FOR IMMEDIATE RELEASE

Development of a compact sensor that identifies the source of electromagnetic interference to prevent malfunction in component for autonomous operation

Improving safety in IoT-based societal infrastructure

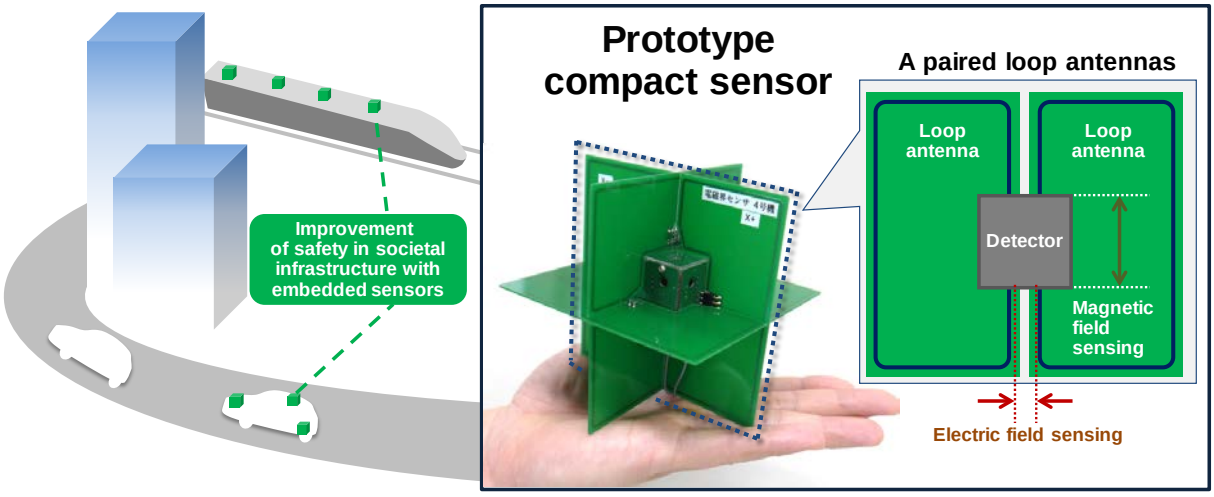

Image of the compact sensor developed & use-case scene

Tokyo, March 16, 2017 --- Kanazawa University and Hitachi, Ltd. (TSE: 6501, Hitachi) today announced the joint development of a compact sensor capable of identifying the source of electromagnetic interference(1) that causes malfunction in component for autonomous operation. The realization of the compact sensor will not only allow multiple sensors to be embedded in vehicles such as automobiles and trains, but also by configuring it with several antennas, enable the direction of this low-frequency electromagnetic interference emitted by aging components to be precisely detected, and thus allow the accurate identification of the electromagnetic interference source. By using this sensor, the risk of malfunction in autonomous operation component or transport systems can be avoided by continuously monitoring electromagnetic interference, and preventing the loss of sensor data related to cruise control. Kanazawa University and Hitachi will continue with the application of sensing technology detecting electromagnetic interference, to contribute to improving safety in societal infrastructure.

In the recent years with the progress of IoT, initiatives are rapidly growing to connect components embedded in automobiles or trains, or autonomous operation. To ensure the long term reliability and safety of aging component and systems, it is necessary

not only to increase the reliability of the components themselves but also to obtain normal sensor data. Low-frequency electromagnetic interference that interferes with surrounding signals and sensor data, however, leaks from aging or integrated electronic components that may result in equipment or system malfunction.

Currently, there are two technologies to identify the source of low-frequency electromagnetic interference: (a) the application of high-frequency direction-of-arrival (DOA) estimation[(2)] used in wireless communication, and (b) the application of DOA estimation using Poynting vector[(3)]. High-frequency DOA estimation, however, requires either larger sensors or the installment of sensors over a wide area, etc., therefore making practical application in autonomous operation component difficult. On the other hand, DOA estimation using Poynting vector measures either the electric or magnetic field, and obtains the other value by conversion to determine the probable direction of the source, producing an error of approximately 45 degrees[(4)] preventing the accurate identification of the electromagnetic interference sources.

To precisely identify the source of low-frequency electromagnetic interference, Kanazawa University and Hitachi developed a compact sensor applying the Poynting vector method that can simultaneously measure both the electric field as well as the magnetic field in three dimensions from the same location. Features of this sensor are as follows:

1. **Two loop antennas[(5)] arranged in a pair structure to enable simultaneous measurement of electric and magnetic fields**
   Two loop antennas, conventionally only used in magnetic field measurement, are arranged as a pair structure on the same plane to enable simultaneous measurement of the electric field occurring between antenna.

2. **Three pairs of loop antennas arranged to cross each other achieves sensor's high accuracy and small-size**
   Three paired loop antennas are arranged so that the circuit for detecting electromagnetic interference set in the center can obtain all the data at once. This allows the data on the electric and magnetic fields to be simultaneously detected in three dimension. As the loop antennas are aligned perpendicularly, measurement accuracy is improved without interference from each other. In addition, as the detection circuit is integrated in the center of the pair structured loop antenna, a compact size of 110 cubic mm was realized.

Using the sensor developed to identify the direction of electromagnetic interference of 200kHz – 10MHz, detection with an error of less than 2 degrees of the actual direction was confirmed. This converts to an error of less than 10cm when the distance between the sensor and the noise sources is 3m. By using three sensors, it is possible to specify the source of electromagnetic interference as the point where the three detected directions cross, thus allowing component malfunctions to be prevented.

Kanazawa University and Hitachi, by applying this sensor to the establishment of error prevention systems for autonomous operation component, will contribute to enhancing the safety of societal infrastructure.

A part of this achievement will be presented at the IEICE General Conference to be held from 22nd to 25th March 2017 at Meijo University, Nagoya, Japan.

(1) Electromagnetic interference: Weak electromagnetic wave from circuits and power devices of electronics that causes interferences to surrounding electronic field and loss of sensor data. This can be the factor of communication failure or electronic errors.
(2) High-frequency DOA estimation: Most of these techniques are based on phase delay of antenna arrays with a sophisticated algorithm like multiple signal classification (MUSIC) or estimation of signal parameters via rotational invariance technique (ESPRIT). To achieve high resolution in the incident angle, it is necessary to place receiving sensors for each distance of about half the wavelength. A Lüneburg lens with photonic sensors or power detectors is another DOA technique. But it is necessary to make the lens size larger than the wavelength. So if the frequency of electromagnetic wave is 1MHz, it requires placing sensors for each 150m distance or a lens larger than 300m.
(3) Poynting vector: Vector that shows the direction of electromagnetic wave and the amount of energy.
(4) Error of approximately 45 degrees: If the distance between the sensor and the source is 3m, the location error would be 3m.
(5) Loop antenna: Antenna is loop shaped wire made of metals, etc.

About Kanazawa University

The origin of Kanazawa University dates back to a smallpox vaccination center established by the Kaga Clan in 1862. We have a history of 150 years in Kanazawa. Succeeding the history and tradition of multiple predecessors, the university was established in1949. We are comprised of 3 colleges and 16 schools, 6 graduate schools, University Hospital, Cancer Research Institute and other sectors. The enrollment is over 10,300, and students come from 43 nations and 1 region around the world. For more information, please see: http://www.kanazawa-u.ac.jp/e/

About Hitachi, Ltd.

Hitachi, Ltd. (TSE: 6501), headquartered in Tokyo, Japan, delivers innovations that answer society's challenges. The company's consolidated revenues for fiscal 2015 (ended March 31, 2016) totaled 10,034.3 billion yen ($88.8 billion). The Hitachi Group is a global leader in the Social Innovation Business, and it has approximately 335,000 employees worldwide. Through collaborative creation, Hitachi is providing solutions to customers in a broad range of sectors, including Power / Energy, Industry / Distribution / Water, Urban Development, and Finance / Government & Public / Healthcare. For more information on Hitachi, please visit the company's website at http://www.hitachi.com.

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