Guest Editorial RF and Communication Technologies for Wireless IMPLANTS

THIS special issue includes seven interesting articles that tackle some of the existing challenges and design issues related to the use of RF and Communication Technologies for wireless implants. An in-body medical device is a miniature device that is inserted in the human body to collect physiological signals and images or to act like a prosthetic device restoring certain body functions. In order for these devices to communicate with the external world, radio frequency (RF) wireless technologies are often used to maintain their operation for a longer period of time. This is achieved by integrating wireless communication technologies within these devices. In some situations, a body worn device is used to receive the medical information from the devices in the human body and then transmit to remote stations for remote medical monitoring.

The attempt to insert electronic devices inside the human body started more than 50 years ago, aimed at understanding biological activities with recording the electrocardiogram, pressure and temperature for medical diagnosis [1]–[4]. Recent advances in micro-electro-mechanical systems and low-power integrated circuit technology have enabled the design of complex in-body devices. There are several commercial in-body medical devices already used in the clinical settings for diagnosis of diseases. Some of the current examples are pacemakers, implantable cardioverter-defibrillators, wireless endoscopes, wireless neural implants, cochlear and retinal implants. These devices have improved the quality of life for many patients. Currently, researchers are working to add new features with help of advanced nano- and micro-technologies. New sensing mechanisms, advanced wireless telemetry links, and low-power RF building blocks are still required to enable high performance and better diagnostic capabilities for better healthcare applications. However, size constraints present a significant problem when designing such links. New developments also consider wireless energy mechanism to provide power supply for wireless implants operating within the body.

This special issue has received 19 submissions. After rigorous review, seven has been selected to cover the recent research activities related to wireless implants and their operation in the human body.

The paper by Bat *et al.* “A 0.33nJ/bit IEEE802.15.6 /proprietary MICS/ISM wireless transceiver with scalable data rate for medical implantable applications,” presents a CMOS configurable wireless transceiver designed to operate at the 402–405 MHz Medical Implant Communication Service (MICS) band as well as at the 420–450 MHz Industrial, Scientific, and Medical (ISM) band. They demonstrated a complete implant system using this transceiver in the paper in order to be compliant with the newly established IEEE 802.15.6 standard [5].

Wireless neural recording from a large group of neurons simultaneously requires a high-data rate wireless telemetry link. In “Wireless gigabit data telemetry for large-scale neural recording” Kuan *et al.* address the design issues of such a high data-rate biotelemetry system and present a wireless gigabit data link for high-density neural recording implants using a 60-GHz wireless link.

The paper by Xiao *et al.*, “An implantable RFID sensor tag for continuous glucose monitoring” presents a wirelessly powered implantable sensor tag for continuous blood glucose monitoring with a dimension of 5 mm $\times$ 17 mm. The proposed tag achieves a glucose range of 0–30 mM with a sensitivity of 0.75 nA/mM.

Two papers “In-body to on-body ultra wideband propagation model derived from measurements in living animals” and “Experimental path loss models for in-body communications within 2.36–2.5 GHz,” evaluate signal propagation in the body using the communication systems of ultra-wide band and 2.4 GHz link, respectively. The first paper by Floor *et al.* characterizes the UWB channel on two living porcine subjects. A path loss model for a frequency range of 1–6 GHz is developed for a propagation distance of 5–16 cm. The paper by Chávez-Santiago *et al.* studies the propagation of the frequency bands of 2360–2400 MHz, which is considered for wearable body area network nodes, and the ISM band of 2400–2483.5 MHz. The paper characterises the path loss in-body channel scenarios showing that wireless links utilising 2.36–2.5 GHz band are feasible for implantable biomedical devices.

The paper by Rigelsford *et al.* “Passive biodegradable implant for subcutaneous soft tissue trauma monitoring,” describes a system that can monitor the healing of soft tissue trauma and diagnosis of infection using an implantable tag. The tag is biodegradable and its electrical length increases due to degradation, as a result the resonant frequency changes which can be detected from outside the patient body.

Finally, the paper by Jegadeesan *et al.*, “Enabling wireless powering and telemetry for neural implants,” discusses wireless power delivery schemes for the implant devices. It outlines efficient wireless power and data link schemes for the peripheral nerve recording and stimulation implants with their design requirements and safety analysis. A preliminary wireless platform has been tested in rats achieving a power delivery of 100 mW and data telemetry at 4.8 kb/s.

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