Frequency Control in Renewable-Rich Isolated Microgrid (Abstract)

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The microgrids are characterised by more inertia-free renewable energy sources with small number of diesel engine driven synchronous generators. The conventional control philosophies which can deliver very good performance in grid connected mode of operation of microgrid can make the system unstable, once the microgrid is isolated from the main grid due to the following facts. When compared with conventional grid system, the microgrid is much smaller in size and it is well known fact that the smaller systems are subjected to larger deviations for the same disturbance when compared with bigger systems. Since the microgrids are having little number of synchronous generators with smaller capacities, the inertia support from these generators to the microgrid under disturbances is also less. On the other hand, the penetration of power electronic converter interfaced renewable energy sources is much higher in microgrid which will not give any inertia support. In addition, the renewable energy sources are traditionally controlled to deliver maximum available power to the system due to their environment friendly nature and higher unit costs; hence the reserve available with these sources is zero. Therefore, the frequency regulation in an isolated, renewable rich microgrid is a challenging task which necessitates huge amounts of storages/reserves. As it is confirmed by IEEE and PWC in their reports, the key barrier for the microgrid technology is its high cost, mostly from the generators and storages. Hence, it can be concluded that **any technology which helps to retain the balance of Generation and Load, thereby regulating the frequency in an isolated renewable-rich microgrid under all operating conditions with minimum, if possible without any extra storage or dump loads and importantly without any extra power electronics and control apparatus is of great significance.**

To address the aforementioned issue, this research considers a microgrid characterized by more inertia-free generators, such as Solid Oxide Fuel Cell (SOFC), Photovoltaic (PV) Generators, and diesel engine driven synchronous generator (DEG) along with some critical and noncritical loads. A novel, smart, coordinated control philosophy which can provide storage free solution for the frequency regulation in a isolated renewable-rich microgrid is proposed in this research, for the first time, with best possible utilization of available renewable energy sources on priority basis. In the proposed strategy, taking the benefit of same inertia-free nature of the PV generator, its output is controlled in coordination with other resources with the help of *neuro-fuzzy controller*, either only for transient frequency regulation or for both transient and steady-state frequency regulation, depending on the load demand. The considered artificial neural network (ANN) is trained with a novel *adaptive-predictor–corrector* based tracking mechanism, first of its kind. The fuzzy part of the controller derives the reference voltages for the control of the PV generator subjected to the limits provided by the ANN. In the proposed philosophy, all the sources will be in frequency control service (FCS) mode with pre-decided order of priorities except the PV, which can toggle between maximum power output mode and FCS mode. The option of coordinated demand response control is also explored along with the generation control during the extreme loading conditions. Since, the PV is a fast acting source and is also participating in FCS mode through *derating* there is no need of any storage such as battery, super capacitor and fly wheel to improve the frequency response.

The proposed controller has been evaluated under different operating conditions and is exhibiting superior performance in achieving the desired control objectives. Results from the numerical simulations are confirmed from the experiments in real-time environment. The proposed coordinated control philosophy can save millions of rupees, expending on Batteries and Diesel generators, both in terms of capital and operating/maintenance costs, involved in isolated operation of microgrid.