Research and Application of Unit Automatic Monitoring Integration Based on Grid Side in Gas Turbine Power Plant

Li Zhang*, Fang Zhang, Yu Wei, Tiankuo Wang and Longfei Yu
Huadian Electric Power Research Institute Co., LTD., Hangzhou, China

*Corresponding author e-mail: 15268101198@163.com

Abstract. In view of the original independent grid-related parameters scattered in electrical and thermal equipment, such as the AVC, PMU, primary frequency and DCS, this paper improves the operation reliability of grid-connected power plant equipment, achieves the visualization and retrace ability of grid-related parameters through the centralized monitoring, multidimensional, real-time tracking, intelligent alarm, report customization and log function. Secondly, using these real-time big data, the primary frequency regulation index of the unit is calculated and analyzed in real time, which improves the authenticity and correctness of the primary frequency regulation and AVC, thus to ensure the regulation performance and the stability of the output power frequency.

1. Introduction
Nowadays, many grid-related devices, such as DCS, PMU, NCS, AGC and AVC, are applied in the power plants. Corresponding business of these devices are the core business of the power plant. However, their parameters exist information fragmentation, unreasonable settings and contradictory. On the one hand, it influences the safe and stable operation of network devices seriously, which relates to the safe operation level of the unit and the coordination level of the power plant and the grid; on the other hand, operational assessment indicators of the AGC and AVC are seriously affected, thus results in an adverse situation in the "two detailed rules" assessment of the power plant. Therefore, it is necessary to carry out the centralized monitoring, multidimensional, real-time tracking, intelligent alarm, report customization and log function on the parameters of the devices. Accordingly, this paper introduces the overall design scheme and describes the relationship among the modules in the system. Then, the parameters related to primary frequency modulation are collected through Winpcap data capture and monitoring method. Additionally, this paper puts forward the calculation method of contributing power to the parameters for quantitative assessment of primary frequency modulation. Finally, based on the historical data of the unit in Longyou Power Plant as a model sample, the primary frequency modulation and AVC assessment analysis of the unit is implemented. Especially, during the epidemic situation, the operation status of the unit can be viewed online remotely.
2. Method

2.1. Data Communication
The on-line monitoring system of network parameters is deployed in the safety zone III of the power plant, using the Web application deployment mode. The network parameter monitoring system needs to collect data from DCS system, AGC/AVC system and NCS system of safety zone I of the power plant through the original OPC server, and enter the PI real-time database of safety zone II after entering the firewall. Add a new communication server, which is responsible for PMU image data acquisition, and enter the PI real-time database of zone II through the existing firewall of the power plant. PI real-time database in zone II is stored in Zone III real-time database image server after horizontal isolation. The online monitoring platform for network related parameter information is deployed in Zone III, in which the real-time calculation and relational database are deployed in the application server, and the web application and other applications call the web service of the system data to be deployed in the web server.

2.2. Data Collection
Several important parameters in the calculation of primary frequency modulation are determined by the phase measurement unit (PMU) in the first mock exam center is directly deployed in the dispatching centers, so the DCS database of the power plant do not store the corresponding data. Considering the fact that the security factors cannot directly connect to the PMU device, it is necessary to intercept the corresponding data packets by listening to the data link of the PMU device substation to the main station, and thus ensure the consistency of the data collected and the data received by the provincial regulation. In the same way, it can improve the accuracy of assessment results. The interception of data is mainly carried out with the help of Winpcap. Data packets are captured through Winpcap dynamic link library. Since the communication protocol between PMU substation and main station is TCP / IP protocol, after analysis according to TCP / IP protocol, we need to decompose the data twice, and according to the protocol requirements of real-time dynamic transmission protocol of power system, we need to decompose the data in TCP / IP data packets. In order to analyze block, it is necessary to save the phase and analog data about the frequency of power grid and the theoretical value of primary frequency modulation in the SQL database, and then send the SQL data to the PI real-time database in zone II to realize the firewall control strategy.
3. **Primary frequency**

The primary frequency modulation assessment is an analysis of the response of the signal sent to the unit of the power plant to start corresponding actions when the dispatching center finds that the grid frequency exceeds the dead band frequency range. Generally speaking, the active output of the unit can be summarized as low-frequency multi engine and high-frequency few engines. Because the frequency deviation of East China power grid is small, the unit power change caused by primary frequency modulation is often covered by AGC load response, so the error of direct monitoring primary frequency modulation performance is too large. Therefore, this paper proposes the design of on-line monitoring system for primary frequency modulation parameters, which uses Winpcap dynamic link library and configuration frame file in PMU to capture and analyze and decode TCP / IP data packets, and sends the decoded data to PI real-time database. The web end obtains the data from PI database for primary frequency modulation assessment and analysis, and considers the reasons of secondary security. The acquisition of PMU data based on the listening mode will not produce any handshake connection and other operations to the PMU device, which greatly avoids the security risks.

3.1. **Power assessment of primary frequency modulation**

When the system frequency (in 1 minute) exceeds the primary frequency modulation dead zone, and the actual output change is the same as the system frequency deviation value plus or minus sign (low frequency more power and high frequency less power), and the actual output change is zero, it is counted as unqualified time period. Among them, the difference between the actual output of the adjacent 1 minute is taken as the actual output change. The current month's primary frequency regulation assessment power shall not be higher than 0.5% of the current month's unit generating capacity.

3.2. **Primary frequency modulation input rate**

The input rate of primary frequency modulation is equal to the percentage of the input time of primary frequency modulation function and the grid connected operation time. The lower limit of monthly input rate of primary frequency modulation is 90%. When it is less than one percentage point (including less than one percentage point), 0.1% of the generating capacity of the unit in the current month is counted as the assessment energy.

3.3. **Pass rate of primary frequency modulation**

1) When a unit is connected to the grid for operation, if the contribution of the unit's primary frequency regulation function is positive (or the unit's primary frequency regulation action instruction indicates that the unit operates during this period) during an integral period when the grid frequency exceeds the unit's primary frequency regulation dead zone, the statistics show that the unit operates correctly once for primary frequency regulation, otherwise, it is an incorrect operation once. The calculation formula of the correct action rate per month is:

\[
\text{The correct action rate} = \frac{f_{\text{correct}}}{f_{\text{correct}} + f_{\text{wrong}}} \times 100\%
\]

Where \(f_{\text{correct}}\) is the number of correct actions per month, \(f_{\text{wrong}}\) is the number of wrong actions per month.

2) The correct operation rate of primary frequency regulation is assessed according to the unit. For the unit whose monthly correct operation rate of primary frequency regulation is less than 80%, the monthly assessment power is:

\[
(80% - \lambda_{\text{Action}}) \times P_{N \times 24} \times \alpha_{\text{primary frequency}}
\]
Where $\lambda_{\text{Action}}$ is the correct operation rate of the unit in primary frequency modulation month; $P_N$ is the unit capacity (MW); $\alpha_{\text{primary frequency}}$ is the assessment coefficient of primary frequency modulation, and the value is 3.

4. Primary frequency assessment results

Select a period of time, and then through the calculation of indicators in the first two sections, you can get the primary frequency control assessment results in this period of time on the system, view and export them in the form of reports. Select the unit number to query on the interface, query start time and query end time. The display result is as shown in the following figure.

![Figure 2](#1 unit primary frequency modulation assessment report interface)

5. AVC evaluation

5.1. Operation rate of AVC

AVC refers to the automatic voltage reactive power control of the power grid, realizing intelligent AVC, ensuring power quality, improving transmission efficiency, reducing network loss, and realizing stable and economic operation. The calculation method of AVC operation rate is as follows:

$$\lambda_{AVC} = \frac{t_{\text{operation}}}{t_{\text{work}}}$$

Where $\lambda_{AVC}$ is the unit operation rate; $t_{\text{operation}}$ is the AVC monthly operation time; $t_{\text{work}}$ is the monthly operation time of the unit.

5.2. AVC adjustment qualification rate

After the voltage or reactive power command of the AVC master station is issued by the power dispatching trading agency, the unit AVC device is qualified if it is adjusted to the range required by the
target command within 3 minutes. The unit AVC regulation qualification rate is the ratio of the number of qualified execution points to the number of orders issued by the power dispatching trading agency.

The reactive power of \( t \) time unit is \( Q_0 \), \( t+1 \) time is \( Q_1 \), \( t+2 \) time is \( Q_2 \).

The \( t \) time instruction is \( Q' \), and the \( t+1 \) time instruction is \( Q'' \).

The criteria for judging eligibility are:

- When \( [Q_0 + 0.7 \times (Q' - Q_0) - Q_0] \times [Q_0 + 0.7 \times (Q' - Q_0) - Q_1] \leq 0 \) or \( [Q_0 + 0.7 \times (Q' - Q_0) - Q_0] \times [Q_0 + 0.7 \times (Q' - Q_0) - Q_2] \leq 0 \), \( t \) time AVC adjustment is qualified.
- When \( (Q_0 - Q') \times (Q'' - Q') < 0 \), the \( t \) time AVC adjustment is qualified.

6. AVC assessment results

Select the operation data of January 2020, and then calculate the indicators in the first two sections to obtain the AVC assessment results of this period on the system, and view and export them in the form of a report. Select the unit number, query start time and query end time to query on the interface, and display the results as shown in the following figure.

Figure 3. #1 unit AVC assessment report interface

7. Conclusion

In this paper, based on the primary frequency modulation and AVC on-line monitoring system of PMU device, according to the actual network topology and actual work needs of power plants, the B/S structure is adopted to obtain the relevant parameter information through data interception, then the calculation and display is carried out in the form of Web interface through the study of the functional structure and implementation scheme of two detailed check management systems of East China Power Network. The system has been installed and debugged in Longyou Power Plant in Zhejiang Province. Through actual monitoring, it is found that the system meets the design goals and the actual needs of the power plant, and has been confirmed in the safety and reliability of the power plant. Moreover, PMU data collection is achieved by using data interception, which can minimize the generation of system security problems, facilitate power enterprises and provincial dispatching companies to master and manage the primary frequency modulation input and AVC input of power plants, and effectively improve the economic and social benefits of power plants.

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