TECHNICAL INSIGHTS

SENSOR

TECHNOLOGY ALERT

25th April 2014

1. HEADSET FOR MONITORING BRAIN ACTIVITY

Monitoring of brain waves has various emerging or potential applications in healthcare, gaming, and consumer electronics. The brain waves are electrical activity recorded as voltage fluctuations within the neurons in the brain. The recording of the electrical activity is used in electroencephalography (EEG), which is done by placing multiple electrodes on the scalp. In healthcare, the electrical activity is monitored mainly to diagnose epilepsy, as well as coma, sleep disorders, and other situations. It is also used to monitor the functioning of brain in intensive care units (ICUs).

In a collaborative effort between Switzerland-based medical research, design and commercialization company, NeuroPro, the Belgium-based research organization, Imec; and the Swiss innovation house Creaholic, an innovative EEG headset has been developed. The headset, NeuroTrail, combines clinical quality EEG with a user friendly design that can provide real-time wireless monitoring of the brain waves.

The headset was designed by Creaholic and enables recording of a high-quality EEG with a low setup time. The headset is also able to fit a wide variety of head sizes and shapes where individual electrodes can be easily moved based on the requirement. The headset can record brain waves without using gel that has been traditionally used for EEG. The data collected is wirelessly transmitted to a smart phone or tablet for analysis and representation. It leverages cloud computing technology for the analysis and NeuroPro's data visualization technology. The data acquisition technology is based on Imec's wireless EEG platform that has low-power consumption. The system consists of 8-channel monitoring chipset where each channel contains two active electrodes. NeuroTrail uses patented algorithm for predicting seizures in real-time by using the EEG signals as input.

The reduced set up time of the EEG monitoring headset is expected to create new opportunities in ambulatory monitoring, home monitoring of patients, as well as consumer applications. For instance, developers can create

gaming applications where characters can be controlled using brain waves. This can lead to a new dimension of immersive gaming, which can surpass the experience provided by gesture recognition technologies. In healthcare, apart from predicting the occurrences of seizures, the device can be used for cognitive analytics to understand how the brain responds to various stimuli. It can also enable patients affected by paralysis or other diseases to communicate in a more efficient way using brain computer interfaces.

Neuropro is currently looking for partners that can help in further developing the headset for specific applications. Even though medical applications remain at the forefront as potential application for the NeuroTrail headset, consumer applications has a lot of potential in the medium- to long-term.

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2. DEVICE FOR LESS EXPENSIVE DETECTION OF ANTHRAX

Anthrax is a disease that can cause serious and fatal illness to both animals and human beings. It is caused by the bacteria *Bacillus anthracis (B.anthracis)* that is present worldwide. The bacteria can form endospores, which can survive extreme harsh conditions for decades and even centuries. Since the bacteria is normally present in the soil it enters animals mainly during grazing. Humans can contract the disease by inhaling *B.anthracis*, consuming contaminated meat, as well as through skin contact. The disease can be fatal if not treated early.

Currently, to detect anthrax- infected animals, samples are required to be transferred to laboratories for analyzing. Laboratory staff are also exposed to risks as they deal with the endospores. Most farmers in less developed countries are not able to conduct this diagnostic test, as normally it cost about $30. This high cost of testing deters the farmers from going for the test even if they suspect infection of cattle. This leads to the risk of cattle deaths as well as humans contracting the disease.

Sandia National Laboratories, which is managed by Sandia Corp., a subsidiary of Lockheed Martin Corp., USA, and operates as a contractor for the US Department of Energy (DOE)'s National Nuclear Security Administration, has developed a credit-card-sized anthrax detector using a microfluidics platform that can enable safe, fast, and cheap detection of the deadly *B.anthracis* bacteria. This device, known as *Bacillus anthracis* Diagnostic (BaDx), promises to bring down the cost of diagnostics test to about $5 to $7, which will be more affordable to users worldwide.

The device does not require any battery to operate. It is immune to a wide range of temperature and is able to detect minute quantity of endospores. It can detect the presence of *B.anthracis* even when only 100s of endospores are present while currently available methods require a much larger quantity of endospres (about 1 million) to give a positive detection. A trained technician is required to operate the device. The device contains selective growth media, which amplifies the *B.anthracis* when introduced into an amplification chamber. A lateral flow assay is used for the detection of the bacteria, which is done using magnetically operated valves. A change is color determines the presence of the bacteria. After the testing is completed, a chemical process can be implemented to sterilize the device. It can also be sealed and closed so that the live bacteria cannot be extracted and misused.

The researchers are currently working on improving the lateral flow assay. The device has been tested by the Department of Internal Medicine of the University of New Mexico. The development of the device was funded by the Laboratory Directed Research & Development Program of Sandia. The technology has been licensed to a New Mexico-based company, Aquila, which will commercialize the BaDx. There is key potential for this device to be used by both governmental agencies as well as farmers.

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3. SURFACE ACOUSTIC WAVE-BASED SWITCHGEAR MONITORING SENSORS

Switchgear is one of the most important components for electric power distribution systems. It comprises electrical disconnect switches, fuses, and circuit breakers that serve as a key control point for distribution. An increase in load results in the rise of temperature of these components, developing hotspots, which is an indicator of incipient fault. The development of hot spots can lead to corrosion and if timely action is not taken it can lead to switchgear failure. Switchgear failure is a major reason for power outages and often causes injury to personnel because of flashing. The need for switchgear monitoring is gaining more significance as the demand for electricity has increased multifold, and also due to the aging of components. Even the financial costs associated with a single event of failure can be high. Thus, efficient, reliable, and continuous monitoring of switchgear equipment is crucial.

Conventional methods of measuring the temperature in switchgear include wired sensors and infrared imaging techniques. Although infrared imaging can provide wireless monitoring, it is not typically used for continuous temperature measurement. Wired systems have their own limitations as various problems such as arcing and flashover issues arise with them.

IntelliSAW (United States) has come up with a passive sensor system for monitoring switchgear. The company's IS485 platform enables multiple sensors (up to 48) based on surface acoustic wave (SAW) technology to provide temperature-related information of key areas such as input bus bars, input and output connections of switch or breaker, and output cable connections. The sensors do not require any external power supply and can withstand high temperatures up to 150 degrees C, making them maintenance free. Its operating range of -25 degrees C to + 125 degrees C provides enough buffer as switchgear equipment is generally shutdown after it crosses the 100 degrees C mark. These sensors are also immune to arcing issues and can be implemented like a plug and play device. The IS485 is compatible with multiple protocols such as RS485, CAN, Modbus & IEC 61850, and thus can be easily integrated with various SCADA (Supervisory Control and Data Acquisition) systems.

IntelliSAW's temperature sensing solution consists of a reader (radio frequency transceiver) electromagnetically linked to the SAW sensor elements. This reader emits a radio frequency (RF) signal, which when received by the

sensor antenna activates the sensor. Interdigital transducers present on the sensor induce a surface acoustic wave whose resonant frequency is affected by temperature. The receiver part of the reader measures this change in frequency to determine the temperature of each sensor. Thus, the sensor part of the system draws its power from the RF signal provided by the reader. The reader part only requires either 5 V direct current (DC) or 24 V DC external power to operate.

The most prominent application of the system is in switchgear monitoring. The system can also be potentially modified to monitor overhead and underground transmission lines. By having such continuous monitoring facilities, the envisioned smart grid can be realized.

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4. RECENT PATENTS IN THE FIELD OF LEVEL SENSORS

Level sensors generally refer to sensors that detect the level of liquids, granules, slurries, and powders. Level sensors are vital in process industries, including, water management, pharmaceuticals, packaging, and food and beverage. Level sensors are generally of two types: continuous and discrete point. While point level sensors determine whether the level of the targeted substance is above or below a specified level and can mark the height of a single discrete liquid, continuous level sensors determine the exact level of the targeted substance within a specified range and can allow for the level of the media to be known at all times.

Key technologies used for point detection include magnetic, pneumatic or conductive sensors. For continuous measurement, technologies such as magnetoresistive, hydrostatic pressure, gamma rays (nuclear) based sensors are used. Ultrasonic (which emit acoustic waves), capacitive, microwave, and optical sensors can be used for both point detection, as well as, continuous detection. In applications such as automobiles, fuel level sensors are used, which are required to be highly robust.

Exhibit 1 lists some of the recent published patents related to level sensors.

Areas of interest include fluid level sensors, capacitive level sensors, and acoustic liquid level sensors.

PATENT TITLE	PUBLICATION DATE / NUMBER	APPLICANT/ ASSIGNEE	INVENTORS	ABSTRACT
SENSOR SYSTEMS FOR MEASURING AN INTERFACE LEVEL IN A MULTI-PHASE FLUID COMPOSITION	03.04.2014; WO/2014/051989	GENERAL ELECTRIC COMPANY	SURMAN, Cheryl, Margaret	A sensor includes a resonant transducer, the resonant transducer being configured to determine the composition of an emulsion. The composition of the emulsion is determined by measuring the complex impedance spectrum values of the mixture of the emulsion and applying multivariate data analysis to the values.
FLUID LEVEL SENSOR AND RELATED METHODS	27.03.2014; US 20140085363	Van Brocklin Andrew L	Van Brocklin Andrew L	In an embodiment, a fluid level sensor includes a sensor plate and a current source. The fluid level sensor also includes an algorithm to bias the current source such that current applied to the sensor plate induces a maximum difference in response voltage between a dry sensor plate condition and a wet sensor plate condition.
ADHESIVE DISPENSING DEVICE HAVING OPTIMIZED RESERVOIR AND CAPACITIVE LEVEL SENSOR	20.03.2014; US 20140076923	NORDSON CORPORATION	Clark Justin A.	An adhesive dispensing device includes a heater unit for melting adhesive, a fill system communicating with a receiving space for feeding the heater unit, and a reservoir for receiving melted adhesive from the heater unit. The dispensing device also includes a capacitive level sensor located along a sidewall of the receiving space such that the level of adhesive in the receiving space can be detected by sensing the difference in dielectric capacitance where the adhesive is located compared to where air acts as the dielectric. The size of the driven electrode produces a broader sensing window capable of generating multiple control signals corresponding to different fill levels of adhesive. The receiving space and reservoir are minimized in size so that adhesive is not held at elevated temperatures long enough to char or degrade

PATENT TITLE	PUBLICATION DATE / NUMBER	APPLICANT/ ASSIGNEE	INVENTORS	ABSTRACT
ACOUSTIC FLEXURAL ORDER LEVEL SENSOR	20.03.2014; WO/2014/043356	STREET SMART SENSORS LLC	KNOWLES, Terence, J.	A liquid level sensor includes a rod having a first portion and a second portion, and a wave generation unit affixed to one end of the rod. The wave generation unit generates a wave group that propagates in at least a shear order and a flexural order, and the frequency of the shear wave is based on the diameter of the rod.
FUNNEL WITH LEVEL SENSOR	06.03.2014; US 20140060698	TENNISON Tamara L	TENNISON Tamara L	A funnel for transferring a flowable ingredient into a receiving container and which indicates the level of the flowable ingredient in the receiving container. The input end of the funnel extends downwardly to the output end which has a smaller circumference than the input end. At least one sensor is located on the outer surface of the funnel body adjacent to the output end with each sensor located at a different distance from the input end. As the flowable ingredient fills the receiving container, the flowable ingredient is sensed by each sensor which then activates a display to provide an indication of the level of the flowable ingredient in the receiving container, with the final indication being that the receiving container is full. The final indication causes the output end to seal such that transfer of the flowable ingredient is stopped.

PATENT TITLE	PUBLICATION DATE / NUMBER	APPLICANT/ ASSIGNEE	INVENTORS	ABSTRACT
SYSTEM FOR MEASURING MATERIAL LEVELS USING CAPACITANCE AND TIME DOMAIN REFLECTOMETRY SENSORS	20.02.2014; US 20140049274	Hafer Kevin G.	Hafer Kevin G.	An apparatus and system for measuring levels of two or more materials maintained within a storage tank using a combination of both a capacitance sensor and a time domain reflectometry ("TDR") waveguide sensor is disclosed. The apparatus includes a combined circuit for the capacitance sensor and TDR sensor that creates a separation between the return signal from the capacitance sensor and the TDR sensor. The need for the return signal separation is due to the generation of false reflection signals from the capacitance circuitry. In a preferred embodiment, the separation in time is created by moving the capacitance false reflections further in time than the true signal returns. An alternative preferred embodiment would delay the true TDR signals passed the capacitance false reflections. Another alternative preferred embodiment would provide a substantially matched impedance of the capacitance circuit to the TDR circuit, to substantially eliminate the false reflections.
FAULT DIAGNOSIS DEVICE FOR FUEL LEVEL SENSORS AND FAULT DIAGNOSIS METHOD FOR FUEL LEVEL SENSORS	06.02.2014; WO/2014/021136	NISSAN MOTOR CO., LTD.	TAKAHASHI, Akio	A fault diagnosis device for fuel level sensors, for detecting fuel remaining in a fuel tank provided with at least a first tank and a second tank, comprises a area determination means for determining, on the basis of fuel level sensor output values, a fuel residual area divided in accordance with output characteristics of a fuel level sensor, and a area fault diagnosis means for diagnosing faults in a fuel level sensor for each area by comparing the amount of fuel consumed from when the area changed and a fault determination threshold set separately for each area. The area fault diagnosis means sets the fault determination threshold to the value corresponding to the fuel consumption equivalent required for exiting a dead zone area in the dead zone area, in which the change in fuel level sensor output values is smaller when the fuel consumption source switches from the first tank to the second tank.

Exhibit 1 lists some of the recent published patents related to level sensors.

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