Guest Editorial
Selected Papers From the 2018 IEEE International Solid-State Circuits Conference

THE IEEE International Solid-State Circuits Conference (ISSCC) is the flagship conference of the IEEE Solid-State Circuits Society and the foremost global forum for presenting advances in solid-state circuits and systems-on-a-chip. From 2010–2017, the IEEE TRANSACTIONS ON BIOMEDICAL CIRCUITS AND SYSTEMS has highlighted selected papers from ISSCC on topics related to biological and healthcare applications. This special section features five selected papers from ISSCC 2018, held in San Francisco, California, USA from February 11 to February 15, 2018.

This set of papers offers a sample of the rapidly expanding developments in solid-state circuits for health monitoring, therapeutics, diagnostics, and medical research applications. The selection of these papers, whose final decision was based on a thorough peer review process, was coordinated with the IEEE JOURNAL OF SOLID-STATE CIRCUITS (JSSC), to avoid overlap with its ISSCC 2018 special issue, which includes biomedical papers as well. We acknowledge the ISSCC 2018 General Chair, Prof. Anantha Chandrakasan, and the Editor-in-Chief of the IEEE TRANSACTIONS ON BIOMEDICAL CIRCUITS AND SYSTEMS, Prof. Mohamad Sawan, for their support.

The paper by Lee *et al.* from KAIST entitled "A Low-power Photoplethysmogram-based Heart Rate Sensor using Heartbeat Locked Loop" describes the implementation of a novel ultra-low power heart rate sensor based on the principle of photoplethysmography (PPG). The paper describes a heartbeat locked loop (HBLL) synchronised to the peak of the PPG waveform, which generates a narrow window that turns on the LED and analog-front-end only when a peak is expected in the PPG signal. The prototype PPG sensor implemented in 0.18 μm CMOS has an effective duty-cycle of 0.01% and consumes only 43.4 μW at a heart rate of 60 bpm. The error of the proposed sensor is less than 2.1 bpm for heart rates below 180 bpm.

The paper by Stanslaski *et al.* from Medtronic, Mayo Clinic, University of Florida, and University of Oxford entitled "A Chronically-Implantable Neural Coprocessor for Investigating the Treatment of Neurological Disorders" presents a new implantable electronic medical device that is flexible and configurable in its functions, for better understanding and more effective treatments of disorders of the nervous system. The device includes five custom integrated circuits required for bi-directional neural interfacing, the supporting firmware/software ecosystem, and the verification and validation activities to prepare for human implantation. A number of design aspects are discussed in more detail, including enhanced sensing-stimulation performance for improved bidirectional communication to the nervous system, implementation of rechargeable technology to extend device longevity, and application of MICS-band telemetry for algorithm development and data management.

The paper by Jung *et al.* from Georgia Institute of Technology, Kennesaw State University, Impinj Inc, and the University of Leeds entitled "A Reduced-Wire ICE Catheter ASIC with TX Beamforming and RX Time-Division Multiplexing" presents a single-chip reduced-wire active catheter application-specific integrated circuit (ASIC), equipped with programmable transmit (TX) beamforming and receive (RX) time-division multiplexing (TDM). The ASIC is designed to drive a 64-channel 1D transducer array in intracardiac echocardiography (ICE) ultrasound catheter and is implemented in 60 V 0.18-μm HV-BCD technology. The chip layout is designed to a footprint of 2.6×11 mm^2 enabling it to fit in a catheter of <3 mm diameter. The proposed system reduces the number of wires from >64 to only 22 by integrating a TX beamformer, which is programmable using a single low-voltage differential signalling (LVDS) data line. In RX mode, the system uses 8:1 TDM with direct digital de-multiplexing, providing raw channel data, which enables dynamic RX beamforming using individual array elements. The system has been successfully used for B-mode imaging on a standard ultrasound phantom with 401 mW of average power consumption. The ASIC has a compact element pitch-matched layout, which is also compatible with capacitive micromachined ultrasound transducer (CMUT)-on-CMOS application. This system addresses cable number and dimensional restrictions in catheters to enable ICE imaging under magnetic resonance imaging (MRI) by reducing radio-frequency (RF)-induced heating.

The paper by Lee *et al.* from Cornell University entitled "A 250 μm $\times$ 57 μm Microscale Opto-Electronically Transduced Electrodes (MOTEs) for Neural Recording" is aimed at recording neural activity in live animals *in vivo* with minimal tissue damage for understanding the nervous system. They present a new device for tetherless optoelectronic neural interfacing implemented in 180 nm CMOS, and heterogeneously integrated with an AlGaAs diode that functions as both a photovoltaic and light-emitting diode. These microscale optoelectrically transduced electrodes (MOTEs) are powered by and communicate through an optical interface to enable high temporal resolution

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electrical measurements without a tether or a bulky RF coil. The size of MOTE presented in this paper is 250 μm × 57 μm, and it consumes 1 μW while capturing and encoding neural signals before transmission.

The paper by Xu *et al.* from imec entitled "A 665 μW Silicon Photomultiplier-Based NIRS/EEG/EIT Monitoring ASIC for Wearable Functional Brain Imaging" presents a sub-mW ASIC for multimodal, low-cost, functional brain imaging. The ASIC is co-integrated with electrodes and optodes as an active sensor to measure electroencephalography (EEG), bio-impedance (BioZ), and near infrared spectroscopy (NIRS) on scalp. The proposed NIRS readout utilizing near infrared light can be used to measure pulse oximetry and blood oxygen saturation levels (SpO_2). While traditional photodiodes are supported, the readout also allows the use of silicon photomultipliers (SiPMs) as optical detectors. The SiPM improves optical sensitivity while significantly reducing the average power of two LEDs to 150 μW. At the circuit level, a SAR-based calibration scheme compensates maximum 40 μA current from ambient light, while digital dc-servo loops reduce the baseline static SiPM current up to 400 μA, leading to an overall dynamic range of 87 dB. When EEG, BioZ and NIRS are enabled at the same time, one ASIC consumes 665 μW including the power of LEDs.

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Dr. Mohseni has been an Associate Editor for several IEEE journals since 2008, as well as a member of the Technical Program Committee of the IEEE RFIC Symposium (2012–2015), CICC (2012–present), and ISSCC (2017–present). He was a recipient of several awards including the National Science Foundation CAREER Award in 2009, Case School of Engineering Research Award in 2011, first-place prize of the Medical Device Entrepreneur's Forum at the 58th annual conference of the ASAIO in 2012, and EECS Mihajlo "Mike" Mesarovic Award for Extraordinary Impact in 2013. He has been a member of the IEEE Solid-State Circuits, Circuits and Systems, and Engineering in Medicine and Biology Societies, as well as the administrative committee of the IEEE Sensors Council (2014–2017). He was the General Co-Chair of the 2018 IEEE Biomedical Circuits and Systems (BioCAS) Conference, Cleveland, OH, USA.

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Dr. Genov is a co-recipient of the Jack Kilby Award for Outstanding Student Paper at the IEEE International Solid-State Circuits Conference, Best Paper Award of the IEEE Transactions on Biomedical Circuits And Systems, Best Paper Award of IEEE Biomedical Circuits and Systems Conference, Best Student Paper Award of IEEE International Symposium on Circuits and Systems, Best Paper Award of IEEE Circuits and Systems Society Sensory Systems Technical Committee, Brian L. Barge Award for Excellence in Microsystems Integration, MEMSCAP Microsystems Design Award, DALSA Corporation Award for Excellence in Microsystems Innovation, and Canadian Institutes of Health Research Next Generation Award. He was a Technical Program Co-Chair at the IEEE Biomedical Circuits and Systems Conference and a member of IEEE International Solid-State Circuits Conference International Program Committee. He was also an Associate Editor for the IEEE TRANSACTIONS ON CIRCUITS AND SYSTEMS-II: EXPRESS BRIEFS and IEEE SIGNAL PROCESSING LETTERS, as well as a Guest Editor for the IEEE JOURNAL OF SOLID-STATE CIRCUITS. He is currently an Associate Editor for the IEEE TRANSACTIONS ON BIOMEDICAL CIRCUITS AND SYSTEMS and a member of IEEE European Solid-State Circuits Conference Technical Program Committee.