RF Integrated Circuits for Medical Applications: Meeting the Challenge of Ultra Low Power Communication

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Abstract

The development of medical devices has evolved in concert with the development of integrated circuit over the last 30 years. Circuit technology has facilitated the evolution of medical devices and the burgeoning health costs of increasingly affluent populations have created a large demand for the new technology medical devices.

Of the three categories of medical devices, implanted, in-vitro and external, the first is the most challenging in terms of power consumption. Implanted medical devices include *stimulatory devices* such as pacemakers, implantable cardioverter defibrillators, neurostimulators and cochlea implants and *measurement or control devices* such as drug infusion, implanted diagnostic sensors and the very rapidly growing implanted diabetes monitor.

Despite the performance afforded by modern IC technology, electronic systems associated with implanted medical applications present formidable low power design challenges. For example, most implanted pacemakers have lifetime requirements of greater than 7 years with maximum current drains of the order of 10-20 uA. The communication systems are budgeted at total currents averaged over the device lifetime of no more than about 15% of the total power budget or 2-3 uA due to the current consumption demands of supporting pacing therapy.

Receivers in implanted medical systems must sniff (or sense) periodically for the presence of an external communication device and conserve power by remaining off in a very low power state when not sniffing. To save power, the time between sniffs should be as long as possible, but this is typically limited to 1-10 seconds due to application considerations such as the need for delivering therapy.

More generally, the principles of duty-cycling and receiver sniffing are basic concepts that are applicable to numerous low power systems. Many applications such as industrial sensors (especially in hostile or difficult environments), security systems and tracking systems require very low power consumption. Existing protocols such as Zigbee, Bluetooth and 802.11 do not have very low power sniffing mechanisms that support these low duty cycle applications.

The proposed presentation will include a brief history of medical telemetry along with a summary of the key design challenges for these very low power high reliability applications. The key concepts and circuit elements are usable in other domains that require similar low power consumption. This is becoming increasingly important with the very rapid growth of short-range wireless sensors in which battery power consumption is important.

Three examples of medical transceivers, one for each of the implanted, in-vitro and external categories, will be provided:

• An ultra-low power RF communication IC designed specifically for implanted medical applications in the 402-405 MHz MICA band, but that can also be used in the 433 MHz ISM band.

• An ultra-low power video transmitter for the Given Imaging swallowable camera-capsule that has revolutionized endoscopic imaging.

• A 2mW, 800-960 MHz ultra-low power audio transceiver for hearing applications, also suitable for wide range of wireless sensor applications.

Brief Description of Presentation

The presentation will essentially present the material as outlined in the abstract with the following key areas addressed

- History of Medical Telemetry and recent changes
- Review of medical implant application, challenges and requirements
- Solutions to low power challenges
- Presentation of examples of design solutions
- Ultra-Low Power implantable transceiver
- Given Imaging swallowable camera-capsule for endoscopic imaging
- Ultra-Low Power Audio Transceiver for hearing applications

Presenters Profile

Didier Sagan received the Engineer Diploma (M.Sc.equivalent) in Electronic Engineering in 1993 from the Ecole National Superieure d'Electronique et de ses Applications (ENSEA), Cergy-Pontoise, France. He received a DESS CAAE (MBA equivalent) from the University of Lyon III, France in 1994.

He has worked for GEC Plessey Semiconductor in Plymouth, UK from 1996 to 1999, first as a designer of on chip custom memories and then as an analog designer. He was principally involved in the design of analog-to-digital converters (ADC) and digital-to-analog converters (DAC).

Since 2000, he has been with Zarlink Semiconductor in San Diego, USA. Until 2003 he was an analog designer, in charge of various ultra-low power analog blocks, among them ADCs, DACs and oscillators, targeted at integrated circuits for medical applications. In 2003 he transferred to the marketing group as Product Architect with the task to define with our customers the technical aspects of new devices for the Ultra-Low Power Communication Division. In 2007 he became the Product Line Manager for the division's non-implanted products. Besides looking after the existing products, his main responsibility is to define and execute the roadmap of future products.

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