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Coordinated Control Strategy of Hybrid AC/DC Microgrid with Photovoltaic and Energy Storage System

HU Yiwen [1], LIU Chuang [1*], WANG Jingyue [1], PEI Zhongchen [1]

1 School of Electrical Engineering, Northeast Electrical Power University, Jilin 132000(*Corresponding Author)

ABSTRACT

Around microgrid with PV and energy storage system, this paper adopts a module-level configuration scheme and proposes coordinated control strategy to further release the potential of PV power generation and promote the efficient operation of energy storage unit. Firstly, aiming at the 'barrel effect' caused by PV module mismatch and low efficiency of energy storage converter, the module-level PV power optimizer and the energy storage partial power converter are configured respectively to maximize the utilization of solar energy and electrical energy. Secondly, the multi-mode switching of PV array and energy storage unit under on/off-grid conditions is discussed, and a coordinated control strategy of microgrid with PV and energy storage system is proposed to realize the smooth switching and power automatic distribution of each unit in different control modes. Finally, a 30kW microgrid with PV and energy storage system simulation platform is built by using Matlab/Simulink to verify the feasibility and effectiveness of the proposed coordinated control strategy.

Keywords: PV power optimizer, energy storage partial power converter, power balance, coordinated control strategy

NONMENCLATURE

Abbreviations	
PV	Photovoltaic
MPPT	Maximum power point tracking
MPP	Maximum power point
PCC	Point of common coupling
SOC	State of charge

1. INTRODUCTION

Driven by the national goal of "double carbon", renewable energy, represented by PV power generation, will become the backbone of energy consumption structure[1].However, the mismatch of power output caused by PV modules in the actual operation of PV systems will lead to the "barrel effect" of PV strings, which will result in a significant reduction of the output power of the whole PV array and reduce the efficiency of PV power generation[2]. Meanwhile, along with the large-scale grid connection of massive PV, its randomness and intermittent characteristics will directly affect the safe and stable operation of microgrid. Therefore, there is an urgent need to utilize the power complementary characteristics of energy storage[3] to smooth out the power fluctuation of PV power generation, promote the deep integration of PV, energy storage, load and grid, and realize the full consumption and efficient utilization of renewable energy.

PV power optimization systems are important for the power optimization, condition monitoring and protection of PV modules. The literature [4] classifies the current circuit topologies applicable to module-level PV power optimizers and analyzes the operating principles and applicable scenarios of several commonly used topologies, and analyzes and summarizes several topologies in terms of efficiency, cost and complexity.

Traditional energy storage units are more often grid-connected using full power bi-directional DC/DC converters for voltage regulation, which has the problems of low operation efficiency, large footprint and high pre-investment cost. In order to solve the above problems, literature [5] analyzed and compared the topologies available for bidirectional DC-DC partial power converters with high voltage gain and high

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power to supply the load and charge the energy storage unit at the same time, so as to maximize the consumption of renewable energy. Some of the load is cut out at 0.1s, at which time the charging power of the energy storage unit rises in order to maintain the power balance of the system. Adjust the SOC state of the energy storage battery pack to 80% at 0.2S, at this time, in order to prevent overcharge, the energy storage unit is cut out. However, since the output power of the PV array is much greater than the total load power, the PV power optimizer switches from the MPPT control mode to the power-limited control mode to ensure the balance, safe and stable operation of the system.

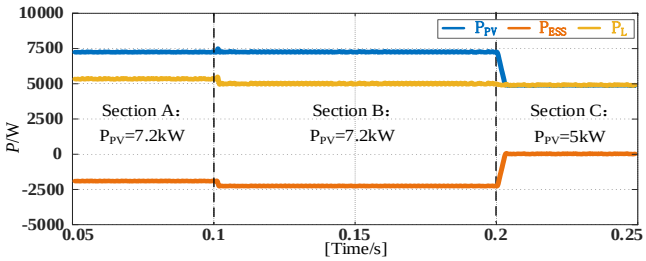

Fig. 10. Output power of each unit of microgrid under islanded condition

5. CONCLUSION

Through the comparison with string-level PV power optimizer and full power energy storage converter and the simulation results of various working conditions, it can be seen that the used module-level configuration scheme can eliminate the 'barrel effect' and improve the efficiency of energy storage units under on/off-grid conditions . Meanwhile, combined with the SOC state of energy storage battery pack, the proposed coordinated control strategy of microgrid with PV and energy storage system can manage and control the working mode of each converter, realize the independent power distribution of each unit, quickly eliminate the power fluctuation caused by PV and load, and ensure the safe and stable operation of the system while maximizing the consumption of renewable energy.

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