



## Body-Worn Spiral Monopole Antenna for On-Body Communications (Invited Paper)

Kammersgaard, Nikolaj Peter Iversen; Kvist, Søren Helstrup; Thaysen, Jesper; Jakobsen, Kaj Bjarne

*Published in:*

Journal of electromagnetic engineering and science

*Link to article, DOI:*

[10.5515/JKIEES.2015.15.4.213](https://doi.org/10.5515/JKIEES.2015.15.4.213)

*Publication date:*

2015

*Document Version*

Publisher's PDF, also known as Version of record

[Link back to DTU Orbit](#)

*Citation (APA):*

Kammersgaard, N. P. I., Kvist, S. H., Thaysen, J., & Jakobsen, K. B. (2015). Body-Worn Spiral Monopole Antenna for On-Body Communications (Invited Paper). *Journal of electromagnetic engineering and science*, 15(4), 213~218. <https://doi.org/10.5515/JKIEES.2015.15.4.213>

---

### General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

# Body-Worn Spiral Monopole Antenna for On-Body Communications

(Invited Paper)

Nikolaj P. B. Kammersgaard<sup>1,2</sup> · Søren H. Kvist<sup>2</sup> · Jesper Thaysen<sup>2</sup> · Kaj B. Jakobsen<sup>1,\*</sup>

## Abstract

A novel body-worn spiral monopole antenna is presented. The antenna consists of a ground plane and a spiral monopole. The antenna was designed for Ear-to-Ear (E2E) communication between In-the-Ear (ITE) hearing instruments at 2.45 GHz and has been simulated, prototyped, and measured. The antenna yielded a measured and simulated E2E 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.

**Key Words:** Body-Centric Communication, Creeping Waves, In-the-Ear Hearing Instruments Antenna, On-Body Path Gain, WBAN.

## I. INTRODUCTION

Body-worn antenna research for body-centric communication has increased over the last decade. Ever smaller electronics have enabled a wide range of new applications where wireless communication can be implemented. Many of these new applications have been developed for medical devices, such as hearing instruments (HIs). There is considerable interest within the HI industry in obtaining Ear-to-Ear (E2E) communication between HIs. An E2E link improves the acoustic performance of HIs as well as the usability. Besides E2E communication there is an interest in communication with both on- and off-body accessories, for example smartphones, smart watches, or TVs. By the use of the license-free and worldwide industrial, scientific, and medical (ISM) band between 2.40 GHz and 2.48 GHz both E2E and accessory communication can be obtained. At the same time it will enable communication with electronics with Bluetooth. Antennas suitable for Behind-the-Ear (BTE) HIs have been presented in the literature with an E2E path gain

of  $-52$  dB [1]. BTE HIs are located behind the ear and are mass produced whereas In-the-Ear (ITE) HIs are placed in or right outside the ear canal and are custom-made to fit the user's ear and ear canal. This makes it harder to achieve a high E2E path gain for ITE HIs. The ITE antennas that have been presented in the literature have not yielded E2E path gains significantly above  $-90$  dB [2, 3]. In the following a novel ITE antenna, which is the first to make E2E communication feasible between ITE HIs is presented. The antenna was first presented briefly in [4]. This is an augmentation of the article presented in [5].

## II. THEORY

At 2.45 GHz, the human body is very lossy [6]. Therefore, the electromagnetic energy cannot propagate through the body. It has been shown that the electromagnetic energy propagates around the human body as creeping waves instead [7]. Models for the E2E propagation channel have been presented in [8, 9].

Manuscript received October 00, 0000 ; Revised December 00 ; Accepted January 00, 0000. (ID No. 00000000-000J)

<sup>1</sup>Department of Electrical Engineering, Electromagnetic Systems, Technical University of Denmark, Kongens Lyngby, Denmark.

<sup>2</sup>GN ReSound A/S, Ballerup, Denmark.

\*Corresponding Author: Kaj B. Jakobsen (kbj@elektro.dtu.dk)

This is an Open-Access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (<http://creativecommons.org/licenses/by-nc/3.0>) which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

© Copyright The Korean Institute of Electromagnetic Engineering and Science. All Rights Reserved.