

The research of high voltage switchgear detecting unit

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Abstract. In order to understand the status of the high voltage switch in the whole life circle, you must monitor the mechanical and electrical parameters that affect device health. So this paper gives a new high voltage switchgear detecting unit based on ARM technology. It can measure closing-opening mechanical wave, storage motor current wave and contactor temperature to judge the device's health status. When something goes wrong, it can be on alert and give some advice. The practice showed that it can meet the requirements of circuit breaker mechanical properties temperature online detection.

1. Introduction

High voltage switchgear is the key role between the power generation and distribution. Its safe operation guarantees the reliability of the power grid. High voltage switchgear can play a great role in the power grid system. It can make grid work well[1]. And then from the requirement for our country smart power grids construction, intelligent high voltage switchgear can monitor, think, analyze, control things and other function, all in one device. It achieves a higher level of technology.

The international power grid conference investigated and showed that control and assist part failure come after mechanical failure. 29% high voltage circuit breaker major failure and 20% minor one may be due to control and assist part[2]. The switchgear second loop adopts the traditional electromagnetic mechanical structure that can't meet the demand of modern power grids[3]. So with further automatic grids development, it must go towards intelligence.

2. Composition

Intelligent high voltage switchgear is composed of switchgear and intelligent unit, both form a combined system through sensor and controller as shown in the figure 1. Unit sends data to upper computer through IEC61850[4]. Upper computer uses expert system to analyze the device status data and estimate the device lifetime.



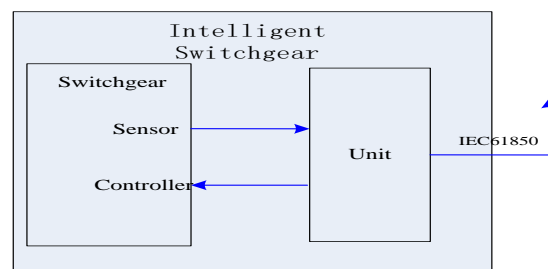


Figure 1. Intelligent Switchgear Structure Chart

The switchgear structure change that comes from the integrated design of intelligent switchgear shouldn't affect switchgear performance. The technological parameter should meet the national standards. Various sensors will be placed in and out of the switchgear connected by analog cable. The intelligent units placed in the intelligent unit cabinet should integrate control, measurement, monitor and other basic functions.

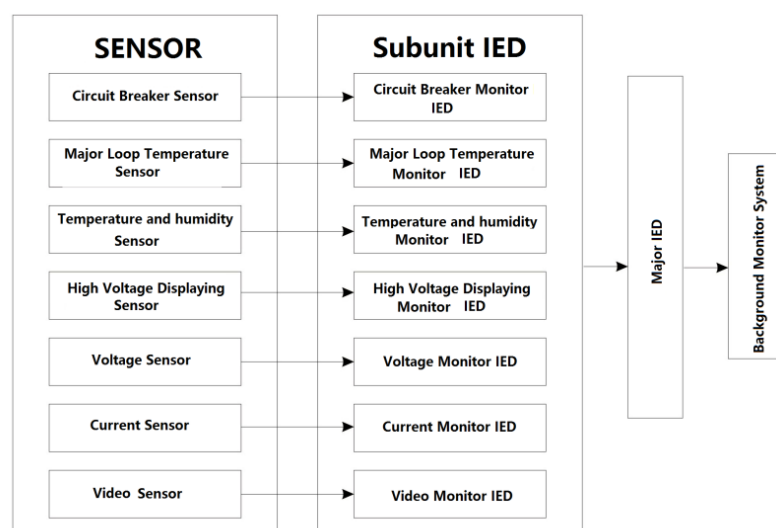


Figure 2. High Voltage Switchgear Intelligent Unit

The research of high voltage switchgear intelligent unit key technology is to study the integrated design based on the use of various sensors as shown in the figure 2.

The high voltage switchgear intelligent unit is composed of circuit breaker sensor, major loop temperature sensors, temperature and humidity sensors, high voltage displaying sensor, voltage sensor, current sensor and video sensor.

The circuit breaker sensors is used for monitoring breaker's mechanical properties, closing and opening coil current, operating stroke and speed.

The major loop temperature sensors is used for monitoring breaker's contact and busbar connector temperature.

The video sensors is used for monitoring breaker's room, busbar room and cable room.

The background monitor system has various functions such as data storage, analysis, report forms, expert decision that can pre-estimate the device life.

3. Key Point Research

3.1. Breaker's Contact and busbar Connector Temperature Sensors

The breaker's contact and busbar connector temperature sensors is composed of temperature sensor and receiver using wireless communication. The temperature sensor is installed on the breaker's

contact and busbar connector. The receiver is installed in the switchgear instrument room. The structure is as shown in the figure 3.

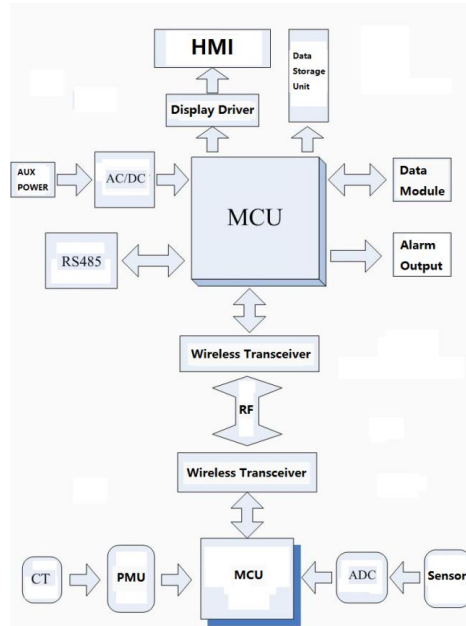


Figure 3. Major Loop Temperature Measure Principle Chart

The temperature sensor is composed of NTC resistance, CT power supply, signal conversion and transmit module as shown in the figure 4. NTC resistance put on the surface of breaker's contact closing to plum contact. NTC resistance value comes after the temperature change as shown in the figure 5.

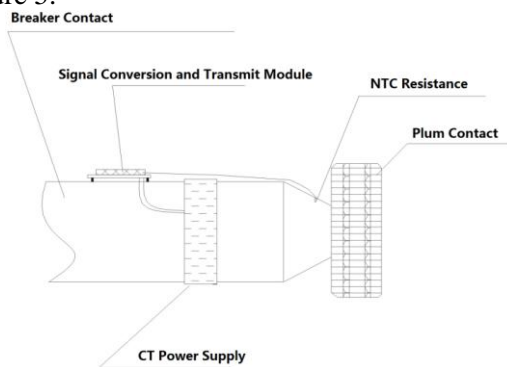


Figure 4. Temperature Sensor Principle Chart

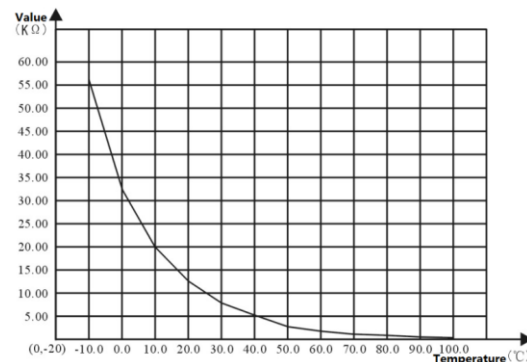


Figure 5. NTC Resistance Value-Temperature Diagram

The value of NTC resistance changes with the temperature. And it's transmitted to measuring MCU by the signal conversion and transmit module.

The signal conversion and transmit module is composed of high frequency receiving amplifier, rectifier filter, decoding circuit and alarm circuit. The wireless signal with temperature message and address codes is amplified by high frequency receiving amplifier. It's transmitted to decoding circuit and then give an alarm. The picture of real products is shown in figure 6.

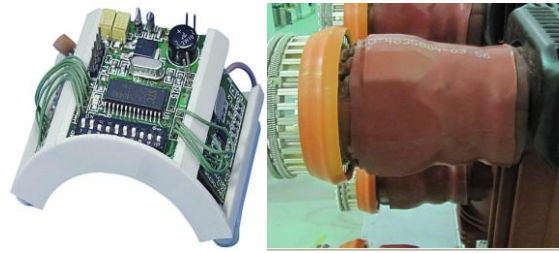


Figure 6. Temperature Sensor Picture of Real Products

3.2. Circuit Breaker's Mechanical Properties Sensor

Electromagnet is usually first level control element in the high voltage circuit breaker. The DC power supply is added to most of breakers. So there are many important mechanical error messages in the DC electromagnetic coil current waveform. The inductance value L depends on the size of coil and iron core. It has a close relation with iron core stroke S , and increases as S gets bigger. Hall sensor is used to measure the coil current, as shown in the figure 1, electromagnetic coil drive current value is 1-2A. The relation wave between coil current and time is shown in figure 7, A-electromagnet connecting rod activate, spring deformation, C/D-rod nearly arrives at deepest position, E-rod arrives at the deepest position, F-main contactor opens, G-assist contactor opens, H-rod and spring return to original position.

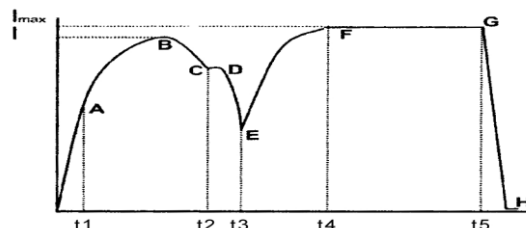


Figure 7. oil current and time wave diagram

It's shown from figure 7 that you can analyze the breaker's mechanical state from the wave. If point B becomes high, mechanism has jam error caused by the increase of resistance. If the wave disappears, the coil is broken. If point G goes left side, the action costs much more time and reduces speed[5].

The operating stroke can be detected by grating sensor, resistor sensor and so on. It chooses linear stroke sensor that is installed at linear action mechanism. It chooses rotate stroke sensor that is installed at rotate action mechanism. The output of the sensor goes by preprocess, such as isolation, clear, logical process, and you can get the breaker's operating stroke and time characteristic wave. The following parameters is calculated from the wave, average speed, average speed before closing and opening period(10ms)[6]. The difficulty is that stroke sensor can not be installed in the moving contact. So it can not directly measure the stroke that is converted. Figure 8, breaker's mechanical characteristic detection block, shows that displacement sensor is installed at the bottom fixed by stand. When vacuum envelope moves, sensor moves and displacement signal changes to electrical signal.

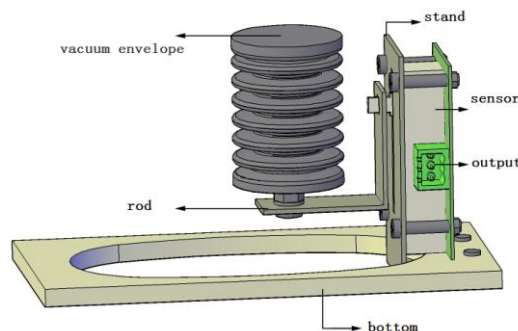


Figure 8. Mechanical characteristic installation

3.3. Intelligent Unit Embedded Software

The intelligent unit embedded software designed by the newest ARM technology made the monitoring terminal smart including CRC, the seamless coupling of terminal and secondary equipment, video monitoring and the other functions.

4. Test Result

In order to determine the feasibility of the high voltage switchgear detecting unit, a test bed is required.

Six temperature sensors are located on the surface circuit breaker's contacts, 3 above and 3 below. The circuit breaker current is 1375A, power-on hours count is 6 hours. Table 1, you can compare the test unit temperature against the standard value.

Table 1.

Conta ct Phase	Positi on	Time	1h	2h	3h	4h	5h	6h
A	above	Test Unit	24	56	69	76	80	82
		Increment Value		32	45	52	56	58
		Standard	28	60	75	81	84	87
		Increment Value		32	47	53	56	59
		Difference Value	4	4	6	5	4	5
B		Test Unit	23	54	68	76	80	83
		Increment Value		21	45	53	57	60
		Standard	28	60	75	82	85	87
		Increment Value		22	47	54	57	59
		Difference Value	5	6	7	6	5	4
C		Test Unit	24	56	69	76	80	82
		Increment Value		22	45	52	56	58
		Standard	27	60	75	81	84	86
		Increment Value		23	48	54	57	59
		Difference Value	3	4	6	5	4	4
A	below	Test Unit	24	55	66	71	74	75
		Increment Value		31	42	47	50	51
		Standard	28	61	73	77	80	81
		Increment Value		33	45	49	52	53
		Difference Value	4	6	7	6	6	6
B		Test Unit	24	55	67	72	75	77

C	Increment Value		31	43	48	51	53
	Standard	28	61	74	78	81	83
	Increment Value		33	46	50	53	55
	Difference Value	4	6	7	6	6	6
	Test Unit	24	55	66	71	74	75
	Increment Value		31	42	47	50	51
	Standard	27.7	60	72	77	79	81
	Increment Value		32	44	49	51	53
	Difference Value	4	5	6	6	5	6

From the above data analysis, test unit value is basically the same as standard value. The difference value is small and caused by the different location that the sensors are placed.

Based on the above principle high voltage circuit breaker mechanical characteristic online detection can measure opening coil current wave, closing coil current wave, closing coil broken, opening coil broken, storage coil current wave, storage time, opening time-stroke wave closing time-stroke wave. It's shown in figure 9.

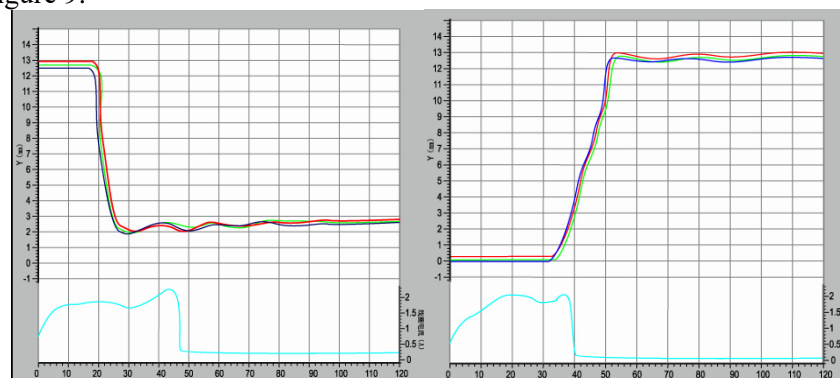


Figure 9. Mechanical characteristic wave block

Now, off line mechanical characteristic detective device uses breaker's moving contact and fixed contact voltage signal to measure breaker's iron closing and iron opening point. Based on the current signal, it can learn the iron closing and opening point, and measure the opening distance and super distance.

For the online detective device, it can use the above method, because there are high voltage when breaker's working. It can not add current signal to judge the closing and opening point. So the above parameter must be measured by the iron closing and opening point.

In order to solve the above problems, it uses the pressure sensor installed at the bottom of breaker's spring to get the state of the closing and opening iron point. But this method just suits to the new building breaker.

The mechanical closing opening stroke and electrical wave is recorded to compare with original data. If it finds $\pm 5\%$ deviation, it shows that breaker's mechanism has some errors and it will affect breaker's closing and opening action. It recommends that the circuit breaker should be overhauled.

5. Conclusion

Based on the above principle high voltage switchgear detecting unit can measure opening coil current wave, closing coil current wave, closing coil broken, opening coil broken, storage coil current wave, storage time, opening time-stroke wave closing time-stroke wave. For the online detective device, it can use the above method, because there are high voltage when breaker's working. It can not add current signal to judge the closing and opening point. So the above parameter must be measured by the iron closing and opening point. In order to solve the above problems, it uses the pressure sensor installed at the bottom of breaker's spring to get the state of the closing and opening iron point. It depends on the change of the pressure to judge the points. Abnormal temperature change is often the direct characterization and early warning of electrical equipment failure or accident. Through the real-time temperature monitor, it help us find high voltage switchgear problems timely and solve them. The test result shows that high voltage switchgear detecting unit really works.

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