Analysis on Galloping Properties from Transmission Line Vibration Data

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Abstract. At the beginning of 2020, a large-scale cold wave has affected the Bohai rim and central China, causing icing and galloping of transmission lines in Beijing, Tianjin, Hebei, Liaoning, Shandong, Hubei and other places, and causing some lines to trip. In this paper, the temperature and other real-time data of line condition were considered, and a real-time analysis algorithm of galloping characteristics was proposed. In the process of this cold wave, a galloping phenomenon is recorded and analyzed in detail, which provided scientific and technological support for galloping prevention and control.

1. Foreword
The traditional analyzing way has relatively severe shortage in the aspects of reliability, service life and precision of power source and communication all the time\textsuperscript{[1-6]}. However, along with introduction of low power consumption sensing technology with high reliability and wireless communication technology with low power consumption, the chip-level integrated type galloping analyzing modular possesses the advantages and characteristics of “low power consumption, high reliability and long service life”, an it is able to conduct real-time collection to the galloping displacement of power transmission circuit conductor running in severe atmospheric environment. The on-site installation effect of modular is as shown in Figure 1:

Figure 1 Installation of Galloping Analyzing Modular
Through installing galloping analyzing sensor in Hubei Province, the information level for prevention and control of State Grid in Hubei Province is enhanced, and this provides powerful technical support for constructing internationally leading energy internet enterprise with Chinese characteristics.

2. Galloping Prevention and Control System
The galloping prevention and control system is consisted of galloping analyzing modular, open mobile communication networks and galloping forecasting and warning platform.

Through deploying galloping analyzing modular in appropriate position of conductor, the information collection of comprehensive status of conductor can be realized. The analyzing terminal adopts ultra-low power consumption measurement scheme, eliminates common-mode interference, and enhances measurement precision. All analyzing terminals complete information collection of comprehensive status characteristic parameters of conductor motion synchronously, and through micro power wireless network, the acceleration, speed, displacement, angle, temperature and other required data are sent to the open mobile communication networks for further fitting and intelligent judgment.

Based on analyzing data, the border gateway on tower realizes data protocol conversion and intelligent analysis, and judges the galloping occurrence and development situation. In case of judging that galloping occurs, the warning information will be sent in a real-time way, and then the open mobile communication networks will pack the data such as acceleration, speed, displacement and environmental parameters; through open mobile communication networks, the data is to be transmitted to the galloping analyzing early warning system of power transmission circuit.

3. Analysis on Galloping Properties
The occurrence of conductor galloping is influenced by multiple factors such as wind, ice and circuit parameters, and the actual motivation of galloping has relatively strong randomness. If the circuit galloping does not cause tripping or severe mechanical fault, the galloping cannot be found in time easily.

From February 14-16, 2020, the large scope of cold wave influenced regions including Circum-Bohai Sea region and Central China, thus causing icing and galloping of power transmission circuits in Beijing - Tianjin - Hebei, as well as Liaoning, Shandong and Hubei, and causing tripping of some circuits.

From Figure 2 and Figure 3, it can be known that when the circuit is galloping, the time is wee hours, and influenced by epidemic situation and rain, snow and freezing weather (at temperature of 0-6℃), exact analyzing cannot be conducted in time in routine way. Through the galloping analyzing system, the branch center has successfully monitored the short-term small-amplitude (continuous time shorter than 1 hour, amplitude value about 0.5-1m) galloping phenomenon at #216-#217 of ±500kV Yihua line and at #28-#29 of 500kV Jiangtao line.

Figure 2 Analyzing result of ±500kV Yihua Line galloping (Seen as mark “●”)

(a) Frequency

(b) Amplitude
For the galloping analyzing modular is still equipped with air temperature analyzing module, it can conduct real-time analyzing to running environmental temperature of galloping analyzing modular, and the temperature change situation in the regions where the #216-#217 of ±500kV Yihua line and #28-#29 of 500kV Jiangtao line are located is as shown in Figure 3. According to data, it can be known that for two gears of circuits and sections, and adjacent gear circuit sections in the same region nearby, they have the following characteristics in the aspect of running environmental temperature in winter:

1. The environmental temperatures of two gears of circuit are relatively high, and by the end of April, the overall average air temperature in the location is above 10℃, even if in January – February when the weather is the coldest in routine meteorological meaning, the maximum temperature still can reach 20℃ above. Meanwhile, the temperature difference of single day is relatively large, exceeding 20℃ at most. Especially at the beginning of December, the daily maximum temperature is nearly 30℃, while the minimum temperature is below 10℃. The violent fluctuation of temperature may form temperature impact effect, which causes influence on metal (such as suspension line clamp) and rubber members (such as rubber gasket of damping spacer) of circuit key parts, thus causing decline of its anti-fatigue capability.

2. Influenced by cold air, two gears of circuit suffered from violent temperature reduction weather in four time periods, i.e. February 14-16, February 26-29, March 26-30, and April 9-12. Especially in the time period February 14-16, after long-term and large-scope precipitation, the temperature reduced...
from the maximum 24.8 °C to the scope of -1.1 to 5.4 °C, thus causing slight icing of circuit, and further inducing slight galloping under the function of gale.

(3) Compared with #216-#217 of Yihua line, in the place about 30 km near the south side of the region where the #28-#29 of Jiangtao line is located, the environmental temperature is obviously higher than the former one. However, no matter during the temperature rising or temperature reduction process, the change trends of air temperature in two places show relatively good consistency.

As a kind of dynamic load, the accumulation effect of galloping to structural fatigue effect of circuit cannot be neglected. The accumulated fatigue effect of multiple times of slight galloping may cause severe faults. Therefore, it is necessary to continue to strengthen analyzing to circuits in the region where the galloping may occur easily, record galloping characteristics of conductor systematically, evaluate circuit defects and hidden hazards which the galloping may cause in time, thus reducing potential threat of fatigue to circuit safety.

4. Summary
In winter from 2019 to 2020, the State Grid Corporation of China deployed new type of chip-level integrated type galloping analyzing system on key circuits in regions such as Hubei Province, and through implementing the construction and running & maintenance of “galloping analyzing system of power transmission circuit” continuously, a series of achievements have been obtained, and they are summarized as below:

(1) Based on the mechanism research and test analysis achievement at early stage, the real-time calculation and analysis and judgment methods for galloping analyzing data of power transmission circuit was established. Through the running in the whole winter, a relatively good analyzing effect has been obtained, which provides technical support for galloping in winter and even overall prevention and control of wind vibration.

(2) Through long-term continuous analyzing, it is found that during the large-scale cold wave period on February 15, there was short-term small-amplitude galloping at #216 of ±500kV Yihua line and at #29 of 500kV Jiangtao line.

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