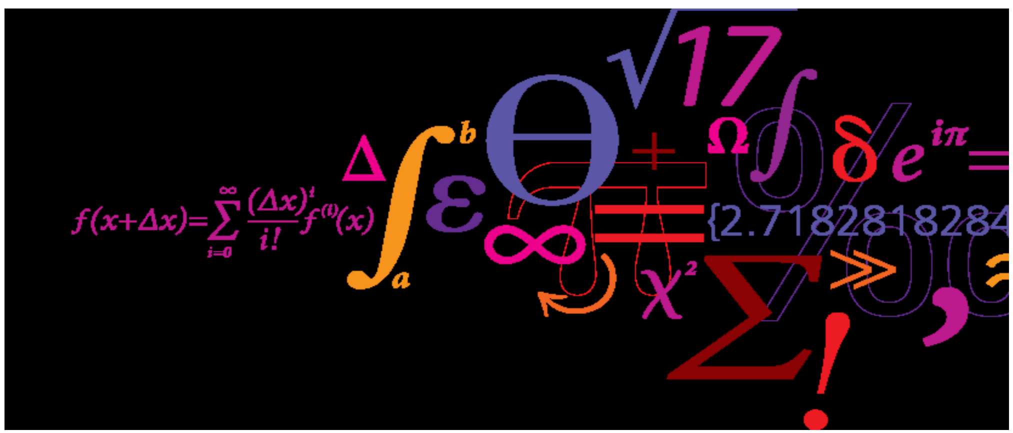
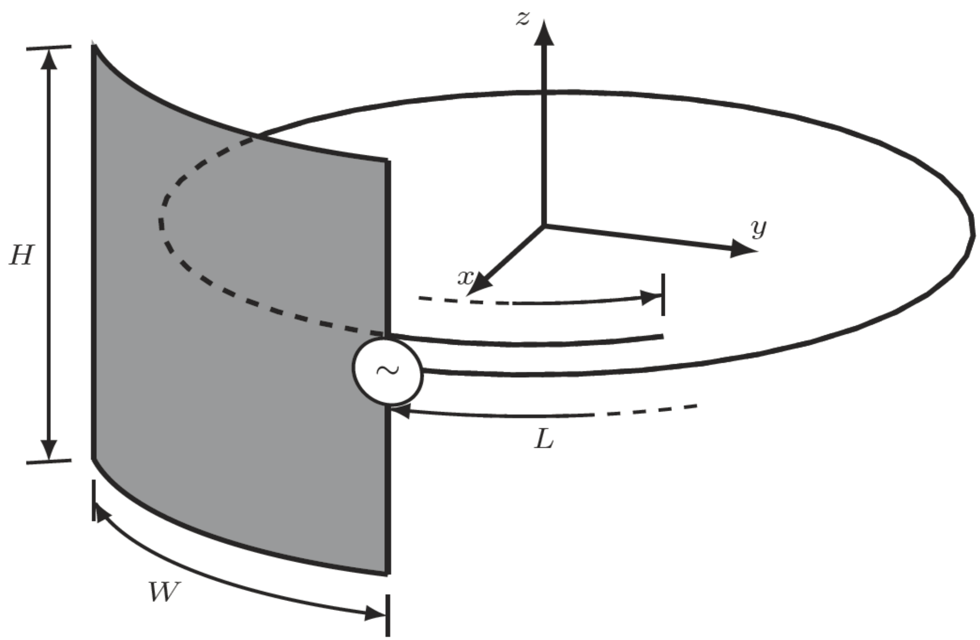
Body-Worn Spiral Monopole Antenna for Body-Centric Communications

Nikolaj P. I. Kammersgaard*†, Søren H. Kvist†, Jesper Thaysen†, and Kaj B. Jakobsen*
Department of Electrical Engineering, Technical University of Denmark,
DK-2800 Lyngby, Denmark.
†GN ReSound A/S, Lautrupbjerg 7, DK-2750 Ballerup, Denmark. npivka@elektro.dtu.dk, skvist@gnresound.com, thaysen@gnresound.com, kbj@elektro.dtu.dk



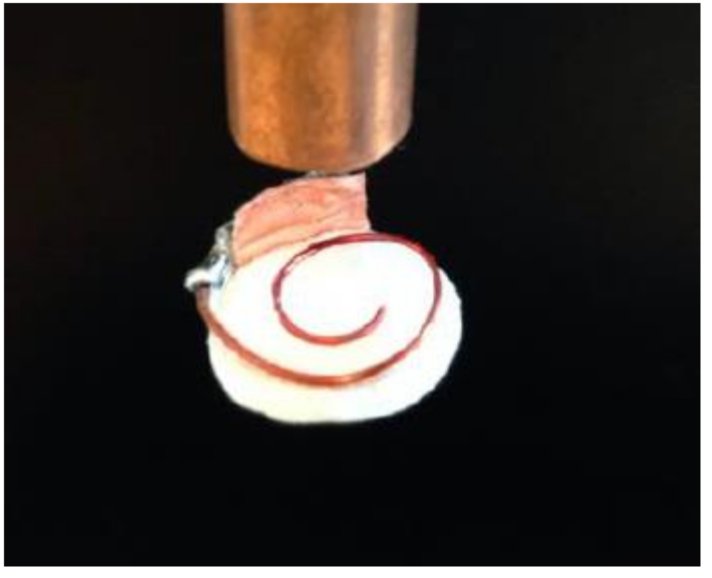
DTU Electrical Engineering
Department of Electrical Engineering

Abstract: A novel body-worn spiral monopole antenna is presented. The antenna consists of a ground plane and a spiral monopole. The antenna is designed for Ear-to-Ear (E2E) communication between In-the-Ear (ITE) Hearing Instruments (HIs) at 2.45 GHz and has been simulated, prototyped and measured. The antenna yields a measured and simulated Ear-to-Ear path gain at 2.45 GHz of -82.1 dB and -85.9 dB, respectively. The radiation pattern of the antenna when mounted in the ear is presented and discussed.



Introduction

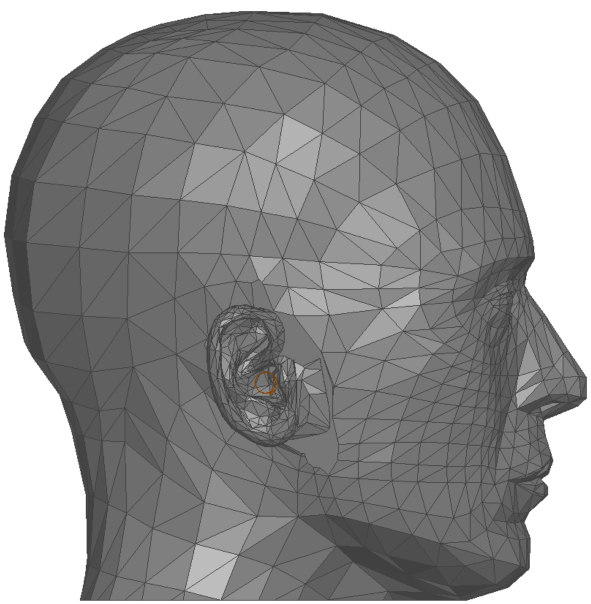
Body-centric wireless communication has in recent years been the focus of attention for a lot of research. One of the main motivations is the commercial interest for wireless systems in body-worn devices. Particularly, it is of special interest to the hearing instrument (HI) manufacturers to investigate the possibility of Ear-to-Ear (E2E) communication. The interest is focused on the 2.40 GHz to 2.48 GHz ISM band. Suitable antennas have been presented for behind-the-ear in [1,2]. For in-the-ear placement there has only been presented antennas with an E2E path gain below -90 dB [3,4]. This area has been discussed in [5-11].

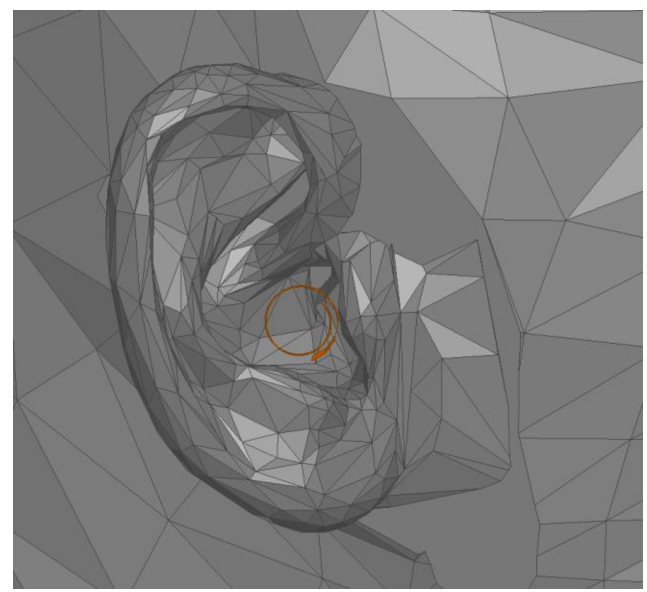


Theory

Models for the ear-to-ear path gain are presented in [5,6]. The channel is modeled as a number of creeping waves along elliptical paths around the head. The on-body radiation pattern $G_{on-body}(\varphi)$ introduced in [6] is used to model the magnitude of the launched creeping waves. Here, it will be used to evaluate the radiation patterns:

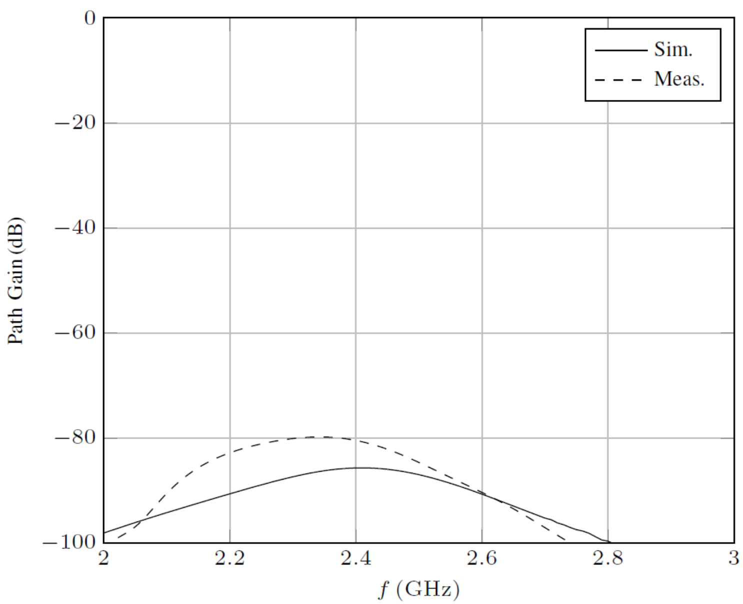
$$G_{on-body}(\varphi) = \int_0^{\pi} G_\theta(\theta,\varphi) e^{j\angle E_\theta(\theta,\varphi)} \sin\theta \, d\theta$$

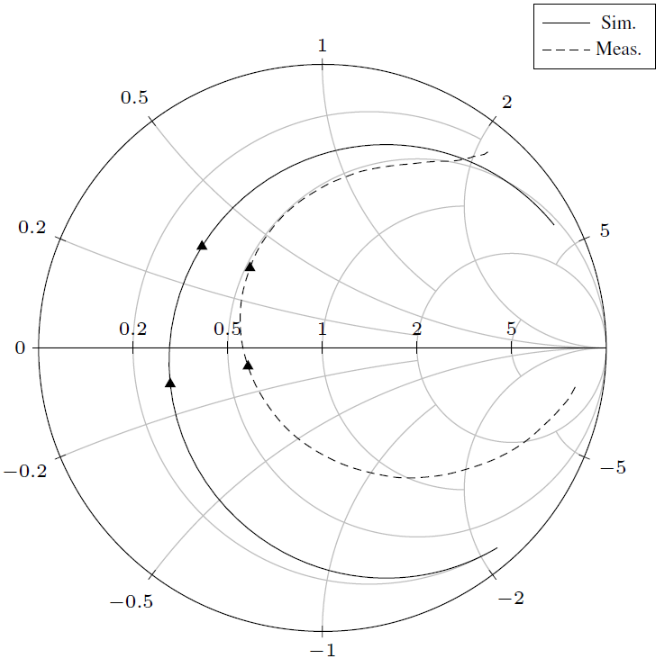




Results and Discussion 1

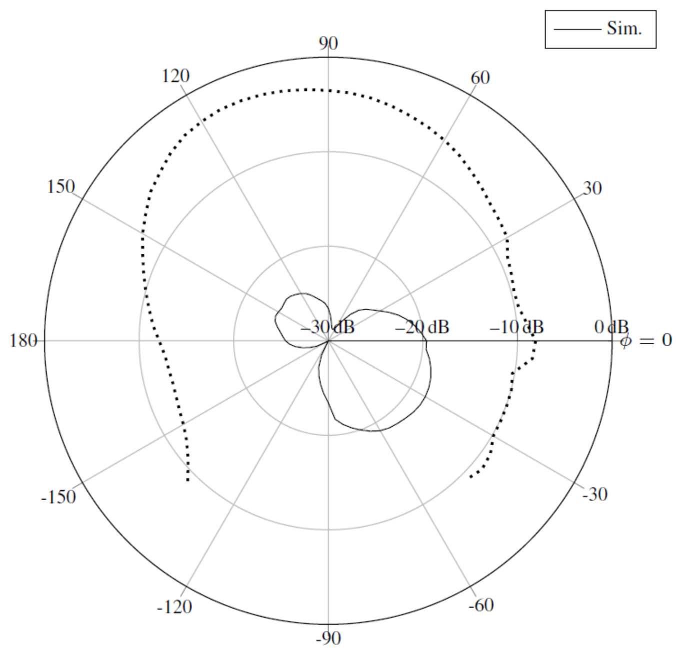
- Measured and simulated ear-to-ear path gain at 2.45 GHz of -82.1 dB and -85.9 dB, respectively.
- Well matched within the 2.45 GHz ISM band.
- Good correspondence between measurement and simulation results.

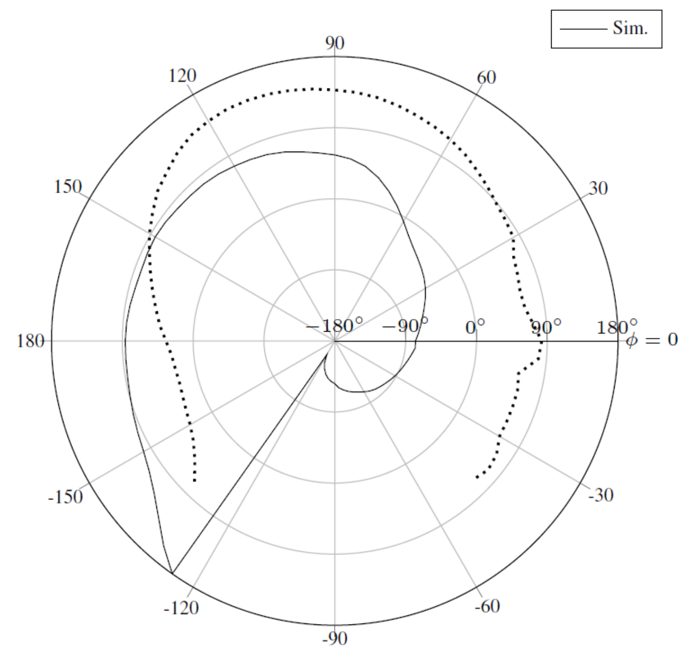




Results and Discussion 2

- The radiation pattern magnitude shows that the main part of the energy is launched in waves towards the front of the head.
- The radiation pattern phase shows that the phase can be modified by the shape of the antenna.





Conclusion

A novel ITE antenna has been designed, simulated, prototyped, and measured. It is the first ITE antenna, which is feasible to implement and yields a high enough path gain to be used with standard Bluetooth ICs. The measured and simulated E2E path gain at 2.45 GHz was -82.1 dB and - 85.9 dB, respectively. The antenna was well matched in the entire ISM band. The radiation pattern showed two lobes. The main lobe was towards the front of the head opposite to what has been observed for BTE antennas. Therefore, it is suggested that it is investigated whether the existing models of the E2E path gain can be improved. Furthermore, it was found that it is possible to modify the phase of the on-body gain for ITE antennas through the antenna design.

References

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