

SE1: Healthy Radios: Radio & Microwave Devices for the Health Sciences

Co-Organizer/Chair:
Co-Organizer

Jacques C. Rudell, University of Washington, Seattle, WA
Ali Hajimiri, Caltech, Pasadena, CA



More than a century ago, Guglielmo Marconi made the first transatlantic radio transmission which forever changed the way people exchange information with one another. Scientist and engineers have spent the better part of the last century developing more efficient radio circuits, systems and software for wireless communication. Recently, the scientific community has begun exploring the use of radio-frequency circuits for bio-medical applications. These "Healthy Radios" can be categorized into two sub-topics. The first is the use of radios to communicate sensed information from the human body to the outside world. The second is the use of traditional radio circuits for medical analysis. The first two speakers in the "Healthy Radios" session will explore using radio circuits for biomedical sensing and diagnosis, such as early-cancer detection and Protein and DNA analysis. The next two speakers will describe current work on communication with radios links for body area networks (BAN) and implantable devices. This session will conclude with an overview on the state-of-the-art in CMOS medical imaging.

Panelists Statements**CMOS RF Biosensor Utilizing Nuclear Spin Resonance – An RF Designer's Approach to Early Cancer Detection**

Donhee Ham, Harvard University, Cambridge, MA

I will present our recent work that showcases how silicon RF chips can be used not only for wireless applications, but also for biosensing aimed at early cancer detection in direct interface with biological systems. The main function of our RF chip is to manipulate and monitor RF dynamics of protons in water via nuclear magnetic resonance (NMR). Target biological objects such as cancer marker proteins alter the motions of protons, which is the basis for our biosensing. The RF chip has a noise figure of 0.6 dB. This high sensitivity made possible our construction of an entire NMR system around the RF chip in a 2-kg portable platform, which is 60 times lighter, yet 60 times more sensitive than a state-of-the-art commercial benchtop NMR system. With abilities to sense one protein molecule in 40 trillion water molecules, and to detect various cancer markers, this work is a circuit designer's approach to pursue early cancer detection and improved human healthcare.

**Wireless Telemetry Plays a Significant Role in Orchestrated Care: Concerto™/Virtuoso™ with MICS Frequency Band**

Javad Masoud, Medtronic, Minneapolis, MN

Advancements in radio technology have led to innovations in implantable medical devices. These innovations have redefined the management of chronic diseases including heart disease, diabetes, neurological disorders, spinal conditions and vascular disease. Wireless medical devices have the ability to deliver therapies that improve millions of lives worldwide each year and provide greater freedom to enjoy life. The radio frequency technology permits communication between external instruments and implanted medical devices over distances of several meters, making an array of potential benefits to clinicians and patients alike. The Medical Implant Communications Service (MICS) frequency band allows optimal operation in clinics and operating rooms. The wireless telemetry system allows transmission of patient data remotely and automatically to physicians using distance wireless telemetry, enabling better patient care.

**Integrated Radio-Frequency Biosensors for POC Applications**

Ali Hajimiri, Caltech, Pasadena, CA

Future Point-of-Care (POC) microarray diagnostic systems require advanced bio-molecular sensing schemes that can achieve high sensitivity and hand-held portability at battery-level power consumption all within a very-low price-tag. This type of system is anticipated to open the door for a variety of new applications such as medical diagnostic, early cancer detection, biological agent detection, military support, environmental monitoring, epidemic disease control, forensic analysis, etc., which are believed to boost the current microarray annual revenue to over \$5B dollars in year 2010. Traditional sensing techniques are bulky, expensive, and slow. Thus, RF techniques for detection of small biological matter offer attractive alternative solutions to overcome these challenges. We will discuss such techniques as ways to replace the existing conventional microarrays biosensors and to eliminate the bulky external elements leading to highly scalable low-cost handheld biosensing devices.

**Medical Imaging: RF Radio Design to the Rescue**

Kris Iniewski, CMOS Emerging Technologies,

Vancouver, BC, Canada

Equipment for medical imaging modalities that encompasses X-ray, CT, ultrasound, MRI and nuclear medicine (SPECT/PET) is a \$30B market that so far has been largely ignored by IC design community. Even larger opportunities exist in imaging equipment at molecular level that are estimated to be around \$100B. Imaging biological processes at the molecular level promises great advances in disease detection and drug development. Today, RF radios are used in MRI while low noise amplifiers and ADCs are used virtually in all medical imaging circuits. However, integrating tens of thousands of imaging channels/pixels in one chip is still not possible due to excessive power dissipation levels. The talk highlights some opportunities in using RF design techniques and smart signal processing in order to achieve required density and power targets.

**BANning Low Power Radio Design**

Brian P. Otis, University of Washington, Seattle

Research in body area network design will allow the communication of valuable health monitoring data for diagnostics and closed-loop control. It will also reveal numerous as yet unsolved problems in radio design. Miniaturization and power concerns, already important considerations in portable radio design, are amplified in emerging BAN diagnostic applications. The jury is still out on the best way of designing body-worn radios: UWB? Narrowband? MEMS-assisted? Additionally, the security concerns involved in deploying a network of low power minimalist radios transmitting highly personal information are immense. All of these issues must be tackled to meet one of the great emerging grand-challenges: integration of a self-powered transceiver onto a contact lens to perform on-eye display and sensing. A contact lens-mounted radio requires completely thin-film integration and unprecedented low levels of peak/average power dissipation. We'll discuss current research status in the BAN space and describe future challenges.