Development of a Self-powered Weigh-in-Motion System

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19ITSUTSA01

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$49,943

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Tran-SET
University of Texas at San Antonio

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$99,886

Developing a piezoelectric-based self-powered weigh-in-motion system

This study further develops a roadside piezoelectric energy harvesting system. The basic sensing element is a stack of 6 piezoelectric disks, 1-inch in diameter, connected in parallel. A set of 4 of these stacks supports a metal load carrying plate installed flush with the pavement surface. These piezo stacks exhibited a linear voltage versus stress behavior that is relatively independent of loading frequency. This will allow estimating of axle loads. At the same time, these 4 piezoelectric stacks generate very high voltages (i.e., 100 Volts for a car axles and 800 Volts for a truck axle) but relatively low amperages (i.e., 10-100 mA depending on load level). The electrical power generated is sufficient to keep the rechargeable batteries on site sufficiently charged to power at 3.3 V a microprocessor with a power consumption of 0.4 µA "dormant" and 40 µA "awake" (e.g., Analog Devices ADuCM4050). This dual-role for the piezo-stacks developed represents a leap forward in weigh-in-motion (WIM) technology. It will allow the development of a low cost WIM system that can operate off the electrical grid. This will provide state agencies a much better informed picture of the utilization of their roadway and bridge infrastructure.

Problem Statement

Traditional systems for weighing and classifying vehicles in-motion involves fixed weigh-in-motion (WIM) systems that cost at about $80k per lane. They are based on PC technology that requires access to electric and telephone grid to operate and transmit the data. These installations are expensive to install and as a result, State DOT can afford operating only few of them. Texas, for example, has fewer than 40 state-wide. New low-power microprocessors powered by piezoelectric elements can revolutionize this type of traffic data collection. Using the same piezoelectric elements for sensing the load can provide a self-sustained WIM system that can operate independently of the power grid.

Objectives

The objective of the proposed study is to develop a self-powered weigh-in-motion system. Conventional WIM systems collect traffic load data essential for mechanistic-empirical pavement design. They are PC-based, require electrical network connections and are very capital and maintenance demanding. Developing an inexpensive WIM system is challenging It involves the following research tasks:

Task 1: Laboratory evaluation of the output of the four piezo-stacks already developed.

Task 2: Use FEM simulations to design and CAM technology to manufacture a metal enclosure with its top lid supported in each corner by one of the piezo stacks developed.

Task 3: Develop the electronic interface that will condition and convert the electrical output of the four piezo-stacks into two elements.

Task 4: Select a low power microprocessor for data acquisition and develop the software necessary for vehicle classification and axle load weighing.

Task 5: Field test the prototype system developed by arranging a full-scale demonstration.

Task 6: Implementation will focus on technology transfer (T2).

Intended Implementation of Research

Education and Workforce Developments: the following educational activities will be pursued as part of this project:

- A final report
- A presentation at the annual Tran-SET conference
- Communication of the capabilities and the cost effectiveness of the WIM system developed to decision-makers at various governmental levels as described in the following T-2 plan.
- A peer-review journal publication (ASCE or Elsevier)

- Workforce development through material to be incorporated into graduate student training (e.g., courses CE 5423 and CE 5723).

Anticipated Impacts/Benefits of Implementation

Anticipated impacts of the project output have not been determined at this time. They will be reassessed at the end of the technical phase.

Web Links

- TranSET's website (https://transet.lsu.edu/research-in-progress/)
- TRB's Research in Progress (RIP) database (https://rip.trb.org/View/1644427)

Tran-SET

Tran-SET is Region 6's University Transportation Center. It is a collaborative partnership between 11 institutions (see below) across 5 states (AR, LA, NM, OK, and TX). Tran-SET is led by Louisiana State University. It was established in late November 2016 "to address the accelerated deterioration of transportation infrastructure through the development, evaluation, and implementation of cutting-edge technologies, novel materials, and innovative construction management processes".

Learn More

For more information about Tran-SET, please visit our website, LinkedIn, Twitter, Facebook, and YouTube pages. Also, please feel free to contact Mr. Christopher Melson (Tran-SET Program Manager) directly at transet@lsu.edu.