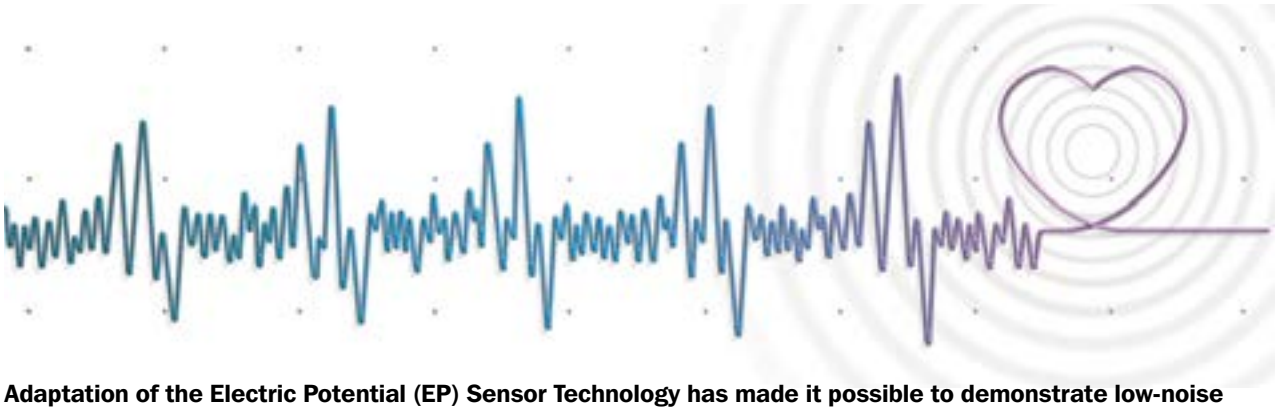
Electric Potential Sensor Technology: from fundamental physics to commercial success



Adaptation of the Electric Potential (EP) Sensor Technology has made it possible to demonstrate low-noise ECG signal acquisition without the need for gels or resistive contact with the skin. This has simplified the clinical procedure significantly.

Electric Potential Sensor Technology, which arose from fundamental physics research at the University of Sussex, has led to the development of a novel, highly sensitive, non-invasive electric sensor. As a result of significant multimillion pound investment and commercial development in collaboration with the UK Company Plessey Semiconductors Ltd, the 'EPIC' sensor was successfully brought to market. This technology has the potential for widespread application and deep penetration in a number of sectors, including healthcare, sports, security, safety, aerospace, automotive and geophysics.

Overview

Electric Potential (EP) Sensor Technology was conceived at the University of Sussex in the laboratory of Robert Prance (Professor of Sensor Technology, Engineering and Design, Sensor Technology Research Centre) while working in the Department of Physics. The technology emerged as a result of an Engineering and Physical Sciences Research Council (EPSRC)-funded fundamental physics project on low-temperature quantum circuits. The focus of the original research was to study SQUID (superconducting quantum interference device) systems as simple macroscopic quantum objects. As part of this research, specialised electronic instrumentation had to be developed, which allowed the accurate detection of the electrical charge in a quantum system.

Funding to develop this novel and unique sensor as an independent research project was provided by two further EPSRC research awards (1993-1997). This research culminated in the production of wideband (quasi DC to 200 MHz), ultra-high impedance sensors capable of detecting spatial potential, electric field or charge. Impedance is the opposition that a circuit presents to an alternating current when a voltage is applied. The EPS can accurately detect electric fields (potentials) without the need for physical contact. The sensor was used as the basis for a novel imaging microscope system and work on larger-scale electronics showed promising results in electrophysiological applications such as electrocardiograms (ECG). ECG conventionally uses low-impedance (ie high-current, low-voltage) wet-gel electrodes. By adapting the EP sensor it was possible to demonstrate low-noise ECG signal acquisition without the need for gels or resistive contact with the skin. This simplified the clinical procedure significantly, providing a system that was stable, electrically and mechanically robust, and chemically and biochemically inert.

Subsequent funding allowed extensive research development and significant publication, which led to the EP sensor winning the Institute of Physics Measurement Science and Technology 'Best Paper Award' (2002) and the

filing of the first of a suite of seven patents, a number of which are now granted worldwide. It became clear that the technology could be used in a large range of applications. Continued EPSRC and industry funding enabled a broad range of projects exploring the technology's potential in many applications, including electrophysiological sensing, movement detection and tracking, human-machine interfacing, nuclear magnetic resonance instrumentation, materials characterisation (ie analysis and measurement of a material's structure), surface-charge imaging for forensic fingerprinting, and stress monitoring for geophysical applications and structural-health monitoring.

Achieving impact

This original basic research has generated multimillion pound investment to develop the EP Sensor Technology in a diverse range of engineering and other settings. There has been substantial impact on industrial sensor solutions and growth to the worldwide revenue of a UK company, Plessey Semiconductors Ltd. This work has also generated income for the University from licence fees for the technology, patent costs and royalties, which began in 2013. Because of the technology's generic nature, the sensors have immense capacity to develop in terms of size and diversity of their application.

In London, in May 2010, a generic version of the EP sensor system was showcased at a Position Sensitive Detectors in Physics meeting organised by the Research Instrumentation Special Interest Group (RSIG), which was intended to facilitate interaction between high-energy physics research and the security and medical sectors. This led to a dialogue with Plessey Semiconductors Ltd, culminating in an exclusive manufacturing licence in December 2010. The first integrated-circuit version of the sensor was successfully implemented by Plessey and was ready for designing into products by September 2011. A second sales licence was agreed in June 2012 and the technology is now being marketed as the Electric Potential Integrated Circuit (EPIC) sensor. Plessey has made major investment in EP sensors, particularly in creating employment opportunities dedicated to technology development, application support and sales and marketing.

Prance's research group has also worked with the University's Research and Enterprise Division and the Sussex Innovation Centre on campus, with funding from the Enterprise Panel (University of Sussex) and the South East Health Technologies Alliance, to develop awareness of the technology in the wider community. Given the potential that the generic EP Sensor Technology has for broad application and deep penetration in several areas, there was a perceived need to engage and educate the market and potential users about its wide-reaching capabilities across many sectors. Thus, evaluation licences were granted for 12-month periods to several interested organisations, including business and other potential partners such as universities and government laboratories. Revenue generated from this activity was then used to manufacture a batch of pre-production prototypes (by a local Sussex business, Interface2 Ltd, Newhaven) for distribution under these licences. To date, the University has placed 20 evaluation licences and has direct collaborative involvement across diverse market sectors such as healthcare, sports, security, safety, aerospace, automotive and geophysics.

EP Sensor Technology has received widespread external recognition for its contribution both to research and commercialisation activities. This includes several awards: the Research Councils UK (RCUK) *Big Ideas for the Future* report (2011), the Institute of Engineering and Technology Innovation Award 2011, 'Measurement in Action', and the gold award at 'Best of Sensors Expo 2011'. It was also listed on the EDN 'Hot 100 products' list (2011) and has featured in *Nature Research Highlights, New Scientist, Homeland Security Newswire* and *The Economist*.

Future impact

Current research projects are likely to lead to innovative solutions for the monitoring of gas turbine engines and for the acquisition of electroencephalograms (EEG) for diagnostic purposes. The efficiency of gas turbine engines depends critically on the clearance between the fan and the casing. Prance's team are developing a new sensor to enable real-time acquisition of this data in order to optimise the operation of the engine. Ultimately, this could impact on global CO_2 emissions. Using the experience gained with ECG signals, another project aims to enable easy acquisition of EEG signals for diagnostic purposes. Currently, EEG is not used regularly due to the difficulty and cost of acquiring high-quality data. Thus, this project is expected to impact cost and quality of healthcare provision.

Funding and partnership

Initial research was funded by the EPSRC and an RCUK Basic Technology award. In addition to Plessey, there have been several other partnerships with commercial organisations: Rescon Ltd; a multipartner EU grant with Philips Healthcare and Plessey (2012-2016, over £20 million); and Technology Strategy Board-funded aerospace instrumentation, with Meggitt Sensing Systems and Plessey Semiconductors (2012-2014, £1.1 million). Other partnerships have included a scientific collaboration with CAST on surface-charge density imaging, including forensic fingerprinting; and geophysical and structural health monitoring with the British Geological Survey.

Working with us

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