# GUJARAT TECHNOLOGICAL UNIVERSITY

**Minor Degree: Solar Energy Systems**
**Subject Code : N117AJ01**
**Semester – 7 (w.e.f. AY 2026-27)**
**Subject Name : Solar System Integration Challenges**

**Prerequisite : Basic Electrical Engineering, Basic Electronics**

**Rationale :** Integration of more and more renewable energy sources with the electrical grid may lead to various issue related to voltage and power in the electrical grid. This course will be helpful to understand problems and its solutions with the case studies. Also this course will also help to explore more on advancement in the grid-tied inverter topologies in order to address the issue with the solar grid integrations after attending this course.

**Teaching and Examination Scheme :**

| Teaching Scheme | | | Credits | Examination Marks | | | | Total Marks |
|---|---|---|---|---|---|---|---|---|
| | | | | Theory Marks | | Practical Marks | | |
| L | T | P | C | ESE (E) | PA (M) | ESE (V) | PA (I) | |
| 2 | 0 | 2 | 3 | 70 | 0 | 30 | 0 | 100 |

**Content :**

| Unit No | Course Content | No. of Hours |
|---|---|---|
| **1** | Discuss grid integration challenges: Intermittency and Variability, Grid Stability and Power Quality, Grid Management and Flexibility, Policy and Regulatory Frameworks, Grid Infrastructure and Capacity. | 03 |
| **2** | Power quality issues with grid Integration of solar photovoltaic systems, IEEE-1547 standards for the grid integration. | 04 |
| **3** | Challenges of solar grid integration and case study: Steady State Overvoltage, Voltage Fluctuations due to Intermittency in Generation, Interaction with Distribution Equipment – Voltage Regulators, Tap Changers, and Capacitor Banks. | 07 |
| **4** | Challenges of solar grid integration and case study: Reverse Power Flow, Voltage Unbalance, Temporary Overvoltage (TOV), Protection and Control Issues. | 08 |
| **5** | Voltage profile fluctuation with solar integration on weak electrical network, voltage profile fluctuation with the strong electrical network, series resonance and parallel resonance in the electrical grid. | 04 |
| | Total Hrs. | **26** |

**Suggested Specification table (Theory) :**

| Distribution of Theory Marks (%) | | | | | |
|---|---|---|---|---|---|
| **R Level** | **U Level** | **A Level** | **N Level** | **E Level** | **C Level** |
| 40 | 30 | 20 | 10 | - | - |

**Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)**

**Reference Books :**

1. Rajiv K. Varma, *"Smart Solar PV Inverters with Advanced Grid Support Functionalities"*, Wiley - IEEE Press, USA, Dec. 2021, 512 pages, ISBN: 978-1-119-21418-2.
2. Deutsche Gesellschaft für Sonnenenergie (DGS). *Planning and installing photovoltaic systems: a guide for installers, architects and engineers*. Routledge, 2013.
3. Burdick, Joseph, and Philip Schmidt. *Install your own solar panels: designing and installing a photovoltaic system to power your home*. Storey Publishing, 2017.

**Course Outcomes :** Upon completion of this course students should be able to :

| Sr. No. | Course Outcomes | % weightage |
|---|---|---|
| 01 | Understand the key challenges with solar integration with grid. | 40 |
| 02 | Analyze different challenges of solar integration with case study. | 40 |
| 03 | Evaluate the voltage profile fluctuation on grid. | 20 |

**Suggested List of Experiments :**

(1) To study impact of change in radiation and temperature on the PV Modules PV Characteristic.
(2) To study various phase locked loop algorithm in the presence of distorted grid.
(3) To do total harmonic distortion analysis of square wave voltage waveform.
(4) Analyze impact of switching frequency on power quality of inverter.
(5) To analyses impact of X/R ratio on voltage fluctuation with the solar PV power injections.
(6) To study impact of grid integration on conventional protection systems.
(7) To study series and parallel resonance in the grid.
(8) To study causes of life cycle reduction of the OLTC transformer due to grid integrations.

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