Design of Hybrid Microgrid To Enhance Optimal Power Flow In Hybrid Microgrid

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Abstract—Over decades, a paradigm change in electrical energy generation has occurred, from the use of large generating plants to the use of smaller generating units linked to distribution networks in the form of microgrids with renewable energy sources. Because of its benefits such as better power sharing, improved system dynamics, and optimum management, hybrid AC/DC Hybrid Microgrid (MG) is gaining popularity. However, the complex structure makes modelling and stability analysis extremely difficult. When it obtains power from those tools, it faces issues such as uncertainty and Steady-State (SS) issues. Small-signal stability (SSS) is required for synchronizing minor disruptions. The hybrid DC-AC microgrid with MPSO-PID controlled boost converter for integration of PV is proposed in this strategy. By controlling the duty cycle of PID controller, the DC voltage can be maintained constant and there by improving the small signal stability of the MG.

Index Terms—Microgrid, Small Signal Stability, Modified Particle Swarm Optimization (MPSO), Proportional Integral Derivative (PID) Controller

I. INTRODUCTION

A microgrid is a localized group of electricity sources and loads that can operate autonomously or in conjunction with the main grid. It can be connected to the grid or operate in isolation, and it typically includes distributed energy resources (DERs) such as renewable energy sources, energy storage systems, and controllable loads. Microgrids are designed to provide reliable and resilient power supply, improve energy efficiency, and integrate renewable energy sources into the electricity system. Microgrids offer several advantages, including improved reliability and power quality, increased energy efficiency, and the potential for cost savings[1]. By integrating renewable energy sources such as solar photovoltaics and wind turbines, microgrids can reduce greenhouse gas emissions and contribute to environmental sustainability [2]. The operation of microgrids is facilitated by advanced control and management systems, which enable the coordination of multiple distributed energy resources and ensure the stability and reliability of the microgrid [3]. These control systems utilize advanced algorithms and real-time data to optimize the operation of the microgrid, manage energy flows, and respond to changes in demand and supply.

In addition to their technical capabilities, microgrids also have important implications for energy policy and regulation. The integration of microgrids into the existing electricity infrastructure requires regulatory frameworks that support their deployment and operation [4]. Policymakers and regulators need to address issues related to grid interconnection, market participation, and economic incentives to encourage the development of microgrids [5][6][7]. In conclusion, microgrids represent a promising approach to enhancing the resilience, sustainability, and efficiency of electricity systems. Through the integration of renewable energy sources, advanced control systems, and supportive policy frameworks, microgrids have the potential to play a significant role in the future of energy supply and distribution.

The physical diagram of MG is shown in figure 1. The centralized control model for microgrid is finding it very difficult from immense connectivity demands as the penetration rate of distributed energy resources (DERs) continue to rise. A variety of algorithms, such as nonlinear process, inverter-based autonomous processing, and others, have been proposed in recent years to overcome these challenges. The ones relying on the majority principle have gotten a lot of coverage[8].

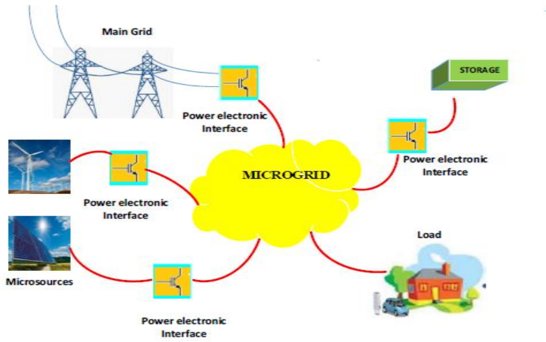

Figure 1 Physical diagram of basic microgrid

To achieve optimum transmission losses for microgrids, consensus-based distributed primary and secondary controls for microgrids are suggested and adopted, as well as consensus-based distributed tertiary control [23][24][25]. To overcome these difficulties an efficient, robust, reliable and more accurate algorithm is required. In this paper MPSO based control algorithm is used to improve the small signal stability of the system.

II. PROPOSED SYSTEM

In this section the small signal stability issue of hybrid dc-ac microgrid is explained in detail. Thus the performance of the SSS with the Proportional Integral and Derivative Controller is improved in aggregation with the MPSO.

The power in the proposed work is generated using a combination of RES, such as PV and WECS and is supplied to the loads in the HMG. The BC is then used to power a grid-linked HMG, as well as the current, which is controlled by the FA control. The PIDC is then used to manage the FA in order to avoid compatibility problems. To address the problem of reliability while also improving SSS, the MPSO is used to solve the optimization problem targeted at the controller, resulting in a better result.

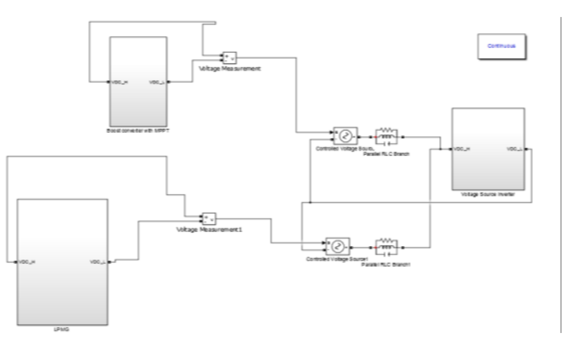

Figure 2 Proposed Hybrid microgrid which is implemented in MATLAB

Figure.2 evinces the simulation model of the proposed SSS enhancement system. The power from PV array is fed to inverter via boost converter. The voltage at the DC bus is maintained by the boost converter. By maintaining constant voltage at DC bus small signal stability can be improved. MPSO algorithm optimizes the parameters of PID controller in order to control the duty cycle of the boost converter.

III. RESULTS AND DISCUSSION

This section is presented for analyzing the proposed SSS enhancement system's performance. For this, MATLAB/SIMULINK platform is utilized. The parameters of the proposed HMG is shown in table 1.

Table 1: Parameters of HMG

Parameters	Specifications
PV panel	
Maximum power (P_{mpp})	2kW
maximum point Current (I_{mpp})	4A
Temperature	25°C
maximum power point Voltage (V_{mpp})	510.3V
Irradiance	1000 W/m2
Wind Parameter	
Voltage	415V
Power	1kW
Frequency	50Hz
Speed of wind	12 m/s

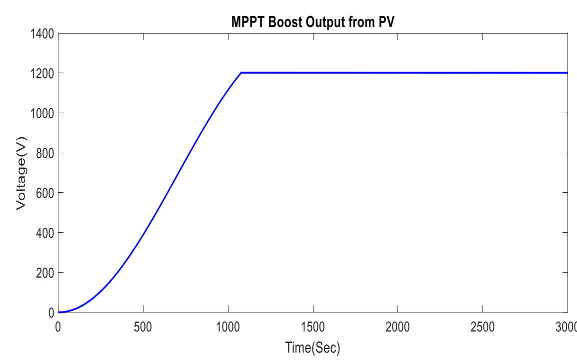

Figure.3 MPSO Boost output

Figure 3 shows the output voltage from the boost converter.

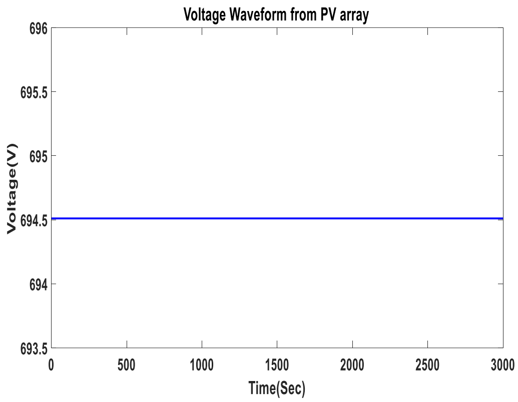

Figure.4 Analysis of voltage waveform from PV array

Figure 4 evinces the voltage waveform as of the PV. The analysis is made by means of varying the time between the generations. But, this analysis gives a constant voltage of 694.5V in all time variation

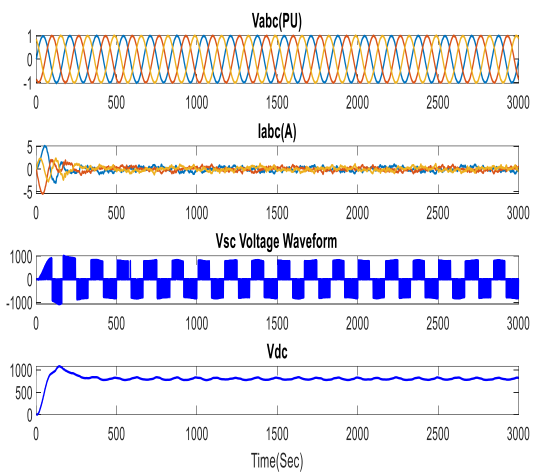

Figure.5 Analysis of voltage and current waveform from DC bus

Figure 5 evinces the simulated outcomes of the voltage as well as current waveform of the implemented work. The first 2 Simulink results show the current waveforms. In 0.02s, the current wave varies as of -1kA to 1kA in the first result, and also the current varies as of -5kW to 5kW in the second result. Next, the third, fourth, and fifth simulated outcomes show the voltage waveforms. In between the time intervals, the voltage ventures into the negative value for the first 3 time-interval and it has a positive value for another 3time-interval.

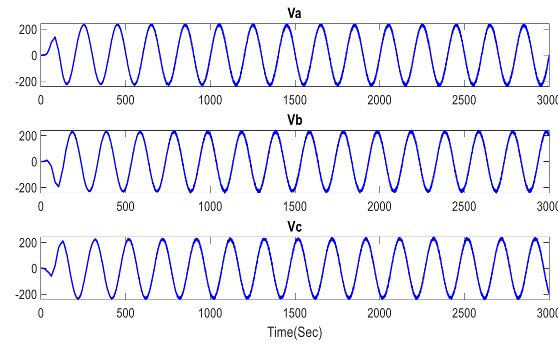

Figure.6 Analysis of voltage and current waveform from DC bus

Figure.6 evinces the AC distribution grid voltage profile. Here, the voltage varies between -200V to 200V. The simulated outcomes of the distribution grid voltage profile are analyzed centered on time in seconds. The attained voltage is the same as of 0.05s to 0.3s.

IV. CONCLUSION

Small Signal Stability of the power system has continued to be a challenging problem in power system operation and control. SSS has been analyzed considering time delays for investigating the effects of constant and time varying delays on the stability of power system. This work proposed a PIDC with MPSO algorithm in DC-AC hybrid MG for enhancing the SSS. The optimum tuning parameters aimed at the PIDC are chosen for controlling the FA using well-established metaheuristic techniques, the statistical findings these techniques have been designed to tune the parameters of power system stabilizers so that the scheme's output can be maintained. The MPSO acquired the higher most fitness value when compared to the other metaheuristics techniques.

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