Active Control of Sound Radiation from a Small Transformer Using Near-field Sensing

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The active control of noise radiated from a small transformer using near-field sensing strategies is investigated. Two cost functions that are minimised are the sum of the sound intensities at the error sensors and the sum of the squared sound pressures at error sensors in the near-field. The effects of the sensing strategies and the error sensor arrangement (location and number) on the control performance were studied numerically using transfer function measurements. To verify the numerical simulation, experiments were carried out using a real time control system. A small transformer was located in an anechoic room for testing. The control system consists of eight control shakers mounted on the transformer, eight error microphones located in the near-field and a ten channel controller. Both predicted and test results are given.

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1. INTRODUCTION

In contrast to traditional means of controlling transformer noise, which involves the construction of large barriers or full enclosures, one promising alternative is to use active sound cancellation.[1-7] Hesselmann[1] and Angevine[2] demonstrated that global control can be achieved for a transformer in an anechoic room, provided that the transformer is completely surrounded by loudspeakers. In Angevine's work, independent single channel controllers were used to minimise the sound level in the vicinity of each control source. He found that the attenuation is dependent on the number of control sources and that this dependence is stronger at lower frequencies. In Berge et al's work,[3,4] an adaptive algorithm for active control of noise radiated from real transformers was developed. Using one loudspeaker control source and one error microphone, they found that significant noise reduction can only be achieved over a very narrow zone − 2 m to each side of the error microphone for a 100 Hz tone and 1 m for a 200 Hz tone. Angevine and Wright[5] and Angevine[6,7] demonstrated some success using multiple-loudspeaker type control sources to minimise the transformer noise. Eight loudspeakers were arranged in two rows of four in front of a transformer tank and eight error microphones were located 10 metres away from the transformer tank (at the same side of the transformer as the loudspeakers). The results showed that significant noise reductions over a wide area (15 to 20 dB over an azimuth angle of 35 to 40 degrees) can be achieved. At about same time, other researchers[8,9] reported an attempt to actively control transformer noise using Active Structural Acoustic Control (ASAC). In their control system, piezoelectric actuators are bonded to the transformer tank as vibration control sources and microphones are used to sense the error signals. The control system with multiple inputs/outputs computed and adapts to changes in the system and the system environment. The typical sound reduction is about 15-20 dB at 120 Hz and 10-12 dB at 240 Hz.

Martin and Roure[10-12] implemented an active noise control system on a small industrial transformer (630 KVA) located in an anechoic room. Spherical harmonic expansion and a genetic algorithm were employed to estimate the number and locations of actuators and error microphones. The results demonstrate that at 100 Hz, a global sound reduction of 10–25 dB is achieved using eihgt loudspeaker control sources and ten error sensors. For the case of 200 Hz, a 30 dB reduction is achieved at some locations, but at other locations a 5-10 dB increase can be observed. They suggested that the control results could be improved by using more control sources and decreasing the distance of the control sources to the transformer. Li et al[13] reported predictions of the achievable noise reduction for a large transformer (160 MVA and dimensions $4\times4\times5$ m) using active noise control. The average noise reduction at the error sensors was predicted using measured data, which were the transfer functions from the control inputs to error sensor outputs and the primary sound pressure field. The cost function that was minimised was the sum of the squared sound pressures at the error sensors in the near-field. Ninety six error sensors were evenly arranged around the transformer. The results demonstrate that, in the near-field using 80 vibration control sources, the average sound pressure reduction achievable at the error sensors is 23.1, 16.0 and 16.0 dB for 100, 200 and 300 Hz respectively. When 80 loudspeaker sources are used, the average achievable sound pressure reduction at the 96 error sensors is 19.6, 12.8 and 10.3 dB for 100, 200 and 300 Hz respectively.

Here, an active control system for the cancellation of noise radiated from a small transformer (50 KAV and dimensions $0.35\times0.82\times0.82$ m) was evaluated. The aim was to study the effect of near-field error sensing strategies on the control performance and the influence of the error sensor arrangement (number and location) on the global control re-