NIRMA UNIVERSITY

Institute:	**Institute of Technology**
Name of Programme:	**BTech in Electrical Engineering**
Semester:	**VI**
Course Code:	**3EE212DE24**
Course Title:	**Modelling and Control of Grid-connected Renewable Sources**
Course Type:	**Disciplinary Minor (Elective I)**
Year of Introduction:	**2024 – 25**

L	T	Practical component				C
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Course Learning Outcomes (CLOs):

At the end of the course, the students will be able to –

1. acquire knowledge of grid operation with penetration of renewable energy sources **(BL3)**
2. perform modelling of electrical resources **(BL3)**
3. design control of grid connected wind generators and solar photovoltaic systems **(BL6)**
4. identify challenges and issues of grid integration with RES **(BL4)**

Contents: **Teaching Hours: 45**

Unit I **Grid integration of Renewable Energy Sources** **05**

Introduction to grid operation with penetration of renewable energy sources, reliability of electricity supply, impact of distributed generation on the Power system, voltage quality and design of distributed Generation

Unit II **Grid Stability with Renewable energies** **10**

System inertia and primary frequency support, assessing and enhancing system strength, distribution system and hosting capacity, forced oscillation detection and countermeasures, large-scale deployments of battery energy storage and integration of EV charging station, storage impact on LV and HV grid, effective and efficient management of grid storage

Unit II **Modelling and Control of Grid Connected Wind Generators** **15**

Introduction to a wind energy generation system, introduction, basic concepts of a fixed speed wind turbine (FSWTs), basic wind turbine description, power control of wind turbines, wind turbine aerodynamics, commercial wind turbine, variable speed wind turbines (VSWTs), Modelling of variable speed wind turbine, control of a variable speed wind turbine, electrical system of a variable speed wind turbine, wind energy generation system based on DFIM, VSWT, electrical configuration of a VSWT based on the DFIM, electrical configuration of a wind farm, WEGS control structure, grid code requirements, frequency and voltage operating range, reactive power and voltage control capability, power control, power system stabilizer function, low voltage ride through (LVRT), voltage dips and LVRT, electric power system, voltage dips, VSWT based on DFIM manufacturers modelling of small scale wind turbine

Unit III **Modelling and Control of Grid-connected Solar Photovoltaic Systems** **15**

Solar cell (PV), operating principle, types of solar cell, Photovoltaic array (PVA) power system and design of boost converter, grid connected SPV system, system configuration , equivalent circuit of solar cell and equations: double diode

model, single diode model, approximate model, simplified model, maximum power point tracking (MPPT) techniques, selection of dc link capacitor voltage, design and selection of dc link capacitor, design of ac inductors, control algorithm, control of VSC, control of UPF operation, control of ZVR operation, Grid Integration Challenges and Solution Strategies for Solar PV Systems: Output power prediction, voltage stability, frequency response, reactive power support, impact of harmonics/power quality, angular stability, Fault/low voltage ride-through capability, protection challenges, transmission, communication, and security challenges, electricity market challenges, environmental and socio-economic challenges, solutions for grid integration problems: grid codes, advanced control strategies, energy storage systems, renewable energy policies

Self-Study Component:
The self-study contents will be declared at the commencement of semester. Around 10% of the questions will be asked from self-study contents.

Tutorial:
There shall be 6 tutorials based on above syllabus.

Suggested Readings:

1. Farhangi, Hassan, Joós, Géza, Microgrid planning and design-a concise guide, IEEE press Wiley publication
2. G.B. Gharehpetian and S. Mohammad Mousavi Agah, Distributed Generation Systems. Design, Operation and Grid Integration, Butterworth-Heinemann
3. Gonzalo Abad, Jesu´s Lo´pez, Miguel A. Rodrı´guez, Luis Marroyo, Grzegorz Iwanski, Doubly Fed Induction Machine Modeling and Control for Wind Energy Generation, IEEE -Wiley
4. Kulkarni, Anil M., Padiyar, K. R - Dynamics and control of electric transmission and microgrids, John Wiley & Sons
5. Lingling Fan, Control and Dynamics in Power Systems and Microgrids (CRC Press)
6. Lingling Fan, Zhixin Miao - Modeling and Analysis of Doubly Fed Induction Generator Wind Energy Systems, Academic Press
7. Math Bollen, Fainan Hassan, Mohamed E. El Hawary, Integration of Distributed Generation in the Power System, Wiley-IEEE Press
8. S.P. Chowdhury, P. Crossley, S. Chowdhury, Microgrids and Active Distribution Networks, IET

L = Lecture, T = Tutorial, P = Practical, C = Credit

w.e.f. academic year 2024-25 and onwards