Design and Implementation of Disconnector Condition Monitoring System Based on Attitude Sensor

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Abstract. In order to meet the new requirements of substation for the status monitoring of disconnector switch, a disconnector status monitoring system based on MPU9250 was designed. It realizes the double confirmation of status monitoring of disconnector switch in substation. A status determination algorithm of disconnector switch was proposed.

Keywords: Disconnector · Double confirmation · MPU9250

1 Introduction

The state of disconnector switch in domestic power system is generally judged by the remote signal, which is confirmed by operator observation. There are many problems with this approach. Therefore, it is particularly important to develop an effective and reliable state monitoring method for disconnector switches. In paper,the research condition of breaking-closing position monitoring technology for intelligent disconnecting switches is summarized [1].

By researching the attitude estimation and control of 4-axis rotorcraft [2–4], we introduce the attitude sensor commonly used in 4-axis rotorcraft to opening and closing state monitoring system of the disconnector switch. In order to accurately distinguish the disconnecting state of the real time disconnector switch, anopening and closing state monitoring system based on attitude sensor is designed, which providessafety guarantee for power system operation.

2 Hardware Structure

The system includes the attitude sensor installed on the disconnector switch, the receiving device used to receive attitude information and the process attitude data to judge the disconnector switch's opening and closing state. The upper computer used to display the opening and closing state in real time and record the opening and closing record. The system's topology is shown in Fig. 1.

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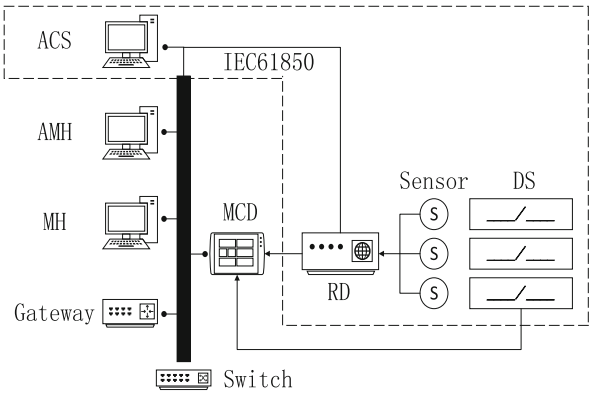

Fig. 1. The framework of disconnector switch status monitoring system

2.1 Function of Attitude Sensor

The attitude sensor MPU9250 is installed on the main shaft of the actuator of the disconnector switch to collect the rotation angle of the main shaft. The switching state of the disconnector is judged by the angle, and the angle data, acceleration, angular acceleration and other data are uploaded to the receiving device through the Modbus-RTU communication protocol. Data is processed based on Kalman filting algorithm [5, 6] and the unscented Kalmam filter algorithm is used for data fusion [7]. Based on the relevant information, the receiving device judges the switching state of the disconnector and controls the output of the corresponding switching quantity. The relevant data is uploaded to the monitoring host and auxiliary control system through the IEC61850 protocol [8, 9].

2.2 Receiving Device Hardware Design

The receiving device obtains sensor data through the RS485 interface, and judges the state of the disconnector switch through the calculation algorithm and logical judgment algorithm. The judgment result is uploaded to the monitoring system through RS485 or IEC61850 and the corresponding hard contact is opened. The hardware diagram of receiving device is shown in Fig. 2.

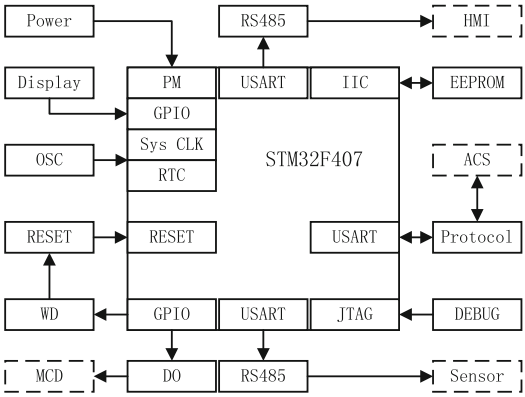

Fig. 2. Hardware diagram of receiving device.

3 State Determination Algorithm of Disconnector

3.1 The State of Disconnector Switch Judgment

The attitude sensor collects the angle of the disconnector in real time. During the deployment, the sensor needs to be calibrated according to the disconnecting and closing position of the disconnector switch. If the initial state of the disconnector switch is on, the sensor is calibrated to 0°. The Angle margin between the opening and closing positions of the isolator is defined as Δ. The attitude sensor is defined to measure the angle at the beginning of the motion as θ_s and the angle at the end of the motion as θ_f after being awakened. The state judgment method of the disconnector switch is shown in formula 1.

$$\theta_o - \Delta \leq \theta_f - \theta_s \leq \theta_o + \Delta \tag{1}$$

When the angle measured by the attitude sensor satisfies formula 2, the state of the disconnector switch can be determined as off to on.

$$-\theta_o - \Delta \leq \theta_f - \theta_s \leq -\theta_o + \Delta \tag{2}$$

When the angle measured by the attitude sensor satisfies formula 3, the state of the disconnector switch can be determined as opening abnormal state.

$$\Delta < \theta_f - \theta_s < \theta_o - \Delta \tag{3}$$

When the angle measured by the attitude sensor satisfies formula 4, the state of the disconnector switch can be determined as closing abnormal state.

$$-\theta_o + \Delta < \theta_f - \theta_s < -\Delta \tag{4}$$

3.2 State Judgment Logic

To judge the state of the disconnector switch, the receiving device shall determine the opening and closing position and state of the disconnector switch by analyzing the sensor data installed in A, B and C. According to the position and state judgment logic to the isolation switch on and off state to determine. The diagram of position judgment logic is shown in Fig. 3.

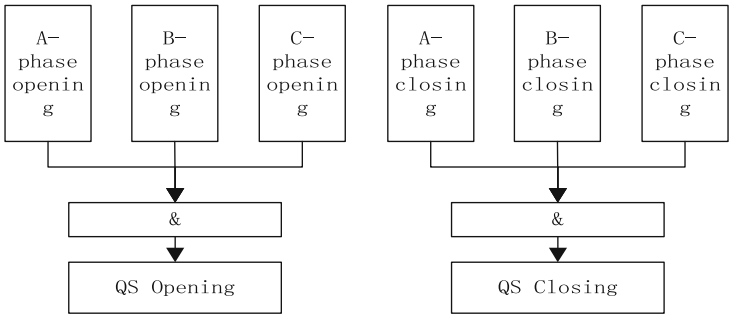

Fig. 3. Diagram of position judgment logic.

The position determination result is taken as the input parameter of the state determination result. The state judgment of the disconnector switch is realized according to the state determination logic. The diagram of state judgment logic is shown in Fig. 4.

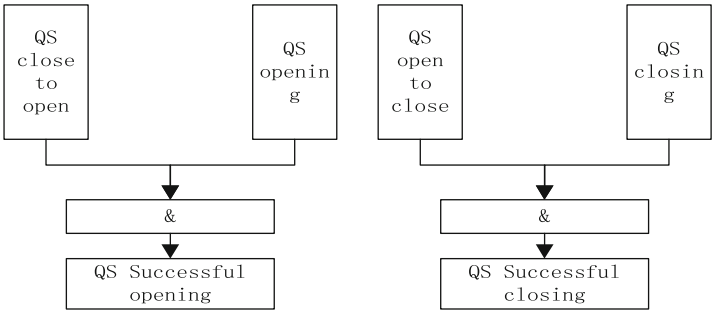

Fig. 4. Diagram of state judgment logic.

4 Software Design

The software of state monitoring system includes attitude sensor program and receiving device program. After the attitude sensor program is initialized, the sensor configuration is loaded and the attitude data is cyclically monitored to calculate the 3-axis acceleration,

angular velocity, magnetic force value and temperature. The data is corrected and packaged in Modbus standard format. If a data request is received from the receiving device, it is sent to the receiving device. When a large angle change is detected, the transmission interrupt will be awakened and the data will be actively uploaded to the receiving device, while the data is actively uploaded to the receiving device. The flow chart of sensor programming is shown in Fig. 5. The receiving device program completes the initialization, loads the configuration information of the receiving device. It starts to query the data of each sensor. According to the sensor data received to judge the disconnector switch state and the state of the output of the corresponding hard contacts, the data is packaged into Modbus protocol standard packet. It sends to the IEC61850 protocol conversion module through the serial port, protocol conversion module according to the data point table to map the data to the IED model. The final implementation of IEC61850 communication function. The flow chart of receiving device programming is shown in Fig. 6.

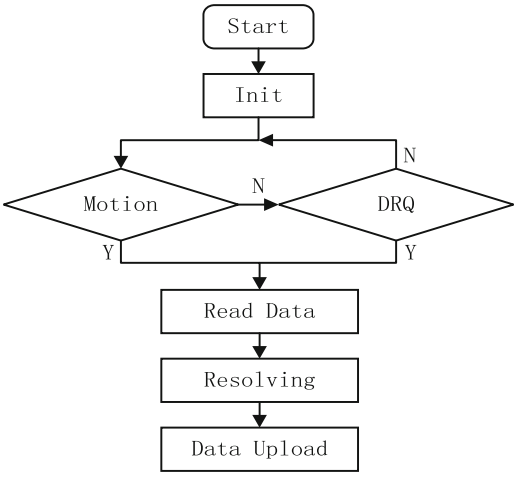

Fig. 5. Flow chart of sensor programming.

In order to verify the reliability of the system, repeated simulation tests are carried out for the system. The simulation test is the consistency test of switching state.

The consistency test method is to simulate the actual application process. The sensor is fixed on the main shaft of the disconnector switch operating mechanism. The opening and closing of the disconnector switch is simulated by rotating the main shaft of the operating mechanism. The system was simulated for 100 times in each of four states. The experimental results are shown in Table 1.

The consistency of disconnector switch is shown in Table 1. The accuracy of the opening and closing of four states reached 100% via 400 tests, which meets the practical application needs. It can be judged that the device can determine the disconnecting switch switching state stably and accurately.

Mentioned experimental data shows that the system can monitor the switching state of the disconnector stably and reliably in real time.

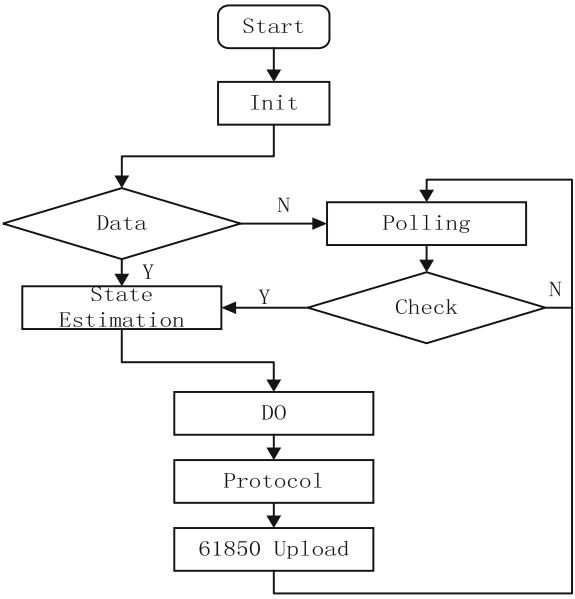

Fig. 6. Flow chart of receiving device programming.

Table 1. Opening and closing state to determine the consistency of the experimental results.

Path	Number of replicated tests	Number of correct tests	Number of errors	Consistency%
Closing in place	100	100	0	100
Closing abnormal	100	100	0	100
Opening in place	100	100	0	100
Opening abnormal	100	100	0	100

5 Conclusion

The state monitoring system designed in this paper can effectively realize the real-time monitoring of the state of the disconnector switch, which provides an effective criterion for double confirmation of disconnector switch in substation. The experimental results show that the system can effectively improve the monitoring accuracy of substation disconnector switch state. Mentioned research can support the intelligent development of substation.

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