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Modeling and structural optimization of acoustic imaging sensor unit for detecting abnormal noises of dry-type transformer

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I. INTRODUCTION

Dry-type transformers are one of the most important equipment in the power system, and their operating status directly affects the safety and reliability of the entire system. Therefore, it is necessary to monitor the safety and reliability of dry-type transformers. Dry-type transformers may have abnormal noise defects during the operation process. The traditional method is that the operation and maintenance personnel can detect and recognize by hearing, but this method is highly subjective and the judgment is not scientific enough. In recent years, acoustic imaging technology has continued to develop. Acoustic imaging technology can obtain information such as the location of abnormal noise defects by analyzing the acoustic signals of dry-type transformers. The detection effect of acoustic imaging technology is greatly affected by the microphone array. A good microphone array can improve the accuracy and resolution of acoustic imaging. Therefore, this article discusses the abnormal noise defect of the dry-type transformer based on the acoustic information characteristics of the dry-type transformer under different operating conditions. The acoustic imaging sensor unit is used for modeling, and the influence of the microphone array shape, array aperture, number of array elements and other factors on the acoustic imaging detection of dry-type transformers is analyzed, and the sensor unit is optimized.

II. Abnormal sound of dry-type transformer

The abnormal noise of dry-type transformers mainly comes from abnormal mechanical vibration and abnormal discharge at the high voltage end. The mechanical vibration is mainly the iron core vibration caused by the magnetostrictive effect of the silicon steel sheet, and the vibration caused by the electromagnetic force on the winding. Abnormal mechanical vibrations of dry-type transformers may cause damage to the mechanical structure of dry-type transformers, which in turn may cause insulation failures. Abnormal noise caused by abnormal discharge on the high-voltage end is mainly due to factors such as surface burrs, structural looseness and local insulation degradation, which cause corona or partial discharge along the surface at the high-voltage end or live winding of dry-type transformers, and abnormal discharge noise is often higher.

III. FUNCTIONAL CHARACTERISTIC

Acoustic signals are generated from the vibration source, and then propagate in all directions in the space to form a spatial beam. If an array composed of a certain number of sensors is arranged on the beam propagation path to record the time difference between the beams reaching each sensor, this time difference can be used to infer the position information of the sound source. After processing the position information of the sound source, the sound source image can be obtained, and then fused with the visible light image obtained by the high-definition camera to form a multi-information image with both acoustic signal position information and visible light image information. This method is acoustic imaging technology.

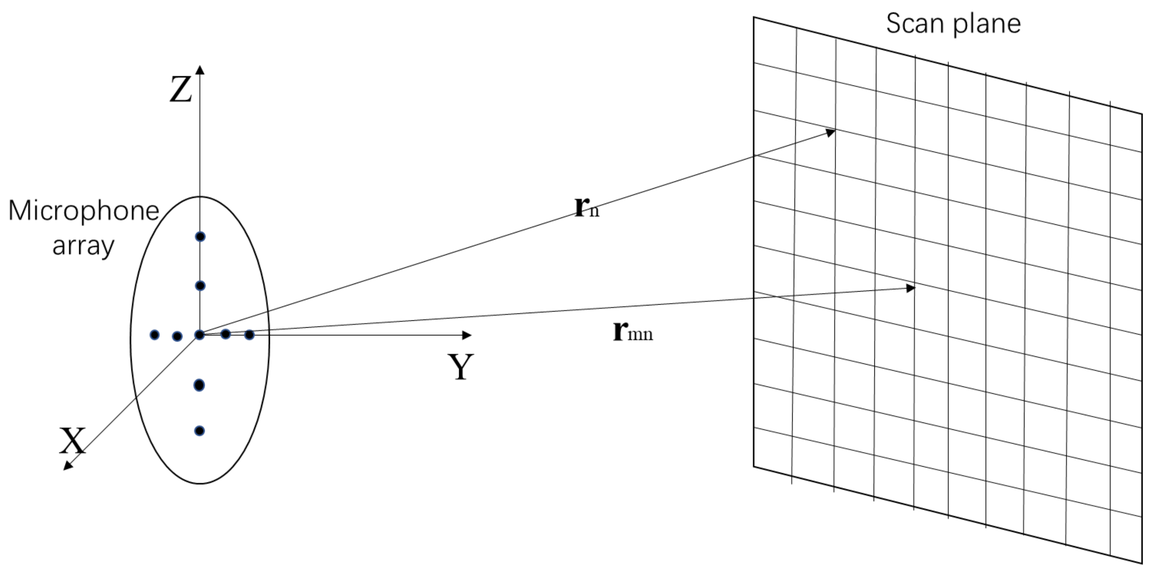

Fig. 1 Acoustic imaging detection model

IV. Model and optimize the sensing unit

The acoustic imaging performance of the sensor array is reflected by the beam response graph. The influence of the microphone array shape, detection frequency, array aperture, and the number of array elements on the beam response is analyzed, and a microphone array with better comprehensive performance for detecting abnormal sound defects of dry-type transformers is obtained. The array contains 40 sensors, distributed in a multi-arm Archimedes spiral. The array has 8 cantilevers with 5 sensors on each cantilever. The array aperture is 0.7m, and the array is 1.5m away from the dry-type transformer.

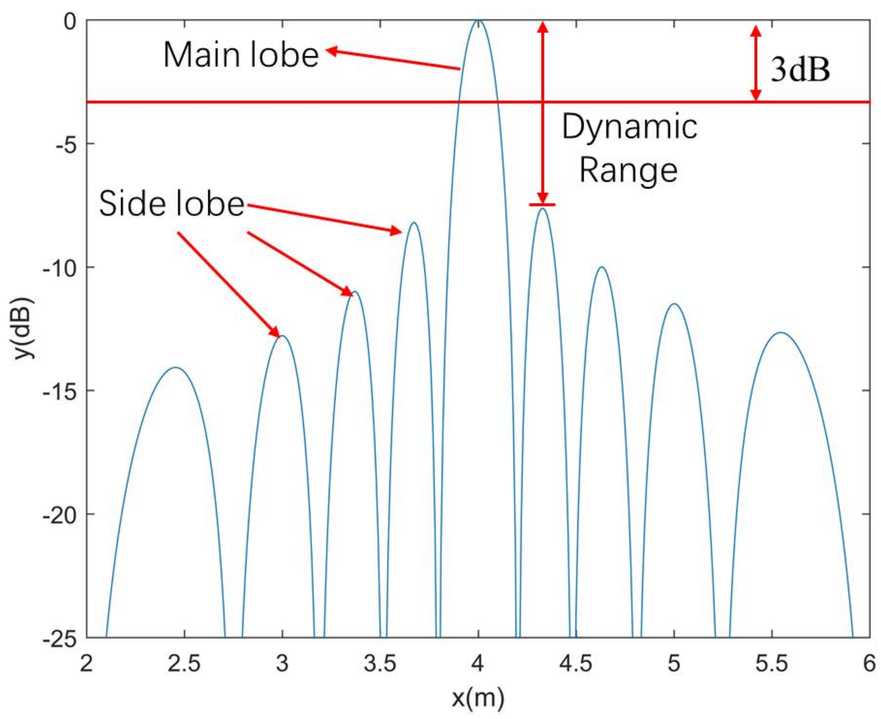

Fig. 2 Beam response graph

V. CONCLUSION

This article introduces some abnormal noise characteristics and acoustic imaging technology of dry-type transformers. According to the abnormal sound characteristics of dry-type transformers, the detection frequency of acoustic imaging is determined, and the sensor array used for acoustic imaging is modeled and optimized. The finally obtained acoustic sensor array has good performance in detecting abnormal noise of dry-type transformers.

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