| COURSE CODE | COURSE NAME | L-T-P-CREDITS | YEAR OF INTRODUCTION |
|---|---|---|---|
| EE403 | DISTRIBUTED GENERATION AND SMART GRIDS | 3-0-0-3 | 2016 |

**Prerequisite: Nil**

**Course objective**.

- To develop a conceptual introduction to various distributed generation systems, micro grids, smart grids and their control

**Syllabus:**

Introduction to distributed generation and smart grids - Distributed Energy Resources – Micro Grids and their control – Protection issues for Microgrids - Smart Grids: Components – NIST Reference architecture – Smart meters - Wide Area Measurement System (WAMS), Phase Measurement Unit (PMU) - demand response- Demand Side Management - Smart Substations, HAN, NAN, SANET, Cloud computing in smart grid – Power Quality issues with smart grid

**Expected Outcome:**

The students will be able to:

i. Explain various distributed generation systems
ii. Understand the microgrids and their control schemes
iii. Understand various developments happening in the field of Smart Grids.

**TEXT BOOKS/REFERENCES:**


1. Ali Keyhani, Design of Smart Power Grid Renewable Energy Systems, ISBN: 978-0-470-62761-7, Wiley
2. James Momoh, Smart Grid: Fundamentals of Design and Analysis, ISBN: 978-0-470-88939-8, Wiley
3. R. C. Durgan, M. F. Me Granaghen, H. W. Beaty, “Electrical Power System Quality”, McGraw-Hill
4. Remus Teodorescu, Marco Liserre, Pedro Rodriguez, Grid Converters for Photovoltaic and Wind Power Systems, ISBN: 978-0-470-05751-3, Wiley
5. S. Chowdhury, S.P. Chowdhury and P. Crossley, Microgrids and Active Distribution Networks, ISBN 978-1-84919-014-5, IET, 2009


**COURSE PLAN**

| Module | Contents | Hours | End. Sem. Exam. Marks |
|---|---|---|---|
| I | Distributed generation – Introduction - Integration of distributed generation to Grid – Concepts of Micro Grid - Typical Microgrid configurations - AC and DC micro grids - Interconnection of Microgrids - Technical and economical advantages of Microgrid - | 7 | 15% |

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| | Challenges and disadvantages of Microgrid development<br>Smart Grid: Evolution of Electric Grid - Definitions and Need for Smart Grid, Opportunities, challenges and benefits of Smart Grids | | |
| **II** | Distributed energy resources: Introduction - Combined heat and power (CHP) systems - Solar photovoltaic (PV) systems – Wind energy conversion systems (WECS) - Small-scale hydroelectric power generation - Storage devices: Batteries: Lead acid, nickel metal hydrate, and lithium ion batteries , ultra-capacitors, flywheels<br>Control of Microgrids: Introduction to Central Controller (CC) and Microsource Controllers (MCs) - Control functions for microsource controller, Active and reactive power control, Voltage control, Storage requirement for fast load tracking, Load sharing through power-frequency control | 6 | 15% |
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| **III** | Protection issues for Microgrids: Introduction, Islanding, Different islanding scenarios, Major protection issues of stand-alone Microgrid - Impact of DG integration on electricity market, environment, distribution system, communication standards and protocols.<br>Smart Grid: Components – NIST Smart Grid Reference Architecture<br>Introduction to Smart Meters, Electricity tariff – one part tariff, two tariff and maximum demand tariff - Dynamic pricing: time-of-use (TOU) pricing, critical-peak pricing (CPP) and Real Time Pricing- Automatic Meter Reading(AMR), Plug in Hybrid Electric Vehicles(PHEV), Vehicle to Grid, Smart Sensors, Home & Building Automation.<br>Intelligent Electronic Devices (IED) and their application for monitoring & protection, Wide Area Measurement System (WAMS), Phase Measurement Unit (PMU). | 7 | 15% |
| **IV** | Smart energy efficient end use devices-Smart distributed energy resources- Load Curves-Load Shaping Objectives-Methodologies - Peak load shaving - Energy management-Role of technology in demand response- Demand Side Management – Numerical Problems | 7 | 15% |
| **V** | Advanced Metering Infrastructure (AMI), Home Area Network (HAN), Neighborhood-Area Networks (NANs), Sensor and Actuator Networks (SANETs)<br>Smart Substations, Substation Automation, IEC 61850 Substation Architecture, Feeder Automation. | 7 | 20% |

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| **VI** | Cloud computing in smart grid: Private, public and Hybrid cloud. Cloud architecture of smart grid.<br>Power quality: Introduction - Types of power quality disturbances - Voltage sag (or dip), transients, short duration voltage variation, Long duration voltage variation, voltage imbalance, waveform distortion, and voltage flicker - Harmonic sources: SMPS, Three phase power converters, arcing devices, saturable devices, fluorescent lamps, harmonic indices (THD, TIF, DIN, C – message weights)<br>Power quality aspects with smart grids. | 8 | 20% |

**QUESTION PAPER PATTERN:**

Maximum Marks: 100 Exam Duration: 3Hourrs.

**Part A**: 8 compulsory questions.

One question from each module of Modules I - IV; and two each from Module V & VI.

Student has to answer all questions. (8 x5)=40

**Part B**: 3 questions uniformly covering Modules I & II. Student has to answer any 2 from the 3 questions: (2 x 10) =20. Each question can have maximum of 4 sub questions (a,b,c,d), if needed.

**Part C**: 3 questions uniformly covering Modules III & IV. Student has to answer any 2 from the 3 questions: (2 x 10) =20. Each question can have maximum of 4 sub questions (a,b,c,d), if needed.

**Part D**: 3 questions uniformly covering Modules V & VI. Student has to answer any 2 from the 3 questions: (2 x 10) =20. Each question can have maximum of 4 sub questions (a,b,c,d), if needed.