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Proposal of a loudspeaker for low frequency range by composite vibration type ultrasonic motor
複合振動型超音波モータを用いた低音再生用スピーカの一提案

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1. Introduction

The loudspeaker driven by ultrasonic motors is characterized by a precise low frequency reproduction due to its high mechanical impedance. The conventional electrodynamic loudspeaker suffers disturbance due to a mechanical resonance. It is because radiator of the conventional loudspeaker is driven indirectly.
The authors reported the DMDS (dual motor de-spin) loudspeaker by rotation of the ultrasonic motors at USE 2008. This model, however, included some complexity by rotation to linear conversion mechanism.
As is well known, there are two types of ultrasonic motors, rotational and linear motions. This paper proposes a new model which utilizes linear motion of composite vibration type ultrasonic motors.
Performance of this model is improved because of its simple driving mechanism. In additon to that, two types of connecting constructions between driver and radiator are compared and a practical design is examined.

2. Composite vibration type ultrasonic motor

The authors used HR8 ultrasonic motor by Nanomotion Ltd., Israel. It is quoted as a long life of 20000 hours, but its maximum velocity is rather limited to 270 mm/s. **Fig.1** shows its external view.

Fig.1 HR8 external view

Driving principle of this motor is explained by **Fig.2**. The Piezoelectric effect in piezoceramics converts electrical field to mechanical strain. Under special electrical excitation drive and ceramic geometry of the motors, longitudinal extension and transverse bending oscillation modes are excited at close frequency proximity. The simultaneous excitation of the longitudinal extension mode and the transverse bending mode creates a small elliptical trajectory of the ceramic edge, thus achieving the dual mode standing wave motor.

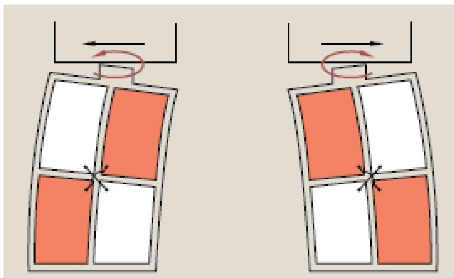

Fig.2 Composite vibration driving model

This ultrasonic motor is driven by ac signal of 40 kHz from a driving circuit. The velocity is varied in the range of ±270mm/s by the input dc voltage of ±10 V to the circuit.

3. Loudspeaker construction

Two loudspeaker models were prepared to compare connecting structure of cone radiator and slider driven by the motors.
Model 1, shown in **Fig.3**:
The cone and the slider were connected by a brass rod and a silicon rubber damper.
Model 2, shown in **Fig.4**:
The cone and the slider were connected directly.

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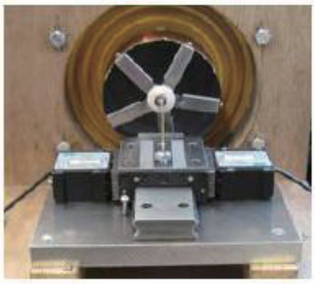

Fig.3 Model 1

Fig.4 Model 2

4. Experimental results

Measurement results of frequency response are shown in **Fig.5**. Distance between the loudspeaker and microphone was 5 cm, and the input dc voltage of 8 V was loaded to the driving circuit.
The frequency response of the Model 1 includes a peak at 56 Hz. This peak seems to be a resonance by silicon rubber damper.
The frequency response of the Model 2 does not include this remarkable peak.
The structure of Model 2 is, therefore, more suitable for a practical system.

5. Conclusion

The authors proposed a new loudspeaker model for a precise low frequency reproduction, which utilizes linear motion of composite vibration type ultrasonic motors. Performance of this model is improved because of its simpler driving mechanism than it of the conventional models. Two types of connecting constructions between driver and radiator are compared and a practical design is examined.

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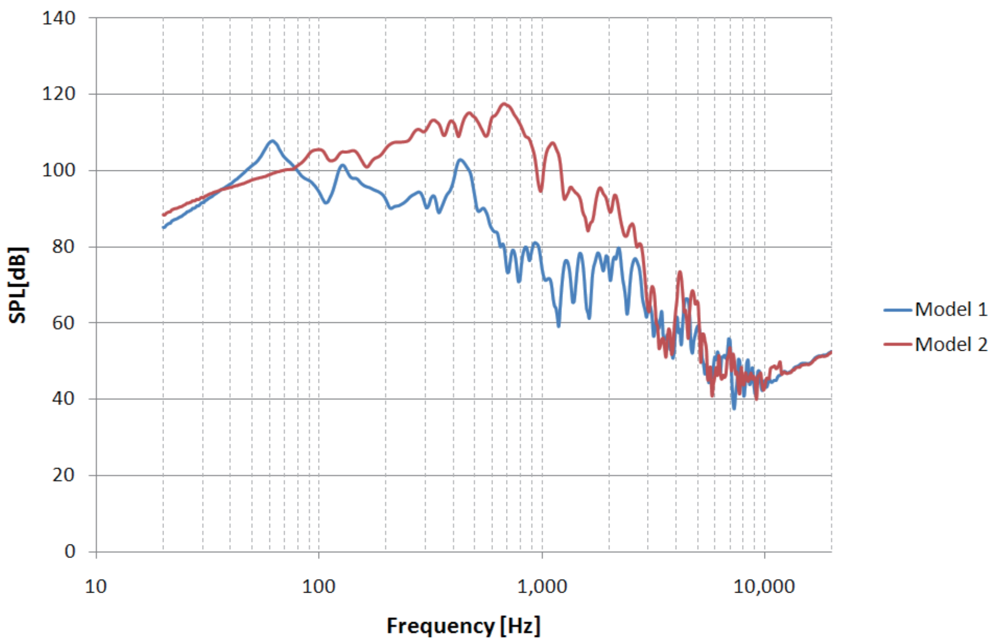

Fig.5 Output sound pressure frequency response