Fault Diagnosis and Monitoring Device Design for the Electrical Life Test of Low Voltage Circuit Breaker

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Abstract. In the electrical life test, the low voltage circuit breaker may have a variety of faults. At present, that lacks effective fault diagnosis method and monitoring device. To solve the above problem, the method of fault diagnosis and the design of monitoring device are proposed in this paper. The method of fault diagnosis includes the collection of test parameters and the model establishment of fault diagnosis. Based on the fault diagnosis model, the electrical life test monitoring device is designed. The device is used to collect the test data in real time, and analyzed the logic to determine whether the fault occurred during the test. When the fault occurred, the device will automatically take protective measures. In order to improve its intelligence, the intelligent monitoring device is designed based on Device net bus technology. It has been implemented in the Device net control network and has the function of Internet of things. So the real-time monitoring test process of remote network can be realized.

Keywords: Low voltage circuit breaker · Electrical life test · Fault diagnosis Monitoring device · Device net

1 Introduction

At present, the research of fault diagnosis for circuit breaker is mainly focused on the high voltage circuit breaker (HVCB), but there are few researches of fault diagnosis for low voltage circuit breaker. The research method of fault diagnosis is signal analysis for HVCB. Firstly, collecting the vibration signal as HVCB opening and closing, and then these theories such as the particle swarm optimization (PSO) algorithm, support vector machine (SVM), empirical mode decomposition (EMD), wavelet transform, neural network, artificial immune network, fault diagnosis expert system and so on are applied to process the collected signal, so the fault type can be determined.

Based on PSO, combining algorithms such as least squares support vector machine (LSSVM) [1, 2], particle swarm fused kernel fuzzy C-means (P-KFCM) [2] and radial basis function (RBF) [3] neural network to research. In [1], the PSO algorithm is adopted to optimize the parameter of LSSVM algorithm, so the diagnosis speed and accuracy by PSO-LSSVM algorithm is better than traditional SVM algorithm. In [2], this method combined P-KFCM and SVM solves local optimum problem can

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effectively improve reliability of diagnostic. In [3], the accuracy and precision of RBF network model based on PSO are higher than traditional neural network model. In [4], the EMD amount of energy and SVM theory are combined to identify the difference of vibration signals and fault type. In [6], based on the combined method of fast kernel independent component analysis (fast KICA) and the ensemble empirical mode decomposition (EEMD) decomposition, the signal is processed as input feature vector of SVM. The wavelet theory is combined with SVM theory, wavelet transform and wavelet packet analysis and applied for fault diagnosis. In [7], the empirical wavelet transform (EWT) and one-class support vector machine (OCSVM) are combined and proposed as new mechanical fault diagnosis method, that can diagnose the mechanical fault high reliability. In [8], the zero-phase filter time-frequency entropy is analyzed based wavelet packet and then the SVM classifiers are introduced for fault diagnosis under different conditions. In [10], the grey theory is applied in fault diagnosis, a new diagnostic model based on the grey relation analysis method (GRAM) is established and that can effectively diagnose the mechanical failure of circuit breaker. In [11], based on artificial immune network (ai Net), an on-line self-learning classifier artificial immune network (C-ai Net) is proposed for identifying mechanical failures. It can achieve more precise judgment than neural network method. The expert system is applied in fault diagnosis [12, 13]. In [12], the method based on the expert system and neural network, it can deal with the fault data that sent from on-line monitoring equipment and then discover the fault type. In [14], it is proposed for real-time fault diagnosis. In [15], a robust diagnosis method is proposed and that improves the anti-interference performance. In [16], a new analytic model is established to take into account of the possible malfunctions of protective relays and circuit breaker as well as the missing and false alarms. The research of fault diagnosis is less for low voltage circuit breaker. In [17], based on EMD and intrinsic mode function (IMF), the fault identification model of extreme learning machine is built. The research on the electrical life is another important aspect for the electrical equipment [18, 19]. In [19], it is the influence and experimental study on electrical life under different protected circuit conditions. In [20], it summarizes these methods that are typically used in industry to evaluate the service life of low voltage power circuit breaker and molded case circuit breaker. In [21], a new method is proposed for the life assessment of electrical components, that supports the decision-making in future deregulation of the electric energy market. In [22], it establishes a new comprehensive model based on cloud model that considers fuzziness and randomness of uncertainty at the same time for electrical life.

If those above research methods are applied in this paper, there are three problems: 1. the fault judgment of electrical life test may happen the erroneous judgment that may directly lead to accidents; 2. if those above methods are used to analyze and judge whether the fault occurs based on collected signal, there is time lag for the judgment of the fault; 3. it is a heavy work and no practical significance to analyze the signal of each waveform.

2 Method of Collecting Test Parameters

In the process of the electrical life test for the low voltage circuit breaker, there are specified parameters, such as the test voltage U, the test current I, the connection time T_j, the opening time T_f, and the test number N. The test has these characteristics: many times, long cycle and difficult to find fault. In the process of test, there may be various kinds of faults, such as the contact welding, the serious wear of the contact, the failure of the mechanical structure, the clamping of the auxiliary device and so on. When the fault occurs, it is possible to cause other accidents, so the test process needs to be monitored in real time. The traditional monitoring method is to collect waveforms of voltage and current, as shown in Fig. 1. The real-time waveform of voltage and current is observed by the tester, and the fault is judged based on the change of the waveform. On the one hand, this method generates a large number of invalid and non fault data records; on the other hand, it depends on the time and experience of the tester.

To solve the above problem, a method for collecting test parameters is proposed in this paper. This method selects five parameters that are the test voltage effective value, the test current effective value, the connection time, the opening time and the test number. The collection of these above parameters uses electronic devices that collect effective value, compared with the use of waveform collection equipment, and greatly reduces the cost.

The electrical life test of three-phase low voltage AC circuit breaker is taken as an example. The method of collecting test parameters is shown in Fig. 2 that is the electrical life test system. These symbols of A, B, C represent the A phase, B phase, C phase of power supply, respectively. The vacuum circuit breaker is connected in the system in series. If the vacuum circuit breaker is opened, the power supply of the test system is cut off. These symbols of I_A, I_B, I_C represent these current transformers of A phase, B phase, C phase, that are used to collect these current signals. Z_1 represents the short-circuit impedance of inlet end for the circuit breaker. Z_2 represents the electrical life impedance of the outlet end for the circuit breaker. These symbols of U_A, U_B, U_C represent the voltage collection signals between the ends of the inlet and the outlet of A phase, B phase, C phase for the circuit breaker. It is marked as "C", as the circuit breaker is closed. It is marked as "O", as the circuit breaker is opened. Each "C-O" operation in the electrical life test is recorded as the completion of a single test that is cycle. The voltage effective value is collected between the inlet end and outlet end of the contact. If the test is normal, as the contact state is closed, the contact resistance between the contact ends is almost zero, and so the voltage effective value is almost zero; as the contact state is opened, the inlet end is charged, the outlet end is suspended, and so the voltage effective value between the contact ends is the power phase voltage. The current effective value is collected with current transformer which primary side is hollow that achieves the effect of electrical isolation.

During the electrical life test, these values of normal state parameters are shown in Table 1. In the process of test, if the waveform of the parameters is collected, the normal test waveform is shown in Fig. 1.

In Fig. 1, there are I_A, U_A, I_B, U_B, I_C, U_C in waveform channels from top to bottom. The time that the voltage disappears but the current existences is the connection time

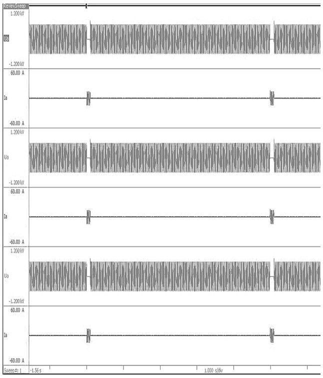


Fig. 1. The normal test waveform

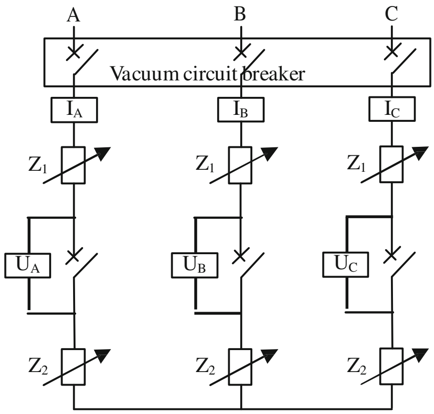


Fig. 2. The electrical life test system diagram

Table 1. The normal state parameter

U_A		U_B		U_C		I_A		I_B		I_C		T_{jA}		T_{jB}		T_{jC}		T_{fA}		T_{fB}		T_{fC}	
C	O	C	O	C	O	C	O	C	O	C	O	C	O	C	O	C	O	C	O	C	O	C	O
0	U	0	U	0	U	I	0	I	0	I	0	T_j	/	T_j	/	T_j	/	/	T_f	/	T_f	/	T_f

and marked as T_j. The time that the current disappears but the voltage existences is the opening time and marked as T_f. These effective values of I_A, U_A, I_B, U_B, I_C and U_C are measured from Fig. 1, as well as T_j and T_f.

3 Established Fault Diagnosis Model

3.1 Typical Fault Examples

In the process of the electrical life test, the three-phase low voltage AC circuit breaker may have the following typical faults in Fig. 2. The fault description and analysis are described as follows.

Fault 1. One phase contact cannot be closed normally, such as that the contact is worn seriously, the mechanical structure can not be closed normally, the contact tripped and other reasons, but these remaining two phases can be closed normally. For example, the A phase contact can not be normally closed, but these contacts of B and C phase can be normally closed, which waveform is shown in Fig. 3.

Fault 2. Two phase contacts cannot be closed normally, such as that these contacts are worn seriously, the mechanical structure can not be closed normally, the contact tripped and other reasons, but the remaining one phase can be closed normally. For example, these contacts of A phase and B phase can not be normally closed, but C phase contact can be normally closed, which waveform is shown in Fig. 4.

Fault 3. Three phase contacts cannot be closed normally, such as that these contacts are worn seriously, the mechanical structure can not be closed normally, the contact tripped and other reasons, which waveform is shown in Fig. 5.

Fault 4. One phase contact cannot be opened normally, such as that the contact is welded, the mechanical structure can not be opened normally and other reasons, but these remaining two phases can be opened normally. For example, the A phase contact can not be normally opened, but these contacts of B and C phase can be normally opened, which waveform is shown in Fig. 6.

Fault 5. Two phase contacts cannot be opened normally, such as that these contacts are welded, the mechanical structure can not be opened normally and other reasons, but the remaining one phase can be opened normally. For example, these contacts of A and B phase can not be normally opened, but C phase contact can be normally opened, which waveform is shown in Fig. 7.

Fault 6. Three phase contacts cannot be opened normally, such as that these contacts are welded, the mechanical structure can not be opened normally and other reasons, which waveform is shown in Fig. 8.

Fault 7. The connection time is a fault that connection time is longer than specified time, such as that the contact wears seriously, the test auxiliary device leads to the fault and other reasons. That waveform is relatively simple, compared to Fig. 1 can be understood, so it is not shown separately.

Fault 8. The opening time is a fault that opening time is longer than specified time, such as that the contact wears seriously, the test auxiliary device leads to the fault and other reasons. That waveform is relatively simple, compared to Fig. 1 can be understood, so it is not shown separately.

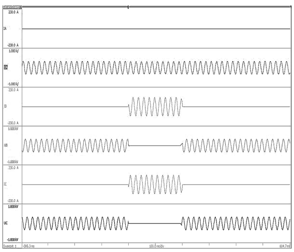


Fig. 3. Fault 1

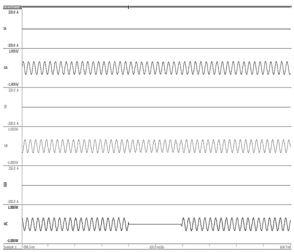


Fig. 4. Fault 2

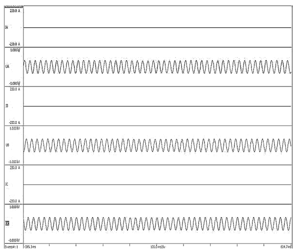


Fig. 5. Fault 3

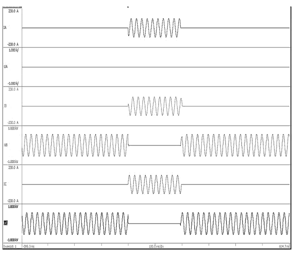


Fig. 6. Fault 4

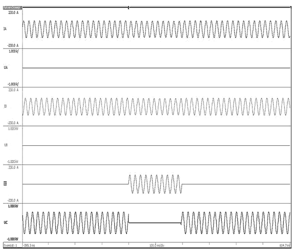


Fig. 7. Fault 5

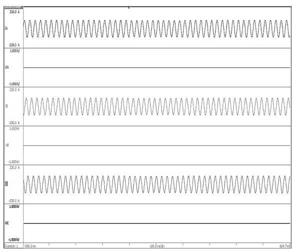


Fig. 8. Fault 6

In Figures from 3, 4, 5, 6, 7 and 8, there are I_A, U_A, I_B, U_B, I_C, U_C in waveform channels from top to bottom. Compared Figs. 1, 3, 4, 5, 6, 7 and 8, can be found that these parameters change differently in different faults. Based on the above data analysis of fault waveform, the fault diagnosis model is established as follows.

3.2 Established Mathematical Model

The rated voltage and current of the circuit breaker are marked as Ue and Ie respectively. According to the electrical life test requirement, the test voltage is $U = [1,\ 1.05]Ue$, the test current is $I = [1,\ 1.05]\ Ie$, the test number is N. T_j and T_f have not test requirements, but according to long term test experience, this paper sets requirements: the connection time is within $1.1T_j$, the opening time is within $1.1\ T_f$. Those above five parameters change within a reasonable range as the test is normally carried out. Those above five parameters change beyond a reasonable range as the fault occurs during the test. These parameters collected by the monitoring device are the test voltage effective value U_1, the test current effective value I_1, the connection time T_{j1}, the opening time T_{f1}, the test number N_1. The mathematical relationship is established and shown in Table 2.

Based on the mathematical relationship in table, there are fault examples from 1 to 8, and the mathematical model is established with function. The normal state and fault state of these parameters can be represented by the truth value "0" and "1", respectively. The mathematical relationship of Table 2 is shown in the truth table as shown in Table 3. These parameters are measured independently, but that are related to each other. The relationship among these parameters is expressed with the algorithm "or" ($\oplus$).

Table 2. The mathematical relationship

Parameter	Normal	Fault
Voltage	$U_1 \in U$	$U_1 \notin U$
Current	$I_1 \in I$	$I_1 \notin I$
Connection time	$T_{j1} < 1.1T_j$	$T_{j1} \geq 1.1T_j$
Opening time	$T_{f1} < 1.1T_f$	$T_{f1} \geq 1.1T_f$
Test number	$N_1 \leq N$	$N_1 > N$

Table 3. The truth value table

Parameter	Normal	Fault
S_1	0	1
S_2	0	1
S_3	0	1
S_4	0	1
S_5	0	1

$S = \{s_1, s_2 \cdots s_m\}$ represents a parameter set that may fault, $s_m = 1$ represents the fault state of parameter *m*, $s_m = 0$ represents the normal state of parameter *m*, *m* represents the number of parameters. In this paper $m = 5$, s_1 represents the test voltage, s_2 represents the test current, s_3 represents the connection time, s_4 represents the opening time, s_5 represents the test number. In the circuit, *n* represents a phase in a three-phase circuit, $s_{mn} = \{s_{mA}, s_{mB}, s_{mC}\}$, A phase, B phase and C phase are expressed respectively with s_{mA}, s_{mB}, s_{mC}. The fault state of *n* phase of *m* parameter is expressed with $s_{mn} = 1$ and the normal state of *n* phase of *m* parameter is expressed with $s_{mn} = 0$. In the process of electrical life test, the contact is divided into two states: closed and opened that are expressed with s_{mnC} and s_{mnO} respectively. Those are expressed with set $s_{mn} = \{s_{mnC}, s_{mnO}\}$. Their fault states are expressed with $s_{mnC} = 1, s_{mnO} = 1$ and their normal states are expressed with $s_{mnC} = 0, s_{mnO} = 0$.

In summary, the relationship of these above parameters is represented in (1).

$$S = \{s_1, s_2, s_3, s_4, s_5\} = \begin{cases} s_1 = \{s_{1A}, s_{1B}, s_{1C}\} = \{\{s_{1AC}, s_{1AO}\}, \{s_{1BC}, s_{1BO}\}, \{s_{1CC}, s_{1CO}\}\} \\ s_2 = \{s_{2A}, s_{2B}, s_{2C}\} = \{\{s_{2AC}, s_{2AO}\}, \{s_{2BC}, s_{2BO}\}, \{s_{2CC}, s_{2CO}\}\} \\ s_3 = \{s_{3A}, s_{3B}, s_{3C}\} = \{\{s_{3AC}, s_{3AO}\}, \{s_{3BC}, s_{3BO}\}, \{s_{3CC}, s_{3CO}\}\} \\ s_4 = \{s_{4A}, s_{4B}, s_{4C}\} = \{\{s_{4AC}, s_{4AO}\}, \{s_{4BC}, s_{4BO}\}, \{s_{4CC}, s_{4CO}\}\} \\ s_5 = \{s_{5A}, s_{5B}, s_{5C}\} = \{\{s_{5AC}, s_{5AO}\}, \{s_{5BC}, s_{5BO}\}, \{s_{5CC}, s_{5CO}\}\} \end{cases} \tag{1}$$

Considering the logical relationship of the fault, the function expression of the fault diagnosis model is as follows:

$$s_{mn} = s_{mnC} \oplus s_{mnO} \tag{2}$$

$$s_m = s_{mA} \oplus s_{mB} \oplus s_{mC} \tag{3}$$

$$S = s_1 \oplus s_2 \cdots \oplus s_5 \tag{4}$$

s_1, s_2, s_3 and s_4 are real-time monitored of each cycle, s_5 is cumulatively counted once. According to the above logic operation, the result of logic operation S = 1 can be judged as a fault, as the truth value of one parameter is changed from “0” to “1”.

3.3 Example Analysis of Fault Diagnosis

From fault 1 to fault 6, the test voltage effective value, the test current effective value, the connection time and the opening time have changed significantly, and the specific

Table 4. The specific change of parameters

Parameters	Fault 1		Fault 2		Fault 3		Fault 4		Fault 5		Fault 6	
	C	O	C	O	C	O	C	O	C	O	C	O
U_A	U	U	U	U	U	U	0	0	0	0	0	0
U_B	0	U	U	U	U	U	0	$\sqrt{3}$ U	0	0	0	0
U_C	0	U	0	U	U	U	0	$\sqrt{3}$ U	0	U	0	0
I_A	0	0	0	0	0	0	I	0	I	$\sqrt{3}$ I/2	I	I
I_B	$\sqrt{3}$ I/2	0	0	0	0	0	I	0	I	$\sqrt{3}$ I/2	I	I
I_C	$\sqrt{3}$ I/2	0	0	0	0	0	I	0	I	0	I	I
T_{jA}	0	/	0	/	0	/	T_j+ T_f	/	T_j+ T_f	/	T_j+ T_f	/
T_{jB}	T_j	/	0	/	0	/	T_j	/	T_j+ T_f	/	T_j+ T_f	/
T_{jC}	T_j	/	T_j	/	0	/	T_j	/	T_j	/	T_j+ T_f	/
T_{fA}	/	T_j+ T_f	/	T_j+ T_f	/	T_j+ T_f	/	0	/	0	/	0
T_{fB}	/	T_f	/	T_j+ T_f	/	T_j+ T_f	/	T_f	/	0	/	0
T_{fC}	/	T_f	/	T_f	/	T_j+ T_f	/	T_f	/	T_f	/	0

Table 5. The truth value of fault 1

s_{1AC}	s_{1AO}	s_{1BC}	s_{1BO}	s_{1CC}	s_{1CO}	s_{2AC}	s_{2AO}	s_{2BC}	s_{2BO}	s_{2CC}	s_{2CO}
1	0	0	0	0	0	1	0	1	0	1	0
s_{3AC}	s_{3AO}	s_{3BC}	s_{3BO}	s_{3CC}	s_{3CO}	s_{4AC}	s_{4AO}	s_{4BC}	s_{4BO}	s_{4CC}	s_{4CO}
1	0	0	0	0	0	0	1	0	0	0	0

change of parameters is as shown in Table 4. Based on the mathematical model, fault 1 is taken as an example to analyze, and the truth value table is shown in Table 5.

Based on the truth value in Table 5, the result is $S = 1$ that the logic relationship is calculated with (1)–(4), so it is judged for the test fault. In accordance with the same method, the fault truth table of the above fault example 2 to 8 is listed for logical calculation. The results show that the fault diagnosis model can be used to judge whether the fault occurred in the test process.

4 Design of Monitoring Device

4.1 General Idea

Based on the above fault diagnosis model, the overall design idea of the monitoring device is as follows.

Step 1. The fault diagnosis model is established. According to the test requirements, the fault diagnosis model is established, and the data of the fault diagnosis model is input into the monitoring device, which is the basis for judging whether the fault occurs in the test process.

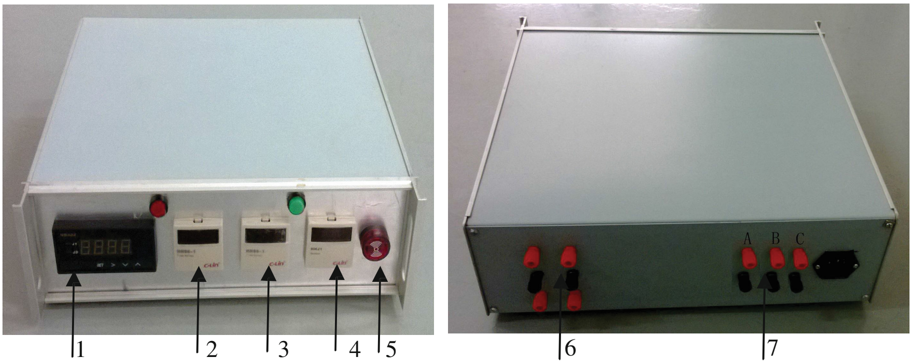
Step 2. The real time data is collected. These characteristics of this test are long cycle, high operating frequency, high fault rate, so that need to collect real time data which is transmitted to the monitoring device.

Step 3. The data is judged. The collected real time data is calculated according to the fault diagnosis model to judge whether the fault occurs.

Step 4. The protective measure is taken. If there is no fault, the monitoring device will not take protective measure, and then the test continues. If there is a fault, the monitoring device will take protective measure (e.g., the vacuum circuit breaker is opened in Fig. 2). The test is stopped and the tester is informed to deal with the fault.

4.2 The Production of Monitoring Device

Based on the above fault diagnosis model, the monitoring device is made in this paper, which can effectively monitor the test process. The test voltage effective value is monitored with the voltmeter. The test current effective value is monitored with the ammeter. The connection time and opening time are monitored with the time relay. The test number is monitored with the counter. A simple circuit is used to realize the logic judgment and output, and has the function of automatic alarm and automatic protection when the fault is detected.



a. Front of the monitoring device b. Back of the monitoring device

Fig. 9. a. Front of the monitoring device b. Back of the monitoring device

Where 1. voltmeter, 2. connection time relay, 3. opening time relay, 4. counter, 5. buzzer, 6. output contacts, 7. voltage signal input terminals

It can be seen from Figs. 3, 4, 5, 6, 7 and 8 that the change of voltage and current is mutual when fault occurs, so one parameter can be selected for monitoring. In this paper, the voltage type monitoring device and the current type monitoring device are designed respectively. Taking the voltage type monitoring device as an example, the front of the monitoring device is shown in Fig. 9a, and the back of the monitoring device is shown in Fig. 9b. The voltmeter has these functions of data storage and logic judgment, and can set the upper and lower limit of the voltage effective value. That is, the upper limit value is 1.05Ue, the lower limit value is Ue. When the upper and lower limits of the voltage effective value are collected, the logic output of the voltmeter is 0. In another condition, it is 1. Two time relays are used to collect the connection time and the opening time. They have these functions of data storage and logic judgment. When the time that the real time collected does not exceed the set time, the logic output of the time relay is 0. In another condition, it is 1. The counter is used to collect the test number, and it has these functions of data storage and logic judgment. When the number that the real time collected does not exceed the set number, the logic output of the counter is 0. In another condition, it is 1. The internal circuit structure is built to achieve the judgment function of fault diagnosis model. When a fault occurs, the buzzer sends out a sound warning that the test had fault; the output contacts action makes the vacuum circuit breaker automatically open and cut off the main circuit of the electrical life test system. These voltage signal input terminals collect U_{A}, U_{B}, U_{C} voltage effective value in Fig. 2.

4.3 The Working Flow Chart

Combined with Figs. 2 and 9, the electrical life test of the three-phase low voltage AC circuit breaker is taken as an example to illustrate the working flow chart of the monitoring device, as shown in Fig. 10.

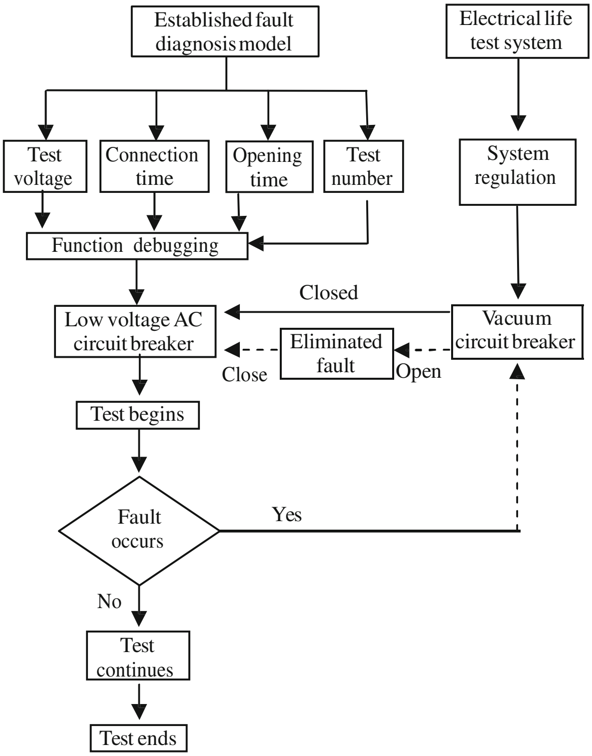


Fig. 10. The working flow chart of monitoring device

The working flow chart of the monitoring device is described in detail in Fig. 10. First of all, based on the fault diagnosis model of Table 2, these test parameters of test voltage value, connection time, opening time and test number are respectively set in the voltmeter, connection time relay, opening time relay and counter. And then, these faults of test voltage, connection time, opening time and test number are simulated in a simple circuit, the monitoring device can monitor the occurrence of the fault and then takes protective measure. All functions are normal and the monitoring device is connected to the low voltage AC circuit breaker. The electrical life test is carried out in the electrical life test system that is regulated and test parameters meet the requirements. The vacuum circuit breaker is connected with the low voltage AC circuit breaker in the main circuit of the test system. The open control of vacuum circuit breaker is connected with the output contact of the monitoring device, as part of the control circuit for the test system. As the electrical life test is carrying, the monitoring device monitors real time test data and analysis whether the fault occurs. If there is no fault, the test continues until the end of the test. If the fault occurs, the output contacts of the monitoring device move, so that the vacuum circuit breaker is opened, and the tester hears the alarm sound to eliminate the fault then the vacuum circuit breaker is closed.

The device is verified in the electrical life test, and it can detect and take protective measure when the typical fault occurs from fault 1 to 8. The practical application proves the practicability and effectiveness of the monitoring device.

5 Intelligent Monitoring Device Based on Device Net

In order to improve its intelligence, the intelligent monitoring device is designed based on Device net bus technology in this paper. The device has been implemented in the Device net control network and has the function of Internet of things. The main work of this part includes three parts: hardware design of communication module, software design and data analysis.

First, these external signals including I_A, U_A, I_B, U_B, I_C, U_C and status signal of vacuum breaker are selected. These signals are photoelectric isolation and D/A conversion as input signals, where the vacuum circuit breaker realizes remote wireless control through I/O interface. PIC18F458 microcontroller is used as the control chip for hardware design, and these above signals are transmitted to the microcontroller. Then, the software design scheme includes the establishment of object model and I/O information connection. Finally, the SST-DN3-PCU-1 master card is used as a network analyzer to analyze the data communication between Device net and the test progress in

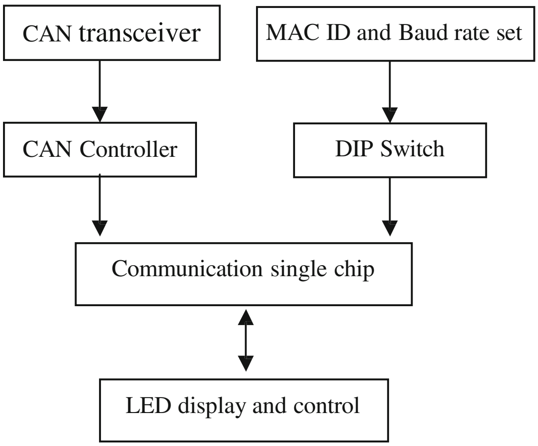


Fig. 11. The flow chart of hardware communication module design

detail. These operation parameters and status of intelligent monitoring device are uploaded to the network to realize remote monitoring and operation, and the real-time monitoring test process of remote network can be realized.

The flow chart of hardware communication module design is shown in Fig. 11, as follows

The hardware communication module design. The PIC18F458 is used as communication module control chip, and the chip is integrated with CAN controller.

The CAN transceiver chip uses the PCA82C250T as the bus driver. The main function of communication module is explained as follows.

(1) The CAN bus protocol is used to realize the basic functions of CAN communication transceiver and controller.
(2) The MAC ID and baud rate of the node are set by the DIP switch. The DIP switch sets the node address and can transmit data at three baud rates of 125K, 250K and 500K
(3) The SPI serial communication is used between the communication module MCU and the control unit to realize data exchange between the bus and the control unit
(4) The bus module communication status is displayed on LED display, according to the test needs, we can remote control, modify the test parameters, and transmitted to the monitoring device.

Software design. According to the functions that the data acquisition unit and the

Table 6. The object model

Object class	Message router	Device net	Connection	Analog input point	Discrete output point	Discrete input point
Data	1	1	1 explicit message 1 I/O message	6	1	1

control unit of the intelligent monitoring device can complete, these parameters that need to be transmitted in the network are defined. There are 8 I/O message data: I_A, U_A, I_B, U_B, I_C, $U_{C,}$ N and vacuum breaker Open/Close control signal. There is 1 explicit message: vacuum breaker status signal. Thus, the object model of the intelligent monitoring device is defined, as shown in Table 6.

Data analysis. This article uses the Device Net Network Analyzer analysis component in SST-DN3-PCU-1 as the network analyzer to obtain the data transmitted online. According to the fault model calculation method established above, the obtained data is analyzed in real time to determine whether there is a fault during the process. The data analysis and process is the same between monitoring device and intelligent monitoring device so we will not repeat the description.

6 Conclusions

In this paper, through the method of collecting test parameters, establishing fault diagnosis model and the design of monitoring device, effectively solves the problem of fault diagnosis and monitoring device for low voltage circuit breaker in the electrical life test. This paper has these following advantages compared with the traditional electrical life test method.

1. Collected parameters real time, based on the established fault diagnosis model, to determine whether the fault occurred in a timely manner.
2. The design of the monitoring device achieves fault diagnosis through effective value collection. Compared with the waveform collection method, the monitor device has no data storage and waveform generation, so the cost of equipment is reduced.
3. The design of the monitoring device has the function of automatic alarm and protective measures. The fault diagnosis does not rely on the experience of the tester to judge. Do not need the tester in the test site in real time, which saves labor cost.

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