Research of Smart Microgrid Energy Monitoring System based on EMS

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Keywords: Microgrid; Monitoring system; Multi-energy complementary; EMS.

Abstract. A kind of microgrid energy monitoring system based on Energy Management System (EMS) is researched in this paper. A professional compound energy power station integrated automation remote monitoring system for multi-energy complementary microgrid system is developed. Control board of energy management system is developed by DSP + CPLD, control interface is developed by Zijingqiao software. The software development platform realized remote start and shutdown control for each distributed generation unit of internal microgrid. Power monitoring system can calculate and display the cumulative generating capacity, and it has data report functions and can alarm when parameters are beyond the limits. The monitoring system achieved historical data storage and playback of microgrid power plants based on database management mode; it achieved good monitoring and management to power plant.

Introduction

With the development of economy, the drawbacks of ultra-large-scale power systems are also becoming increasingly apparent as the rapid growth in electricity demand and the expanding of power grid ^[1]. Run stability of traditional power network is poor, traditional power network is difficult to adapt user's requirements of electrical safety and reliability as well as diversification of supply needs. Microgrid is a kind of autonomous system which can achieve self-control, protection and management. It relies on its own control and management functions as a complete power system to achieve power balance control, system operation optimization, fault detection and protection, power quality control function, etc. Microgrid has tremendous energy consumption on aspects of reducing energy consumption, improving power system security and reliability, etc. It meets smart grid's demand of build flexible, energy clean, system safety, resource economical and friendly ^[2, 3].

But there are also many problems on microgrid itself. Most of distribute generation are new cleanning energy, system stability is poor, control is difficult. Due to the complexity of Microgrid system, it is necessary to monitor microgrid system effectivily, grasp the state of distribute generation in Microgrid, detect power quality ^[4], improve power generation stability and efficiency. Currently professional development of remote monitoring technology for microgrid is still not mature enough; microgrid power utilization efficiency is low.

Composition of Multi-energy Complementary Microgrid

Multi-energy complementary microgrid system is composed by three distributed micro generations of photovoltaic power generation, wind power generation and energy storage system, as shown in Fig. 1. All of the distributed generations are integrate controlled by an energy management system (EMS). EMS can achieve the purpose of smooth operation of the whole microgrid system by optimizing energy storage. When the grid under normal circumstances, multi-energy complementary microgrid system can complement each other and connect to the grid system to maximize the use of new energy sources. When the grid is unnormal, in case of power failure, microgrid quickly cut off from the local grid, at the same time the non-sensitive loads are cut down to assure uninterruptible

power supply requirements for sensitive loads. Microgrid based on EMS can improve power supply quality effectively.

Fig.1 The Structure of wind/PV/storage Microgrid System

Microgrid Monitoring System Architecture

The microgrid energy monitoring platform based on EMS is composed by the following parts: the man-machine interface, local monitor, Industrial Personal Computer (IPC), EMS, isolated RS485 hub, remote monitor, etc., where the local monitor sets man-machine interface. Local monitor connects with IPC through isolation RS485 hub^[5, 6]. The remote monitor receives IPC's data through the network transmission, IPC connects with EMS. EMS is provided with a main control board and the input and I/O ports, which is connected with the isolated RS485 hub. It collects information of distributed generations, energy storage and battery management system (BMS), load, the bidirectional converter PCS, grid monitoring meter through various distribution isolated RS485 hub. Ethernet communication is used for communication between IPC to EMS, as shown in Fig. 2.

Fig.2 The wind/PV/storage Microgrid Monitoring System Structure

Man-machine interface of the Monitoring System

Monitoring interface is developed based on Zijinqiao configuration software platform, which is professional integrated automation remote monitoring software for multi-energy power plant system. This software is capable of remote start and stop control in internal microgrid system and each power generation unit (inverter) among this system. This system can calculate and display the cumulative generating capacity and show message such as sunshine, wind and other environmental parameters. It also has data report functions and can alarm when parameters are beyond the limits. The monitoring system achieved historical data storage, playback, daily and monthly report of power plant based on database management mode. Multi-energy complementary microgrid remote monitoring system can effectively improve the remote integrated automatic measuring and control levels of power plants. Power remote monitoring system take the technical maturity of C language development, it is easy to software debugging and relate function extensions.

Fig.3 The Monitoring System software of Each Level

All menus of monitoring software and man-machine interface are divided according to their functional properties. Function boundaries of the software is clear, ease of operation, the function structure is shown in Fig. 3, the user can click a button on the navigation bar to enter the corresponding menu.

The first level menu includes: total system diagram, control interface, the main interface, data query, the real-time database, alarm window, logging and operation guide;

The second level menu includes: integrated control, load control, wind power control, photovoltaic control, daily reports, monthly reports, event logging, the operation records, etc.

Control Interface of Monitoring System

Control interface is one of the main work interfaces of this monitoring software. It is responsible for system control in each power generation unit (inverter), includes start, stop, control and operation mode switching. As shown in Fig. 4. Operation interface are consist of seven parts.

Host storage integrated control and BMS control. The wind/PV/storage Microgrid monitoring system adopt methods of a master-slave control, storage as the main control system. Only when the storage operating or connect with the network, other slaves can be put into operating, otherwise it is prohibit running. There are two communication status: normal or overtime. Black start and prohibit can choose manually according to the situation. Host storage consolidated control can be achieved on and off-grid control. The grid and off-grid conditions are mutually exclusive. Here grid and off-grid conditions are stes in terms of energy storage.

Running and load control. When the storage is operating or connect with the grid, the ayatem can control the rest of the equipment, there are two modes to control: manual and automatic mode. All slave machine control can achieve all slave communication modes switch and slave machine state control of on or off. As well asl communication indicator. Where loads refer to controllable loads, which can be put into running and removed, and display its status by the indicator with the communication button and restore button.

Distributed Generation control. Wind power and PV are the main distributed generation in this system. Wind power system operating status can be divided into solution brakes and brake failure

types. Fault types are divided into self-protection and security. PV system operating states are divided into standby, start, connect with the grid, abnormal shutdown, shutdown. normal Fault types are divided into faults and fault types. Active power decrease rate instructions and reactive power compensation power factor can be filled in the percentage.

System Control. Microgrid system control can control the overall operation of the system and display. The operating states of each device are distinguished by different colors, green represents run, gray represents stop. Control interface monitoring four parts, includes storage monitoring, load monitoring, wind power monitoring system and photovoltaic system.

Fig.4 Operation Interface Screenshot - Control Interface

Data Storage and Alarm

The system can check operating data by daily reports and monthly reports of microgrid system. Daily reports can query the report of the day before and after. Monthly reports can query the data of previous month and next month. Historical data of any day or month can also be checked. The data documents can be printed. Alarm window mainly record data anomalies occurred, shows their types. Diary records include the events and operating records. Events records are started by software, operating records are taken notes on changes of certain parameters.

Fig.5 Operation Interface Screenshot - Data Query Interface

Real-time database is a platform for backend data processing. This function achieved data storage and displayed the corresponding changes. The database is consisted by scripts and point

configuration, the scripts are simple software programs, and point configuration is the most important part of the software functions. On the one hand, it is connected to the interface, on the other hand it is connected with the drive, data query interface is shown in Fig. 5.

Conclusions

Monitoring platform integrated monitoring and control functions of multi-energy complementary Microgrid. It realized data analysis and fault alarm. Data of multi-energy complementary microgrid system transports to smart EMS through isolate RS485 Hub, EMS makes data processing, analysis and logical judgments for data. The real-time information transmitted over the network to a remote monitor, which achieved remote monitoring and fault diagnosis to multi-energy complementary Microgrid system. The smart system's safety and distributed energy sources efficiency of multi-energy complementary microgrid is raised by collecting running information, local and remote monitoring and control to the Microgrid system. It realized remote, intelligent, real-time and accurate monitoring to microgrid.

Acknowledgements

This work was financially supported by the National 863 Project for "Regional distributed photovoltaic system integration technology research and demonstration" (Project No. 2011AA05A308). It was also supported by the International Science and Technology Cooperation project for "Microgrid Technology Research and Demonstration for Smart Grid Application" (Project No.2014DFG62610), the TNA project of grant No. TF012536 and Shanghai Municipal Commission of Economy and Informatization program (Project No.ZB-ZBYZ-04-13-2906).

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