Research Of Maintenance Mechanism About Fault Recorder in Intelligent Substation

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Abstract. Currently in the secondary equipment maintenance process of intelligent substation, there are no GOOSE sending soft pressure platen and maintenance pressure platen between the fault recorder and secondary equipment. It cannot isolate the fault recorder and maintenance equipment through repair mechanism in the equipment maintenance process. Therefore, it will produce a large number of taped files and fault information in the fault recorder and cause interference and security risks to the normal operation of the substation. This article will focus on the mechanism of fault recorder and maintenance in the intelligent substation in order to achieve safe isolation between fault recorders and other devices in maintenance.

Keywords: Intelligent Substation, Fault Recorder, Maintenance Mechanism.

1. Introduction
With the development of high automation in power system, the fault recorder has become an indispensable configuration for analyzing electrical faults in power system. In the maintenance process of conventional station, the maintenance personnel often remove the common end of the fault recording signal on the maintenance equipment and disconnect the voltage and current of the fault recorder, so as to isolate the fault recorder from the maintenance equipment. It can prevent the analog signal and outlet signal from being added to the fault recorder by mistake during the protection device calibration and transmission in the maintenance interval, which will cause interference to the normal operation of other equipment in the substation.

In the maintenance process of intelligent station, this method obviously cannot be copied. The implementation of safety measures in the maintenance of secondary equipment in intelligent substation is very different from that in traditional substation. Different from the requirement that the conventional station must have an obvious physical disconnection point, the secondary equipment in the intelligent station often uses the maintenance mechanism of message and the switch on/off of Goose sending soft platen to complete the isolation of maintenance equipment. However, the fault recorder used in intelligent substation does not have this maintenance mechanism to ensure that other equipment can be reliably isolated from it during maintenance, and the operation of other equipment will not be affected during its self-maintenance.

This paper proposes a maintenance mechanism of fault recorder in secondary equipment maintenance of intelligent station to realize the safety isolation between the fault recorder and other devices during maintenance.
2. Introduction of Maintenance Mechanism

2.1. Maintenance pressing platen
The maintenance platen of intelligent substation can only be operated locally, which is also the only hard platen for intelligent substation protection. The protection device realizes the maintenance mechanism of different messages through the switching of the maintenance platen.

2.2. Message maintenance quality bit
IEC61850 defines the quality factor q of MMS, GOOSE and SV messages, which is used to indicate the message transmission quality. As shown in the table 1, the q contains 4 bytes of 16 bits of data, and the 11th bit is the maintenance bit. When the device maintenance platen is put into operation, the maintenance bit of the q of the three messages sent by the device is set to 1.

| Bit | 0-1 | 2 | 3 | 4 |
|-----|-----|---|---|---|
| Property name | Legitimacy | Overflow | Over range | Bad quotation |
| Bit | 5 | 6 | 7 | 8 |
| Property name | Oscillation | Fault | Old data | Inconformity |
| Bit | 9 | 10 | 11 | 12 |
| Property name | Inaccurate | Source | Maintenance | Atresia |

The information of the secondary equipment of intelligent transformer is mainly transmitted by SV, MMS and GOOSE message. After being put into the maintenance platen, the SV, MMS and GOOSE message sent by the device will have the maintenance quality identification. The message received by the next level device will be compared with the status of the maintenance platen of this device. If the maintenance status of the devices on both sides is consistent, the message will be processed effectively, otherwise invalid. The maintenance mechanisms of the three types of messages are as follows:

2.2.1. MMS message. The device sends the status of the maintenance platen to the client; When the device maintenance platen is put into operation, the test bit of signal quality q in the sending message should be set; According to the test bit of quality q in the message, the client judges whether the message is a maintenance message and makes corresponding processing. When the message is a maintenance message, the message content will not be displayed in the briefing window, and no sound alarm will be given, but the picture will be refreshed to ensure that the state of the picture is consistent with the actual situation. The maintenance message should be stored and can be queried through a separate window.

2.2.2. GOOSE message. When the device maintenance platen is put into operation, the test in goose message sent by the device should be set; The GOOSE receiver device will compare the test bit in the received GOOSE message with the maintenance status of the device itself. Only when they are consistent can the signal be processed or acted effectively; For the measurement and control device, when the device maintenance platen is put into operation or the test bit of goose message received is 1, the test bit of the quality q of the relevant signal in the uploaded MMS message will be set to 1.

2.2.3. SV message. When the maintenance platen of the merging unit is put into operation, the test bit of the quality q of the sampling value data in the sending sampling value message should be set to true;
When the test bit of the quality q of the SV receiver device is true, the device shall be able to calculate and display the amplitude of the sampled data under the maintenance state even if the protection of relevant parts is withdrawn;

If the protection configuration is duplex, all merging units of the received sample value control block of the protection configuration should also be duplex. The two sets of protection and merging units are completely independent in physics and protection. The maintenance of one set of merging unit does not affect the operation of the other. At the same time, for protection devices with multiple SV inputs, when an SV receiving soft platen exits, it should exit its sampling value. The interruption or maintenance of the SV will not affect the operation of the device.

3. Introduction of Digital Fault Recorder in Intelligent Substation

With the popularization of intelligent substation, the networking of secondary equipment requires the recorder to change from the traditional analog and switching input to SV message and GOOSE message input. Currently the digital wave recorder used in the intelligent station is shown in Figure 1. Similar to the protection device, the fault recorder receives the switching data of the required interval by the GOOSE of A network and B network and receives the analog data of the required interval by SV network of merging unit.

![Figure 1. The structure diagram of ordinary digital recorder filter.](image)

The digital wave recorder of intelligent station adopts the modular design method, and each module mainly completes the following five functions:

a. The digital switch input module and analog input module are responsible for receiving the two networks of GOOSE message SV message, forming a real-time data and going to the next operation.

b. The start, operation and logic judgment module of the CPU of the fault recorder, which calculates the received switching value and analog value of each interval after time synchronization. If the starting value is triggered, the fault recorder can start the wave recording immediately according to the requirements, record the analog and digital values of each interval in the fault state, and transfer the formed wave recording file to the storage unit.

c. The storage unit is responsible for storing the recording file in the file directory of COMTRADE in the hard disk of the device. And the waveform file name is ‘IED name_Logical device name_Fault number_Failure time’, in which the logical device name does not include the IED name, the failure serial number is a decimal integer, and the failure time format is ‘month year day.Hour minute second.millisecond’.
d. The communication unit configures the RecMade and FltNum data of the fault recorder RDRE to the data set, and uploads them to the MMS network in the form of report for the monitoring system to read;

e. Through IEEE1588, second pulse timing and B code timing, the time synchronization unit ensures that the sampling time of each device is on the same reference value.

4. Research on the Scheme of Fault Recording Maintenance Mechanism

The fault recorder of intelligent station so far does not have maintenance mechanism, nor does it have soft platen to isolate multiple goose messages. That is to say, the virtual terminal connection between fault recorder and each bay protection device does not pass the SCD file, and there is no soft pressing platen for virtual terminal switching on or off. Therefore, in the process of maintenance, we often take the way of pulling out the optical fiber for maintenance. This hard isolation method will not only cause damage to the optical fiber, but also does not meet the requirements of uninterrupted maintenance, which will cause hidden dangers to the operation and maintenance of secondary equipment. With the popularity of intelligent substation, the maintenance of secondary equipment in intelligent substation will be launched in a large scale, and the action of fault recorder will gradually be included in the evaluation index. How to implement fault recorders’ safety measures in the maintenance of intelligent substation will be a problem that each maintenance company must face.

Through the debugging research in the Zhejiang 500kV Zhiyan substation and the intelligentized reconstruct project of 500kV Shuanglong substation, it is found that the following modular form of digital fault recorder can be used to implement the safety measures.

As shown in Figure 2, In order to ensure the protection device is isolated from the fault recorder during maintenance, the improvement of fault recorder mainly includes the following points:

4.1. Adding a message analysis program and set maintenance pressure platen

The maintenance bit of the received SV message and goose message quality bit is mainly analyzed after adding a message analysis program to the program module of fault recorder. And the maintenance platen is set on fault recorder, which can only be operated by operators locally.

![Figure 2. The structure diagram of improved digital recorder filter.](image)
The fault recorder can change its own maintenance state by switching the maintenance platen on or off. Through the comparison between the self-maintenance status and the received message, the maintenance mechanism of fault recorder is realized. When the maintenance bits are consistent, the fault recorder receives the analog value in SV message and the switch value input of GOOSE message, records and broadcasts the unexpected variables in the message. If the maintenance bits are inconsistent, the fault recorder will mark the source address of the message as maintenance status and receive the message from the device, but won’t handle the message sent from the address.

During the maintenance of interval equipment, the maintenance platen of the maintenance equipment is put into operation, and the maintenance platen of the relevant fault recorder is in the exit state, so as to ensure the isolation of the fault recorder from the maintenance equipment. When the fault recorder is overhauled, it is isolated from other operating equipment after its maintenance platen being put on. And the maintenance quality position of the MMS message is set to 1, which can be used by the background to filter the maintenance message.

4.2. Adding switching soft platen
Switch on / off platens of different intervals are set on fault recorder. When a switch on / off platen is put into operation and the corresponding interval is in the running state, the fault recorder correctly receives SV and GOOSE message of the interval, and records the running state of the interval. When the switch on / off platen exits, it is considered that the interval is in the exit operation state and the message sent by devices of the interval is not received.

4.3. Setting SV and GOOSE soft platens of different devices
According to the situation of no power outage maintenance, that is, the primary equipment is not powered off, and the secondary equipment is powered off in turn, the SV receiving soft platen and GOOSE receiving soft platen of different devices can be set on fault recorder, so that the fault recorder can only isolate the maintenance device in the corresponding interval and not isolate other normal operation device in the interval, so as to achieve the purpose of no power outage maintenance.

5. Hardware design of maintenance mechanism
The hardware structure of digital fault recorder includes fault recording unit and fault analyzing unit. The fault recording unit is a background computer, which is responsible for recording data. And the fault analyzing unit is the front-end computer. They are connected through network. The background computer sends fault recording data to the front-end computer through the network, and uses the analyzing software installed in the front-end computer to analyze the recording data.

The fault recording unit is the core part of the whole device, which adopts DSP + ARM structure, and is divided into IEC61850 message processing module, time synchronization module, fault recording start discrimination module, data communication module, etc. The DSP module completes the functions of message processing, data synchronization, recording start discrimination, and the ARM module completes the function of data communication management.

The DSP chip used in the design scheme this paper is TMS320VC5509 produced by Texas Instruments (TI), which has powerful performance and can be directly accessed with ARM chip through HPI interface. The Ethernet control chip matched with it is DM9000 B chip produced by Taiwan Lianjie International Company. It is a fully integrated and low-cost single fast Ethernet controller chip, cooperating with optical fiber interface and network interface to realize real-time data recording.
6. Software design of maintenance mechanism
The software design of the fault record maintenance mechanism discussed above is shown in Figure 3. The data of SV sampling value sent by merging unit to bay level equipment adopts IEC61850-9 standard. And the data of GOOSE switch displacement sent by protection control unit adopts IEC61850-8 standard. The DSP module discriminates the type of the received message firstly, obtains the quality factor Q, and then processes the maintenance mechanism. Only when the maintenance states are consistent can the message be received and processed.

7. Summary
The maintenance mechanism of fault recorder proposed realizes a multi-layer safety measure between the fault recorder and the secondary equipment in secondary equipment maintenance of intelligent station, ensures the isolation of maintenance equipment and fault recorder, and ensures the normal operation of substation.
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