

## **REVIEW**

by Eng. Dimitar Mihaylov Tokmakov, Ph.D

Professor at the ECIT department, Faculty of Physics and Technology,

University of Plovdiv "Paisii Hilendarski"

on the dissertation for the award of the educational and scientific degree "PhD"

by: field of higher education: *5 Technical sciences*

Professional field : *5.3. Communication and computer engineering*

Doctoral programme: "*Automation of areas of the intangible sphere (medicine, education, science, administration, etc.)*"

**Author: Svetoslav Genchev Hadzhigenchev**

**Topic:" GEOELECTRICAL RESISTIVITY TELEMETRY SYSTEM IN SEISMOGENIC ZONES"**

Scientific supervisor:

Assoc. Prof. Slavi Lubomirov, Ph.D - Paisii Hilendarski University of Plovdiv

### **1. General description of the presented materials**

By order no. RD-21-123/19.01.2024 of the Rector of the University of Plovdiv "Paisii Hilendarski" (PU) I have been appointed as a member of the scientific jury for the defense of a dissertation work on phys. Eng. Svetoslav Genchev Hadzhigenchev on the topic: "System for telemetry of geoelectrical resistance in seismogenic zones", presented for the acquisition of the educational and scientific degree "doctor" in the field of higher education 5. Technical sciences, professional field, 5.3. Communication and computer engineering, doctoral programme Automation of areas of the intangible sphere (medicine, education, science, administrative activity, etc.).

The Ph.D. student Phys. Eng. Svetoslav Genchev Hadzhigenchev studied at the doctoral program at the Department of Electronics, Communications and Information Technologies (ECIT) at Plovdiv University "Paisii Hilendarski" and with scientific supervisor Prof. Slavi Lyubomirov.

Presented by the PhD student, Phys. Eng. Svetoslav Genchev Hadzhigenchev set of materials on paper is in accordance with Article 36 (1) of the Regulations for the Development of the Academic Staff of the PU and includes the following documents:

- Application to the Rector of the PU to disclose the procedure for the defense of a dissertation work;
  - curriculum vitae in European format;
  - statement from the PhD supervisor regarding the initiation of the procedure;
  - minutes from the department council related to reporting the readiness to open the procedure and preliminary discussion of the dissertation work;
  - dissertation work;
  - abstract of the didertstion;
  - list and copies of scientific publications on the topic of the dissertation;

## **2. Brief biographical data for the doctoral student**

I do not know the doctoral student personally, and I obtained biographical information from the presented autobiography.

Phys. Eng. Svetoslav Genchev Hadjigenchev graduated from the Faculty of Physics of Sofia University "Kliment Ohridski" with master degree in "Physics" with a specialization in Physics of the Earth, Atmosphere and Space in 1982. In 1989, he completed a second higher education as an electrical engineer with master degree in "Electronic Technology and Microelectronics" at VMEI-Gabrovo.

His work began at the "National Institute of Geophysics, Geodesy and Geography – Bulgarian Academy of Sciences“ in 1982 as a seismologist at the "Rozhen" seismic station.

Since 1998 until 2001 is the head of the accredited Central Testing Laboratory in Gamakabel AD – Smolyan, Bulgaria, and is responsible for measurement and testing of cables and wires, metrology, standardization and quality control.

Since 2012 until 2022 he is the chief expert - physicist at the Regional Health Inspectorate, Smolyan, Bulgaria where he deals with measuring factors of the working environment: microclimate, lighting, noise, dust, electromagnetic fields, radon and chemical agents.

He has competences in designing and programming microcontrollers, measuring the concentration of fine dust particles, carbon, sulfur and nitrogen dioxide, radon and processing the results of the measurements.

From 02.2022 he is enrolled as a full-time doctoral student in the ECIT department, of the Faculty of Physics and Technology at Plovdiv University "Paisii Hilendarski" in the field of higher 5. Technical sciences, professional field, 5.3. Communication and computer engineering, doctoral programme Automation of areas of the intangible sphere (medicine, education, science, administrative activity, etc.) with supervisor, Assoc.prof. Slavi Lyubomirov, Ph.D and topic of the dissertation work: "System for telemetry of geoelectrical resistance in seismogenic zones".

Bearing in mind the data from the autobiography, as well as his successful training as a full-time doctoral student at the Faculty of Physics and Technology at Plovdiv University "Paisii Hilendarski", I can conclude that the doctoral student Phys. Engineer Svetoslav Genchev Hadzhigenchev has the necessary educational and practical training.

### **3. Actuality of the topic and appropriateness of the set goals and tasks**

The problem of earthquake prediction is still unsolved worldwide despite the numerous scientific studies and publications on the subject. That is why the topic of the dissertation work is extremely relevant and modern, looking for a harbinger of earthquakes by measuring changes in physical parameters in given seismogenic zones.

The topic of the current dissertation is related to research in the field of earthquake forecasting and, more specifically, to the monitoring of one of the established prognostic effects - the change in the electrical resistance of the earth's crust in the process of earthquake preparation.

The purpose and tasks are formulated after the introduction in the dissertation. The main goal of the research, stated in the thesis, is "to develop a system for telemetry of geoelectrical resistivity and other earthquake harbingers in seismogenic zones."

To achieve the goal of the dissertation, the following tasks are set:

1. To study the results of studies of changes in geoelectrical resistance and the existing methods and means of its measurement, carried out in order to establish their relationship with earthquakes.

2. To choose a suitable method and to design an apparatus for measuring the variations of the geoelectrical resistance. Simulate the operation of the main blocks with integrated design and analysis environments. To develop a method for calibration and verification of the apparatus. To investigate the influence of noises on the results of measurements.

3. To carry out a hardware implementation of an apparatus for measuring the variations of the geoelectrical resistance. To develop measurement management software and install the equipment in field conditions.

4. To implement a system for transmission, processing and visualization of data from geoelectrical and other measurements. To develop a program for initial processing of the received data.

I believe that the tasks set in this way meet the purpose of the dissertation and their successful implementation is a guarantee of high-quality scientific research.

#### **4. Knowledge of the problem**

In the literature review, the doctoral student examined the current state of the problems of earthquake prediction by various harbingers by studying 70 literature sources indexed in the world research databases Scopus and Web of Sciences, most of them up-to-date from the last 10 years.

I believe that from the literature research done, the doctoral student classified the harbingers of earthquakes according to the data from the literature review, as he also described his own experience in this field as a seismologist at the Rozhen seismological station.

The ambiguity of earthquake harbingers is assessed, emphasizing that it is possible to find a correlation between geoelectrical resistivity changes and observed harbinger effects and local earthquake parameters.

This gives me reason to judge that the PhD student is familiar with trends and research in earthquake harbingers, geoelectrical resistivity measurement systems, and interpreting the data from these measurements as an earthquake harbinger.

#### **5. Research methodology**

In connection with the fulfillment of the formulated goal of the dissertation work, the doctoral student used various theoretical and practical approaches and methods to solve the set tasks. The object of the study is a geoelectrical resistivity telemetry system in seismogenic zones.

I believe that the Ph.D. student Phys. Eng. Svetoslav Genchev Hadzhigenchev correctly structured his work methodically, following the stages for any scientific research - he studied the problem, proposed a solution, which he implemented, tested and analyzed.

The developed, designed and realized apparatus for measuring the variations of geoelectrical resistance is a complex system of hardware, software, power supply unit and communication part, which measures the geoelectrical resistance and transmits the measurement data remotely.

The doctoral student correctly uses a system approach and has decomposed the process into component processes, performing an analysis for each of them, proposing and implementing a schematic or software solution, and subsequently integrating these solutions into a complete system. From a methodological point of view, in his development, the doctoral student has demonstrated scientific culture and professional skills for integrating the solutions of broad-spectrum and complex tasks into one common installation, given the different nature of the system's modules and the need for their joint work. The used work methodology is correctly selected in accordance with solving the set tasks and achieving the goal.

## **6. Characterization and evaluation of the dissertation work**

The dissertation submitted for review has a total volume of 166 pages and contains 86 figures (photos, diagrams, graphs), 5 tables and 19 formulas. The dissertation is composed of an introduction, four chapters, and a conclusion with contributions of the dissertation, a list of scientific works related to the development, directions for future developments, references and appendices.

The dissertation research was conducted within the framework of a doctoral program at the ECIT department of the Plovdiv University, on the basis of which the main research, project and experimental activities were carried out.

In the first chapter with a volume of 46 pages, a literature review of the problems of earthquake prediction, classification of harbingers and the place of geoelectric resistance variations in them is made. Bulgarian experience in earthquake monitoring and forecasting is also presented. Scientific data on the nature of earth's electrical resistivity are presented. The methods for measuring the geoelectrical resistivity are presented. Some results of observations of apparent

resistance variations in the process of preparing for earthquakes in Bulgaria and around the world are discussed.

In the second chapter of the dissertation, an apparatus for measuring the variations of the geoelectrical resistance was designed and implemented. A symmetrical Schlumberger circuit was chosen for the designed and implemented installation, which has a number of advantages over other measurement methods. The geographical location of the installation in the land of the village of Dunevo, region Smolyan, Bulgaria.

Presented is block diagram of the field part of the implemented equipment, including the following blocks: ESP32 - central processing module, RTC - real time clock, SD card, AMPU - voltage measurement channel amplifier, AMPI - measurement channel amplifier of current, H BRIDGE - H bridge, DC-DC - controllable inverter, I2C ADC, I2C DAC - ADC and DAC on I2C bus, LORA - LoRa modulation module, PM - power management module, TLP250 - opt isolators, ISO1540 - I2C bus isolators, HLK5D1212 - isolated DC-DC converters, Rain CPU - processor for measuring precipitation, Rain Gauge - vessel for precipitation, ATH20 - module for measuring meteorological parameters, Ri - resistance for measuring current.

A block and principle diagram of the developed system, results of computer simulations, a system calibration methods are all presented.

Chapter three is dedicated to the software control and practical implementation of the apparatus for measuring the variations of the geoelectrical resistance. An algorithm of operation of the measurement control program and fragments of the code forming the firmware for ESP32 are presented. Original printed circuit boards developed and an overview of the constructed and assembled system are shown. Photos of the installed electrodes in the area of the land of the village of Dunevo, region Smolyan, Bulgaria as well as photos of setting up the equipment in the field.

The results of the observations of the geoelectrical resistance during realized earthquakes for the measurement period with a magnitude  $\geq 2.5$  and distances up to 100 km from the observation site are presented. The factors drought and amount of precipitation influencing the variations of the geoelectrical resistance were evaluated.

Chapter 4 is dedicated to the embedded IoT system for remote transmission of the data via a LoraWan modem and the use of the Thingspeak platform (property of MathWorks) to record, visualize and analyze the received data. A snippet of the code for processing the raw data in

Thingspeak's MATLAB Analysis is presented. A web page for visualization of the data from the measurements has also been developed at the address: <http://www.ra-monitoring.bg.cm/>.

The dissertation work was developed in the ECIT department of Plovdiv University "Paisii Hilendarski" and the system for measuring the variations of the geoelectrical resistance was implemented in real field conditions.

Phys. Eng. Svetoslav Genchev Hadjigenchev has carried out development and research work, conducted experimental studies and made generalizations and conclusions, and the results are presented through appropriate photographic, tabular and graphic material.

## **7. Contributions and significance of the development for science and practice**

In the presented dissertation work, there is a correspondence between the goal, the tasks set for its realization, and the presented results of the theoretical and experimental developments, and essentially the work contains results that can be defined as scientific-applied and applied contributions with a predominance of applied ones.

At the conclusion of the dissertation, the doctoral student presented his view of the contributions of the development, which are divided into two categories - scientific and applied:

Scientific and applied contributions:

1. The existing methods, techniques and means in the field of recording the changes in the geoelectrical resistance in connection with the preparation of earthquakes have been studied and systematized.

2. The possible sources of noise, the ways of their reduction and the results of the observations of variations of the apparent resistance in the process of earthquake preparation are analyzed.

3. The anomaly registered by the author when measuring the apparent resistance in the area of the town of Strazhitsa, after the destructive earthquake of 07.12.1986, is shown and analyzed. (M=5.7). It is assumed that the observed anomaly (~14%), preceding the largest (for the observation period) aftershock, that of 11.05.1987. (M=3.6), is related to seismic activity.

4. The effect of drying on the contact resistance of the electrodes was investigated, resp. of the operating current value and the measured geoelectrical resistance. A cross-correlation was performed with temperature and precipitation.

As applied contributions, the doctoral student has indicated the following:

1. Equipment for measuring the variations of geoelectrical resistance and meteorological parameters has been designed and implemented in hardware. It was installed in the land of the village of Dunevo, region Smolyan.

2. Modules for calibration and verification of the equipment for measuring variations of the geoelectrical resistance have been implemented. An estimate of the error of the measurements was made.

3. Data obtained from the geoelectrical resistivity register and meteorological parameters for an eight-month period are presented, together with recorded earthquakes of magnitude greater than 2.5 on the Richter scale and epicentral distances up to 100 km. An algorithm for removing outliers and smoothing the "raw" data is described.

4. The software enables registration, transmission, processing, storage and visualization of the received sensor data in a cloud platform. A MATLAB program was created to process the data from the station and visualize it in real time.

I believe that the claims presented by the doctoral student with a classification of the contributions correspond and detail the results obtained, according to the specifics of their significance.

The value of the development should be highly appreciated, given that the developed measurement system is implemented in real field conditions and collects data on the geoelectrical resistance in the specified area. I believe that the received contributions can be defined as essential for science and practice.

## **8. Evaluation of publications on the dissertation work**

The PhD student Phys. Eng. Svetoslav Genchev Hadzhigenchev has presented a list of 5 works, all of which are in Bulgarian language. Four of the publications he is the only one author and one is co-authored with his supervisor.

Four of the publications are at scientific conferences of the Union of Scientists in Bulgaria, which are peer-reviewed, and one is at an international scientific conference and was published in the collection of the University Publishing House at the University of Plovdiv "Paisii Hilendarski".



Through the presented scientific publications related to the dissertation, the doctoral student Phys. Eng. Svetoslav Genchev Hadjigenchev has obtained 90 points in relation to the minimum national requirements for the publication activity with the required 30 points, i.e. crosses the threshold of three times.

The data presented in this way give me reason to conclude that the necessary publicity of the research in the dissertation has been ensured.

### **9. Personal participation of the doctoral student**

From the presented five publications on the dissertation work, essentially reflecting the obtained results of the development, there is no doubt about the personal participation of the doctoral student, as well as evidence of his substantial contribution to the obtained results.

### **10. Abstract**

The abstract has a volume of 32 pages and faithfully reflects the content of the dissertation. The work is in a summarized form, containing a general description of the dissertation work, the purpose and tasks of the dissertation work, results of the literature research in the first chapter, the main highlights of the doctoral student's work, presented in the remaining three of four chapters, conclusion, main contributions and research papers of the dissertation work.

### **11. Critical remarks and recommendations**

I have no particular remarks regarding the presentation and the design of the dissertation work.

The dissertation shows that the goal has been achieved and that the candidate has in-depth theoretical knowledge of the relevant specialty and the ability for independent research.

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

I take the liberty of recommending that the PhD student continue to upgrade the geoelectrical resistivity telemetry measurement system thus developed by adding new sensors to measure other physical quantities of the environment that could be other harbingers of a given earthquake.

It is also good for the doctoral student to prepare an integral article on the subject of the dissertation in English, to be published in a journal with an impact factor indexed in the world databases Scopus and Web of Science.

## **CONCLUSION**

The dissertation work represents a valuable scientific development and the doctoral student Phys. Eng. Svetoslav Genchev Hadzhigenchev has fulfilled the set goals and tasks.

The dissertation contains original scientific-applied and applied contributions and meets the requirements of the Law on the Development of the Academic Staff in the Republic of Bulgaria (ZRASRB), the Regulations for the Implementation of ZRASRB and the relevant Regulations of the Plovdiv University "Paisii Hilendarski" for awarding the doctoral degree.

The dissertation shows that the Ph.D. student Phys. Eng. Svetoslav Genchev Hadjigenchev possesses in-depth theoretical knowledge and professional skills in scientific specialty 5.3 Communication and computer technology, demonstrating qualities and skills for independent conduct of scientific research and solving tasks.

Taking into account the merits, relevance, significance of my dissertation submitted for review, I give it a positive evaluation and suggest that the scientific jury award Phys. Eng. Svetoslav Genchev Hadjigenchev the educational and scientific degree "DOCTOR" in scientific field 5. Technical sciences, Professional field: 5.3. Communication and computer technology, doctoral program "Automation of fields from the intangible sphere (medicine, education, science, administrative activity, etc.)"

20.02.2024

Prepared by:.....

/prof. Dimitar Tokmakov, Ph.D/