

**Ukrainian Scientific
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Conference**

SRM

The logo for the Scientific Research Methodology (SRM) conference. The letters 'SRM' are rendered in a large, bold, black sans-serif font. Surrounding the letters is a network diagram consisting of several colored nodes (red, blue, yellow, orange) connected by thin lines, suggesting a research or data network.

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The Ukrainian Scientific and Practical Conference "Scientific Research Methodology – 2024" provides a platform for multi-dimensional discussions on theoretical concepts and methods in modern scientific research, approaches and integrated methods deployed in various scientific disciplines to solve complex problems, state-of-art methods and tools for investigating latest technologies and their impact on scientific activity, quantitative and qualitative methods of data collection and analysis in various scientific disciplines, and legal aspects related to intellectual property and research publications.

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DEVELOPMENT AND RESEARCH OF A MICROPROCESSOR CONTROL SYSTEM FOR AN ELECTRICAL MEASURING ROBOT

Abstract. This paper discusses the development of a microprocessor-based control system for a precision measurement robot, which ensures precise object positioning in the working area and high-accuracy external signal measurement. The system is based on the use of an ATmega16 microcontroller that controls the robot's actuators and processes data from sensors. For synchronization and data exchange with a PC, the UART interface is used. The paper presents system performance results in various modes and provides algorithms for controlling the actuators.

Key words: microprocessor, measurement robot, precision positioning, ADC, UART, control algorithms.

Introduction. In recent years, automation has played a significant role across various industries and scientific fields. Microprocessor systems enable high precision in operations, automate control and measurement processes, which is crucial for minimizing human error and increasing productivity. Microcontrollers are now widely used in robotics, particularly in the development of precision measurement robots.

Measurement robots are used for accurate measurements of environmental parameters, objects, and processes. In such systems, ensuring precise positioning of the robot within the working area is critical for improving measurement accuracy. Microprocessor systems equipped with analog-to-digital converters (ADCs) convert analog sensor signals into digital data, facilitating further processing.

The objective of this work is to develop a control system that combines high measurement accuracy, reliability, and ease of use.

The main goal of this work is to design a microprocessor-based control system for a precision measurement robot, ensuring precise object positioning in the working area and enabling interaction with a personal computer for data processing and analysis.

Research Tasks:

1. Analyze modern methods and algorithms for object positioning in automated systems.
2. Develop a software algorithm for controlling the robot's actuators.
3. Implement the conversion of analog sensor signals into digital data using ADC.
4. Ensure synchronization and data exchange between the microprocessor system and the PC via the UART interface.

Methods and Materials. The system is based on the ATmega16 microcontroller, which interfaces with the sensors and the robot's actuators. The built-in 10-bit ADC, connected to eight inputs, is used for measuring analog signals. Data is transmitted to the computer via UART, allowing the user to control the robot in real time.

The control algorithm for the actuators includes the following steps:

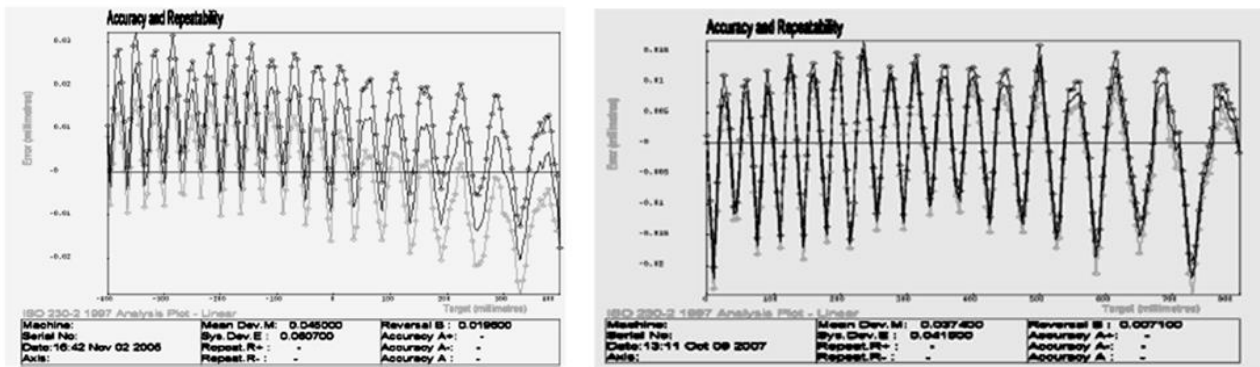
1. System initialization (LCD display, UART, ADC).
2. Processing sensor signals.
3. Controlling the robot’s movement based on commands received from the PC via UART.
4. Performing measurements using the ADC.
5. Transmitting data to the PC for processing.

Thanks to the application of precision control algorithms, high positioning accuracy of the robot in the working area was achieved. The use of the ATmega16 microcontroller, which provides real-time processing of sensor data, allowed for stable control of the robot's movement without failures and significant deviations from the trajectory. The actuator control algorithm supports working with different types of motors, ensuring smooth movement and accuracy up to a few millimeters.

Results of comparing positioning accuracy in different modes of system operation:

- Mode 1: Absence of external interference – accuracy up to 1 mm.
- Mode 2: Operation under temperature changes – accuracy up to 2 mm.
- Mode 3: Operation under electromagnetic interference – accuracy up to 2.5 mm.

The positioning accuracy of the measurement robot system was evaluated based on multiple measurements in accordance with ISO 230-2:2014 standards, using the ML-10 laser interferometer. The results indicate that the positioning accuracy along the X and Y coordinates falls within acceptable limits, with a deviation not exceeding 42 μm after structural optimization (Fig. 1a and 1b).



a b
Fig. 1. Comparison Before and After System Improvement

These graphs illustrate a significant reduction in system errors following the implementation of structural modifications.

Results After System Enhancement:

- Y-coordinate accuracy improved from 61 μm to 42 μm.
- Accumulated backlash error decreased from 20 μm to 7 μm.

Reliability forecasting was conducted through lifecycle analysis of the system. The evaluation of the mean time between failures (MTBF) indicated that the system could operate for over 10,000 hours, meeting high reliability standards for automated control systems.

Key Factors Influencing Reliability:

- High number of components: hundreds, sometimes even thousands.
- Complex structural organization: featuring cyclic connections and multifunctional elements.

Thus, the system demonstrated high operational stability even under challenging conditions, maintaining minimal deviations from the specified parameters.

The UART interface (Universal Asynchronous Receiver-Transmitter) plays an important role in the system, as it provides two-way data exchange between the microcontroller and the PC. This allows the user to control the robot in real time, issuing commands for movement, stopping, or changing the direction of motion. At the same time, data about the system's status and measurement

results are sent to the PC. During testing, a stable data exchange rate of 9600 baud was achieved, which allows for prompt information transfer without significant delays.

The system was tested under various conditions, including the presence of electromagnetic interference and temperature changes. It was found that due to optimized signal processing algorithms and the stability of the ADC operation, the system maintains high measurement accuracy even in the presence of external factors. For example, when operating under temperatures varying from 20°C to 40°C, the measurement accuracy deviation did not exceed 0.5%.

During testing, it was established that the proposed control system for the electric measuring robot can be successfully used in industrial environments for measurement automation. The system can also be integrated into scientific experiments where precise measurement and positioning of objects are important.

Conclusions. The developed microprocessor-based control system for a precision measurement robot ensures high-accuracy object positioning in the working area and efficient measurement processing. The use of ADC and the UART interface allows the system to be integrated into various automated environments. This system can be beneficial in industrial and scientific settings where high measurement accuracy and process automation are required.

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