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DEVELOPMENT AND IMPLEMENTATION OF SOFTWARE FOR MANAGING THE ENRICHMENT PROCESS.

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Annotation: This work is dedicated to the development and implementation of software for managing the technological enrichment process using the Siemens TIA Portal engineering platform. The study examines the structure, functions and capabilities of TIA Portal, including PLC programming, HMI/SCADA visualization, communication configuration and diagnostics. Special attention is given to the SIMATIC S7-1200 controller and the WinCC system, which together provide a flexible and reliable automation environment. Within the project, a complete control system was created, including input/output configuration, functional block programming, start-up logic for the enrichment process and a PID-based control algorithm for regulating NaCN concentration. An interactive HMI visualization was developed to display process parameters, equipment status, alarms, and real-time data. The implemented system ensures stable monitoring and control of the enrichment operations, improves process accuracy, increases safety, and enhances overall technological efficiency.

Key words: technological enrichment process, software, control system, input/output, controller, algorithm, human–machine interfaces, programmable logic controller, industrial networks.

Introduction. Modern industrial technologies increasingly rely on software tools for remote monitoring, control, and automation of production processes. Among them, the Siemens TIA Portal platform stands out as one of the most comprehensive engineering environments used for developing industrial automation systems. TIA Portal integrates a wide range of tools and components such as programmable logic controllers (PLCs), human–machine interfaces (HMIs), digital controllers, industrial networks, diagnostic systems, and various configuration utilities [1]. Its architecture allows engineers to create complete automation projects, including PLC programming, visualization, configuration of communication networks, diagnostics, testing, and data exchange services-ensuring high reliability and flexibility of industrial control systems [2].

TIA Portal utilizes graphical and logical elements, programming languages, and HMI design tools to implement complex control algorithms [3]. Standard functions such as counters, timers, comparison blocks, arithmetic operations, and signal processing tools can be programmed in:

- LAD (Ladder Diagram)
- FBD (Function Block Diagram)
- STL (Statement List)

The platform supports all modern Siemens PLC families, including SIMATIC S7-300, S7-400, S7-1200, S7-1500 [4]. In this project, the SIMATIC S7-1200 controller is used due to its flexibility, modular structure, Ethernet connectivity, and suitability for small and medium automation tasks.

TIA Portal software widely uses graphic elements, logic elements, programming languages, and screen HMI blocks to create software for an automated control system. Providing the necessary functions when creating a software-controlled system, i.e., connecting counters, timers, and other standard functions that transmit information in binary code signals under control and managing the received data, can be done using LAD, FBD, and STL programming languages [1].

TIA Portal is a software from Siemens for developing automated control systems based on Simatic S7-300, S7-400, S7-1200 and S7-1500 programmable logic controllers. It provides the

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following software and hardware for controlling technological processes based on the SIMATIC 7-1200 controller. These include a PC for programming, TIA Portal V15.1 SP1, a SIMATIC S7-1200 controller, connecting the controller to the computer via an Ethernet cable, and operator panels for monitoring and control. PLCs have three types: discrete, analog and special inputs. The SIMATIC S7-1200 PLC is a new model of microcontrollers for solving various automation problems [4]. The S7-1200 PLC can be connected to a PC with various communication modules, signal modules and boards for input and output of analog and discrete signals.
WinCC is an open visualization system designed to connect various controllers. It defines communication channels and centralizes communication. All important communication channels for connecting SIMATIC S7 controllers are included in the WinCC system.
SIMATIC WinCC (Windows Control Center) is a HMI (Human Machine Interface) system, a software for creating a human-machine interface. WinCC is designed for the development and implementation of high-level automated control systems for technological processes. The main features of WinCC include visualization of the technological process (Graphic Designer), configuration and deployment of communication with PLCs (Tag Management), recording, archiving and displaying information about technological processes (Alarm Logging), design of reporting systems (Report Designer), provision of simple WinCC integration of standard interfaces OLE, ODBC and SQL in the internal data network of the enterprise, and construction of a client-server system. The interface device used for communication between a PLC and WinCC is a driver [5].

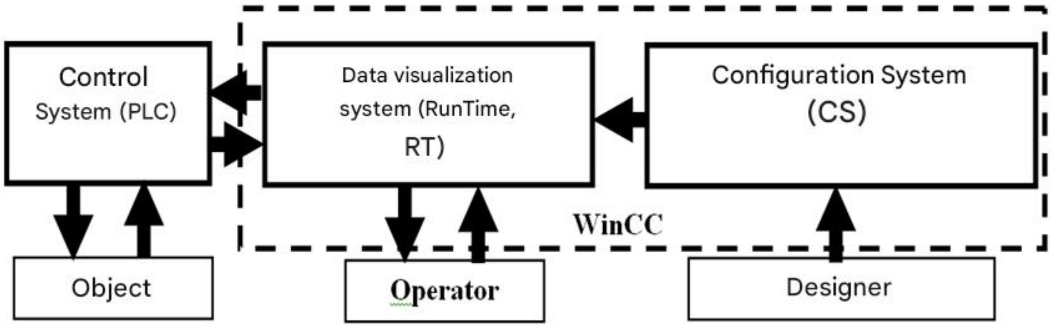

Figure 1. The structure of the WinCC package.
SCADA (supervisory control and data acquisition) was originally considered a control system. The first SCADA systems were used to obtain information from measuring instrument panels, lights and tape recorders. The operator controlled them manually using various control buttons. These devices were and are still used to obtain information and control in factories, enterprises and power plants. The figure below shows a sensitive element for a panel system.
The sensor element has the following advantages for SCADA system panels:
• It is simple and does not require any CPU, RAM, ROM or other software.
• The sensor elements are directly connected to the measuring instruments, lights and switches on the panel.
• It is easy and inexpensive to introduce simple devices such as buttons or indicators into it (in most cases).
In modern manufacturing and industrial processes, in mining, in the national economy and domestic services, in the field of recreation and security, telemetry is often necessary to connect equipment and systems located at long distances [6]. This distance can be from one meter to thousands of kilometers. Telemetry is used to send commands and programs and receive monitored information from long distances.
SCADA stands for supervisory control and data acquisition. SCADA collects all the collected data, sends it to a central site, and performs the necessary analysis and control, and then the data

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is displayed on several operator screens or displays. The necessary control signals are then transmitted to the process.

Data collection, logical analysis of data has been used in industrial systems and controls since the early days. In particular, with the advent of the CPU and a number of electronic devices, manufacturers have incorporated digital electronics into the control elements. PLC is one of the control systems that is still widely used in industry [7]. With the development of control and inspection equipment in factories and enterprises, PLCs have been divided into several parts, making these systems smarter and smaller. PLC and DCS (distributed control systems) are used as shown below.

SCADA systems originated as tools for remote monitoring of technological parameters in factories, power plants, and large industrial networks. Early SCADA devices included simple panel instruments, indicators, switches, and tape-based data recorders. Modern SCADA systems, however, integrate:

- Real-time data acquisition
- Alarm systems
- Process control
- Historical data archiving
- Remote access

For long-distance monitoring—sometimes thousands of kilometers—telemetry systems transmit commands and receive feedback signals. SCADA systems collect data from PLCs, RTUs, or intelligent devices and provide operators with real-time control capability [8].

PLC / DCS SCADA system has the advantages of being able to record and store a huge amount of data on a computer, display the data requested by the user in any way, connect thousands of sensitive elements in a large area, input real-time data into the operator system, collect a lot of data from RTUs, and view the data not only on site, but also from anywhere.

Modern SCADA systems integrate both PLCs and DCS architectures. They allow:

- Logging massive amounts of data
- Displaying data in a user-friendly format
- Connecting thousands of measurement points
- Real-time control and monitoring
- Access to data from remote locations

Results. Many sensing devices today are equipped with their own processing power and communication modules—known as Intelligent Electronic Devices (IEDs). These devices communicate through industrial buses such as PROFIBUS, PROFINET, DeviceNet, and Foundation Fieldbus.

Today, the demand for smaller and smarter systems is growing, and sensitive elements are being provided with data from PLC. These devices are called IEDs (intelligent electronic devices) or IEDs (intelligent electronic devices). IEDs are connected to a computer via communication channels such as Profibus, Devicenet or Foundation Fieldbus. These devices have sufficient intelligence to receive information, communicate with other devices and work with the general part of the program. Each of these intelligent sensing elements has several additional sensing elements on board. Typically, an IED combines an analog input sensing element, an analog output, PID control, a communication system and a program memory into a single device.

The development of a visualization project for the enrichment process in the TIA PORTAL software environment is carried out as follows. A new HMI panel is selected to visualize the created project. To load the created program or to test the program, it is necessary to connect the selected HMI panel to the processor. Connecting the HMI panel to the controller is as follows.

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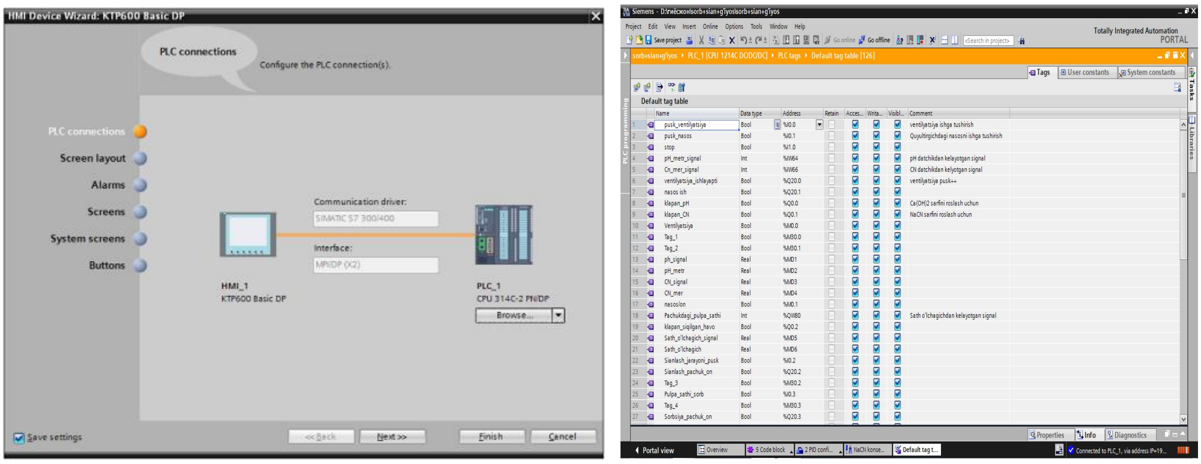

Figure 2. Connecting the controller and HMI panel (a), list of input and output signals (b).

To create a program, input and output signals are required. Logical operations are performed based on these signals. Input-output variables are as follows. To test and use the created program, this program is placed in the Main Organization block (Main OB1), the program is saved to memory and loaded into the controller.

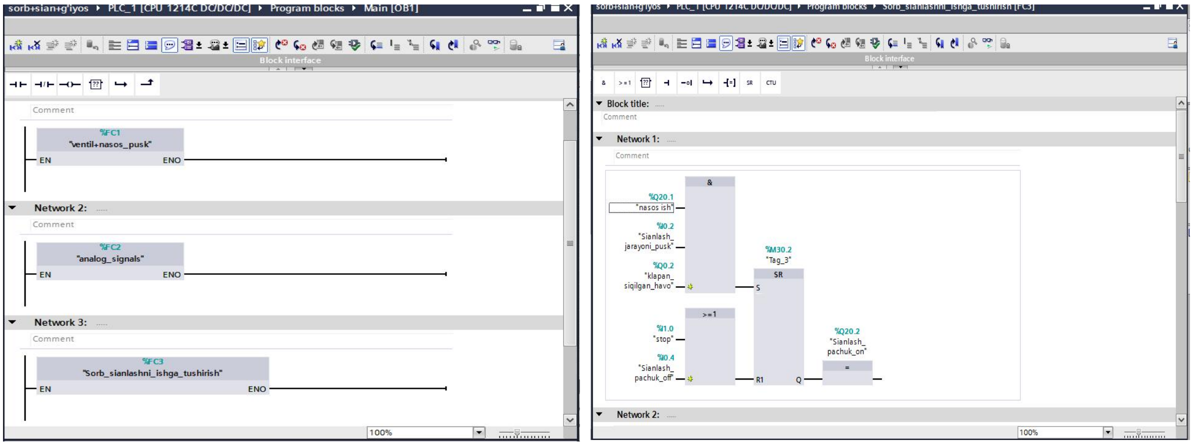

Figure 3. Overview of programs in the Main OB block (a), program created in FBD to start the enrichment process (b)

The enrichment process startup program is written in the FBD programming language in the Function block. A program was written to adjust the enrichment process parameters using a PID controller. Adjusting the NaCN concentration using a PID controller looks like this.

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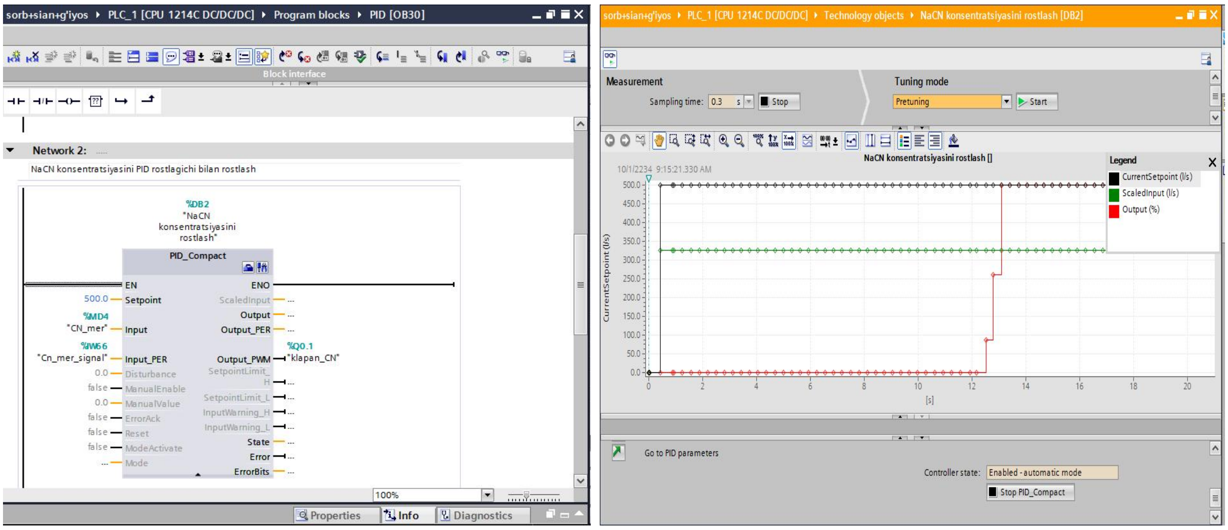

Figure 4. Application of PID controller in the program (a), PID controller tuning graph (b)

To check the created program, the Go online command is used. The PID controller adjustment graph is as follows. To illustrate the inputs and outputs of the enrichment process, a functional view of the process was created in the WinCC environment for the HMI.

Conclusion. The research successfully demonstrated the feasibility and effectiveness of using TIA Portal for developing an automated control and visualization system for the enrichment process. The integration of SIMATIC S7-1200 PLCs with the WinCC HMI/SCADA environment enabled a unified and efficient platform for real-time monitoring, data acquisition, parameter adjustment and operator interaction.

The implemented PID controller improved the accuracy of NaCN concentration control, contributing to higher quality and stability of the enrichment process. The created HMI interface provided clear visualization of technological parameters, simplified operator tasks, and improved the safety and reliability of system operation.

Overall, the developed automation solution significantly enhances process performance, reduces manual intervention, and opens opportunities for further optimization based on advanced control strategies, intelligent diagnostics, and integration with modern industrial networks.

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