National Institute of Technology Rourkela

Synopsis Seminar

Seminar Title	: Performance Enhancement of Grid Integrated Low-Voltage Small-Scale AC Microgrid using Photovoltaic and Battery fed Unified Power Quality Conditioner
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Venue	: EE Seminar room (new), EE 401
Date and Time	: 19 Nov 2024 (11:30 A. M.)

Abstract : Quality and continuity of electrical power supplied to the consumers especially to critical loads is very crucial irrespective of any discrepancy in the power system. With the rigorous intervention in the domain of distribution energy resources (DERs) and power electronics technologies, there is a progressive growth of microgrid ecosystems in the power sector. However, this progressive approach catalyzes fluctuations in the service provided to the consumers, particularly in case of remotely placed low-voltage small-scale AC microgrid (ACMG). It encounters various issues such as supply voltage fluctuations, voltage instability, more losses and load unbalance due to its low inertia, low voltage and increased distance from the main grid. Unified power quality conditioners (UPQC) has been primarily used in high voltage system for power quality improvement. Unlike the conventional approach of single objective based control, there is a requirement to control and operate the power conditioners to fetch multiple benefits out of it to simultaneously ensure reliability, efficiency and stability of the medium and low voltage microgrid.

This research work presents a grid-integrated photovoltaic and battery energy storage system fed UPQC (PV-BESS-UPQC) for performance enhancement of remotely placed low-voltage small-scale ACMG. The detailed discussion on the design, sizing and realization of laboratory scale experimental prototype of grid integrated PV-BESS-UPQC is presented for a three-phase three-wire 110 V (L-L, rms) and 1.5 kW system. This work focuses on the improvisation of the control methodologies and operating principles of UPQC along with incorporation of DERs to enhance the overall performance of the system.

Fundamental frequency estimation and grid phase information extraction are the prerequisites for synchronized operation of any system specifically, in case of weak grid. Therefore, an adaptive notch filter based on variable leaky least mean square algorithm (VLLMS-ANF) is presented for fundamental frequency estimation then, utilizing the estimated frequency disturbance free grid voltage based unit templates are generated using normalised comb filter fed second order harmonic oscillator (N-CF-SOHO).

Proper and faster generation of switching signals for the control of UPQC requires swift generation of reference current and voltage signals for UPQC control. Subsequently, an adaptive approach based on VLLMS algorithm is presented for decoupling of active-reactive components of load current and the in-phase quadrature component of grid voltage for desired reference signal generation.

Further, an adaptive and coordinated control algorithm for PV-BESS-UPQC system is proposed to ensure minimum utilization of sag compensating power during grid voltage sag. This minimises unnecessary conduction losses in UPQC switches and reduces burden on grid to compensate sag by strategically ensuring availability of battery for sag compensation.

Finally, a switch protection scheme is presented to protect the switches of UPQC from load induced current transients. This approach limits current through UPQC switches within its rated capacity by modifying the reference grid current signal. The grid integrated PV-BESS-UPQC system with its proposed control methodologies is investigated both in simulation using MATLAB/Simulink and experimental platform through digital controller dSPACE MicroLabBox 1202 under all possible system dynamics to analyse the efficacy and practical feasibility of the proposed work.