Research on Characteristics and Distribution of Audible Noise in UHV Converter Station Based on Artificial Intelligence

Lianke Xie¹*, Xingang Ma¹, Guoying Zhang¹

¹Laboratory of Chemistry and Environmental Protection, State Grid Shandong Electric Power Research Institute, Jinan, China, 250002

*Corresponding author e-mail: liankexie@epri.org

Abstract. Because of its unique advantages in long-distance line loss, UHV transmission is widely used in large capacity transmission projects. As an important part of power transmission system, high voltage converter station is of great value to ensure transmission stability, applicability and practicability. However, UHV converter station will bring great noise pollution, so it is necessary to analyze and study its noise characteristics by certain means, so as to lay a foundation for noise suppression. Based on this, this paper first analyzes the test method of the noise source in UHV converter station, and then gives the specific suppression measures of audible noise in UHV converter station.

Keywords: Audible Noise, UHV Converter Station, AI

1. Introduction

Due to the typical unbalanced characteristics of resource distribution and energy demand distribution in China, for example, the eastern coastal area has a large demand for electric energy, but there is a shortage of energy, while the western region is rich in energy, but the power demand is small. In this context, a series of transmission and transformation projects such as the west to East power transmission project emerge as the times require [1]. Due to the unique advantages of UHV transmission in long-distance line loss, it has been widely used in large capacity transmission projects. As an important part of power transmission system, high voltage converter station is of great value to ensure transmission stability, applicability and practicability. However, the operation process of UHV converter station will bring greater noise pollution, which will have adverse effects on the surrounding environment. It is urgent to suppress and study the noise, so as to improve the stability and efficiency of the whole system.

The main noise sources in UHV converter station include several system components as shown in Figure 1 below. It is of great value to study the noise characteristics and distribution law of these noise generating components for suppressing and eliminating noise from the source [2]. Among them, for the audible noise of converter station valve external cooling equipment, the research on its noise amplitude and noise characteristics is still not deep enough, and there is still a lack of systematic testing and effective analysis of the spectrum characteristics in this aspect. As another main noise source of converter station, the research on the characteristics and distribution of noise of filter
capacitor needs to separate and identify the magnitude and frequency components of noise when the filter capacitor works normally from the complex phase sound field of converter station.

![Diagram of noise components](image)

**Figure 1.** Main noise components sources in UHV converter station.

On the other hand, with the iterative development and progress of computer tech represented by AI signal processing, it has been widely and deeply applied in many fields, and has achieved remarkable application results. AI signal analysis is applied to the coherence analysis of vibration and radiation noise of objects, which can effectively identify and separate the noise generated by objects. AI can separate the working noise of equipment in UHV converter station, realize the preliminary analysis of noise characteristics, and provide the basis for the establishment of sound power level test method and the environmental impact prediction of audible noise in converter station.

In addition, due to the powerful data analysis function of AI tech, it can effectively evaluate the pollution degree of audible noise in converter station to the environment, and does not provide scientific data basis for noise suppression and reduction [3]. Through the systematic statistical analysis of the noise spectrum in converter station, the key indicators of audible noise are obtained, so as to optimize the design of UHV converter station, the construction of noise suppression measures, as well as the detailed field investigation and test of noise in converter station, so as to provide reference for audible noise prediction. Therefore, the research on the characteristics and distribution of audible noise in UHV converter station based on AI has important practical value for noise control, land resource saving, project cost reduction and station stability protection.

2. Test of noise source in UHV converter station

2.1. Measurement method of noise in UHV converter station

A specific UHV converter station in central and western China is selected for on-site noise test [4]. The facility layout structure of the converter station is that the converter and pole valve hall are arranged in the central position of the station, as shown in Figure 2 below. Noise reduction and noise suppression measures such as sound insulation cover, sound insulation barrier and converter muffler are adopted. The measured results are the audible noise influence of the equipment in the converter station during operation. In addition, the measurement points are evenly and densely arranged in the converter station for noise measurement, including the measurement points near the noise source and each area in the station. The main noise sources inside the converter station are tested, and the measured noise and distance at the noise source boundary are analyzed and recorded, and avoid the interference of other devices in the process of internal measurement.
2.2. Noise measurement results of main sound sources in converter station

The noise level and frequency spectrum of the noise equipment in operation are measured, and the spectral centroid of noise at each main noise source in converter station is obtained, as shown in Table 1, and the distribution of noise level and frequency level of all the equipment can be seen from table 1. Then the noise characteristics of the noise source equipment and the noise distribution law in the station are analyzed [5]. Among them, as the core equipment of converter station, converter valve converts AC voltage into DC voltage. The device is inside the building, with external enclosure and sound insulation structure, so it generally does not produce obvious audible noise. The noise spectrum centroid of converter valve hall is in the middle frequency range, so it has the characteristics of medium frequency.

Table 1. The spectral centroid of noise at each main noise source.

| Noise source                     | Centroid range of noise spectrum       |
|----------------------------------|--------------------------------------|
| Converter valve                  | 1100-1800 Hz                         |
| Converter transformer            | 150-640 Hz                           |
| Reactor                          | 210-610 Hz (DC) / 490-700 Hz (AC)     |
| Capacitor bank                   | 220-620 Hz (DC) / 280-610 Hz (AC)     |
| Air conditioning cooling unit    | 350-660 Hz                           |
| Station transformer              | 280-510 Hz                           |

Secondly, converter transformer is also an important component of converting current and one of the important noise sources of converter station. Generally speaking, the size of audible noise generated is proportional to its power [6]. Based on the spectrum of audible noise drawn from the measurement results, it can be seen that the noise spectrum centroid of converter transformer is in the low frequency range, so it has low frequency characteristics. In addition, the reactor is divided into high voltage DC smoothing reactor and AC filter reactor. The centroid of noise spectrum of HVDC smoothing reactor is also in the low frequency range, and has typical low frequency characteristics. For AC filter reactor, the monitoring spectrum centroid also has typical low frequency characteristics.

For the capacitor bank in converter station, it is mainly divided into DC field capacitor and AC field capacitor. The noise measurement of AC field capacitor needs to avoid the influence of reactor. Through the measurement, it is found that the noise spectrum centroid is in the low frequency range and has the characteristics of low frequency. For DC field capacitors, the monitoring results are similar. The frequency spectrum curve of air conditioning cooling unit in converter station is relatively straight, and the spectrum centroid of noise also has typical low frequency characteristics. The frequency spectrum of station transformer in converter station is in the form of broken line, and the spectral centroid of noise is also in the low frequency range.
Through monitoring the audible noise of all equipment in converter station represented by converter valve, converter transformer, reactor, capacitor bank, air conditioning cooling unit and station transformer, the noise of all the equipment is compared under the same monitoring conditions, and the results are shown in Figure 3 below.

![Figure 3. Noise level distribution of converter station equipment.](image)

3. Suppression measures of audible noise in UHV converter station

3.1. Suppression of audible noise in UHV converter station

The noise suppression methods of UHV converter station are mainly realized by controlling the noise source and blocking the noise transmission path. In the aspect of noise source control, low noise equipment or audible noise generated by noise source equipment is mainly used. In the aspect of cutting off the noise transmission path, it is mainly to physically isolate and protect various sound insulation walls and enclosures, so as to realize the change of noise transmission line. In addition, the structural layout of converter station will also have a significant impact on the characteristics and distribution of audible noise in the station. Therefore, noise reduction layout design should be carried out in the design stage of converter station, so as to minimize the adverse impact of audible noise on the surrounding environment.

3.2. Specific measures to control audible noise of UHV converter station

The specific measures to control the audible noise of UHV converter station mainly include the suppression of equipment noise and the layout design of the converter station itself. So as to realize the control of noise source, the change of noise path and the change of sweep range.

3.2.1. Layout design of UHV converter station

In the design of UHV converter station, the equipment with higher audible noise level should be arranged in a centralized way, and the equipment should be far away from the boundary of converter station, so as to increase the attenuation distance of audible noise, so as to reduce the impact on the environment inside and outside the station. The field test shows that the arrangement of high noise equipment far away from the boundary can significantly reduce the scope and degree of audible noise in converter station. In order to reduce the audible noise inside the converter station, part of the low-level noise source equipment can be arranged in the corner of the site area, so as to reduce its impact on the site environment. In addition, the building inside the converter station can also be used as an important barrier to isolate the transmission path of noise. Therefore, in the stage of design, it is necessary to carry out noise suppression and optimization design from the overall perspective to reduce the overall impact of noise.

3.2.2. Noise control of noise source equipment in UHV converter station
First of all, in the aspect of noise reduction measures of UHV converter station sound source point, it is necessary to reduce converter transformer noise, dry smoothing reactor noise and capacitor bank noise level. Secondly, the measures to reduce the noise in the way of noise transmission, make full use of the site topography, optimize the layout of equipment in the station area, and set up sound barriers. In addition, the noise barrier is set on the wall of converter station to limit the noise standard within the specified value.

4. Conclusion
In summary, AI signal analysis is applied to the coherence analysis of vibration and radiation noise of objects, which can effectively identify and separate the noise generated by objects. AI can separate the working noise of equipment in UHV converter station, realize the preliminary analysis of noise characteristics, and provide the basis for the establishment of sound power level test method and the environmental impact prediction of audible noise in converter station. Based on this, this paper first analyzes the measurement methods of noise sources in UHV converter station, and studies the noise measurement results at the main noise sources in the converter station. Secondly, the audible noise suppression methods of UHV converter station are studied, and the specific measures to control the audible noise of UHV converter station are analyzed.

References
[1] Deng Xu, Wang Dongju, Shen Yang. ±1 1100 kV Zhundong Sichuan UHVDC transmission project main circuit parameter design [J]. Power automation equipment, 2014, 34 (4): 133-140.
[2] Guo Xianshan, Ying Xin, Zeng Jing. General design research and application of ±800 kV converter station [J]. Electric power construction, 2014, 35 (10): 36-42.
[3] Huang Cheng, Li Xiaolin, Ren Junhui, et al. Study on AC / DC PLC noise filter of Nuozhadu ±800 kV DC transmission project [J]. High voltage apparatus, 2014, 50 (8): 87-92.
[4] Huang Ying, Li Zhiyuan, Huang Guoxing, et al. Study on measurement method of audible noise power level of power capacitor [J]. Power capacitor and reactive power compensation, 2013, 34 (3): 28-32.
[5] Ruan Xueyun, Li Zhiyuan, Song Jian. Application of vibration velocity method in sound power measurement of converter transformer [J]. High voltage apparatus, 2015, 51 (4): 24-28.
[6] Ruan Xueyun, Li Zhiyuan, Weihaozheng, et al. Noise prediction model and simplified research of converter transformer. Applied acoustics. 2011, 30 (3): 235-240.