On-line Monitoring System for Mechanical Characteristics of Vacuum Circuit Breaker

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Abstract. According to the present situation, this paper have developed a mechanical characteristics on-line monitoring system of vacuum circuit breakers with TMS320F2812 chip from TI Company as the central processing unit. It can work on-line for a long time and can communicate with upper computer by RS-485 which can display the curve of the mechanical characteristics.

Introduction

In power system, as the most important switchgear, the circuit breaker shoulders the dual task of protection and control of the whole power system. Twice worldwide surveys that CIGRE has made for the reliability of high-voltage circuit breakers, as well as statistical analysis of the National Academy of Sciences on the high-voltage power switch failure show that 80% of the high-voltage circuit breaker fault is due to poor mechanical properties and most of the fault is the problem of operating mechanism[1,2].

In recent years, the rapid development of sensor technology and signal processing technology provides the technical foundation for on-line monitoring of mechanical characteristics of vacuum circuit breaker many manufacturers develop the appropriate on-line monitoring equipment for mechanical characteristics of high voltage circuit breaker based on their own needs. However, most of those monitoring equipment can only monitor one or several mechanical characteristics parameters and don’t have wide applications. In addition, detections of some devices of those are still not ideal. [3,4].

In this paper, we studied the 10kV vacuum circuit breaker with permanent magnetic actuator and developed a new on-line monitoring system for mechanical characteristics of vacuum circuit breaker based on DSP2812 and high-accuracy displacement sensor.

The hardware system design

The design mainly consists of sensors, slave computer and upper computer. We uses linear displacement sensor with high linearity to collect the displacement signal. The slave computer uses TMS320F2812 chip as the central processing unit of this monitoring system to analyze opening and closing signal. The upper computer is worked out by Visual C++. The work flow of the system is as follows: TMS320F2812 chip receives the signals and processes them to calculate the opening time, closing time, overrun, opening range and average velocity of the vacuum circuit breakers [5]. These parameters are displayed on the LCD12864 to be looked up in the work field conveniently. At the same time, these parameters are transmitted to upper computers by RS-485 and the mechanical characteristics are displayed [6].

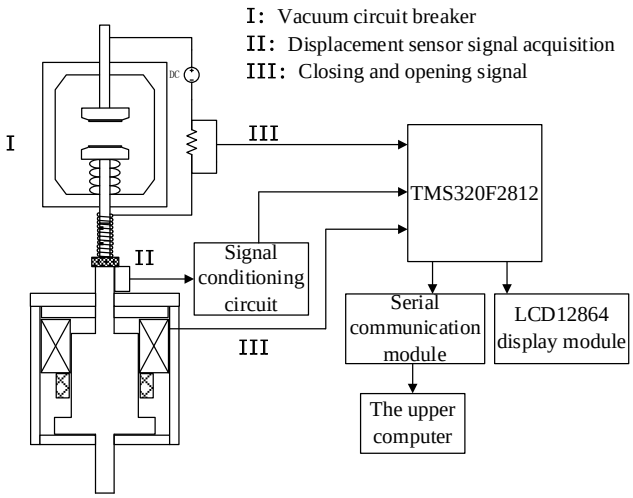

Figure 1. The hardware system's diagram of on-line monitoring system for mechanical characteristics of vacuum circuit breaker

Figure 1 provides the hardware system's diagram of on-line monitoring system for mechanical characteristics of vacuum circuit breaker in this paper.

In order to accurately measure closing and opening mechanical characteristic of vacuum circuit breaker, we choose KTM-50mm in this paper, which is a type of displacement sensor, to measure stroke signal of moving contact. The effective stroke of KTM-50mm (micro linear displacement sensor) is 50mm.There is one cushion stroke of 2mm at both ends of the sensor, the sealing grade is IP67.

The A/D converter of TMS320F2812 is used as AD sampling module of the system in this paper.

System Software Design

On-line monitoring hardware system for mechanical characteristics of vacuum circuit breaker needs to provide the necessary chips, peripherals and so on. The software design of the on-line monitoring system uses the modular and structured programming, mainly include: the main program, A/D data acquisition part, data processing part, LCD part and communication part. Figure 2 is the work flow chart for the main program of the entire software system.

The monitoring system can get the sampling time, real-time displacement parameter and the average speed of action through the AD sampling module and data processing.

The monitoring system needs to upload the data to the upper computer, and in the transmission process, data is transmitted in the form of ASCII codes. One standard ASCII is correspond to eight-digit binary number and the TMS320F2812 sampling precision is 12 bits, so when we set the communication protocol, the transmission of two ASCII as a sample data. Figure 3 is a flowchart of data conversion.

After the transfer to the host computer, it is displayed and decoded by the host computer.

The design of upper computer

The upper computer debugging interface is shown in Figure 4. When the data is transmitted to the upper computer, the received data needs to be decoded and restored by the upper computer. The restored data will be displayed as curves of the movable contact of the vacuum breaker formed and stored in a text document from where we can see every millisecond position whenever necessary.

Through the upper computer interface, it can be achieved that the mechanical characteristic curve of the vacuum breaker can be real-time displayed, from which the entire course of action can be viewed very intuitively. When the system draw a dangerous conclusions after systematic analysis, a warning light at the bottom of the left will lights up, and the pop-up dialog box displays the fault type. Finally, these data can provide ample and accurate basis for maintenance and troubleshooting of the vacuum breaker.

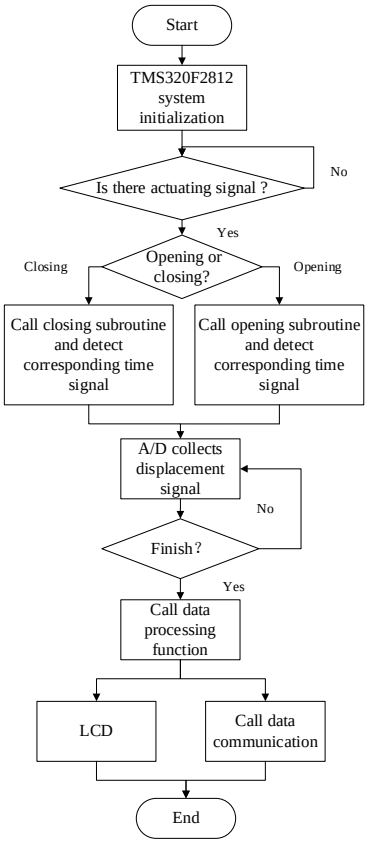

Figure 2. Flow chart of the main program

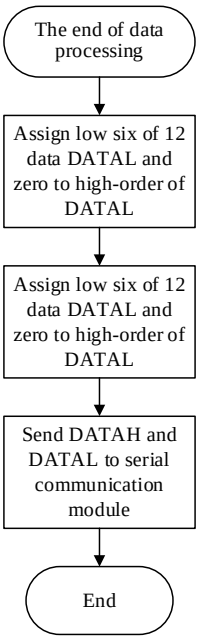

Figure3. Flowchart of data conversion

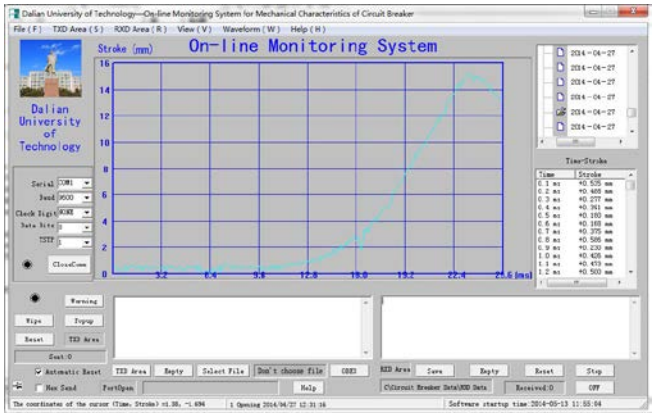

Figure4.The upper computer interface

Experiments

The experiment uses 10kV vacuum circuit breaker as research object. The total stroke of the vacuum circuit breaker is 15mm, opening range is 11±1mm, the capacitance value of the discharge capacitor is 22000μF, and voltage is 200V, which is just a reference to test the accuracy of the system. The opening time is 8.0ms and closing time is 22.4ms measured by the mechanical characteristics tester.

Figure 5 and Figure 6 show the closing and opening mechanical characteristic curve tested by the monitoring system. Table 1 and Table 2 show the closing and opening mechanical testing and actual parameters. To test the stability and accuracy of the monitoring system, the experiment compares the testing data and actual data.

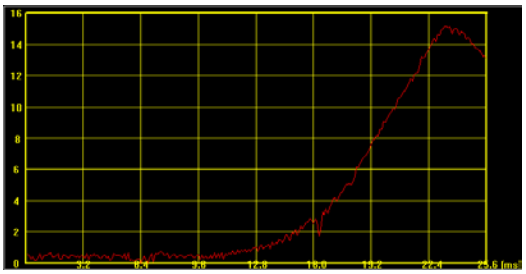

Figure5.Closing mechanical characteristic curve

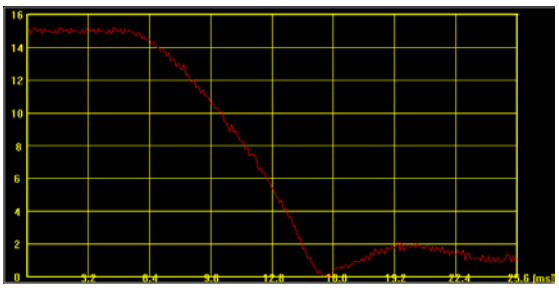

Figure6.Opening mechanical characteristic curve

TABLE I. CLOSING MECHANICAL CHARACTERISTIC PARAMETERS

	Overrun（mm）	**Opening range（mm）**	**Stroke（mm）**	**Closing time（ms）**
Testing value	3.8	10.7	14.5	21.8
Actual value	3.9	10.8	14.7	
Absolute error	-0.1	-0.1	-0.2	
Relative error	2.50%	0.90%	1.30%	

It can be seen from Figure 5 and Table 1 that the excitation time is about 9.8ms and the closing time is about 21.8ms in the closing process of the breaker.

From Figure 6 and Table 2 we can see that the exciting time of the opening process is about 4.2ms and the opening time is 8.2ms, thus the curve is basically complete and the motion state of the later part.

TABLE II. OPENING MECHANICAL CHARACTERISTIC PARAMETERS

	Overrun（mm）	Opening range（mm）	Stroke（mm）	Opening time（ms）
Testing value	3.8	10.8	14.7	8.2
Actual value	3.9	10.9	14.8	
Absolute error	-0.1	-0.1	-0.2	
Relative error	2.50%	0.90%	1.30%	

Figure 5, 6 and Table 1, 2 show that the test results of the mechanical characteristics online monitoring system of the vacuum circuit breaker is almost the same with the actual mechanical characteristics parameters It can be learned that the mechanical characteristics curve displayed can also truly reflect the movement of the opening and closing process proving that the entire system is authentic and reliable compared to mechanical characteristic curve.

As shown in Figure 7, the system considers that this action time is so slow that it has exceeded a reasonable margin of error after the comparative analysis with historical data that the alert prompts and preliminarily determines the fault type is mechanism jammed, which provide strong support for staff to find fault timely to analyze the type of failure.

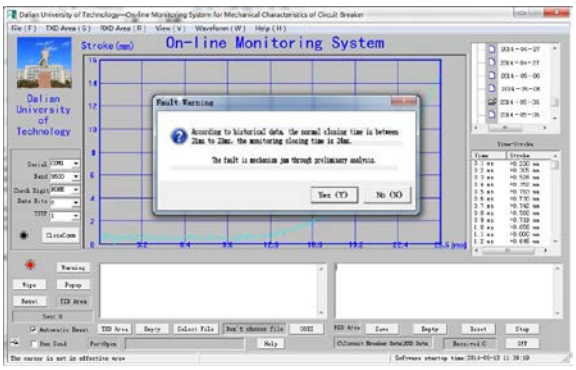

Figure7.Failure warning schematic

Conclusion

The paper developed an on-line monitoring system for mechanical characteristics of the vacuum circuit breaker which uses TMS320F2812 as the core processing chip, conducted experiments to prove its reliability, and obtained the following conclusions:

- (1) Experimental results show that the system can accurately measure the displacement curve of the opening and closing of the vacuum circuit breaker and then get the other parameters ,does not affect the normal operation of breaker;
- (2) Using TMS320F2812DSP as a core processing chip can accurately capture mechanical characteristics of the breaker and reflect the abnormal vibrations of a very short period of time;
- (3) The system can display real-time working status of mechanical characteristics of the breaker by using the upper computer;
- (4) According to the collation and analysis of the historical data, the system can send a fault alarm and prompt the type of fault which can provide strong support for the timely detection of breaker mechanical failure and reparation as soon as possible.

Acknowledgment

This paragraph of the first footnote will contain the date on which you submitted your paper for review. This work was supported in part by the National Natural Science Foundation of China (Project Number: 51277019) and in part by the National Natural Science Foundation of China (Project Number: 51337001).

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