

# **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 of the dissertation:** Eng. Nikolay Petkov Manchev, MSc

**Dissertation topic:** „Development and research of a low energy wireless communications platform for the Internet of Things”

**Reviewer:** Prof. Eng. Stanimir Mihaylov Sadinov, PhD

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

The topicality of the set issue and related research on the dissertation work are defined as significant and broad-spectrum in terms of the development of wireless communications and the implementation and expansion of services in them.

The research and problems considered in the dissertation submitted for review include the processes related to the processing, transmission and reception of data through an established communication channel based on LoRaWAN technology, its receivers and transmitters - modulation, the coding of the channel, the characteristics of the receiver/transmitter complex, synchronization and configuration of software and hardware modules making up the platform.

The chosen subject makes it possible to combine heterogeneous statistical analytical and software methods for data analysis and processing, and the means of information and communication technologies are used for configuration, monitoring and control of LoRaWAN low-energy communication systems for data transmission in different wireless environments (urban/extra-urban), by determining optimal measurement ranges of specific technical parameters and criteria related to the effective operation and setup of low-energy wireless LoRaWAN networks.

## **2. Review of cited literature**

The dissertation includes an introduction, four chapters, a conclusion, a list of abbreviations used, a list of publications on the dissertation, a list of references and 6 Appendices directly related to and clarifying the research in the individual chapters. The dissertation has a volume of 204 pages, was developed based on an analytical review of 130 literary and Internet sources, including 86 in English and 44 Internet-based sources. The exposition in the first chapter of the dissertation shows a good knowledge of the possibilities and parameters of low-energy communication systems, as well as the international standards regulating their possibilities and requirements. This knowledge

has allowed the dissertation student to correctly assess the current state of the problem and formulate research goals in the dissertation work.

The cited literature covers the period of the last 20 years, with nearly 60% of the total amount analyzed in the interval of the last 10 years. It can be said that an assessment of the problem has been made, which makes it possible to take into account the achievements to date related to the reflection of significance and usefulness in the planning, construction, operation and management of low-energy wireless LoRaWAN networks and their communication channels.

### **3. Research methodology**

The object of research is both the transmission air (wireless) environment and the behavior in it of the signal parameters characterizing LoRaWAN networks for data transmission, both in closed and open areas, in urban and non-urban environments.

The subject of research are the various processes related to transmission, reception and synchronization, as well as the dependencies concerning modulation, channel coding, multiplexing, characteristics of the receiver/transmitter complex, synchronization and configuration of software and hardware modules making up the platform. The research methods are mainly divided into separate chapters, such as analytical, simulation and practical, and cover the dependences of the parameters characterizing the implementation of communication.

The research site is exemplary, concerning practical research in a certain part of a coverage area and in laboratory conditions with the available measuring equipment.

The aim of the research is to create methodologies of procedures related to good practices in configuration, monitoring and control of LoRaWAN low-energy communication systems for data transfer in different wireless environments (urban/extra-urban), by determining optimal measurement ranges of specific technical parameters and criteria related to the effective operation and setup of low-energy LoRaWAN wireless networks.

The aim of the dissertation is to develop and research a platform for low-power wireless communications in the context of the Internet of Things, using low-power hardware components with sufficiently large computing capacity, which use open-source software tools or with a final software product with the inability to change.

For the realization of the formulated goal, the tasks set by the dissertation are related to:

- identification of risks for low-energy communications, through theoretical research and analysis of existing threats to information resources in these communications and platforms;
- to analytically model data traffic under different conditions of the transmission environment (urban and non-urban) based on the existing theory and practice in the field of low-energy wireless networks;
- creating a simulation model of wireless data transmission to predict network capacity and evaluate the performance of a low-energy communications platform;

- practical implementation of an exemplary low-energy platform on which to conduct experimental tests and research and to create recommendations for its application and construction in the context of the dissertation work.

#### **4. Dissertation Contributions**

In view of the scientific and research work carried out, two categories of contributions can be grouped, reflecting the qualities and new aspects when compiling the dissertation work, and after repeated discussions, they were cleared of commonly known facts and reformulated in a positive direction:

- ❖ Scientific-applied contributions:
  - Proven message encryption algorithms using the low-energy LoRaWAN protocol, which ensure the security and reliability of transmitted data, have been established and researched. The use of the linearly varying frequency (Chirp) method has been proposed, which contributes to greater data security, thus using a narrower frequency band used in wireless communications.
  - An approach to determine the coverage efficiency of low-energy wireless networks in an urban environment is proposed, based on certain indicators, divided into three groups - reliability, delay and credibility.
  - An algorithm is proposed, presenting a practical approach for the implementation of an RF gateway and a sequence in conducting the experimental studies in a closed and open area.
  - The influence of the signal-to-noise ratio on the quality of wireless coverage in a specific open area is investigated. A comparative assessment was made between the practically obtained results and the simulation results in the same radio coverage area, as the object of research are the parameters of the final device, the RF gateway, the attenuation in the coaxial line, etc.
- ❖ Applied Contributions:
  - For the purposes of the dissertation work, a final device of a communication system has been practically implemented using the low-energy LoRaWAN protocol for wireless communications with remote control of electrical contacts with contact status feedback.
  - A final device with solar power has been practically realized, which has been tested over a period of 3 years under different weather conditions. Its economy is achieved through the newly created software library for optimization of end device consumption during non-transmission of data.
  - The possibility of VPN connectivity of several routers with the implemented low-energy communication system using the LoRaWAN protocol has been proposed and implemented, in order to store the data in a certain place. In such a case, there is no need to purchase additional hardware to save the data, while also providing opportunities for processing, analysis, visualization and research of the data from one centralized point.

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

Regarding the reflection of the results of the dissertation work, six publications at international conferences and scientific publications, fully covering the minimum requirements regarding the considered criterion, have been presented. Three of the works were presented at the "Unitech" International Scientific Conference and two at a national conference and "TechCo", one of them being independent, and the other five being prepared in co-authorship with the scientific supervisors and author team. The publications were issued in peer-reviewed collections from the international scientific conference "Unitech" and the national conference "TechCo" in the study period 2020-2022, actually representing nearly 2/3 of the content of the dissertation work. One of the publications was presented at an international scientific conference and published in the journal JESTR, which has a Scopus rank. In the Scopus databases, there are also other publications by Eng. N. Manchev, as well as citations, and at the moment his "Hirsch" factor is  $h=2$ . The publications present a large part of the conducted research and present the main conclusions of the dissertation work.

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

In the presentation of the dissertation work, a significant amount of scientific research and experimental activity was realized by the doctoral student under the guidance of his scientific supervisors. I believe that a huge share of the conducted research and compiled analyzes in connection with summarizing the results are entirely personal contributions of Eng. N. Manchev. The orientation of the obtained results greatly enhances the currently existing research on signal treatment processes - generation, coding, modulation, transmission and reception of LoRaWAN signals - by synthesizing analytical and simulation models and conducting practical experimental results. The doctoral student actively participates in the educational process by developing experimental productions and experimental stands, participates in the teams and in research projects at TU-Gabrovo of a practical-applied nature.

## **7. Abstract and author reference**

The abstract is in a volume of 34 pages, with the numbering of the mathematical expressions and figures corresponding to that in the dissertation work. I believe that the abstract is structured well and in accordance with the requirements, reflects sufficiently fully and correctly the relevance of the work, its purpose and tasks, applicability of the results and approbation.

From the author reference made, I did not find any plagiarism by the author in the presented dissertation and the published works related to it. I believe that, in terms of content and layout, the dissertation and the abstract meet the requirements of the Law on the Development of the Academic Staff in the Republic of Bulgaria and the Regulations for the Acquisition of Scientific Degrees and the Occupancy of Academic Positions at TU-Gabrovo.

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

I believe that methodical, in-depth and with different focus sets of researches in software and real experimental environment have been done regarding the issues raised

in the dissertation work. In connection with the described research, analyzed results, synthesized models and implemented practical experiments, the following remarks and recommendations can be defined:

- In separate places in the notes of the presentation, stylistic and grammatical errors regarding the speech when presenting the information are noticeable, which do not detract from the work of the doctoral student;
- It would also be nice to have a list of the symbols and notations used in the formulas and text;
- When presenting the literary sources, it would be good to separate the Internet addresses from the others and arrange them in alphabetical order;
- Also, when citing and describing literary sources, it would be good to give more detailed information with ISBN/ISSN, issues, publishers and pages.

In the future, I recommend that the doctoral student actively participates in the research teams of the Technical University of Gabrovo in international and national projects and publishes the achieved results in ranked conferences and journals from the Scopus/WoS databases.

## 9. Conclusion

The topic of the dissertation is current and well developed. The problem set and the research related to it, as well as their justification, are satisfactorily significant and comprehensively described in the development.

I believe that the submitted dissertation **meets** the requirements of the Law on the Development of the Academic Staff in the Republic of Bulgaria. The achieved results give me reason **to propose** that the educational and scientific degree "Doctor" **be acquired** from the mag. Nikolay Petkov Manchev, Eng in the field of higher education - 5. "Technical sciences", professional field - 5.3. "Communication and computer technology", doctoral program - "Communication networks and systems".

29.01.2024

Reviewer: /signature/  
/Prof. Eng. Stanimir Mihailov Sadinov, PhD/