Construction of Experimental Power Grid Centre (EPGC)

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Abstract

The Experimental Power Grid Center (EPGC) was completed and officially opened on 1st November 2011. EPGC is the program under Institute of Chemical and Engineering Sciences (ICES), a research institute under The Agency for Science Technology and Research (A*STAR), Singapore to research and develop the new technologies for intelligent and decentralized power distribution, interconnection and utilization.

EPGC is an experimental power grid facility with the total capacity up to 1MW. There are three buses which can be configured as independent, serial, parallel, looped configuration.

1 Preface

Meidensha Corporation delivered along with the building a central controller for the grid, Distributed Energy Resources (DERs), and emulators for the Experimental Power Grid Center (EPGC) and it opened on 1st November 2011.

This facility is provided with a three-phase four-wire bus over the entire length. Distributed energy resources, such as renewable energy and electrical storage systems and various simulated load equipment are connected to the 3 phase 4 wire bus. The experimental grid can simulate the various distribution networks.

In this paper, we report on the MicroGrid Central Controller (MGCC) to manage the entire Experimental Grid system.

2 Configuration of EPGC Grid Central Controller

Fig. 1 shows the configuration of the Experimental Grid system at EPGC. Distributed Energy Resources are composed of the following equipment.

(1) 3 Diesel Generators (DG) of 40kW, 100kW, 200kW
(2) Photovoltaic (PV) System: 60kW
(3) Ultra-Capacitor (EDLC): 60kW ±30s, 90kW ±30s
(4) Lead-Acid (LA) Battery: 110kWh
(5) Lithium-ion Batteries (Li1, Li2): 2 × 20kWh

The following equipment are provided as programmable emulators that enables various experiments.

(1) Power Grid Emulator (PGE): 90kW 4 quadrant
(2) Wind Turbine Emulator (WTE): 10kW
(3) Programmable Load Banks (PLB) consist of three unit of 50kW, 150kW and 300kW

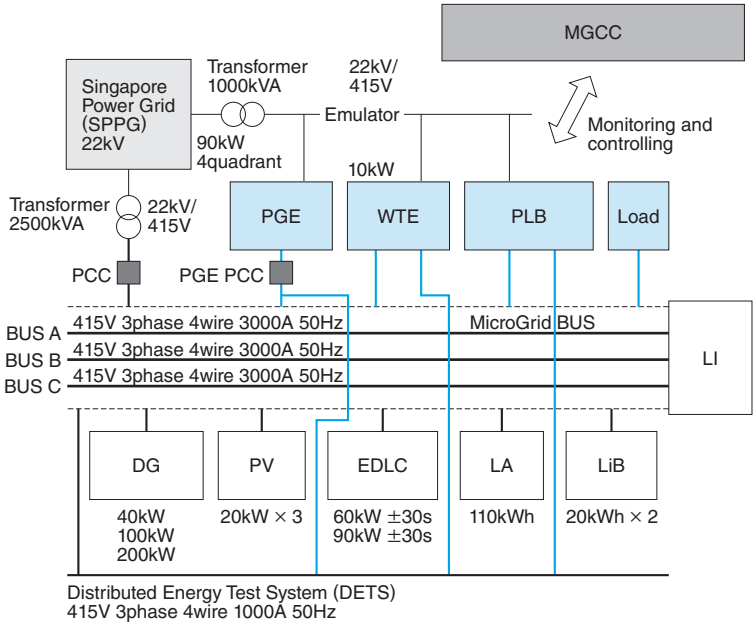

Fig. 1 Configuration of MicroGrid

Power systems composed of MicroGrids, various distributed energy resources, and a MicroGrid supervisory control unit (MGCC) used for these is shown.

The EPGC Grid can be operated in both Grid connected mode where it is connected to the supply network and in islanded mode. The grid can be operated using the PGE which allows a change in voltage and frequency. Therefore, this system can be used for experiments that simulate the power system conditions to verify the control and protection systems for DERs.

In grid connected mode it is necessary to continue to supply stable power to the target load using multiple DERs. Therefore,a constant power control at PCC has been implemented. On the other hand, in islanded operation it is necessary to maintain a constant voltage and frequency. In order to achieve these goals, the system control is performed by combining the control by the optimal operation planning pattern and Real-time load following control with the load following control by electrical storage system. Fig. 2 shows the block diagram of the system.

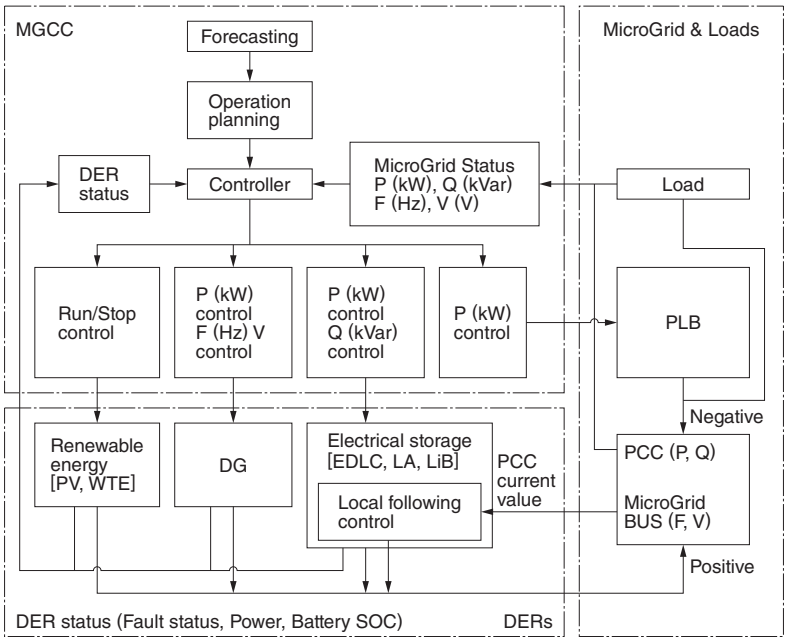

Fig. 2 Control flow of MicroGrid System

The diagram shows the control of distributed energy resources from the MGCC and the MicroGrid control conducted by the power storage system.

3 MGCC

MGCC is a computer system for monitoring and controlling of the whole facility MicroGrid EPGC, Monitoring facility of MGC is the 22kV distribution system in EPGC, 415V low-voltage system, distributed energy resources and simulated equipment, as shown in Fig. 3.

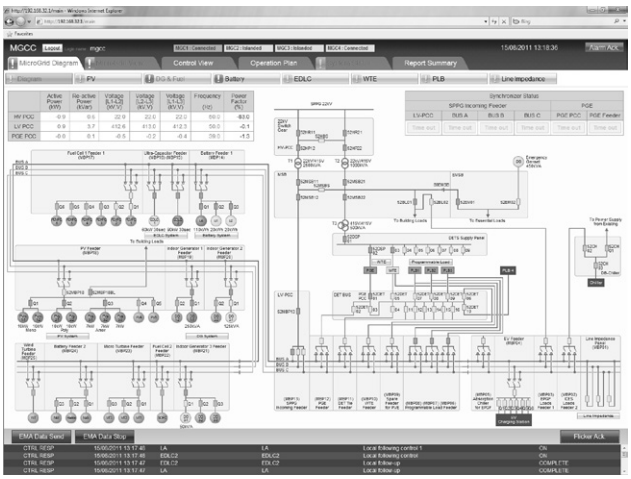

Fig. 3 Single Line Diagram GUI of MGCC

A supervisory screen of the MGCC is shown. This screen is used for the supervisory control of electrical facilities in the EPGC as a whole.

3.1 Controlling for MicroGrid

In grid connected operation, it sends the power output command to distributed energy resource from MGCC in accordance with the pattern of optimal operation plan that is created every hour. The grid central controller implements the real-time load following control for distributed energy resource with a period of 5 seconds while continuously monitoring the status of the power flow at PCC. It controls the power at PCC in the following period to complement the difference between the load demand and fluctuation of renewable energy power of the day.

In Islanded operation, DG is a source of voltage and frequency in this Grid, which has a drooping characteristic. Therefore, the frequency in the MicroGrid will fluctuate depending on power output of DG. The central controller will monitor the frequency in the micro-grid at all times, it control to the diesel generator so as to keep the frequency at 50Hz.

In the transition operation, the control is carried out to regulate the voltage of the diesel generator to be the same as the voltage of the coming power grid system.

Fig. 4 shows the GUI of MGCC. MGCC has four controllers,, it is possible to operate four simultaneous MicroGrids within EPGC.

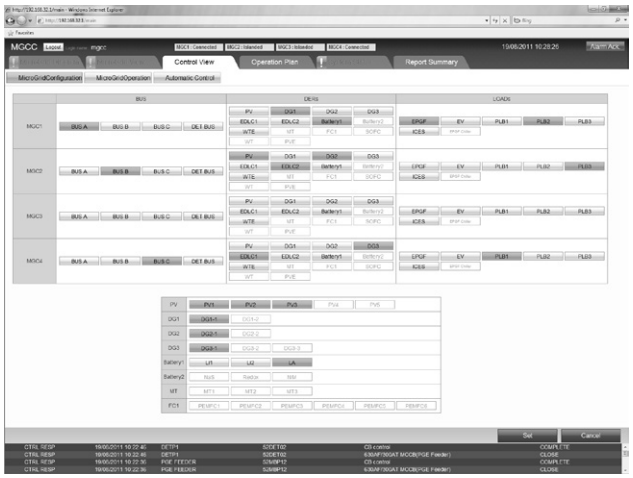

Fig. 4 MicroGrid Setting GUI of MGCC

A setup screen of the NGCC is shown for the operation of the MicroGrid.

4 Postscript

In this paper, we introduced overview of an experimental grid and its controller developed based on Meiden's expertise in Microgrids.

This project paves the way for future collaborative research with EPGC in area of MicroGrids.