R E V I E W

of a dissertation
for awarding an educational and scientific degree of "Doctor" in

in the field of higher education – 5. Technical Sciences
the professional field – 5.3 "Communication and Computer Engineering"
doctoral program – "Communication Networks and Systems"

Author: eng. Seyhan Sadak Myumyunali
Thesis: "Research and Improvement of the Quality of Service in Satellite Communication Channels"
Reviewer: Prof. Raycho Todorov Ilarionov, D.Sc.

1. Relevance of the problem considered in the dissertation in scientific and scientific-applied terms

The coverage of large, densely populated areas, as well as the territory of a given country, can be done jointly with the help of satellite and terrestrial transmitters for local and regional networks, which leads to a new understanding of the concept of "radio coverage". The increase in popularity of satellite TV leads to an increase in the requirements for it. The main trends are an increase in the number of TV programs, an increase in their quality (switching from SDTV to HDTV), the possibility of using additional services. The given requirements lead to the need to increase the throughput of the satellite channel. In order to increase the bandwidth of the channel, new modulations are introduced with a higher multiplicity, which, however, have a lower noise immunity. From here comes the need to optimize the parameters of the used channel codes or to develop new ones that have higher efficiency.

The subject of research are the processes related to the processing, transmission and reception of satellite communication signals in satellite transmitters and receivers - modulation, channel coding, multiplexing, polarization characteristics of the signal, synchronization, configuration, adjustment and coordination of the transceiver equipment. As criteria for determining the quality of service, various evaluation parameters and quality indicators such as equivalent isotropic radiated power (EIRP), field strength, spectral and vector characteristics of the signal and the signal-to-noise ratio were used in criteria of maximum permissible values of the modulation error ratio (MER), bit (BER) and packet (PER) error rates, etc.

I believe that the topic of the dissertation work is extremely relevant.

2. Degree of knowledge of the state of the problem and creative evaluation of the literary material

The PhD student has made a broad review of modern literature on the subject. He cited 138 sources, and a large percentage of them were issued after 2015. The way of presentation, terminology, style and level of the presented note speak of a good knowledge of the issue. The formulated tasks and the achieved results are a guarantee of an excellent preparation of the author. In the dissertation, a good analysis of the state, problems and prospects in the construction and operation of satellite and communication channels and services is made. All this speaks of a creative depth and broad knowledge of the topic of the dissertation work.

3. Correspondence of the chosen research methodology with the purpose and tasks of the dissertation work

The author's desire for a complex solution to the problem is evident from the first chapter. This determines not only the chosen research methodology, but also the structuring of the contributing chapters.

I believe that there is compliance of the chosen research methodology with the defined goal and tasks of the dissertation work. The results of the theoretical studies, as well as the logic of these studies, determine the credibility of the material on which the PhD student's contributions are based.

4. General analytical characteristics of the dissertation work

The dissertation work is presented in a total volume of 129 pages, including an introduction, five chapters, a conclusion, scientific contributions, references, a list of publications on the subject of the dissertation.

The first chapter is presented in a volume of 20 pages. It presents the state, problems and perspectives in the construction and operation of satellite communication channels and services. The relative share of satellite communications in the Republic of Bulgaria is defined. The standards for satellite distribution of digital television signals are described. Conclusions and assessment of problems of satellite television broadcasting and methods for their solution are made. The main goal is clearly formulated - to present and study the processes of signal processing - generation, coding, modulation, transmission and reception of DVB-S/S2 signals - by synthesizing simulation models and conducting practical experimental results. The main tasks of the dissertation are also defined.

The second chapter has a volume of 30 pages. It refers to the synthesis of models for the simulation study of a digital system according to the DVB-S2 standard. A block structure of a DVB-S2 model and basic signal processing operations are proposed. All the blocks of the model are described. The results of simulation studies and modeling and study of coding processes and their efficiency in digital signal transmission are presented. They are presented in graphical and tabular form and relevant conclusions are drawn. In the MATLAB environment, a description of the parameters of the simulation model is made to study the coding processes and their efficiency. The results of the conducted simulations are also described. It is proposed a comparative analysis of the simulation results.

The third chapter has a volume of 14 pages. This chapter presents an experimental study of signal parameters and characteristics in satellite digital television systems. The main parameters of the digital transmission network are defined. An experimental study was carried out in order to detect and eliminate existing disturbances. The modulation error ratio MER (Modulation Error Ratio) is derived, which covers all parameters of the vector diagram. For the purposes of experimental research and analysis of digital signal transmission according to the DVB-S/S2 standard, the experimental set-up is proposed, which is described with a block diagram. All the steps of the research are described in detail. Measurements of transponders with different frequencies are made and the results are shown in graphical and tabular form. It is proposed a comparative analysis of the experimental results and conclusions of the study.

The fourth chapter has a volume of 30 pages. It is related to the study of the communication channel parameters for the "satellite-earth" connection. The author analytically presented the determination of the energy budget of the communication channel "Artificial satellite - Earth", giving examples accordingly. It has defined the

main noises that affect the communication channel. An important parameter that is presented is the bandwidth of the link channel, and free space losses and the influence of the Doppler effect are accounted for. Research has been done for a communication channel for connection with an artificial satellite of the "CubeSat" type. A scheme of the experimental set-up is proposed. On the basis of the considered platform, four studies have been carried out, which show the complex influence of all parameters on the quality of the communication channel: orbit height, transmitter power, choice of modulation format, transmission coefficients, etc.

Chapter Five includes 17 pages. It is related to the study of the performance of a satellite communication system for data transmission under efficient modulation methods. An analysis of the performance of a satellite data communication system in terms of quality of service (QoS) is performed. A study and analysis of the effectiveness of polarization modulation in satellite communication systems has been carried out.

The separate main conclusions in the dissertation summarize the conclusions formulated in the separate chapters and list the scientific contributions of the development.

The volume and structure of the dissertation meet the requirements.

5. *Evaluation of the contributions in the dissertation work and their significance*

The contributions formulated by the author of the dissertation are the following:

Contributions of a scientific nature - not proposed.

Contributions of a scientific and applied nature:

1. Analytical models of the "satellite-earth" link communication channel have been synthesized, through which a comparative analysis is performed to determine the throughput of the link channel under different theoretically applicable variants of signal modulation.
2. Simulation models were created in Matlab/Simulink virtual environment. Research has been done to comprehensively evaluate the degree of influence of individual configuration parameters and signal processing stages on the quality of service by evaluating the bit error rate (BER), the signal-to-noise ratio (SNR) in the transmission channel and the vector diagram of the signal in scenarios with different modulation formats and transmission power in DVB-S2 standard. The effectiveness of BCH and LDPC signal coding in a satellite DVB-S2 link channel has been evaluated. The signal-to-noise ratio (SNR) threshold levels for various combinations of encoder configuration parameters and coding depth, respectively, have been established in order to ensure quasi-error-free signal reception for QPSK and 8-PSK modulation formats.
3. A simulation model of a DVB-RCS satellite communication system for broadband data transmission with time division multiple access MF-TDMA and mesh topology is developed. Mechanisms for continuous resource allocation, rate-based dynamic capacity, and volume-based dynamic capacity have been evaluated for efficient frequency utilization and service quality maintenance. Research and comparative analysis of the performance (according to the network throughput criterion) of the DVB-RCS satellite communication system for broadband data transmission has been made in 3 different scenarios regarding the delivered services: for delay-tolerant services; for delay-sensitive services; performance evaluation as a function of the number of users.

4. A comprehensive model has been developed and studied for the analysis of the effectiveness of the application of polarization modulation in order to more optimally use the available frequency resources and accelerate the synchronization time in high-frequency narrowband or high-dynamic satellite communication. Research has been carried out to evaluate the quality of service by determining the SER coefficient and its limit values for different PM and DBPSK modulation formats and comparative analysis with Monte Carlo simulation in satellite AWGN channel.

Contributions of an applied nature:

1. Practical experiments have been conducted and an approach has been proposed for optimal selection of frequency parameters and construction equipment for a satellite communication system and ensuring quality broadcasting of satellite television programs.
2. An experimental set-up of a communication channel for connection to an artificial satellite of the "CubeSat" type with hardware transceiver modules and a module-simulator of a satellite communication channel was developed and studied in laboratory conditions. A study was made to evaluate the packet error in a communications channel for connection with an artificial satellite of the "CubeSat" type, and graphical dependences were presented, providing information for the search for optimal solutions in the selection of the operating frequency range, altitude and parameters of the orbit, the transmission power, parameters of the receiving-transmitting antenna, as well as to evaluate the influence of the complex combination of these parameters.

6. Assessment of the degree of personal involvement of the PhD student in the contributions

I accept the thus formulated claims for scientific-applied and applied contributions to the scientific field under consideration. It should be noted that the author has very carefully defined and balanced the scientific-applied from applied contributions. Each of them is clearly expressed in the dissertation work. Perhaps there is room for one or two more applied contributions, given the topicality and novelty of the issues under consideration.

The detailed description as well as the presentation and analysis of the results indicate that this scientific work is the author's personal work.

7. Assessment of publications on the dissertation work

The PhD student defends his work with 6 publications as follows:

- 6 of them are in Bulgarian language;
- One of them is independent;
- All 6 publications are in international scientific journals.

The reviewer is not aware of the facts regarding the citations. The publications describe various aspects of the dissertation work and I believe that they have given the scientific community an opportunity to become familiar with it. They cover the subject of the dissertation work.

On the basis of the presented materials, the PhD student meets the minimum national requirements and the requirements of the Regulations for the acquisition of the educational and scientific degree “Doctor”.

8. *Presence or not of a direct economic effect achieved from the results of the dissertation work*

The author has not deposited implementations of scientific achievements in practice. No direct economic effect is indicated either.

9. *Recommendations for future use of contributions*

The author is recommended to find a way to protect the intellectual property of the scientific results and to implement them in the educational process.

10. *Assessment of the compliance of the abstract of dissertation with the requirements for its preparation, as well as its adequacy in reflecting the main points and scientific contributions of the dissertation work*

The abstract of the dissertation is 39 pages long and follows the structure of the dissertation. It is well laid out. It presents the main elements of the conducted research and the obtained results. Adequately reflects the content of the dissertation work and the obtained results.

11. *Critical remarks on the dissertation*

The topic is extremely current, perspective and quite difficult. It requires high-tech equipment. The material is mainly research in nature and no economic effect could be expected, bearing in mind the state of the art in this industry.

The direct use of block diagrams and other illustrations that are directly taken from foreign literature without citation does not make a good impression. In Chapter 3 there is more fragmentation of the material in places. There are minor spelling and stylistic errors. These remarks do not detract from the dissertation work, bearing in mind that the author is a young man who is now entering the world of science.

12. *Motives and clearly formulated conclusion*

I don't know the author personally. My conclusion is based on the materials provided to me.

The dissertation meets the requirements for topicality, necessary volume, structure and publications. The author has demonstrated knowledge of the researched problem and skills to solve it.

I believe that the presented dissertation work meets the requirements of the Law on the Development of Academic Staff in the Republic of Bulgaria and the regulations of the Technical University of Gabrovo. The achieved results give me grounds to propose to the Honorable Jury that the educational and scientific degree "Doctor" should be awarded to eng. Seyhan Sadak Myumyunali in the field of higher education – 5. Technical sciences, professional field – 5.3 Communication and computer engineering, doctoral program – “Communication networks and systems”.

09.01.2023 г. ***Reviewer:*** ……/signature/……..…

(*Prof. Raycho Todorov Ilarionov, D.Sc.*)