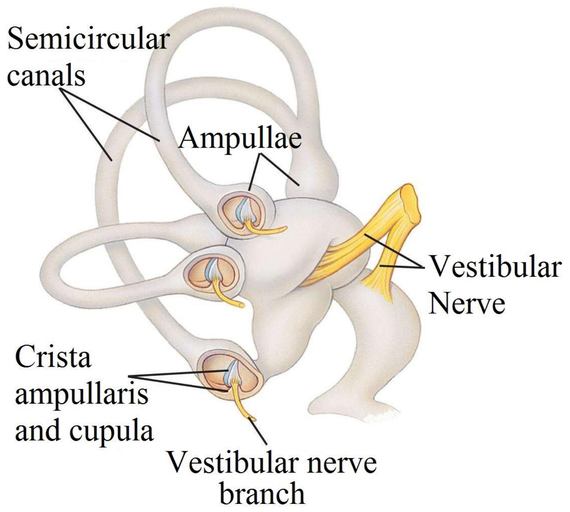
Evaluation of Induced Excitation of the Peripheral Vestibular System Using Micro Scale Inductors

S. Mukesh, P. T. Bhatti
School of Electrical and Computer Engineering, Georgia Institute of Technology, Atlanta, GA, USA

Introduction: Vestibular prosthetic devices (VPDs) aim to improve the quality of life of patients who suffer from bilateral vestibular dysfunction by restoring the functionality of peripheral vestibular system. While unilateral vestibular sensory loss may be compensated for using rehabilitation, bilateral vestibular sensory loss is disabling and there is no effective treatment for patients who fail to benefit from rehabilitation exercises and medication. Fig. 2 shows the arrays developed to over come this disability through the use of electrical stimulation [1].



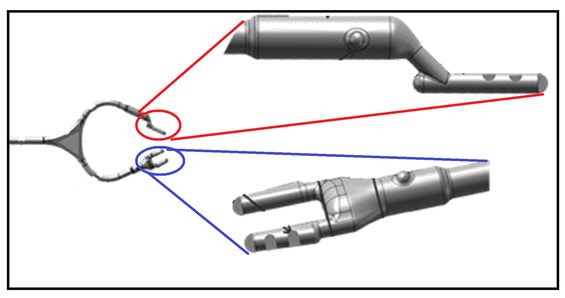


Figure 2. Array for vestibular stimulation used currently in clinical trials.

Figure 1. Peripheral vestibular system.

In this poster. We propose the use of magnetic stimulation to excite the peripheral vestibular system offering lower risk, lower complexity and an improved selectivity for the VPDs.

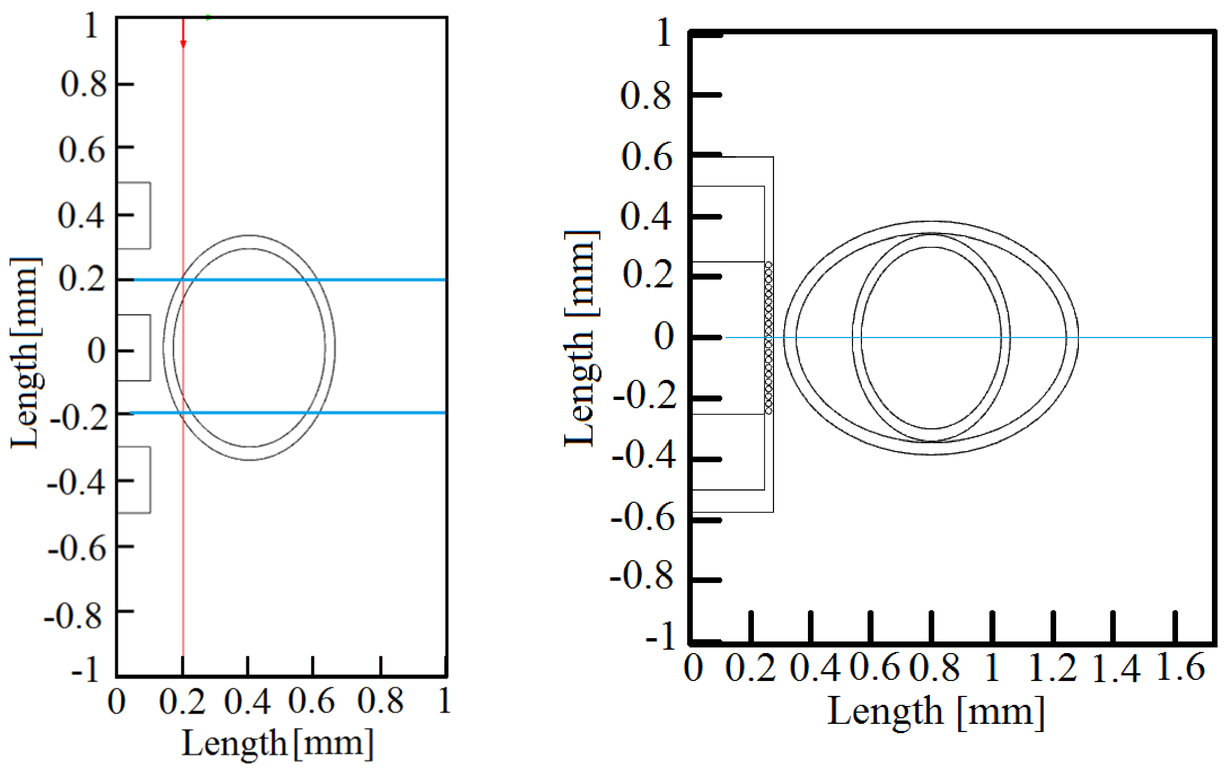


Figure 3: Geometries for verifying electrical and magnetic stimulation of the peripheral vestibular system. (Right) shows that the electrodes are present inside the bony labyrinth, whereas (Left) the electrode sits outside it.

Methods: Low frequency AC/DC module is used and Magnetic Fields (mf) and Electric Currents (ec) physics are utilized. Fig. 3 shows the geometries used.

Material	Electrical Conductivity [S/m]	Relative Permittivity	Relative Permeability
Quartz	1e-12	4.2	1
Copper	5.998e7	1	1
Parylene-C	1e-14	3.1	1
Perilymph	1.8	30	1
Endolymph	40	30	1
Tissue	0.27	948.6	1
Bone Tissue	0.097	184.71	1
Nerve	0.155	554.83	1

Table 1. Electrical properties of materials

Results: The ampulla is modelled for both electrical and magnetic stimulation and it is shown that magnetic stimulation is effective without the need to drill through the bony labyrinth. The electrical properties of the various layers modeled are presented in Table 1. Figure 4 shows that the fields induced inside the cupula, where the neurons are present, is in the range of ~10V/m [2].

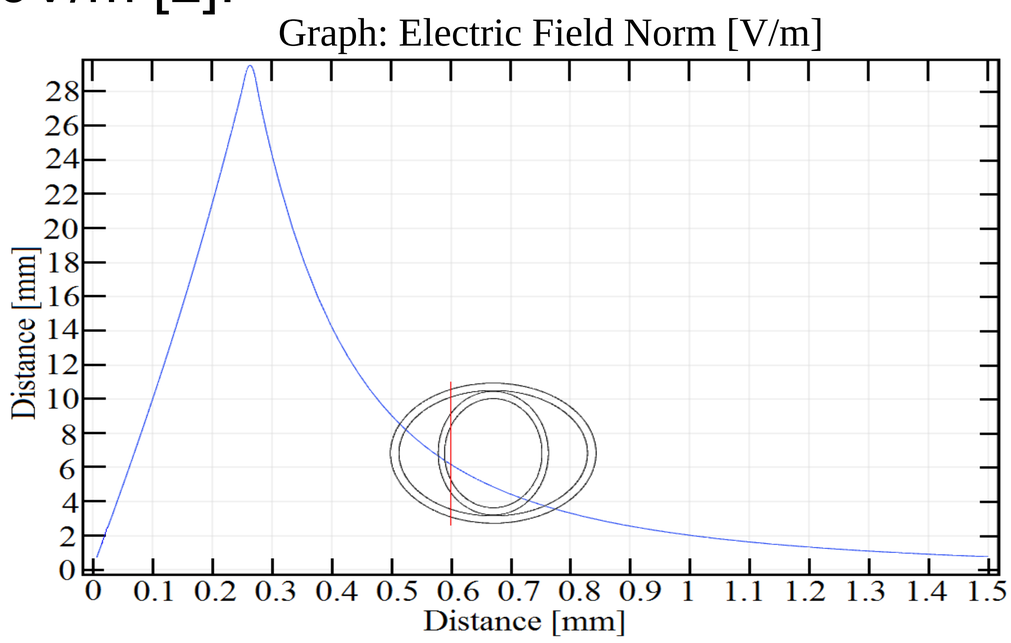


Figure 3: Electric Fields induced by the millimeter scale inductor sitting outside the bony labyrinth of a peripheral vestibular ampulla.

References:

1. C. C. D. Santina et al., Implantable vestibular prosthesis, Patent No. US9242094 B2, (2016)
2. G. Bonmassar et al., Microscopic magnetic stimulation of neural tissue. Nature Communications,3-921 (2012)