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A WIDE-BAND PIEZOELECTRIC TRANSDUCER FOR OTOACOUSTIC EMISSION APPLICATIONS

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1. INTRODUCTION

Conventional electrodynamic bone conducting transducers for otoacoustic emission applications are not capable of high frequency output. The high frequency limit for bone conducting otoacoustic emission [1, 2] with conventional transducers is within the range between 6 kHz and 10 kHz. A wide-band piezoelectric otoacoustic emission transducer that is capable of high frequency output to beyond 25 kHz has been developed. This transducer is usable to more than 50 kHz. Initial trials have shown that sensation can be detected by a human subject for frequencies beyond 35 kHz when the transducer is placed in contact with the mastoid.

2. TRANSDUCER DEVELOPMENT

The transducer consists of four lead zirconate titanate (PZT) elements, with the polarities arranged as shown (Fig. 1). The rear of the transducer is anchored to a relatively heavy brass base such that the vibrating force is diverted to the front of the transducer. The assembled elements are sealed with a silicon compound (RTV) and encased in a nylon shell. The active elements are 13 mm in diameter, and the overall dimensions of the transducer are 25 mm outside diameter and 43 mm long. The actuator face is insulated with a thin mylar film.

3. TEST RIG

The test arrangement shown in Fig. 2, consists of a heavy steel base (30 x 30 x 2.5 cm) with two vertical blocks. One of the blocks is fixed with its front

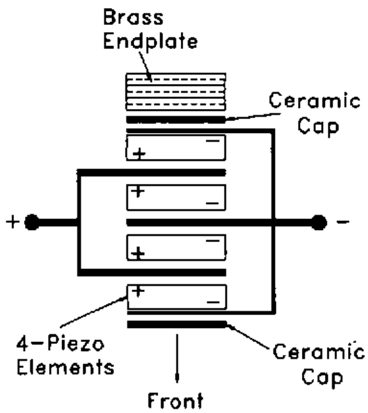

Fig. 1 Schematic arrangement of the wide-band piezoelectric transducer

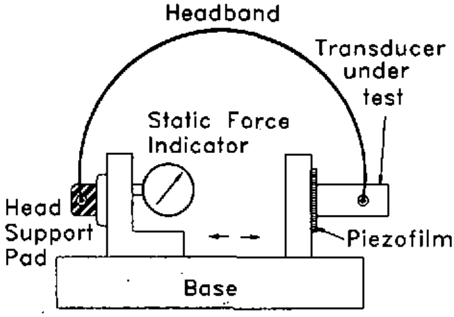

Fig. 2 Test rig arrangement

surface embedded with a piezo-film that is used as a vibration sensor for the evaluation of the output level of the transducer under test. The second block has a static-force sensor. By changing the distance between the two blocks, the tension of the headband that is holding the test transducer can be varied. In use, the test transducer (NRC model Oto2, see Fig. 3) replaces the conventional electro-dynamic transducer, and the commercial headband performs its intended task of securing the test transducer at the forehead of the test subject. During evaluation, thin pieces of artificial skin samples were inserted between the piezo-film and the test transducer to simulate the test conditions of a human subject.

Fig. 3 NRC transducer model Oto2

3. TEST RESULTS

With three pieces of artificial skin samples, and at a constant driving voltage of 40 V p-p at the input of the test transducer, frequency responses were measured with a Brüel and Kjær 3550 signal analyser (equipped with a 100 kHz input module) by monitoring the piezo-film output via a buffer DC amplifier that has a gain of two. The driving force generated by the test transducer is estimated to be less than 10 mN at 10 kHz.

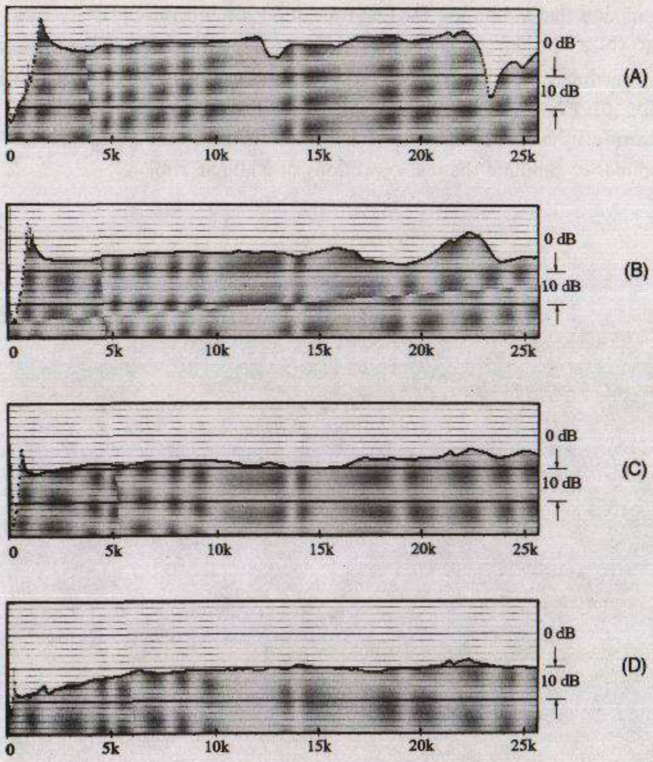

Fig. 4 Frequency response of NRC Oto2 transducer with an input of 40 V p-p and at a headband force of 4 N: (A) without artificial skin; (B), (C) and (D) measured with 1, 2 and 3 mm thick artificial skin, respectively.

(1) Without any artificial skin, and with a static headband force of 4 N, the frequency response is shown in Fig. 4A. The transducer output level is flat to approximately ± 4 dB up to 22 kHz. The transducer is useable to more than 50 kHz. There was little change in the response when the static force was varied from 1.5 N to 4 N. The dip of the response curve at approximately 23 kHz may be due to damping by the piezo-sensor at the test-rig and by the mylar insulator film. The damping effect is under further investigation.

(2) With the inclusion of the 1 mm, 2 mm and 3 mm thick artificial skin samples, the frequency response curves are shown in Fig. 4B, 4C and 4D, respectively. The headband static force was maintained constant at 4 N for the above tests. It can be seen that the response levels become lower as the skin thickness increases.

4. CONCLUSIONS

The test transducer can operate with a relatively flat response up to 22 kHz. If necessary, a higher driving force can be obtained with a larger driving voltage or with larger diameter piezo-elements. A transducer of similar design (patent pending) has been developed for commercialization.

References

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