Monitoring and Management Technical Research for Battery Energy Storage

Zhong Xue(✉), Bei Dong, and Yao Zhang

Nanjing SAC Power Grid Automation Co., Ltd., Nanjing 210003, China
774708256@qq.com

Abstract. Battery energy storage technology plays an indispensable role in the application of renewable energy such as solar energy and wind energy. The monitoring system of battery energy storage is the key part of battery energy storage technology. This paper presents a battery energy storage monitoring system, which can monitor the voltage and temperature of the battery in real time through the visual human-computer interface, can support authority management, can support protection and control actions such as battery access and connection, can regularly analyze and summarize battery performance indicators, and can support IEC61850 EMS and PCS power conversion. It is proved that the system can obviously improve the control efficiency of battery energy storage, improve human-computer friendliness and reduce the cost of manpower.

Keywords: Battery energy storage · Monitoring · Battery cluster · Human machine interface · Authority management

1 Introduction

Battery energy storage technology plays an indispensable role in the application of renewable energy power generation such as solar energy and wind energy. The monitoring system of battery energy storage is the key part of battery energy storage technology. The current battery energy storage schemes mostly build battery energy storage warehouses with a large number of lead-acid batteries and Ni MH batteries, and the batteries are densely placed according to different categories. However, due to the small space in the battery energy storage bin, strong chemical smell and poor temperature, humidity and light environment, it is not suitable for manual operation. The current battery energy storage solutions mainly have the following disadvantages: first, there is a lack of visual battery energy storage monitoring equipment. If people don't enter the warehouse, they can't get the key information such as battery real-time voltage and temperature; Second, there is a lack of man-machine remote control means for battery protection operation. The access, connection and switching of batteries must be operated manually, which is very dangerous and inefficient [1, 2]; Third, lack of means to obtain long-term battery monitoring data, unable to analyze battery performance and power consumption trend;

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Fourth, it does not support the communication connection with the monitoring background through IEC61850 protocol; Fifth, power conversion with PCs is not supported. Aiming at this series of pain points, this paper proposes a battery energy storage monitoring system that supports visual operation, real-time monitoring of battery voltage and temperature, remote battery protection operation, data storage, IEC61850 background monitoring and PCs cooperative operation.

2 System Architecture

The system architecture design is mainly composed of the following sub units: battery box management unit (hereinafter referred to as BMU), battery cluster management unit (hereinafter referred to as bcmu), battery bin information management unit (hereinafter referred to as bimu) and external communication unit. Battery box management unit (BMU) is the smallest management unit of the system. The system usually puts 12 energy storage batteries in an independent battery box [3]. BMU is used to monitor the voltage, temperature, alarm and other information of these 12 single batteries. A battery box contains 12 batteries, which is the factory default value of the system and can be configured and adjusted according to the actual situation. Battery cluster management unit (bcmu) is the management unit used to manage the battery box of the system. The system usually places 20 BMUs in a battery cluster box, and monitors, controls and transmits the information generated by 20 BMUs. One battery cluster contains 20 battery boxes, which is the factory default value of the system and can be configured and adjusted according to the actual situation. Battery bin information management unit (bimu) mainly has the following five functions: first, bimu provides a visual human-computer interaction interface to facilitate field personnel to monitor battery clusters, battery boxes and battery information in real time. Second, bimu provides authority management for different personnel roles to improve the security and reliability of bimu; Third, bimu can distinguish real-time data, give abnormal alarms, and provide a visual interface for protection operations such as access, connection and switching of battery clusters and battery boxes; Fourth, bimu provides can communication interface, RS-485 communication interface and Ethernet interface to interact with each unit; Fifthly, bimu provides SQLite database for persistent energy storage battery data for subsequent analysis and display. The external communication unit is not a sub module of the system, but it is two communication units that generate more information interaction with the system [4]. They are IEC61850 background and PCs energy storage converters respectively.

The overall architecture design of the system is shown in Fig. 1.

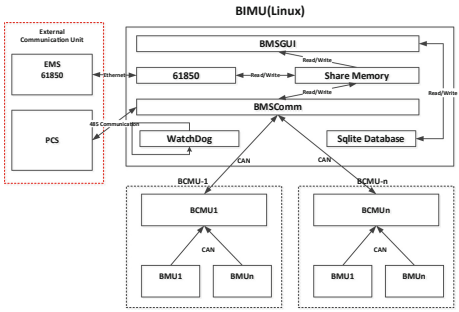

Fig. 1. System framework design

3 Module Design

As mentioned above, the system is mainly composed of three sub units. This chapter mainly introduces the detailed internal design of each sub module.

3.1 BIMU

Battery compartment information management unit (bimu) is an embedded tablet device developed using QT based on Embedded Linux environment. Bimu shell is made of aluminum alloy, with high-strength structure and excellent heat dissipation performance [5]. At the same time, the surface adopts metal wire drawing process, which is beautiful, atmospheric, firm and durable. The hardware parameters of bimu are shown in Table 1.

Table 1. Hardware parameters.

Name	Parameters
Shell length	246 mm
Shell width	180 mm
Shell depth	35.6 mm
weight	1.6 kg
Screen size	190 mm × 140 mm
cpu	ARM Cortex A8,1 GHz
Memory	Inline 512M DDR3 SDRAM
Static storage	Inline 512M NAND-Flash

The software architecture of bimu consists of the following modules: battery management interface module (bmsgui), battery communication module (bmscomm), battery management database module (bmsdb), IEC61850 module (bms61850).

Battery management interface module: This module mainly supports the application function of battery monitoring and management and provides corresponding man-machine interface for operation. The application functions of battery monitoring management include real-time information collection, real-time data calculation and discrimination, battery status alarm protection, setting setting setting value, battery data storage, battery historical data statistics, B-code timing, fault recording and personnel authority management [6]. The module is designed and written in embedded QT language. Among them, real-time information collection refers to the real-time collection of battery cluster information and alarm, battery box information and alarm, battery voltage and temperature, which is mainly used for the display of battery bin, battery cluster and battery box in bmsgui. Data real-time calculation and discrimination refers to the algorithm discrimination of the data collected in real time, and the alarm operation or protection operation shall be made for possible abnormalities. Setting fixed value refers to setting the value range for the parameters of battery bin, battery cluster and battery box, and supports dynamic adjustment of the upper and lower limits of the value range. Battery data storage refers to persisting can message, RS-485 message, 61850 message, battery temperature and voltage information and system operation records received by bimu into SQLite database, and providing interface to support addition, deletion, modification and query. Battery historical data statistics refers to the analysis and display of battery data storage records [7]. B code timing refers to the time calibration of bimu through the B code timing interface. Fault wave recording refers to the automatic wave recording operation for a period of time when an abnormal alarm occurs on a battery and is saved in the standard COMTRADE file format. Personnel permission management refers to providing different permissions and passwords for different operators to avoid misoperation [8].

Battery communication module (bmscomm): This module mainly has five functions: first, create and refresh shared memory in real time; Second, periodic data interaction through shared memory and bmsgui; Thirdly, real-time data exchange with bcmu through can communication protocol; Fourth, data exchange with PCs through RS-485 protocol; Fifthly, bmsgui is notified of real-time displacement alarm through socket. The module is designed and written in embedded QT language.

Battery management database module (bmsdb): This module mainly provides SQLite database interfaces for bmsgui and bmscomm, such as adding, deleting, modifying, querying and batch transaction operations. The module is designed and written in embedded QT language.

IEC61850 module (bms61850): This module mainly supports data interaction with external devices through MMS and goose communication protocols. The module is designed and written in C language.

The overall architecture design of bimu is shown in Fig. 2.

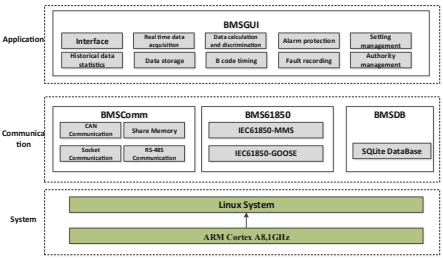

Fig. 2. BIMU framework design

3.2 BCMU

Battery cluster management unit (bcmu) is a management unit for battery cluster box developed based on single chip microcomputer using C language. Bcmu has three main functions: first, collect information points on the battery cluster box; Second, summarize the can messages sent by BMU through can communication; Third, after analyzing the information collected by the first and second functions, reorganize the can message and send it to bimu [9].

There are 29 kinds of can messages sent from bcmu to bimu. The trigger conditions and transmission frequency of each message are different.

3.3 BMU

Battery box management unit (BMU) is a management unit for battery box and single battery developed based on single chip microcomputer using C language. BMU has three main functions: first, collect information points on the battery box; Second, collect the information points on the single battery in the battery box; Third, summarize all collected information points into can messages and send them to bcmu [10].

There are 11 kinds of can messages that need to be sent from BMU to bcmu. The trigger conditions and transmission frequency of each message are different. Some message information is shown in the figure below (Figs. 3, 4).

Trigger mode	Frame No.	0Bit	1Bit	2Bit	3Bit	4Bit	5Bit	6Bit	7Bit	Frequency /ms
Timing transmission	0	Total Voltage	Total Voltage	TotalElectric Current	TotalElectric Current	SOC	SOC	Reserve	Reserve	500
Timing transmission	1	Max Voltage	Max Voltage	Max Voltage Number	Min Voltage	Min Voltage	Min Voltage Number	Reserve	Reserve	500
Timing transmission	2	Max temperature	Max temperature	Max temperature Number	Min temperature	Min temperature	Min temperature Number	Reserve	Reserve	500
Timing transmission	3	IC1 0 No. BatteryVoltage	IC1 0 No. BatteryVoltage	IC1 1 No. BatteryVoltage	IC1 1 No. BatteryVoltage	IC1 2 No. BatteryVoltage	IC1 2 No. BatteryVoltage	IC1 3 No. BatteryVoltage	IC1 3 No. BatteryVoltage	500
Timing transmission	4	IC1 4 No. BatteryVoltage	IC1 4 No. BatteryVoltage	IC1 5 No. BatteryVoltage	IC1 5 No. BatteryVoltage	IC1 6 No. BatteryVoltage	IC1 6 No. BatteryVoltage	IC1 7 No. BatteryVoltage	IC1 7 No. BatteryVoltage	500
Timing transmission	5	IC1 8 No. BatteryVoltage	IC1 8 No. BatteryVoltage	IC1 9 No. BatteryVoltage	IC1 9 No. BatteryVoltage	IC1 10 No. BatteryVoltage	IC1 10 No. BatteryVoltage	IC1 11 No. BatteryVoltage	IC1 11 No. BatteryVoltage	500
Timing transmission	6	IC1 0 temperature	IC1 0 temperature	IC1 1 temperature	IC1 1 temperature	IC1 2 temperature	IC1 2 temperature	IC1 3 temperature	IC1 3 temperature	5000
Timing transmission	7	IC1 4 temperature	IC1 4 temperature	IC1 5 temperature	IC1 5 temperature	IC1 6 temperature	IC1 6 temperature	IC1 7 temperature	IC1 7 temperature	5000
Timing transmission	8	IC1 8 temperature	IC1 8 temperature	IC1 9 temperature	IC1 9 temperature	IC1 10 temperature	IC1 10 temperature	IC1 11 temperature	IC1 11 temperature	5000

Fig. 3. BIMU and BMU CAN message

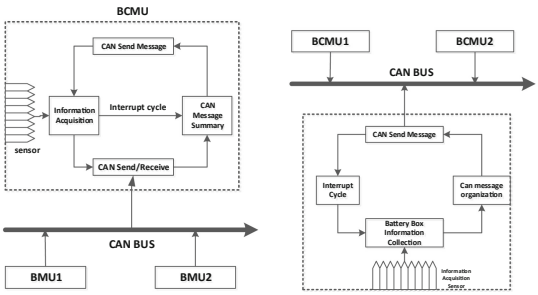

Fig. 4. BCMU and BMU framework design

3.4 External Communication Unit

External communication unit mainly refers to two parts: IEC61850 background EMS and PCs energy storage converter. These two parts are not the internal components of the system, but they are the two parts that communicate and interact most closely with the system. Therefore, this chapter only introduces and shows the data interaction part. Bimu and IEC61850 background EMS interact through iec61850-mms communication protocol to support IEC61850 background EMS to remotely monitor and control battery clusters and battery boxes [11]. Bimu and PCs energy storage converters mainly interact through RS-485 communication protocol to support PCs and bimu to cooperate to charge and discharge the battery.

The architecture of the external communication unit is shown below.

Fig. 5. External communication design

4 System Application

The system has been put into grid operation in Qinhuangdao Power Grid phase III energy storage project and Guodian Nanzi plant battery energy storage project. We take the real interface of battery compartment, battery cluster, battery box and displacement event of the system as an example.

The battery compartment interface of the system is shown in Fig. 5. At the top of the battery compartment interface is the company logo and function menu. The upper left side of the battery compartment interface is the battery compartment parameter name and parameter value. If there is any abnormal parameter value, the name will change to red font. The upper right side of the battery compartment interface is the battery compartment alarm name and alarm status. If there is an abnormal alarm status, the name will change to red font. The icons below the battery compartment are all battery clusters in the

compartment. If there are abnormal parameters and alarms inside the battery cluster, the battery cluster icon will turn red. At the bottom of the battery compartment interface are communication abnormal status, parameter abnormal quantity, alarm abnormal quantity, time and date.

Fig. 6. Battery heap GUI and battery cluster GUI example

At the top of the battery cluster interface is the company logo, battery cluster name and function menu. The upper left side of the interface is the battery cluster parameter name and parameter value. If there is any abnormal parameter value, the name will change to red font. The upper right side of the battery cluster interface is the battery cluster alarm name and alarm status. If there is an abnormal alarm status, the name will change to red font. The icons below the battery cluster are all battery boxes in the cluster. If there are abnormal parameters and alarms inside the battery box, the battery box icon will turn red. At the bottom of the interface are communication abnormal status, parameter abnormal quantity, alarm abnormal quantity, time and date.

The battery box interface of the system is shown in Fig. 6. At the top of the battery box interface is the company logo, battery box path and function menu. On the upper side of the interface are the parameter name and parameter value of the battery box. If there are abnormal parameter values, the name will change to red font. The lower side of the battery box interface is the voltage and temperature of all batteries in the box. At the bottom of the interface are communication abnormal status, parameter abnormal quantity, alarm abnormal quantity, time and date.

5 Conclusion

Conclusion this paper introduces the design idea and overall architecture of battery energy storage monitoring and management system from three aspects: system architecture design, detailed module design and system application.

The system is characterized by: first, it provides a visual battery energy storage monitoring equipment, which can obtain the key information such as real-time voltage and temperature of the battery outside the battery compartment through the liquid crystal interface; Second, it provides the means of interface remote control battery protection operation. The battery access, connection and switching do not need manual operation, which reduces the risk of manual operation and improves the operation efficiency; Third, it provides a means to obtain the long-term monitoring data of the battery, which can

regularly analyze the battery performance and power consumption trend; Fourth, support the communication connection with the monitoring background EMS through IEC61850 protocol, and support the remote control of the battery energy storage system by EMS; Fifth, support battery energy storage system and PCs to cooperate in power conversion. The actual operation and test results show that the scheme is feasible, correct and easy to use.

Practice has proved that the system will greatly improve the R & D and test efficiency of battery energy storage system, shorten the development cycle, reduce the development labor cost, increase product competitiveness and improve customer satisfaction.

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