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СОДЕРЖАНИЕ

CONTROL AND DIAGNOSTICS SYSTEM OF TRAIN RADIO COMMUNICATION DEVICES ON RAILWAY SECTIONS

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Abstract The article analyzes the process of remote monitoring of train radio communication devices in railway transport and considers a method for rapid and unscheduled monitoring of their condition in order to prevent their failure. We developed software for the control device and a database to store received signals. A method for transmitting the results obtained in a mobile car laboratory to the site electromechanics in real time via wired and wireless communication channels is analyzed. Based on the results obtained from the implementation of the developed microprocessor-based software-based train radio communication equipment parameter monitoring device, it was found that it is possible to increase the safety of railway traffic, increase the stability and reliability of radio communication equipment, reduce their time interval during train operations, and improve schedule plans.

Keywords: train radio communication, railway sections, control and diagnostics, communication reliability, operational safety, device monitoring, communication systems, railway transport.

СИСТЕМА КОНТРОЛЯ И ДИАГНОСТИКИ УСТРОЙСТВ ПОЕЗДНОЙ РАДИОСВЯЗИ НА УЧАСТКАХ ЖЕЛЕЗНОЙ ДОРОГИ

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Аннотация: В статье проанализирован процесс дистанционного контроля состояния средств поездной радиосвязи на железнодорожном транспорте и рассмотрен способ оперативного и внепланового контроля их состояния с целью предупреждения выхода из строя. Разработано программное обеспечение для устройства управления и база данных для хранения полученных сигналов. Проанализирован способ передачи результатов, полученных в передвижной вагонной лаборатории, электромеханику участка в режиме реального времени по проводным и беспроводным каналам связи. На основании полученных результатов внедрения разработанного микропроцессорного программного устройства контроля параметров средств поездной радиосвязи установлено, что возможно повышение безопасности движения поездов, повышение устойчивости и надежности работы средств радиосвязи, сокращение их временного интервала при движении поездов, улучшение планов расписания.

Ключевые слова: поездная радиосвязь, железнодорожные участки, контроль и диагностика, надежность связи, безопасность эксплуатации, контроль устройств, системы связи, железнодорожный транспорт.

In railway transport, ensuring stable communication between the dispatcher and the locomotive driver is one of the key tasks of train traffic control. Train radio communication device is used to coordinate the actions of workers engaged in various railway transport operations. In this regard, train radio communication equipment must function continuously and be in good condition, for which the electrician is responsible. Monitoring the technical condition of the equipment is carried out by the electrician once a quarter.

In the railway transport of the Republic of Uzbekistan, in JSC Uzbekistan Temir Yollari (UTY), there is no system for remote diagnostics of the radio communication system in real time, which significantly complicates the timely detection of faults and prompt response to emerging problems. In addition, the process of checking the technical condition of radio communication equipment requires significant time expenditures, which leads to delays in maintenance and a decrease in the overall efficiency of the system.

Most existing solutions measure signal levels, noise immunity, communication quality, and data transmission delay [1, 3]. However, existing systems have a number of disadvantages:

– most of the solutions used require significant operator involvement, which increases the likelihood of subjective errors and reduces the efficiency of diagnostics;

– modern control systems are not sufficiently integrated with automated control and monitoring systems for rail transport;

– in some cases, the control methods used do not allow for the accurate determination of subtle deviations that can lead to serious equipment failures;

– existing control systems mainly detect faults that have already occurred, rather than predict their possible occurrence based on an analysis of operating parameters.

Taking into account the above, an urgent task is the introduction of modern methods for diagnosing the technical condition of train radio communication devices, as well as the development and implementation of a system for predicting malfunctions in accordance with the requirements of the rules for the technical operation of railways.

To improve the efficiency of diagnostic systems, it is necessary to implement:

–real-time monitoring systems that will allow for prompt tracking of changes in radio communication equipment parameters without time delays;

– automated self-monitoring systems that minimize the need for operator intervention;

– intelligent machine learning algorithms that allow for fault prediction and preventive maintenance;

– hybrid data processing systems that combine local monitoring and remote analytics with the ability to store large volumes of information for subsequent analysis;

– high-precision sensor modules capable of recording the slightest deviations in radio station operating parameters in real time.

The development of control systems in this direction will significantly increase the reliability of radio communication, minimize maintenance costs and improve the safety of railway traffic [2].

Based on the above requirements, a module for measuring the parameters of a train radio communication device was developed. This module is installed in a special laboratory car and allows remote measurement of the parameters of radio communication devices in real time. It is possible to connect the module to a computer and analyze the parameters via a computer display.

The developed module includes a specialized module that checks all the parameters of train radio communication devices. The device connected to the module analyzes for compliance with operational standards. The structural diagram of the connection of the measuring system with a stationary radio station is shown in Figure 1.

The developed device contains a microcontroller, which has a built-in algorithm for measuring the parameters of train radio communication devices, as well as software developed in the C++ programming environment.

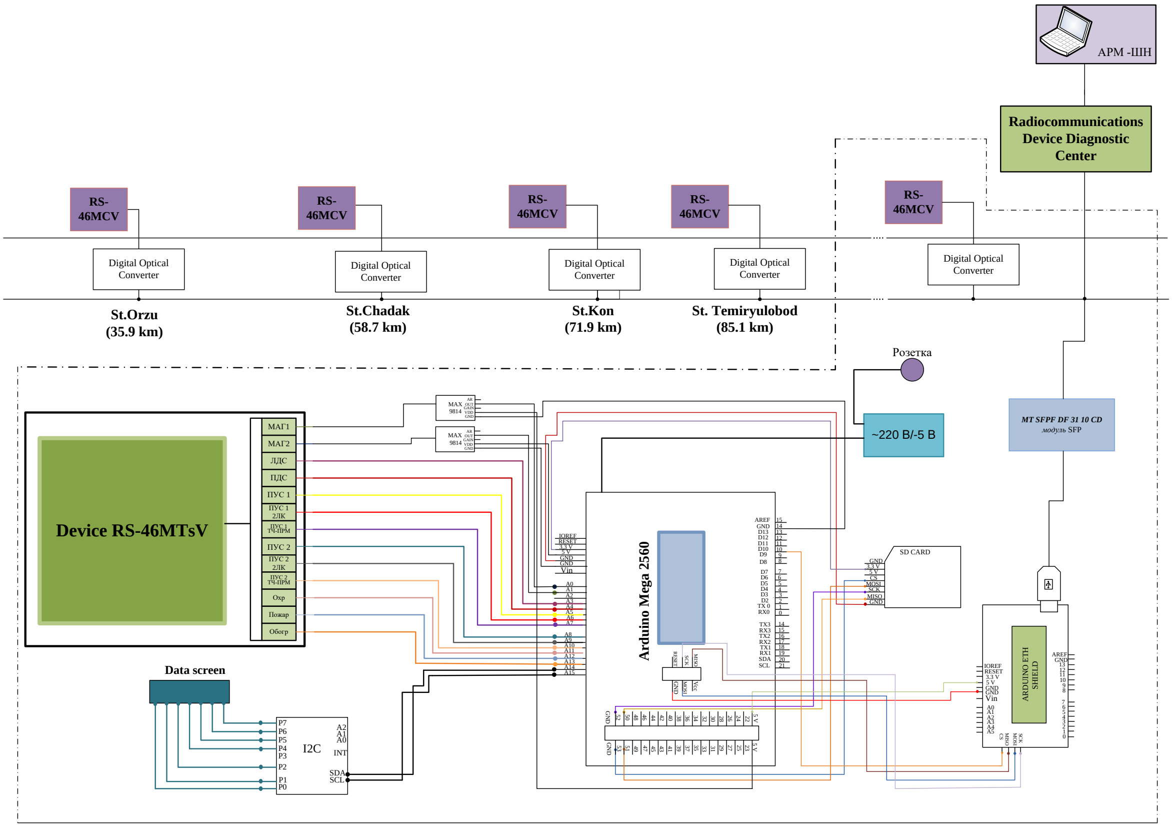

Figure 1. Structural diagram of the module for analyzing noise affecting the device and measuring signals

The use of the I²C interface in radio monitoring and control systems allows you to organize efficient data exchange between the microcontroller and peripheral modules. With the help of this interface, it is possible to obtain information about the measurement parameters and the current state of the radio station, as well as transfer it to a computer for subsequent analysis. The use of this approach ensures optimization of the system's operation by reducing the number of devices, increasing the reliability of data transmission, and increasing the ability to integrate several devices into a single network. This makes the I²C interface an important tool in creating automated systems for monitoring and diagnosing radio communication equipment. The interface diagram is shown in Figure 2.

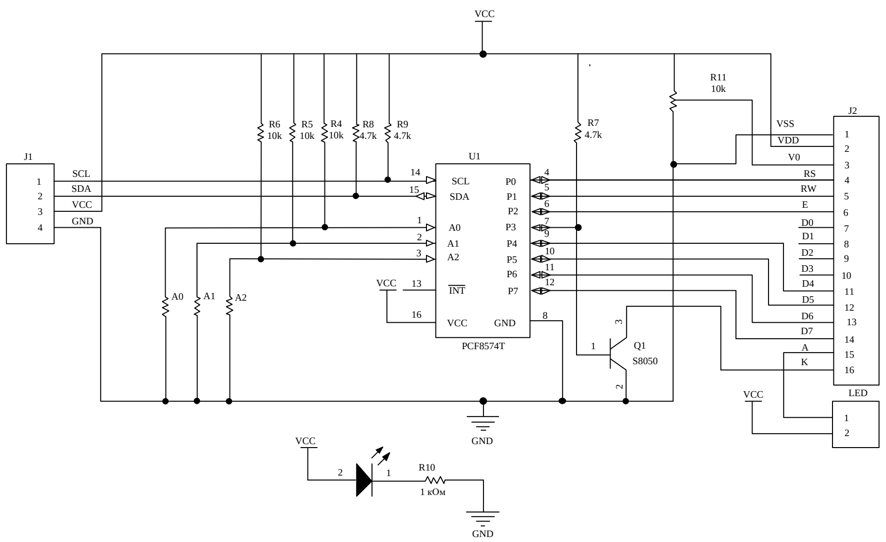

Figure 2. I²C interface diagram

At the same time, the built-in recording module records all conversations between the train dispatcher (DNC) and the duty officer station (DSP) and between the DNC and the driver, which significantly improves the quality of the audio recording and allows for an archive of conversations to be maintained for further analysis. [4].

Additionally, the module has an integrated SD card designed to store all information about the status of monitoring devices. This allows you to keep detailed records of the parameters of radio communication equipment, track the history of changes and quickly analyze possible malfunctions [7, 9]. The SD card provides the ability to monitor the status of monitoring devices and to quickly analyze possible malfunctions. The SD card contains 3 schematics - 3 keys.

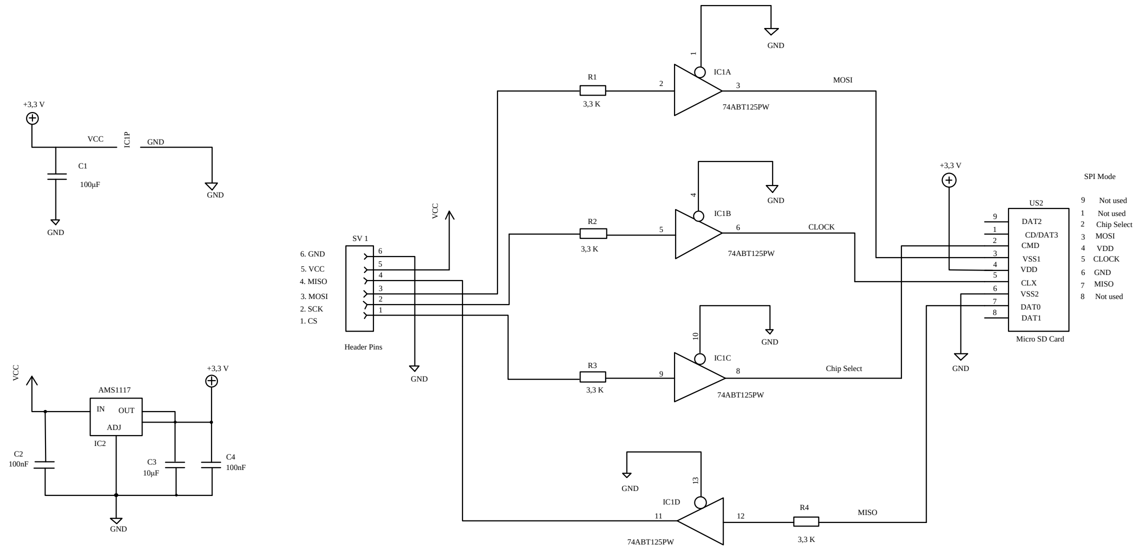

Figure 3. SD card schematic diagram

Connecting an SD card to the microcontroller allows you to efficiently transfer all information about the device's status to the “Radio Communication Equipment Diagnostics Center”. This helps automate monitoring, reduce time and increase economic efficiency. In addition, it ensures the speed and accuracy of such data transmission, minimizing the need for manual verification of device parameters. [8].

In addition, in emergency situations, the GSM module allows for rapid transmission of messages or emergency calls, which significantly reduces the response time to emergencies and increases the time to eliminate emergencies. The developed module significantly increases the efficiency of monitoring, reduces time spent on diagnostics and contributes to the improvement of railway traffic safety. Thanks to automated data collection and processing, it is possible to integrate the system into the general infrastructure of railway radio communication management, which makes it an important element of the digitalization of the transport industry [10, 12].

In order to test the module's performance, an experiment was conducted at the Kuchluk-Ozodlik stations. Figure 4 shows the measurement of radio signal parameters conducted at the Kuchluk-Ozodlik stations, demonstrating changes in the signal level and its distribution.

During the monitoring at the Kuchluk - Ozodlik stations, all parameters of both stationary and mobile radio stations were measured, including signal power, distribution level and communication quality. These data allowed for a generalized analysis of the radio stations operation, identification of weaknesses and ways to improve the efficiency of the railway transport communication system. The following features were identified: between stations, in the section, there was deterioration in signal distribution, and interference caused by external influences was detected. To improve the quality of communication, it was proposed to install repeaters, which would improve the signal and reduce the noise level in this section. [9, 11].

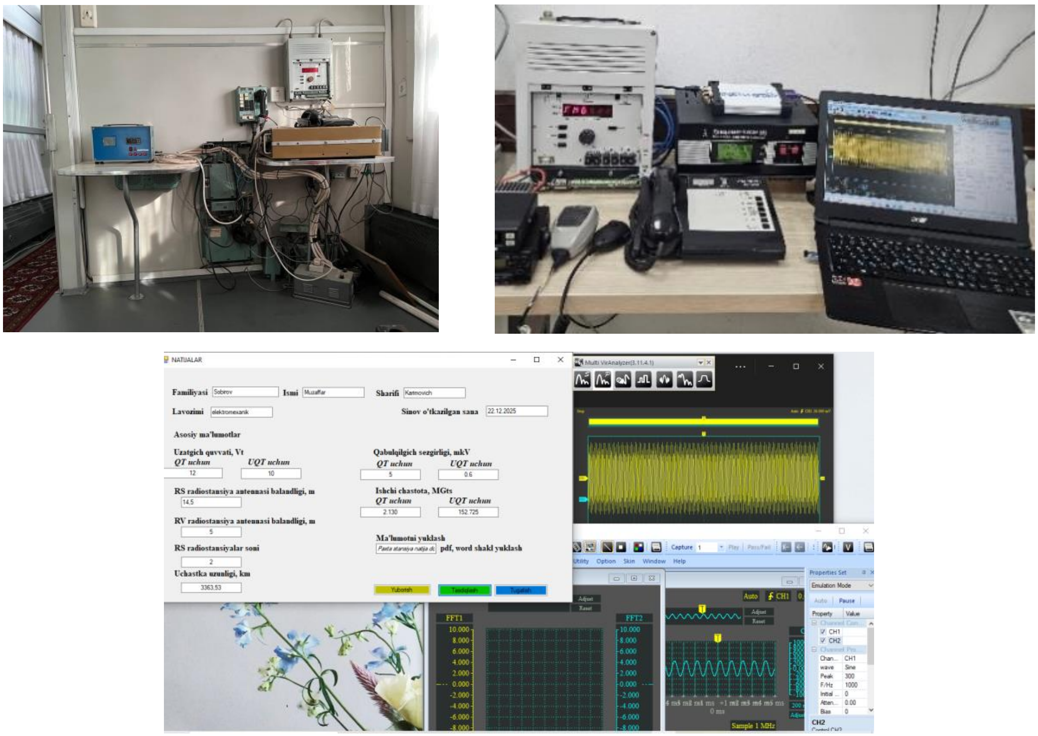

Fig. 4. Measurement of radio signal parameters, demonstrating changes in signal level and its distribution

The conducted research showed that the developed module for monitoring and diagnostics of train radio communication provides effective monitoring of the technical condition of equipment in real time. Thanks to the integration of fiber-optic and wireless (GSM) communication channels, data is transmitted to the dispatcher promptly, which allows for a timely response to changes in communication parameters.

The main achievements of the upgraded module:

Automation of diagnostic processes – the need for manual checking is eliminated, which reduces the time spent on maintenance.

Collection and storage of data – the use of an SD card allows you to keep an archive of measurements, providing analysis of the dynamics of changes in radio communication parameters.

Increased communication reliability – prompt detection and troubleshooting reduces the likelihood of equipment failures.

Economic efficiency – reduced operating costs and minimization of downtime increase the overall efficiency of the radio communication management system.

The proposed module is a system that allows you to fully monitor the status of the radio station in real time. This significantly improves the quality of the system's operation, reduces the likelihood of malfunctions and failures, and also minimizes the number of dead zones. It is worth noting that the recording module in the system provides the ability to store data for subsequent analysis and diagnostics. In addition, the system can operate independently, without requiring constant operator intervention. Due to these capabilities, the implementation of this system will increase reliability, efficiency and cost-effectiveness, reduce maintenance costs, and improve overall control over the status of the radio station.

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