The Study of Application of Real-Time Simulator in Taipower Shu-Lin Microgrid

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I. Background

With the international trends and promotion of energy transition policies, microgrid has the benefits of integrating distributed energy, reducing costs, emissions, and power outages. It has become one of the important development technologies in electric power system. Microgrid control system (MGCS) plays an important role in the secondary control function of the microgrid. The stability of the microgrid in the process of dispatch and transition operation depends on the performance of the MGCS. In addition, during the integration, the testing requirements of the inverter-based renewable energy (IBRs), such as solar inverters, power conditioning system (PCS), etc., have also become a key success factor.

In recent years, international technical associations have successively published guidelines related to microgrid (Table 1). The International Electrotechnical Commission (IEC) proposes project planning, design, and protection guidelines for microgrid. The Institute of Electrical and Electronics Engineers (IEEE) publishes microgrid controller specifications and testing standards. The standards mention that the Real-Time simulator (RTS) characteristics can provide microgrid devices with a pre-test platform. Two testing technologies, Control Hardware in Loop (CHIL) and Power Hardware in Loop (PHIL), provide a simulation electric power system (EPS) test environment for MGCS and IBRs. Therefore, the advantages of integration and interactive test without connecting to the EPS can be achieved. The weaknesses of the equipment can be detected in advance to improve performance, reduce the risk of the device connecting to the EPS and improve the stability of operation. Therefore, this article will introduce hardware in the loop test technique and application situation in the Shu-Lin microgrid.

Table 1 International Standards for Microgrids

Standard	Title
IEC TS 62898-1 (2017)	Guidelines for microgrid projects planning and specification
IEC TS 62898-2 (2018)	Guidelines for operation
IEC TS 62898-3-1 (2020)	Technical requirements-Protection and dynamic control
IEEE 2030.7 (2017)	IEEE Standard for the Specification of Microgrid Controllers
IEEE 2030.8 (2018)	IEEE Standard for the Testing of Microgrid Controllers
IEEE 1547.1 (2020)	IEEE Standard Conformance Test Procedures for Equipment Interconnecting Distributed Energy Resources with Electric Power Systems and Associated Interfaces

II. Method

Control Hardware in the Loop (CHIL) test refers to building all high voltage and power equipment as a simulation model (Fig 1). Control devices such as protection relays or microgrid controllers are connected to real-time simulators using interface cards or network communication. CHIL technique can test the performance of control equipment by operating a simulation electric power system under conditions of faults and extreme disturbance without causing damage. This is the most important feature of the technique. Power Hardware in the Loop (PHIL) test refers to connecting the partial high-power device to a real-time simulator through a power amplifier (Fig 2). It allows the device to be tested at rated voltage and power to evaluate device performance and calibrate model parameters. PHIL test has the advantage of high fidelity, faithfully presenting the dynamic response of the device. However, the test range is limited by the response time and rated specifications of the power device, and there is also a risk of equipment damage due to improper control.

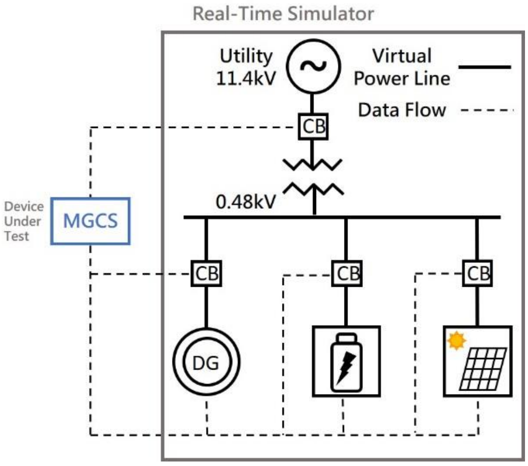

Fig.1 CHIL Test Case

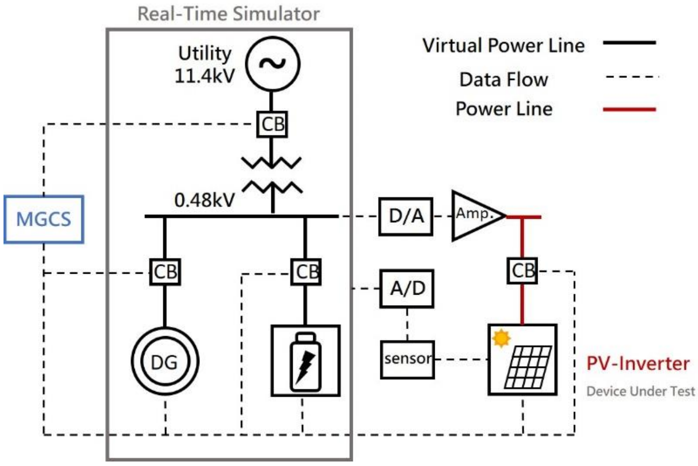

Fig.2 PHIL Test Case

In 2021, Taiwan Power Company completed the first phase of the intellectual target of the Shu-Lin microgrid, enabling the microgrid to have the functions of grid-connected operation, planned islanding, island operation, and black-start. We also implement CHIL to perform functional tests on the Shu-Lin MGCS. The primary level of the power and control system is built by the real-time simulator, as shown in Figure 3. The secondary level of MGCS can monitor and control the virtual microgrid model through the IEC 61850 communication protocol, as shown in Figure 4. The test procedure was transmitted a close signal from Shu-Lin MGCS at first. The real-time simulator is received by the synchronous relay (25 relay) model. The relay model starts to measure the voltage, frequency, and angle difference between the point of interconnection. When the synchronous condition is established, VCB7 will be closed by relay. Microgrid's state changes from island operation to grid-connected operation. The BESS also changes from Grid Forming Mode to Grid Following Mode.

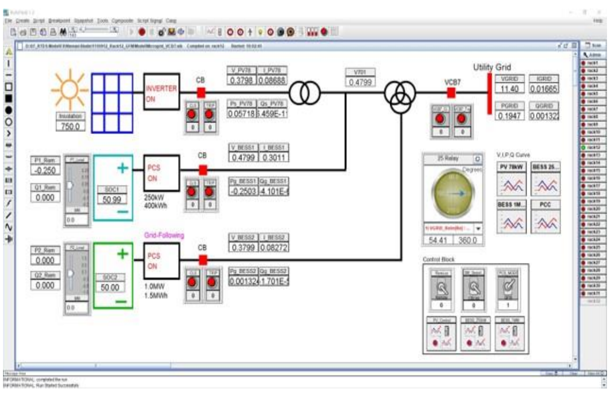

Fig.3 HMI of Real-Time Simulator

Fig.4 HMI of Shu-Lin MGCS

III. Conclusion

This article reviews the specifications and test standards for microgrid and MGCS formulated by IEC and IEEE, which can be used as an analysis reference before the construction of microgrid projects. We also implemented a basic CHIL testbed for the Shu-Lin MGCS. It can be used to develop the technique of testing, analyzing, and building MGCS in line with international standards.