

# OPINION

By **PhD Eng. Atanaska Dimitrova Bosakova-Ardenska, Professor at the University of Food Technologies - Plovdiv**

of a dissertation on the award of the educational and scientific degree "**Doctor**"

by: field of higher education 5. Technical sciences

professional field 5.3. *Communication and computer engineering*

doctoral program *Automation of fields from the non-material sphere (medicine, education, science, administrative activity, etc.)*

**Author:** Tihomir Tihomirov Lovchaliev

**Topic:** DESIGN OF ANTENNAS FOR 5G AND AUTOMATED TESTING OF THEIR PARAMETERS

**Scientific supervisor:** Assoc. Prof. Eng. Nadezhda Miteva Kafadarova, PhD

## 1. General presentation of the procedure and the doctoral student

Based on an order of the Rector of Plovdiv University "Paisii Hilendarski" (PU) RD-21-720 of 02.04.2024 I have been appointed as a member of the scientific jury to provide a procedure for the defence of a dissertation on "Design of antennas for 5G and automated testing of their parameters" for acquiring the educational and scientific degree "Doctor" in the field of higher education 5. Technical sciences, professional field 5.3. Communication and Computer Engineering, PhD Program "Automation of Fields from the Non-Material Sphere (Medicine, Education, Science, Administrative Activity, etc.)". The author of the dissertation is Tihomir Tihomirov Lovchaliev – full-time PhD student at the Department of ECIT (Electronics, Communications and Information Technologies) with research supervisor Assoc. Prof. PhD Eng. Nadezhda Miteva Kafadarova from Plovdiv University "Paisii Hilendarski".

The set of materials presented by the PhD student is in accordance with Article 36 (1) of the Regulations for the Development of the Academic Staff of Plovdiv University and includes the following documents:

- application to the Rector of Plovdiv University for disclosure of the dissertation defence procedure from 25.03.2024;
- CV in European format;
- protocol of the Department Council related to reporting readiness for opening the procedure and preliminary discussion of the dissertation;
- dissertation (PhD thesis);
- abstract of PhD thesis;
- a list of scientific publications on the topic of the dissertation;

- copies of scientific publications;
- a declaration of originality and authenticity of the attached documents;
- reference for the fulfilment of the minimum national requirements set out in the Regulations for Implementation of The Law on The Development of The Academic Staff in The Republic of Bulgaria for acquiring the educational and scientific degree "Doctor" in the professional field 5.3 Communication and computer engineering.

The PhD student Tihomir Lovchaliev has acquired the Bachelor's Degree in Information physics and Communications and the Master's Degree in Telematics at Plovdiv University "Paisii Hilendarski" in 2018. Since 2016 he has held a managerial position at the NRA (National Revenue Agency), Plovdiv and he is responsible for the administration of workstations on the territory of Southern Bulgaria. The PhD student is fluent in English and Russian.

## **2. Relevance of the topic**

The dissertation presents a system for automated testing of basic parameters related to the operation of 5G antennas. The system is designed and built based on detailed theoretical consideration of the types of antennas, their parameters and ways of measuring them, initially making a prototype allowing subsequent improvement of the system. The operability of the automated testing system was established through experiments on the territory of the Telecommunications Laboratory at the Faculty of Physics and Technology at the University of Plovdiv using different types of antennas, including self-designed and implemented ones. The observed in recent years development of communication technologies, and particularly those that are related to different types of mobile networks, determines the need to provide well-trained engineers in the field. In this regard, the system presented in the dissertation can enrich the practical training of telecommunication specialists, which confirms the relevance of the topic and its practical orientation.

## **3. Knowledge of the problem**

A total of 74 literary sources were used in the dissertation, most of which are from the last ten years. Chapter one (Overview of modern approaches to the study of antenna parameters for mobile applications) discusses the types of antennas for mobile applications, their main characteristics and how to measure them. Based on the theoretical consideration, the aim of the dissertation work was formulated - "The aim of the dissertation work is to design antennas for 5G and develop a system for automated testing of the parameters of their directional action diagrams" and the tasks to be solved for its achievement are set.

#### **4. Methodology of the study**

To achieve the main objective of the dissertation, eight tasks have been formulated related to the design and implementation of an active prototype system for studying the directivity model of 5G antennas and its subsequent testing to determine major flaws; the construction of a functioning system for automated testing of basic parameters of 5G antennas; the use of the automated system for analysing the radiation pattern of main types of antennas as well as a self-designed and manufactured 5G antenna. The diagrams obtained through the automated system for the radiation pattern of the tested antennas presented in the planes of the electric and magnetic field vectors are compared with the theoretical ones. To improve the visual representation of the diagrams, a filter was used to reduce the high-frequency components, and it was found that the use of a second-order polynomial when applying the Savitzky-Golay filter significantly improves the graphical representation of the measured values.

#### **5. Characterization and evaluation of the dissertation and contributions**

The dissertation presented has a total volume of 156 pages and contains an introduction, six chapters, a conclusion, a list of publications on the dissertation, a declaration of originality and a list of literary sources. Chapter One "Review of modern approaches to the study of antenna parameters for mobile applications" presents a detailed theoretical overview of the types of antennas, their parameters and how to measure them, not clearly outlining the existing automated systems for measuring the directional action of antennas and their advantages and disadvantages. In this sense, the overview made can be considered insufficiently completed. The dissertation lacks applications that would help for a deeper understanding of the implementation of the presented automated system.

The PhD student has formulated a total of seven applied scientific contributions, which essentially reflect what has been achieved, but I believe that some of them should be considered as contributions of an applied nature. For example, the development of firmware for the Arduino Uno for the control of the stepper motor driver, as well as the development of an antenna for 5G, should be considered as contributions of an applied nature. In addition, the contribution formulated by the PhD student "A critical theoretical analysis of existing modern approaches to the study of antenna parameters for mobile applications has been carried out." should be reformulated given the lack of a systematic summary presentation of the advantages and disadvantages of existing automated systems for measuring the directional action of antennas, which does not give rise to such a statement. However, the results presented in the dissertation are undoubtedly due to in-depth theoretical knowledge in the field and contain sufficient contributions of a "scientifically applied" and "applied" nature.

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

The PhD student has submitted a total of six publications related to the dissertation, which form a total of 85 points with a minimum required of 30. In two of the presented publications the PhD student is the independent author, and in the others there are one, two or three co-authors. Two of the publications are papers from the XXXI International Scientific Conference Electronics (ET), the proceedings of which are published in the IEEE (Institute of Electrical and Electronics Engineers Xplore Digital Library) and indexed in Scopus. The PhD student is the second co-author in two of the publications on the topic of the dissertation and the third co-author in two other publications. Two of the publications are in Bulgarian and the other four are in English. All publications presented under the procedure reflect the results presented in the dissertation, which undoubtedly speaks of the active participation and personal contribution of the doctoral student.

## **7. Abstract of doctoral thesis**

As part of the materials under the current procedure, an abstract of doctoral thesis in Bulgarian and English is presented in a volume of thirty-two pages in Bulgarian (31 pages plus title page) and thirty-one pages in English (30 pages plus title page). The materials presented in the abstract show in summarized form the most significant results achieved by the doctoral student.

## **8. Recommendations for future use of dissertation contributions and results**

The automated system for analysing the radiation pattern of antennas for 5G presented in the dissertation clearly shows the real action of the antennas, which could undoubtedly be used to enrich the practical activities of students studying disciplines in the field of communication engineering and technology. As guidelines for future work, I would recommend the actual implementation of the developed system in the teaching process and its adaptation to track the working modes of other types of antennas. The developed system could be improved by analysing the performance in visualization of the diagrams and studying the influence of different types of filters on both the performance and the optimal graphical presentation of the results. In addition, it would be good to promote the results achieved more widely through participation in established international scientific forums and the publication of articles in periodicals with a high impact factor.

## **CONCLUSION**

The dissertation paper contains contributions of a scientifically applied and applied nature that meet the requirements of the Law on The Development of The Academic Staff in The Republic Of Bulgaria, Regulations for Implementation of The Law on The Development of The Academic Staff in The Republic of Bulgaria and the relevant Regulations of Plovdiv University "Paisii Hilendarski". The presented dissertation shows that the PhD student Tihomir Tihomirov Lovchaliev has theoretical

knowledge and professional skills in the scientific specialty "Automation of fields of the non-material sphere (medicine, education, science, administrative activity, etc.)" by demonstrating the qualities and skills to independently conduct scientific research.

As a result of the above, I give my *positive assessment* of the conducted research, presented by the above-reviewed dissertation, abstract, achieved results and contributions, and *I propose to the honourable scientific jury to award the educational and scientific degree "Doctor" to Tihomir Tihomirov Lovchaliev in field of higher education: 5. Technical sciences, professional field 5.3. Communication and Computer Engineering doctoral program "Automation of fields of the non-material sphere (medicine, education, science, administrative activity, etc.)"*.

09 May 2024

**Prepared the opinion:** .....

/Prof. PhD Eng. Atanaska Bosakova-Ardenska/