

OPINION

from **NIKOLAI ATANASOV SHOPOV, PhD**
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of the Technical Faculty,
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for a dissertation for awarding the educational and scientific degree "**doctor**"

Field of higher education: **5. Technical sciences**

Professional area: **5.3. Communication and Computer engineering**

Doctoral program: **Automatization of areas in the intangible sphere (medicine, education, science, administrative work, etc.)**

Author: **Tihomir Tihomirov Lovchaliev**

Title: „**Design and automated testing of the parameters of 5G antennas**“

Adviser: **Assoc. Prof. Nadezhda Kafadarova, PhD – Plovdiv University “Paisii Hilendarski”**

1. General presentation of the procedure and the PhD candidate

By order № RD-21-720/02.04.2024 of the Rector of Plovdiv University "Paisii Hilendarski" I have been appointed as a member of the scientific jury in the procedure for the defense of a dissertation on the topic “**Design and automated testing of the parameters of 5G antennas**” for acquiring the educational and scientific degree "doctor", Field of higher education: 5. Technical sciences Professional area: 5.3. Communication and Computer engineering, doctoral program: Automation of areas in the intangible sphere (medicine, education, science, administrative work, etc.) author of the dissertation is **M.Sc. Tihomir Tihomirov Lovchaliev**. The set of paper materials presented by the doctoral student is in accordance with Article 36 (1) of the Regulations for the Development of the Academic Staff of the PU and PP of the LDAS in the Republic of Bulgaria. The PhD student has attached 6 publications on the subject of the dissertation.

Mag. Tihomir Tihomirov Lovchaliev completed his secondary education in 2011 at the Professional School of Electrical Engineering and Electronics - Plovdiv.

In the period 2011–2015, he studied at the "Paisii Hilendarski" PU in the bachelor's program "Information Physics and Communications", and in 2018, he graduated from EQD "Master" with the specialty "Telematics". Since 2016, he has been working at the National Revenue Agency - Plovdiv.

I don't know mag. Tihomir Tihomirov Lovchaliev in person, but I believe that he is successfully developing in the field of computer and communication technologies, constantly improving his knowledge and skills.

2. Relevance of the topic

Mobile communications are constantly evolving, having even reached the fifth generation (5G) in the last forty years. Each subsequent generation adds to the previous one new capabilities, applications and increases the speed and volume of exchanged information. Similarly to the other fields of technology, mobile telecommunications technologies require extensive and ongoing scientific research, both to develop new technologies and to test and analyze existing ones.

The correct selection of antenna and operating frequency is essential for the quality of the radio link and for improving the efficiency and reliability of wireless communication systems. The presented dissertation work is aimed at theoretical and practical development of a system for studying the directional action diagrams of different antennas in laboratory conditions.

The topic of the dissertation is up-to-date, corresponds to modern trends and the problems solved in it have practical application.

3. Knowledge of the problem

The PhD student Tihomir Tihomirov Lovchaliev has cited 74 literary and informational sources, almost all of them in Latin. The bibliographic reference includes titles of literary sources from 1991 up to the present. The main part of the works cited were published in the last 10 years. From the list and analysis of the cited literary sources, it can be concluded that the doctoral student has understood the current state and development trends of the problems solved in the dissertation work.

4. Research methodology

The presented dissertation has a total volume of 154 pages, containing 72 figures and 24 tables.

The dissertation consists of an introduction, six chapters, conclusions, contributions and a list of the author's publications.

In the introduction, consisting of 4 pages, the different generations of wireless networks are considered and the topic of the subject under consideration is justified, related to the improvement of the technologies for the manufacture of antennas and the systems for researching their main characteristics.

Chapter one "Overview of modern approaches to parameter study on antennas for mobile applications" is 29 pages long. It covers 5G mobile communication systems, main types and characteristics of antennas, measurement methods and types of errors in antenna research. The purpose and tasks of the dissertation are formulated.

Chapter Two "Design of an antenna research system" is 35 pages long. It presents the development of a prototype 5G antenna research system. The main functional nodes building up the antenna research system based on a personal computer, GW Instek GSP-9300 spectrum analyzer, Arduino UNO microcontroller and stepper motor are presented.

The next chapter (31 pages), the PhD student devoted to the implementation of a working system for the study of an antenna directivity model. An electromechanical functional unit and a software have been developed.

In the fourth chapter (3 pages) the way of working with the developed antenna research system is presented.

In the next chapter entitled "Construction of antenna directivity pattern for 5G using the developed system" (27 pages), initialization of the system is done and results of research carried out in the "Telecommunications" laboratory at the Faculty of Physics and Technology of PU "Paisii Hilendarski" are presented.

Doctoral student Lovchaliev dedicated the last, sixth chapter to "Design, manufacture and research of an antenna for 5G" (11 pages). An antenna was designed and simulations were made with the ANSYS HFSS software product. Prototype measurements were made and results are presented using the developed antenna test system.

The chosen methodology corresponds to the goal set in the dissertation work and the tasks that lead to its achievement.

5. Characteristics and assessment of the dissertation work and contributions

After thoroughly familiarizing myself with the dissertation work and publications of the PhD student Tihomir Tihomirov Lovchaliev, I am convinced that the results achieved from the research and carried out developments were obtained entirely with his participation. With the work presented, the PhD student demonstrates his knowledge and skills for in-depth research and solving scientific problems of a scientific-applied and applied nature.

After getting acquainted with the applied scientific works of M.Sc. Lovchaliev, I believe that the developed ideas and the obtained results have become available to the scientific circles in our country through the publications and reports presented at conferences in the state and abroad.

In the self-assessment of contributions presented by the PhD student, a total of 7 items are formulated, which are classified as scientifically-applied. I believe that the presented contributions accurately reflect the results obtained by the PhD student Tihomir Tihomirov Lovchaliev.

In my opinion, the contributions are scientific and applied, being in the field of hardware and software development for telecommunications purposes.

In my opinion, contributions are about adapting methods and algorithms and creating new constructs, models and software in a dynamically developing field.

6. Assessment of the publications and personal contribution of the PhD student

The results obtained during the development of the dissertation work are presented in six publications. Two of the publications are indexed in SCOPUS. Two reports stand alone and are published in the scientific works of the Union of Scientists in Bulgaria - Plovdiv. I believe that the PhD student's dissertation publications reflect the main contributions he claims to have made.

7. Abstract

The submitted abstract is 32 pages long and meets the requirements for its preparation. It correctly reflects the main results and contributions of the dissertation work.

8. Recommendations for future use of dissertation contributions and results

I have the following recommendations and guidelines for future work:

- I believe that some of the chapters can be combined, e.g. third and fourth.
- Research can also be conducted in the special, isolated chambers and the results obtained can be compared.

These recommendations do not relate to the essence of the contributions, therefore they do not affect my personal positive impression of the scientific production and other merits of the doctoral student.

CONCLUSION

After thoroughly familiarizing myself with the dissertation work and publications of doctoral student Tihomir Tihomirov Lovchaliev, I am convinced that the results achieved from the research and development carried out, were obtained entirely with his participation. With the work presented, the doctoral student demonstrates his knowledge and skills for in-depth research and solving scientific problems of a scientific-applied and applied nature.

The dissertation contains scientific-applied and applied results, which represent an original contribution to science and meet all the requirements of the Law on the Development of the Academic Staff in the Republic of Bulgaria (LDASRB), the Regulations for the Implementation of LDASRB and the relevant Regulations of Plovdiv University "Paisii Hilendarski".

Based on the analysis, I give a positive assessment of the dissertation work and consider it justified to offer a **M.Sc. Tihomir Tihomirov Lovchaliev** to acquire the educational and scientific degree "doctor" Field of higher education: 5. Technical sciences Professional area: 5.3. Communication and Computer engineering, doctoral program: Automation of areas in the intangible sphere (medicine, education, science, administrative work, etc.).

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Plovdiv city

Prepared the opinion:
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