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PROJECT TOPIC:

**DEVELOPMENT OF A
MONITORING SYSTEM FOR THE
GEOTECHNICAL CONDITION OF
MINE AND QUARRY WORKINGS
BASED ON INTELLIGENT FIBER-
OPTIC SENSORS**

Project implementation period: 2023 - 2025



The work is being carried out with funding and support from the Ministry of Trade and Integration of the Republic of Kazakhstan

project BR19980899

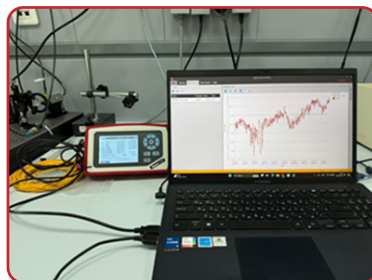
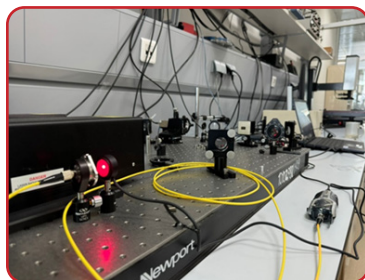
PROJECT TOPIC:

DEVELOPMENT OF A MONITORING SYSTEM FOR THE GEOTECHNICAL CONDITION OF MINE AND QUARRY WORKINGS BASED ON INTELLIGENT FIBER-OPTIC SENSORS

Project implementation period: 2023 -2025 rr.

PROGRAM OBJECTIVE: The development of methods and means of control based on intelligent fiber-optic measurement systems with high metrological characteristics, along with conducting comprehensive scientific research to create prototypes and implement them in production. The aim is to enhance safety and economic efficiency in mining operations at mines and quarries, as well as the practical implementation of digital technologies in Industry 4.0.

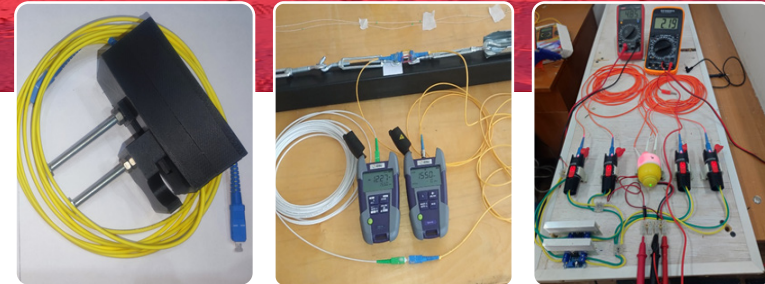
BRIEF DESCRIPTION: The monitoring system for the geotechnical condition of mine and quarry workings based on intelligent fiber-optic sensors is built on an original hardware-software complex. It operates in real-time mode with the ability to transmit and archive the obtained data.



RESULTS OF THE WORK:

As a result of the research, patents were prepared and obtained, along with certificates of inclusion in the state register of rights for objects protected by copyright:

1. Certificate No. 47983 dated 28.06.2024. Control Code for Sensors of the Intelligent Fiber-Optic Monitoring System for the Geotechnical Condition of Quarries and Pits. Alkina A.D., Mehtiev A.D., Neshina E.G.
2. Utility model patent "Fiber-optic sensor for monitoring the stability of quarry slopes", No. 8004
3. Utility model patent "Fiber-optic system for monitoring deformation and displacement of roof rocks in explosive environments", No. 8699
4. Patent application for the utility model "Fiber-optic system for monitoring the stability of quarry slopes"
5. Patent application for the utility model "Fiber-optic system for monitoring changes in rock pressure"



The hardware-software complex for monitoring the displacement (deformation) of rock masses provides measurement accuracy of 0.1 mm with a sensor length of up to 30 km. An original method for intelligent numerical assessment of changes in the parameters of backscattered radiation falling on the surface of a photomatrix installed at the exit of the optical fiber has been developed. This occurs when mechanical impact causes changes in the properties of the backscattered spot and the transition of pixels from one intensity state to another.

A key aspect of this work is the search for a new technical solution and data processing methodology to ensure a fundamentally important distinction from methods like optical interferometry, reflectometry, and Bragg fiber gratings, which are already well-studied and known.

The use of a photomatrix is a major difference from the single-pixel photodetector, which forms the basis of known methods. The hardware-software complex performs optical-digital analysis of all changes in the pixel image of the photomatrix, which distinguishes it from similar methods that only capture changes in light wave scattering or intensity amplitude.

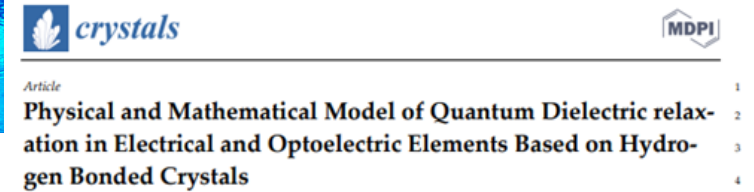
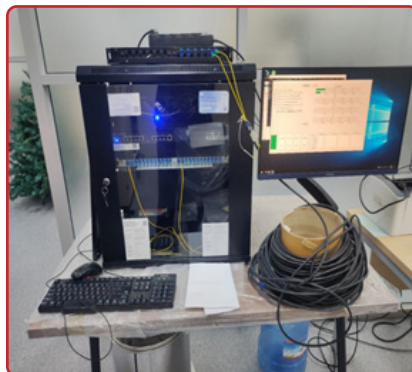
STATUS:

Laboratory samples of fiber-optic displacement sensors for rock masses in mines and quarries have been developed, along with software, an autonomous power supply system, and data transmission over distances of up to 30 km.

FIBER-OPTIC SENSORS (FOS)

They are ideally suited for use in the mining industry due to their small size and weight, low power consumption, resistance to environmental impacts, electromagnetic interference protection, good performance indicators, corrosion resistance, low cost, complete explosion safety, flexibility, wide signal bandwidth, ability to multiplex signals, and significant mechanical strength.

The relevance of the project is determined by the importance of preventing sudden changes in parameters that affect the strength of mine workings in quarries and pits, ensuring the protection of personnel from sudden collapses. The project proposes to improve labor safety by utilizing new scientific advancements related to the use of fiber-optic technologies, specifically the fiber-optic sensor included in the hardware-software complex.



As a result of the research, articles have been prepared and published in peer-reviewed scientific journals indexed in the Web of Science database and/or with a CiteScore percentile of at least 35 in the Scopus database.

1. Kalytka, V. Mekhtiyev, A. Neshina, Y, et al. Physical and Mathematical Models of Quantum Dielectric Relaxation in Electrical and Optoelectric Elements Based on Hydrogen-Bonded Crystals// Crystals - 2023, 13(9), 1353 (percentile 54)
2. Mekhtiyev, A. Neshina, Y. , et al. Power supply via fiber-optical conductor for sensors of mine working monitoring system// Eastern-European Journal of Enterprise Technologies – 2023, №5 (percentile 45)
3. Fiber-optic system for controlling open pit side rock displacement. News Of The Academy Of Sciences Of The Republic Of Kazakhstan, Series Of Geologyand Technical Sciences, (percentile 40)
4. Fiber-Optic Monitoring System Review: Perspectives and Current State. Sensors, (Switzerland), (percentile 80)
5. Physical And Mathematical Models Of Nonlinear Relaxation Polarization And Conductivity In Crystals With Ionic-Molecular Chemical Bonds, Applied Sciences (Switzerland), (percentile 79)
6. Generalized Nonlinear Quasiclassical Model Of Space-Charge Polarization In Ionic Dielectrics With A Complex Crystal Lattice Structure, Applied Sciences (Switzerland), (percentile 79)

The article describes a system of power transmission via fiber-optic cable, which allows the supply of power to sensors and other electronic devices of ultra-low power located in places of mining workings, for which the mandatory requirement is fire safety. The developed system will allow to replace the application of copper conductors. The result of this research is the developed laboratory bench that allows measuring the current and voltage parameters in the photodetector branch. The equivalent generator method has been used, as well as the known circuit laws with two dedicated nodes for an active two-terminal network. When analyzing the literature, the existing scientific achievements, and discoveries in the field of research, an own concept of research has been formed that is different from foreign analogs. During the experiment, the studies have been per-

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POWER SUPPLY VIA FIBER-OPTICAL CONDUCTOR FOR SENSORS OF MINE WORKING MONITORING SYSTEM

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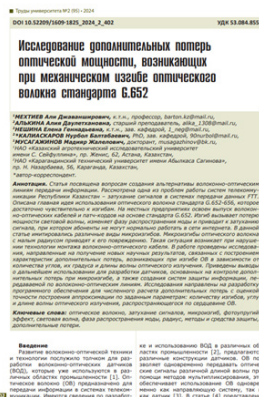
Yelena Neshina
Corresponding author
Candidate of Technical Sciences, Head of Department
Department of Power Systems**
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RESULTS OF THE WORK:

As a result of the research, articles have been published in journals recommended by the Committee for Ensuring Quality in Science and Higher Education of the Ministry of Science and Higher Education of the Republic of Kazakhstan.

Mehtiev A.D., Neshina E.G., Aimagambetova R.Zh., Kalyaskarov N.B., Yurchenko A.V.

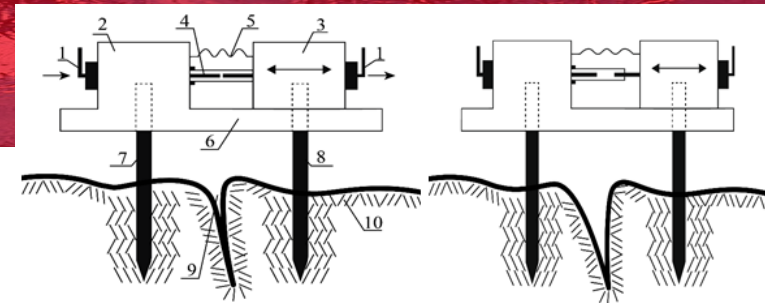
Development of a Fiber-Optic Sensor for Monitoring the Identification of Geotechnical Condition // Karaganda. University Proceedings – 2023. - No. 3. Pp. 421-427.



Mehtiev A.D., Alkina A.D., Neshina E.G., Kalyaskarov N.B., Musagazhinov M.Zh.

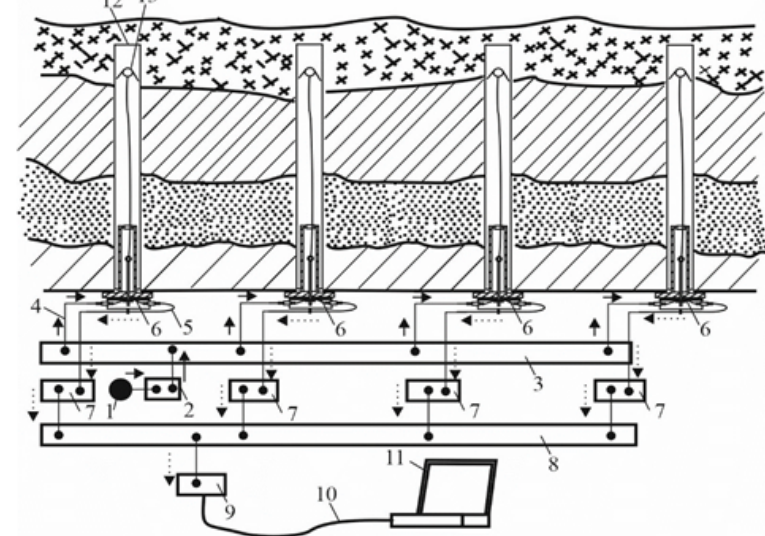


Investigation of Additional Optical Power Losses Arising from Mechanical Bending of G.652 Optical Fiber // Karaganda. University Proceedings – 2024. - No. 2. Pp. 402-409.



1 – optical fiber, 2 – fixed connector, 3 – movable connector, 4 – ferrule, 5 – spring, 6 – base, 7 – fixed reference, 8 – movable reference, 9 – crack, 10 – soil.

Schematic diagram of the sensor for monitoring the displacement of rock masses and controlling the crack opening process.

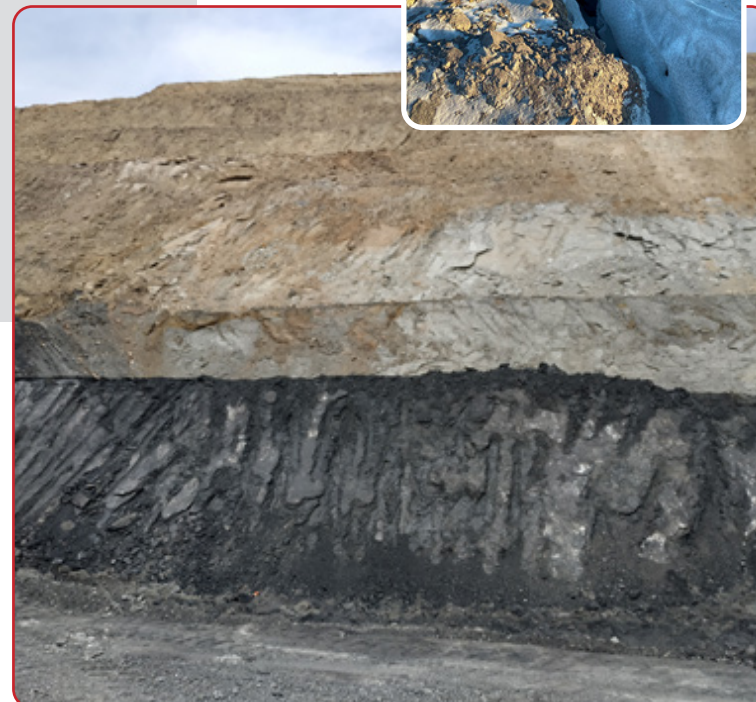
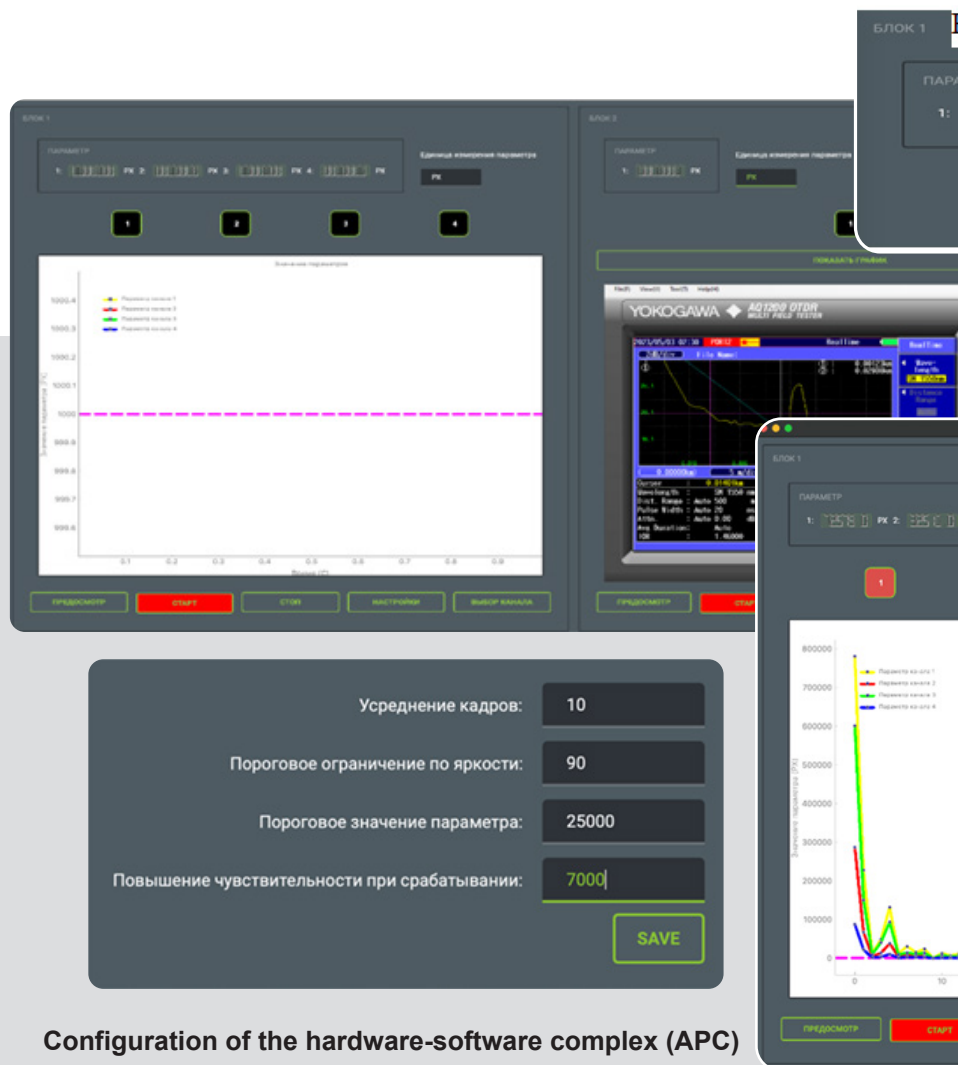


1 – Coherent laser light source, 2 – Polarizer and optical isolator, 3 – Optical splitter, 4 – Forward fiber, 5 – Return fiber, 6 – FOS (Fiber-Optic Sensor), 7 – Photodetector, 8 – Data pre-processing unit, 9 – Computer interface unit, 10 – Connecting cable, 11 – Personal computer with software, 12 – Borehole, 13 – Fixing element.

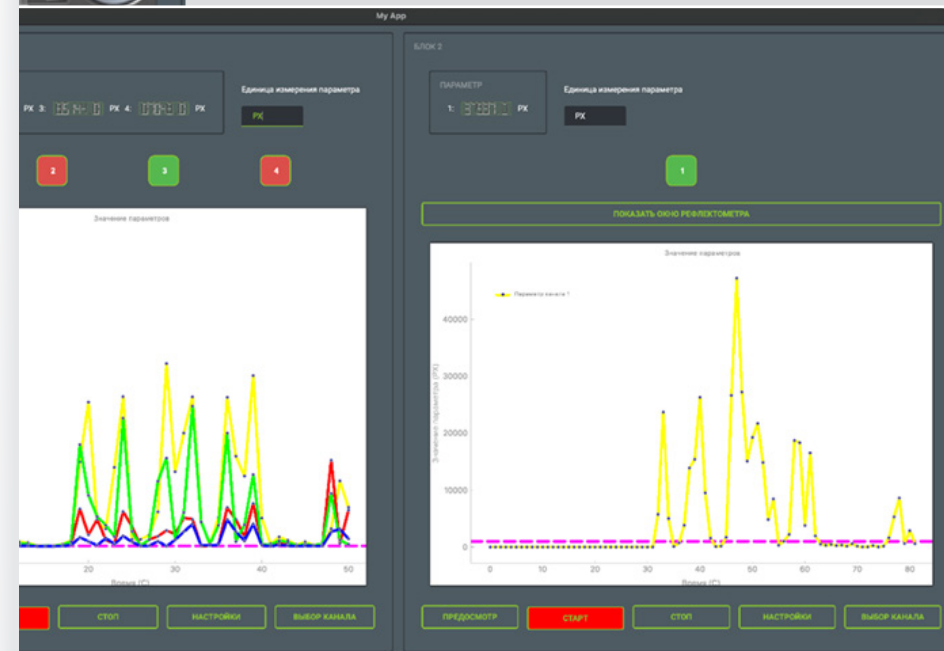
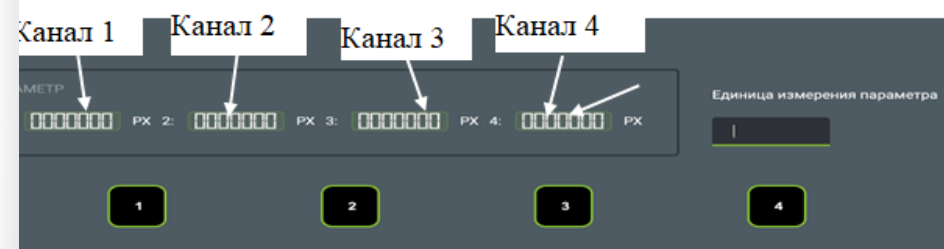
Scientific Supervisor: Mehtiev Ali Dzhavanshiroich, Candidate of Technical Sciences, Associate Professor, Tel.: +7 775 678 9999, e-mail: barton.kz@mail.ru

HARDWARE-SOFTWARE COMPLEX FOR MONITORING BASED ON FIBER- OPTIC SENSORS

JSC "KAZAKHMYN CORPORATION"
PIT "MOLODEZHNY"



LLP "AKZHARYK KOMIR" PIT "AKZHARYK KOMIR"



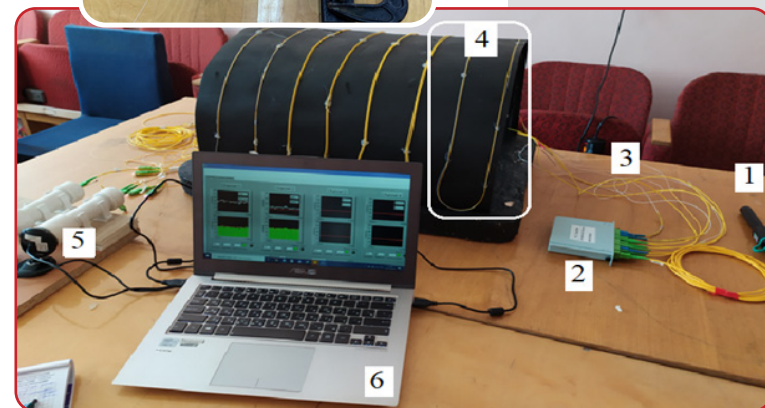
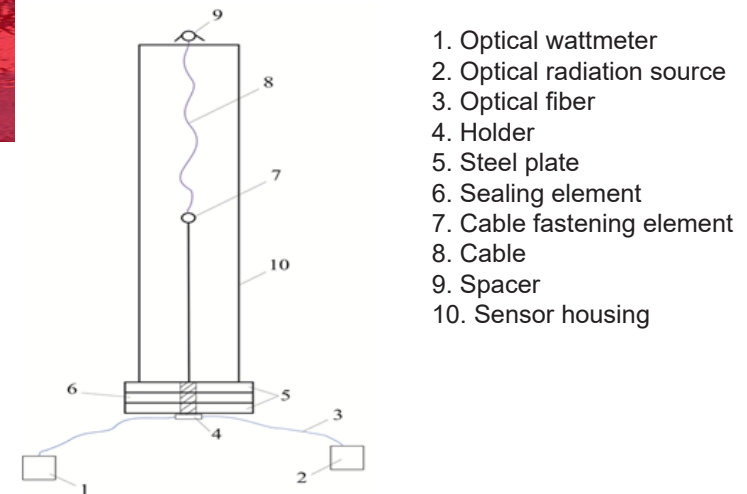
"QARMET" MINES (ARCELORMITTAL TEMIRTAU)

VISIT TO KOSTENKO MINE

ANALYSIS OF PROBLEMS AND SEARCH FOR SOLUTIONS



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