OPINION

for a dissertation work

for acquiring the educational and scientific degree "Doctor"

Field of higher education: 5. Technical sciences

Professional field: 5.2. Electrical engineering, electronics and automation

Doctoral Program: "Microelectronics"

Author of the dissertation: Eng. Rumyana Angelova Stoyanova

Topic of the dissertation:

"Development of innovative methods and mechanisms for Piezoelectric Energy Harvesters"

Member of the scientific jury: Assoc. Prof. Ivaylo Raychev Belovski, PhD

1. Topic and relevance of the dissertation

The European directive for the increasingly widespread use of "green" energy requires the improvement and increase in the efficiency of known RES resources and the search for new alternative sources.

Conventional energy sources in the form of fossil fuels are limited in nature and, moreover, their use leads to a deterioration of environmental cleanliness, especially in the locations of energy generating companies. On the other hand, the ever-growing need and easy accessibility of mobile devices of various nature leads to an increased use of rare earth elements, which after the end of their life cycle pose a danger to the environment if not recycled in an appropriate manner.

One of the methods for converting mechanical energy into electrical energy is the use of piezoelectric transducers (piezoharvesters).

Piezoelectric conversion is the most significant mechanism for harvesting mechanical energy due to its high electromechanical coupling coefficient and piezoelectric coefficient compared to electrostatic, electromagnetic, and triboelectric conversion.

The dissertation focuses specifically on the possibility of synthesizing a microgenerator of electrical energy based on the piezoelectric effect - the conversion of mechanical vibrations, which are insignificant or parasitic for a given process, into electrical power.

The objectives of the dissertation are clearly formulated and mainly related to: presentation of a methodology for describing a vibration harvester; development of models of monomorphic and bimorphic piezoelectric harvesters; creation of a methodology for describing a compression piezoelectric harvester; development of a model of a compression piezoelectric harvester; experimental studies of the proposed models of vibration and compression piezoelectric harvesters.

I believe that the topic discussed is extremely relevant, and the goals and objectives set have been fulfilled to the required extent.

2. Contributions of the dissertation work

I assess the contributions in the dissertation work as scientifically applied and applied. I accept the author's formulation, namely:

Scientific and applied contributions

1) Based on the considered physical and mathematical principles of operation of piezoelectric harvesters, it is suggested that piezoelectric vibrating beam harvester structures can be considered as a specific special case of piezoelectric compression harvesters;
2) Advanced equivalent circuits of a beam-type vibrating piezoelectric harvester are proposed in order to reflect the real conditions to which this type of structure may be subjected;
3) A model of a planar structure of a compression-type piezoelectric harvester has been created, which reflects the features of the elements that make up this device and is based on the basic principles of the resistance of materials to vertical and horizontal forces. A parallel electrical connection between the individual elements of the compression harvester is proposed on a reasonable assumption - the serial electrical connection of elements in this case is not suitable, since in order to generate a signal for the entire matrix, all its elements must be subjected to mechanical pressure simultaneously;
4) It is proposed to include a rectifier part in the measurement circuits, assessing the amount of energy acquired by the harvesters due to obtaining the variance of the experimental results obtained for the obtained AC power;
5) Two variants of a planar design of a compression piezoelectric harvester and a methodology for their study are proposed. The studies prove that the vertical force of intermittent (impact) nature achieves better efficiency compared to the continuous (horizontal-rotational) impact, which correlates with the model proposed in the third chapter.

Applied contributions:

1) In connection with the development of compression piezoelectric harvesters, a design has been created for more efficient energy harvesting by reducing the distance between the active elements of the harvester;
2) The adequacy of the used measurement schemes of the AV and VA types, as well as the combination between them, has been assessed. The results for the DC part show a high degree of convergence, which proves the correctness of the use of a rectifier part in the experimental setup.

3. Publications and citations of the dissertation

The author presents a total of five scientific publications on the dissertation work . The results of the scientific research work have been published in collections of reports from international scientific conferences – X Nationa l Conference “ELECTRONICA 2019”; 13th National Conference with International P articipation “Electronica 2022”; XXXI International Scientific Conference Electronics (ET); UNITECH' 2019; UNITECH' 2022. Three of the

reports are in collections, refereed and indexed in the world-renowned SCOPUS database. 2 citations have also been noted so far.

Eng. Stoyanova also declared participation as a reviewer of two reports in an international scientific conference, refereed and indexed in the world-famous SCOPUS database.

4. Abstract

After reading the abstract, I believe that its limited volume sufficiently presents the most essential part of the dissertation work, which allows for an assessment of its relevance, problems, and also the proposed methods for research and modeling of piezoelectric energy harvesters.

5. Critical notes on the dissertation

I have no substantive comments on the dissertation. I would recommend the author to continue his research work in the field of devices and algorithms for efficient generation of electrical power from piezoelectric transducers. I also hope that the next scientific publications of Eng. Stoyanova will also find a place in scientific publications with an impact factor or impact rank.

6. Conclusion

My assessment of the presented dissertation is **positive**. I believe that the dissertation **meets** the requirements of the Act on the Development of the Academic Staff in the Republic of Bulgaria, the Regulations for its implementation, as well as the Regulations for the Acquisition of Scientific Degrees and Occupancy of Academic Positions at the Technical University of Gabrovo. The achieved results give me reason to propose that the educational and scientific degree **"Doctor"** be acquired by **Eng. Rumyana Angelova Stoyanova** in the field of higher education - 5. Technical Sciences, Professional Direction - 5.2. Electrical Engineering, Electronics and Automation, Doctoral Program: "Microelectronics".

Signature: /signature/

27.12.2024 /Assoc. Prof. Ivaylo Belovski, PhD/