Journal of Physics: Conference Series

PAPER • OPEN ACCESS

Transformer Behavior Feature Identification and Analysis Technology Based on Acoustic Interference

To cite this article: Tao Su *et al* 2022 *J. Phys.: Conf. Ser.* **2310** 012051

Transformer Behavior Feature Identification and Analysis Technology Based on Acoustic Interference

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Abstract: At present, most of the researches are based on linear systems, whose convergence speed and steady-state error are irreconcilable, and in actual operation, nonlinear factors greatly reduce the control performance of linear systems. If the nonlinear problem in the system can be solved, the active noise reduction system can choose low-cost electroacoustic devices with nonlinear distortion, which can not only improve the noise reduction performance, but also has special significance for reducing the cost of the system. Therefore, the main purpose of this paper is to study the feature identification and analysis of transformers based on sound wave interference. This paper explores the propagation, absorption and radiation process of the vibration generated by the transformer core and winding in the surrounding space, and finally obtains the vibration and noise signals of the transformer body, as well as the air sound field distribution at a specific spatial Experiments show that, compared with before the noise reduction experiment, the mean value of the noise in each main frequency band is reduced by about 7dB after the noise reduction experiment.

1. Introduction

Compared with passive noise reduction technology, active noise control technology has the following advantages: the control device is small in size and easy to install; it has a better control effect on low-frequency noise and does not affect the operation of noise reduction equipment; it can be based on the inherent characteristics of the primary sound source, adjust the relevant parameters of the control system to control the noise in a targeted manner. Since the noise around the power transformer has frequency stability and discrete line spectrum, the noise reduction effect of the active noise control technology is better. Because the substation is generally wider, there are fewer restrictions on the placement of the secondary sound source and error sensors [7].

There are many practical theories about transformer identification and acoustic interference. Among them, Nevzorov A A demonstrated an adaptive information transmission system with phase diversity, achieving a transmission rate of 1 kbit/s under multipath propagation and significant intersymbol interference[9]. Nazareth P mainly designed a hole-aware routing protocol called Location-Free Hollow Avoidance Routing (LFVAR) protocol [8].

Aiming at the contradiction between the system convergence speed and the steady state error, the paper introduces the convex combination filter into the active noise control system, and gives a detailed theory of the combination algorithm and system stability, convergence speed and steady state error used in the structure. Derivation, the theory proves that the combined algorithm can take into account the steady-state error and convergence speed to achieve good comprehensive performance. Two main methods used in nonlinear noise control systems are studied respectively.

2. Research on the Identification and Design of Transformer Behavior Characteristics Based on Acoustic Interference

2.1 Nonlinear Distortion
In the actual operation of the control system, due to the changes in the pressure, temperature and humidity of the acoustic space, the acousto-electric devices work in the nonlinear saturation region or the long-term operation appears aging, etc., and the nonlinear factors lead to the distortion of the electrical and acoustic signals [3]. The nonlinear distortions present in active noise control systems can be classified into four categories:

2.1.1 Nonlinear factors of noise signal.
The noise signal is usually emitted by a time-varying system and may not be random noise or white noise, but a deterministic nonlinear noise signal like turbid noise. When the linear active noise control system works in a nonlinear sound source environment, the control effect is greatly reduced because the built-in adaptive controller cannot perform the adaptive filtering calculation for the nonlinear sound source well.

2.1.2 Non-linear factor of secondary channel.
When modeling the secondary channel transfer function from the secondary speaker to the error sensor, the secondary channel transfer function model may be a non-minimum phase function model, thus violating the causal constraints and causing nonlinear distortion[2].

2.2 Reasons for Nonlinear Variation
Some parameters of sensors and speakers can no longer be regarded as constants. The output signal may undergo nonlinear variation[5]. The main reasons for the nonlinear variation of sensors and speakers are as follows:

In the active noise reduction system of the power transformer, the moving coil type electric speaker is generally used as the secondary sound source. There are two reasons for nonlinear distortion in dynamic loudspeakers. The first is the nonlinear variation of force compliance. The second is the nonlinear variation caused by the magnetic force factor[1].

2.3. Research on The Measurement Algorithm of Sound Pressure Method
The sound pressure system is mainly based on the principle of high pressure level, and the measurement target is the pressure, that is, the pressure change rate after the surface pressure disturbance.

Average A-weighted sound pressure level before correction:

$$\overline{L}_{PA0} = 10\lg(\frac{1}{N} N \sum_{i=1}^{N} 10^{0.1 L_{PAi}}) \quad (1)$$

In the formula, N is the total number of measuring points, and LPAi is the A-weighted sound pressure level of the measuring points.

Average A-weighted sound pressure level of background noise:

$$\overline{L}_{bgA} = 10\lg(\frac{1}{M} N \sum_{i=1}^{N} 10^{0.1 L_{bgAi}}) \quad (2)$$

In the formula, M is the total number of measuring points, and LbgAi is the A-weighted sound pressure level of the background noise.

Corrected average A-weighted sound pressure level:

$$\overline{L}_{pA} = 10\lg(10^{0.1\overline{L}_{pA0}} - 10^{0.1\overline{L}_{bgA}}) - K \quad (3)$$

In the formula, K is the environmental correction value.

3. Experimental Research on Transformer Behavior Feature Recognition Based on Acoustic Interference

3.1. Convex Combination Filters

The convex combination filter is introduced into the active noise control system to coordinate the contradiction between the steady-state error and the convergence speed of the classical algorithm, and the stability, convergence speed and steady-state error of the convex combination algorithm are deduced.

3.2. Establishment and Meshing of Transformer Multiphysics Simulation Model

The circuit model, parameter selection, material setting and meshing of the transformer multiphysics simulation model are set as follows:

3.2.1. Circuit model

The high and low voltage windings of the transformer are replaced by three sets of primary windings and secondary windings, respectively, and the rated load current flowing in the windings is used as circuit excitation to realize multi-physical field coupling. At this time, the secondary winding coil is short-circuited, and the phase difference of the three-phase winding excitation under the load short-circuit condition is 120°.

3.2.2. Model establishment and parameter selection

The transformer body is mainly composed of iron core, winding and fixed clips. There are many factors that affect the vibration signal, such as transformer shape, structure and material properties. In order to facilitate the calculation, the geometric model of the transformer is simplified, and the windings are designed to be distributed as "even multi-turn".

3.2.3. Material setting

After the model is built, the material of each part of the transformer is defined. In the transformer model studied in this paper, the winding is defined as copper wire wound, and the iron core silicon steel sheet is made of soft iron material. The physical parameters involved. The current in the circuit module is the excitation source of the electromagnetic field of the model, and the relationship between the differential equation of the electromagnetic field and the current density J is used

4. Experimental Analysis of Transformer Behavior Feature Recognition Based on Acoustic Interference

4.1. Sound pressure Level Analysis

The sound pressure method is used to measure the noise of the UHV transformer, and the noise sound pressure values measured at each measuring point are shown in Table 1:

Table 1. Sound pressure value of each measuring point

Measuring point	SPV (dB)	Measuring point	SPV (dB)	Measuring point	SPV (dB)	Measuring point	SPV (dB)
1	70.5	19	67.6	37	78	55	72.2
2	70.4	20	70.1	38	73.9	56	73.7
3	70	21	69.8	39	72.6	57	70.6
4	70.9	22	68.8	40	71.6	58	71.5
5	71.3	23	71.3	41	71.6	59	72.4
6	71.7	24	71.8	42	70.5	60	73.9
7	73.3	25	72.6	43	69.9	61	75.1
8	75	26	71.8	44	69.9	62	75.2
9	76.4	27	74.5	45	68.4	63	77.2

10	75.1	28	73.7	46	68.1	64	76.4
11	74	29	77.1	47	67.2	65	75.5
12	74.1	30	77.6	48	67.1	66	76.7
13	72.6	31	81	49	68	67	78.1
14	71.7	32	76.9	50	68	68	78.2
15	69.3	33	73.3	51	69.2	69	75.8
16	68.7	34	75.2	52	70.3	70	73.8
17	69.8	35	86.5	53	70.7	71	73.7
18	67.3	36	77.2	54	71.3	72	77.4

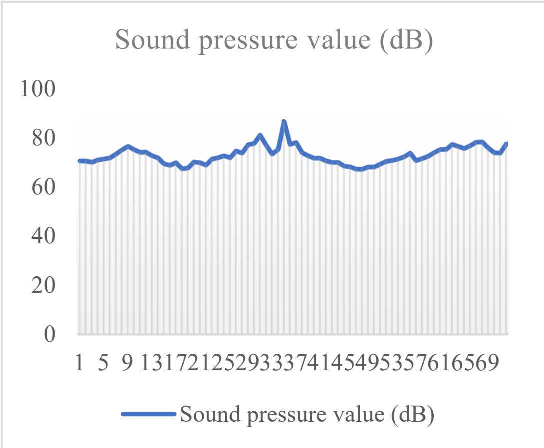

Figure 1. Sound pressure value of each measuring point

It can be seen from Figure 1 that among the noise sound pressure values measured by the transformer method, the minimum is 67.1dB, the maximum is 86.5dB, and the average is about 72.8dB, far exceeding the national limit.

4.2. Active Noise Reduction Based on LMS

When the filter coefficient L = 260 is selected and the convergence coefficient is 3 μ 3 10- = ′ , the noise effects before and after noise reduction at the error sensor are shown in Table 1:

Table 2. Noise reduction effect of active noise reduction experiment of UHV transformer

Noise reduction amount/dB frequency/Hz	Before noise reduction	After noise reduction
100	71	64
200	73	63
300	69	62
400	66	60
500	61	57
600	65	60
700	64	59.5
800	63	62
900	62	59
1000	57	56

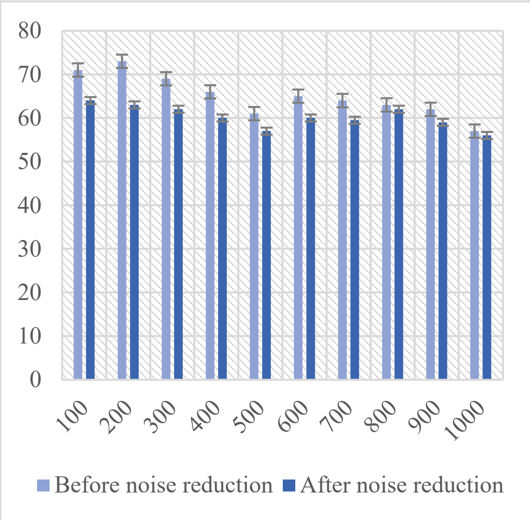

Figure 2. Noise reduction effect of active noise reduction experiment of UHV transformer

It can be seen from Figure 2 that before the active noise reduction system is not running, the average multi-frequency noise of the UHV transformer is about 80.35dB, and the average noise after noise reduction is about 73.21dB. After the experiment, the mean value of noise in each main frequency band is reduced by about 7dB.. The experimental results show that the system It has a good noise reduction effect on the noise of UHV transformers.

5. Conclusions

Most of the previous researches on active noise control technology were carried out under linear ideal conditions, but in actual operation, the system is often nonlinear. Studies have shown that nonlinear factors in the system will have a serious impact on the noise reduction performance of active noise reduction systems. If the nonlinear problem in the system can be solved, it will not only greatly improve the noise reduction performance, but also have special significance in reducing the cost of the system. Therefore, by consulting a large number of domestic and foreign literatures, and their clever combination structure can combine the advantages of the two filters, improve the overall performance of the nonlinear filter, and enhance the ability to adapt to the actual environment.

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