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Research of a method for Synchronized Phasor Data transmission Based on IEC61850

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Abstract. At present, the communication services for the Wide Area Measurement system in intelligent substation don’t use the IEC-61850 system yet, which causes a lot of inconvenience and problems. In order to solve these problems, this paper proposes a method of Synchronized Phasor Data transmission based on IEC-61850. In this method, the communication services of Wide Area Measurement system are converted to IEC-61850 system, and find a way that can map the existing functions to the IEC-61850 system. Firstly, a method for high-speed data transmission and fast control is proposed. Then functional services that cannot be fully implemented by IEC-61850 services are expanded to fill the gaps in a prescribed way. Finally, from the perspective of unified substation information platform, the prospects of this scheme are analyzed.

1. Introduction

Intelligent substation is a more advanced application based on digital substation[1]. In order to make an intelligent substation “smarter” with some prominent features, multiple information systems representing the characteristics of “Information Isolated Island [2]” within the substation shall be integrated so as to integrate all the information on a single unified platform [3], avoid waste of resources due to information data repeatability and achieve information interaction among different information systems, thus providing a much “smarter” advanced application.

After years of development and construction, power system has increasingly high requirements on power quality and stability control. Application of the wide area measurement system also becomes more widespread, which is vital for monitoring the dynamic characteristics of the power system which cannot be obtained from the traditional real-time monitoring system [4-6]. At present, equipment and systems with different functions within the intelligent substation have gradually completed resource integration and information unification. Multiple information systems such as the real-time monitoring system, the information protection slave station, the fault recording system, the on-line monitoring system of primary equipment and the power energy collection system have already achieved an information communication system based on IEC-61850. Therefore, it is imperative for conversion of wide area measurement system based on synchronized phasor data acquisition system to IEC-61850 information communication system.

Although 61850 modeling of synchronized phasor data is described in Q/GDW 1844-2012 Technical Specification for Synchronized Phasor Measurement Units for Intelligent substations[7] in China, the description only contains the outline of modeling and no clear definition of information service is made. Therefore, the traditional transmission protocol is still used in practical application, making the synchronized phasor data acquisition system still isolate from other information systems.
In order to realize an information system based on IEC-61850, this paper proposes a method of synchronized phasor data transmission based on IEC-61850. In this method, the functions of synchronized phasor dynamic data transmission, on-line management and off-line data query will be completed based on IEC-61850 communication protocol so that the information of synchronized phasor data acquisition system is integrated into the information system of the intelligent substation in a standard interaction method.

2. Existing Synchronized Phasor Transmission Method
At present, the 1344 protocol is used for transmission between synchronized phasor units and WARMS master station. Two common versions of the protocol are Q/GDW 131-2006 Technology Guidance of Power System Real Time Dynamic Monitoring System [8] and GB/T 26865 Real-time Dynamic Monitoring System of Power System [9]. The major difference between the two versions is the definition of the server and that of the client in the data channel, where the former defines the master station as the server and the latter defines the slave station as the server. The functional service is completely the same and the fields generated in the message are slightly different. Seeing from functional services, there is no difference between the two versions.

2.1 Overview of existing Synchronized Phasor transmission mode
At present, synchronized phasor data are collected and calculated by each acquisition unit first, and a self-describing file CFG1 of the acquisition unit is generated to describe its own functional configurations simultaneously while the phasor data are generated. Afterwards, the self-describing file of each acquisition unit will be integrated by data concentrator to produce a complete self-describing file CFG1 of all the information within the substation and summarize synchronized phasor measurement data of all the acquisition units, realizing data interaction with the master station in the form of complete self-describing information and data.

Fig. 1 Structure for Synchronized Phasor Data transmission in intelligent substation at present

2.2 Significance of changing existing transmission mode
Since an exclusive protocol is employed by the synchronized phasor data acquisition system at present, it is necessary to establish a separate network system physically in the construction of intelligent substation, as shown in the figure below:
At present, sampled data within the intelligent substation are completed by the same unit of the process layer in a unified manner, providing a basis that the measurement of synchronized phasor, real-time measurement value and electric energy can be finished in the same unit. Although the data network of the process layer has completed unification, the transmission of synchronized phasor data to the upper layer has not been unified into IEC-61850 system. The measurement unit must provide a separate physical network card to form a separate network to the upper layer, making the synchronized phasor data acquisition system substantially separate from other information systems.

Since both the process level and the bay level have finished unification, the integration to IEC-61850 system for the transmission mode of synchronized phasor data to the master station is significant. Once the transmission of synchronized phasor data is converted to IEC-61850 system, a network structure of information system will be directly reduced physically. Meanwhile, synchronized phasor data are no longer separate data and they will be integrated into the network of station level together with other information within the substation, making it possible to analyze problems through combined use of synchronized phasor data and other data information.

3. Overview of Synchronized Phasor Data Transmission based on 61850

After IEC-61850 system is employed by synchronized phasor data acquisition system, the synchronized phasor data will form a unified data service interface for the station level. Master stations of any level or with any functions may only need to access to the network of the station level to simultaneously access to synchronized phasor data service and services of other information systems with the standard and uniform access method, as shown in the figure below:

As shown in Fig.3, if synchronized phasor data acquisition system completes the conversion to IEC-61850 system, data of various units of the bay level will be uniformly integrated into the network of the station level. The system network will be clearly divided into two layers. If other information systems are required to obtain synchronized phasor data for advanced applications, they can obtain
data from the station level. On the other hand, if WARMS master station needs information except for synchronized phasor, such as various emergency signal and device alarm, it can also obtain relevant data from other information systems via the network of the station level.

4. Research of a Method for Synchronized Phasor Data Transmission Based on 61850

Main functions of the synchronized phasor acquisition system include:
1. Dynamic data transmission
2. Off-line data query
3. Management

Now we will conduct a research on how to realize these functions in IEC-61850 system.

4.1. Dynamic data transmission

Dynamic data transmission includes the transmission of phasor, analog and state.

(1) The application of phasor and analog requires high density data to form time section. Therefore, a very high transmission speed is necessary. It is not feasible to use MMS message with a low speed and transmission has to be carried out by SV message at the station level. The IEC 61850-90-5 part has defined the R-MSVCB data control block[10], which is used for transmission of SV message at the station level.

(2) In order to realize the quick control launched by the master station and that triggered by the received state signal, it is necessary to provide a state transmission service with high transmission speed and fast response, which cannot be satisfied by low-speed MMS of the station level. Then the IEC 61850-90-5 part has defined the R-GOCB data control block for transmission of GOOSE message at the station level to the master station so as to realize the demand on high-speed transmission of state and application of quick control of the master station.

Process of interaction for dynamic data is as follows:

4.2 Off-line data query

Due to lots of synchronized phasor data, it is necessary for the local measurement unit to store all the dynamic data to form dynamic data files. Meanwhile, in case of system disturbance, the synchronized phasor measurement unit will generate recording files with local storage. The master station needs to query the dynamic data files and recording files with local storage when analyzing disturbance.
4.3 Data management function

4.3.1. Open or close dynamic data
Opening or closing dynamic data is completed by writing services of the characteristic value SvEna of R-MSVCB control block. When the characteristic value is written as True, dynamic data transmission is opened; when it is written as False, dynamic data transmission is closed.

4.3.2. Change dynamic data transmission speed
Similar to sampled data of the process level, dynamic data are also measured values with high density and equal time intervals. Therefore, the dynamic data here can be regarded as sampled data, with the transmission speed as the sampling rate. In this way, transmission speed can be set based on the characteristic value SmpRate of R-MSVCB control block.

4.3.3. Upload self-describing file CFG1
In IEC-61850 system, the self-describing file is ICD file. The master station obtains the ICD files of slave stations with two methods: the first one is off-line mode, which means the off-line production of SCD file containing ICD of slave stations. The master station may obtain ICD of slave stations by reading SCD files. The second one is on-line mode, which means direct on-line reading of ICD information of slave stations through directory services. This mode is applicable to slave stations with less information. If ICD of slave stations contains much information, this mode will be very time consuming.

4.3.4. Download CFG2 file
Since dynamic data covers all the data collected in the whole station, data in real-time transmission by the master station at ordinary times are only a part of all the data. It is necessary to provide the master station with the function to transmit the selected data from all the data of the whole station.

Here, it may be realized by custom data set of IEC-61850. As loss of custom data will occur when power is down, an interaction process is defined here to ensure the correctness of phasor transmission, as shown in the figure below:
Fig. 6 Process of data enable when power is on

5. Conclusion
It is feasible and significant to convert synchronized phasor acquisition system to IEC-61850 system. This method integrates the synchronized phasor acquisition system and other information systems of the substation on a single unified platform, closely connecting the originally isolated information with the information of other information systems, which provides a basis for conjoint analysis of information. In the future, with integration of various information systems, simplification of repeated data acquisition, unification of repeated data transmission and integrated application of various system data, the means of conjoint analysis will become more and more mature, making it possible to conduct unified analysis and process of information from multiple substations within a region in order to complete macro overall control.

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