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ANALYSIS OF EMF BY NEURO-RECORDING SYSTEM IN HUMAN BRAIN

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ABSTRACT

Neurorecording implies the recording of electrical activity produced by neurons. It involves acquiring extra cellular neuropotentials, propagating down branch like extensions of neurons and the axons. The recording and transmitting of neuro potentials wirelessly exclusive by means of electromagnetic backscattering techniques, affording substantially simpler circuitry and potentially safer and more reliable approach for implantable wireless neuro recording. In the present device design, neuropotentials modulate an externally generated carrier by means of nonlinear elements, such as varactors. The wireless measurements of emulated neuropotentials acquired by the microsystem demonstrate its promising capabilities for neurological applications. A fundamental practical barrier for wireless brain-implantable systems includes heat dissipation by on-chip circuitry, which may cause permanent brain damage. The fully passive system does not need to regulate or rectify externally generated power in order to activate onboard circuitry. As a result, sophisticated and complex circuitry is completely excluded. The measurement of wireless electromagnetic transmission schemes operating at Near infra-Red (NIR) frequencies and it directly relates to the heat generated within biological tissue media. Therefore, the heat dissipation caused by on chip circuitry is reduced.

I. INTRODUCTION

The aim of developing wireless neuro interfaces is to resolve complex challenge underlying basic understanding and treatment of the Central Nervous System (CNS). Neuro interfacing enables scientists to probe into the brain and form a direct causal link between a person’s behavior and the highly complex network of billions of neurons making up the CNS. Neurointerfacing embodies both the recording and the stimulation of neurons for closed-loop interaction with the brain.

Neuro interfacing enables scientists to probe into the brain and form a direct causal link between a person’s behavior and the highly complex network of billions of neurons making up the CNS. Neurointerfacing embodies both the recording and the stimulation of neurons for closed-loop interaction with the brain. Neurorecording implies “recording” of electrical activity produced by neurons. It involves, more specifically, acquiring extracellular action potentials, i.e., neuropotentials, propagating down branchlike extensions of neurons, the axons. When the neuropotentials are acquired from the brain’s outermost layer, the cerebral cortex, the potentials are denoted as Electrocorticographic (ECG) signals.

The ECG signals typically are on the order of several microvolts and within a few hertz to thousands of hertz and are correlated with the most active region of the brain. Early-stage clinical applications of cortical Neurorecording systems have revealed important discoveries in the field of neuroscience and neurology and also manifested into important prosthetic and rehabilitative remedies for patients suffering from a range of disabilities rooted in the CNS. neurorecorder attempts to address these requirements through a design of microelectromechanical systems—based on a fully passive circuit capable of wireless telemetry of neuropotentials. Wireless neurorecording microsystems typically comprise microelectrodes to probe the neurons, complex circuitry to amplify the substantially low neuropotentials and to process and prepare these signals for wireless telemetry, and a wireless link (antenna or inductive coil) to transmit the neuropotential signals.

II. METHODOLOGY

Wireless neurorecording microsystems typically comprise microelectrodes to probe the neurons, complex circuitry to amplify the substantially low neuropotentials and to process and prepare these signals for wireless telemetry, and a wireless link (antenna or inductive coil) to transmit the neuropotential signals. The integrity of neuropotential recording and wireless transmission commonly necessitates sophisticated mixed-signal circuitry. However, the level of circuit complexity is multiplied for multichannel operation, and neural applications often require dozens to hundreds of channels. Furthermore, the number of channels is directly correlated to the amount of power consumption, which, in turn, determines the degree of heat dissipation.

The mode in which wireless transmission is realized in implantable microsystems may be distinguished by three categories:

1. Active systems
2. Passive systems
3. Fully passive systems

Active systems contain an internal energy source, a small rechargeable battery or energy harvester, which supplies all of the power needed to operate enclosed circuitry. However, in terms of implantable systems, several drawbacks are immediately apparent: The internal energy source increases the overall size of the implant, batteries will need to be recharged or replaced, and energy harvesting sources usually require additional power regulation circuitry that again enlarges the implant size.

COMPONENTS OF WIRELESS NEURORECORDING SYSTEM

The wireless neurorecording system consists of two components:

1. The neurorecording and backscattering microsystem.
2. The external dual-band interrogator.

NEURORECORDING AND BACKSCATTERING MICROSYSTEM

A passive harmonic mixer frames the basic operation of the neurorecording and backscattering microsystem. This mixer inputs the neuropotential signals and incident microwaves at the intermediate frequency (IF) port and local oscillator (LO) port, respectively. The mixer combines these two signals (fm at IF and f0 at LO) and upconverts them to 2f0 ± fm, at the RF port. The third-order intermodulation products 2f0 ± fm are wirelessly backscattered to the external interrogator in the form of amplitude modulated transmission where they are downconverted and demodulated.

A more straightforward mixing scheme may be applied to generate the first harmonics f0 ± fm. However, neuropotentials occupy a low-frequency spectrum between 1 Hz to several kilohertz (IF) and are typically on the order of several tens of microvolts in amplitude (Vm). The incident microwaves (LO), on the other hand, are relatively higher in magnitude in comparison to the IF/RF signals. Unlike magnetic fluxes, as associated with inductive coupling, EM waves physically reflect from surrounding surfaces, including the interfaces between different biological media.

These structural reflections manifest into electrical noise, causing interference and desensitization particularly near the LO band (f0). Therefore, it is preferable to separate the neuropotential signals from these strong reflections by transmitting the information using higher order mixing products. Details on the microsystem's mixing and backscattering of third-order harmonics are laid out in the following sections.

The on-chip antenna acts as both the LO and RF interfaces for the mixer, while the neuroprobe acts as the IF port. The bypass capacitor decouples the RF and LO signals from the IF port, effectively short circuiting the neuroprobe at high frequencies. The antenna itself has a near-zero impedance at dc, which effectively short circuits the radiation ports at low frequencies. The antenna is implemented as a capacitively loaded slot antenna to allow proper optimization of its impedance at LO and RF frequencies. A layout of the entire microsystem less the loading capacitors, varactors, and bypass capacitor was produced and simulated in High Frequency Structure Simulator (HFSS, Ansoft Corporation). The result is incorporated into a schematic circuit model including the varactors, bypass capacitor, and parasitic elements.

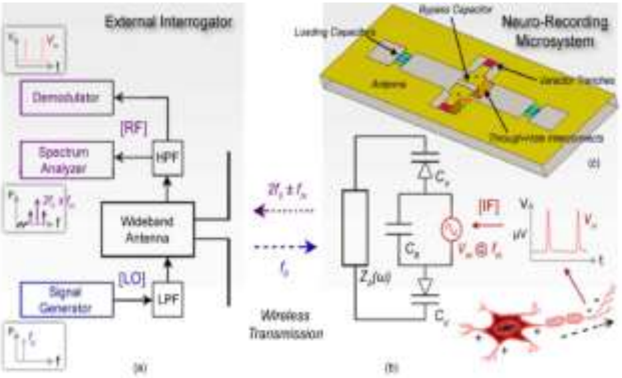


Fig.2.1 Overview of Wireless Fully Passive Neurorecording System.

This circuit model can be analyzed in Advanced Design System (ADS, Agilent Technologies) environment using harmonic balance simulations to verify generation of targeted harmonic mixing products (2f0 ± fm). Parameters of the dielectric films, substrate, antenna, and biological media were included in the HFSS model, which solves Maxwell's equations in the structure using finite-element method.

This simulation produced s-parameters at the IF port (feed through electrodes), a pair of varactor ports (trench pads for mounting varactors and connection to antenna), a pair of loading metal–insulator–metal (MIM) capacitor ports (across antenna slot), and the LO and RF port (the latter two designated as a single wave port above the surface of the modeled scalp), which were then imported back into the ADS schematic environment to optimize the value of the loading capacitors for In fig. 2.1 (c) Layout of the neurorecording microsystem. The on-chip planar slot antenna is loaded by the capacitors located at both ends of the slot. The bypass capacitor and varactors on the topside interface directly with the neuropotentials on the backside via through-hole interconnects.

EXTERNAL DUAL-BAND INTERROGATOR

The external dual-band interrogator utilizes a linearly tapered slot antenna (LTSA) to support the wireless system’s wideband characteristics. The LTSA was designed in HFSS to optimize the antenna’s efficiency to sufficiently radiate EM energy at LO (f0) and receive the backscattering signals at RF. As shown in Fig. 2.2 a, the return loss (S(1,1)) is greater than 7 dB for 2.3 to 2.7 GHz and 4.6 to 5.5 GHz denoting less than 1 dB mismatch loss in either transmit or receive links when the interrogator operates at the fundamental incident frequency of 2.3 to 2.7 GHz.

The mismatch effect is minimal for the interrogator operating at 2.45 to 2.6 GHz. In order to isolate transmit and receive channels, the LTSA is connected to a diplexer stage, comprising a low pass filter (LPF) operating in the incident frequency band (transmitter, f_0) and a high pass filter (HPF) operating in the backscatter frequency band (receiver, $2f_0 \pm f_m$).

The response characteristics for the diplexer filters as simulated in ADS Momentum are shown in Fig. 2.2 b, depicting a passband roughly extending from 2.0 to 3.0 GHz for the LO port and 4.25 to 5.5 GHz for the RF port, with greater than 60 dB isolation between the two ports. The layouts for the LTSA and diplexer were combined in ADS, as shown in 2.3. The LTSA and diplexer were milled on Rogers Duroid 5880 (0.020 inches, ½ oz. / sqft. rolled copper) substrate.

Nodes located close to each other have correlated data. All nodes begin with the same amount of energy capacity in each election round, assuming that being a CH consumes approximately the same amount of energy for each node.

Carrier frequency offset causes a number of impairments including attenuation and rotation of each of the subcarriers and intercarrier interference (ICI) between subcarriers. In the mobile radio environment, the relative movement between transmitter and receiver causes doppler frequency shifts, in addition, the carriers can never be perfectly synchronized. These random frequency errors in OFDM system distort orthogonality between subcarriers and thus intercarrier interference (ICI) occurs. A Number of methods have been developed to reduce this sensitivity to frequency offset.

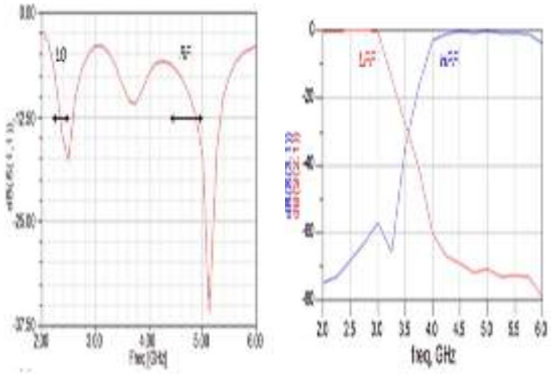


Fig. 2.2 External Dual Band Interrogator

II.PROPOSED SYSTEM

To overcome the heat dissipation problem Wireless neuro reording system is designed using Near Infra Red Sensor. Block Diagram of wireless neuro recording system using Near Infra Red Sensor is shown in fig. 3.1. The carrier signal generated by the signal generator is given to low pass filter. Low pass filter allows the low frequency component and the infrared signal is fed to the human brain which consist of numerous neuro cells. This carrier signal is then added with the EMF signal in the brain. This resultant signal is sensed by the NIR sensor and it is filtered and manipulated by the signal conditioner.

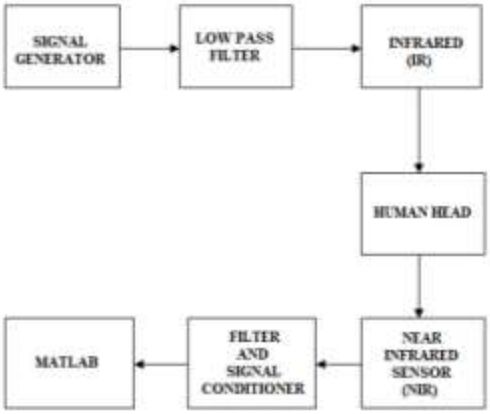


Fig. Wireless Neuro Recording System using Near Infra-Red Sensor.

III.RESULT

MATLAB is a software package for doing numerical computation. It was originally designed for solving linear algebra type problems using matrices. Its name is derived from MATrix LABoratory. MATLAB has since been expanded and now has built-in functions for solving problems requiring data analysis, signal processing, optimization, and several other types of scientific computations. It also contains functions for 2-D and 3-D graphics and animation.

SIMULATION RESULTS

NORMAL PERSON

Neuro analysis of a normal person is shown in the Fig.

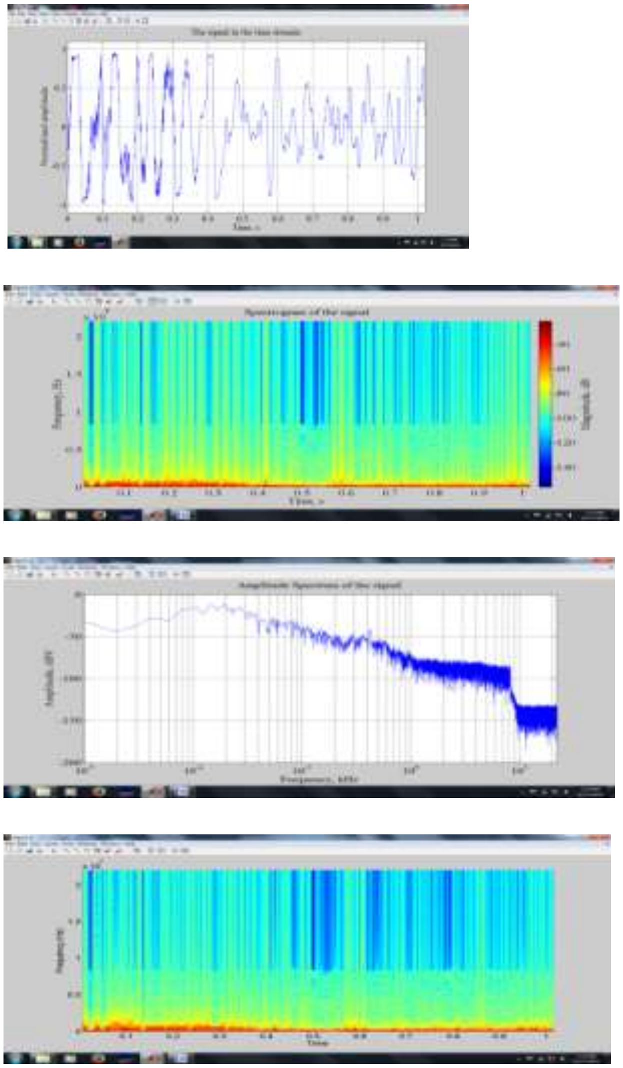
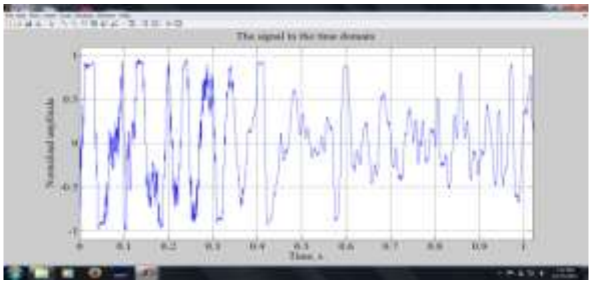


Fig. Neuro Analysis of a Normal Person.

WHEEZING

Neuro analysis of a person suffering in wheezing is shown in the Fig.



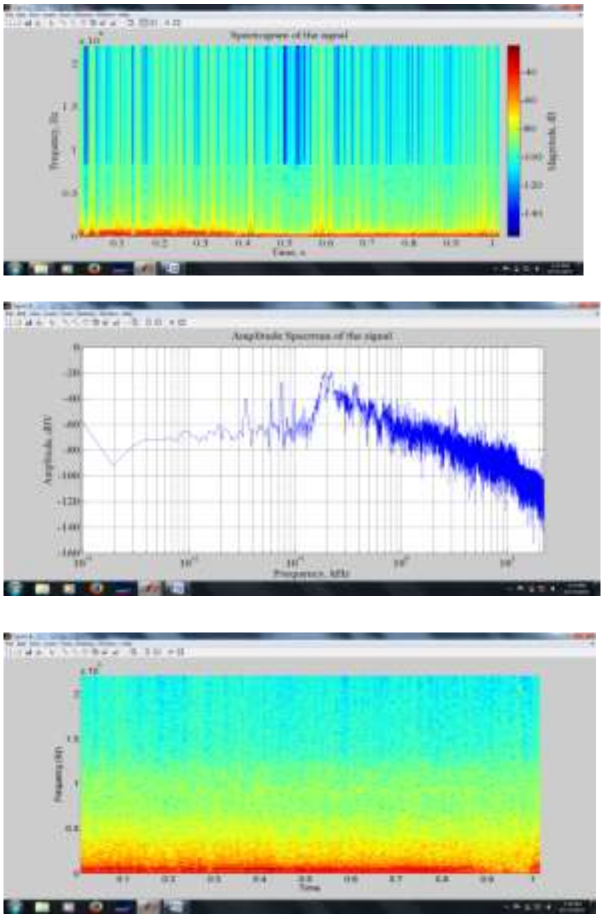
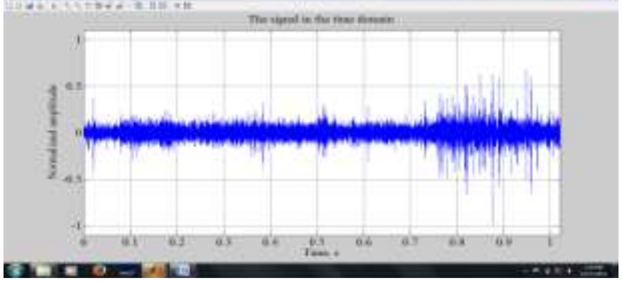


Fig. Neuro Analysis of a Person Suffering in Weezing.

COLD

Neuro analysis of a person suffering in cold is shown in the Fig.



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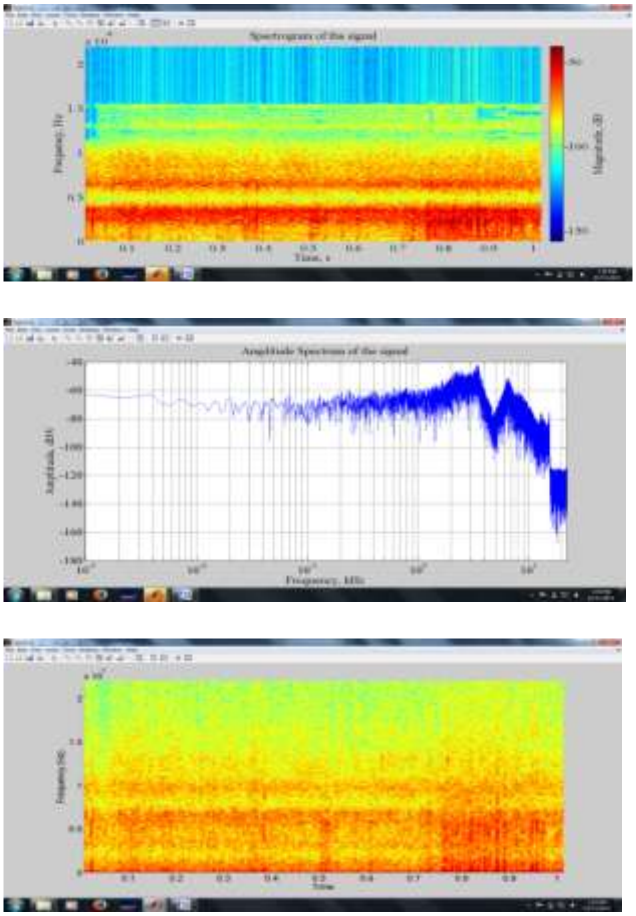
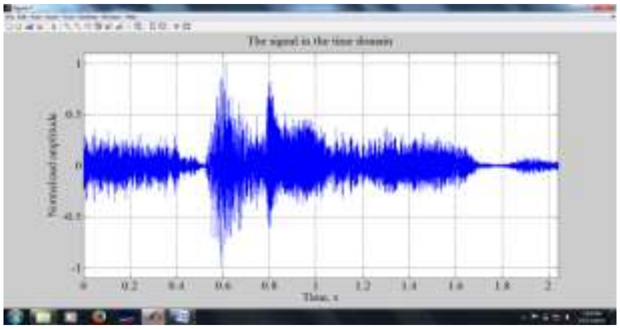


Fig. Neuro Analysis of a Person Suffering in Cold

ASTHMA

Neuro analysis of a person suffering in asthma is shown in the Fig.



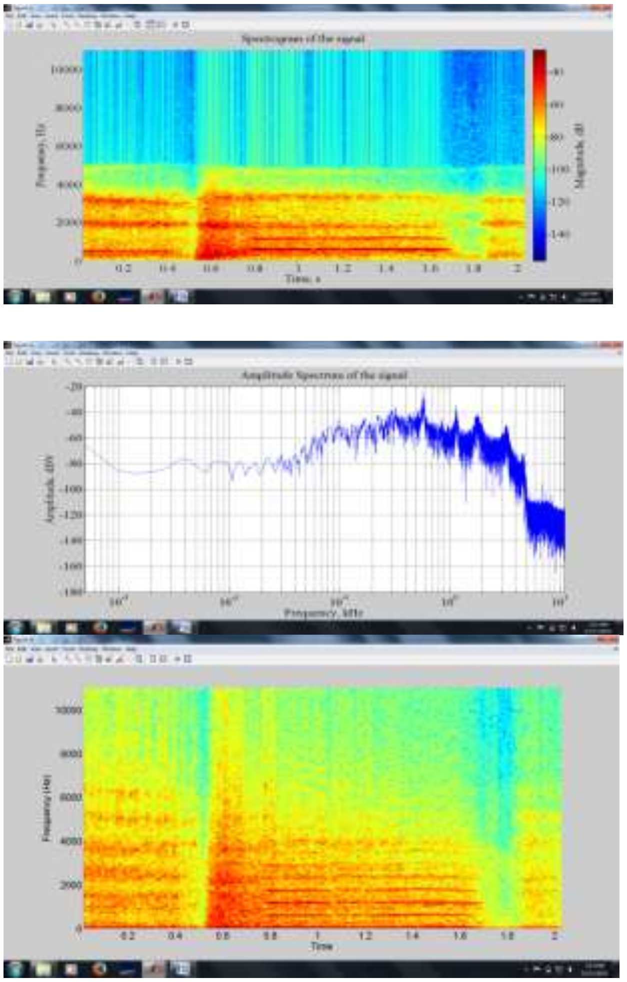
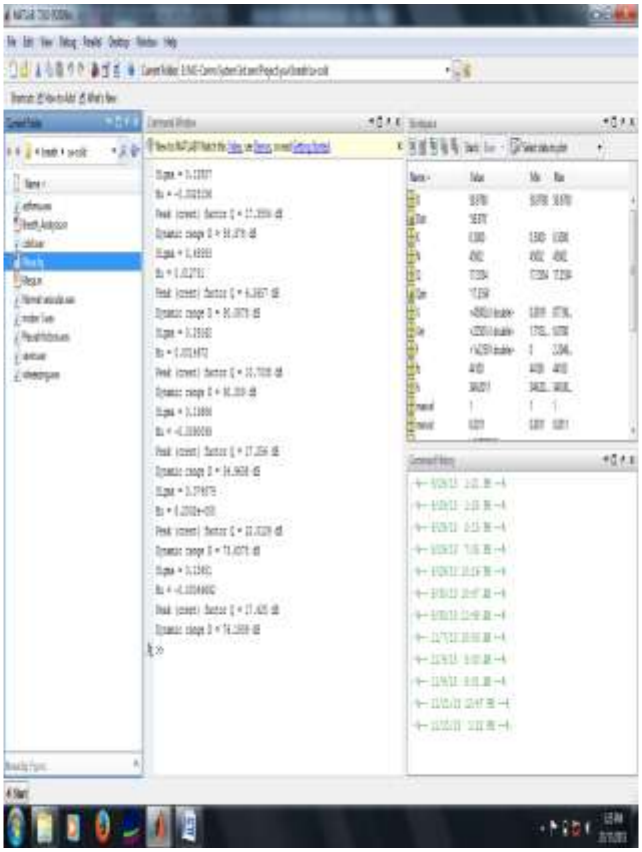


Fig. Neuro Analysis of a Person Suffering in Asthma.

PARAMETERS MEASUREMENTS

Various parameters such as sigma, mu, peak factor and dynamic range are measured during the neuro analysis of a person suffering in various problems are shown in Fig.



III. CONCLUSION

The fabricated microsystem has demonstrated the ability to wirelessly acquire neuropotentials in an entirely passive manner by way of microwave backscattering. The neurorecording microsystem prototype reported in this paper has displayed a sensitivity closer to a few millivolts, still an order ofmagnitude lower than that needed for typical cortically derived europotentials (approximately tens to hundreds of microvolts). The spectral response, on the other hand, is not limited by typical bioamplifier design characteristics and extends from near dc to apparently hundreds of kilohertz. Thus, its bandwidth easily accommodates the characteristic frequency range of cerebral neuropotentials (10 Hz to 3 kHz). At this stage, the sensitivity and size of the microsystem are the main challenges in deploying the microsystem for practical use in cerebral recording. Future work will focus on increasing the sensitivity and decreasing the size of the microsystem so that it may be deployed in cortical applications. One approach to enhancing sensitivity is to decrease noise, most likely due to external source coupling. Because the simplicity of the microsystem relies on its fully passive modality and its few components, it is likely that further noise suppression must be addressed in the design of the external receiver system. The sensitivity of the microsystem might be improved further by optimizing the design of the mixer by utilizing varactors with stronger nonlinearities to augment the modulation by neuropotentials in the generation of third-order harmonics. Furthermore, its footprint may be reduced by fabrication of a monolithic microsystem, free of any peripheral off-chip components, through deposition of ferroelectric films possessing similar nonlinear properties to varactor components.

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