National Institute of Technology Rourkela

Synopsis Seminar

Seminar Title	: Power Management and Power Quality Enhancement in Hybrid Microgrid with Integrated Energy Storage Solutions
Speaker	: Chinmaya Jagdev Jena (Rollno : 518ee1010)
Supervisor	: Pravat Kumar Ray
Venue	: New Seminar room, EE Dept. (EE 401)
Date and Time	: 26 Mar 2025 (4:30 P. M.)
Abstract	:

Microgrids are becoming popular as an alternative to rising energy needs in urban and rural areas in a sustainable manner. The incorporation of renewable energy sources (RES), and more so photovoltaic (PV) systems, into microgrid planning is crucial to guaranteeing energy supply and environmental advantage. Nevertheless, the unpredictable nature of solar power and load fluctuations complicate system stability and power quality. Besides, power electronic interfaces cause harmonics and electromagnetic interference, which require sophisticated control methods. To compensate for these problems, this study employs a dual energy storage system (DESS) that integrates batteries for long-term energy storage and supercapacitors for high-speed energy fluctuations. The hybrid energy storage system (HESS) maximizes power management, stabilize energy fluctuations, voltage regulation, and battery lifespan extension through optimized charge-discharge cycles. Even with its benefits, microgrids are not immune to power quality issues posed by nonlinear loads and high-frequency switching devices, and effective filtering and compensation measures are necessary.

For guaranteeing stability during microgrid operation, a powerful control strategy is needed to manage DC bus voltage and power flow. This research work explores the usage of Finite Control Set Model Predictive Control (FCS-MPC) for power flow control in DC-DC converters and DC-AC converters with benefits like fast dynamic response, predictability, and constraint satisfaction. Moreover, a leaky least mean square (LLMS) algorithm is used in the voltage source converter (VSC) with a modified version to improve power quality at the point of common coupling (PCC) by capturing fundamental load current components and reducing harmonic distortion. The work also involves electric vehicle (EV) charging through constant current (CC) and constant voltage (CV) techniques with FCS-MPC for effective energy usage and system stability. The presented power allocation scheme (PAS) regulates power among the PV system, DESS, and the grid with dynamic balance and keeps the state of charge (SoC) of the storage devices intact. The conceived microgrid design and control policies are verified via in-depth MATLAB/Simulink simulations and a prototype tested based on the MicroLabBox 1202 digital controller for a wide range of operating scenarios.