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Smart power management algorithm in microgrid consisting of photovoltaic, diesel, and battery storage plants considering variations in sunlight, temperature, and load

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ABSTRACT

Integration of utility scaled solar electricity generator into power networks can negatively affect the performance of next generation smartgrid. Rapidly changing output power of this kind is unpredictable and thus one solution is to mitigate it by short-term to mid-term electrical storage systems like battery. The main objective of this paper is to propose a power management system (PMS) which is capable of suppressing these adverse impacts on the main supply. A smart microgrid (MG) including diesel, battery storage, and solar plants has been suggested for this purpose. MG is able to supply its local load based on operator decision and decline the power oscillations caused by solar system together with variable loads. A guideline algorithm is also proposed which helps to precisely design the battery plant. A novel application of time domain signal processing approach to filter oscillating output power of the solar plant is presented as well. In this case, a power smoothing index (PSI) is formulated, which considers both load and generation, and used to dispatch the battery plant. A droop reference estimator to schedule generation is also introduced where diesel plant can share the local load with grid. A current control algorithm is designed as well which adjusts for PSI to ensure battery current magnitude is allowable. MG along with its communication platform and PMS are simulated using PSCAD software. PMS is tested under different scenarios using real load profiles and environmental data in Malaysia to verify the operational abilities of proposed MG. The results indicate that PMS can effectively control the MG satisfying both operator and demand sides.

1. Introduction

Public needs in modern societies beside optimal consumption and/or generation of electricity necessitate the integration of intelligent power management systems (PMSs) into power networks. This matter has brought a new concept which is so-called "Smartgrid". Smartgrid incorporates advanced measurement technologies, control algorithms, and communication platforms into present power grid. These features are helpful to optimize the utilization of renewable energy (RE) prime movers which contribute in the generation of electricity in large scales [1,2]. A combination of distributed storage (DS), RE distributed generation (DG) systems and loads which can operate in parallel with the grid or in autonomous modes is so-called "Microgrid". Microgrid (MG) can be considered as a cluster of load and generation in smartgrid that brings many advantages for the system. The benefits can be pointed out i.e. increasing RE sources depth of penetration, decreasing environmental emissions, utilizing waste heat, providing ancillary services, making the balance between generation and consumption, and bringing continuous backup power supply for redundant and sensitive processes [3]. Renewable resources such as wind and solar photovoltaic (PV) are naturally intermittent and hence energy storage systems (ESSs) like battery can be exploited together with them to compensate for this drawback [4]. Solar PV plant in high penetration levels can modify the load profile and create technical challenges for the system in steady-state and transient operating modes. The fluctuating output power is one example brought to this end [5,6]. Ramp ups/downs in solar plant output power are completely unpredictable. These fluctuations can be governed by several factors i.e. passing clouds, PV

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