Signal-Triggered Automatic Acquisition Method for Electrical Leakage Fault Data of Electrical Circuits

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Abstract. Conventional electrical circuit leakage fault data acquisition technology of leakage fault information collection, Failure to eliminate noise interference, resulting in failure to achieve real-time acquisition of circuit leakage fault data. There is a problem of low data accuracy and large noise interference, therefore put forward based on signal trigger electrical wiring leakage fault data automatic acquisition methods. Electrical wiring leakage fault detection based on signal trigger automatic acquisition mechanism, structures, acquisition model system, the acquisition model system hardware, electrical wiring to realize automatically leakage failure data acquisition model building; Automatically determine the leakage failure data acquisition software workflow, based on the leakage current fault detection algorithm and software anti-interference design, implementation is based on signal trigger automatic electric circuit leakage failure data collection. The experimental data show that the proposed automatic collection method is 35.24% more accurate than the traditional collection method, which is suitable for automatic collection of leakage fault data of different electrical circuits at different times.

Keywords: First signal triggering · Second electrical wiring · Third leakage failure · Forth automatic data collection

1 Introduction

Literature [1] proposed the STC15F2K60S2 single-chip microcomputer as the control core, the selected test simulation trigger signal leakage current, not less than twice the maximum value of the normal leakage current of the electrical circuit and equipment; the sensitivity of the leakage fault test signal, priority is given to 30 mA When the rated leakage current is equal to or less than 30 mA, the protection action time is less than 0.1 s. When the rated leakage current is greater than 30 mA, the requirement is less than 0.2 s. The device is a supplement to the traditional leakage protection device. According to the indirect leakage detection and direct leakage detection. The result is compared with the actual leakage position distance to complete the test Reference. Literature [2], the selective leakage protection circuit mainly uses the principle that the zero-sequence current of the fault line is opposite to the zero-sequence current phase of the non-faulty line, and the zero-sequence current phase of the fault line lags the zero-

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sequence voltage phase, by comparing the zero-sequence current with The phase of the zero-sequence voltage and the relationship between the amplitudes and the set amplitudes are used to collect the data of the circuit leakage faults. Literature [3] extracted the fault arc current characteristics under linear load and nonlinear load by analyzing the experimental data, and proposed two fault arc diagnosis methods: the typical characteristic current "zero rest" phenomenon for linear load fault arc Based on the grid fractal theory, the mathematical statistical method is used to extract the characteristic of the rate of change of the fault arc current, and the fault diagnosis of linear load fault arc is realized.

Above conventional electrical leakage failure data collection technology can collect the leakage failure information, but when the electrical circuit is used for long time automatic failure data collection, due to the limitations of the acquisition system hardware and software, there is a lack of accuracy of the collected data and large noise [1], and is not suitable for automatic collection of electrical leakage failure data for a long period of time. For this reason, a signal-triggered automatic acquisition method of electric leakage failure data of electric circuits is proposed. Based on the signal triggering automatic collection mechanism of electrical failure detection of electrical circuits, the digital signal is serially analyzed and processed through the leakage failure excavation algorithm, the acquisition model system is established, the hardware composition of the acquisition model system is determined, and the automatic collection of the electrical leakage failure data model of the electrical circuit is constructed. Determine the leakage failure data automatic acquisition software workflow, based on leakage current failure detection algorithm design, use the RFSFT termination reset circuit in the microcontroller, the capacitor and grounding resistance form a power-on reset circuit, so that the program is transmitted from the 0000H unit. Realize the anti-jamming design of the software, and complete the proposed signal-triggered automatic collection method for electrical failure data of electrical circuits. In order to ensure the validity of the data collection method for the electrical leakage failure of the designed electrical circuit, the electrical leakage failure condition test environment of the electrical circuit was simulated and two kinds of different electrical circuit leakage failure data acquisition methods were used to conduct the simulation test of the accuracy of the collected data. The test conclusions show that the data acquisition method for electrical failure in electrical circuits is highly effective.

2 System Objectives and Analysis

The signal-triggered automatic collection method for electrical leakage failure data of electrical lines mainly includes:

(1) The signal-triggered electrical circuit leakage failure detection automatic acquisition mechanism is analyzed to make use of the occurrence of a leakage failure, and the current vector of the phase line and the neutral line is not equal to zero, thereby calculating the line and the approximate position of the failure.

(2) Calculate the amplified leakage trigger signal and send it to the MCU for calculation. Perform analog-digital conversion on the signal. Determine the acquisition model system and the hardware components of the acquisition model system according to the system performance indicators and system signal characteristics.
(3) The leakage current failure detection algorithm is established. Based on the software anti-jamming design, the electrical line leakage failure data is automatically collected, and the lack of accuracy of the collected data and large noise during the long-term automatic fault data collection of the electrical circuit is solved.

3 Constructing an Automatic Acquisition Model for Electrical Leakage Failure Data of Electrical Lines

3.1 Signal-Triggered Electrical Circuit Failure Detection Automatic Acquisition Mechanism

Leakage failure detection system is installed at the electric meter of the electric circuit network or at a certain distance. When the low-voltage electrical line does not fail normally, the current zero-sequence circuit entering and output from one end of the electrical line network is zero, and the leakage failure detection device is in standby operation. When a leakage failure occurs somewhere in the electrical line, some of the leakage current flows through the medium into the earth. As a result, the total amount of current flowing into and out of the electrical circuit network is deviated. When the leakage current reaches the operating current of the leakage failure detection device, the system will detect the trigger signal. After a series of processing of the trigger signal, according to the size of the leakage current signal through the corresponding algorithm program, we can determine how far the leakage fault distance detection device is. At the same time, we can have a reference to the compilation of leakage failure detection devices, and comprehensive analysis of the location of the electrical failure where the leakage failure occurs [2].

3.2 Collection Model System Construction

Low-voltage electrical lines generate a part of residual current in the event of a leakage failure, also known as zero-sequence current. The zero-sequence current is used as a trigger signal for the detection of leakage failure, and a detection system is constructed. The detection element is a zero-sequence current transformer. In the event of a leakage failure on the line, the current vector sum of the phase and neutral lines is not equal to zero, resulting in an induced electromotive force. After this trigger signal is amplified, compared, and processed by analog-to-digital conversion, it is sent to the MCU for calculation, and a series of analysis and processing is performed on the digital signal through the leakage fault finding algorithm. In order to calculate the line and the approximate position of the failure, the data is displayed through the LED, and an audible and visual alarm device is triggered to perform a leakage safety alert. Its electrical circuit leakage failure detection system structure shown in Fig. 1 [3].

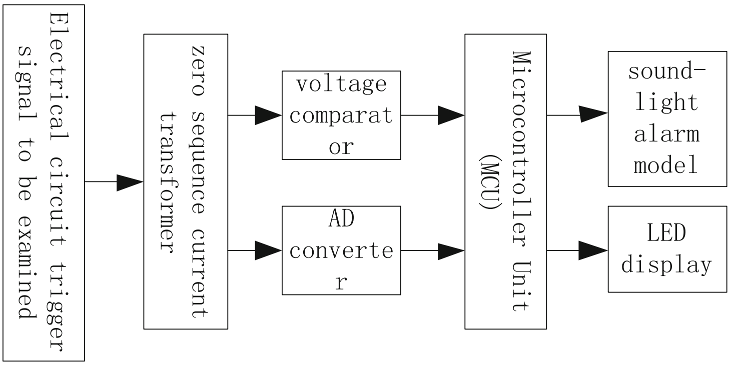

Fig. 1. System block diagram

3.3 Determining the Hardware Composition of the Acquisition Model System

The leakage failure detection system is installed on the low-voltage electrical line to detect the zero-sequence current on the line. When the electrical line is not faulty, there is no electrical equipment or circuit leakage. At this time, the zero-sequence current vector on the line is zero; When a fault occurs on the line, a single-phase ground fault current I_d is bound to be generated. The zero-sequence current $I_0 = I_N + I_d$ detected at this time is obviously greater than the three-phase unbalanced current when there is no fault, and I_0 is treated as the initial trigger signal. U_1 is a linear operational amplifier. Through the feedback loop and the input loop to determine the magnification, that is, by adjusting the potentiometer RW adjust the magnification, so that the trigger analog signal voltage between 1–5 V, the output resistance of the load resistor R8 is 100 Ω, so the trigger current output range of the signal is 10–50 mA. U_1 operational amplifier IN + and IN− are differential inputs, through the potentiometer can set the gain magnification $B = (1 + \frac{R_2 + R_3}{RW + R_1})$, is 1–10 times [4]. After the differential mode signal is amplified, it is converted into an analog signal and sent to the analog-to-digital conversion circuit.

After the calculation of the leakage trigger signal is still an analog signal, to be sent to the MCU microcontroller for calculation, you need to carry out analog-digital conversion of the signal. Analog-to-digital conversion is the process of converting an analog input into a digital value. The analog-to-digital conversion circuit is a key component of the entire data acquisition section. Analog-to-digital conversion is the process of converting analog input into digital value. The analog-to-digital conversion is based on system performance and system signal characteristics. It is processed by 10-bit A/D conversion chip TLC1513. The analog input voltage is 0–+5 V corresponding figure. Values 0–1024 [5]. The circuit is a key component of the entire data acquisition section. The circuit connection is shown in Fig. 2(a), where pin AO is the input of the leakage trigger signal, and a falling edge change at the LS terminal resets the internal counter and controls the enable. ADDRESS is a serial data input terminal. The pass-through serial address is used to select the next analog input signal or test signal to be converted [6]. DATAOUT is a 3-state serial output terminal for A/D conversion. It communicates with the microprocessor or the peripheral serial port and can be flexibly programmed for data length and format.

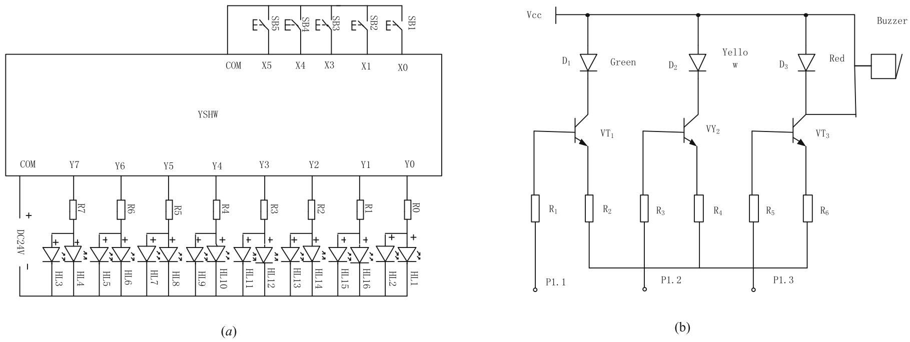

Fig. 2. Leakage trigger signal analog-to-digital conversion circuit and sound and light alarm module circuit

The trigger signal is converted into digital signal and sent to the MCU for processing. The single-chip microcomputer is the data processing core of the entire control circuit, and the latest enhanced 8051 series single chip STC15F2K60S2 is used, which has two independent serial ports; Built-in crystal oscillator and reset circuit make its anti-interference ability greatly enhanced; And has a plurality of I/O ports, high speed, low power consumption, it is important that the cost is lower, and it is very suitable for the large-scale use deployment of this system. Its pin distribution and connection circuit, I/O port as chip select signal, sound and light alarm control signal, keyboard, LED display and other functions are used [7].

If the entire electrical line works normally and no leakage fault occurs, the working status indicator will flash green. Its working state is controlled by the l/O port P1.1 of the one-chip computer, the flashing of the indicator lamp is controlled by the one-chip computer program to control and output the pulse square wave to control the on-off of the triode VT. When there is a leakage failure, the microcontroller program will set the port Pl.3 high, the transistor VT, conduction, red alarm light flashes, while the buzzer alarm sound; A flashing yellow light indicates that the microcontroller has started the leakage protector and cut off the electrical circuit. The sound and light alarm module circuit shown in Fig. 2(b) [8].

Relying on the signal-triggered automatic fault detection and detection mechanism of the electrical circuit, an acquisition model system and a hardware system of the acquisition model system are built to realize the automatic collection of the electrical leakage fault data model of the electrical circuit.

4 Realizing Automatic Collection of Electrical Leakage Failure Data

4.1 Working Process of Leakage Failure Data Automatic Acquisition Software

The system software workflow is shown in Fig. 3. The system is in a low power standby operation state when the electrical line is normal and no failure occurs. When a leakage fault occurs in the electrical circuit, an electrical leakage trigger letter is generated, and after hardware amplification and analog-to-digital conversion, it is sent to the single-chip microcomputer for calculation and analysis. Locate the location of the leakage failure according to the leakage failure excavation algorithm, and send the result to the display screen through the serial communication, at the same time start the sound and light alarm module. If the leakage current exceeds the set threshold, the microcontroller controls the start-up of the leakage protector and performs power-off operation on the line to ensure the safety of the electrical circuit and personnel [9].

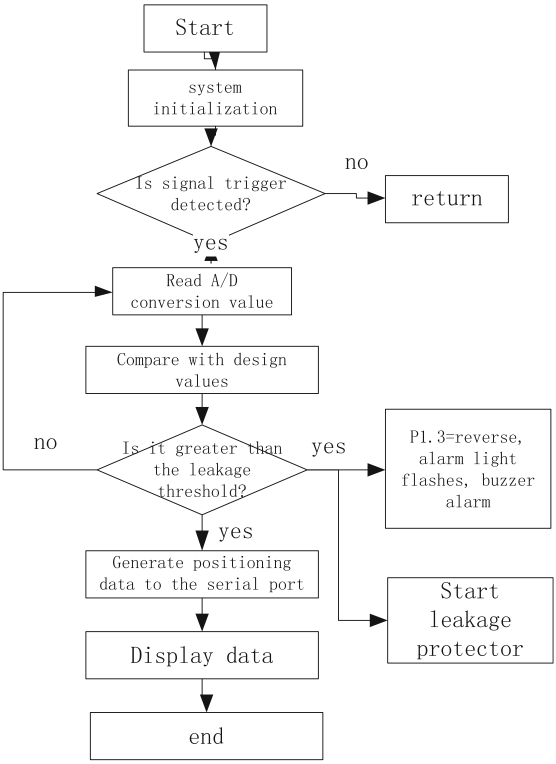

Fig. 3. Working process of software

4.2 Establish Leakage Current Failure Detection Algorithm

When a leakage failure occurs in an electrical circuit, to determine the location of the circuit leakage, it is necessary to calculate the magnitude of the leakage current in the electrical circuit. And need to determine the voltage between power neutral point MQ and load neutral point MI. In the low-voltage circuit, three-phase voltage ($U_{L1,}$ $U_{L2,}$ U_{L3}) and neutral point MQ are connected. At the load side, three load impedances Z_1, Z_2, and Z_3 are connected, and two neutral points MQ and MI are connected by impedance Z_{QL}. The pressure drop on this impedance is U_{QL}. U_{QL} is calculated as follows [10]:

$$U_{QL} = \frac{\frac{U_{L1}}{Z_1} + \frac{U_{L2}}{Z_2} + \frac{U_{L3}}{Z_3}}{\frac{1}{Z_1} + \frac{1}{Z_2} + \frac{1}{Z_3} + \frac{1}{Z_{QL}}} \tag{1}$$

The conventional configuration of the three-phase filter is that three X capacitors are connected to the neutral point and connected to ground through the Y capacitor or to the housing of the filter. Leakage currents can be ignored for balanced-capacitor networks. On the other hand, when the highest imbalance between the phases is reached, the electrical network achieves the highest leakage current. The causes of the imbalance include the tolerance of the capacitor value and the voltage imbalance of the power supply network. Therefore, the key element of the leakage current is the voltage U_{QL} generated by the unbalance of the capacitors C_{X1}, C_{X2}, and C_{X3}. For most filters, the rating is the same, *jw* represents current tolerance. The leakage current $I_{leakmax}$ produced by the voltage drop U_{QL} at the capacitor C_Y can be determined according to the following equation:

$$I_{leak\max} = U_{QL} \cdot jw \cdot C_{Yn} \tag{2}$$

In the formula, $\omega = 2 \bullet \pi \bullet f$, the tolerance of the rated value of the condenser in the passive filter is ±20%. The highest drop in Cr occurs when the two X capacitors have the smallest tolerance, and one capacitor has the maximum tolerance. In addition, assume that Cr has the largest tolerance value. Substituting these assumptions into Eqs. (1) and (2), the leakage current is:

$$|I_{leak\max}| = \omega \cdot C_{Y\max} \frac{U_{\max} C_{X \cdot \max} - U_{\min} C_{X \cdot \min}}{C_{X \cdot \max} + 2C_{X \cdot \min} + C_{Y\max}} \tag{3}$$

Then, the analog return digital return value A_d is:

$$A_d = \frac{I_d \times R_d}{U_{ref}} \times 1024 \tag{4}$$

In the formula, I_d is the trigger current signal after amplification processing, R_d is the load end resistance, 100 Ω, U_{ref} is the reference voltage for A/D conversion taking l–5 V, 1024 is the maximum resolution of ten A/D converters.

4.3 Software Anti-jamming Design

Since most of the working environment of the leakage failure detection device is outdoors, there are a large number of interference signals, and the electromagnetic interference caused by the electrical lines is very large, which may cause distortion of analog signal input, disorder of control signals, control failure, system crash, disorder of signals on address or data bus. Therefore, the system's anti-jamming design is related to the reliability of the system operation. In addition to strengthening the hardware anti-jamming, special design must be performed on software anti-jamming. If the system program runs away and enters an endless loop, the system service program starts execution automatically from 0000H and terminates the reset circuit on the microcontroller's RFSFT. The capacitor and ground resistors form a power-on reset circuit, which allows the program to be executed from the 0000H unit when the program is powered on. Both the power-on reset circuit and the manual reset circuit can provide a high-level reset signal greater than 10 mA for the reset chip. The reset chip MAX813L has a watchdog timer and voltage monitor inside. When the system program is stuck in a dead-end cycle or the power supply voltage suddenly changes, it will not cause crashes, data read-write errors, or malfunctions, which will cause the system to reset and operate in the event of a failure.

Based on the construction of automatic collection of electrical wiring leakage failure data model, relying on leakage failure data automatic acquisition software, reasonable work, and leakage current failure detection algorithm and software anti-jamming design, automatic collection of electrical wiring leakage failure data is achieved based on signal triggering.

5 Experimental Test and Analysis

In order to ensure the effectiveness of the proposed method for automatic detection of electrical failure in electrical wiring based on signal triggering, simulation experiments were conducted. During the process of testing, different electrical wiring leakage failure status was used as a test object to conduct data acquisition accuracy simulation tests. Different types of failure in the electrical failure status of the electrical circuit, as well as on-line acquisition duration, are simulated. In order to ensure the validity of the test, the conventional electrical wiring leakage failure data acquisition technology was used as a comparison object, and the results of the two simulation experiments were compared, and the test data was presented in the same data chart.

5.1 Experimental Test Preparation

In order to ensure the accuracy of the simulation test process, the test parameters of the experiment are set. In the simulation test process in this paper, different electrical circuit leakage failure status was taken as the test object, two different electrical circuit leakage failure data acquisition methods were used to conduct the data acquisition accuracy simulation test, and the simulation test results were analyzed. Because the analysis results obtained in different methods are different from the analysis methods, the test environment parameters must be consistent during the test. The test data set results in this paper are shown in Table 1.

Table 1. Test parameter settings

Simulation test parameters	Execution range/parameter	Note
Leakage per unit time	0.1–15 kWh	Independent variable
Online automatic collection time	24 h × 7	Using two different design methods to conduct design analysis one by one
Simulation system	DJX-2016-3.5	Windows platform

5.2 Experimental Test Results Analysis

During the test process, two different methods for data collection of electrical faults in electrical circuits were used to work in a simulated environment, and the changes in the accuracy of the acquired data were analyzed. At the same time, due to adopting two different methods for data collection of electrical faults in electrical circuits, the analysis results cannot be compared directly. For this purpose, third-party analysis and recording software is used to record and analyze the test process and results, and the results are displayed in this test by comparing the results in the curve. In the simulation test result curve, the third-party analysis and recording software function is used to eliminate the uncertainty caused by the simulation laboratory personnel operation and simulation of computer equipment factors, only for different electrical circuit leakage failure status, different electrical circuit leakage failure data collection Methods, the accuracy of simulation test data acquisition. The comparison curve of the test results is shown in Fig. 4. Based on the results of the test curve, the third party analysis and recording software was used to arithmetically weight the electrical leakage failure data collection method of the electrical circuit proposed in this paper and the accuracy of the collected data of the conventional electrical leakage failure data collection technology, resulting in the proposed automatic acquisition method. With the traditional acquisition method, the accuracy of the collected data is increased by 35.24%, which is suitable for the automatic collection of the leakage failure data of different electrical lines at different times.

The experiment takes the Re state as the test object, and uses two different circuit leakage fault data acquisition methods to carry out the data acquisition precision simulation test. It is concluded that the data acquisition accuracy of the proposed acquisition method is 35.24% higher than the traditional method, which is suitable for automatic at different times. Collect leakage fault data of different electrical lines. It can solve the traditional method because it can not eliminate the noise interference, which can not realize the real-time acquisition of the circuit leakage fault data. It has the problems of low data precision and large noise interference, and has high comprehensive applicability, which provides for the data leakage research of future circuit leakage faults. A certain research basis.

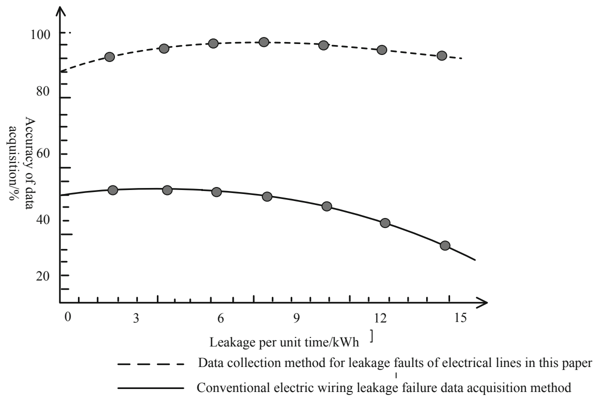

Fig. 4. Comparison curve of the test results

6 Conclusion

This paper proposes a signal triggering method for the automatic collection of electrical leakage failure data of electrical circuits, an automatic acquisition model was constructed based on leakage failure data of electrical circuits, and an automatic leakage failure data acquisition software, leakage current failure detection algorithm and software anti-jamming were designed to achieve signal-based automatic collection of electrical leakage failure data of electrical wiring to complete the research of this paper. The experimental data shows that the method designed in this paper has extremely high effectiveness. It is hoped that the study in this paper can provide a theoretical basis for the online acquisition method of electrical leakage failure data in electrical circuits.

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