On Line Monitoring System of Non-contact Infrared Temperature Measurement for Distribution Switchgear

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Abstract. This paper proposes online monitoring and early warning system based on MLX90640 non-contact busbar temperature measurement switchgear. It uses MLX90640 infrared sensor module to measure the temperature of the switchgear busbar and then uses the E30-433T20D wireless communication method to transmit the temperature data to the local terminal. The practice test shows that the temperature measurement point terminal can accurately measure the bus temperature and feed the temperature back to the local switchgear terminal, which can achieve high-precision temperature measurement and early warning of the temperature of the switchgear busbar and can abnormally the temperature of the busbar in the cabinet. The position is accurately positioned to facilitate fault condition maintenance, improve the reliability of the switchgear operation, and ensure the safety of the switchgear system.

Introduction

In the power system, the switchgear busbar is an important part of the electrical main wiring. It connects the various current-carrying branch circuits in the power distribution device and plays the role of collecting, distributing and transmitting electrical energy. The high-voltage current-carrying busbar often causes the temperature to rise due to contact point oxidation, loose contact, excessive load, phase-to-phase short circuit, poor heat dissipation environment, etc., causing overheating failure of the switchgear. Due to the narrow space structure in the switchgear and the high-voltage state of the busbar operation, direct manual inspection and temperature measurement is not convenient. Therefore, an appropriate temperature monitoring method is used to carry out online real-time monitoring and early warning of the temperature of the high-voltage current-carrying busbar of the switchgear. It is an important means to ensure the safe operation of the switchgear.

Electrical fires are important safety hazards in the operation of power distribution systems. Investigations show that electrical fires account for a high proportion of fires and may cause serious casualties and economic losses, affecting people's normal production and life. The power distribution cabinet is a high-incidence part of electrical fires, and the safe and stable operation of the power distribution system is closely related to people's production and life. It is also important to monitor and troubleshoot fire hazards in the safe operation of electrical equipment.

At present, point-type smoke/temperature fire detectors, common radiation-type smoke detectors and cable-type temperature detectors are commonly used in power systems. The point type smoke detector has low alarm sensitivity, passive detection, and the installation position are at the top. It is not suitable for fire warning of electrical equipment such as the main transformer of the substation. The ordinary on-line smoke detector requires a large amount of visible smoke to block the alarm. Its sensitivity is much lower than that of a point smoke detector. Moreover, the smoke detector is only an alarm of smoke after the occurrence of equipment fire. The process of fault formation is not
recorded. It is impossible to judge the formation of fire during the process of equipment aging and current change. It is impossible to carry out early warning and process the equipment in advance.

At this stage, infrared detection technology has a wide range of applications and relatively mature technology. Especially in the electrical fire early warning monitoring system, infrared thermal imaging technology has great superiority compared with the traditional fire monitoring method.

Compared with other temperature measurement methods, non-contact bus wireless temperature measurement has some advantages. The wireless temperature measurement system is reliable and stable in practical application, compact in size, simple in structure, easy to install and does not affect the structure of the switch cabinet. When the wireless temperature measurement module is applied to the switch cabinet, the structure of the switch cabinet does not need to be changed, only the installation location hole is punched at the location of the location installation to install, without affecting the various performances of the switch cabinet. At present, domestic and foreign power equipment manufacturers and scientific research institutions have developed a variety of on-line monitoring and early warning system for wireless transmission of temperature measurement on the bus of switchgear. The wireless temperature measurement system of the switch cabinet is developed based on the wireless temperature measurement technology. It can monitor and warn the temperature of the bus bar, upper and lower contacts, cable joints and other parts of the switch cabinet on-line in real time, so as to facilitate the operation and maintenance personnel and the remote monitoring center to master the operation of on-site on-off equipment.

System Hardware Design

This paper introduces on-line monitoring and early warning system based on MLX90640 non-contact busbar temperature measurement switchgear. The temperature measurement point terminal is powered by lithium battery plus a small volume MLX90640 infrared temperature sensor and E30-433T20D RF module. After the temperature measurement terminal detects the temperature, it transmits to the E30-433T20D receiving module of the local terminal through E30-433T20D wireless communication, and the local terminal can display the temperature and alarm information. Different switchgear local terminals upload the temperature and alarm information of each switchgear to the database server for storage management through network networking, and the client can simultaneously monitor the temperature and alarm information of different switchgear, the system can be used in this way to form a distributed online monitoring and early warning system.

![Diagram](image)

Figure 1. Block diagram of the monitoring system.

The whole system consists of three parts: data sensing system, wireless network transmission system and upper computer application system. According to the actual situation of the area, the data sensing system deploys infrared thermal imaging processor, microprocessor, wireless time-frequency module, etc. in the switchgear as the infrared thermal imaging monitoring terminal, and the wireless data transmission station as the base station of the wireless transmission system.
carries out the radio frequency communication between the platforms. The back-end deployment management platform, central storage, decoding, display, and other devices serve as remote data monitoring centers. The block diagram of the monitoring system is shown in Figure 1.

The principle of the temperature measurement point terminal hardware is to use the main chip STM32 to drive the MLX90640 infrared temperature sensor to collect the bus temperature of the anchor point on the bus. The temperature is transmitted from the main chip to the local terminal of the switchgear through the E30-433T20D radio frequency module. The local terminal of the switchgear compares the temperature of the busbar received with the alarm warning temperature value of each switchgear of the system to realize the alarm function. Figure 2 shows the block diagram design of the infrared thermal imaging monitoring terminal.

**Temperature Measurement Terminal Hardware Design**

The hardware design circuit diagram of the temperature measurement point terminal is shown in Figure 3. The hardware circuit is mainly composed of an integrated MLX90640 digital infrared temperature sensor and an E30-433T20D wireless RF hardware circuit.

**MLX90640 Digital Infrared Sensor**

The infrared temperature sensor captures the infrared energy radiated by all objects. Infrared radiation is part of the electromagnetic spectrum. Infrared is between the spectrum visible light and the radio waves. The infrared wavelength is usually expressed in μm, and the infrared spectrum ranges from 0.7 to 1000 μm. In practice, the infrared temperature measurement uses a wavelength range of 0.7 to 40 μm. The infrared temperature sensor is used to capture the spectral data of this band. The infrared temperature sensor is a sensor consisting of an optical system, photodetector, signal amplifier and signal processing, signal output, and other parts. The optical system converges the target infrared radiant energy in the field of view. The infrared radiant energy is concentrated on the photodetector and converted into a corresponding electrical signal, which is then converted into a temperature value of the measured object.

**MLX90640 Infrared Temperature Sensor**

The MLX90640 series is a digital high-precision infrared non-contact type temperature sensor chip manufactured by Melexis, an industrial standard and a fully calibrated 32*24-pixel thermal infrared array sensor, adopting a 4-pin TO-39 package and an I²C-compatible digital interface,
wherein the temperature range of the temperature-measuring sensor is -40~300 °C, and the temperature discrimination degree can reach 0.1 °C. Through the I²C interface, you can access the infrared array, the ambient temperature, and the VDD real-time data stored in the internal RAM.

Large capacity lithium battery is used to supply power to the temperature measuring point terminal. MLX90640 uses a fully compatible digital interface with I²C, which can communicate with MCU with this interface. MCU should be able to provide 2.6 V~5.0 V communication power supply, and the sensor can supply reliable power with 3.3 V supply voltage.

**E30-433T20D Radio Frequency Communication Circuit**

E30-433T20D is a wireless serial port module (UART) based on Silicon Labs original imported SI4438 RF chip, with characteristics of half-duplex, transceiver, transparent transmission mode, direct plug-in, and TTL level output. With a working frequency band for 425~450.5MHz (default 433MHz), 100MW transmission power and an air wake-up function (ultra-low power consumption), it is suitable for a variety of environments, thus the product has been mass production, a large number of applications in a variety of industries.

The module has a software FEC forward error correction algorithm, the coding efficiency is high, the error correction capability is strong, in the case of burst interference, the interfered data packet can be actively corrected, and the reliability and the transmission distance can be greatly improved. In the absence of FEC, such packets can only be discarded. The module has the function of data encryption and compression. The data transmitted by the module in the air is random, and the data interception is meaningless through the strict encryption and decryption algorithm. The data compression function has the probability to reduce the transmission time, reduce the probability of interference, and improve the reliability and transmission efficiency.

**On-Site Operation of the System**

In order to verify the feasibility of the system under the above theoretical analysis, our team built a set of thermal response experimental test system of distribution cabinet based on infrared thermal imaging technology.

![Thermal imaging in working state](image)

Figure 3. Thermal imaging in working state.

In order to reflect the transient thermal change process of the power distribution cabinet during the continuous operation, the infrared thermal imager is used to obtain the infrared thermal image in the working state of the power distribution cabinet, as shown in Figure 3.

It can be seen from the image that the comprehensive early warning and monitoring system of electric fire in the distribution cabinet can accurately and effectively reflect the change of temperature in the distribution cabinet and give feedback in time, which has good practicability.

**Conclusion**

This paper briefly introduces the principle of infrared temperature measurement and its sensor and puts forward a design scheme of on-line monitoring and warning system using MLX90640 non-contact busbar temperature measuring switch cabinet. The test results show that the system can realize the on-line monitoring and early warning function of high precision and high-speed response.
to the busbar temperature of the switch cabinet. Meanwhile, the terminal of temperature measuring point is small, the installation and positioning are convenient, and the wireless method is easy to be reconstructed, and the operation and maintenance of operation and maintenance of fault state is convenient, so as to ensure the safety and stability of the switchgear system.

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