OPINION

By Prof. Dr. Eng. Nedyalko Todorov Katrandzhiev, Professor at UFT-Plovdiv

of dissertation for awarding the educational and scientific degree **"Doctor"**

in the field of higher education *5 Technical sciences*

professional field *5.3. Communication and computer technology*

doctoral program *"Automation of areas of the intangible field (medicine, education, science, administrative activities, etc.) ".*

Author: *mag. Eng. Stanislav Mitkov Assenov*

Topic: *"Design, research and optimization of wireless sensor nodes with low power consumption ".*

Supervisor: *Assoc. Prof. Dr. Eng. Dimitar Mihailov Tokmakov - Paisii Hilendarski University of Plovdiv.*

1. General presentation of the procedure and the doctoral student

According to the procedure mag. Eng. Stanislav Mitkov Assenov presented the following documents: request to the Rector of the University of Plovdiv for disclosure of the procedure for defence of the dissertation; CV in European format; Protocol of preliminary discussions in the Department; dissertation work; abstract in Bulgarian and English; list and copies of scientific publications on the topic of the dissertation - 8 pcs.; list of noticed citations; reference for fulfilment of the minimum national requirements; declaration of originality and authenticity of the attached documents. All documents meet the requirements and I admit the candidate for further evaluation.

2. Relevance of the topic

Wireless sensor nodes are increasingly used. Their number is constantly increasing. Their application from industrial monitoring, through the implementation of "Smart Home ", has already reached the house of the average consumer to cover personal needs. All this gives impetus to the improvement of wireless sensor nodes and solve the biggest problem for them - their power supply. There can be hundreds to thousands of sensor units in a "Smart Home" that need to be optimized so that batteries need to be replaced as rarely as possible. That is why research related to power supply and methods for optimizing the consumption of sensor nodes, is a topical issue that has not yet been solved completely.

3. Knowledge of the problem

During the development of the dissertation mag. Eng. Stanislav Mitkov Assenov referred to 165 literary sources, all of which are in Latin. Of these, 24 are articles or documentation from Internet sites. Only two publications of Bulgarian scientists have been noted. However, the large number of literature sources presupposes a good knowledge of the problem by the doctoral student and his coping with the set tasks.

4. Research methodology

Four tasks are set to achieve the dissertation goal, namely "To design, research and optimize wireless sensor nodes by applying new approaches and technological solutions leading to a reduction in their energy consumption". They are well selected and solving them would lead to the goal.

5. Characteristics and evaluation of the dissertation and contributions

I appreciate the dissertation as useful for the scientific community. Scientific and applied contributions have been achieved. The most important of them are:

Scientific and applied

- A developed and implemented energy efficient LoRaWAN protocol has been proposed, through which the consumed energy is reduced by up to 35% compared to the conventional protocol.
- A mathematical model of the energy life cycle of a battery-free wireless sensor unit has been developed.
- A simulation model of a battery-free sensor unit in the middle of MATLAB has been created.
- Innovative circuit solutions have been proposed to reduce the power consumption of LoRaWAN wireless sensor unit in low energy mode.

Applied

- The parameters influencing the energy consumed by the wireless LoRaWAN sensor nodes have been determined and proven.
- Various implementations of LoRaWAN sensor units, including battery-free IoT applications, have been designed, developed, and tested.
- The noted citations, 7 in number, are related to the first labor publication of the doctoral student, which is 2019. The other publications are from 2020 and 2021 and are to be evaluated.

6. Evaluation of the publications and personal contribution of the doctoral student

The publications presented in the dissertation cover the main accents on the topic. The doctoral student, mag. eng. Stanislav Mitkov Assenov, has one independent publication and is a co-author in seven other scientific publications, as he is the first author of six of them. Six of the publications are indexed in Scopus / Web of Science and two are in Scientific Papers of USB-Plovdiv. Most of the publications are only with the research supervisor of the doctoral student. Personal items contributing skills is undoubtedly considering that it is the first author of six publications and has oneself.

7. Abstract

The abstract is presented in Bulgarian and English and reflects the most important moments of the dissertation.

8. Recommendations for future use of the dissertation contributions and results

I have known the doctoral student since 2013, when for the acquisition of a master's degree, I taught the discipline "Computer Graphics and Design" in two parts at UFT-Plovdiv. I am aware of its potential and I believe that it could present the graphic information in the dissertation much better.

Recommendations and notes

There are figures that are not copyrighted, but there is no literary source in their titles - e.g., FIG. 1.2, 1.9., 3.2 .4. and others. It is possible for some source that is indicated in the text, but it is good to have it in the title of the figure.

Different spelling (lowercase / uppercase) of the word LoRaWAN - I'm sure the PhD student knows how to spell but has not complied - it is important to follow.

The reference is not unambiguously formatted (including the reference to the doctoral student's publications).

In the algorithm of FIG. 3.4.3 has a line without an arrow.

Many schemes lack points defining connections.

I recommend that in the future the doctoral student be included in larger research teams.

CONCLUSION

The dissertation work includes scientific, research and applied results that are original contributions to science and meet the requirements so the Law on the development of academic staff in the Republic of Bulgaria (LDASRB) Implementing Regulations of LDASRB and relevant Rules of PU "Paisii Hilendarski ".

The dissertation shows that the doctoral student mag. Eng. Stanislav Mitkov Assenov has in-depth theoretical knowledge and professional skills for independent research.

Due to the above, I confidently give my **POSITIVE** assessment of the research to prove a scientific thesis and **propose to the esteemed scientific jury to award the educational and scientific degree "Doctor" to Mag. Eng. Stanislav Mitkov Assenov in the field of higher education: 5 Technical sciences, professional field 5.3. Communication and computer technology doctoral program "Automation of areas of the intangible field (medicine, education, science, administrative activities, etc.)".**

26.08.2021   **Prepared the opinion**:..

<div align="right">(Prof. Dr. Eng. Nedyalko Katrandzhiev)</div>