The Application of IEC 61850 for Microgrid

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Abstract. This paper discussed the possibility of modeling Microgrid based on IEC 61850. IEC 61850 standard hit a great success in substation automation system with its good interoperability and three-level hierarchy structure containing substation level, bay level and process level. In addition, Microgrid took similar three-level control, which was therefore the application foundation. This paper tried a new application of IEC 61850 for Microgrid by modeling based on the unique characteristics of this standard, and finally built the Microgrid model.

Introduction

The smart distribution network recommended that its system applied the advanced information technology to realize the grid with digitization, informatization, automation and intelligentize. And then the smart distribution network could interact with users to meet the demand of key techniques.

The Microgrid is a certain kind of electrical network controllable system with micro energy equipment and local loads. It can not only operate by connecting to the grid, but also operate independently[1]. But many domestic factories that produce the distributed energy equipment and storage devices have their own communication methods and communication protocols like Modbus, IEC 60870-5-103 and IEC 60870-5-104, which reduces the interoperability between factories. For easy design for the information integration and control system, it is necessary to set up a communication consistency protocol for improving the interoperability between devices from different factories. But the concrete standard have not come up yet. While IEC 61850 is successfully applied in substation communication, this paper promotes the idea of extending its modules of data and communication service to the Microgrid for solving the interoperability between different kinds of devices.

Communication Data Structure for Microgrid

Overview of IEC 61850

IEC 61850 is a standard recommended by the International Electrotechnical Commission (IEC) originally for the design of substation automation systems[2]. Moreover, IEC 61850 is the foundation of the communication network in digital substation, regulating the configurations, modules, services, functionalities and syntax & semantic for the system and communication network.

Meanwhile, this standard has some unique characteristics so that it can be well applied to the Microgrid, which are information hierarchy, the information module isolated from communication protocol, data self-description, object-oriented unified modeling[3]. Based on the substation automation system functions of the control, supervisory and protection, IEC 61850 divides the system logically into three levels, namely the substation level, bay level and process level. It is a good idea to transfer this hierarchy to Microgrid. Figure 1 showed the hierarchy about the substation communication system.
Nowadays, the standard is mainly applied to the substation, but it doesn’t cover the application of the distribution automation (DA). However, due to the characteristics of IEC 61850, it’s possible to dig out the potential application for Microgrid in the DA area.

**Microgrid System Structure Design Based on IEC 61850**

Generally, the Microgrid consist of micro generation unity (wind power, Solar energy, fuel cell, diesel engine), load unity and storage unity. Furthermore, Microgrid takes hierarchy control to manage its system, and Figure 2 showed the topology structure about the Microgrid.

In Figure 2, RMC (Remote Manage Center) mapped into the Station Level in substation system based on IEC 61850. MGCC (Microgrid Center Controller) is for Bay Level and the rest were the devices in the Process Level. For every distributed power source, Microgrid system offered MC (Microgrid Controller), LC (Load Controller) and SC (Storage Controller) for stable operation. Figure 3 was the general model for Microgrid, which met the condition of IEC 61850 application from its topology structure. Thus, the IEC 61850-Based Microgrid Model was shown as Figure 3.

In IEC 61850, the Generic Object Oriented Substation Event (GOOSE) is widely accepted as the most important one of the data transmission services defined in IEC 61850. GOOSE is a fast connection-less communication service used for the transfer of time critical data where high speed and security are achieved by the messages repeated for many times. For Microgrid, GOOSE was used for connecting MGCC and MC with Distributed Energy Resource. In this figure, ECP (Electrical Connection Point) transferred the electrical parameters into Microgrid, which was regarded as an important component of the system. Comparing to IEC 61850, the distributed power source with its related controller and ECP was similar to Process Level in IEC 61850.
MGCC and MC were similar to the Bay Level in IEC 61850. RMC was mainly for Microgrid energy management, thus regarded as the Station Level.

![Figure 3. IEC 61850-Based Microgrid Model.](image)

**Modeling for Microgrid**

This part aimed at modeling for the DER devices, ECP and MGCC in the grid. DER devices offered the functions of telemetry, telecontrol and telesignalling. ECP transferred the electrical parameters into the system, and MGCC was for coordinating all kinds of control.

**Modeling for DER Devices**

As for devices, this paper took photovoltaic generator as an example. Based on related researches, most articles built models for DER devices by using some new logical nodes, but this paper found a new modeling method, which took the whole photovoltaic generation system as a entirety putting all the measurement parameter in a GGIO (General I/O). By using this simple method, we can avoid using logical nodes that we are not familiar with. The concrete model was shown as Figure 4.

![Figure 4. The modeling for photovoltaic generator.](image)

This paper regarded photovoltaic generator as a logical device named as PG and gave a prefix “pgp” to GGIO which meant photovoltaic generator panel and included all the measurement parameters. After finishing modeling, all the parameter would find related data objects in the model. For example, the temperature about photovoltaic generator panel will store in “PG/pgpGGIO.AnInl.mag.f”. MV was used for measurement, SPS for telesignalling and SPC for telecontrol. Besides, this method was suitable for other distributed energy resources.

**Modeling for ECP**

For ECP modeling, this thesis chose the Logical Node from IEC 61850-7-420, including DCRP, DOPR, DOPA, DOPM, DPST, DCCT, DSCC, DSCH, XCBR, CSWI, MMXU, MMTR\(^{[9-12]}\). The IEC model for ECP modeled by UML (Unified Modeling Language) was shown as Figure 5.
Modeling for MGCC

From Figure 3, in addition to ECP, there were existing LC and SC, therefore, this paper built IEC 61580 UML model for LC and SC in the same way, including CSWI, ZLAD, ZBAT, ZBTC, XCBR, MMTR for LC and ZBAT, ZBTC for SC, as shown in Figure 6 and Figure 7.

Figure 5. ECP of IEC 61580 Model.

As the core of the Microgrid, MGCC coordinated with MC, LC and SC to manage the energy generation and the storage[12]. The coordinating process guaranteed the smooth transition between
connecting the electrical network and disconnecting it. In this section, we need to use the logical node from IEC 61850 7-420 for its modeling. What’s more, this paper choose some typical logical nodes for modeling MC because IEC 61850 7-420 contained too many logical nodes for energy. Figure 8 showed MGCC model and Figure 9 showed MC model.

![Figure 8. MGCC of IEC 61580 Model.](image)

![Figure 9. MC of IEC 61580 Model.](image)

The MGCC couldn’t control or supervise ECP directly. It must realize related functions through a DER controller. DER controller was a Logical Device including Logical Node of LLN0, LPDH, DRCT, DRCS, DRCC, MMXU and CSWI, as shown in Figure 10.

![Figure 10. DER Controller of IEC 61580 Model.](image)
Conclusion

IEC 61850 is an international standard for communication networks and systems proposed originally for applications within the substations, which was later extended to cover systems outside substations as well. The purpose of this paper is to demonstrate through practical examples that the features of standard could be utilized for Microgrid. Based on the data model of IEC 61850, This paper maps the related Microgrid models into the three-level hierarchic structure of IEC 61850 applied in the substation system. And then this paper demonstrates the Object Oriented (OO) approach of IEC 61850 through modeling some important devices, especially for MGCC.

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