Online Over voltage Monitoring Method Based on Contactless Induction Technique

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Abstract. The operation experience and research shows that over voltage is the main factor which caused grid insulation damage in the power system, but also the main reference option of electrical equipment in insulation conditions selection. Research on system broadband transient current sensing technology based on advanced magnetic field sensors for non-contact measurement, research on system broadband over voltage sensing technology based on advanced optical electric field sensors for non-contact measurement, and development of new micro-sensing technology Distributed connection of non-contact sensing terminals, building a sensor network system for transparent sensing of transient information in substations, realizing passive and wireless communication design, realizing transparent sensing of incoming and outgoing transient information in the station, portable and easy to install, which is the transient information of the power grid Obtain analysis to provide solid data support, greatly improve the level of transient information monitoring in the substation, and improve the reliability of power grid operation.

1. Introduction

Over voltage accidents occur in the power grid from time to time, but because the current fault recorders and monitoring devices used are signals obtained from voltage transformers, the signal distortion is relatively serious, but it is difficult to find out the cause of the accident, and make the fault analysis and judgment Very difficult. There are capacitive voltage dividers, voltage transformers, and optical fiber voltage sensors as voltage sensors, but they all have their own limitations. Although the capacitive voltage divider has a simple structure, high measurement accuracy, and good transient response and load characteristics, it will oscillate during the measurement process, and when the voltage divider is connected in parallel to a system with a higher voltage level, its long-term operation must be considered. A series of issues such as reliability, heat generation, impedance matching, AC shock and safety are critical [1]. Most voltage transformers use ferromagnetic materials as cores, which are mainly used to obtain low-voltage signals, and it is difficult to catch high-frequency over voltages. Optical fiber voltage sensors have the characteristics of high safety and good frequency response characteristics, but active optical fiber voltage sensors need to install a high voltage divider in the system to operate; passive optical fiber voltage sensors have poor temperature characteristics [2], and the measurement accuracy is greatly affected by temperature, which also restricts its application in power systems.
2. The theoretical basis of non-contact voltage sensor

In summary, for the existing substation transient information monitoring technology, there is an urgent need to develop new distributed substation transient information sensing technology to achieve low-cost, easy-to-install non-contact transparent sensing.

Compared with the traditional technology, the current measurement technology based on magnetic field sensing has the characteristics of simple and reliable insulation structure, small size, light weight, good linearity, and large dynamic range. It can be distributed at various points that need to be monitored. At the same time, the transient signal has short existence time, high frequency and large amplitude. The characteristics of the magnetoresistive current sensor are suitable for accurate acquisition of high-frequency transient signals.

3. Background of project research

Transparent sensing of transient information in substations requires accurate acquisition of the voltage and current transient signals of key nodes everywhere, and this system complete data storage and analysis. At present, the available data sources in the substation are PT and CT, and the measurement of transient information is also derived from this. Domestic and foreign scholars have carried out relevant research on transient information monitoring and analysis in substations based on existing equipment, and have achieved certain results.

Anhui Electric Power Research Institute used CT and PT to analyze transient signals and found that transient signals with non-periodic components would cause delay TA due to the mutual inductor maintenance. The study found that the delay size is related to the primary time constant of the system, the time constant of the secondary loop of the transformer, the amplitude of the non-periodic component, the working cycle of the CT, and the transient area coefficient of the CT. Due to the different equipment models and batches of each manufacturer, the TA cannot be uniformly calibrated. When the station is monitoring transient information, TA will affect the accuracy of perception analysis [3].

With the development of smart substations, the traveling wave signal of the line has been monitored to a certain extent. Dong Xinzhou of Tsinghua University discussed the feasibility of the use of full-band fault information in the digital substation, and proposed a design plan for the optimization of the transmission system and signal acquisition; Fan Jin of Xi’an University of Posts and Telecommunications put forward a multi-functional integrated intelligent device based on transient fault information based on the existing equipment of smart substation, introduced the utilization method of transient fault information, and verified it in the laboratory.

In terms of measurement, Tan Xiangyu of Yunnan Electric Power Research Institute proposed a fast transient overvoltage measurement scheme based on electric field. The electric field around the GIS bus bar was measured by a MEMS electric field sensor. A large number of experiments were carried out to determine the linear relationship between the electric field strength and the bus voltage, and the sensor Carry out calibration to realize VFTO measurement. In terms of optical measurement of transient voltage, the development abroad is relatively fast. ALSTHOM and ABB both produced corresponding voltage sensors in the 1980s and 1990s and connected them to the network for operation. Japan's Hitachi has produced a 77kV optical voltage sensor that can be connected to the network. The sensor head uses a BGO crystal, and a capacitive voltage divider is used to separate a lower voltage signal from the measured bus high voltage and add it to the optical voltage sensor. Many OVT prototypes of 123kV~765kV developed by the French company ALSTHOM have been in operation in France and North America [4].

In terms of communication technology, wireless communication in substations can be used for substation environmental monitoring, substation primary equipment status monitoring, substation secondary equipment status monitoring, fault monitoring and early warning, intelligent inspection, unattended substation safety monitoring, static picture data, Video data. However, due to the increasingly serious electromagnetic interference in the substation, higher requirements are put forward for the communication of automation equipment. In the application of short-distance wireless communication technology in smart grids, electromagnetic interference mainly suffers from corona
interference, radio interference, lightning impact, and radiated electromagnetic fields generated by switching operations. The electromagnetic compatibility design in the smart grid should not only consider that communication equipment and other electrical equipment can work normally under the specified electromagnetic interference intensity, but also consider that the electromagnetic interference intensity of the communication equipment sent to the substation must be within the specified. Within the scope, it is ensured that wireless devices and systems will not produce unbearable electromagnetic disturbance to any power and electrical equipment in the environment, thereby ensuring the safe and stable operation of power grid equipment.

4. Research on Sensing Technology for Transparent Sensing of Transient Information in Substation

In the formula: I represents the current flowing in the wire, d represents the distance between the giant magnetoresistance sensor device and the wire, and H represents the intensity of the magnetic field generated at the giant magnetoresistance sensor device.

At this time, the giant magnetoresistance sensor is placed at a distance from the wired, the size of the magnetic field is sensed by the size of the resistance, and then the current is calculated. Based on this effect, on the wire of the power system, due to the existence of current, a magnetic field will be generated around the wire. As shown in Figure 1.

![Figure 1 Principle of current measurement of giant magnetoresistive sensor](image)

There is a slight error in the voltage amplitude, which is caused by the errors in the equipment module, data conversion and other links in the simulation environment, and because of the inductance in the loop, the phase has a slight deviation. However, the maximum error of amplitude and phase does not exceed 0.1%. Regardless of whether it is a steady-state process or a transient process, the theoretical and measured values obtained by non-contact voltage sensors have a high degree of fit. When the power supply parameters (amplitude, frequency, etc.) and line parameters (line spacing, line length) are changed, and the corresponding voltage conversion matrix is also changed, the error still does not exceed 0.1%, indicating that the non-contact voltage sensor is basically affected. Affected by changes in external parameters, the working state is stable.

5. Conclusion

In view of the problems of various voltage sensors in the internal overvoltage monitoring system, this paper proposes a non-contact voltage sensor model based on the principle of electromagnetic induction coupling, which monitors the induced line voltage by setting an induction line under the overhead line, and then uses the voltage The conversion matrix calculates the system voltage value. The voltage conversion matrix is determined by the circuit parameters. In order to verify its feasibility, we use ATP to establish single-phase and three-phase models for simulation, and divide the two processes of steady state and transient state.

At the same time, the power supply parameters and line parameters are appropriately changed to determine its impact on the non-contact voltage sensor. Whether the work characteristics are affected. The results show that the non-contact voltage sensor has high measurement accuracy, can accurately
capture voltage signals, and can also achieve accurate measurement of high-frequency voltage signals, regardless of the input form, and the working state is stable.

Compared with existing voltage sensors, non-contact voltage sensors have the following characteristics:

a) In higher-level power grids, non-contact voltage sensors are safer than high-voltage dividers. The voltage value induced by the non-contact voltage sensor is generally small, and has no direct electrical connection with the power grid, and its operation is safe and reliable.

b) The non-contact voltage sensor has no ferromagnetic part, which avoids the ferromagnetic resonance caused by the non-linear core part in the case of a fault.

c) The sensor device has good frequency response characteristics, high measurement accuracy, and can capture high-frequency signals, which is very effective for collecting and measuring voltage data during operation.

d) The equipment is simple, the cost is low, and it is easy to promote.

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