Research on On-line Monitoring Technology of Running State of Time Synchronization Device Based on IEC61850

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Abstract. Smart substation time synchronization is an integral part of the safe and stable operation of substations. Establishing an effective online monitoring technology, the accuracy, stability and status information of the time synchronization information are the focus of substation commissioning, operation and maintenance and overhaul. This paper analyzes in depth the current status, technical route and program implementation of the existing smart grid time synchronization, improves the time synchronization online monitoring technology, and strengthens the monitoring of the excessive operation process of the timing equipment, providing reference for the future time-synchronized online monitoring technology of the smart substation.

Introduction

Smart substation is an important part of the smart grid. The time synchronization device serves as a unified standard time source for the entire station to provide time information and synchronization information for various secondary devices in the station, such as dispatch automation system, relay protection device, fault recorder, time sequence recording devices, remote device, lightning positioning systems, merging units and IED devices [1], it plays a key role in the safe and stable operation of smart grids.

With the continuous development of the smart grid, higher requirements have been put forward for safe and stable operation of the grid system, lean data collection, real-time monitoring of the operating status and comprehensive analysis of the dispatch management. Currently, the validity and stability of the time synchronization status of the on-site time synchronization system (time service and timed equipment) are judged by the time synchronization device (time service equipment) itself. At the same time, a small amount of operating status of the time synchronization device itself is also sent to the monitoring background. Through the above methods, the closed-loop monitoring of the time synchronization system in the station is realized. In recent years, IEC 61850 has achieved certain applications in time synchronization device information exchange. However, the current running state parameters sent by the time synchronization device itself are not comprehensive enough, and their own operating states cannot be completely described and expressed. It is not convenient for secondary equipment debugging, maintenance, fault tracing and background scheduling decisions.

The purpose of this paper is to research and analyze the on-line monitoring technology of intelligent substation time synchronization system, establish a more comprehensive monitoring means and methods, and extend the application of secondary monitoring back-end to provide a reference for on-line monitoring of smart substation time synchronization system.

Current Status of Time Synchronization Monitoring Systems

Since 2013, the State Grid issued the "Notice of the State Commissioning Center on Strengthening Time Synchronization Operation Management of Power System" from [2013] No. 82, and after five
years of technical route formulation, monitoring and management plan establishment, time synchronization supervision work and steady progress, the power time synchronization monitoring technology has played a huge role in the safe operation of the power grid. However, with the continuous technological innovation of the smart grid, the ability to synchronize the running status of the time needs to be improved. Therefore, research time synchronization application evaluation monitoring, realizing the integrated intelligent monitoring of timing equipment, timed equipment, and trend data, provides a powerful reference for the development direction of smart grid time synchronization.

On-site Time Synchronization System Online Monitoring Technical Solutions

Time Accuracy Monitoring Of Timed Equipment. Based on the principle of ping pong (four time markers) to monitor the time accuracy of time synchronization devices and other timed equipment, in the station control layer and the interval network polling monitoring according to a preset cycle through NTP, uniformly analyze the monitoring results and send them to the monitoring background. In the monitoring of the process level timed device is achieved through the GOOSE method, the monitoring terminal sends a request command, and the timed equipment sends a corresponding time mark response command to obtain the time offset of the timed equipment. Since smart devices all adopt the DL/T860 as a standard architecture, smart devices can output GOOSE, SMV and other information through the network. This information also has clear time information, providing a time basis for on-line monitoring of time offsets of these devices [2]. The accuracy of the time deviation monitored by the network NTP method and the GOOSE method is generally above the millisecond level. It is limited by the current network communication technology. In the short term, there is no monitoring program that is more suitable for on-site monitoring of network applications and with higher accuracy. With the development of communication technologies, it is believed that there will be better solutions in the future.

Figure 1. Existing time synchronization online monitoring scheme.

Monitor the Running Status of the Time Synchronization Device. In addition to the timing accuracy of the equipment being time-controlled, the time synchronization of its own small amount of operating status also needs to be uploaded to the monitoring background in a timely manner to facilitate background debugging, analysis, and management. According to the current power grid specifications, the status information sent by the time synchronization device is mainly the status of each time input source, such as the steady state data such as Beidou, GPS, and external input B code source status. Time synchronization Device status monitoring information is shown in the table below[3]:

![Diagram of monitoring scheme](image)
Table 1. Time Synchronization Device Status Monitoring Information.

<table>
<thead>
<tr>
<th>No.</th>
<th>Status information</th>
<th>No.</th>
<th>Status information</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>BDS source signal status</td>
<td>11</td>
<td>BDS time hopping detection status</td>
</tr>
<tr>
<td>2</td>
<td>GPS source signal status</td>
<td>12</td>
<td>Ground cable time transition detection status</td>
</tr>
<tr>
<td>3</td>
<td>Ground cable signal status</td>
<td>13</td>
<td>Hot-standby source time transition detection status</td>
</tr>
<tr>
<td>4</td>
<td>Hot-standby source signal status</td>
<td>14</td>
<td>IRIG-B time source 1 time transition detection status</td>
</tr>
<tr>
<td>5</td>
<td>IRIG-B time source 1 signal status</td>
<td>15</td>
<td>IRIG-B time source 2 time transition detection status</td>
</tr>
<tr>
<td>6</td>
<td>IRIG-B time source 2 signal status</td>
<td>16</td>
<td>Crystal tamed state</td>
</tr>
<tr>
<td>7</td>
<td>GPS antenna status</td>
<td>17</td>
<td>Initialization state</td>
</tr>
<tr>
<td>8</td>
<td>BDS antenna status</td>
<td>18</td>
<td>Power module status</td>
</tr>
<tr>
<td>9</td>
<td>GPS satellite receiving module status</td>
<td>19</td>
<td>Time source selection state</td>
</tr>
<tr>
<td>10</td>
<td>BDS satellite receiving module status</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The Current Lack of Time Synchronization Online Monitoring

Insufficient Monitoring of the Operating Status of the Time Synchronization Device. At present, the background monitoring can only monitor a small amount of time synchronization device operating status, closed-loop monitoring is not perfect, in the actual production and operation process, the secondary equipment in the station due to timing accuracy decline, timing failure, etc., on-site maintenance and repair personnel cannot be timely positioning Failure point. The traditional approach is to fully inspect the entire timing link, including: time synchronization equipment, signal cables, and timed equipment, causing unnecessary time and energy wastage.

In the same way, in the on-site commissioning and acceptance process, the acceptance of the protection function test, the merger unit test, the primary measurement accuracy, the fault wave recording test, the network analysis function and the trend data quality assessment all require the support of the time synchronization device. By evaluating the differences in data balance and evaluating the quality of the operational data and the quality of the relevant intervals, the capability of secondary system fault diagnosis and equipment operation defect assessment can be improved.

The Time Synchronization Device Does Not Monitor the Accuracy of the Timed Equipment. The time accuracy monitoring based on NTP and GOOSE networks is currently only in the order of milliseconds. In the short term, it can meet the current requirements for time monitoring accuracy in the existing stations, but it is not conducive to monitoring background refinement and dynamic data analysis. The timing accuracy of the current time synchronization device can reach within 1 microsecond, and the monitoring accuracy still stays at the millisecond level. Obviously, the true timing of the timed device cannot be accurately measured.

Monitoring Background Integrated Display Analysis and Processing Capacity Is Not Enough. The monitoring background should not only be used as the site's unified information collection, data processing and dispatching decision-making role, but also have the functions of failure analysis, process state over monitoring, risk estimation, data visualization, etc. In the event of a failure, debugging and maintenance Work provides more detailed and comprehensive data support.

Analysis of Time Synchronization Online Monitoring Technology

Since the monitoring technology of this cup has matured since the current time synchronization is being granted, this article only analyzes the monitoring of the running status of the time synchronization device. See Table 2 below for details:
Table 2. Time synchronization device supplementary status monitoring information.

<table>
<thead>
<tr>
<th>No.</th>
<th>Status information</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Recovery process</td>
</tr>
<tr>
<td>2</td>
<td>Sliding step time</td>
</tr>
<tr>
<td>3</td>
<td>Remaining recovery time</td>
</tr>
<tr>
<td>4</td>
<td>Time source switching information</td>
</tr>
<tr>
<td>5</td>
<td>BDS transition time</td>
</tr>
<tr>
<td>6</td>
<td>GPS transition time</td>
</tr>
<tr>
<td>7</td>
<td>Each output signal monitoring status</td>
</tr>
</tbody>
</table>

Separately explain the contents of the above table:

1) Recovery process

   The process of the time synchronization device recovering from the punctual state to the standard time signal is referred to as the time synchronization device recovery process, since the time when the failure of the external timing source returns to normal can be long or short. As time passes, the internal time of the time synchronization device will gradually produce a clock difference with the standard time, and the longer the time difference is, the more likely it is that tens of milliseconds to several hundred milliseconds may occur. Therefore, during the recovery of the time synchronization device to the standard signal, the monitoring background needs to know the operating status of its over-process in order to analyze the impact of the recovery process on other timed devices.

2) Sliding step time

   In the conventional time synchronization device, the sliding stepping parameters in the recovery process can be seen only in the device terminal. When a fault occurs due to time-related alarms in the equipment in the station, the dispatcher, plant and station need joint maintenance personnel to reach the fault site for troubleshooting and analysis. It is time-consuming and inefficient.

3) Remaining recovery time

   In order to better evaluate the impact of the time synchronization device on the time synchronization system in the recovery process, the remaining recovery time in the recovery process needs to be provided to the monitoring background. If the time is longer, regional isolation and manual intervention can be used to directly restore the standard signal.

4) Time source switching information

   During the actual operation of the time synchronization device, the signal strength, time quality, and signal clock error of each external time source are unavoidably fluctuating with the natural environment, the electromagnetic environment, transmission attenuation, and other reasons. The time source switching strategy performs the source switching action. This process may affect the timing and measurement accuracy of the device when it is granted, and it is not conducive to traceability analysis when the fault occurs.

5) BDS, GPS transition time

   The time synchronization device normally outputs a stable timing signal. In the external time reference source, the timing of the satellite timing is the highest. Once the transition occurs, the current timing scheme and hardware design cannot accurately locate the moment of failure, and cannot provide first-hand accurate data for subsequent fault analysis.

6) Each output signal monitoring status

   Closed-loop monitoring is not only the monitoring of the time synchronization status and the timing accuracy of the timed equipment. During the actual field operation, maintenance personnel will find that even if faults due to timing have been located, the point of failure may occur at both the time service end and the time service end, and it is still unclear how to handle the fault. Therefore, the closed-loop monitoring of the output timing signal is needed at the timing end to ensure the correctness of the timing signal at the output end.

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Intelligent Online Monitoring Technology Implementation Plan

Combined with the current time synchronization system online monitoring technology program, the supplementary monitoring of the over-process operation status of the time synchronization device can ensure that the monitoring background masters more comprehensive operational data. It is conducive to the evaluation of secondary equipment operation quality, risk estimation, and fault tracing. The following figure shows the topology of intelligent online monitoring technology:

Figure 2. Intelligent online monitoring technology topology.

Conclusion

With the continuous development of the smart grid and the integrated monitoring of time synchronization and data quality, the research and analysis of steady-state data and over-process data of the time synchronization device is more conducive to commissioning acceptance, maintenance and operation monitoring. Seize every link of the time synchronization system, solve the problem of low efficiency of troubleshooting in the actual operation process, and improve the stability of the equipment operation within the station, the measurement data lean requirements.

References

