TECHNICAL INSIGHTS

SENSOR

TECHNOLOGY ALERT

28th November 2014

1. SMART SENSOR PLATFORM THAT HARVESTS ENERGY FROM MULTIPLE SOURCES

Technological advancements are valued as they make our lives more productive, safer, and comfortable—from weather monitoring to enabling smart cities in the future. To actualize smart cities and factories in the future, there is a need to deploy a network of advanced, tiny sensors. Deploying sensors to make the environment smart can provide key benefits, but the deployment itself is a major challenge. At present, sensors often need an external source of power to operate. Grids and batteries are the two external sources that are currently used to power sensors. Both these sources of power have drawbacks. For instance, grid connected sensors require a cable, which can limits the use of the sensor. Battery-powered sensors will last as long as the battery life. There is a need for a device that is able to harness energy from the environment, such as from radio waves, solar energy, vibrations, or other sources. The device should be quick to deploy and easy to use. In addition, the device should not have any adverse impact on the environment, and it should not be complicated or expensive to maintain.

To address the above-mentioned challenges, researchers from several companies and research institutes are working under the project called Symbiotic Wireless Autonomous Powered system (SWAP) funded by the European Commission under the Seventh Framework Programme (FP7). The goal of the project is to develop an advanced sensor platform that can power itself using ambient energy.

The SWAP team is developing an advanced sensor platform that can integrate multiple sensing circuitry and energy harvesting, such as thermal, solar, vibration and radio waves into an individual device. The researchers are also developing an intelligent algorithm that can identify the source of energy and efficiently manage the obtained energy from multiple environments. While performing monitoring tasks, the algorithm will reduce the amount of data being sent for monitoring and in turn reduce energy consumption. The project is under the development and testing stage.

Once the project is fully developed, the sensor platform will be used in factories as an autonomous sensor that is able to power itself. The sensor platform will play a crucial role in enabling the Internet of Things with the help of interconnected sensor networks. This autonomous sensor network is very quick to deploy and easy to use. This advanced sensor platform will also be used in weather and environment monitoring. In future, this sensor platform will be used to monitor forest fires, traffic and pollution monitoring, water metering, and it might also be deployed in smart parking guidance systems.

The SWAP project has total total funding of €991149 (approximately $1235829), received from the European Commission. The different partners associated with the project are Worldsensing (Spain), Patavina Technologies (Italy), Centre Tecnològic de Telecomunicacions de Catalunya (CTTC) in Spain, Consorzio Ferrara Ricerche (Italy) and the University of Padova (Italy). The project and its funding were initially commenced on August 2010. The researchers are currently working on merging the algorithms with the hardware. Once the project is commercialized, it is expected to get a good response from different industries and applications, including smart factories.

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2. CERAMICS ENABLING HIGH TEMPERATURE SENSORS

Sensors are actively being deployed in extremely hostile and hot environments in several industries, such as in automotive and aerospace industries, and in various industrial processes. The sensors currently being used in these environments can have a limited capability in extremely hot environments. This poses a challenge in monitoring and collection of data. The data collected by these sensors in extreme environments may have discrepancies, which further leads to taking wrong actions based on incorrect data. There is a need for a sensor that can withstand high temperatures and provide accurate results irrespective of the environmental conditions. The sensor needs to be robust, easy to use, and cost-effective.

Toward fulfilling the above-mentioned needs, researchers from Queen Mary University of London and Westfield College, University of London, are working together for the European Commission project called High Temperature Sensor (HITS). The project is categorized under Marie Sk³odowska-Curie actions. The researchers are developing a sensor using ceramics, which can withstand high temperatures.

The HITS team is developing high temperature sensors using Aurivillius phase ceramics because of their piezoelectric properties and high Curie temperature. The researchers have studied various properties of the ceramic material such as electrical conductivity and magnetism before employing it in the construction of the sensor. Studying the ceramic material was the first phase of the HITS project. The researchers have tested the product by exerting high pressure and rapid heating of 500 degrees C per minute. The ceramic material exhibits piezoelectric properties that will be useful to monitor and measure the pressure, force, and strain with accurate sensing capabilities.

The sensor will be used in extremely hot environments, such as industrial processes, power generation industry, automotive industry, and aerospace industry, among others. The high temperature sensors will achieve a sensing ability that is highly accurate under hot conditions. The sensors will be robust and easy to use and cost-effective. In the future, sensors enabled by ceramics and used in hot environments will be able to operate without external power source. They can also be used to convert heat energy into electricity. Thus, enabling sensors with Aurivillius phase ceramics can greatly increase opportunities for the sensor industry.

The project is funded by the European Commission under the FP7 Program. The project is still under development and the researchers are working toward enabling different sensors using ceramics. The project was begun in 2013 with phase one devoted to the study of ceramic materials that can be used in hot environments. The work has potential to get a good response from power generation industry, among others.

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3. SENSORS ENABLING ROBOTIC TECHNOLOGIES FOR SATELLITE SERVICING

At present, there is a need for a device or advanced technology that can service a satellite in orbit and fix such issues, and can be easily guided by human beings.

To address the above-mentioned challenge, researchers from the European Space Agency and governments of different countries and institutes are working under the European Commission's program for the development of robotic technologies for servicing satellites in space. The project is currently in the initial development stage.

The project is designed in two phases. The first phase will focus on designing and manufacturing high performance, reliable, robotic building blocks, which will further help in operations in space environment. The second phase of the project will focus on functions and concepts that will involve highly autonomous operations that can take place from remote locations and by human-to-machine communication. Robotic building blocks involve materials and structures, sensors and actuators, processing algorithms, and sensor fusion. Sensor fusion derives data from disparate sources such that the resulting information is in some sense better than that possible when these sources are used individually.

Once the technology is commercialized, it will be deployed for on-orbit satellite servicing, and other robotic activities on earth; for instance, it might be deployed in the automobile industry. It will be employed for activities that are too risky for humans to undertake such as in nuclear, chemical, biological, and submarine environments. To get an approval from the government, the project needs to be validated at three different levels—In-orbit demonstration, International Space Station (ISS) infrastructure, and earth analogues. After demonstrating the validity of the technology at three different stages, this technology can be employed in space robotics. Thus, it can be hoped that by employing advanced robotics technologies, issues related to satellites in space can be resolved without human intervention.

The project is funded by the European Commission. The total funding for the project is expected to be €52,000,000 (approximately $64,836,980). The project partners for the Space Robotics Technologies are the European Space Agency, several different agencies from various countries in Europe, the European Space Policy Institute, the Interdisciplinary Centre for Space Studies, and the United Nations Office for Outer Space Affairs. The project commenced on December 2013. The researchers are currently working on robotics concepts and functions, which involve tele operations for near-Earth locations and human–machine communication.

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4. RECENT PATENTS IN THE FIELD OF ENERGY HARVESTING USING THERMOELECTRIC SENSORS

Energy harvesting is used to convert ambient energy to electrical energy. Energy harvesting makes available backup power without using batteries, and thus increases the life time of sensors or sensor networks. With technological advancements, there is a growing demand for self-sufficient sensors that can operate on their own without external power sources.

A recent patent in energy harvesters (US20140016665) is for an energy harvesting device with a thermoelectric sensor, powered using machine surface temperature and ambient air temperature, assigned to Robert Paul Stachow. From 1967 to November 2014, approximately 152 patents have been registered with the title thermoelectric sensor. From 1970 to October 2014, approximately 129,162 patents have been registered under energy harvesting. Approximately, 47 patents have been registered under energy harvesting using thermoelectric elements.

There are several intermittent sources of ambient energy from which energy can be harvested. The different types of sources include thermal, solar, vibration and radio frequency (RF) waves. There is a need to assure reliability and increase the power capabilities of harvesting energy. Harvesting energy through temperature change (thermoelectric energy harvesting) can allow heat to be saved that otherwise would be lost. However, this method may be subject to limited conversion efficiency.

Energy harvesting has growth opportunities in various application segments, such as building or home automation, medical devices, military/ defense, automotive, consumer electronics, power industry, machine monitoring, and environmental monitoring.

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
ENERGY HARVESTING SURVEY APPARATUS AND METHOD OF DETECTING THERMAL ENERGY	16.01.2014; US20140016665	Stachow Robert Paul	Stachow Robert Paul	An energy harvesting survey apparatus includes a main body having a first end positioned proximate to a machine configured to produce thermal energy and a second end positioned a predefined distance from the first end. At least one first sensor is coupled to the first end and is configured to detect a temperature of a surface of the machine. At least one second sensor is coupled to the second end and is configured to detect a temperature of ambient air substantially surrounding the machine. A circuit is coupled to the first and second sensors, and is configured to generate at least one output representative of an expected power output of a thermoelectric generator coupled to the machine based at least in part on the detected machine surface temperature and the detected ambient air temperature. A display device is coupled to the circuit and is configured to display the output.
ELECTRIC CAR CAPABLE OF BEING CHARGED FROM A POWER NETWORK AND HARVESTING ENERGY FROM NATURE AND AN ELECTRIC ENERGY SUPPLY METHOD USING THE SAME	28.05.2013; KR1020130055394	KOREA ELECTROTECHNO LOGY RESEARCH INSTITUTE	BAE, JUNG HYO	PURPOSE: An electric car capable of supplying electric energy and an electric energy supply method using the same are provided to supply AC or DC energy anytime and anywhere by using electricity. CONSTITUTION: An electric car(100) includes an electric energy generator(102), a transformer(114), and a battery(124). The electric energy generator generates electric energy by using nature energy and converts the generated electric energy into DC energy. The electric energy generator includes a micro wind power generator(104), a solar power generator(106), a vibration generator(108), a thermoelectric generator(110), and a piezoelectric generator(112). The transformer converts electric energy which is provided from the outside into DC energy. The transformer converts DC energy which is stored in the battery and supplies electric energy to the outside. The battery stores DC energy which is provided from the electric energy generator or the transformer. COPYRIGHT KIPO 2013 null [Reference numerals] (100) Electric car; (102) Electric energy generator; (104) Micro wind power generator; (106) Solar power generator; (108) Vibration generator; (110) Thermoelectric generator; (112) Piezoelectric generator; (114) Transformer; (116) AC/DC converter; (118) DC/DC converter; (120) Sensor; (122) Controller; (124) Battery
WIRELESS MEASUREMENT SYSTEM CAPABLE OF CONTINUOUS POWER SUPPLY USING ENERGY HARVEST	21.05.2013; KR101264041		KANG, JUNG MIN	PURPOSE: A wireless measurement system is provided to prevent temporary interruption of measurement data transmission due to blackout or replacement through continuous power supply using energy harvest. CONSTITUTION: A wireless measurement system includes a measurement sensor(10) and a measurement module(100). The measurement sensor measures physical values of a measurement target instrument. The measurement module consists of a data processing unit(110) and a power supply unit(120). The power supply unit generates thermal energy or kinetic energy generated in the measurement target instrument, converts into electric energy itself and supplies to the data processing unit. The data processing unit converts measurement data transmitting from a plurality of wireless sensors into a wireless signal and transmits the wireless signal. The measurement module is located in an outer side of an engine cylinder of a moving object being as a measurement target instrument or is located in a driving shaft of a moving object or in a piston inside of the engine cylinder. COPYRIGHT KIPO 2013 null [Reference numerals] (10) Measurement sensor; (111) Signal processing unit; (112) A/D converting unit; (113) Data transmitting unit; (121) Thermoelectric element and piezoelectric element; (122) Power charging unit

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
GEOTHERMALLY-COOLED SOLAR THERMOELECTRIC ENERGY HARVESTER	16.05.2013; US20130118543	Kim Kyoung Joon	Kim Kyoung Joon	A solar thermoelectric generator (STEG) is disclosed. A STEG includes a thermoelectric generator (TEG) configured to convert light energy from solar light into electrical energy, and a heat transfer structure coupled to the TEG where a portion of the heat transfer structure is configured to be embedded in the earth. The TEG includes a first side and a second side, wherein the solar light is incident on the first side of the TEG and the heat transfer structure is configured to provide cooling for the second side of the TEG using geothermal cooling. The use of geothermal cooling to provide cooling for the second side of the TEG increases the temperature difference across the TEG of the STEG, thereby increasing the net generation efficiency of the STEG.
ENERGY HARVESTER, CAPABLE OF IMPROVING A HEAT COOLING EFFECT OF A STRUCTURE RADIATING HEAT	20.12.2006; KR101222005		KIM, JAE EUN	PURPOSE: An energy harvester is provided to convert thermal energy and vibration energy into electric energy by being installed in a structure generating energy and heat at the same time. CONSTITUTION: A thermoelectric module(20) converts thermal energy received from a vibration-heat radiation source(50) into electric energy. The thermoelectric module comprises a n-type semiconductor, a p-type semiconductor, and a heat radiation unit(25). The heat radiation unit electrically connects the n-type semiconductor and the p-type semiconductor. A vibration module(10) converts vibration energy received from the vibration-heat radiation source into the electric energy. The vibration module comprises a plurality of cantilevers(11) and an additive mass(12). COPYRIGHT KIPO 2013 null
FSYSTEM AND METHOD FOR THERMAL PROTECTION OF AN ELECTRONICS MODULE OF AN ENERGY HARVESTER	13.12.2012; US20120312345	Ward Marcus S.	Ward Marcus S.	A thermoelectric energy harvesting system may include a thermoelectric generator and an electronics module. The thermoelectric generator may produce a voltage in response to a temperature difference across the thermoelectric generator and generate power when coupled to a load. The system may include a housing mounted on top of the thermoelectric generator. The housing may include a cavity containing the electronics module. The electronics module may condition the power generated by the thermoelectric generator. The cavity may be enclosed by an inner surface of the housing. A radiation shield may cover at least a portion of the inner surface and may block radiative heating of the cavity from the housing.
Self-optimizing energy harvester using generator having a variable source voltage	13.12.2012; US20120313612	Schneider Leif E.	Schneider Leif E.	A self-optimizing energy harvester comprises a thermoelectric generator coupling to a thermal source, producing a source voltage greater than a minimum start-up voltage, where the thermoelectric generator drives a boost circuit and a feedforward circuit, delivering power to a load. A conventional boost circuit has a maximum output power only at the input voltage for which a fixed set point resistor is chosen. The feedforward circuit dynamically optimizes the boost circuit according to a dynamic set point resistance, thus increasing output power for a wide range of input voltages, relative to using a fixed reference resistor. The dynamic set point resistance is the sum of a variable resistance and a reference resistance. A sample element forms a differential voltage between the source and input voltage elements, and the variable resistance corresponds to the differential voltage. A reference resistor is chosen to establish the minimum start-up voltage

Exhibit 1 lists some of the patents related to energy harvesting using thermoelectric element.

Picture Credit: Frost & Sullivan

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