Wearable and Implantable Antennas for Wireless Body-Centric Sensing Systems

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ABSTRACT
In this poster abstract, we present recent advances on implantable and wearable antennas for wireless body-centric sensing systems. Prominent examples of such systems are the wireless brain-machine interface (BMI) system and wearable embroidered antennas. In the poster, we present more detailed simulation and measurement results.

1. INTRODUCTION
Wireless body-centric sensing systems based on mobile control units, wearable garment-integrated antennas, and miniature implant antennas, have a great demand in the fields of biomedicine, personal healthcare, and safety and security.

At the moment, establishing reliable wireless links to implants and off-body units from the on-body antennas is one of the major bottlenecks for the system performance hindering the large-scale deployment of body-centric wireless sensing systems. This is because the conventional antennas perform poorly in the proximity of dissipative body tissues and are based on structures which do not meet the requirements of wearable or implanted devices. A major challenge is also the extreme antenna miniaturization required to maintain the size of the implanted devices clinically viable.

2. WEARABLE TEXTILE ANTENNAS
For comfort and ease of use, wearable antennas need to be seamlessly integrated with regular clothing. Here the embroidery techniques and conductive fabrics provide compelling means for fabrication.

We have designed and characterized antennas created with both techniques for wearable ISO-18000 compliant passive radio-frequency identification (RFID) tags operating in the frequency range of 840-960 MHz. In our measurement a body-worn tag based on an embroidered dipole antenna achieved the read range of 4 m in the configuration shown in Fig.1. This should be sufficient in many identification applications. Moreover, we have shown that conductive fabrics can be used to form ground planes for wearable patch antennas. This is an important development, since patch antennas benefit from built-in antenna-body separation provided by the ground plane and thus achieve potentially higher read range compared with dipole-type tags. In the future, we will apply the discussed techniques for wearable antennas in wireless BMI systems, which are discussed below.

Figure 1. Wearable tag based on an embroidered antenna.

3. ANTENNAS FOR BMI SYSTEMS
Fully wireless BMI will restore the mobility and communication for people suffering from debilitating neurological conditions by enabling the direct brain-control of prosthetics and computers. For the sustained everyday use of BMI, the cortical implant needs to be battery-free. This can be achieved by utilizing communication by means of reflected power. In such systems, the remotely powered implant is a smart reflector, which resembles a passive RFID tag.

To maximize the power transmission within human safety limits (specific absorption rate; SAR) we have proposed novel transmit loop configurations to provide spread-out near electric field without compromising the power efficiency of the inductive link. We have presented a monolithic integration of 6.5×6.5 mm^2 implant loop with a grid of neural electrodes on a thin-film for wireless electrocorticography. Simulations suggested that we can achieve link power efficiency of -16.6 dB and deliver 0.48 mW to the implant at 0.38 V at 400 MHz. For more localized neural recordings, smaller implants are needed. Prompted by this need, we proposed a cubical 1 mm^3 implant antenna with a magnetic core. Simulations suggested it provides the link power efficiency of -23.3 dB (9-dB improvement compared with a planar 1 mm^2 loop) and 91 µW to the implant IC at 137 mV at 300 MHz. Fig. 2 summarizes the BMI antenna development.

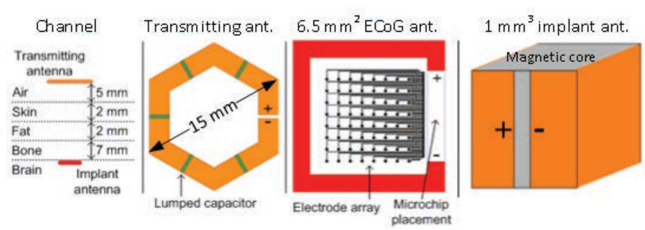

Figure 2. Antennas for BMI systems.

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