

REVIEW

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Subject: submitted dissertation for the acquisition of an educational and scientific degree "Doctor of Philosophy" in professional direction 5.3. "Communication and Computer Engineering" .

Author of the dissertation: Teodora Ivanova Pasarelska, doctoral student of self-study in the doctoral program "Telecommunications" – New Bulgarian University (NBU).

Topic of the dissertation: "Investigation of methods for planning and distribution of the radio frequency spectrum in the Republic of Bulgaria".

Scientific supervisor: Prof. Plamen Marinov Tsvetkov, PhD.

Grounds for submitting the review: member of the Scientific Jury, according to Order No. 3-RK-27/17.10.2024 of the Rector of the NBU.

The review was prepared in accordance with the Law on the Development of the Academic Staff of the Republic of Bulgaria, the Rules for the Implementation of this Law and the Ordinance on the Development of the Academic Staff at the NBU.

1. Significance of the researched problem in scientific and scientific-applied terms

The dissertation, which I have the opportunity to review, examines the methods of planning and distribution of the radio frequency spectrum in the Republic of Bulgaria, addressing an important and complex issue. The radio frequency spectrum is a key element in the development of telecommunications, which makes the studied topic extremely relevant and important. Solving this issue is essential for the future of the gigabit society and for building high-capacity data networks.

The main emphasis in the dissertation is current, because concerns the efficient management of radio frequency spectrum and access to broadband networks. Of interest is the developed methodological solution for simulation analysis, which investigates the mutual influence between the radio-electronic devices of different users of the airwaves. This methodology can be applied in solving practical problems.

The proposed work also presents new trends and approaches for assessing the impact on the operation of terrestrial radionavigation systems and radioelectronic equipment in the frequency bands intended for 5G networks. I believe that this research is important, especially in the context of the introduction of new technologies in the telecommunications field.

In addition, the doctoral work analyzed numerous factors related to spectrum planning and management, which are essential for the implementation of new technologies and services.

In conclusion, the research and analysis in this work are thorough, interconnected and correctly presented, giving a comprehensive view of the issues under consideration. The dissertation

has a significant scientific and applied scientific contribution in the field of radio frequency spectrum management in Bulgaria.

2. Precisely formulated objectives and tasks of the dissertation

The dissertation submitted to me for review includes specific and precisely formulated goals and objectives.

At the beginning of the doctoral work, the following main goals and tasks are set in the conditions of the Republic of Bulgaria.

MAIN OBJECTIVES:

- 1) Study of the methods of allocation, planning and management of the radio frequency spectrum to ensure the implementation of modern wireless broadband electronic communication services and achieve efficient, shared, dynamic and loyal use of this resource;
- 2) Allocation of sufficient and appropriate radio frequency spectrum for the provision of telecommunications services;
- 3) Ensuring conditions for coordinated and harmonized use of the radio frequency spectrum.

In order to achieve the stated goals, the following main tasks are set in the dissertation work.

MAIN TASKS:

Task 1: Analysis of the current state of the methods, approaches and strategies for planning and management of the radio frequency spectrum in the Republic of Bulgaria and their harmonization with European and world trends.

Task 2: Research and analysis of the basic principles and current trends in the management and allocation of the radio frequency spectrum.

Task 3: Exploring the possibilities and planning the necessary technical, regulatory and organizational procedures to ensure the implementation of modern wireless broadband electronic communication services.

Task 4: Development of approaches and methodology for radio frequency spectrum management. Development of computer models, conducting simulation and real field studies of objects.

With a view to the fulfillment of the set goals and objectives, the dissertation researches and analyzes the main principles in the management and distribution of the radio frequency spectrum, related to its effective use in radio frequency ranges and radio frequency bands, as well as its efficient management.

The doctoral work was developed and aims to serve as a scientific-methodical guide in solving real problems in the management and distribution of the radio frequency spectrum.

As a summary follows yes it should be noted that as a result on the job by the topic from the side of the doctoral student , the placed goal and and tasks are fulfilled .

3. Degree on familiarity on the condition on the problem and compliance on the one used literature

Extensive research and in-depth analyzes in the dissertation work indicate a high level and detailed knowledge of the state of the researched problem. The studies done are correct and

impeccable and present a thorough understanding of the specifics of the particular field by the PhD student.

literary works are used in the dissertation work the source , which shows a broad overview of scientific literature and publications in the field of doctoral work. The literature used is in accordance with the subject of the dissertation, corresponding to and covering the basic principles of the management and distribution of the radio frequency spectrum.

I am pleased to emphasize the thoroughness and comprehensiveness of the doctoral student regarding the researched problem. The dissertation uses a large set of specific concepts for the field of telecommunications , which PhD student shows that knows in depth .

The announcer's style is scholarly and well-structured, with no grammatical or spelling errors. Scientific research, different concepts and approaches are structured with consistency and method. Analyzes and discussions on the researched problem contain detail and completeness.

The extensive volume of literature and scientific information has been clearly and skilfully used, analyzed and summarized. The professional experience and skillful actions of the doctoral student can be seen in relation to the prepared methodology, in which simulation studies and tests of radio equipment were carried out .

In summary, it can be noted that the doctoral student shows thoroughness and a high degree of knowledge of the state of the researched problem. The doctoral thesis shows detail and completeness regarding the realized studies, analyzes and measurements.

The literature used is in accordance with the topic of the doctoral work.

4. Correctness at the citation on representative number authors

The dissertation presented by PhD student Teodora Pasarelska can be considered correct at the citation on representative number authors .

of literature was used in the doctoral work sources total 212 in number, which shows a broad overview of the scientific literature and publications in the specific field of telecommunications. The bibliography has been used competently and skilfully, and a significant volume of literature and scientific information has been analyzed and synthesized, which is correctly cited in the text of the dissertation.

5. Availability on substantiated and developed theoretical model on the research

In the dissertation there is a developed and substantiated theoretical model on the research . In the first chapter of the doctoral thesis is analyzed the current one condition on radio frequency spectrum in the Republic Bulgaria and harmonization with European and global ones trends . In her thoroughly everything are researching the ground ones networks and radio frequency 900 MHz and 1800 MHz bands . Examined are radio frequency 2 GHz, 2.3 GHz, 2.6 GHz and 3.6 GHz bands , 700 MHz and 800 MHz bands . Investigate everything the radio frequency spectrum for fourth generation (LTE), for terrestrial digitally radio broadcasting - DVB-T, frequencies scopes appropriate for networks from the " dot " type to dot " and networks from the " dot " type to a lot points " , as well as satellite telecommunications networks for provision on mobile services , radio frequency spectrum for devices with a small range on action , frequency scopes intended for " Machine-to-Machine " communication (Machine to Machine-M2M) and others . Through methodical productions analyze the ground ones networks and radio frequency 900 MHz and 1800 MHz bands . Researched are radio frequency 2 GHz, 2.3 GHz, 2.6 GHz and 3.6 GHz bands , 700 MHz and 800 MHz bands . They are

examining everything radio frequency spectrum for fourth generation (LTE), for terrestrial digitally radio broadcasting - DVB-T, frequencies scopes appropriate for networks from the " dot " type to dot " and networks from the " dot " type to a lot points ", as well as satellite telecommunications networks for provision on mobile services , radio frequency spectrum for devices with a small range on action , frequency scopes intended for " Machine-to-Machine " communication (Machine to Machine-M2M) and others .

The PhD student, using a variety of means, researches and models the methods for distribution , planning and management on radio frequency spectrum , as everything accentuates on method for usage on spectrum , which it is not individual certain , method at individually determined limited resource , method on licensed joint access to radio frequency spectrum and method for determination the right for usage on radio frequency spectrum .

In the dissertation very skillfully with a view of the defined theoretical model , are scientifically refined and systematized characteristic elements and specific aspects of the radio frequency spectrum which are related to its distribution , planning and management in the Republic of Bulgaria . The model also reflects achievements and harmonization with European and global guidelines and trends. In this chapter, using a theoretical model on the research of the doctoral student aims to clarify a number of problems and solve key challenges in practice in the construction of radio communication systems and the use of effective radio frequency ranges .

The developed model summarizes the specific ones features of the research problem from theoretical and scientific-applied point of view point , which are indicated from PhD student at the beginning on the dissertation labor .

6. Compliance on the chosen one methodology and methodology on research with the set purpose and tasks on dissertation labor

In the dissertation work, a methodology and a research methodology were chosen, which clearly correspond to the set ones goals and objectives of the dissertation work. The PhD student follows methodically presented plan for action in the following points:

- analytical review of the current state of the radio frequency spectrum in the Republic of Bulgaria and harmonization with European and world trends.
- extensive analysis of terrestrial networks and radio frequency bands 900 MHz and 1800 MHz. 2 GHz, 2.3 GHz, 2.6 GHz and 3.6 GHz radio frequency bands, 700 MHz and 800 MHz bands are considered.
- survey of the radio frequency spectrum for the fourth generation (LTE), for terrestrial digital radio broadcasting - DVB-T, the frequency ranges suitable for point-to-point and point-to-multipoint networks, as well as satellite telecommunications networks for providing of mobile services, radio frequency spectrum for devices with a short range of action, frequency ranges intended for "Machine-to-Machine" (M2M) communication and others.
- study of methods of allocation, planning and management of radio frequency spectrum, emphasizing method of use of spectrum that is not individually assigned, method under individually assigned limited resource, method of licensed joint access to radio frequency spectrum and method of determining the right to use of radio frequency spectrum.
- research and planning of technical, regulatory and organizational procedures in the implementation of modern wireless broadband electronic communication services.
- a comprehensive study of the deployment of modern wireless broadband electronic communications services. Emphasis is placed on innovations such as 5G technology and IoT integration.

- analyzing spectrum management and the regulatory framework, noting spectrum licensing and allocation, public-private partnerships, organizational strategies and infrastructure development, and operational management.
- development of a methodology for conducting a simulation study to determine the mutual influence between radio electronic equipment of the users of a radio frequency resource for mixed use.
- presentation of scenarios and presentation of a simulation research method . Data is collected and analyzed .
- preparing mathematical analysis and interference models for emerging systems and techniques such as 5G base stations. Mathematical concepts and approaches to the study of base station interference are defined, surveying signal propagation, interference modeling, and interference mitigation techniques.
- carrying out tests and studies , which end with specific results and evaluation of the validation of the mutual influence between the radio-electronic equipment of the users of the radio frequency resource for mixed use.

The chosen methodology and research methodology is in full compliance with the set goals and objectives of the dissertation work.

7. Availability on own contribution at collection and analysis on the empirical ones data

In the dissertation work, one can note one's own contributions at collection and analysis on empirical data . Realized studies , comprehensive analyses and the prepared methodology for conducting a simulation study to determine the mutual influence between the radio-electronic equipment of the users of a radio-frequency resource for mixed use, can definitely be accepted as scientific and scientific-applied results and contributions of the doctoral student .

With pleasure will I note that dissertation work in which everything does so much thoroughly research and analysis on the methods for planning and allocation on radio frequency spectrum in the Republic Bulgaria , talk for high knowledge and enviable erudition in strongly the dynamic one area on telecommunications . She impresses with the precise and specific learned style and expression on author a , with the clear common ideology and with the highly effective methodical with which are performed and described thorough and comprehensive studies . I want specially yes pointed out and higher education value on the dissertation, which can serve as a scientific-methodical guide in solving real problems in practice, to be used by on teachers and students of the NBU, as well as from government services and departments and private organizations

Like summary can yes everything report that in the presented dissertation work there is no article on own contribution at collecting and analyzing on the empirical ones data . The conducted studies are characterized by scientific correctness , competence and credibility , as well as the systematized ones from PhD student findings , conclusions and achieved results in the doctoral work

8. Description on contributions

8. 1. Short characteristic on nature and assessment on credibility on the material , on which everything are building contributions on dissertation labor

I think that declared contributions to the dissertation labor from Theodora Pasarelska are entirely hers author's work . The presented for review labor everything distinguished by a high degree on credibility , scientific competence and precision . Achievements results and contributions in the PhD work wear significant scientific and applied value .

The publications on PhD student are directly related to the topic on the dissertation , as demonstrate thoroughly familiarity on the specific one district . The professional one is obvious experience on the doctoral student in the researched theme which clear it is evident in her independent contribution at collection and analysis on the empirical ones data .

8. 2. Description on contributions on the candidate and the classification them

Contributions to the dissertation labor is correct reflection on the results achieved from PhD student Teodora Pasarelska in her doctoral work . Extensive and in-depth research and analysis in the dissertation labor shows t that PhD student owns envious of knowledge by major in telecommunications and competencies for independent scientific research and publication activity . The dissertation labor contains theoretical model , extensive and detailed studies, findings and results, implemented methodology and solutions on scientific or applied science problems which testify to person contribution on the doctoral student . Doctoral work and preparations abstract objectively present the scientific and applied sciences results and contributions on the doctoral student, being in in unison with the basic set goals and objectives c dissertation labor .

I accept the proposals for contributions of PhD student Teodora Pasarelska, summarizing them:

Scientific Contributions :

H 1. New mathematical models were developed for the analysis of frequency bands and disturbances in them;

Scientific and applied Contributions :

NP 1. A methodology has been developed for conducting simulation studies to determine the mutual influence between radio electronic equipment of the users of a radio frequency resource for mixed use.

NP 2. New approaches for planning and managing the frequency spectrum when implementing IoT technology are proposed and scientifically substantiated.

Attached Contributions :

P 1. An analytical simulation representing the impact of various types of disturbances in networks was performed

P 2. Analysis and study of key frequencies and frequency ranges used for various terrestrial networks, including fixed networks, cable networks, wireless terrestrial networks, etc. wireless communication services and technologies.

P 3. Methods for managing the radio frequency spectrum and approaches for optimizing the joint use of radio frequency resources between different systems and operators have been studied.

P 4. A number of tests and studies have been carried out on the electromagnetic compatibility of land mobile systems in the 700 MHz and 800 MHz bands and specialized ground radar and radio navigation equipment.

Impacts on dissertation labor on the outer one environment

As attached materials by the defense of the doctoral thesis of Teodora Ivanova Pasarelska are deposited us 5 pieces publications . Four of the presented publications are scientific publications articles in peer-reviewed and refereed scientific journals and collections from the NACID reference list. It's the bottom publication represents published through IEEEexplore scientific article in the referenced and peer-reviewed world famous database - Scopus .

The doctoral student has an active participation in national and international conferences and symposia with a number of scientific reports delivered.

I can note that these activities are a testimony to the scientific activity of the doctoral students who are doing publicly estate of the main ones ideas , goals and scientific achievements in the dissertation work with an impact on the external environment .

Personal qualities on the author (if the reviewer it knows).

I don't know personally PhD student Teodora Ivanova Pasarelska and impressions they are only from the dissertation work presented by her .

I can note the thoroughness and comprehensiveness of the PhD student regarding the research problem, as well as the high degree of knowledge of the terminology in this specific research area. The professional experience , skillful actions and competence of the doctoral student are clearly visible in terms of research, analysis, findings and the implemented methodology in the dissertation work .

Opinions , recommendations and notes

I am pleased to note that the dissertation work is of high educational and scientific value and is responsible on everyone requirements and norms.

To the presented dissertation I can to make the following comments and recommendations :

- Part of the dissertation work has a narrative character, typical of a textbook;
- I recommend in the future publication in refereed publications with an impact factor and open access;

CONCLUSION

dissertation submitted for review is a work represents up-to-date , independent and in-depth research . Undisputed and significant scientific and applied scientific contributions in the field of telecommunications have been realized in it. The candidate has professional experience and enviable knowledge in the research field.

The dissertation fully meets the mandatory legal requirements of the Law on the Development of the Academic Staff in the Republic of Bulgaria (ZRASRB) and the Regulations for

its implementation, as well as the regulations of the New Bulgarian University.

In connection with the above, the high value of the doctoral thesis , as well as the scientific and applied sciences candidate contributions , I give positive evaluation on dissertation labor with the theme "Research on the methods for planning and allocation on radio frequency spectrum in the Republic Bulgaria", I personally support and I propose to the Honorable Scientific Jury to award on Teodora Ivanova Pasarelska educational and scientific degree" Doctor of Philosophy" in scientific specialty " Telecommunications " in professional direction "5.3. Communication and computer technology".

Date: 23.10.2024

Signature : 
(prof. Dr. Georgi Popov)