The science fiction future of medical implants is here

Semiconductor solutions contained in hand-held consumer product innovations are now finding their way into medical implantables

Steve Taranovich, Contributing Editor -- EDN, December 12, 2011

With circuit miniaturization/integration, lower power processes and architectures plus great cost savings because of the likes of the iPhone, iPad, Blackberry, etc., the semiconductor solutions contained in these hand-held commercial product innovations are now able to find their way into medical implantables making the seemingly impossible into a realizable and viable solution in the human body.

Innovations from such companies as **Cactus Semiconductor, Inc.**, having a medical focus in integrated circuit design encompassing both implantable and portable applications - such as neuro-stimulation, pacing, defibrillation, ultrasound, and medical monitoring (e.g., glucose meters) - will revolutionize the implantable medical market.

Figure 1 is an example of their capabilities in wireless data and power transmission as well as analog, microcontrollers and transducer capabilities for an implantable medical device with an external controller. Their alliance with Freescale Semiconductor to develop system-on-chip products for the medical market will accelerate innovative new solutions for implantables.

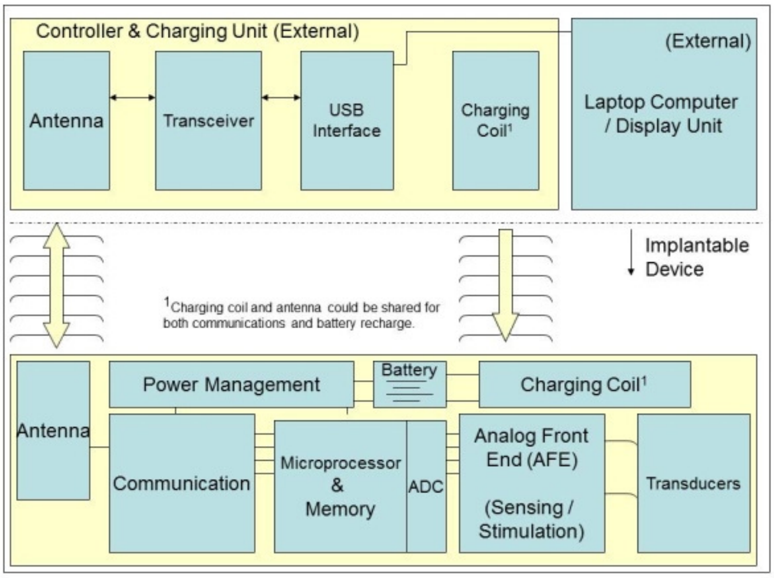

Figure 1: Cactus Semiconductor implantable medical device with external controller (Courtesy of Cactus Semiconductor)

Plessey Semiconductors announced[1] in October 2011 that commercial samples of their Electric Potential Integrated Circuit (EPIC) are now available. The EPIC sensor detects changes in electric field through clothing and even through walls. The first products are optimized for use as a non-contact electrocardiogram (ECG) sensor and provide resolution as good as or better than conventional electrodes. Can brain activity and other electrical signals such as spinal cord activity be far behind (see Figure 2)?

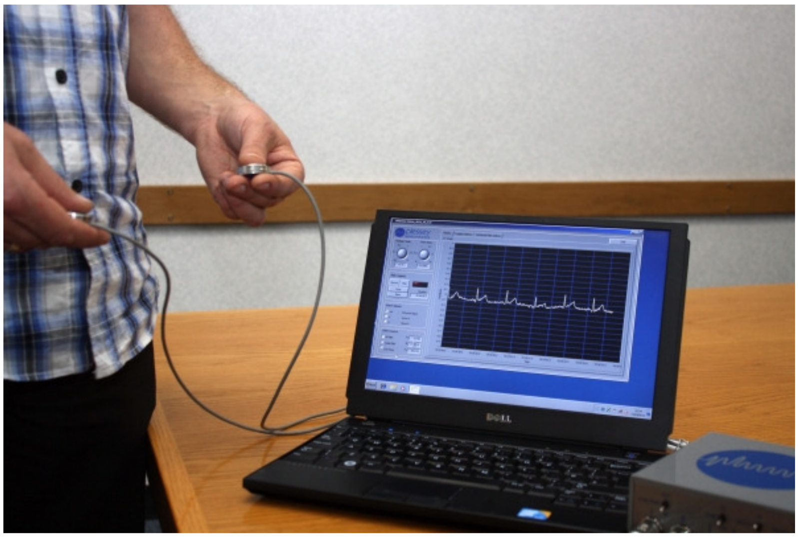

Figure 2: Plessey EPIC Sensors in ECG application (Courtesy of Plessey Semiconductors)

Medtronic[2] is developing the ability to chronically sense, process and telemeter signals from the nervous system that might help address when and how disease is affecting the patient. This will create new clinical applications in the future. It could lead to improved monitoring of disease progression and therapy efficacy in applications as diverse as movement disorders, epilepsy and psychiatric disorders.

As understanding of neural dynamics improves, embedded sensors and chronic signal classification might also help optimize and deliver therapy in real time (i.e., in a closed-loop mode). This could result in a decrease in the burden required from the clinician and patient to optimize the therapy, improved longevity of implantable devices with adaptive titration, and improved patient outcomes with therapy tied to quantitative physiological markers.

The neural interface (NI) technology required for deriving brain state information directly from neural signals is embodied in brain-machine interfacing (BMI). BMI is typically defined as a system that senses and decodes a subject's intentions, usually in the context of motor control.

Bi-directional BMI includes a means to provide feedback to the nervous system, such as stimulation of sensory afferents to provide bi-directional information flow in the nervous system.

The complete implantable system prototyped using state-of-the-art medical device technology previously approved for chronic human use is shown with a cutaway window in Figure 3. The right-hand side of Figure 3 is a close-up of the side of the hybrid board containing the sensing and algorithm electronics. The other side of the hybrid (not pictured) contains the existing stimulator and telemetry electronics.

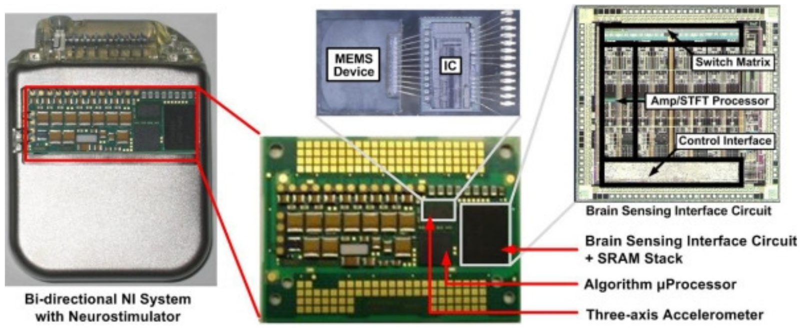

Figure 3: Physical prototype of the implantable bi-directional BMI system (Courtesy of IOP publishing)

Zhong Lin Wang[3] at the School of Materials Science and Engineering at Georgia Institute of Technology has shown that nano-generators are able to convert nanoscale mechanical energy into electrical energy with piezoelectric nanowire arrays. These power sources are critical for sustainable, maintenance-free and continuous operation of implantable biosensors.

Self-powered implantables can eliminate battery needs so that the medical implant will be able to operate as a type of "living species" surrounded by multi-functional nano-devices integrated into a nano-system in the near future.

Dr. Andy Hoffer and colleagues at Lungpacer Medical, Inc. are developing a far less medically invasive technique[4] to electrically pace the phrenic nerves to maintain diaphragm strength and resistance to fatigue that will enable patients on mechanical ventilators to be slowly weaned from those restrictive devices. Using only local anesthesia, the procedure gains access to the phrenic nerves of the diaphragm via needle-puncture of the skin, rather than by using an "open" approach where inner organs are exposed.

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