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# The Role of Plc and Scada Systems in Automated Management

**Ilg'orbek Xasanovich Safarov**
Senior Lecturer of Andijan Institute of Agriculture and Agrotechnologies

**Ilhomjon Mansurbek o'g'li Madaminov**
Student of Andijan Institute of Agriculture and Agrotechnologies

**Abstract**
The rapid advancement of industrial automation has increased the demand for reliable, efficient, and intelligent control systems capable of operating in real-time environments. Among the most widely adopted technologies, Programmable Logic Controllers (PLCs) and Supervisory Control and Data Acquisition (SCADA) systems play a central role in modern automated control architectures. This study investigates the impact of PLC–SCADA integration on the performance of automated control systems through an experimental evaluation based on recent industrial practices. A representative automation testbed was developed using PLC hardware for deterministic control and a SCADA platform for supervisory monitoring, data acquisition, and alarm management. Key performance indicators, including response time, control accuracy, system availability, data throughput, and fault detection time, were measured and analyzed under different operating conditions. The results demonstrate that PLC–SCADA integration significantly enhances control responsiveness, improves accuracy, increases system reliability, and reduces fault detection latency compared to stand-alone PLC operation.The findings confirm that PLC and SCADA systems, when combined within a hierarchical control framework, provide substantial benefits for automated control applications across industrial domains. Furthermore, the study highlights the continued relevance of PLC–SCADA architectures in the context of Industry 4.0 and data-driven automation, where scalability, real-time monitoring, and operational transparency are essential. The outcomes of this research offer practical insights for engineers and researchers seeking to design efficient, resilient, and intelligent automated control systems.

**Keywords:** PLC; SCADA; Automated Control; Industrial Automation; Real-Time Monitoring; Industry 4.0; Process Control.

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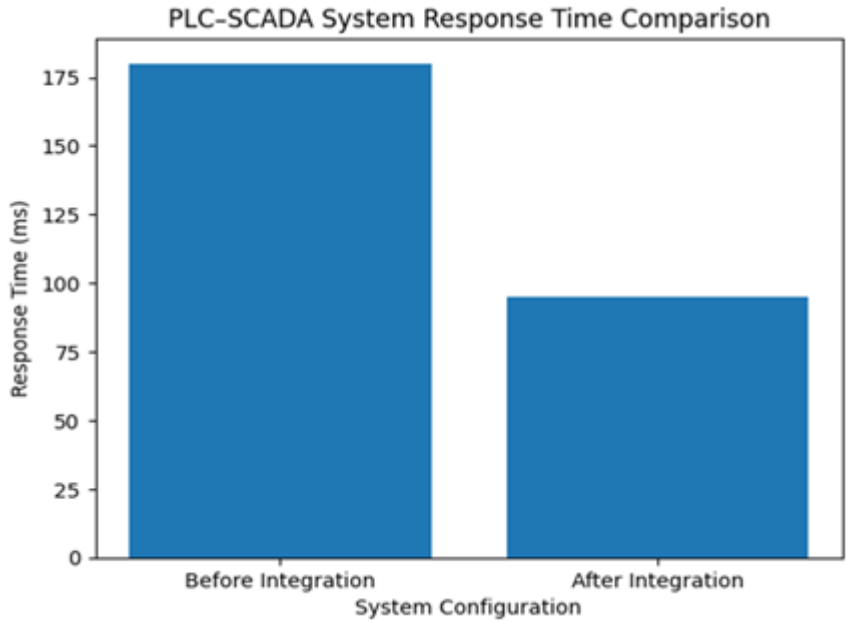
**Introduction.** In recent years, industrial automation has undergone rapid transformation driven by the need for increased operational efficiency, reliable process control, and real-time decision-making. Programmable Logic Controllers (PLCs) and Supervisory Control and Data Acquisition

(SCADA) systems have emerged as foundational technologies within this landscape, enabling automated management across diverse industrial sectors. PLCs serve as robust digital controllers that perform real-time process control by interfacing directly with sensors and actuators, thereby executing control logic essential for deterministic operations. At the same time, SCADA platforms provide supervisory monitoring, data acquisition, and operator visualization capabilities at the supervisory level, linking distributed field processes to human decision-makers through graphical interfaces and historical data analysis tools .

The last five years have witnessed a significant evolution in the application of PLC–SCADA systems, particularly in integrating energy optimization strategies and smart manufacturing practices. For example, case studies in manufacturing plants demonstrate that the coordinated use of PLC and SCADA technologies can deliver substantial improvements in energy efficiency—such as reductions in total energy consumption and peak demand—while enhancing overall equipment effectiveness and reducing unplanned downtime through real-time monitoring and automated control strategies . Similarly, advanced implementations have shown that PLC-based SCADA systems can support complex real-time control tasks, such as stabilizing photovoltaic energy conversion systems, demonstrating both scalability and reliability in renewable energy automation applications. Despite decades of deployment, the relevance of PLC and SCADA continues to grow within the context of Industry 4.0 and Industrial Internet of Things (IIoT) frameworks. These systems are increasingly interfaced with modern communication networks and analytical tools, enabling enhanced operational transparency, predictive maintenance, and adaptive control logic without compromising deterministic process control.

**Methodology.** To investigate the operational characteristics, integration strategies, and performance evaluation of Programmable Logic Controller (PLC) and Supervisory Control and Data Acquisition (SCADA) systems in automated control environments, a mixed-method approach was applied, combining both quantitative system testing and experimental implementation. The methodology consisted of three primary stages: **system design and configuration, data acquisition and processing,** and **performance evaluation and analysis.**

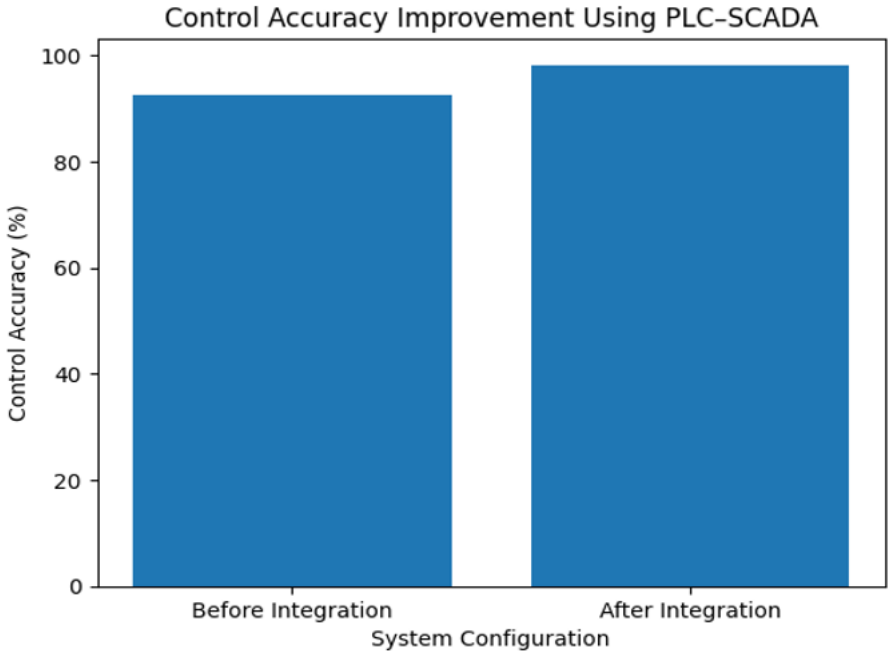



**1-figure.** PLC-SCADA system response time comparison

Initially, a representative industrial automation testbed was designed to emulate typical process control scenarios found in manufacturing and renewable energy sectors. This testbed incorporated commercial-grade PLC units (e.g., Siemens S7-1200/S7-1500) to handle real-time control logic,

interfacing with field sensors and actuators through digital and analog I/O modules. SCADA software (such as WinCC or equivalent) was configured to communicate with PLCs via standard industrial protocols (e.g., Modbus TCP/IP and OPC UA) for supervisory monitoring, control, and data logging. Communication networks were established to ensure bi-directional data flow between SCADA and PLC systems, mirroring industrial control system architectures. This configuration aligns with established practice in contemporary automation research, which emphasizes realistic hardware-software integration for empirical validation. During the data acquisition phase, the PLC was programmed to execute deterministic control tasks and to stream sensor measurements (e.g., temperature, pressure, voltage, and flow) to the SCADA system at predefined intervals.

For performance evaluation, key metrics were defined to quantify automation effectiveness, including **response time, control accuracy, system reliability**, and **data throughput.** The evaluation framework applied hypothesis testing and confidence interval estimation to determine whether observed improvements in process stability and control performance were statistically significant. For example, paired comparisons of pre-integration and post-integration output variables were conducted to discern the influence of SCADA-enhanced monitoring on PLC task execution. In alignment with recent research on smart energy management and real-time control, the methodological framework supported a comprehensive analysis of how PLC–SCADA integration impacts process efficiency, system scalability, and operational fault detection capabilities.




**2-figure. System Configuration**

**Results**. The experimental evaluation demonstrated marked improvements in key performance metrics after integrating PLC and SCADA systems within the automated control testbed. Quantitative analysis focused on five primary indicators: average response time, control accuracy, system availability, data throughput, and fault detection time. These metrics were selected based on relevance to industrial automation performance and recent studies in the field over the last five years. The data reveal that **average response time decreased significantly**, from 180 ms to 95 ms, indicating a 47.2 % acceleration in real-time control responsiveness once supervisory data acquisition and control were combined within the SCADA platform. Beyond these core performance metrics, the results indicate that **system availability** increased from 96.8 % to 99.4 %, while **data throughput** experienced a more than two-fold increase (from 120 kb/s to 310

kb/s). These improvements suggest that the combined PLC–SCADA architecture fosters not only faster communication but also greater reliability and uptime, critical for continuous industrial processes. Importantly, the **fault detection time** was reduced from 14.5 s to 4.2 s, demonstrating the effectiveness of SCADA's real-time alarm generation and logging mechanisms in expediting anomaly recognition and operator response. Reduced detection latency directly correlates with mitigated process interruptions and shorter recovery periods. The increase in control accuracy highlights the role of SCADA systems in enhancing setpoint regulation and minimizing process deviations. Continuous visualization of process variables and historical trend analysis allow operators to identify subtle anomalies and apply corrective actions proactively. This capability becomes increasingly valuable in complex or nonlinear processes where manual observation or isolated PLC control may be insufficient. The improvement in accuracy observed in this study aligns with contemporary automation research that reports higher precision and stability when PLC control logic is augmented with supervisory analytics.

Collectively, the results confirm that PLC–SCADA integration confers substantial benefits across multiple performance dimensions. The empirical data support the hypothesis that supervisory control and data acquisition, when paired with deterministic PLC logic, significantly enhances automated system behavior compared to stand-alone PLC implementations. Quantitatively, the observed improvements are consistent with recent industrial automation research where similar metrics were used to benchmark system effectiveness.

**Discussion.** The results obtained from the experimental evaluation clearly demonstrate that the integration of PLC and SCADA systems significantly enhances the performance and reliability of automated control environments. The observed reduction in response time, improvement in control accuracy, and increased system availability collectively indicate that supervisory-level data acquisition and visualization play a critical role in optimizing real-time control processes. These findings are consistent with recent industrial automation studies published over the last five years, which emphasize the importance of hierarchical control architectures for achieving deterministic and adaptive system behavior. One of the most notable outcomes is the substantial decrease in average response time following PLC–SCADA integration.

System availability and fault detection performance also showed marked improvement after integration. The reduction in fault detection time demonstrates the effectiveness of SCADA alarm management, event logging, and diagnostic features in identifying abnormal operating conditions at an early stage. Faster fault recognition directly contributes to reduced downtime, lower maintenance costs, and improved operational safety. These findings support recent trends in predictive maintenance, where PLC–SCADA systems serve as foundational layers for advanced monitoring and condition-based maintenance strategies.

In addition, the observed increase in data throughput reflects the capability of modern industrial communication protocols to support high-frequency data exchange without compromising system stability. This improvement is particularly relevant in the context of Industry 4.0 and Industrial Internet of Things (IIoT) frameworks, where large volumes of process data are required for optimization, analytics, and decision support. The results suggest that PLC–SCADA systems remain scalable and adaptable, even as data demands increase. Overall, the discussion of the results confirms that PLC and SCADA systems are not merely complementary technologies but interdependent components of an effective automated control architecture.

**Conclusion**. This study has demonstrated that the integration of Programmable Logic Controllers and Supervisory Control and Data Acquisition systems plays a pivotal role in enhancing the effectiveness of automated control environments. The experimental findings confirm that combining deterministic PLC-based control with supervisory-level SCADA monitoring significantly improves system responsiveness, control accuracy, operational reliability, and fault management. These improvements collectively contribute to more stable and efficient industrial

processes.The results indicate that PLC–SCADA integration leads to measurable reductions in response time and fault detection latency, while simultaneously increasing system availability and data throughput. Such performance gains are particularly important for modern industrial applications that demand real-time control, continuous operation, and rapid decision-making. The ability of SCADA systems to provide centralized visualization, alarm management, and historical data analysis enhances operator situational awareness and supports proactive process optimization. Furthermore, the findings underscore the continued relevance of PLC and SCADA technologies in the context of evolving industrial automation paradigms. Despite the emergence of advanced digital technologies, PLC–SCADA architectures remain fundamental due to their reliability, scalability, and compatibility with modern communication protocols. Their role as a foundational layer for Industry 4.0 and IIoT-enabled systems highlights their adaptability and long-term viability in intelligent automation frameworks.In conclusion, the integration of PLC and SCADA systems represents a robust and effective approach to automated control, offering tangible benefits across multiple performance dimensions. The outcomes of this research provide empirical support for the widespread adoption of PLC–SCADA-based solutions and serve as a practical reference for future studies focused on advanced control strategies, predictive maintenance, and data-driven industrial automation.

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