Revolutionary electrical current sensors harvest wasted electromagnetic energy

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These smart wireless sensors can now reach hard-to-access locations such as rails where conventional sensors are either impossible or not cost effective.

Electricity is the lifeblood of modern cities. It flows at every moment

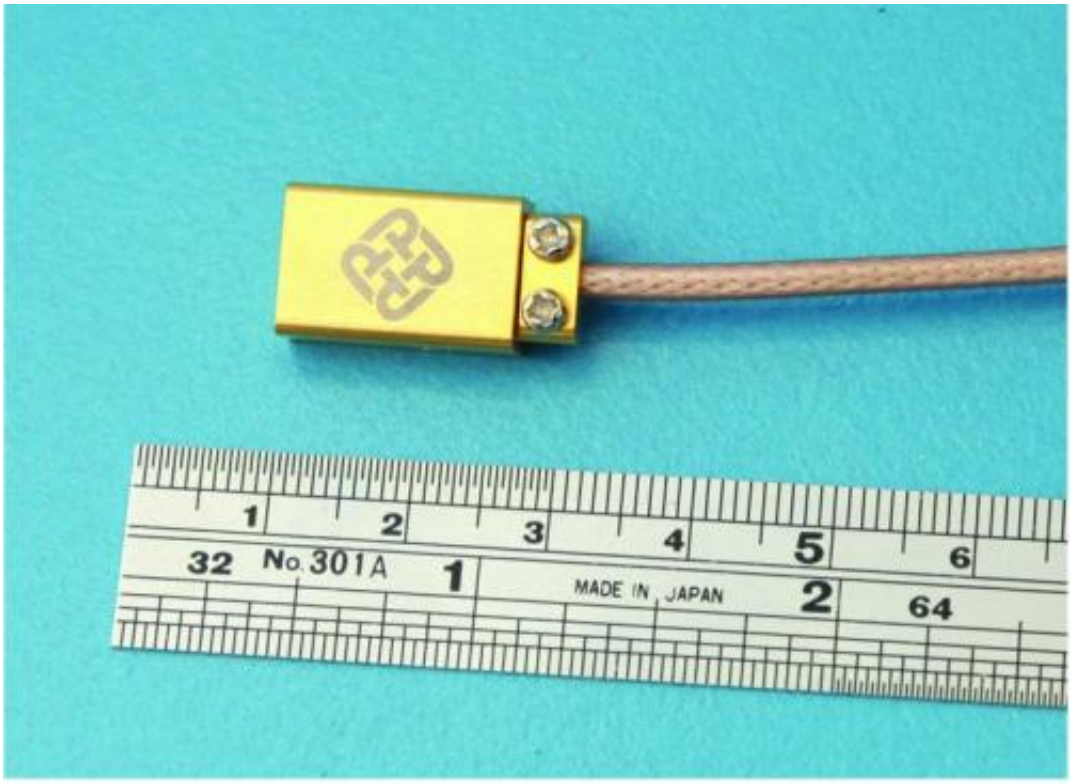
and everywhere to power up everything from home appliances which improve our comfort and convenience, to services like transportation, building, communication and manufacturing that are essential to our daily life. To ensure a reliable operation of power grids and a proper delivery of electricity to where it needs to be, it is crucial to have a loyal guard to keep watch on the activities of electricity transport. As technology advances, the safety, reliability and availability of electrical engineering assets and public utilities can now be guarded by one tiny chip of electrical current sensors.

Measuring about 1 mm in thickness, the chip is a masterpiece by Professor Derek Siu-wing Or and his research team in the Department of Electrical Engineering of The Hong Kong Polytechnic University. The chip can be placed on any sensing point of interest such as electrical cables, conductors, junctions, bus bars, etc. to detect electrical currents. What's more, it does not necessitate the use of additional power supplies and signal conditioners which are generally required by traditional current sensors such as Hall sensors, reluctance coils, etc.

According to Professor Or, the chip is an amazing work of advanced functional materials. Made from rare earth multiferroics with giant magnetoelectric properties, the chip enables a direct detection of magnetic fields generated by electricity and a linear conversion of these magnetic fields into electrical voltage signals. The amplitude of the converted signals is linearly proportional to the magnetic fields, while their frequency exactly follows the magnetic fields. The "magnetoelectric smart material", as called by the team, is then specially engineered into "self-sustainable magnetoelectric smart sensors" that recognize telltale changes of electrical currents within electrical equipment. It is as simple as using a thermometer to give temperatures.

The exciting part is that Professor Or and his team have got rid of power supplies and signal conditioners from traditional current sensors. When

power and signal conditioning requirements are eliminated, the smart sensors do not have power cords and electronic active components. They can be conveniently, safely and reliably used for early fault detection in unthinkable territories.



Surface Mount and Through-Hole Type Magnetoelectric Sensors

Professor Or explained, "Our smart sensors are essentially simple, totally passive and capable of producing large and clear output voltage signals which are 2,000 times higher than the traditional current sensors. This passive and self-sustainable nature allows real-time, nonstop monitoring of the 'health' of electrical equipment, including those carrying high voltages, heavy currents and/or strong electromagnetic fields.

"Besides, these smart sensors can be tailored to harvest electromagnetic radiations emitted by the electrical equipment being monitored and to turn them into useful electrical energy. The stored electrical energy can be used to power up microcontrollers, displays, wireless transmitters, etc., further advancing the smart sensor technology toward 'energy-harvesting smart wireless sensors'."

The smart wireless sensors are being tested in electrical traction systems on trains in both Hong Kong and Singapore to provide in-situ monitoring of traction conditions and to detect electrical faults that may bring train services to a halt.

The benefits of the smart wireless sensor innovation go well beyond these advantages. For example, smart wireless sensors can now reach hard-to-access locations such as rails, tunnels, high-rises, underground premises, meter rooms, etc., where hardwired power cords and signal cables are either impossible or not cost effective. Another example is that the patented technology allows quick detection of malfunctions of ventilation fans inside tunnels, reducing the need of tunnel services suspension.

The journey does not end here; in fact, the research team is working further to perfect the technology. Professor Or said, "We aim to enhance the energy harvesting capability while making the smart sensors even more sensitive and reliable in measurement." Their research work has been supported by E-T-A Elektrotechnische Apparate GmbH (E-T-A) through a EUR500,000 fund. As a global leader in electrical circuit protection, the German company focuses on advancing electrical circuit protection technology. Professor Or and E-T-A are working together to embed the smart wireless sensor technology in new generation electrical circuit protection products that would meet the highest standards in terms of innovation, safety, reliability and efficiency.

A leading power company has engaged Professor Or and his research team in a large scale project to supply, test and commission a significant amount of smart sensors for use in substations. Imagine a power cable that would beep when it is sick and beep even louder when it is about to give out. In the near future, our power grids can be smarter than they currently are.

Provided by Hong Kong Polytechnic University