Accepted Manuscript

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PII: S0360-5442(17)31674-2

DOI: 10.1016/j.energy.2017.10.005

Reference: EGY 11647

To appear in: *Energy*

Received Date: 3 November 2016

Revised Date: 26 September 2017

Accepted Date: 2 October 2017

Please cite this article as: Jasim A, Wang H, Yesner G, Safari A, Maher A, Optimized design of layered bridge transducer for piezoelectric energy harvesting from roadway, *Energy* (2017), doi: 10.1016/ j.energy.2017.10.005.

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Optimized Design of Layered Bridge Transducer for Piezoelectric Energy Harvesting from Roadway 3

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ABSTRACT: This study aims to develop a novel design of piezoelectric transducer with the 11 optimized geometry that is targeted for energy harvesting in roadway under vehicular loading. 12 The Bridge transducer with layered poling and electrode design is proposed to enhance energy 13 output. Finite element analysis (FEA) was conducted to predict energy output and stress 14 15 concentration in the transducer. Multi-physics simulations were conducted to evaluate energy outputs using different lead zirconate titanate (PZT) materials, loading magnitudes, transducer 16 types, and geometry parameters. The optimum configuration of transducer geometry was 17 evaluated considering the balance between energy harvesting performance and mechanical 18 failure potential due to stress concentrations. The novel design of Bridge transducer with layered 19 poling and electrodes produces much greater energy than the traditional bridge and Cymbal 20 transducer. The results show that within the failure stress criteria, the optimized design of Bridge 21 transducer produced an electrical potential of 556V, which could result in 0.743mJ of potential 22 energy (open circuit condition) for a single transducer under the external stress of 0.7MPa. 23 Laboratory testing on energy harvester module showed that simulation results agreed well with 24 the measured power. 25

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KEYWORDS: Bridge Transducer; Piezoelectric Energy Harvesting; Finite Element Analysis;
Geometry Optimization

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30 NOMENCLATURE

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А	Surface area of PZTceramic element (m^2)
С	Capacitance of the material (Farads)
D	Electric displacement tensor (charge/area)
d _{ij}	Piezoelectric charge constant (pC/N)
E	Electric field (V/m)
g _{3i}	Piezoelectric voltage constant of PZT (10 ⁻³ V m/N)
k	Electromechanical coupling factor
L _c	Total width and length of Piezoceramic (mm)
L _i	Inner length of the end cap (mm)
Lo	Length of the cavity base (mm)
n	number of segments between electrodes
P ₃	Piezoelectric polarization at the 3rd axial direction
S	Strain tensor
S^{E}_{ij}	Elastic Compliance tensor at the constant E condition $(10^{-12} \text{ m}^2/\text{N})$
T, T _i	Stress tensor (MPa)

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