Study of New Method Combined Ultra-High Frequency (UHF) Method and Ultrasonic Method on PD Detection for GIS

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Abstract. GIS (gas insulated switchgear), is an important equipment in power system. Partial discharge plays an important role in detecting the insulation performance of GIS. UHF method and ultrasonic method frequently used in partial discharge (PD) detection for GIS. It is necessary to investigate UHF method and ultrasonic method for partial discharge in GIS. However, very few studies have been conducted on the method combined this two methods. From the view point of safety, a new method based on UHF method and ultrasonic method of PD detection for GIS is proposed in order to greatly enhance the ability of anti-interference of signal detection and the accuracy of fault localization. This paper presents study aimed at clarifying the effect of the new method combined UHF method and ultrasonic method. Partial discharge tests were performed in laboratory simulated environment. Obtained results show the ability of anti-interference of signal detection and the accuracy of fault localization for this new method combined UHF method and ultrasonic method.

1. Introduction
GIS plays an important role in power system. Partial discharge is one of the important parameters to detect the insulation performance of GIS. It is recognized that partial discharge caused by free metal particles strongly harms the GIS system. The effects of UHF method and ultrasonic method on the partial discharge in GIS are currently of considerable interest. It is adopted to discriminate early insulation defects in GIS.

With the development of online PD detection, many papers have investigated the PD detection methods. S.Tenbohlen et al has reported a summary of PD measurements applying the UHF methods[1]. Simultaneously, Si et al has developed a data analyzer for ultrasonic detection system[2]. However, very few studies have been conducted on comparison and combination of this two methods. In this paper, the effects of the new method combined UHF method and ultrasonic method on PD detection in GIS were studied. The results revealed that can greatly enhance the ability of anti-interference of signal detection and the accuracy of fault localization.

2. Experiment
For UHF method, partial discharge in the GIS is accompanied by a very steep current pulse. Electromagnetic wave is propagated in the form of transverse electromagnetic waves (TEM) transmission, and high-order transverse electric field wave (TE) and transverse magnetic field (TM) are established[3]. UHF antenna is used to detect electromagnetic waves generated by the partial discharge of GIS for the analysis of electromagnetic wave[4]. For ultrasonic method. The molecules
are violently collided with each other and pressure is created in the moment of partial discharge in GIS. Ultrasonic pulses includes longitudinal wave, shear wave and surface wave. The ultrasonic signal can be collected by the installed ultrasonic sensor in the GIS wall, converted to electrical signals, and then the partial discharge level within the GIS can be measured.

UHF and ultrasonic methods are non-contact measurement methods. On-line PD detection can be achieved based on UHF and ultrasonic methods. Ultrasonic detection is suitable for field testing, while the UHF method can be used for continuous on-line monitoring. More complex equipment is required for ultrasonic method and higher cost is required for UHF method. Considering the advantages and disadvantages of UHF method and ultrasonic method, a new method combined UHF method and ultrasonic method is proposed. This method has mixed distributed sensor technology. Obtained results show strong anti-interference ability, high positioning accuracy and high reliability of this method.

3. Analyzation
This new method for PD source detection is mainly based on the statistical characteristics and phase analysis of PD signal. It is a common pattern recognition problem. It can be carried out by the expert system combined with fuzzy logic, neural network (NN) and fractal analysis. The experimental specimens were made in the laboratory simulation environment. The typical UHF signal waveforms produced by various defects are measured. Due to the limitation of space, the author only selects the UHF signal waveform caused by the discharge of the metal protrusion on the conductor. Waveform characteristics is extracted to establish a defect database and provide the basic data for the application of the expert system, as is shown in Fig.2.

![Schematic diagram of new combined method](image-url)
For this new method, a number of ultrasonic typical signals are produced by different insulation defects. It is showed the different types of defects in the ultrasonic typical signal in Fig.3[5]. The pattern recognition method is used for pattern recognition based on the artificial neural network.

The partial discharge characteristic fingerprints can be constructed from the fingerprint parameters for the partial discharge phase distribution. Fingerprints and maps are an effective basis for judging the type and severity of discharges, and the use of maps can visually characterize the partial discharge profile.

A number of classical characteristic parameters are in the partial discharge analysis[6]. These statistical parameters can be used to construct partial discharge characteristic maps, as is shown in Fig.4. It is effective basis for judging the type of partial discharge and the severity of partial discharge.

**Figure 2.** UHF signal wave form caused by free particles.

**Figure 3.** d) Moving particles e) Beating particles f) Loose screws
Figure 4. Partial discharge characteristic maps.

4. Conclusion
Considering the advantages and disadvantages of UHF method and ultrasonic method, a new method combined UHF method and ultrasonic method is applied in the partial discharge detection. Advantages of UHF method and ultrasonic method are mixed in this new method. It has mixed distributed sensor technology, strong anti-interference ability, high positioning accuracy and high reliability. In our research, we found that on-line PD detection can be achieved by this new method combined UHF method and ultrasonic method. Its key technology is UHF and ultrasonic sensors. The ability of anti-interference of signal detection and the accuracy of fault localization can be greatly enhanced.

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