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A Testing Technique of Microgrid EMS using the Hardware-in-the Loop Simulation (HILS) System

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Abstract

A microgrid is composed of distributed power generation systems, distributed energy storge systems, loads as a small scale power system. Generally, the microgrid is operated by an energy management system (EMS). In this paper, a testing technique for a microgrid EMS using the hardware-in-the-loop simulation (HILS) technique is introduced. Especially, the microgrid is composed of multiple buildings and each building has a combined heat and power (CHP) generator, a photovoltaic (PV) system, a heat only boil (HOB) system, electrical load, and heat load. In addition, electrical and heat energy each building is managed by a building energy management systems (BEMS). The microgrid EMS manages total electrical and heat energies of the microgrid by cooperation with each BEMS. To show validation of the proposed testing technique based on the HILS technique, a HILS system is developed and is tested.

Keywords: *Microgrid, building energy management system (BEMS), energy management system (EMS), hardware-in-the-loop simulation (HILS)*

1. Introduction

A microgrid is composed of the distributed generation systems, distributed storage systems, and various loads as a small scale power system. Since the microgrid has renewable energy sources such as photovoltaic (PV) systems and wind turbine systems, it is evaluated as a green power system. In addition, the microgrid has various applications, such as campus microgrids, building microgrids, village microgrids, and so on. For these reasons, interests on microgrids have been growing and many studies and projects have been performing [1-9].

Meanwhile, energy consumption of residential and commercial buildings has been increasing. In order to increase the energy efficiency of a building, a building energy management system (BEMS), which manages the energy production and consumption of a building, is developing and adopting [10-12].

Recently, the hardware-in-the-loop simulation (HILS) system has been applying to testing embedded controllers and protective devices in the power engineering area. The HILS system is composed of tested embedded controllers and devices and a real-time digital simulator to emulate a plant model. The HILS system can test developed devices and systems like the real environment. Since the HILS system can solve the restrictions on space and time for test and

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development, it can save the development cost and time [13-16].

In this paper, a technique to test a microgrid EMS managing buildings using the HILS system is proposed. The microgrid EMS has interaction with each BEMS to maximize global energy efficiency of buildings grouped as a microgrid. In additional, the microgrid EMS deals heat energy as well as electrical energy. The microgrid is modeled in the real-time digital simulator (RTDS), eMEGAsim RTDS, and interfaced with the microgrid EMS using compactRIO. Through testing the microgrid EMS using the HILS system, the feasibility of the proposed testing technique is shown.

2. HILS System

Since the developed things are tested in HILS environment instead of the real plant, the test technique can save the development cost and time. Also, since the technique is based on a RTDS, the HILS system supplies more reliable test results than software simulation. For this reason, recently the HILS system has been applying to various power engineering fields such as power electronics and power systems. Figure 1 shows the concept of configuration of the HILS system for testing an EMS as an example. In this paper, the plant is microgrid composed of multiple buildings and an embedded system is a microgrid EMS.

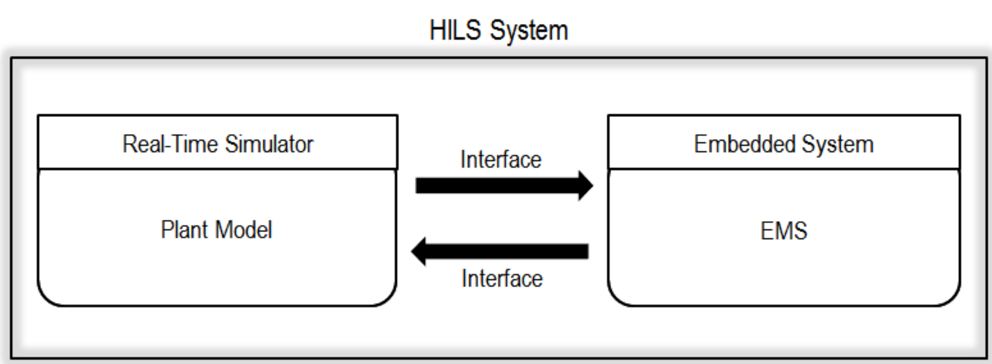

Figure 1. The concept of HILS system configuration

3. Microgrid configuration and EMS

In this paper, it is assumed that each building in the microgrid has a combined heat and power (CHP) generator, a photovoltaic (PV) system, a heat only boil (HOB) system, electrical load, and heat load. In addition, each building is operated by a BEMS. Each building in the microgrid can cooperate with each other for energy efficiency. Optimal operation of electrical and heat energies is managed by a microgrid EMS as shown in Figure 2. The microgrid EMS collects and analyzes a lot of information in the real-time. The system used to efficient energy management

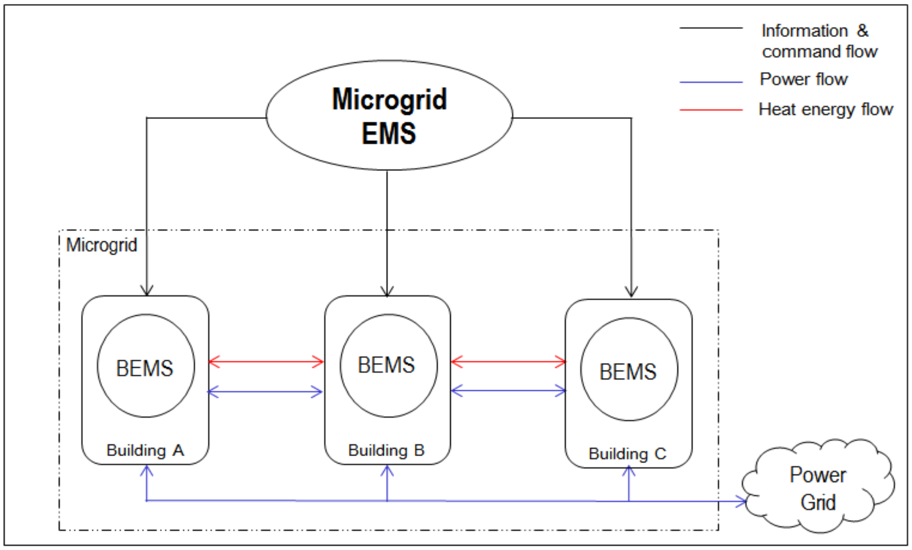

Figure 2. Microgrid configuration

The tested microgrid mechanism has been designed as shown in Figure 3. As shown in the figure, the mcirogrid EMS has interaction with each BEMS to manage electrical and heat energies of the microgrid.

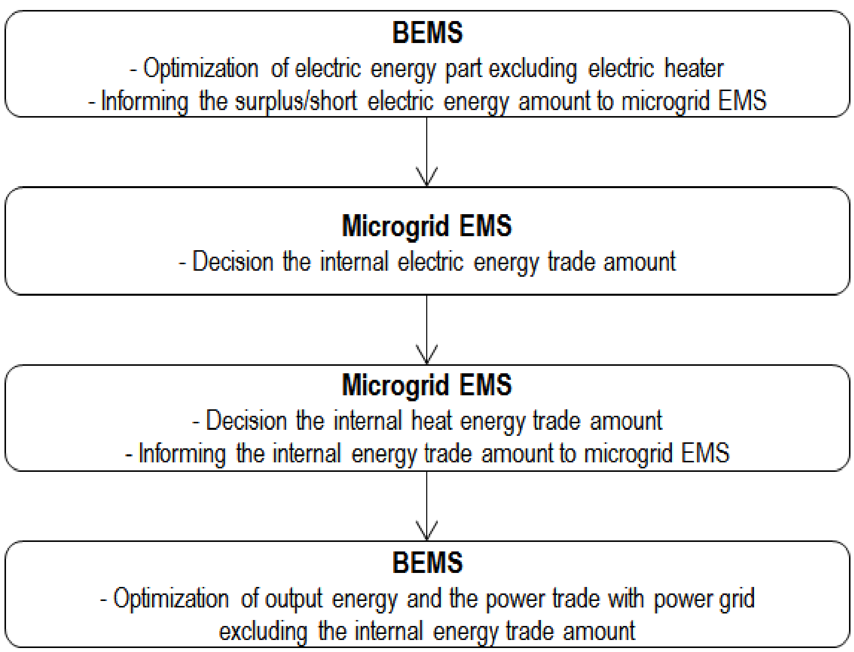

Figure 3. Mechanism of microgrid EMS

4. Microgrid EMS test using HILS system

4.1 Developed HILS system

In this paper, building microgrid EMS has been developed using the visual C++ and CPLEX(ILOG). Figure 4 shows the configuration of HILS system developed to test the microgrid EMS. A microgrid composed of three buildings is modeled in the eMEGAsim RTDS. The compactRIO is used to interface between RTDS and the microgrid EMS.

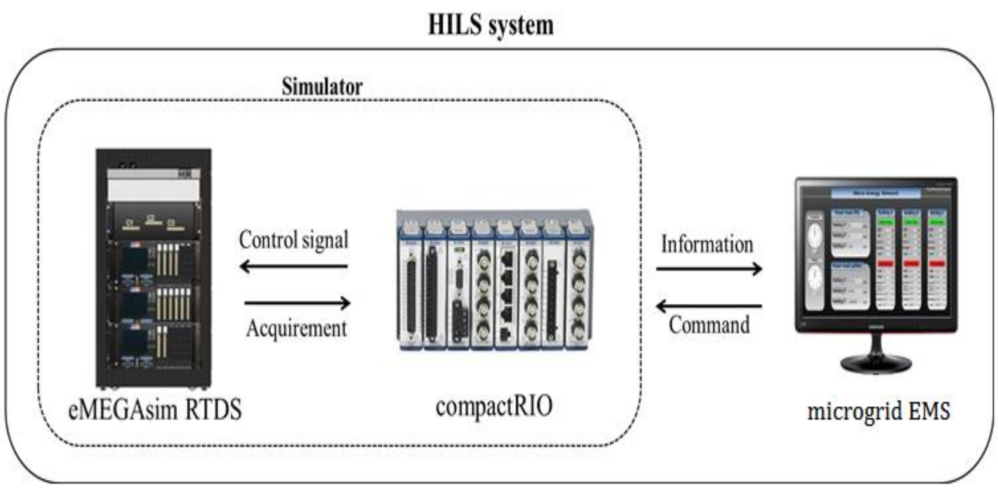

Figure 4. Configuration of developed HILS system

Figure 5 shows the more detailed configuration of developed HILS system.

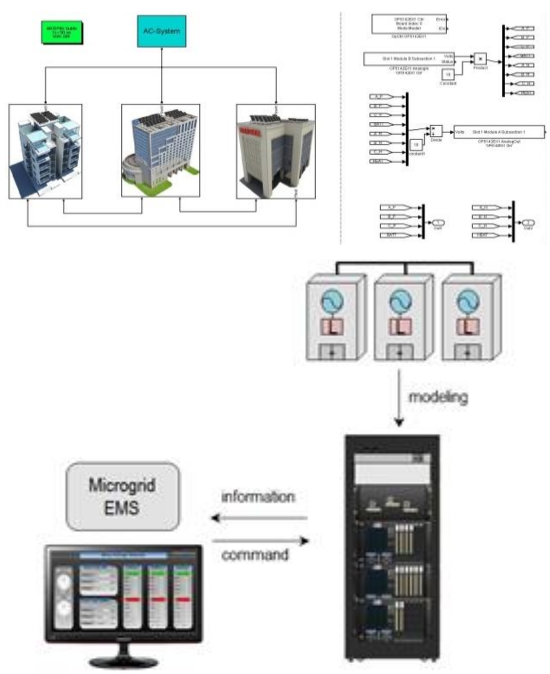

Figure 5. Detailed Configuration of developed HILS system

Figure 6 shows the GUI of the microgrid EMS. Through the GUI of the microgrid EMS, we can check the electric energy production amounts of CHP generators, the output produced from the PV systems, electric and heat energy demand, the heat energy production amount of CHP generators and HOB systems, the internal trade amounts between buildings, and exterior trade amounts with the power grid. In addition, we can check voltage and frequency in the microgrid.

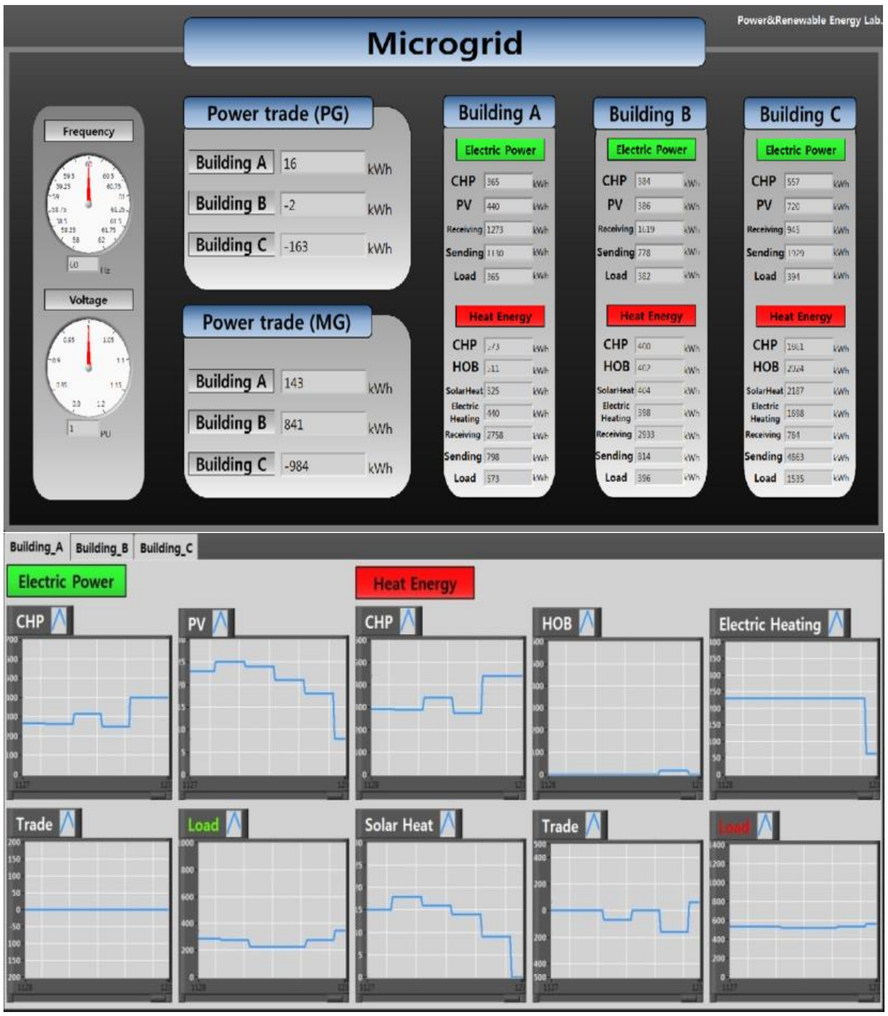

Figure 6. GUI of microgrid EMS

4.2 Test results

Figure 7 shows total operational costs according to operational intervals by operated by without the microgrid EMS and with the microgrid EMS. As shown in the figure, operation by the microgrid EMS can save total operational cost. The result means the microgrid EMS works well.

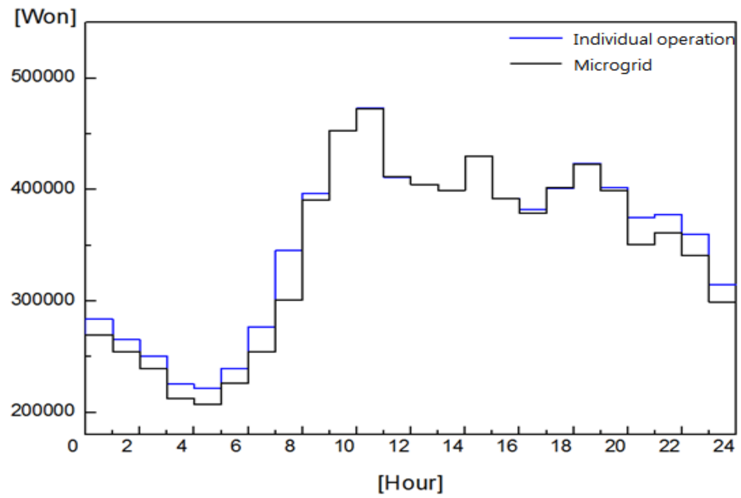

Figure 7. Test result: operational costs

5. Conclusion

In this paper, a testing technique of the microgrid EMS, which is developed by the visual C++ and CPLEX (ILOG), based on the HILS has been proposed. To show the validation of the technique, a microgrid composed of three buildings has been modeled in the eMEGAsim RTDS and the eMEGAsim RTDS has been connected to the microgrid EMS through the compactRIO. From the test results, we can check that the testing technique based on the HILS system is effective.

As a future work, we are planning to add electrical and heat energy storage systems to the microgrid to study their effects.

Acknowledgements

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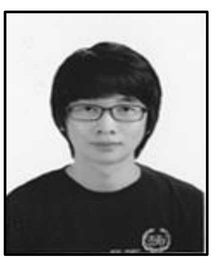

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