A Wireless, Fully-Passive Neurosensing System for Brain Signal Monitoring

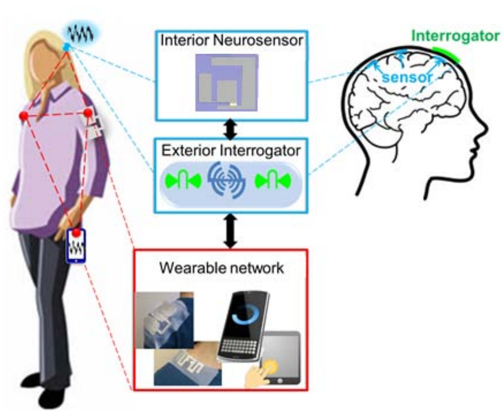
Asimina Kiourti*, Zheyu Wang, and John L. Volakis
ElectroScience Laboratory, Electrical and Computer Engineering
The Ohio State University, Columbus, Ohio 43212
Email: {kiourti.1, wang.1460, volakis.1}@osu.edu

Brain implant technology has the potential for understanding and improving human conditions, e.g. physical control restoration, early seizure detection, prosthetics control, and so on. However, development of such technology has yet to be adopted because conventional wired techniques restrict patient mobility and endanger safety, and due to excessive heating caused by the employed implant electronics. In the latter case, it is necessary to employ batteryless circuitry to suppress possible interference with neurological signals.

To address these above issues, a wireless and fully-passive neurosensing system is proposed [Schwerdet, et.al., J. Micro-Electro-Mech. Syst., pp.1119-1130, 2011]. This system consists of a neurosensor, an implant antenna matched to the sensor, an external RF interrogator antenna, and integrated RF circuits, all packaged on flexible polymer substrate. Once the sensor is activated by the external interrogator through a carrier signal at f_0 = 2.45 GHz, the implant backscatters the local field potentials (LFPs) that exist at a frequency f_m in the 10s of Hz. To increase the sensitivity of the detector, the neurological signals are mixed with the 3rd-order order harmonic ($2f_0 \pm f_m$) generated by a diode that is part of the detector's circuitry. The original LFPs (f_m) are then retrieved after post-processing within the external interrogator. Subsequently, they are re-transmitted to a self-powered body area network (BAN) for reception by a PDA, allowing for continuous real-time monitoring.

Communication between the implant and the interrogator must be guaranteed at the carrier and backscattered frequencies. For this purpose, we propose a novel dual-band (f_0, $2f_0 \pm f_m$) implanted bio-compatible antenna, placed inside the dura/gray matter of the brain. The antenna exhibits a miniature (10 mm × 10 mm) aperture that minimizes trauma, while providing good matching and gain with sufficient bandwidth to mitigate tissue variations. Another dual-band, well-matched, textile-based antenna is employed [Wang, et.al., IEEE Trans. Antennas & Propag., 2012] with the external interrogator. The BAN is also conformal and part of the clothing for inconspicuous communication at multiple frequencies (Bluetooth, WiFi, etc). That is the proposed neurosensing system is continuous and unobtrusive with minimum impact to the individuals' activity to preserve natural lifestyle and comfort for patients.

At the conference we will present an overview of the sensor and communication system, matching circuits, antenna design and link budgets for reliable communication with the implanted sensors.



Overview of the proposed wireless and fully-passive neurosensing system.