SEMESTER S8

SMART GRID TECHNOLOGIES

Course Code	PEEET861	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	None	Course Type	PE - Theory

Course Objectives:

1. To introduce various advancements in the area of smart grid.

2. To introduce distributed energy resources and micro-grid.

3. To introduce cloud computing, cyber security and power quality issues in smart grids.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction to Smart Grid:** Evolution of electric grid, Definitions, Need for smart grid, Smart grid drivers, Functions of smart grid, Opportunities and barriers of smart grid, Difference between conventional grid and smart grid, Concept of resilient and self- healing grid. Components and architecture, Inter-operability, Impacts of smart grid on system reliability, Present development and international policies in smart grid, Smart grid standards. **Information and Communication Technology in Smart Grid:** Wired and wireless communication -radio mesh, ZIGBEE, 3G, 4G and 5G. Digital PLC, DSL, Wi-Max, LAN, NAN, HAN, Wi-Fi, Bluetooth, Bluetooth Low Energy (BLE), Li-Fi. Communication Protocols in Smart grid, Introduction to IEC 61850 standard and benefits, IEC Generic Object-Oriented Substation Event - GOOSE, Substation model.	9
2	**Smart grid Technologies Part I:** Introduction to smart meters, Electricity tariff, Real Time Pricing- Automatic Meter Reading (AMR) - System, Services and Functions, Components of AMR Systems, Advanced Metering Infrastructure (AMI). Plug in Hybrid Electric Vehicles (PHEV), Vehicle to Grid (V2G), Grid to Vehicle (G2V), Smart Sensors, Smart energy efficient end use devices, Home & Building Automation. Intelligent Electronic	9

	Devices (IED) and their application for monitoring & protection: Digital Fault Recorder (DFR), Digital Protective Relay (DPR), Circuit Breaker Monitor (CBM), Phasor Measurement Unit (PMU), Standards for PMU. Time synchronization techniques, Wide Area Monitoring System (WAMS), control and protection systems (Architecture, components of WAMS, and applications: Voltage stability assessment, frequency stability assessment, power oscillation assessment, communication needs of WAMS, remedial action scheme).	
3	**Smart grid Technologies Part II:** Smart substations, Substation automation, Feeder automation, Fault detection, Isolation, and Service Restoration (FDISR), Geographic Information System (GIS), Outage Management System (OMS). Introduction to Smart distributed energy resources and their grid integration, Smart inverters, Concepts of microgrid, Need and application of microgrid – Energy Management- Role of technology in demand response- Demand side management, Demand side Ancillary Services, Dynamic line rating.	9
4	**Cloud computing in smart grid:** Private, Public and hybrid cloud. Types of cloud computing services- Software as a Service (SaaS), Platform as a service (PaaS), Infrastructure as a service (IaaS), Data as a service (DaaS), Cloud architecture for smart grid. **Cyber Security** - Cyber security challenges and solutions in smart grid, Cyber security risk assessment, Security index computation. **Power Quality Management in Smart Grid**- Fundamentals, Power Quality (PQ) & Electromagnetic Compatibility (EMC) in smart grid, Power quality conditioners for smart grid. Case study of smart grid.	9

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Explain the basic concept of distributed energy resources, micro-grid and smart grid	**K2**
CO2	Choose appropriate Information and Communication Technology (ICT) in smart grid	**K2**
CO3	Select infrastructure and technologies for consumer domain of smart grid	**K2**
CO4	Select infrastructure and technologies for smart substation and distribution automation	**K2**
CO5	Formulate cloud computing infrastructure for smart grid considering cyber security	**K3**
CO6	Categorize power quality issues and appraise it in smart grid context	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2										
CO2	3	3	3	3	2							
CO3	3	3	3	3	2							
CO4	3	3	3	3								
CO5	3	3	3	3	3							
CO6	3	3	3	3	3							

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Smart Grid Infrastructure Technology and Solutions	Stuart Borlase	CRC Press	2nd edition
2	Smart Grid: Fundamentals of Design and Analysis	James Momoh	Wiley	2012
3	Microgrids and Active Distribution Networks	S. Chowdhury	Institution of Engineering and Technology	2009
4	Smart Grids Technology and Applications	Janaka Ekanayake, Kythira Liyanage, Jianzhong Wu, Akihiko Yokohama, Nick Jenkins-	Wiley	2012
5	Smart Grids Technology and Applications	Janaka Ekanayake, Kythira Liyanage, Jianzhong Wu, Akihiko Yokohama, Nick Jenkins	Wiley	2012
6	Cybersecurity for the Electric Smart Grid: Elements and Considerations	Barker, Preston, Price, Rudy F	Nova Science Publishers Inc	2012