

Research and Development of High Voltage Circuit Breaker SF₆ Monitoring Terminal

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Abstract: A integrative high voltage circuit breaker SF₆ monitoring terminal device is designed, researched and developed the sensor circuit and radio frequency wireless transmission circuit, real-time online monitor the density and water content changes of SF₆ gas and the trace leakage of the gas, then transmit the monitoring data to data analysis and management system wireless, and installed at work field then carried out the experiment.

1 Introduction

High voltage circuit breaker (switch) as one of the most important equipment of electrical power system, whether the three physical index which included the density, humidity and temperature of the breaker gas SF₆ are in the rated range actually determines the safe operation state of equipment, having an accurate and strict online monitoring for parameters, such as density and water content of SF₆ gas is an important means to ensure the safe operation of power grid SF₆ high voltage equipment.

The breaker monitoring terminal studied in this paper can real-time online monitoring density and water content change of SF₆ gas according to the pressure and temperature changes of GIS high voltage equipment which using SF₆ as insulating gas, it also can monitoring the trace leakage of gas, mastering the change of water content and density momentarily, then give an alarm or lock equipment timely, it convenient for SF₆ gas electrical equipment control, and can analysis the rate of trace leakage of gas timely in short term above alert density value by online monitoring the density and water content of gas, which can replace the impossible monitoring accuracy and reliable monitoring effect that monitoring principles of pressure gauge and density relay can't afford.

2 Monitoring terminal hardware system design of breaker SF₆

Monitoring terminal is mainly composed of four parts which include microcontroller circuit, pressure, humidity transmitters and AD sampling circuit, temperature sensor circuit, and RF transceiver circuit, the digital quantity, converted by temperature sensor are send to CPU to processing through the I2C_bus, the analog quantity after signal processing of humidity sensor and pressure sensor which convert by AD conversion will be send to CPU to processing, and the measured data will be transferred to the distant SF₆ gas monitoring data acquisition relay unit through the wireless radio-frequency circuit. The overall structure is shown in figure 1.

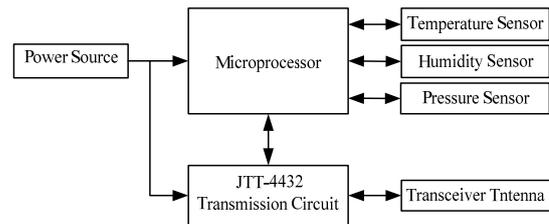


Figure 1. Monitoring terminal structure diagram

2.1 Microprocessor circuit design

Microcontroller adopts MSP430 series single chip MSP430F2131 of TI Company. The working voltage of MSP430F2131 is 1.8-3.6V, the current in normal working conditions is about 200 μ A, under the condition of dormancy, the working current is only 0.7 μ A, which has a unique advantage in ultra low power application powered by battery. The microprocessor circuit is shown in figure 2.

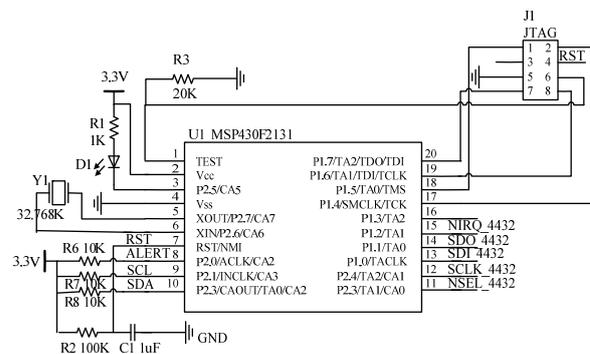


Figure 2. Microprocessor circuit

2.2 Sensor circuit design

The output signals of humidity sensors DMT143, pressure sensor US381-010BG are 4~20mA, current signal turn into voltage signal through sampling resistor and the emitter follower, connect to the analog input of AD chip (ADS1115), then send to CPU chip MSP430F2131 to operating after AD conversion, under the control of the microcontroller, AD chip converts DC voltage to a 16-bit digital quantity, microcontroller reads the data of pressure and humidity and processes the signal, under the control of the microcontroller,

Temperature sensor TMP112 converts the temperature of SF6 gas into 12-bit digital quantity directly, microcontroller reads the temperature data and processes the signal. Gas density calculated by gas equation using temperature and pressure value after collected and packaged through the microcontroller will be sent to relay device by the RF transceiver. Signal processing circuit of humidity and pressure sensor is shown in figure 3, temperature sensor circuit is shown in figure 4.

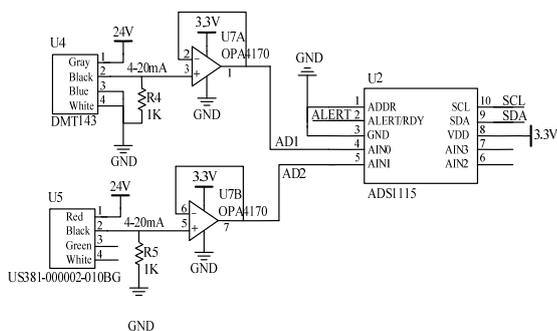


Figure 3. Signal processing circuit of humidity and pressure sensor

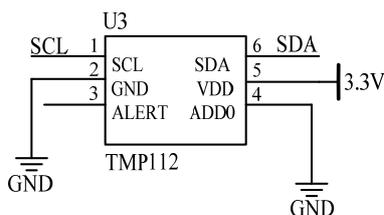


Figure 4. Temperature sensor circuit

(1) Humidity sensor

Using the DMT143 dew point measuring transducer based on Vizela DRYCAP technology, it can be installed directly to the compressed air system with maximum pressure of 50 kg (725 psta)

(2) Pressure sensor

The pressure sensor using the American MEAS US381-000002-010BG, output: 4 ~ 20 mA, measuring range: 0 ~ 1000 (kPa), accuracy: $\pm 0.15\%$, operating temperature range: $-40^{\circ}\text{C} \sim 105^{\circ}\text{C}$.

(3) Temperature sensor

TMP112 converts the temperature of gas into 12-bit digital quantity; microcontroller reads the temperature data and processes the signal. The measurement range of TMP112 from 40°C to 125°C , and accuracy is 0.5°C

2.3 Radio frequency communication circuit design of monitoring terminal

RF communication circuit is composed with high-powered wireless RF chip JTT4432 and high precision peripheral elements, working at 433/470/915 MHZ general ISM frequency band, with a modulator and demodulator, packaging automatically when transmitting, address matching automatically when receiving, CRC

Verifying automatically, after the sending and receiving, the NIRQ Interrupt Pin will be set to high level automatically, showing that sending or receiving have been finished Si4432 provides a SPI interface to the application of the controller, which speed is determined by microcontroller itself, so programming is very convenient Its power consumption is very low, the current is 85mA when transmit with 20dBm output power, when in the receive mode, the current is 15 mA, and current is only $2.5\mu\text{A}$ on standby,. JTT4432 has a total of four work modes, respectively for the power-down and SPI programming mode、 standby and SPI programming model、 receiving mode、 delivery mode, the switching of the working mode is completed through the configuration register 07 H. The circuit is shown in figure 5.

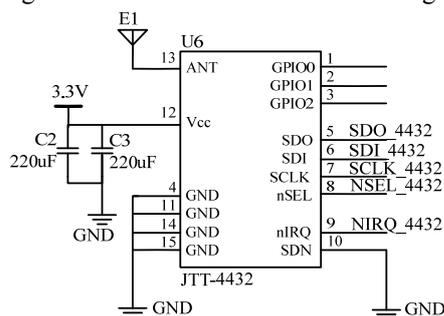


Figure 5. Radio frequency circuit

3 On site operation

Monitoring terminal have proceed the overall debugging and running at BaoJia 500kV substation 500 kV switch(yongbao line 5053 A, B, C phase switch, five series of contact form 5052 A, B, C phase switch) for. Figure 6 for installation on site monitoring device, for. Monitoring devices installed on site is shown in figure 6; monitoring data is shown in figure 7.



Figure 6. Monitoring devices installed on site

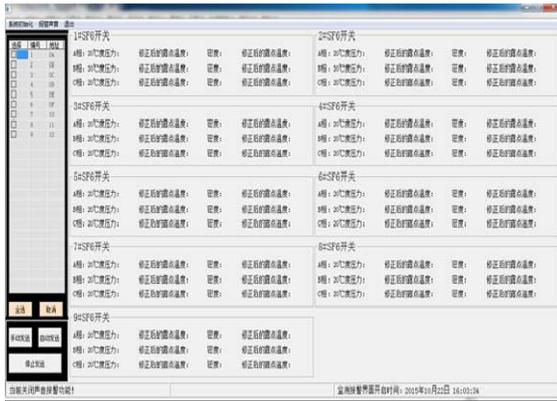


Figure 7. Monitoring data

4 Conclusion

Combined with pressure measurement, temperature measurement, radio frequency communication technology, this paper designed an integrative on-line monitoring terminal of the density, humidity and leakage of SF6 gas, and have been applied on site, and solved the problem lasted for a long time that can't accurate measurement equipment situation truly which caused by the error because of the influence of temperature, pressure measurement mode.

References

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