SMART CITY - STEP ON ME AND I'LL WARN YOU!

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ABSTRACT

Researchers from the Civil Engineering Department of the University of Alicante, in collaboration with the company ACCIONA Construcción S.A., have developed an innovative system that warns of the presence of an object and/or individual close to a certain area by emitting an acoustic and/or light signal. The device is capable of receiving an electrical signal from a conductive cement-based material which, when pressure is applied to it, the cement material itself acts as an electrical switch.

This innovative device has multiple applications in the intelligent sensorization of civil infrastructures, such as: lighting, traffic lights, etc., thus contributing to the sustainable development of the Smart City concept.

We are looking for companies interested in acquiring this technology for its commercial exploitation



INTRODUCTION

Multifunctional cementitious conductive materials consist of concrete, mortars and pastes containing conductive fibers or particles (usually based on carbon or metals) that increase the electrical conductivity of the final material to make it viable for the development of new applications.

Among the interesting technical features of conductive cementitious materials, the following stand out:

- The perception of deformation.
- The perception of structural damage.
- Electromagnetic wave shielding.
- Thermal insulation (room heating or frost protection).
- Electrochemical chloride removal.
- Cathodic protection.
- Other...

The perception of the deformation of a material is understood as the change in the unit variation of the electrical resistivity in volume, which is proportional and reversible to the stress to which it is subjected. If the applied stress is compressive, the electrical resistance in longitudinal direction decreases. On the other hand, if the stress is tensile, it increases in a similar way. In the elastic regime, both responses are reversible, so that the electrical resistance recovers its initial value when the applied stress ceases. This effect, in the case of conductive cementitious materials, could be applied, for example, for structural control or for load control (vehicles or people).

For the perception of deformation to be of sufficient magnitude and reversible, the addition of electrically conductive particles to the cementitious matrix is necessary. In this case, it is not necessary for the added material to form a continuous conductive

path through the material for strain sensing to be effective

TECHNICAL DESCRIPTION

The present invention consists of a device capable of receiving an electrical signal from a conductive cement-based material (pastes, mortars and concretes) which, due to **changes in electrical resistivity when pressure is applied**, pre-amplifying and transforming it, allows **the cementitious material itself to act as an electrical switch.**

With the measurement of the deformation of the cementitious material, new applications can be developed, including, for example, providing the traffic network of a city with **smart materials** that warn drivers that a pedestrian is approaching a sidewalk with the intention of crossing the road (Smart City concept).

In this sense, **a switch system has been developed that warns of the presence of an object and/or individual close to a certain area by emitting an acoustic and/or light signal.**

This switching system (*see Figure 1*) consists of, at least:

- A sensor whose electrical resistance changes when subjected to mechanical stress or strain. This **piezoresistive pressure sensor** is prismatic in shape and is located adjacent to the area of interest.
- A **cementitious composite** consisting of cement, aggregates, water, additives, and a hybrid mixture of carbon nanotubes and expanded graphite that is configured to provide the first electrical output signal in response to the deformation of the material in which it is contained, whose signal is a function of the variation of the electrical resistivity of the material itself.
- Two **electrical electrodes** distributed in levels or layers within the same sensor, which are electrically powered from a **power supply source of direct current electrical energy** at a constant intensity.
- An **electronic evaluation circuit** that receives the first electrical output signal and provides as output, a warning signal to the target object and/or individual.
- Two **evaluating electrodes** distributed in a stacked configuration in levels or layers arranged between two layers adjacent to electrical electrodes, which are electrically connected to the evaluating electronic circuit.
- A **comparator amplifier** that receives the first electrical output signal + a reference electrical signal (from a reference electronic circuit) that provides a second electrical output signal, if certain requirements are met. This comparator circuit provides an output voltage that is used to turn on or off the warning signal provided, for example, to the vertical traffic signal associated with a zebra crossing, by illuminating it or keeping it off.

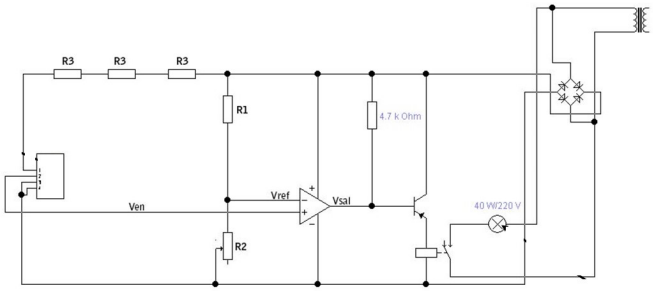


Figure 1: basic schematic of the electronic circuit capable of receiving the signal of the variation recorded in the conductive concrete and emitting a new signal. The characteristics of the electronic components vary according to the conductivity of the concrete and the type of signal to be emitted.

ADVANTAGES AND INNOVATIVE ASPECTS

ADVANTAGES OF THE TECHNOLOGY

The main advantage of this invention is the practical implementation of the theoretical concepts based on the **perception of the deformation or piezoresistivity of cement-based materials with addition of carbonaceous materials with conductive properties**.

This innovative device is characterized because it is **sustainable and environmentally friendly**.

INNOVATIVE ASPECTS OF THE TECHNOLOGY

The object of the present invention combines previous knowledge regarding the manufacture of cement-based materials (capable of sensing their own deformation) with electronic devices capable of making feasible the practical use of this property.

To date, no device has been found on the market that can **transform the variation in the electrical properties of the material into a signal** capable of being implemented in a practical application.

CURRENT STATE OF DEVELOPMENT

The technology has been successfully developed at **laboratory scale**, and is at *Technological Readiness Level* (**TRL**) = **4**.

The circuit can be designed for different types of variables and parameters.

As an example, the technical feasibility of the invention has been tested by applying 50 mA across three resistors of 75Omega to a prototype. The minimum mechanical pressure was set to 80 kg. The voltage set by the potentiometer is 1KOmega (minimum 20 micro volts). A 220V 40W light bulb was activated. The whole circuit was powered by a 220V ACac input and 9Vdc output power supply.

MARKET APPLICATIONS

This innovative device allows multiple applications related to the development of **smart sensors in civil infrastructures**, such as:

- Switching on streetlights when vehicles or people pass by.
- Activating acoustic and/or light signals in the event of dangers (pedestrian crossings, over-heavy vehicles, etc.).
- Modifying the sequencing of traffic lights according to the flow of vehicles.
- Activate safety systems installed in traffic lanes.
- Other applications of interest....

Thanks to the development of electronic devices for the reception and transformation of the signal received as a result of the **variation in the electrical properties of the material**, it is possible to subsequently use it as an open/closed circuit in different practical applications.

These applications are included in the Smart City concept.

COLLABORATION SOUGHT

Companies interested in acquiring this technology for **commercial exploitation** through **utility model licensing agreements** are sought.

Company profile sought:

- Manufacturers of smart sensors.
- Manufacturers of multifunctional conductive cementitious materials

INTELLECTUAL PROPERTY RIGHTS

This invention is protected by a **utility model application**:

- *Utility model title: "Un sistema conmutador de aviso".*
- *Application number: U202132323.*
- *Application date: 23th November, 2021.*

MARKET APPLICATION (2)

TECHNICAL IMAGES (1)

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