Effect of magnet position in electro-magnetic transducer of middle ear implant

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Abstract. The paper is devoted to modelling and numerical analysis of the middle ear with an implantable middle ear hearing device. The main focus is put on elec- tromechanical coupling between the biomechanical subsystem of the middle ear and electrical subsystem of the implant. The electromechanical coupling describes the interaction between electrical and mechanical systems, and it is defined as nonlinear dependence of magnet position relative to the coil's transducer centre. This is a novel approach, that generates new resonances, instabilities, subharmonic and also chaotic stapes vibrations depending on a voltage excitation. Finally, the stapes motion from numerical simulations stimulated by the floating mass transducer is compared to experimental results performed on the human temporal bones. The findings of this research can be used practically to develop a better construction of a floating mass transducer.

Introduction

Sound transfer through the human ear is disturbed very often because of clinically significant hearing deficits [1]. If a hearing loss is mild or moderate, it can be improved by conventional hearing aids (non-invasive, not requiring surgery) that consists of a microphone to pick up sound, amplifier circuitry that makes the sound louder and a miniature loudspeaker to deliver the amplified sound into the ear canal. However, patients with moderately severe or severe hearing loss have to be equipped with more technologically advanced devices, such as implantable middle ear hearing devices (IMEHDs) that is analysed here.

Results and discussion

The model of the IME presented in [2] is now modified and improved in order to fulfil the purpose of this study. First of all, it is assumed according to the physical system construction, that the coil is fixed to the can of the FMT (the improvement of the previous model). Moreover, the EC is presented as nonlinear dependence of the magnet position related to the coil (the modification of the previous model). The new model of IME with the schematic view of the middle ear is shown in Fig.1. Magnet shift (position relative to the coil) is important for

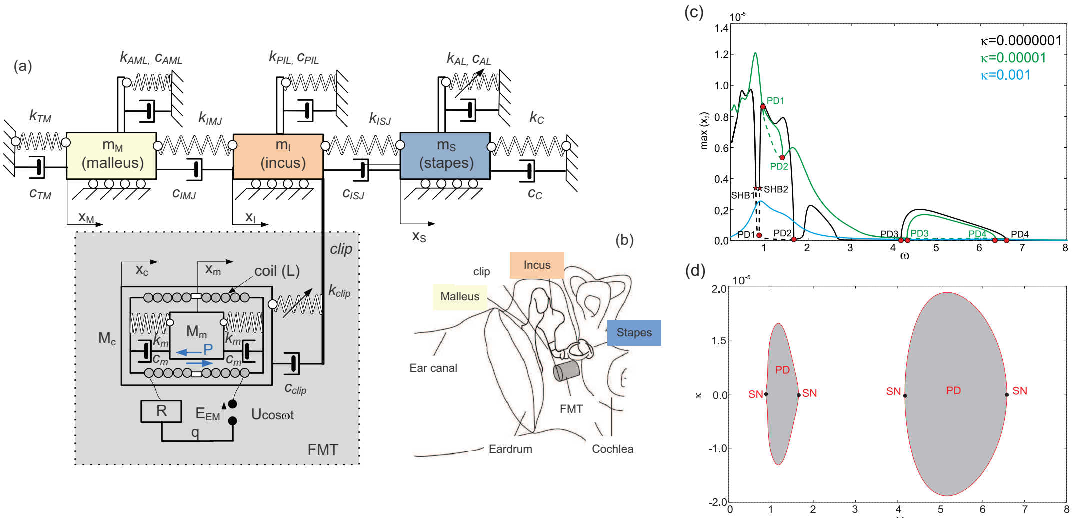

Figure 1: Electromechanical model of the implanted middle ear (a) with resonance curves obtained for different magnet shift κ (b) and regions of subharmonic motion (c).

stapes vibration as presented in Fig. 1b and c because it change the resonance curve, that is amplitudes and resonance peaks (Fig. 1b). Moreover, improper magnet position can cause subharmonic stapes vibrations. That is harmful from medical (practical) point of view.

References

[1] Haynes D. S., Young J. A., Wanna G. B., Glasscock M. E. (2009) Middle ear implantable hearing devices: An overview, Trends in Amplification.

[2] Rusinek R., Kecik K. (2021) Effect of linear electromechanical coupling in nonlinear implanted human middle ear. *Mechanical Systems and Signal Processing* **151**:107391.