Feature Article

Published: March 8, 2012
Find more content on:

- Electronics
- Feature Article

Active Implantable Medical Devices: Winning the Power Struggle

Size, weight and volume matter when developing and manufacturing an electronic implantable device,
but power supply issues are paramount. A look at current and emerging technologies.

By: Yvonne Klöpping
Share

The first pacemaker was implanted more than 50 years ago, setting the pace for people with heart conditions and for technological breakthroughs. Today's devices are not only smaller and more technically refined than their forebears, they are smarter: most pacemakers can automatically send information on their condition via mobile services and transmit data on a patient's health status via integrated sensors. Heart problems or issues with the device itself can be detected in a timely manner, and frequent doctor visits and device checks can be avoided.

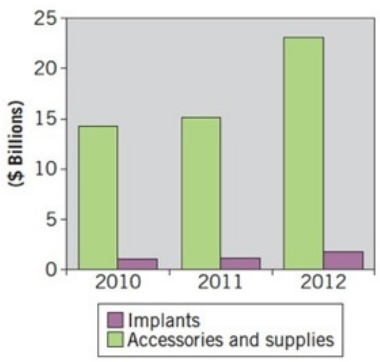

Figure 1: The global market for microelectronic medical implants, according to BCC Research.

According to BCC Research, the global market for microelectronic medical implants, accessories and supplies was worth an estimated US$15.4 billion in 2010. The market is projected to grow to US$24.8 billion in 2016. The global market for microelectronic implants is expected to experience an 8.9% compound annual growth rate (CAGR) over the forecast period. BCC Research found that the fastest-growing segments of the market are ear implants with a projected CAGR of 18.2%, neurostimulators (10.5%) and implantable drug pumps (10.5%). Meanwhile, sales of cardiac implants and accessories are projected to lag behind with a CAGR of 7.4% and 8.4%, respectively. As cardiac implants such as pacemakers and defibrillators are in a mature market, they will not experience the rapid growth of neurostimulators and implantable drug pumps.

Challenges
With the growth of the market and technological developments come challenges that are especially complex when electronics are being designed to live inside the body. After all, any type of implant is perceived as an invader by the organism.

product," says Andrew Diston, Director and Head of Global Medical Technology Practice for Cambridge Consultants (Cambridge, UK). "There is no CTRL-ALT-DEL function." As electronic components themselves are not biocompatible, they need to be encased in high-integrity hermetic housings. The components are not allowed to get warm as this would damage human tissue, so heat dissipation is a challenge. "Any system that puts electrical signals into the body can potentially cause harm, and all electrical systems can fail in some way, so implants have to be designed such that the failure of any of the circuitry does not lead to unsafe conditions or signals appearing at the output of the implant," stresses Diston.

Frédéric Mauron, Director, Active Implant Development, at engineering and contract manufacturing services provider Valtronic (Les Charbonnières, Switzerland) adds that as the implant must last for the life of the patient, it is difficult to find an encapsulation material that can last that long and work for all implants. "Current solutions such as titanium are not suited to extremely miniaturised implants," explains Mauron. "Alternative encapsulation is being explored. Future possibilities include ceramics, silicone on parylene coating and glass encapsulation. All of those [materials] are transparent and enable RF power and data transfer, which is a growing need for implants. They also are more suited to implants with a larger number of connections for stimulation or sensing," says Mauron.

Additionally, interconnects to the casing from an implant with a large number of leads are limited. Valtronic recently implemented so-called ultra-low-profile gold ball wire bonding to reduce the height of wire-bonded and encapsulated die. The ultra low profile process can reduce the overall packaging area by 50% or more compared with conventional aluminium wire bonding.

Other challenges for medical implants include size and external interference from cell phones, MRI scanners and metal detectors. And last but not least there is the issue of power consumption. Leakage, deformations and unreliable capacity performance cannot be tolerated, as the batteries are not easy to replace and can be central to life-sustaining situations.

Powering implants

A major issue in the development of electronic implantables is the powering of implants that perform a stimulative function, according to Mauron. Also, permanent sensing will present powering challenges because the function demands more power to operate. Different concepts address this based on the implant's application, says Mauron.

The three options currently in use are permanent batteries, rechargeable batteries and external power sources. "The battery sources require additional surgery every three to five years to change the battery, which is an expensive and impractical solution in many cases," Mauron says. "External power sources require the patient to follow strict protocols to keep the implant functional and therefore rely on the patient to do what is required. But that can result in a higher chance of error."

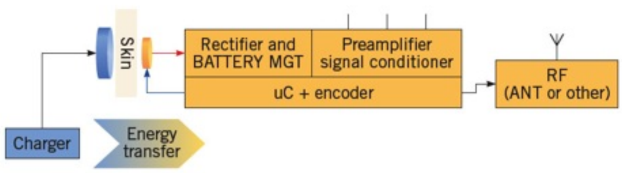

Figure 2: Valtronic's implant charging concept eliminates the need for batteries.

One of the main particularities of powering implants, according to Mihai Osaci, General Manager, Valtronic Technologies Romania SRL (Bucharest, Romania), is the reliability of the powering method. No-battery implant technology, also called inductive coupling charging, is a good illustration of this. The implant is placed under the skull skin, and it is powered by a rechargeable battery that is charged one hour per month by means of RF battery is indefinite . . . at least in theory. "In practice, the lifetime of a battery in a charger depends on the number of charge and discharge cycles and the depth of discharge," explains Osaci.

A new method for powering implants without using a battery, for instance, is a material that can generate power after implantation by absorbing light from outside the body. As reported in medtechinsider in November 2011, Japanese researchers have developed this technology to be applied to the development of a battery-free cardiac pacemaker.

Energy harvesting

The future of powering electronic implants lies in energy harvesting, according to Mauron. He explains that current research is focused on the harvesting of body-produced energy such as piezo- or chemical energy generation. "These technologies are currently in the academic stage, and some clinical animal studies have produced promising results," he adds. Piezo-electric systems harvest energy generated by body motion and use that energy to power implants such as pacemakers. Energy harvesting is the process by which energy that is readily available in the environment is captured and converted into usable electrical energy. The energy harvester module captures milliwatts of energy from light, vibration, thermal or biological sources. A possible source of energy can also come from radiofrequency signals produced by radios, televisions, mobile phones and other wireless devices. This method is already used in implanted RFID tags. An energy harvesting system consists of an energy harvester module and a processor/transmitter block. The power captured is conditioned and stored within a battery, an efficient quick-charging capacitor or one of the newly developed thin-film batteries. As the system is dependent on the available power, a sensor triggers the device at the required intervals. The data is then processed and transmitted to the base station. Industrial applications of energy harvesting include surveillance and security, long-range asset tracking, implantable sensors and equipment monitoring.

Batteries currently used in active medical implants either need replacement via surgery every few years or need to be recharged through cumbersome external devices. "The batteries are expensive, large and one of the weak points in medical implants and limit the capability of implants to carry out more functionality," says Cambridge Consultants' Andrew Diston. "However, the total energy consumed by a medical implant is a tiny fraction of the energy consumed by people every day (i.e., food), so it makes sense to develop systems that can harvest a small fraction of those beef burgers and soda drinks to power them."

Wireless pacing system

Energy harvesting currently is used in a wireless pacing system developed by design and development firm Cambridge Consultants in collaboration with start-up company EBR Systems Technology. With cardiac stimulation leads considered the weak point in pacemaker systems, the Wireless Cardiac Stimulation system (WiCS) uses a leadless electrode to convert mechanical energy, wirelessly transmitted from an ultrasonic pulse generator, into electrical energy, which is used to pace the heart as part of cardiac resynchronization therapy (CRT). The aim of the WiCS is to ultimately eliminate all pacing leads and deliver superior cardiac pacing therapy because of the flexibility in where the electrode can be placed.

"Much of a pacemaker's battery power is spent on monitoring the heart and deciding when to pace. This part of the battery is the same whether it is a wireless or conventional pacemaker," explains Diston. "Overall, there is a small increase in battery size needed to accommodate the wireless pacing system, but the battery life for conventional and wireless systems is comparable. The WiCS has its own battery, so no modifications to existing pacemakers are required."

WiCS leverages advances in energy harvesting microelectronics. A very small leadless electrode is implanted in the desired location within the left side of the heart. The first-generation WiCS device works in conjunction with he pacemaker from the right ventricle. The pulse generator then transmits an ultrasonic pulse to the implanted receiver, which converts the sonic energy into electrical energy to synchronously pace the left and right ventricles. Not only does this reduce the need for the difficult and complicated surgery associated with CRT pacemakers, but by pacing inside the left ventricle it also better mimics the natural activation and mechanical contraction pattern of the heart.

Diston says that the long-term impact of this technology will be to eliminate one of the failure points of modern pacemaker systems—the lead—and to allow electrodes to be placed where leads simply cannot go, resulting in more effective therapy.

Future outlook
Mauron sees the future of electronic implantables in less invasive devices with increased functionality. “Implants will be less one size fits all and more custom,” says Mauron. “A neurostimulator could be designed [to treat] one specific ailment, for instance.”

According to Diston, further integration of the functions of conventional and wireless pacemaker technology is coming. “Ultimately, leads could be eliminated completely, but further development and clinical testing will be needed,” he notes. “More widely, implants can carry out a host of other functions in addition to improving the health of people’s hearts. Major advances in neuromodulation have resulted in systems that act on the nervous system and brain to control pain and motion, eliminating the tremor in Parkinson’s patients, for example. Systems also can control a patient’s mood and help with clinical depression,” Diston continues. “We will see ever increasing uses of electronics in implants in the coming years, a result of Moore’s law by which computing power doubles every two years.”

Yvonne Klöpping is Associate Editor of EMDT

Published in European Medical Device Technology, March/April 2012, Volume 3, No. 2

- Previous story: MicroPort Senior VP Eyes International Growth
- Next story: Taking the Lead in Medtech Innovation

0
Your rating: None

Login or register to post comments

Daily Buzz

- Blog
- Articles
- Product News