

# **REVIEW**

**of a dissertation  
for the acquisition of the educational and scientific degree “Doctor” in**

**field of higher education – 5 Technical Sciences**

**professional field – 5.3 Communication and Computer Engineering**

**doctoral program – “Communication Networks and Systems”**

**Author: Eng. Emmanouil Themistoklis Kypraios**

**Topic: Methods and Algorithms for Research on Multiplexed Signals in Passive Optical Communication Networks**

**Reviewer: Prof. Teodor Bozhidarov Iliev, University of Ruse “Angel Kanchev”**

## **1. Topic and relevance of the dissertation work**

Methods and algorithms for studying multiplexed signals in passive optical communication networks (PON) are important for several key reasons, which cover both the physical layer and network efficiency and reliability. Multiplexed signal analysis algorithms allow solving a number of optimization problems such as optimal allocation of available resources, minimizing spectral overlap and losses, and increasing total capacity without physically expanding the network.

Since in passive optical networks, signals are combined and separated passively, this leads to interchannel interference, chromatic and polarization dispersion, and nonlinear effects at high speeds. Signal analysis and processing methods would help to accurately separate signals, reduce bit error rate (BER), and increase quality of service (QoS).

All of the above indicators are critical for the scalability of PON networks. Methods and algorithms for studying multiplexed signals are the basis for reliable, high-speed, and scalable passive optical networks. They allow to increase capacity, reduce errors, support new services and optimize costs – without changing the passive optical infrastructure.

Based on the above analysis of the current state of passive optical networks with signal multiplexing and its compliance with the formulated objective and main tasks in the dissertation, I believe that the topic of the dissertation and the issues developed in it are relevant and challenging for scientific and applied development.

## **2. Overview of the cited literature**

A total of 79 literary sources were used in the development of the dissertation. Seventy-two (72) of the sources are in English, and five (5) are in Bulgarian. A total of two (2) sources from the Internet were used. A large part of the literary sources are publications, predominantly referenced and indexed in the well-known databases.

The dissertation contains an overview, including sources and materials published mainly in the last 10 years. I believe that the doctoral student has entered the essence of the researched subject area and I can conclude that through the analysis of the literary sources, a correct formulation of the purpose of the dissertation and the main tasks related to its achievement has been achieved.

### **3. Research methodology**

The structure of the dissertation includes an introduction, four chapters, a conclusion, a list of abbreviations used, a list of contributions to the dissertation work, a list of publications on the dissertation work, a list of references. The dissertation has a volume of 126 pages and contains 128 figures and 12 tables.

The introduction in Chapter One of the dissertation demonstrates a good knowledge of the current state and areas of research and development in passive optical communication networks with spectral multiplexing. This knowledge has allowed the author to correctly assess the state of the problem and formulate the research objectives in the dissertation work.

In Chapter Two of the dissertation, a generalized approach for modeling a multi-channel optical communication network is presented, a basic model is developed and a methodology for conducting measurements and testing of WDM PON systems is compiled.

In the Chapter Three of the dissertation, simulation studies have been performed and analyses of the results for a simulation model of a multi-channel WDM system with different formats of external optical modulation of signals and configuration of optical sections have been presented. An algorithm for optimal planning and optimization of the parameters of a multi-channel optical communication line has been synthesized.

In the Chapter Four of the dissertation, a conceptual design, modeling, practical implementation and research of an experimental stand for research of multiplexed optical signals in a passive optical network have been presented. The architecture of the stand and the key control points for conducting research have been presented, and experimental results from conducting measurements have been presented, discussed and analyzed.

The research methodology is based on the application of classical, qualitative and conceptual methods. Classical and qualitative methods are used in the synthesis, study and analysis of simulation models, and conceptual methods - in the practical implementation of an experimental model for research of the processes of spectral multiplexing and signal transmission in a passive optical communication network. For the simulation studies, the OptySystem and MATLAB/Simulink software environments were used, through which exemplary models of optical connection lines in a passive experimental network with spectral multiplexing were developed, demonstrating parametric analyses, search for hidden relationships and optimizations of the complex interaction between parameters. The subject of research are the various processes at the physical level related to the processing of signals in the optical communication channel, as well as the dependencies concerning the parameters determining the performance and efficiency of information transmission under various complex initial conditions.

I believe that the doctoral student has adequately applied the relevant research methodologies and has correctly selected the necessary apparatus for conducting the scientific and applied research on the dissertation work.

### **4. Contributions of the dissertation work**

A reference is attached to the dissertation, containing 4 scientific-applied and 3 applied contributions. In general, I accept the proposed formulation of the contributions in the dissertation, as follows:

A) Contributions of a scientific and applied nature:

1. A methodology and algorithm for optimal planning, sizing, modeling and research of passive optical networks with spectral multiplexing of signals are proposed.
  2. Simulation models are synthesized for research, analysis, performance evaluation and solving optimization problems in high-speed (10Gbps) multi-channel optical networks using different optical modulation formats (NRZ and RZ) of signals and various complex configuration parameters.
  3. The degree of influence of high optical density in the fiber core on the occurrence of nonlinear effects (FWM, SPM and XPM) in different optical modulation formats of signals (RZ and NRZ) is studied. It is established that RZ pulses have a higher peak power and as such are more susceptible to FWM, SPM and XPM. It is established that in the presence of SPM, these pulses can undergo compression and be more efficient than NRZ pulses.
  4. Graphical dependencies related to determining the boundary conditions and the maximum value of the Q-factor for different input parameters and network range are derived by determining the propagation losses, the eye diagrams of the channel optical signals and the optimal value of the input optical power.
- B) Contributions of an applied nature:
5. Simulation models of multi-channel high-speed optical communication networks have been developed and studied to solve optimization problems according to the criteria of achieving a minimum BER value (Min. BER) or maximum Q-factor and ensuring maximum network performance and efficiency at different input signal parameters.
  6. A practical model of a PON network with wavelength division multiplexing of optical signals for the delivery of interactive services has been developed and studied, designed to perform three main tasks: to allow a wide variety of practical research; to be a platform for conducting general research in the field of passive optical networks; to provide convenient and easy training for personnel.
  7. Steps of experimental research have been defined and experimental results are presented for a comprehensive determination and evaluation of the energy balance and parameters of the model for studying multiplexed optical signals in a passive optical network, using specialized measuring equipment.

## **5. Publications and citations of publications on the dissertation work**

A total of six (6) publications have been submitted to the dissertation, which provide 64.98 points and exceed the required 30 points in the scientometric indicators according to the minimum national requirements and the requirements of TU-Gabrovo for acquiring the educational and scientific degree “doctor”.

Two (2) of the publications are single-authored. In one of the remaining four (4) publications, the doctoral student is the lead author, and in three (3) of them – in second place.

The publications are in Bulgarian and were presented at the International Scientific Conference “Unitech” 2025, the National Scientific Conference with International Participation “TechCo” 2023 and 2024 and the “Student Scientific Session” of TU - Gabrovo - 2024.

The content of the publications corresponds to the topic of the dissertation and largely covers and provides the necessary publicity for the main research and conclusions presented in the dissertation.

No evidence of citations of publications was attached to the dissertation, but this is not a requirement for obtaining the ESD “Doctor”.

## **6. Authorship of the obtained results**

No evidence of plagiarism has been found in the materials submitted for defense. I believe that the main part of the research conducted and the compiled analyses of the results are entirely the personal contribution of the doctoral student. The consistently presented research and conclusions in the presented dissertation work and the published scientific publications give me reason to accept the achieved results as reliable and sufficient.

## **7. Author’s abstract and author’s reference**

The abstract for the dissertation of Eng. Emmanouil Kypraios has a volume of 48 pages. It is well structured, reflects and presents precisely, clearly and completely the content of the dissertation and complies with the requirements of The Law on the Development of Academic Staff in the Republic of Bulgaria and the Regulations for its application. The qualitative assessment of the developed author’s abstract is entirely positive.

The attached author's reference fully reflects the main stages of the conducted scientific research and work on the dissertation.

The applicability of the dissertation is related to the creation of methodologies of procedures related to correct approaches in modeling, selection and implementation of architecture, the necessary equipment and correct configuration, through monitoring and evaluation of the parameters of the signals in passive optical networks with wavelength division multiplexing of the signals, related to improving the reliability and efficiency of communication and the quality of services in them.

The analyses performed enrich the existing knowledge on the topic, and the results of the dissertation research find real application in practice with an undeniable technical, economic and educational effect.

## **8. Comments, recommendations and remarks on the dissertation work**

I believe that the dissertation work is of sufficient volume and the necessary depth of research. The doctoral student's activity is at a high level, and the results obtained are significant enough for the educational and scientific degree of “doctor”. The publicity of the work is ensured and proven by publications of papers in refereed and indexed scientific conferences.

I have no significant critical remarks on the doctoral student's scientific production, submitted for review. My recommendations are mainly related to the language and style in formulating the main theses and conclusions in the work, the presence of certain terminological inaccuracies, supplementing the list of abbreviations used and literary sources.

From the point of view of the practical applicability of the dissertation work, I would recommend that the doctoral student expand his focus on the topic by orienting himself towards work on development national and international projects in the field of optical

communications and popularizing the achieved results through participation and publications in international scientific forums, conferences and publications, referenced in the world's scientific databases.

The recommendations and comments made do not diminish the merits of the developed dissertation work and aim to assist the doctoral student in his future research activities.

## **9. Conclusion**

I consider that the presented dissertation meets the requirements of the Law on the Development of Academic Staff in the Republic of Bulgaria.

The achieved results give me reason to propose that the educational and scientific degree “Doctor” be acquired by Eng. Emmanouil Themistoklis Kypraios in the field of higher education – 5. Technical Sciences, professional field – 5.3. Communication and Computer Engineering, doctoral program – “Communication Networks and Systems”.

12.02.2026

**Reviewer:** /signature/  
/Prof. Teodor Iliev, PhD/