R E V I E W

of a dissertation for the acquisition of the educational and scientific degree "Doctor"
in the field of higher education "Technical Sciences",
professional field 5.2 "Electrical Engineering, Electronics and Automation"
specialty "Microelectronics"

Author of the dissertation: Eng. Rumyana Angelova Stoyanova

Topic: "Development of innovative methods and mechanisms for energy piezoharvesters"

Reviewer: Assoc. Prof. Dr. Eng. Nikola Draganov Draganov,
Technical University of Gabrovo

1. Topic and relevance of the problem developed in the dissertation in scientific and applied terms

One of the main trends in modern technologies is the saving and obtaining of electricity, so necessary for every field of technology. The development of technologies and in particular functional electronics has allowed the creation of various alternative low-power sources of electricity, which, despite their low power, some of them can provide the necessary power supply for various primary converters or sensor systems.

The growing interest in energy piezoharvesters and piezostructures is due, on the one hand, to the increased production, as a result of demand, of elements and materials, and, on the other hand, to their easy production and the possibility of varying dimensions, spacings and shapes, which allow their incorporation into various structures.

The topic of the dissertation submitted to me for review is dedicated to the development of innovative methods and mechanisms for energy piezoharvesters, which determines its relevance, both from a scientific and an applied aspect. The dissertation is arranged in 160 printed pages, containing four chapters, illustrated with 180 figures and 76 tables, table of contents and bibliography.

2. Review of the cited literature. Degree of knowledge of the state of the problem and creative interpretation of the literary material

The literature review is extensive and corresponds to the topic of the dissertation. The literature review reflects a total of 200 literary sources (?), of which only 6 are by Bulgarian authors, and 132 are links on the Internet. Three (3) of the sources indicated in the literature review are with the participation of the author. Part of the literary sources (about 65) are visible in world databases.

The analysis of the described literary sources shows that they are from the last ten years. Only 3% (six issues) of those mentioned are by Bulgarian authors. Links to Wikipedia.org (148, 149, 153, 154, 163), to Pomagalo.com (150) and even websites of suppliers of electronic components such as Farnell.com (162) and Comet electronics.bg (160)

are cited, which is extremely frivolous considering the neglect of the scientific works and publications in this field of many Bulgarian scientists, including those from the Technical University of Gabrovo.

Five (5) publications related to the dissertation are presented. They are reports published in proceedings of international scientific conferences in the country, three (3) of which are indexed in Scopus. Only one (1) independent report is presented, and in the remaining four she is a co-author.

At the beginning of each doctoral student's report, the current state of the problem under consideration is briefly presented. It is striking that the style and presentation of the information presented in the articles strongly contrasts with that of the dissertation!

3. **Research methodology. Compliance of the chosen research methodology with the set goal and objectives of the dissertation work**

At the end of the first chapter of the dissertation (p. 39) the goal and objectives of the dissertation are reflected. The goal set, I quote: "-creation and optimization of existing models, as well as mathematical modeling of piezoelectric harvesters of vibration and compression type" does not correspond to the title of the dissertation, which reads "Development of innovative methods and mechanisms for energy piezoharvesters". Such a conclusion can also be drawn from the five tasks set, from which it is not unambiguously clear what the expectations are from their implementation. I quote: task one "1. A methodology for describing a vibration harvester is presented". It would be good to more seriously specify both the goal and the objectives of the dissertation.

4. **Brief analytical characterization of the nature and assessment of the reliability of the material on which the contributions of the dissertation are built**

As a rule, any work of this type begins with a literature review, which presents the problems on the topic and the achievements of the scientific community in this field. In this note, a very rich (excessive) literature review is made, which begins with the first chapter and extends at the beginning of each subsequent chapter.

The note begins with an introduction, which should emphasize the problems addressed in the dissertation work, the reasons for their occurrence, and possibly the difficulties that science faces in resolving them, i.e. how the topic of the dissertation and its goal and tasks that it must solve necessitate. In this regard, it would be good to revise the introduction of the work (even replace it with a new one, rather than using one more suitable for a diploma thesis), with its emphasis shifted to the problems of the dissertation, namely the development of innovative methods and mechanisms for piezoharvesters and the need for its setting. Now it is written in sentences like, I quote: "The constantly growing number of human beings (currently about 8 billion) requires ever-increasing amounts of resources, whether they are energy, food, social or some other kind." (p.13, line 4 from the top), and also a little further down "The growing need for resources, as well as the deteriorating ecological situation, strongly influenced by the increasing world population, determines the demand for alternative technologies and renewable resources. This is especially noticeable in the field of energy production, where methods for discovering and

exploiting alternative sources of electrical energy are being intensively developed. " or " Mechanical energy is widely distributed in the environment ... ", " Piezoelectric conversion is the most significant mechanism for collecting electrical energy ... ", etc. This should be a scientific paper in the scientific specialty "Microelectronics", which should be suggested by keywords for it. The written introduction is more like general talk about energy.

The first chapter is entitled “Literature Review of Energy Harvesters and Their Applications”. It describes in detail many methods and sources of energy. Such as electrical and mechanical energy converters, from the sun, from biomass, from wind, from tides, nuclear transmutation, thermal power plants, nuclear power plants, geothermal energy, from natural gas, gas turbines, hydroelectric generators, wind generators, vanadium flow batteries, hybrid zinc-bromine flow batteries, iron suspension batteries, etc., etc. Chapter one is “filled” with too much redundant information, the description of which should be exhausted with no more than a dozen sentences in its annotation and numbers of cited literary sources.

The main task of the dissertation candidate as a scientist is to acquire the ability to interpret and analyze information from literary sources, and not to copy it verbatim from unverified and non-reviewed sources, such as Wikipedia.org and Pomagalo.com.

Immediately before the goal and objectives of the dissertation (p. 39) there are only three sentences written, which I consider to be the only ones that are key and essential for the content of the first chapter. The entire volume of the first chapter (39 pages) would be appropriate to concentrate attention on the subject, namely piezoelectric harvesters, mentioning in a classification style the types of alternative (micro!) generators of electrical energy, the physical principles and effects used to generate piezoelectricity, the materials used for manufacturing and their properties, the known methodologies and models (mathematical and electronic-simulation) for research and description and finally, within a dozen sentences about the known applications of this type of harvesters from a scientific and practical point of view.

The chapter concludes with the goal and objectives of the dissertation, which should focus on "optimizing existing and creating new constructive and mathematical models of piezoelectric harvesters of vibration and compression type.".

The second chapter, which also begins with a literature review, is dedicated to the mathematical modeling of piezoelectric harvesters. It presents the composition of the materials, their operational characteristics, from whose parameters, by substitution in equations, the graphical dependences of the excitation amplitudes of single-layer and double-layer piezoelectric beams are obtained. The chapter also presents the mathematical description of singlelayer bimorphic and compression piezoelectric harvesters, using the Mathlab software product.

It would be good to analyze the results of the calculations obtained with Mathlab - this is the dissertation this is the scientific. Introducing the parameters into existing and well-known mathematical models and solving them with a software product does not satisfy the goal. Why are the results not described, at least - the values obtained, the nature of the characteristics, etc. It would be good if the conclusions followed exactly the descriptions

of the models developed by the doctoral student. This did not happen due to the rather messy nature of the second chapter, which is expressed in the mixing of what is known so far, described (or re-) from the cited literary sources, and what was actually done namely solving the equations with the Mathlab tool.

Chapter three is titled “Application Models and Simulation of Piezoelectric Vibration and Compression Energy Harvesters.” It begins again with a solid overview that, with a fading function, extends to its end.

The beginning of the chapter (section 3.1.1. Modeling of …) describes already known mathematical models of monomorphic singlelayer, bimorphic and compression type piezoelectric harvesters. An electrical interpretation of a compression type piezoelectric harvester in series and parallel-mixed connection is also made.

Chapter four is devoted to experimental studies of piezoelectric harvesters of vibration and compression type. The chapter starts well. Although rather incompletely, a description of the experimental setup with which the vibration tests were performed is given, and the block and electrical diagrams of the experimental setup are also shown. This is how any similar description of an experiment should begin.

However, upon a less careful examination of the images (Fig. 4.1, p. 99), one notices the incorrect naming of the main element in the experimental setup. The term “shaker” is used for it. Therefore, it is correct to use the name vibration stand.

After describing the experimental setup, it is necessary to describe the conditions under which the research is conducted - ambient temperature, humidity and air pressure, altitude, instruments and apparatus and what parameters they need to have. Then the methodology and algorithm for conducting the experiment are described, step by step. They are not a secret, but only a way to maximally illustrate the work done. Yes, it is written in item 4.2, I quote: "The research was conducted at a temperature of T=33.8 ºC, relative air humidity - 35%, altitude 392 m." But hardly all research was conducted under these conditions, and what is more important, not so much their values, but how they affect the results of the research itself, which is again not described. In this regard, the question arises whether the experiment was set up correctly and whether the results obtained from it are adequate!?

In the fourth chapter, numerous experimental studies of the above-described converters, the so-called harvesters, are presented. However, it is striking that there are no comments on the results obtained. Colored tables with many numbers, colored two-dimensional and three-dimensional graphs are shown, but none of them has been analyzed, or even commented on - what do the numbers in the table mean, why does the nature of the obtained experimental characteristics change so much, what causes their nature, but this is what is scientific, this is what is discernible, and not just to present results obtained under unknown conditions. And here, if the doctoral student knew well the properties of the materials from which the studied converters are made, he would comment on the influence of environmental parameters - temperature, humidity, pressure, altitude, noise, etc. on the parameters of the studied samples. Think about it!

Chapter four ends with conclusions (section 4.6, p. 138). The conclusions in this chapter should derive from the presented results of the experimental studies – what was done,

how it was done, under what conditions, with what, what was obtained and why it was obtained that way. Precisely, briefly and clearly. These are conclusions from conducted scientific studies – experiments, and not a story in a magazine column. The presented Analysis and Conclusion are described in a manner similar to the one described above.

5. Scientific-applied and applied contributions of the dissertation work

When presenting the contributions in a dissertation, the basic rule is that they should be stated precisely, briefly and clearly. These are the claims of the author, with which he fights for the award of an educational and scientific degree. It is normal for them to be divided into scientific, applied and scientific applied. I believe that the presented contributions can be formulated more specifically…

6. Publications and citations on the dissertation. Assessment of publications on the dissertation

The presented publications on the dissertation are five – three articles at the International Scientific Conference "Electronics" and two at the International Scientific Conference "Unitech".

One citation of an article by the author is presented.

7. Authorship of the results obtained. Degree of personal participation of the dissertation candidate in the contributions

I judge the personal contributions of candidate Rumyana Stoyanova by the number of independent publications (only one).

8. Abstract and author's reference

The content of the abstract of the dissertation is presented in a volume of 49 pages and follows the content of the note.

9. Use of the results of the dissertation in practice

No documents have been provided on the use of the results in practice.

10.Notes on the dissertation. Opinions, recommendations and notes

A large part of the remarks and recommendations are set out in point 4 of this review. Here I will point out some remarks from a technical aspect.

- It would be good to revise the introduction, even replace it with a new one, in which the emphasis would be on the main problems raised in the dissertation. Written in this way, it is more like an introduction to a thesis.
- It would be good to rewrite the first chapter and at the end to write precisely and unambiguously the purpose and tasks of the work, consistent with the title of the topic.
- All the conclusions that end the chapters do not follow the work in the respective ones, i.e. what is set, what are the problems and what has been done to solve them. In this regard, it is good to first fundamentally revise the contents of each of the chapters and then summarize and add the conclusions (conclusions).

- When presenting tables, figures or images, it is good for the texts in them to be written in Bulgarian. The Bulgarian language is, first all, national pride for every Bulgarian, especially if he is a candidate for a PhD.

- A large part of the images is too small and invisible to the naked eye. It is accepted that the size of the text (captions, numbering, etc.) in the figures, graphs and tables should be commensurate with that of the main text (±1 point).

- In many places in the introductory part and in the contents of the chapters, very long and meaningless sentences are noticeable, resulting from poor-quality translation of the texts from a foreign language.

- A very extensive literature reference is attached, which on the one hand is good, but its composition is indicative that the author has not familiarized himself with the developments on the topic by Bulgarian scientific teams. It would be good, even from a respectful point of view, for the author to familiarize himself with the Bulgarian developments and cite them.

- The literature reference also includes websites of electronic magazines and non-reviewed sources (148, 149, 150, 153, 154, 160, 162, 163, etc.), which are not good to be present in this list.

- I believe that a large part of the experimental data tables and the Matlab programs that solve the equations should be moved to a separate application.

My personal opinion after detailed and repeated acquaintance with the dissertation work can be concluded that what is presented in the note should resemble a dissertation work, consisting of a concise introduction to the topic of the dissertation, a concise overview first chapter describing a brief classification of only piezoelectric harvesters, physical principles and effects of only piezoelectric harvesters, materials for manufacturing piezoelectric harvesters, models (mathematical and electronic) of only piezoelectric harvesters, applications of only piezoelectric harvesters, unambiguously set goals and tasks. Second chapter - modeling of piezoelectric harvesters, without Matlab programs for drawing graphs (they are known), but comments and analyses of the obtained graphical dependencies, precise and clear conclusions at the end of the chapter about the achieved NEW results. Third chapter simulation studies. Chapter four applications and experimental studies (without shakers), with precise and clear comments and analysis of the results obtained. Analyses and conclusions reflecting the developed INNOVATIVE methods and mechanisms for energy piezoharvesters (read the title), what is new, what was done, how it was done, what was done with, what are the difficulties in achieving the results. Contributions or claims. Clearly and unambiguously written scientific, applied and scientific-applied contributions each with two sentences, not stories.

11.Other questions

None! I have not worked with Eng. Rumyana Stoyanova and I have no joint publications with her.

12.Conclusion with a clear positive or negative assessment of the dissertation work

The dissertation material presented to me for review has undergone significant changes since my first acquaintance with it in July 2024. As a reviewer appointed by Order of the Rector of the Technical University - Gabrovo, I take full responsibility for reflecting the real reality, taking into account the generally accepted rules for the preparation and presentation of such scientific work. The above-described remarks and omissions do not belittle the work of the doctoral student but are intended to increase the quality of the material presented by him.

I believe that the dissertation student Rumyana Stoyanova has presented her dissertation work in a different style, which she considered appropriate, which, although a little distant from the generally accepted conceptuality, illustrates her diligence and desire to achieve a positive result. Of course, behind the presented dissertation work stands the name of the doctoral student, but the responsibility of the scientific supervisor should not be forgotten. He must know and teach his doctoral student scientific behavior and the way in which he collects, analyzes and writes his dissertation work.

As a result of the above, I have sufficient grounds to confidently propose to the Honorable Scientific Jury to award the educational and scientific degree "doctor" to M.Eng. Rumyana Angelova Stoyanova in the field of higher education "Technical Sciences", professional field "Electrical Engineering, Electronics and Automation", scientific specialty "Microelectronics".

Date,
12.12.2024

Prepared by: /signature/
/Assoc. Prof. Dr. Nikola Draganov/