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MAXIMIZING OUTPUT VOLTAGE OF A PIEZOELECTRIC ENERGY HARVESTER VIA BEAM DEFLECTION METHOD FOR LOW-FREQUENCY INPUTS

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Abstract

In micro-scale energy harvesting, piezoelectric (PZT) energy harvesters can adequately convert kinetic energy from ambient vibration to electrical energy . However, due to the random motion and frequency of human motion, the piezoelectric beam cannot efficiently harvest energy from ambient sources. This research highlights the ability of piezoelectric energy harvester constructed using a PZT-5H cantilever beam to generate voltage at any input frequency from human motion. An eccentric mass is used to convert the linear motion of human movement to angular motion. Then, using a magnetic plucking technique, the piezoelectric beam is deflected to its maximum possible deflection each time the eccentric mass oscillates past the beam , ensuring the highest stress is induced and hence the highest current is generated. For testing works, the frequency of oscillation of the eccentric mass is controlled using an Arduino Uno microcontroller. In this work, it is found that when given any input frequencies, the energy harvester produced a consistent AC voltage peak around 5.8 Vac. On the other hand, the DC voltage produced varies with respect to the input frequency due to the number of times the peak AC signal is generated. The highest DC voltage produced in this work is 3.7 Vdc, at 5 Hz, which is within the frequency range of human motion. This research demonstrated that energy can still be effectively harvested at any given low-frequency input , in the condition that the piezoelectric beam is being deflected at its maximum

Author keywords

Energy harvesting; Magnetic plucking; Piezoelectric ; Random frequency

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1 Pillatsch, P., Yeatman, E.M., Holmes, A.S.

A wearable piezoelectric rotational energy harvester

(2013) *2013 IEEE International Conference on Body Sensor Networks, BSN 2013*, art. no. 6575470. Cited 23 times.
ISBN: 978-147990330-6
doi: 10.1109/BSN.2013.6575470

View at Publisher

2 Azam, H., Hanif, N.H.H.M., Ralib, A.A.M.

Magnetically plucked piezoelectric energy harvester via hybrid kinetic motion (Open Access)

(2019) *IIUM Engineering Journal*, 20 (1), pp. 245-257. Cited 2 times.
https://journals.iium.edu.my/ejournal/index.php/iiumej/article/download/981/685/
doi: 10.31436/iiumej.v20i1.981

View at Publisher

3 Fan, P.M.-Y., Wong, O.-Y., Chung, M.-J., Su, T.-Y., Zhang, X., Chen, P.-H.

Energy harvesting techniques: Energy sources, power management and conversion

(2015) *2015 European Conference on Circuit Theory and Design, ECCTD 2015*, art. no. 7300104. Cited 7 times.
ISBN: 978-147999877-7
doi: 10.1109/ECCTD.2015.7300104

View at Publisher

4 Nguyen, S., Amirtharajah, R.

A hybrid RF and vibration energy harvester for wearable devices

(2018) *Conference Proceedings - IEEE Applied Power Electronics Conference and Exposition - APEC*, 2018-March, pp. 1060-1064. Cited 19 times.
ISBN: 978-153861180-7
doi: 10.1109/APEC.2018.8341146

View at Publisher

5 Sang, Y., Huang, X., Liu, H., Jin, P.

A vibration-based hybrid energy harvester for wireless sensor systems

(2012) *IEEE Transactions on Magnetics*, 48 (11), art. no. 6332747, pp. 4495-4498. Cited 82 times.
doi: 10.1109/TMAG.2012.2201452

View at Publisher

6 Pillatsch, P., Yeatman, E.M., Holmes, A.S.

A scalable piezoelectric impulse-excited energy harvester for human body excitation

(2012) *Smart Materials and Structures*, 21 (11), art. no. 115018. Cited 80 times.
http://iopscience.iop.org/0964-1726/21/11/115018/pdf/0964-1726_21_11_115018.pdf
doi: 10.1088/0964-1726/21/11/115018

View at Publisher

7 Ab Rahman, M.F., Kok, S.L., Ali, N.M., Hamzah, R.A., Aziz, K.A.A.

Hybrid vibration energy harvester based on piezoelectric and electromagnetic transduction mechanism

(2013) *CEAT 2013 - 2013 IEEE Conference on Clean Energy and Technology*, art. no. 6775634, pp. 243-247. Cited 19 times.
doi: 10.1109/CEAT.2013.6775634

View at Publisher

8 Fan, K., Tan, Q., Liu, H., Zhu, Y., Wang, W., Zhang, D.

Hybrid piezoelectric-electromagnetic energy harvester for scavenging energy from low-frequency excitations

(2018) *Smart Materials and Structures*, 27 (8), art. no. 085001. Cited 30 times.
http://iopscience.iop.org/article/10.1088/1361-665X/aaae92/pdf
doi: 10.1088/1361-665X/aaae92

View at Publisher

9 Anton, S.R., Sodano, H.A.

A review of power harvesting using piezoelectric materials (2003-2006)

(2007) *Smart Materials and Structures*, 16 (3), art. no. R01, pp. R1-R21. Cited 2178 times.
doi: 10.1088/0964-1726/16/3/R01

View at Publisher

10 Haitao, L., Weiyang, Q., Chunbo, L., Wangzheng, D., Zhiyong, Z.

Dynamics and coherence resonance of tri-stable energy harvesting system

(2015) *Smart Materials and Structures*, 25 (1), art. no. 015001. Cited 121 times.
http://iopscience.iop.org/article/10.1088/0964-1726/25/1/015001/pdf
doi: 10.1088/0964-1726/25/1/015001

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11 *Quantification of Arm Swing during Walking in Healthy Adults and Parkinson ' s Disease Patients: and Validation*
[11]
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5685089/

12 *Is the Relationship Between Stride Length, Frequency and Velocity Influenced by Running on a Treadmill or Overground ?*
[12]
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5685089/

13 Gu, L., Livermore, C.

Impact-driven, frequency up-converting coupled vibration energy harvesting device for low frequency operation

(2011) *Smart Materials and Structures*, 20 (4), art. no. 045004. Cited 249 times.
http://iopscience.iop.org/0964-1726/20/4/045004/pdf/0964-1726_20_4_045004.pdf
doi: 10.1088/0964-1726/20/4/045004

View at Publisher

14 Pozzi, M.

Magnetic plucking of piezoelectric bimorphs for a wearable energy harvester (Open Access)

(2016) *Smart Materials and Structures*, 25 (4), art. no. 045008. Cited 35 times.
http://iopscience.iop.org/article/10.1088/0964-1726/25/4/045008/pdf
doi: 10.1088/0964-1726/25/4/045008

View at Publisher

15 Rubes, O., Hadas, Z.

Design and Simulation of Bistable Piezoceramic Cantilever for Energy Harvesting from Slow Swinging Movement

(2018) *Proceedings - 2018 IEEE 18th International Conference on Power Electronics and Motion Control, PEMC 2018*, art. no. 8521846, pp. 663-668. Cited 7 times.
http://ieeexplore.ieee.org/xpl/mostRecentIssue.jsp?punumber=8490905
ISBN: 978-153864198-9
doi: 10.1109/EPEPEMC.2018.8521846

View at Publisher

16 Mohamad Hanif, N.H.H., Jazlan Mohaideen, A., Azam, H., Rohaimi, M.E.

Rotational piezoelectric energy harvester for wearable devices (Open Access)

(2018) *Cogent Engineering*, 5 (1), art. no. 1430497. Cited 12 times.
http://www.tandfonline.com/toc/oaen20/current
doi: 10.1080/23311916.2018.1430497

View at Publisher

17 Cheng, X., Wu, J., Lou, X., Wang, X., Wang, X., Xiao, D., Zhu, J.

Achieving both giant d_{33} and high T_c in patassium-sodium niobate ternary system

(2014) *ACS Applied Materials and Interfaces*, 6 (2), pp. 750-756. Cited 69 times.
doi: 10.1021/am404793e

View at Publisher

18 Tian, W., Ling, Z., Yu, W., Shi, J.

A review of MEMS scale piezoelectric energy harvester (Open Access)

(2018) *Applied Sciences (Switzerland)*, 8 (4), art. no. 645. Cited 35 times.
http://www.mdpi.com/2076-3417/8/4/645/pdf
doi: 10.3390/app8040645

View at Publisher

19 Gao, S., Ao, H., Jiang, H.

Properties and Performance of General Piezoelectric Materials on a Novel Cantilevered Energy Harvester (Open Access)

(2019) *IOP Conference Series: Materials Science and Engineering*, 562 (1), art. no. 012098.
https://iopscience.iop.org/journal/1757-899X
doi: 10.1088/1757-899X/562/1/012098

View at Publisher

20 *Steminc Steriner & Martins Inc*
[20]
https://www.steminc.com/PZT/en/piezo-ceramic-bimorph-40x10x05mm-2-khz

21 Piefort, V.
(2001) *Finite element modelling of piezoelectric active structures*. Cited 209 times.
[21] PhD thesis. Universit'e Libre de Bruxelles, Faculty of Applied Sciences

22 Tahir, M.S.M., Hanif, N.H.H.M., Kassim, M.H.C.
Performance Measurement of Piezoelectric Energy Harvester with Permanent Magnet Assembly for Wearable Devices

(2021) *Conference Record - IEEE Instrumentation and Measurement Technology Conference*, 2021-May, art. no. 9459994.
http://ieeexplore.ieee.org/xpl/conferences.jsp
ISBN: 978-172819539-1
doi: 10.1109/I2MTC50364.2021.9459994

View at Publisher

23 Von Büren, T., Mitcheson, P.D., Green, T.C., Yeatman, E.M., Holme, A.S., Tröster, G.
Optimization of inertial micropower generators for human walking motion (Open Access)

(2006) *IEEE Sensors Journal*, 6 (1), pp. 28-37. Cited 163 times.
doi: 10.1109/JSEN.2005.853595

View at Publisher

24 Zainal Abidin, M.A., Hazrin Hany Mohamad Hanif, N., Mohd Tahir, M.S.
Energy Storage System for Dual Energy Harvester for Wearable or Portable Devices

(2021) *Proceedings of the 8th International Conference on Computer and Communication Engineering, ICCCE 2021*, art. no. 9467243, pp. 135-139.
http://ieeexplore.ieee.org/xpl/mostRecentIssue.jsp?punumber=9467106
ISBN: 978-172811064-6
doi: 10.1109/ICCCE50029.2021.9467243

View at Publisher

25 Rhimi, M.
(2013) *Power management and damage assessment techniques for self-powered sensing based on piezoelectric*. Cited 2 times.
[25] PhD Dissertation. University of Michigan, Civil Engineering Department

26 Vishnu Sidharthan, P., Bhasker, M.U., Korla, S., Chandrasekhar, M.S.

Energy Harvesting of Synchronized Switch Harvesting on Inductor

(2018) *2018 International Conference on Recent Innovations in Electrical, Electronics and Communication Engineering, ICRIEECE 2018*, art. no. 9009273, pp. 2882-2887.
http://ieeexplore.ieee.org/xpl/mostRecentIssue.jsp?punumber=8988140
ISBN: 978-153865994-6
doi: 10.1109/ICRIEECE44171.2018.9009273

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