Міністерство освіти і науки України

Харківський національний університет радіоелектроніки

Кафедра комп'ютерно-інтегрованих технологій, автоматизації, робототехніки та безпекової інженерії

I Всеукраїнська конференція «Інтелектуальні технології цивільної безпеки та робототехнічні системи аварійно-рятувальних робіт»

I All-Ukrainian Conference “Intelligent Civil Safety Technologies and Robotic Systems for Emergency and Rescue Operations”

ICSTRO
2026
I All-Ukrainian Conference
February 12 - 13, 2026
Kharkiv

УДК: 005:004.896:62-65:338.3

Інтелектуальні технології цивільної безпеки та робототехнічні системи аварійно-рятувальних робіт 2026: матеріали I-ої Всеукраїнська конференція, Харків, 12-13 лютого 2026 р.: тези доповідей / [редкол. І.Ш. Невлюдов (відповідальний редактор)].-Харків: [електронний друк], 2026. – 192 с.

У збірник включені тези доповідей, які присвячені сучасним тенденціям розвитку технологій та засобів моделювання, прогнозування та управління ризиками у сфері цивільної безпеки; техногенна та виробнича безпека: технічні засоби, оцінка ризиків, експертиза; інтелектуальні та робототехнічні системи аварійно-рятувальних робіт; кіберфізичні системи, інформаційна безпека та цифровий захист виробництв; інформаційно-комунікаційні технології в системах управління та моніторингу надзвичайних ситуацій; сталий розвиток, екологічна безпека та соціальна відповідальність у сфері цивільної безпеки; інтелектуальні системи прийняття рішень у сфері цивільного захисту.

Intelligent Civil Safety Technologies and Robotic Systems for Emergency and Rescue Operations 2026: Proceedings of I st All-Ukrainian Conference, Kharkiv, February 12 - 13, 2026: Thesises of Reports / [Ed. I.Sh. Nevlyudov (chief editor).] .- Kharkiv .: [electronic version], 2026. - 192 p.

The collection includes the thesises of reports on devoted to current trends in the development of technologies and tools for modeling, forecasting, and risk management in the field of civil safety; industrial and technological safety, including technical means, risk assessment, and expert evaluation; intelligent and robotic systems for emergency and rescue operations; cyber-physical systems, information security, and digital protection of industrial facilities; information and communication technologies in emergency management and monitoring systems; sustainable development, environmental safety, and social responsibility in the field of civil safety; and intelligent decision-support systems in civil protection.

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Державне підприємство «Південний державний проектно-конструкторський та науково-дослідний інститут авіаційної промисловості»
Головне управління ДСНС України у Харківській області

Всеукраїнська конференція «Інтелектуальні технології цивільної безпеки та робототехнічні системи аварійно-рятувальних робіт» (ICSTRO-2026)

All-Ukrainian Conference “Intelligent Civil Safety Technologies and Robotic Systems for Emergency and Rescue Operations” (ICSTRO-2026)

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SELECTION OF COMMUNICATION INTERFACES FOR A MICROCLIMATE MONITORING SYSTEM

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Annotation**:** The work considers the issue of choosing communication interfaces for microclimate monitoring systems in residential, industrial, and public premises. The main criteria for choosing data transmission channels are analyzed, in particular, the length of the communication line, noise immunity, information capacity, scalability, and the total cost of ownership of the system. Analog, wired digital, and wireless interfaces are compared in terms of their functionality and feasibility of application. Recommendations are given for choosing the optimal solution depending on the scale and operating conditions of the microclimate monitoring system.

Key words: microclimate monitoring, communication interfaces, wireless technologies, Modbus RTU, energy consumption.

ВИБІР ІНТЕРФЕЙСІВ КОМУНІКАЦІЇ ДЛЯ СИСТЕМИ МОНІТОРИНГУ МІКРОКЛІМАТУ

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Анотація**:** У роботі розглянуто питання вибору інтерфейсів комунікації для систем моніторингу мікроклімату в житлових, промислових та громадських приміщеннях. Проаналізовано основні критерії вибору каналів передавання даних, зокрема довжину лінії зв’язку, завадостійкість, інформаційну місткість, масштабованість та сукупну вартість володіння системою. Проведено порівняння аналогових, дротових цифрових та бездротових інтерфейсів з точки зору їх функціональних можливостей та доцільності застосування. Наведено рекомендації щодо вибору оптимального рішення залежно від масштабу та умов експлуатації системи моніторингу мікроклімату.

Ключові слова**:** моніторинг мікроклімату, інтерфейси комунікації, бездротові технології, Modbus RTU, енергоспоживання.

Ensuring stable microclimate parameters is an important condition for the safe and efficient operation of residential, industrial, warehouse, and public premises [1-6]. Controlling temperature, humidity, gas concentrations, and other parameters directly affects human comfort, the preservation of materials, the proper operation of equipment, and the energy efficiency of buildings. The lack of systematic monitoring can lead to hidden environmental parameter deviations, which reduces equipment lifespan and increases operational costs. The overall trend of automation in engineering systems raises the requirements for the reliability and integration of communication solutions, regardless of their specific purpose [7-15].

Modern microclimate monitoring systems are based on distributed measurement nodes that transmit data to a centralized management or dispatch system. The key factor in the effectiveness of such systems is the correct choice of communication interfaces between sensors and controllers. The relevance of the topic is determined by the need to combine reliability, scalability, and cost-effectiveness under increasing demands for the automation and digitalization of engineering systems.

Considering the variety of operating conditions and the requirements for microclimate monitoring systems, the task of reasonably choosing a communication interface between measuring devices and the control system arises. To make such a decision, it is advisable to use a system of criteria that allows comparing different types of interfaces in terms of technical, operational, and economic indicators:

1. An important criterion for selection is the length of the communication line and its noise immunity. The 4–20 mA analog interface is optimal for transmitting signals over long distances (hundreds of meters) in industrial environments with a high level of electromagnetic interference. The current signal has high noise immunity and is less sensitive to cable losses, making it reliable when used with programmable logic controllers. Digital interfaces like I2C and SPI are intended for short distances and are mainly used within a single device or cabinet. They provide high data exchange rates but are very sensitive to interference. The Modbus RTU digital protocol over RS-485 allows data transmission over long lines with high noise immunity and can connect up to 32 devices on a single bus, significantly reducing the number of cables. Wireless technologies (LoRaWAN, Zigbee, Wi-Fi, NB-IoT) eliminate the need for cabling, which is especially relevant for complex or historical sites. When choosing them, it is necessary to consider communication range, bandwidth, and energy consumption.

2. Information capacity and functionality are the second key criteria when evaluating interfaces. The 4–20 mA analog interface transmits only a single parameter and does not support the transmission of diagnostic or service data. Digital interfaces allow for the transmission of not only measured values but also device status, fault information, calibration requirements, sensor identification, as well as multiple physical parameters from a single measurement node. In addition, they provide the ability to remotely change device configurations.

3. System scalability and flexibility are the third evaluation criterion. When using a 4–20 mA analog interface, each sensor requires a separate cable and a separate analog input on the controller. Adding new monitoring points leads to a significant increase in cabling infrastructure. Digital bus solutions, particularly Modbus RTU, allow connecting dozens of devices on a single line, significantly reducing the complexity and cost of deploying a large system. Wireless systems provide maximum flexibility and make it easy to add or move monitoring points, thereby increasing scalability; however, the issue of autonomous power supply needs to be addressed.

4. Deployment and operating costs (Total Cost of Ownership – TCO) are an important criterion for comparison. Analog 4–20 mA systems incur high expenses for cables, installation, and controller hardware inputs, but are characterized by implementation simplicity and low per-connection cost.

Digital interfaces I2C and SPI are the cheapest at the printed circuit board level, but require additional gateways for integration with higher-level systems.

Modbus provides an optimal balance between cost, reliability, and functionality for medium and large systems.

Wireless solutions minimize installation costs but may have higher equipment costs and battery maintenance expenses.

5. Additional criteria – transmission delay (Table 1) and power consumption (Table 2) significantly influence the choice of communication interface. Wired interfaces are characterized by low and deterministic latency, making them suitable for real-time tasks. At the same time, wireless technologies ensure minimal power consumption and the possibility of autonomous operation, which is critically important for distributed microclimate monitoring systems.

Table 1 – Comparison of interfaces by data transmission latency

Interface	Typical delay	Real-time suitability
4–20 мА	Minimum	High
I2C / SPI	Very low	High
Modbus RTU	Low	High
Zigbee	Average	Limited
Wi-Fi	Variable	Low
LoRaWAN	High	Unsuitable
NB-IoT	High	Unsuitable

Table 2 – Comparison of interfaces by power consumption

Interface	Energy consumption	Possibility of autonomous operation
4–20 mA	High	No
I2C / SPI	Low	Limited
Modbus RTU	Average	Limited
Zigbee	Low	Yes
Wi-Fi	High	No
LoRaWAN	Very low	Yes
NB-IoT	Low	Yes

It was established in the course of the work that the selection of a communication interface for a microclimate monitoring system is an important design stage, which affects the reliability, ease of expansion, and total cost of the system. Each type of interface has its advantages and limitations, so a universal solution does not exist.

The analog 4–20 mA interface is advisable to apply in small local systems with 5-10 measurement points, where high noise immunity, compatibility with existing controllers, and ease of integration with existing PLCs are important. The main drawback is the transmission of only one parameter and the difficulty of expanding the system when the number of sensors increases.

Digital wired interfaces, particularly Modbus RTU over RS-485, are the optimal solution for medium and large-scale monitoring systems (from 20 points and above), as they provide a balance between reliability, data capacity, and cost.

Wireless technologies offer the greatest flexibility and ease of installation, especially in hard-to-reach or temporary areas. The most effective solutions are energy-efficient ones, such as LoRaWAN, although they have limitations in terms of speed and data transmission latency.

Overall, for modern microclimate monitoring systems, it is advisable to use a combined approach, integrating wired and wireless interfaces depending on the operating conditions. This allows for the creation of a reliable, flexible, and cost-effective system.

In the course of the work, a systematic comparison and analysis of modern communication interfaces for use in microclimate monitoring systems was carried out. The purpose of the analysis was to identify optimal solutions that ensure the reliability, scalability, and cost-effectiveness of distributed systems for controlling environmental parameters. For an objective comparison, a system of criteria was developed, covering key technical, operational, and cost aspects: the length and interference immunity of the communication line, information capacity, scalability, total cost of ownership (TCO), as well as additional parameters – data transmission delay and energy consumption.

The study established the absence of a universal solution and defined clear areas of effective application for each type of interface. The analog 4–20 mA interface confirmed its effectiveness for small local systems with high requirements for interference immunity, but proved limited in terms of functionality and scalability. The digital wired Modbus RTU interface on the RS-485 bus was identified as the optimal balanced choice for medium and large systems that require reliable data transmission from multiple devices over a single line. Wireless technologies, particularly power-efficient ones (LoRaWAN, Zigbee), demonstrated their indispensability for monitoring in hard-to-reach areas and at sites with complex architecture, albeit with limitations on transmission speed.

Thus, the conducted work allows for a well-founded approach to system design, based on specific operating conditions and technical requirements. The main practical conclusion is the advisability of a hybrid, combined approach, which allows integrating the advantages of wired and wireless interfaces to create a flexible, reliable, and cost-effective microclimate monitoring system.

REFERENCES

1. Fesenko, A. & et al.. Review and selection of optimal sensors for building a production facility microclimate monitoring system. Manufacturing & Mechatronic Systems 2025: Proceedings of IX st International Conference, Kharkiv, October 25-26, 2025: Thesises of Reports, 2025. PP. 50-53

2. Fesenko, A. O. & et al.. Basic provisions for developing an automated system for monitoring microclimate parameters in industrial premises. Information Technologies and Automation – 2025 / Proceedings of the XVIII International Scientific and Practical Conference. Odessa, October 30-31, 2025. – Odessa, ONUT Publishing House, 2025. PP. 194-197

3. Сотник, С. В., Кирпота, Ф. В. Огляд базових елементів автоматизованої системи контролю навколишнього середовища портативної ділянки зеленого побуту. Автоматизація, електроніка та робототехніка (AERT-2023), 2023. – PP. 28-31

4. Khalimonov, Y. I. & et al.. Overview of computer vision areas application for inspection and quality control. Комп’ютерно-інтегровані технології автоматизації технологічних процесів на транспорті та у виробництві : матеріали всеукр. наук.-практ. конф. здобувачів вищ. освіти і молодих учених, 20 листоп. 2024 р. / Харків. нац. автомоб.-дор. ун-т. – Харків, 2024. – PP. 117-121

5. Халімонов, Я. І. та інш.. Створення інтелектуального модулю для автоматизованого моніторингу середовища у приватних та комерційних приміщеннях з використанням комп'ютерно-інтегрованих технологій. International Conference on Advanced Trends in Radioelectronics and Telecommunications dedicated to the 85th anniversary of the Department of Theoretical Radio Engineering and Radio Measurements, 2024. – PP. 176-181

6. Khalimonov, Y. I. & et al.. Monitoring and optimising conditions in production environment. Proceedings of the XVII International scientific and practical conference «Information technologies and automation– 2024», 2024. – PP. 256-258

7. Sotnik, S. Development of a range measurement module on an ultrasonic sensor with a GSM module. Radio Electronics, Computer Science, Control, 2025. – pp. 32-44. Article ID 1607-3274-2025-2-3, https://doi.org/10.15588/1607-3274-2025-2-3

8. Yechevskyi, A., & et al.. Analysis of the data collection process about products at different stages of production. Manufacturing & Mechatronic Systems 2025: Proceedings of IX st International Conference, Kharkiv, October 25-26, 2025: Thesises of Reports, 2025. – PP. 38-41

9. Nevludov, I. Sh. & et al.. Application of artificial intelligence in additive manufacturing (3D printing). Information Technologies and Automation – 2025 / Proceedings of the XVIII International Scientific and Practical Conference. Odessa, October 30-31, 2025. – Odessa, ONUT Publishing House, 2025.

10. Sotnik, S. V. Development of automated control system and registration of metal in continuous casting. Radio Electronics, Computer Science, Control, 2024. Article ID 1607-3274-2024-3-17, https://doi.org/10.15588/1607-3274-2024-3-17

Cherednichenko, T. & et al.. Features of automatic working time control systems. Manufacturing & Mechatronic Systems 2025: Proceedings of IX st International Conference, Kharkiv, October 25-26, 2025: Thesises of Reports, 2025. – PP. 54-57

11. Сотник, С. Розробка автоматизованої інформаційно-пошукової системи вибору маніпулятора промислових роботів. Електромеханічні і енергозберігаючі системи, 2025. Article ID 2072-2052.2025.1.68.6, https://doi.org/10.32782/2072-2052.2025.1.68.6.

12. Levenets, I. O. & et al. The role of artificial intelligence in optimizing information retrieval systems. Information Technologies and Automation – 2025 / Proceedings of the XVIII International Scientific and Practical Conference. Odessa, October 30-31, 2025. – Odessa, ONUT Publishing House, 2025. – PP. 975-977

13. Khalimonov, Y. I. & et al.. Circular economy in automated systems. Sustainable smart cities and communities: business and innovation solutions 2025: Proceedings of I st I International Conference, Kharkiv, April 21, 2025: Thesises of Reports, 2025. – PP. 53-54

14. Marunich, R. V. & et al.. Modern IoT technologies for creating automated access systems. Sustainable smart cities and communities: business and innovation solutions 2025: Proceedings of I st I International Conference, Kharkiv, April 21, 2025: Thesises of Reports, 2025. – PP. 38-39

15. Danylenko, M. M. & et al.. Comparative analysis of modern SCADA packages for production automation. International Journal of Academic Engineering Research (IJAER), 2025. – PP. 26-34