MATLAB |
| 6. | To Study Voltage Source Converter Based Static Synchronous Series Compensator (SSSC) and its operating modes |
| 7. | To Study Various Power Quality Problems in Radial Distribution System |
| 8. | To Study Current Harmonics drawn by Power Electronics Interface |
| 9. | To Study Passive Power Filters Using MATLAB Simulink |
| 10. | To Study the Network Configuring Devices (Static Current Limiter-SSCL) |
| 11. | To Study, Modelling and Simulation of Reference Generation Algorithm (SRF/ISCT) for Series and shunt Compensation (DVR and DSTATCOM) |
| 12. | To Study Distribution Static compensator (DSTATCOM) |
| | |

## VII Semester

| ELH153 | Lab.: Power System Simulation | | | | L= 0 | T = 0 | P = 2 | Credits = 1 |
|---|---|---|---|---|---|---|---|---|
| Evaluation Scheme | MSPA 1 | MSPA 2 | MSPA 3 | MSPA 4 | TA* | ESE | Total | ESE Duration |
| | -- | -- | -- | -- | 60 | 40 | 100 | 3 Hrs |
| **Prerequisites** | Power System and Power Electronics | | | | | | | |

**Course Objective:**

1) To provide better understanding of power system analysis through digital simulation.
2) To present a problem oriented knowledge of power system analysis methods.
3) To identify & formulate solutions to problems relevant to power system using MATLAB

**Course Outcome**

Students will be able to

1) Solve and design the power system problems.
2) Explain, compare various pulse width modulations and apply to different converter topologies
3) Use and evaluate the load balancing for compensation.
4) Design and analyse the renewable energy sources.
5) Design the various controls and its application in power system.
6) Apply and infer the performance of compensators in power system.

**List of Practicals**

1. To study and implement the different multilevel inverters
2. Analysis and implementation of sinusoidal PWM for multilevel inverters
3. To study and simulate PV array with varying temperature and insolation level
4. To study and execute the different modes of operation of SSSC
5. To study and implement TCR for a transmission line
6. To study and simulate vector controlled Im drive using 5 level diode clamped multilevel inverter
7. To study and implement Distribution Static Compensator
8. To study and simulate the open loop balancing algorithm for load balancing

*In Laboratory courses, TA=MSPA 1+MSPA 2+MSPA 3+MSPA 4=60 MARKS