A Study on Advanced Power Electronics and Control Technologies for Enhancing Renewable Energy Generation and Storage Systems

Suresh N
Research Scholar, Bharath Institute of Higher Education & Research, Chennai, India

M K Ilampoornan
Professor-EEE Bharath Institute of Higher Education & Research, Chennai, India

Abstract:

The renewable energy (REN) sources integration like solar and wind into prevailing power grids has become increasingly vital for achieving global sustainability targets. However, effective grid integration poses practical issues because of the erratic and alternative nature of renewable sources and their interface requirements. Central to this integration are power electronics converters, which facilitate efficient and reliable energy conversion while offering the high degree of controllability and flexibility demanded by modern power systems. This study offers a comprehensive outline of strategies for grid integration especially for large-scale generation of REN through power electronics. It examines the technical requirements and operational considerations of integrating key REN sources, as well as energy storage solutions. Special attention is given to control mechanisms, spanning from individual converter-level control (such as general current control strategies) to system-level coordination for maintaining stability, reliability, and efficiency in large, interconnected networks. The paper also explores future research directions aimed at addressing critical issues such as synthetic inertia, harmonics mitigation, and the development of robust, scalable, and adaptive control systems and the integration of REN through power electronics including converters, control systems, and communication infrastructure should likewise account for the environmental impacts from an LCA sustainability perspective. Stress is positioned on the growth of smart grid knowledges, and unified energy management systems. These innovations are vital for transitioning towards a robust and flexible power grid proficient of supporting high levels of renewable penetration.

Keywords:

Grid integration, renewable energy, power electronics converters, system inertia, wind energy, solar PV, energy storage, current control, coordinated operation, smart grid, synthetic inertia, grid stability, control strategies.