Construction and Testing of AC/DC Hybrid Microgrid Research and Test Platform

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1. Research Background and Objectives

In recent years, with the vigorous development of renewable energy power generation, microgrid technology has gradually attracted attention. Microgrid technology can mitigate the impact of renewable energy on the power grid, reduce power loss in the transmission process, and play a key role in ensuring national energy security as an emergency backup power system to improve the stability of the power supply. As an important form of distributed generation, microgrids play an increasingly important role in integrating renewable energy, improving energy efficiency, and ensuring the reliability of power supply. The architecture of the AC and DC composite microgrid research and test platform is shown in Figure 1. The overall architecture of the AC and DC microgrid platform represents an ideal microgrid type that integrates the advantages of both AC and DC microgrids. It not only features easy integration of renewable energy power generation and energy storage systems but also provides direct current supply capability. Furthermore, it can operate under a microgrid architecture with a pure DC power supply, as illustrated in Figure 2, which depicts the configuration of the microgrid system operating solely on DC. This makes AC/DC hybrid microgrids unique in addressing energy transition, enhancing energy self-sufficiency, and optimizing power usage, allowing them to effectively tackle issues that traditional AC grids cannot solve alone.

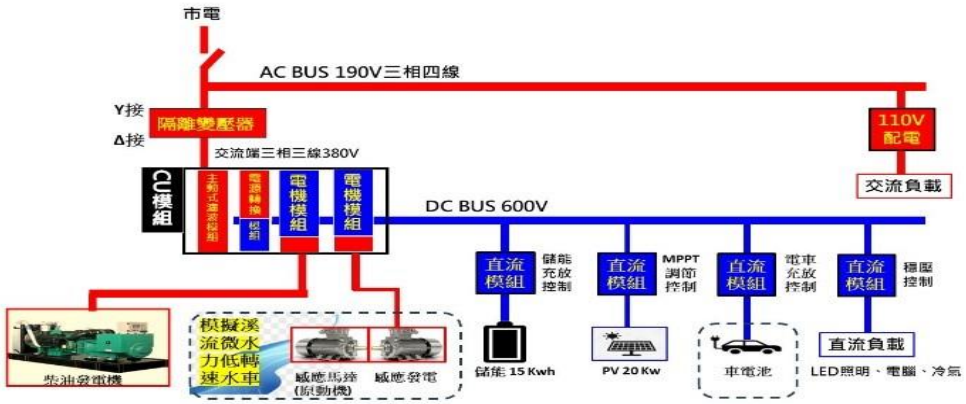

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Figure 1 The architecture of the AC and DC composite microgrid research and test platform

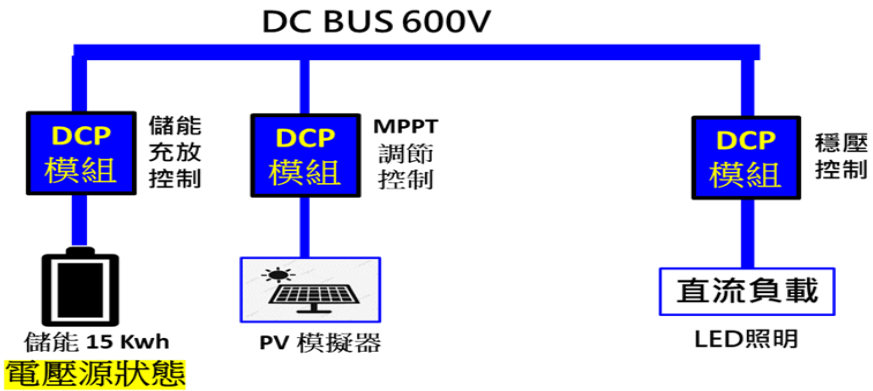

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Figure 2 The configuration of the microgrid system of DC-only operation

2. Research Content

A series of experiments was conducted to explore its stability and function in different modes of operation. It specifically focuses on the following core research directions: evaluating whether the system can depend solely on energy storage batteries and solar photovoltaic systems to maintain stable operation without the support of the mains and exploring the effectiveness of AC/DC composite microgrid integration of renewable energy. Through the operation efficiency test and energy efficiency analysis, the AC/DC composite microgrid was analyzed by the operation capacity test, stability test, and function test to clarify the feasibility and benefits of the AC/DC composite microgrid. Through the self-regulation design of renewable energy generation, energy storage batteries, AC/DC devices, and grid-forming inverters with protection control, the microgrid can maintain stable operation. This design allows the microgrid to function reliably despite variations in power generation, changes in load, and both on-grid and off-grid conditions. The AC/DC composite microgrid research and test platform will be utilized to study key microgrid technologies and verify international standards and specifications. This includes seamless islanding, seamless grid connection, pure DC operation, and other related tests while exploring microgrids with DC power supply functions.

To verify the effectiveness of the system, several tests were carried out. Among them, the photovoltaic storage test (solar-plus-storage charging and discharging), shown in Figure 3, illustrates the configuration of the test, demonstrates the integration of solar energy and energy storage systems, and evaluates the charging efficiency and system stability of the microgrid under varying inputs from the solar photovoltaic system. Seamless islanding and grid-connected experiments were conducted to test the switching ability of microgrids in different modes, and a stability operation test was performed to verify the system's performance under load variation. In addition, the operation of DC loads and various types of stability were studied to verify the system's feasibility in practical applications.

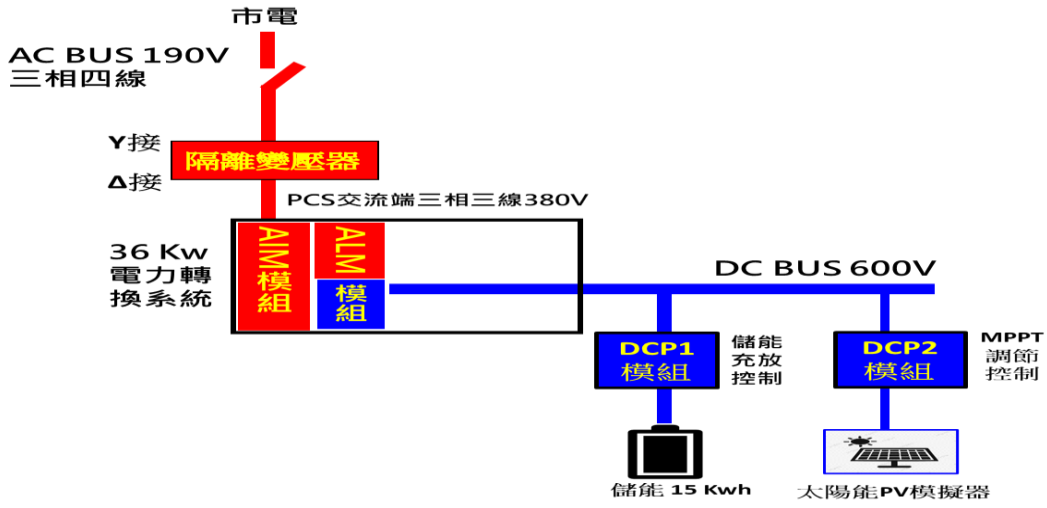

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Figure 3 The configuration of the photovoltaic storage test

3. Conclusion

The AC/DC composite microgrid research and test platform demonstrates excellent performance across different operation modes. It has significant potential in enhancing energy efficiency, integrating renewable energy, and improving power supply reliability. This platform not only enables the system to maintain a stable power supply without relying

solely on mains power, but it can also quickly and stably respond to sudden load changes. Additionally, it operates efficiently and stably during seamless off-grid and photovoltaic storage tests. The AC/DC composite microgrid research and test platform not only provides a valuable reference for the practical deployment of microgrids but also lays a solid foundation for future research directions. Future research can further explore how to optimize control strategies, enhance microgrid resilience, and investigate the potential advantages of AC/DC composite microgrids across different application scenarios, thereby promoting the development of more resilient and sustainable energy systems.