Design and Implementation of HVDC System Power Automatic Control

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Abstract. With the increasing number of UHVDC transmission projects in China, the design, construction, operation management and equipment manufacturing level of China's HVDC transmission projects are also in the leading international level. But the equipment of converter station in our country is basically in operation state, and the dispatch adjusts power frequently according to various reasons. Manual power modification by operators is not only cumbersome and prone to make mistakes, but also easy to incur bad records for inquiring. In this paper, through an automatic power technology, the standard power curve of dispatching is imported into the operator control system, which runs automatically through the operator control system. The automatic power curve setting process realized by the method can reduce the manual operation, reduce the probability of misoperation, and improve the operation reliability. Operators are very satisfied with this automatic power curve, which greatly improves the efficiency of converter station.

1. Introduction of Automatic Power Curve Technology

The power control of DC transmission system is a link of the DC transmission control system. It is a control function of the pole control level, which keeps the power transmitted by the DC system at a given value[1]. Usually, the control of the DC power transmission power is achieved by changing the current setting value of the DC current regulator[2]. According to the adjustment of power grid operation mode and the change of daily load, it needs to adjust the transmission power under the arrangement of the dispatching center every day for the actual operation of HVDC project.[3]. The main parameters of the adjustment are the power value that needs to be transmitted at a specified time point.

Power control usually has two modes of operation control: One is manual control, the power setting value and power lifting rate are manually input by the operator. The others is Automatic control, the power setting is automatically changed according to the pre-programmed DC transmission power (usually in units of days). When number of the power adjustment points is relatively large, the computer sends the power plan value according to the time point, which can reduce the workload of the operating personnel.

The main principle of the automatic power realization method is that the power curve is saved in the server after setting, and the corresponding power instructions are sent after the arrival of the time point. The main principle of the automatic power realization method is that the power curve is saved in the server after setting, and the corresponding power instructions are sent after the arrival of the time point. In addition to the power setting value, the slope value and the advance value of power need to be calculated during the automatic power control[5].

Three conditions for automatic power curve execution: First, the control level of the execution station of the automatic power curve is the system level master station; Second, the operator control position must be currently controllable; Third: Double-click power mode is automatic mode.
The automatic power plan file is a daily power transmission plan issued by the dispatching center corresponding to a HVDC transmission project[6]. The file format is Excel file. The content of the file is power transmission plan arranged by time points. It usually has one power point every 15 minutes and 96 power points per day.

The production planning workstation is connected to the production planning system of the dispatch center and automatically receives the automatic power plan file (Excel format) issued from the dispatch center[7]-[9].

According to the requirements of the power plan of the dispatching center, the automatic power plan setting workstation completes the setting of the execution sequence of the automatic power control in the station. The main parameters that need to be input are the time and reference value of the target power and the power slope value in the process of adjustment[10]-[14].

The reverse isolation device is used to transmit data to devices located in the station LAN under the condition of ensuring physical isolation of the station LAN network (only text files can be transmitted). In the actual project, the computer that receives the automatic power from the dispatch center is the production planning workstation, and the automatic power is set to the server to be executed by the automatic power plan setting workstation. The two workstations are not allowed to connect to a network for security reasons. In the process of automatic power plan setting, there are two ways to input it into the server at the automatic power plan setting workstation after the operator receives the automatic power curve. The first is manual input after printing, and the second is import after recording files to CD-ROM (for security reasons, it is forbidden to use U disk). The second is less workload than the first. The work flow diagram is shown in Figure 1.

![Figure 1. Schematic diagram of the existing automatic power tuning process](image)

At present, the load scheduling is becoming more and more precise. There may be multiple curve adjustments on the same day. It needs to reset the automatic power curve to the server each time, and the process of receiving the curve of the planned workstation is automatic (obtained from dispatching), but there is no hint after receiving, so it needs to be checked and updated manually by the operator, because the power adjustment has timeliness. It needs to check whether there are new curves to be sent out regularly. It also needs to adjust the curves after receiving, which takes up a part of manpower and time.

2. System Design for Automatic Power Curve

This paper provides a method of automatic power curve import. This method detects new power curve on the production planning workstation, transfers the curve conversion format to the automatic power plan setting workstation through isolation device, and imports the curve to the server for execution after confirmation by operators. The logic diagram of automatic power curve import in this paper is shown in figure 2. The implementation method includes the following steps:
1) Monitoring the power plan file receiving directory at the production planning workstation. When a new power plan file is detected, the content of the file is read and converted into a text format file, which is stored in the transmission directory of the reverse isolation device.

2) The text format file is transmitted to the automatic power plan setting workstation by the reverse isolation device.

3) In the automatic power plan setting workstation, the file transfer directory of the reverse isolation device is monitored. When the new file transfer is detected, the operator is notified by event mechanism.

4) After the operator receives the event notification, the newly received files are imported into the server on the automatic power plan setting workstation (the reason for manual import is the regulation requirement, and the command import must be confirmed by the operator on duty). The automatic power control is executed on time.

The purpose of this paper is to simplify the automatic power curve setting process, reduce the workload of operators and improve work efficiency through format conversion and automatic transmission based on the traditional automatic power function.

3. Implementation of the Way

3.1. Design Scheme

In this chapter, we will talk about the technical scheme in detail with the illustration. Automatic power plan automatic import implementation example:

Suppose the dispatch center sends an automatic power curve plan for a certain day, and the file format is an Excel file. This file is automatically transferred to the production planning station of the converter station through the production planning system (step 1 in Figure 3). The steps to perform the automatic power curve in the station are as follows:

- Perform new file detection on the production planning workstation. After the file in the embodiment is successfully received, start the file format conversion and save the converted file to the reverse isolation device configuration directory;
- Automatic transfer the file to the automatic power plan setting station by the reverse isolation device;
- Perform new file detection on the automatic power plan setting workstation, and send an event notification to the operator when the new file transfer is completed;
- The operator who receives the event notification, through the original function or common means, confirms that the file is correct and then imports the curve into the system, and the system executes according to the time point.

![Figure 2. Schematic diagram of the improved automatic power tuning process.](image-url)
In the above process, except that the last step must be manually confirmed according to the procedure, the other steps are automatically completed, and no manual intervention is required after the configuration is completed.

3.2. Specific Implementation
Example: automatic power table dispatched by dispatch center (daily) is shown in table 1.

| time  | Power value |
|-------|-------------|
| 750   | 18:45:00    |
| 1000  | 19:45:00    |
| 1524  | 20:30:00    |

Table 1. An example of a daily power schedule
When the system auto power has been set, this is an example of the system auto power curve.

Figure 3. Automatic power schedule generated by the operator control system.
This system provided a function named “copy today’s curve to tomorrow”, according to that the curve between today and tomorrow should be the same or only a little change. Using this function, little work should be done by the operator and less errors should be made by the operator. The principle of this function is only to modify the time of the next command, that time increased by 24 hours.

4. Summary
Based on the vigorous development of UHVDC transmission project, the number of converter stations is increasing, and the number of HVDC operators is reduced. It takes three to five years to train a qualified HVDC operator. Therefore, reducing the burden of operators and making the monitoring system intelligent and automated are the subjects that our converter stations have been studying. According to the system designed in this paper, the automatic power data sent by dispatch center can be converted into text files, and then imported into the monitoring system through the way of import. Then the relevant reference values of the automatic power transmitted by the monitoring system are raised at the corresponding time, and the corresponding information is executed and fed back by the control system. As a new technology, the automatic power curve technology discusses the method and design steps of the automatic power curve in a small space, and has done related experiments.

According to the implementation method described in the present paper, the automatic power curve of the dispatch center is converted into a text format in the implementation method, and automatically transmitted to the automatic power plan setting workstation through the reverse isolation device. However, with the vigorous development of UHVDC transmission in our country and the increasing investment in the Internet of Things in the power grid, we need to constantly design intelligent control and intelligent products to meet the growing needs of users.
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