Miniaturized Fully-Passive Brain Implant for Wireless Acquisition of Low-Level Neuropotentials

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A miniaturized fully-passive brain implant is proposed (no battery, no rectifiers, no energy harvesting units), capable of wireless and inconspicuous acquisition of very low-level neuropotentials. The implant has a footprint of 9 mm × 10 mm and can detect emulated neuropotentials down to 20 μV_{pp}. This is much smaller as compared to our previous implants (C.W.L. Lee et al, IEEE Trans. Microw. Theory Techn., 63, 2060-2068, 2015), and also provides 25 times improvement over prior work (H.N. Schwerdt et al, J. Microelectromech. Syst., 20, 1119-1130, 2011). The implant sensor incorporates several innovations. Among them are a) an anti-parallel diode pair (APDP) sub-harmonic implanted mixer with high conversion efficiency, and b) a pair of highly coupled interrogator and implanted antennas.

The proposed neurosensing system consists of two sub-systems: a) the fully-passive implant placed under the skin of the human head, and b) the external interrogator placed right outside the scalp. The sensor operation is as follows: First, the external interrogator sends a carrier of 2.4 GHz to turn on the mixer within the implant. Concurrently, the electrodes within the implant detect the neural signals at f_{neuro}. Subsequently, harmonic mixing occurs to generate the signal at 4.8 GHz ± f_{neuro}. This up-converted signal is then re-transmitted back to the external interrogator and demodulated to extract f_{neuro}. It is noted that this frequency doubling via mixing between the transmitted (2.4 GHz) and received (4.8 GHz ± f_{neuro}) signals provides good isolation for proper recovery of f_{neuro}.

This is the first ever demonstration of wireless and unobtrusive reading of brain signals as low as 20 μV_{pp}. Such a low voltage detection implies reading of most neuropotentials generated by the human brain. Thus, the proposed neurosensing system creates transformational health-status monitoring possibilities for several applications (e.g., epilepsy, prosthetics control, early seizure detection, etc). At the conference, we will show the overall sensor/interrogator design and provide measured data of the system's performance.