Chapter 5: Conclusion

With advancement in electrical distribution systems, the usage of Renewable Energy Sources (RESs) with integration to microgrids are being widely used nowadays. Renewable energy sources like solar, wind, hydro powers are majorly employed due to its wide range of availability and usage of the same has provided a lot of advantages like meeting the demand of electricity, undisrupted power productions etc. RESs are integrated with conventional grid systems to meet the growing energy demand and to enhance the power quality. Even though the integration of RES into the grid model has many advantages, it also suffers from few drawbacks as well. The increasing penetration of RES into the grid system affects the stability of frequency in microgrids due to the stochastic nature of photovoltaic (PV) and wind energy generation. Unlike in traditional power generation systems, the lack of rotational inertia in microgrids is one of the critical concerns which affects the integration of RES and grid systems. In order to maintain the stability of microgrids and to effectively utilize RESs and distributed generation (DG) systems, it is essential to control virtual inertia.

In this research, a VIC based MPLC approach for frequency variation control in grid connected RES systems was proposed. The foremost objective of this examine was to evaluate the effect of virtual inertia and to mitigate the issue of frequency instability in RES integrated grid system. The VIC based strategy was mainly designed to address the issues related to frequency instability and to maintain the inertia levels for sudden disconnecting loads. The MPLC based approach was designed to ensure that the system provides the maximum inertia and frequency support whenever there is a significant changes in the in the load. This is constituted as one of the prominent contributions of this research. Here the virtual inertia is estimated with the help of voltage and current controller where the PWM (Pulse Width Modulation) signals are generated, and the compulsory power is sent to the inverter to obtain necessary inertia support obtained by the grid via inverter. Here, the MPC controller was designed with the Model Predictive Control Toolbox in MATLAB. The reference signal is a simple sinusoidal function with a specific reference trajectory. Along with the grid system, we have integrated MPLC and MPPT strategy as well which is aimed to progress the performance of grid systems which are powered by PV and wind turbines. As far as the MPPT approach proposed is concerned, we utilize Perturbation and observation based approach which is widely employed since it can help in extracting the maximum power even under partial shading conditions. Performance evaluation of the proposed study was conducted based on the energy generated by different renewable energy resources for example the Photovoltaic system, and the wind energy system. For obtaining maximum energy from the PV sources, a Maximum Power Point Tracking algorithm is utilized to find and maintain the operating point of the solar panel where it produces the maximum available power. Usage of MPPT is necessary since the output power of the solar panel will not be stable and it varies with respect to various environmental conditions like sunlight intensity, temperature, and shading. From simulation results, it can be validated that the better control over frequency with sudden connection and disconnection of loads is observed.

This research proposes a one-of-a-kind use of subordinate control procedures in view of virtual inertia control to upgrade the recurrence execution and steadiness of interconnected frameworks with high entrance of remaining energy sources.

To mimic inertia power, the subsidiary control technique has been utilized to direct the dynamic force of the ESS in the organized framework. The proposed control strategy is effectively versatile to a multi-region framework, no matter what their size, intricacy, or different qualities. To show the genuine results of mirroring inertia on framework execution and dependability, an exhaustive responsiveness examination of the inertia control boundaries is likewise done. That's what the recreation's discoveries exhibit, in case of a serious crisis, virtual inertia control may really decrease the interconnected power framework's recurrence deviation.

Δf values vary between 17.4215 and 20.3621 with significant frequency variations due to conventional control. The Δf values were consistently smaller between 0.0236 and 0.0369 than the conventional control.

However, to prevent instabilities and structure explosions, virtual inertia control framework offers expected reliability as well as performance contrary to high-RES input, critical load-resolving impacts, as well as low inertia image. A future objective of virtual inertial evaluation is to refine the VI approaches needed to ensure effective integration with renewable energy systems and grid stability.Although the proposed approach was designed to achieve desired results, there are certain limitations of this research, which are as follows:

The proposed VIC and MPLC may be sensitive to variations in system parameters such as network impedance, characteristics of RES, and load profiles. This sensitivity affects the effectiveness of the proposed method in different grid configurations and operating conditions.

The evaluation of virtual inertia and frequency instability mitigation technique mainly relied on system components and dynamics. These assumptions might not fully capture the complexity and nonlinear behavior of real-world grid systems, potentially leading to discrepancies between simulation results and actual system performance.

The proposed VIC and MPLC may have limited scalability and adaptability to diverse grid environments and evolving RES integration scenarios.

The research is still open for future research to address the limitations. The research can be extended to analyze the management of power quality and validate the same through comparative study of the proposed VIC based MPLC approach with other existing approaches. Further we can try exploring the implementation of hybrid controller strategies which can further improve the findings of our proposed research.