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IMPACT OF MAGNETIC MOUNTING FOR INERTIAL ACTUATORS IN ACTIVE CONTROL APPLICATIONS

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ABSTRACT

Active noise control systems performance depend strongly on actuators and their spatial arrangement. For active noise barriers which vibrations are controlled, actuators are usually permanently attached and their removal or shift is most often impossible without damaging them. However, an actuators rearrangement might be beneficial during preliminary tests or future modifications.

This paper explores a magnetic mounting for inertial actuators which are usually permanently glued to the controlled object surface. Magnetic mounting facilitates aforementioned shift or removal, but its influence on the transfer paths and robustness has to be investigated before application. A thorough experimental investigation of these aspects is presented and discussed.

Keywords: *Active structural acoustic control, active noise control, electromagnetic actuators.*

1. INTRODUCTION

Numerous applications use thin panels and shells as sound barriers to reduce the spread of acoustic noise [1–6]. To improve the effectiveness of these barriers, active control systems with inertial actuators can are used. When applied to individual panels or entire device casings, active structural acoustic control (ASAC) systems exhibit superior performance [7–9]. However, to ensure efficient operation of an active system, the actuators must be arranged correctly. The proximity of actuators to particular mode shapes' nodal lines can make controlling these modes impossible. As a result, to control multiple modes in a broader frequency range, multiple actuators are needed to achieve a balanced arrangement, which is a trade-off between considered modes.

In order to find such arrangement of actuators, an optimization algorithm is necessary [10]. Nevertheless, the output of an optimization process requires evaluation in real experiments. It is often beneficial to compare several solutions. Moreover, due to modification of the noise barrier or device casing, the actuators may need to be rearranged. Inertial actuators are usually permanently glued to the controlled object surface, however, the possibility to detach actuators without destroying them would be desired due to aforementioned reasons. Hence, this paper investigates a magnetic mounting for inertial actuators, which would allow an easy rearrangement. The analysis is based on experimentally measured acoustic paths between actuators attached using different methods and several microphones.

2. LABORATORY SETUP

Commercially available Dayton Audio DAEX32EP-4 are used as actuators for this study (their pictures are shown in Figs. 1-2). They are light-weight actuators (123 g) of small size (60 mm) relative to the plate (noise barrier used for tests).

The rectangular steel plate is mounted to a heavy concrete box and it is excited with the actuators. The actuators are driven to generate a random, broadband noise (i.e., band-limited white noise) in order to identify acoustic paths between them and three measurement microphones. A photograph of the experimental setup is shown in Fig. 3.

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Figure 1. Inertial actuator Dayton Audio DAEX32EP-4 visible from the top.

Figure 2. Inertial actuator with visible magnetic mounting.

The utilised magnetic mounting for inertial actuators required an additional intermediate component between the actuator itself and the neodymium magnet. A disk made of PMMA was used for this purpose (6 mm thick and 40 mm in diameter). On one hand, it facilitated the mechanical connection between the magnet and the actuator. On the other hand, it increased sufficiently the distance between them, strongly reducing the magnetic interference between them (the actuator has its own built-in

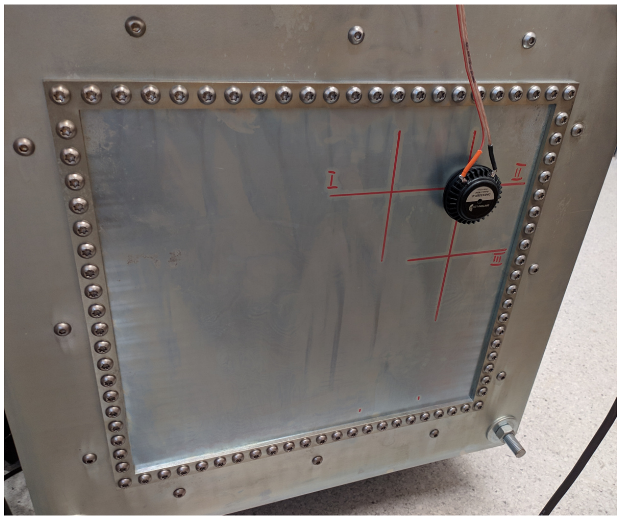

Figure 3. A rectangular plate with an attached actuator.

permanent magnet). The utilized neodymium magnet was 20 mm wide in diameter and 2 mm thick.

3. MEASUREMENTS

The evaluation of the impact of magnetic mounting on acoustic path between the actuators and microphones started from answering a question: how repetitive is the magnetic mounting at a single location? Thus, the actuators with the magnet was attached, measured and detached 10 times at the same position (no. 2). The obtained magnitude responses of the identified paths are presented in Fig. 4. As it follows from analysis, the results are very consistent and reproducible. Hence, a comparison of actuators located at the same position, but using different mounting method is justified.

In the second experiment, the magnitude responses of the acoustic paths are compared for different mountings. The first method is a magnetic mounting using a neodymium magnet, as described in the previous Section. In the second method, a strong 3M double-sided tape was added to the magnet in order to more firmly attach the actuator. If the magnet would provide less stiff connection, the addition of extra adhesive should have an impact on the identified paths. Finally, the third method was the original 3M glue provided with the brand-new actuators (without the PMMA disk and the magnet). The paths obtained for three different positions on the plate are pre-

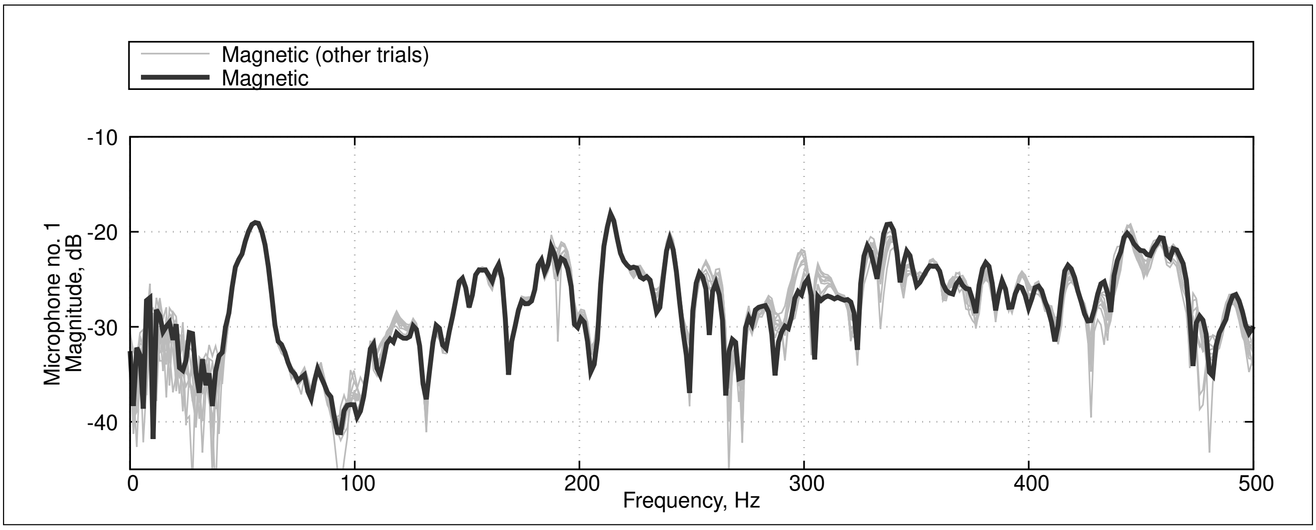

Figure 4. Magnitude responses of paths between actuator attached at position no. 2 and microphone no. 1. The first measurement marked with black colour was followed by another nine, with the actuator detached and attached again at the same position.

sented in Fig. 5. The paths obtained for position no. 1 on the plate, but three different measurement microphones are presented in Fig. 6.

What follows from analysis of Figs. 5-6 is that the addition of glue between the magnet and the plate made no practical impact on the identified paths in the considered frequency range. The discrepancy between these two sets of characteristics (black and red) are due to positioning imperfections, as already depicted in Fig. 4.

When comparing actuators attached with the original glue and magnetically mounted, there are differences visible in both Figs. 5-6. However, they are mainly due to attachment of different mass (of the magnet and the PMMA disc) and at different distance from the plate surface (2 mm of the magnet plus 6 mm of the PMMA disc). Nevertheless, the reduction of both mass and the distance from plate surface made still rather small impact. Some resonances are shifted in the frequency domain. Others are slightly enhances or attenuated due to altered mode shapes. However, the general magnitude of all paths is the same, what means that the energy transfer between the actuators mounted magnetically and with the orginal glue is unaffected (the stiffness of the magnetic mounting is sufficient).

4. CONCLUSIONS

This paper investigated a magnetic mounting for inertial actuators, which allows an easy rearrangement of actuators. The analysis was based on experimentally measured acoustic paths between actuators attached using different methods and several measurement microphones.

The analysis of the performed experiments clearly shows that the magnetic mounting provides as good mechanical connection between the actuators and the object surface as the original glue. It is stiff enough to efficiently transfer mechanical energy in the considered frequency range, while it allows an easy rearrangement of actuators in the preliminary experimental tests of the active control system.

For final applications, addition of an extra extra adhesive is still recommended, as it prevents from detaching the actuators, e.g. after accidentally pulling the cable, etc. However, solely magnetic mounting is a reliable solution for preliminary and experimental phase.

5. ACKNOWLEDGMENTS

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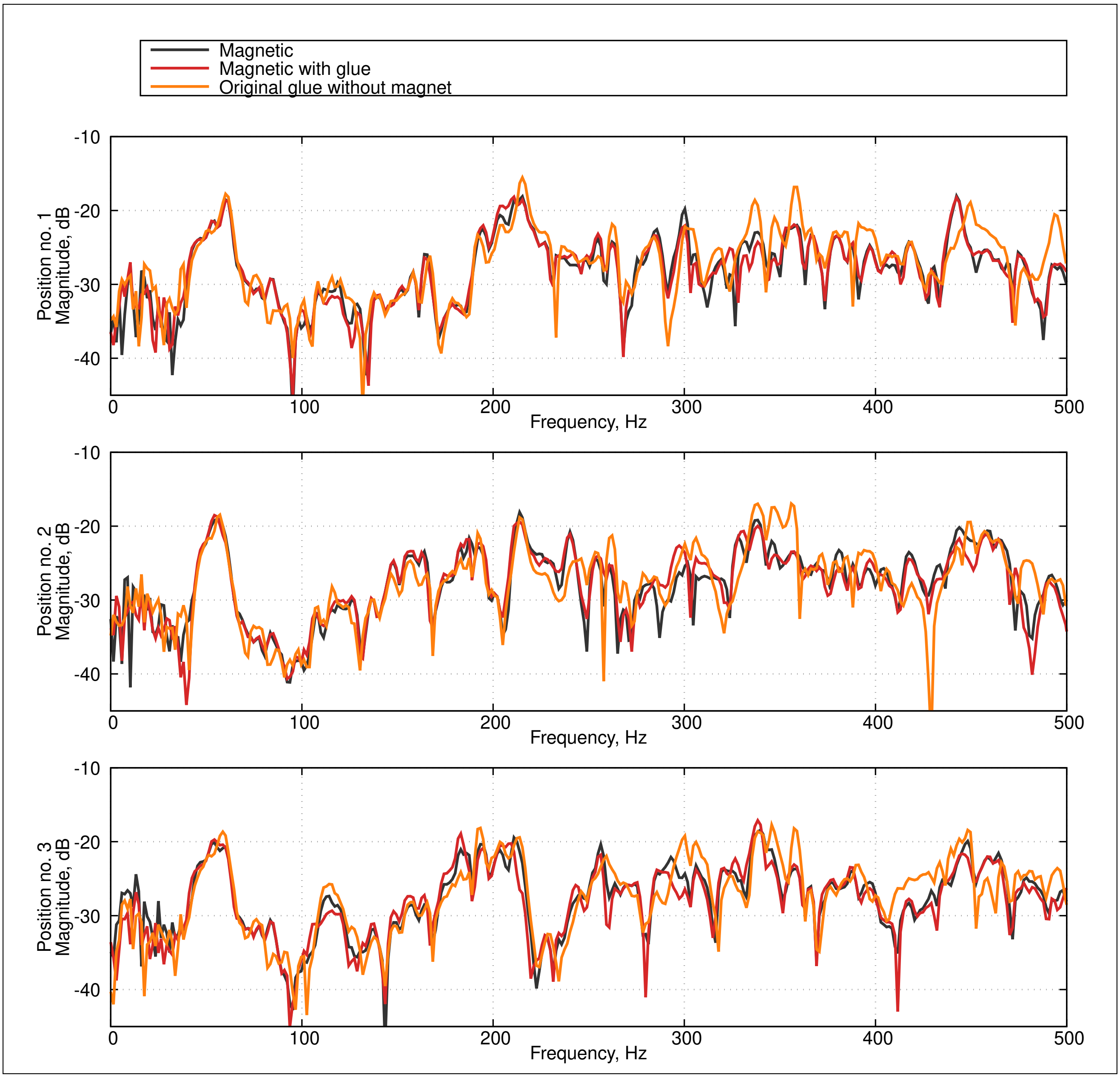

Figure 5. Magnitude responses of paths between actuators attached at positions no. 1, 2 or 3 and microphone no. 1. The figure compares different mountings of the actuator.

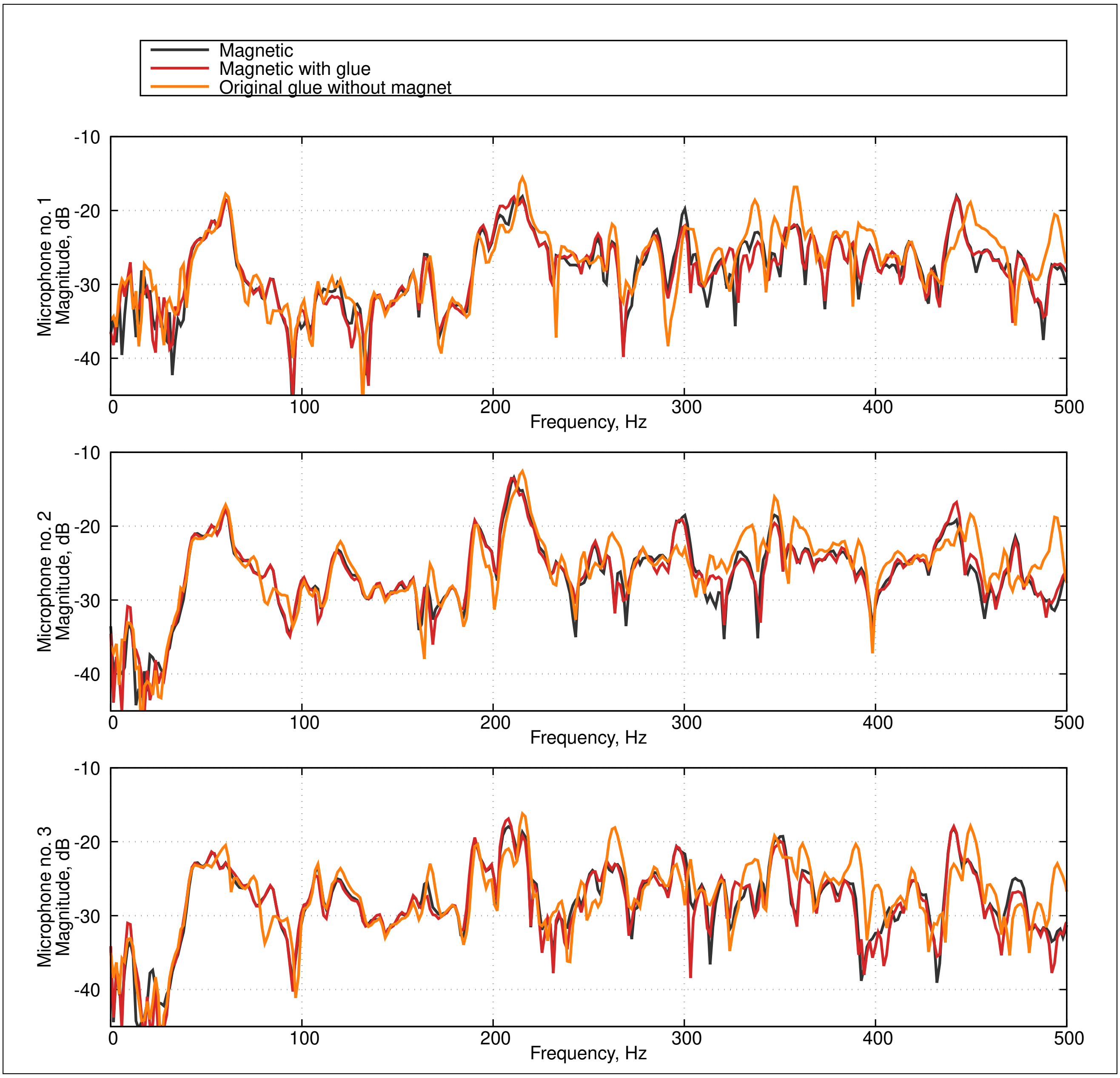

Figure 6. Magnitude responses of paths between actuators attached at position no. 1 and microphones no. 1, 2 or 3. The figure compares different mountings of the actuator.

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