From intra-body experiences

TechnoTalk

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Many people 'have had an out-of-body experience', a feeling of extra-corporeal floating. The sensation may arise from psychological factors, intoxication or even electrical stimulation of the brain. Now researchers are finding applications for electronics *within* the human body. There's no Frankensteinian involvement, but Mark cannot help feeling a slight queasiness.

IN-BODY electronics are not new. Experiments with artificial pacemakers date back to 1899, although all the early trials used external devices. The first clinical implant was in 1958 in Sweden. Although the device failed after three hours, the patient, Arne Larsson, went on to receive 26 different pacemakers during his lifetime, dying at the age of 86 and outliving the inventor as well as the surgeon. Excellent as these devices are, they require electrical power and patients face regular operations (at five to seven-year intervals) to replace worn-out batteries. For this reason, a longer-lasting power source for pacemakers would be welcome news.

Perpetual motion machine?

A development under examination in the US is to use power generated by the heart itself to recharge batteries using piezoelectricity – an electrical charge generated mechanically. This is a particularly benign use of energy harvesting, a technology we have discussed many times in this column. This application, in which human heartbeats generate electricity to recharge the battery of the electronic pacemaker, might appear to be perpetual motion, but of course this is not the case. Pacemakers require only small amounts of power to generate the electrical impulses that help the heart maintain a normal heartbeat, and the energy harvester actually generates more than ten times the power required by modern pacemakers.

The research at the University of Michigan is led by Dr Amin Karami, who said his team's findings suggest this kind of patient-power could eliminate the need for replacements when batteries are spent. 'Many of the patients are children who live with pacemakers for many years. You can imagine how many operations they are spared if this new technology is implemented,' he stated. He added that piezoelectricity might power other implantable cardiac devices such as defibrillators, which also have minimal energy needs.

However, piezoelectricity is not the only solution under examination, especially for body devices that need greater power. For these, the best solution seems to be miniaturised biofuel cells consuming substances naturally occurring in the human body or in its direct environment.

Bio-batteries are here

Or rather not here, but in Poland. Researchers from the Institute of Physical Chemistry in Warsaw have created an organic bio-battery that has direct in-body potential. What's more, it promises comparatively high voltage and long useful life (relative to other biofuel cells at least). It uses oxygen from the air, plus a cathode composed of an enzyme, carbon nanotubes and silicate. It's by no means a competitor for the batteries that you and I use for cellphones or torches, but for powering internal body implants such as heart pacemakers it offers considerable promise.

Of course, organic bio-batteries are not new, as the Institute's Dr Martin Jönsson-Niedziółka, reminds us. 'One of the most popular experiments in electrochemistry is to make a battery by sticking appropriately selected electrodes into a potato. We are doing something similar; the difference is that we are focusing on biofuel cells and the improvement of the cathode. And, of course, to have the whole project working, we'd rather replace the potato with a human being'.

Nothing noxious

Body-function applications are becoming more ambitious. Today, they include cardiac pacemakers or hearing aids; tomorrow it will be contact lenses that change focal length automatically or computer-controlled displays generating images directly in the eye. These devices will only work if coupled to an efficient and long-lasting power supply.

Standard types of battery are unsuitable for powering implants inside the human body, as they use harmfully strong alkalis or acids, unless the battery housing is absolutely impervious. Their size and weight are generally too great too. Biofuel cells offer an essential advantage in that to generate power, it is enough to insert the electrodes into the body. So far, the Polish team has successfully powered a lamp composed of two LEDs, using a stack of four batteries connected in series. There is still a long way to go, and researchers must solve the problem of relatively low electric power that is common to all biofuel cells.

Spoof story?

You could be forgiven for assuming last month's news story about using the human body as a comms channel was an April Fool's joke, but in fact this announcement was made in February. That was when Arizona-based Microchip Technology revealed its BodyCom technology – the first in the world to employ the human body as a secure, low-power communication channel. The company describes it as providing short-range, low data-rate communication for connecting securely to a wide range of wireless applications. According to Microchip, when compared to other wireless technologies, BodyCom offers lower active and standby energy usage, increased security through bidirectional authentication, and simpler circuit-level designs.

The press release is as clear as mud, but fortunately the product video (**https://www.youtube.com/watch?v=dTuXAGUjnQA**) translates better into plain English. The gist of the demonstration is that in situations where you need to prove you are authorised to do something (open a locked doorway, start a piece of machinery or anything similar), you can do this just by putting your finger on a touch pad. The enabling device is a keyfob that remains in your pocket; it sends and receives data through your body, using capacitive coupling. It's a lot easier to understand if you watch the video!

According to the manufacturer, its implementation is simpler than comparable products, plus, it has a lower overall bill of materials and power consumption measured against existing technologies. The system complies with (American) FCC Part 15-B regulations on radiated emissions. Because a wireless transceiver is not used, a significant cost component is eliminated and no radio antenna design work is necessary. At the same time, battery life is extended and there are no high-power inductive fields that might endanger health.

As well as the keyfob security devices used for BodyCom, Microchip provides a development board that can be used to build prototypes and a Windows-friendly software development environment. More about BodyCom at: **www.microchip.com/pagehandler/en_us/technology/embeddedsecurity**.