Design and Application Analysis of Intelligent Low-voltage Switchgear Based on Internet of Things

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Abstract—Low-voltage switchgear is a key control device in the power distribution network, which integrates a large number of lines and power electronic components. Once a failure occurs, it will cause serious economic losses. With the continuous upgrade and expansion of the power system construction scale, the traditional low-voltage switchgear can no longer meet the requirements in terms of function or performance, and is replaced by a new type of intelligent switchgear. This paper designs an intelligent low-voltage switchgear based on the Internet of Things, real-time monitoring of temperature and key electrical parameters, and improves the reliability and maintainability of the switchgear.

1. INTRODUCTION
Low-voltage switchgear is a compound type that integrates power electronic components in the cabinet-type packaging space. The equipment, which mainly works in the power distribution system, can complete the functions of data collection, transmission and control, and is an important part of power distribution[1-2]. Today, with the development of Internet of Things technology, smart switchgear is gradually replacing traditional non-smart switchgear. The intelligent switch cabinet makes full use of the advantages of field bus, digital transmission, communication network, wireless tradition and other technologies. It integrates telemetry, remote adjustment, remote control, remote communication and other functions in one. It can be mastered by simple operation on the host computer[3-5]. Real-time working status of remote switchgear equipment. Once there is a device failure in the intelligent switchgear, the controller will quickly control the circuit breaker to disconnect the source of the fault, and at the same time send the detailed information of the fault to the remote monitoring center, so as to quickly arrange the technician to go to the site for repair, which not only improves the maintenance efficiency, but also Reduced the security risk of the power system[6-10].

2. DESIGN OF INTELLIGENT LOW VOLTAGE SWITCH CABINET BASED ON INTERNET OF THINGS
The intelligent low-voltage switchgear designed in this paper is based on the original equipment, further adding intelligent control devices and logic, and using the Internet of Things to complete the intelligent upgrade of the traditional low-voltage switchgear. Considering that the number of switch cabinets in the power grid is huge and scattered, the wireless communication mechanism is adopted in the communication method, and the cost effective CC2530single-chip microcomputer is the main control core, which controls the sensors to collect and transmit parameters such as temperature, voltage, and current in real time. Once the parameter exceeds the preset threshold, immediately start the fan and other equipment for adjustment to achieve remote monitoring.
The operation of the power system includes power generation, transmission, transformation, distribution and electricity consumption. At present, the vast majority of electricity used by consumer electrical equipment comes from low-voltage switchgear transmission, while in switchgear, low-voltage switches and electrical equipment (such as power meters and protection modules, etc.) play the role of control and protection, and are the core equipment of low-voltage switchgear. The functions of energy-efficient low-voltage switchgear should include detection, communication, control protection and daily maintenance, etc. Among them, the detection function is used to monitor important electrical parameters, such as voltage, current, harmonic content, power consumption, frequency, active power, reactive power, power factor, etc. The communication function transmits related data to the monitoring host through wired or wireless means, and realizes the "four remote" (telemetry, remote control, remote adjustment, remote signaling) operation of the low-voltage switchgear. Stability and anti-interference are often used in the field High RS485 interface. Control and protection functions include overcurrent protection, overvoltage protection and fault ground protection. Routine maintenance functions include systematic judgment and prompting of various early warning parameters such as high current connection point temperature, circuit breaker mechanical life, and electrical contact wear.

The schematic diagram of the structure of the intelligent low-voltage switchgear based on the Internet of Things is shown in Figure 1. The system consists of intelligent appliances and embedded tablet computers. Among them, intelligent appliances include intelligent universal circuit breakers, power meters, joint temperature rise measuring instruments, ground fault alarms, switch measuring instruments, and insulation status measuring instruments. The embedded tablet computer is a high-performance touch-control all-in-one computer for industrial control. It has the characteristics of ruggedness, shockproof, moistureproof, dustproof, high temperature resistance, multi-slot and easy expansion. It can be perfectly integrated with industrial configuration software. We can use the rich resources of the PC system to realize advanced and complex man-machine interface.

The intelligent low-voltage switchgear is developed and implemented using configuration software. Configuration software is a special software for collecting and process control of on-site production data. It provides various communication interfaces and software ports for the upper database and lower layer acquisition equipment, can communicate with the equipment of various manufacturers, and is combined with the network system. The configuration software provides a concise development environment and does not require system integration through programming. It provides users with a friendly development interface and a simple and convenient engineering implementation method. Engineers can achieve design goals quickly by assembling each module. Configuration software can greatly shorten the engineer's system integration time, improve its work efficiency, and make the operation very easy. It is particularly important to note that when we use the configuration software, we must follow the habit of electrical operation. The intelligent low-voltage switchgear developed by configuration software has the functions of monitoring display, alarm, user authority management, data management, equipment maintenance, network communication and so on.
Figure 1 Low-voltage switch cabinet structure based on Internet of Things

There can be multiple alarm formats for data over threshold, such as percentage. The alarm mode of this intelligent low-voltage switchgear includes alarm box, alarm data flashing, GSM short message alarm, mail alarm, telephone alarm and sound and light alarm, etc. The storage method of alarm data includes alarm summary table and sequence event record. Users use the search tools provided by the system software to search and print.

3. DETAILED DESIGN
The temperature monitoring module is mainly composed of a communication interface, a power module, a signal acquisition unit, and a switch output. The intelligent switchgear directly leads the 220V AC power line from the main bus. The transformer first steps down the high voltage signal, and then uses the LM3173 chip to regulate the output voltage stably, and finally provides the best working voltage and current for the single chip microcomputer. This design does not need to introduce an external power supply, avoiding the trouble of repeatedly replacing and maintaining the battery.

The temperature acquisition unit uses the MF521033950 type thermistor. The resistance value of the device at normal temperature is about 10k, or to meet the rapid temperature response of -20-120 °C, the measurement accuracy is relatively high, and it has a very compact structural design. Does not take up too much space. The thermistor converts the temperature change into a resistance value change, and finally converts it into a voltage signal through current, and then digitizes it by a high-precision A/D converter to complete the temperature collection. RS232 serial communication is used between
the microcontroller and the sensor. The microcontroller recognizes the sensor according to the sensor address and processes the temperature signal in real time. When the temperature exceeds the threshold, the fan is started to dissipate heat; when the temperature is below the threshold, the heater is started to heat up, so that the low-voltage switchgear always works under the best conditions. During failure or regular power failure maintenance, the remote switch cabinet needs to be opened and closed remotely, and the relay can be used to achieve this function. This system uses the TLP521 type relay, which is a photocoupler with the advantages of photoelectric isolation. Connect the relay with IP control equipment to realize remote opening and closing control.

The intelligent switchgear in this paper can achieve real-time real-time voltage, current and equipment online status measurement and transmission. Because the working voltage of the electrical equipment in the switchgear is 220V AC, the single-chip microcomputer cannot directly measure it, so the idea of voltage conversion is used to step down the 220V AC through the ZMPT101B voltage transformer. The voltage transformer is connected to the primary side through a large resistance to achieve a milliamp-level current output, which is then converted into a voltage signal through the resistor. Because the output current is extremely small, the voltage transformer almost runs in the no-load state, has a good linear relationship, and achieves a high measurement accuracy.

The traditional current transformer has high accuracy in the small current range, but it can not be well adapted to the measurement task of large current. Therefore, this paper uses the shunt scheme to complete the current collection. The shunt has the characteristics of non-magnetic saturation, low price and high accuracy, which can meet the measurement of large AC current, and is very suitable for current monitoring of low-voltage switchgear. In order to monitor the state of the equipment, this system uses a combination circuit of photocoupler, light-emitting diode and light-emitting transistor to identify the working state of the equipment, which can accurately reflect the opening and closing state of the equipment contacts and realize the circuit breaker and contactor. Waiting for the status monitoring of opening and closing of key equipment.

4. APPLICATION ANALYSIS
The intelligent low-voltage switchgear designed in this paper is applied in the distribution network of an administrative village in a suburb of a city. It can achieve automatic temperature control in high temperature and icy weather. It has successfully achieved automatic opening under multiple lightning strikes, and completed the closing quickly and accurately under the remote control of the staff on duty. The application results show that the low-voltage switchgear based on the Internet of Things has stable and reliable operation, convenient operation and maintenance, fast and accurate control response, which significantly improves the safety performance of the distribution network where it is located, greatly reduces the labor intensity of unnecessary human maintenance and high-volume operation and maintenance. The cost has achieved good economic benefits and has been recognized by users.

5. CONCLUSION
With the rapid development of technologies such as field, digital transmission, communication network, and wireless tradition, many power equipment manufacturing companies have begun to invest a lot of money in research and development of new intelligent switch cabinets, and continue to use new technologies and new processes. The increasing intelligence has injected new vitality into the construction of smart grids and other electrical systems. In the future of deepening industrialization and urbanization, the scale of the power system will be even greater, which provides a broad market space for the development of intelligent low-voltage switchgear.

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