



## SIMULATION OF AUTOMATIC CONTROL SYSTEMS IN THE FACTORY I/O PLATFORM

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DOI: <https://doi.org/10.24136/jaeec.2025.019>

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**Abstract** – The digital transformation of industry, referred to as Industry 4.0, is increasing the importance of virtualizing industrial processes. As technology advances, industrial production is becoming more complex and requires more efficient management tools. Industrial process virtualization is one such tool that allows industrial processes to be accurately simulated in order to better understand and optimise them. This undoubtedly has an impact on the approach to the design and subsequent implementation of production automation investments. This paper presents an analysis of the possibility of using, in the process of simulating industrial automation systems, platforms such as Factory I/O and PLCSIM software, which is a component of TIA Portal. For this purpose, a control and visualisation system for a product sorting line was implemented in the aforementioned environments. The research carried out confirmed the very high suitability of the Factory I/O platform for the creation of 3D simulations and virtualisation of industrial processes, as well as the possibility of integrating this platform with the TIA Portal software for PLC programming.

**Keywords** – Factory I/O, TIA Portal, PLCSIM, PLC, simulation

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### INTRODUCTION

In the design process of automated control systems, it is very important to understand the interrelation of system components before they are put into operation and subjected to actual operation. Therefore, it is essential to carry out dynamic simulation to model processes and systems in real time, taking into account different conditions and scenarios [1, 2]. This provides a better understanding of the dynamics of the processes taking place and their interactions, which is very important for the effective design of systems, including the development of control programs for them. The main advantages of simulation of automatic control systems include, among others:

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- accurate modelling of systems in a secure virtual environment,
- testing of different scenarios of system behaviour,
- optimisation of algorithms and resources,
- failure rate testing of components,
- prototyping of systems.

On the basis of the simulation studies carried out, an analysis is carried out, which influences the final quality assessment of the designed control system, taking into account aspects such as compliance with technical specifications, functionality or performance, among others. This process is carried out to exclude inadequacies in the control system software at the design stage and to ensure safety [3-6]. An additional advantage can be the ability to document the system, including visualisation of its operation for demonstration and training purposes.

Currently, in the era of Industry 4.0, control systems are mainly built using PLCs, for which software is developed using various programming languages dedicated to this purpose [7-11]. Therefore, it is important that the simulation environment is capable of interfacing with IT tools provided for PLC software development. One such platform is Factory I/O, which allows automatic control systems to be created in 3D and then simulated in conjunction with actual control programmes [12-16]. Factory I/O contains a rich library of predefined automation components that are used in the designed virtual factory. They include components such as photocells, inductive sensors, various types of barriers, roller conveyors, turntables and many other elements (Fig. 1).



**Fig. 1. Examples of components found in the Factory I/O platform (own study)**

At the same time, Factory I/O includes an interface to work with most of the relevant PLC programming environments (Fig. 2).



Advantech USB 4704 & USB 4750  
Allen-Bradley Logix5000  
Allen-Bradley Micro800  
Allen-Bradley MicroLogix  
Allen-Bradley SLC 5/05  
Automgen Server  
Control I/O  
MHJ  
Modbus TCP/IP Client  
Modbus TCP/IP Server  
OPC Client DA/UA  
Siemens LOGO!  
Siemens S7-200/300/400  
Siemens S7-1200/1500  
Siemens S7-PLCSIM

**Fig. 2. Parameterization of Factory I/O in terms of programming platform selection (own study)**

An additional advantage of the Factory I/O platform is the ability to simulate the failure of control system components, such as a malfunctioning photocell. This makes it possible to check how correctly the system detects and responds to possible component failures. A further advantage is that the operation of the system can be observed thanks to the view from the built-in cameras. In the following discussion, the design of a product sorting line will be used as an example of an automatic control system.

## **1 PRODUCT SORTING LINE PROJECT**

The product sorting line, designed in the Factory I/O environment, consists of two conveyors. At the first conveyor there is a product generator, which feeds the sorted products into the conveyor. A control module with an operator panel is located at this conveyor, allowing control of the sorting line. A vision sensor is located at the end of the first conveyor, which is responsible for detecting the products to be sorted. The second conveyor is equipped with three sorters, directing the sorted products to the appropriate gutter ending in a box. Counting of sorted products is enabled by a retro-reflective sensor. A view of the sorting line design developed in the Factory I/O environment is shown in Fig. 3.

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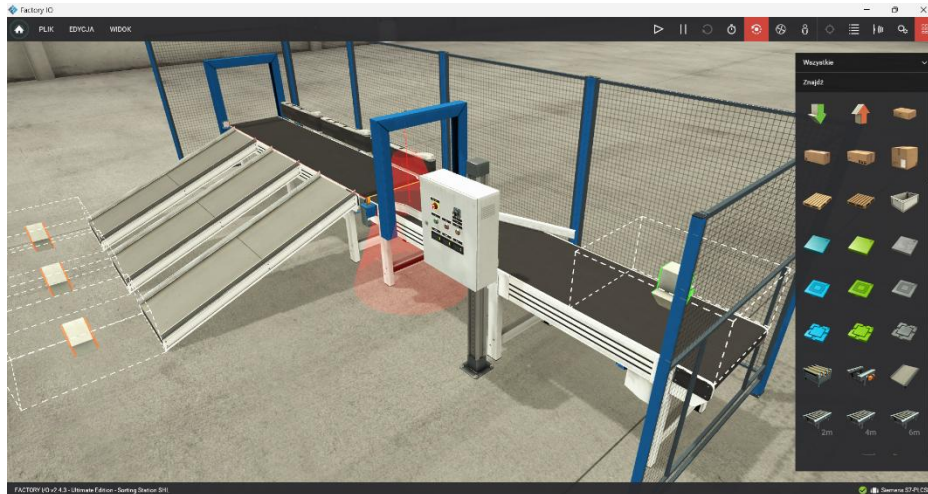


Fig. 3. Product sorting line project at Factory I/O (own study)

The sorting line control software was developed in the TIA Portal environment using the Ladder Diagram (LD) language. The interaction between TIA Portal and the sorting line simulation platform in Factory I/O is implemented via a specialized controller. Parameterization of this controller requires mapping of sensor inputs and actuator outputs. A view with the parameterization of the controller for the sorting line is shown in Fig. 4.

At exit	%I0.0	%Q0.0	Entry conveyor
Start	%I0.1	%Q0.1	Stop blade
Reset	%I0.2	%Q0.2	Exit conveyor
Stop	%I0.3	%Q0.3	Sorter 1 turn
Emergency stop	%I0.4	%Q0.4	Sorter 1 belt
Auto	%I0.5	%Q0.5	Sorter 2 turn
FACTORY I/O (Uruchomiony)	%I0.6	%Q0.6	Sorter 2 belt
Vision sensor	%ID30 (DINT)	%Q0.7	Sorter 3 turn
		%Q1.0	Sorter 3 belt
		%Q1.1	Start light
		%Q1.2	Reset light
		%Q1.3	Stop light
		(DINT) %QD30	Counter 1
		(DINT) %QD34	Counter 2
		(DINT) %QD38	Counter 3

Fig. 4. Parameterization of Factory I/O for product sorting line (own study)

As mentioned, the program controlling the product sorting line was created in LD. The data structure of "PLC Tags" is shown in Fig. 5.

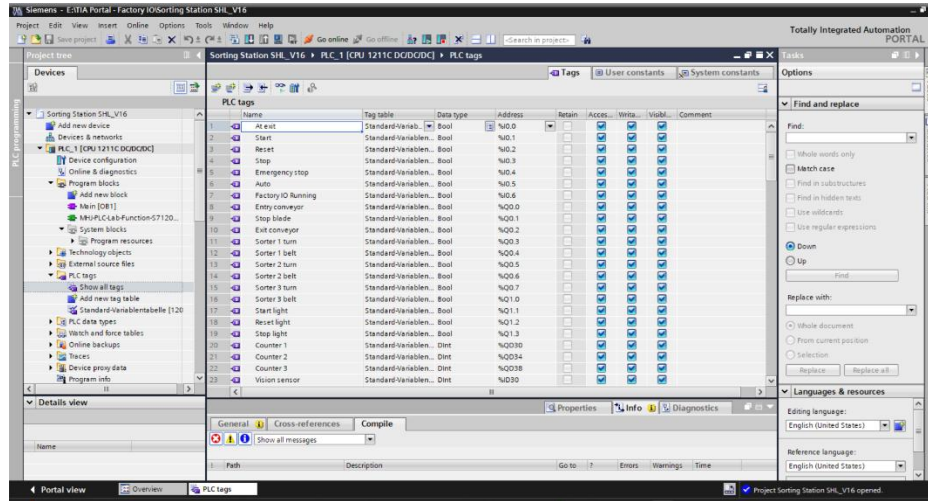


Fig. 5. Data structure in the TIA Portal for product sorting line (own study)

The “Main” program in block OB1, which controls the product sorting line, consists of the following networks: “Factory IO”, ‘Bit Data’, ‘Assign value’, ‘Conveyor’, ‘Reset’, ‘Sorter 3 turn and Sorter 3 belt’, ‘Sorter 2 turn and Sorter 2 belt’, ‘Sorter 1 turn and Sorter 1 belt’, ‘Counter’ and ‘Light logic’. An example of the TIA Portal main window showing a portion of the sorting line program code is shown in Fig. 6.

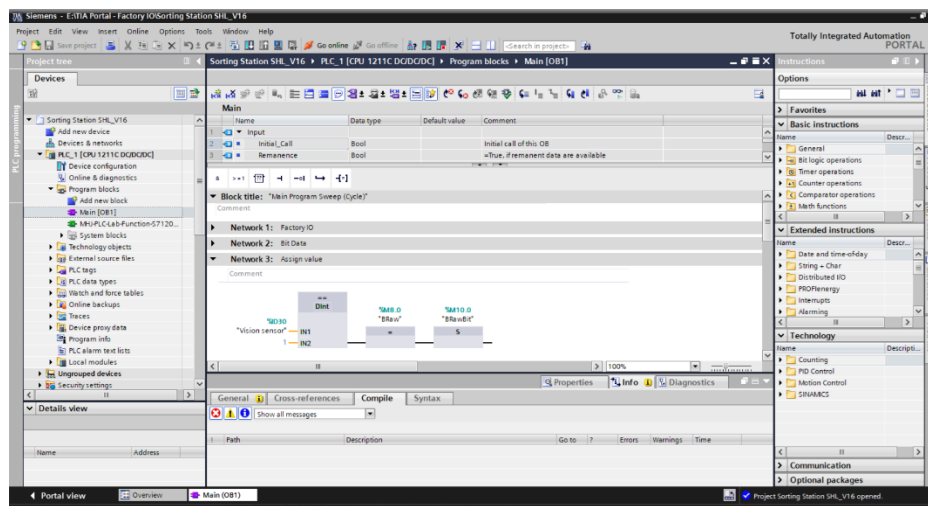
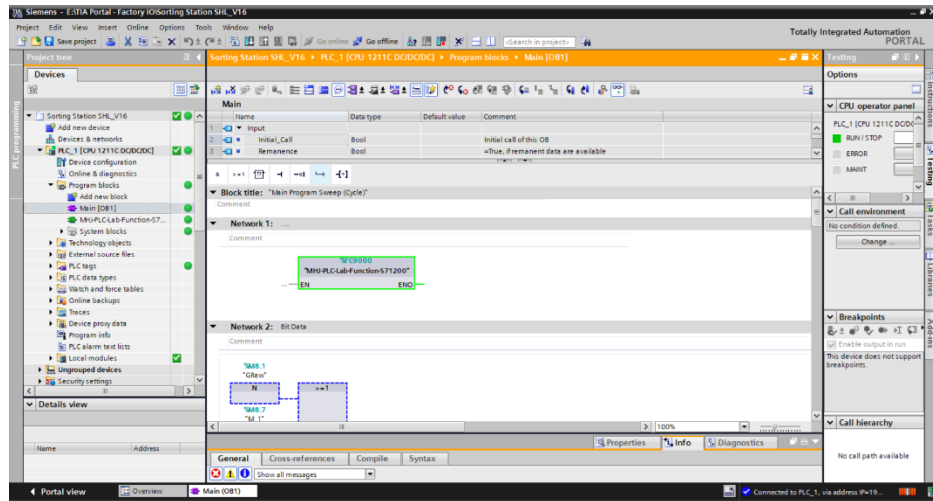


Fig. 6. The program that controls the sorting line in the TIA Portal (own study)

The TIA Portal platform, together with the PLCSIM simulator of the PLC, makes it possible to

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check the functionality of the developed program controlling the product sorting line. Figure 7 shows a visualization of the program's operation in the TIA Portal.



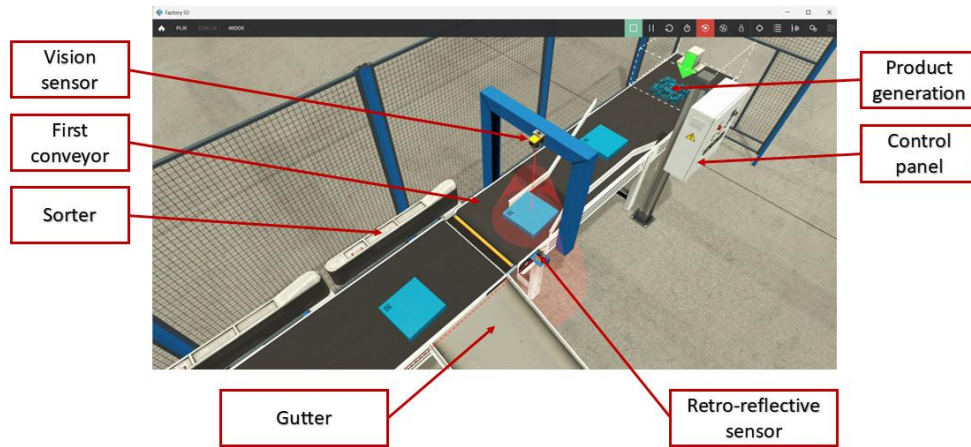
**Fig. 7. Simulation of PLC and product sorting program in TIA Portal (own study)**

Operating the control module on the operator panel by setting the automatic operation mode and switching on the sorting line starts the product generator, which feeds the sorted products into the first conveyor (Fig. 8).



**Fig. 8. View of the sorting line operator panel (own study)**

The products are then transported and once they are in the area of the vision sensor, they are recognized (Fig. 9).



**Fig. 9. Simulation of product recognition by the vision sensor of the sorting line (own study)**

As a result of product recognition, by the vision sensor, the corresponding sorter is activated, and thus the products transported by the second conveyor reach the target gutters. At the same time, a retro-reflective sensor located at the beginning of the second conveyor counts the sorted products, which is visualized on the control panel. Figure 10 shows a simulation of sorting line operation in the Factory I/O.



**Fig. 10. Example simulation of product sorting in Factory I/O (own study)**

## 2 SUMMARY

Simulation is an extremely important element in the design process of industrial automation systems. It plays a key role during the testing and development of control systems. One of the most important simulation tools is the Factory I/O platform, which is designed to work with the most prominent PLC and industrial automation suppliers, including: Siemens, Allen-Bradley, Omron, Mitsubishi, Schneider Electric, Beckhoff. At the same time, the platform takes into account a variety of communication protocols allowing the integration of systems from different manufacturers. Importantly, simulation can be performed both by connecting to the actual PLC and by using a controller simulator. Thus, Factory I/O is a simulation platform extremely useful for automation engineers designing various industrial control systems. Enabling interactive testing makes it possible to effectively increase design efficiency by, among other things, eliminating design errors, mainly in control applications. The Factory I/O platform also has an important educational function, enabling the development and training of future automation engineers. This article presents the results of research on the usefulness of the Factory I/O platform in the process of 3D simulation of a selected industrial automation system, which was a product sorting line. At the same time, the possibilities of integrating Factory I/O with the TIA Portal platform for PLC programming were assessed. The software controlling the product sorting line was written in LD, and simulation was carried out using the PLCSIM tool, which is a TIA Portal environment package.

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