

# GUJARAT TECHNOLOGICAL UNIVERSITY

## ELECTRICAL ENGINEERING (07) SMART GRID TECHNOLOGY AND APPLICATIONS SUBJECT CODE: 2740703 M.E. 4<sup>TH</sup> SEMESTER

**Type of course:** Regular

**Prerequisite:** Concepts of basics of electrical engineering, power system and of renewable energy generating sources.

**Rationale:** NA.

**Teaching and Examination Scheme:**

Teaching Scheme			Credits C	Examination Marks						Total Marks
L	T	P		Theory Marks		Practical Marks				
			ESE (E)	PA (M)	ESE (V)		PA (I)			
ESE	OEP	PA			RP					
3	2#	0	4	70	30	30	0	10	10	150

**Content:**

Sr. No.	Content	Total Hrs	% Weightage
1	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, What is a Smart Grid?, The Smart Grid Enables the ElectriNetSM, Local Energy Networks, Electric Transportation, Low-Carbon Central Generation, What Should Be the Attributes of the Smart Grid?, Why Do We Need a Smart Grid?, Is the Smart Grid a “Green Grid”?, Smart Grid Initiative for Power Distribution Utility in India (Term paper).	10	15%
2	Sensing, Measurement, Control and Automation Technologies: Smart metering and demand-side integration, Introduction, Smart metering, Evolution of electricity metering, Key components of smart metering, Smart meters: An overview of the hardware used Signal acquisition, Signal conditioning, Analogue to digital conversion, Computation, Input/output, Communication, Communications infrastructure and protocols for smart metering, Home-area network, Neighbourhood area network, Data concentrator, Meter data management system, Protocols for communications, Demand-side integration, Services provided by DSI, Implementations of DSI, Hardware support to DSI implementations, Flexibility delivered by prosumers from the demand side, System support from DSI.  Smart Appliances, Automatic Meter Reading (AMR), Outage	20	40%

	<p>Management System(OMS), Plug in Hybrid Electric Vehicles(PHEV), Vehicle to Grid, Grid to Vehicle, Coordination of PHEV charging and discharging cycle, Smart Sensors, Home &amp; Building Automation, Phase Shifting Transformers.</p> <p>Smart Substations: Substation Automation equipment, Current transformers.</p> <p>Voltage transformers, Intelligent electronic devices, Bay controller, Remote terminal units, Faults in the distribution system, Components for fault isolation and restoration, Fault location, isolation and restoration, Voltage regulation.</p> <p>Feeder Automation, Geographic Information System(GIS), Intelligent Electronic Devices(IED) &amp; their application for monitoring &amp; protection, Smart storage like Battery, Pumped Hydro, SMES, Compressed Air Energy Storage, fuel cells, super capacitors and its case studies.</p> <p>Transmission System Operation: Wide Area Measurement System (WAMS), Phase Measurement Unit (PMU), WAMPAC.</p>		
3	<p>Micro Grids And Distributed Energy Resources: Concept of micro grid, need &amp; applications of micro grid, formation of micro grid, issues of interconnection, protection &amp; control of micro grid. Islanding, need and benefits, different methods of islanding detection.</p> <p>Distributed Energy Resources: Small scale distributed generation, Distributed Generation Technology, Internal Combustion Engines, Gas Turbines, Combined Cycle Gas Turbines, Micro turbines, Fuel Cells, Solar Photovoltaic, Solar thermal, Wind power, Geothermal, - all sources as a DG. Advantages and disadvantages of DG.</p>	10	20%
4	<p>Power Quality Management In Smart Grid: Power Quality &amp; 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.</p> <p>Information And Communication Technology For Smart Grid: Advanced Metering Infrastructure (AMI), Home Area Network (HAN), Neighborhood Area Network (NAN), Wide Area Network (WAN). Bluetooth, Zig-Bee, GPS, Wi-Fi, Wi-Max based communication, Wireless Mesh Network, Broadband over Power line (BPL).</p>	10	20%
5	<p>Smart Grid – The New and Improved Power Grid: A Survey By: Xi Fang, IEEE COMMUNICATIONS SURVEYS &amp; TUTORIALS, VOL. 14, NO. 4, FOURTH QUARTER 2012.</p>	2	5%

#### Reference Books:

1. Ali K., M.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.
3. JanakaEkanayake, N. Jenkins, K. Liyanage, J. Wu, Akihiko Yokoyama, "Smart Grid: Technology and Applications", Wiley.
4. Jean Claude Sabonnadiere, NouredineHadjsaid, "Smart Grids", Wiley Blackwell.
5. Tony Flick and Justin Morehouse, "Securing the Smart Grid", Elsevier Inc.

6. Peter S. Fox-Penner, "Smart Power: Climate Change, the Smart Grid, and the Future of Electric Utilities", Island Press.
7. SMART GRID Fundamentals of Design and Analysis, James Momoh, IEEE press, A John Wiley & Sons, Inc., Publication.
8. Bhavesh Bhalja, R. P. Maheshwari and N. G. Chothani, "Protection and Switchgear, Oxford University Press, New Delhi, India, 2nd Edition, 2015.
9. Smart Grid: Technology and Applications by Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama wiley India

**Course Outcome:**

After learning the course the students should be able to:

- Know what a function of smart grid is, what is the futuristic grid.
- Issues while implementing the smart grid approach.
- Concept of Microgrid and distributed generation.
- Need of communication technology in smart grid.

**List of Tutorials:**

1. Prepare a detailed presentation on smart grid initiatives taken in India.
2. Prepare presentation on smart sensors used in building automation. Also discuss its merits with respect to energy conservation.
3. Prepare a draft/presentation on working of PMU (phasor measurement unit).
4. Prepare a presentation on benefits and application of WAMS.
5. Prepare a presentation on demand side integration and management.
6. Prepare a presentation on how the coordination of PHEV is performed with the grid.
7. Prepare a draft of IEEE standards for Grid integrations.
8. Prepare a different types of distributed energy resources with its relative merits and demerits.
9. Discuss effect of interconnection of various DERs in the power system network either by preparing draft or presentation.
10. Prepare a simulation of islanding in MATLAB or any other software.
11. Prepare presentation on IEEE-519, 1992 standards for power quality.
12. Prepare a step wise draft on how the power quality audit is carried out.

**Review Presentation (RP):** The concerned faculty member shall provide the list of peer reviewed Journals and Tier-I and Tier-II Conferences relating to the subject (or relating to the area of thesis for seminar) to the students in the beginning of the semester. The same list will be uploaded on GTU website during the first two weeks of the start of the semester. Every student or a group of students shall critically study 2 papers, integrate the details and make presentation in the last two weeks of the semester. The GTU marks entry portal will allow entry of marks only after uploading of the best 3 presentations. A unique id number will be generated only after uploading the presentations. Thereafter the entry of marks will be allowed. The best 3 presentations of each college will be uploaded on GTU website.