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Alternative Ways to Control an Object using Plc S7 - 1200 Controller

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Abstract*: The paper concerns an alternative ways of object control using S7 1200 controller. Author's solution is based on an external Matlab program with Simulink extension. Standard ways of controlling an object with the use of a controller to control and analyze the operation of this object use either the controller itself or a graphical representation of the system using an HMI operator panel. An alternative way of controlling a three-phase electrical motor using an external software Matlab with Simulink extension was invented and created in the university laboratory. Algorithm of controlling the object has been created in Matlab environment, through which it is possible to control the object and to read parameters of voltage, output current or even torque. The program is fully compatible with TIA Portal software, which uses TSEND_C and TRCV_C function blocks to exchange data with a PC running Matlab. The entire control process is based on the TCP protocol, while the object is connected through the inverter to the controller using the Modbus RTU protocol. A comparison of the presented solution with currently used solutions has been made. At the end of the article, all advantages and disadvantages of the discussed solution are presented, as well as personal comments on the solution.

***Keywords*: PLC, Matlab, Simulink, Object System Control**

I. INTRODUCTION

Over the past few decades, the use and usefulness of PLC's in industry has been growing steadily. Technology is constantly evolving and accelerating year on year, resulting in industry companies needing to constantly improve and find new ways to meet the increased demand for products and services. PLCs have been created for this very purpose. They are supposed relieve people in the process of control and steering of e.g. production line or even at the ship. In the article describe [6] the use of PLC technology with HMI panel for watertight door control system. Thus, they are expected to work faster and more reliably than humans. One of the most common tasks, which performs the controller is to control some executive object. Such an object may be a electrical motor, robot arm or even an actuator. An interesting solution was shared by the authors of [3]. Just connecting the controller with the object, is not enough to start the production process. In large manufacturing plants usually use not one but hundreds or even thousands of such executive devices, plus various types of sensors and safety devices. An important element is the way we want our objects to be controlled. The entire logic of the program is located in the memory controller, while the processes occurring in the entire process are only seen from the program level. In order to facilitate the control of the entire production process devices such as HMI panel were invented. This device allows for visual representation of the process occurring in the work of the controller and east control of the work of the controller. Another device that is used for visualization of control is a PC station[7], where you can create your own visualization through dedicated programs such as SCADA [8]. A solution that is being systematically implemented in the industry is connecting controllers with Web or OPC severs [5]. There are many solutions for the work of the controller, visualization or its programming. In this article, the authors will try to present an alternative way of control and display information from a PLC, which will control an object such as a three-phase [4] electrical motor through inverter and Matlab software [1][2].

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II. METHODS OF CONTROLLING AN OBJECT WITH A PLC

We can divide the control methods by PLC into many ways. The most common division is the control method by distance:

- Local control
- Remote control
- Integrated control

Local control is a control where the driver is located directly at the executive object, most often it is placed in an electrical box from which pushbuttons, switches and displays in the form of meters are derived. In this case we act directly on the inputs and read directly from the outputs of the controller. This is a standard solution which must always be used because we must have direct access to the controller in the event of any failures or program changes where we would like to connect to the controller. Another control is the remote control which was created in order to control the object remotely from a distance. Initially, these distance were limited by the length of the cable and its transmission speed, but now we are able to control the object on the other side of the world from our own computer at home [7]. This is possible through the use of the Internet network and servers. New production processes usually use dedicated servers, in order to be able to control a given process from another place on earth without the need to go to that place [8]. The way in between is integrated control, this is the way in which HMI panels or PC's are most often
Used [9].

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This control is partly based on remote control, but is usually limited to one plant. The controller with the object, which are placed on the production hall can be controlled from the HMI panel, which is located for example 500 meters away in the room of the person who controls all production processes in the factory. The operator panel is often connected to the controller with a wire, but nowadays wireless solutions using servers and wireless network are also used more often [10]. This solution differs from remote control in that insight into the processed has only a person who is at the operator panel, and not as in the case of remote control, any person who knows the login data to the online server. In this paper an alternative solution will be presented which is based on the use of Matlab program installed on a PC station, from which it is possible to control an object such as a three-phase motor accurate reading of motor data such as values of voltages and currents [11] [12].

III. MATLAB PROGRAMMING ENVIROMENT

The programming environment that has been used to control facility through PLC is Matlab along with Simulink extension. Matlab is a computer program that is an interactive environment to perform scientific, engineering calculations and create computer simulations. Language used to program in Matlab is high level language and syntax is modeled on C language. It uses the same logical language as in most programming languages. Functional difference between programming in Matlab [2] from even though the usual obtained can be easily displayed in the form of various graphics, charts or objects 2D and 3D. Another advantage of Matlab is a large content of fully compatible various extensions called Toolboxes. Toolboxes are additional functions, which can be installed for free to extend the functionality of Matlab [5]. It is worth to notice, that to Toolboxes library are also added author's extensions, it means, that everyone can create own additional functions to Matlab. In our solution we use the most popular extension called Matlab Simulink. It is a package used to model and simulate dynamics systems and graphically present obtained results in real time. There is also an extension for data exchange via TCP protocol [11] with the controller (Fig.1).

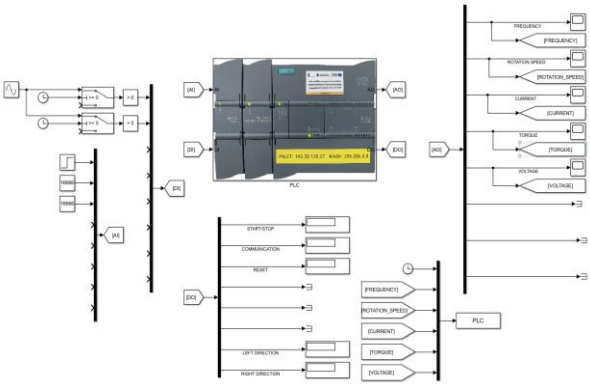

Figure 1 A Circuit Created in Matlab Simulink to Control an Object Through a PLC

Advantages of Matlab over TIA Portal or SCADA is the fact that it is a program that can perform complex calculations, received data can be presented in graphical, numerical form, but also to do on the basis of these data complex calculations. Other mentioned programs are only used to receive data and display it, in case of SCADA you can also archive data. However, the main difference with Matlab is the possibility of further processing of the data received. There is a possibility to create even an object working in ideal conditions and compare it with an object working in real conditions, which as we know are never ideal and on the basis of that compare how much our introduced solution deviates from the ideal obtained from mathematical calculations (Fig.2).

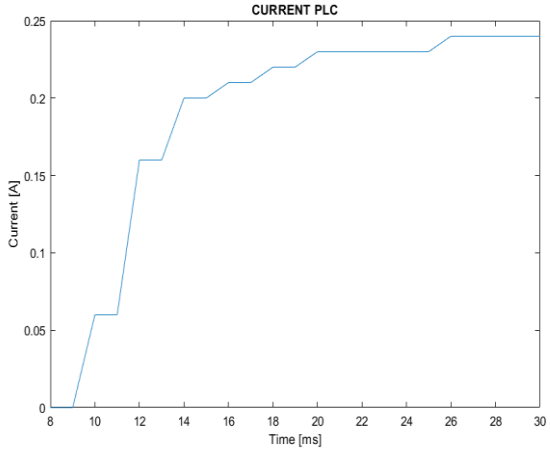

Figure 2 Example of phase current measurement of a three-phase motor read in Matlab

IV. SYSTEM CONFIGURATION

In this example of object control, in addition to external software, which is Matlab, we also use TIA Portal, because it is a dedicated program for programming Siemens S7-1200 controllers with use two networks Modbus RTU [13,14] and Ethernet. Matlab program is only used to receive data, process it or send data to the controller. Both software communicate through the PC using Ethernet network. Connection scheme looks as follows (Fig.3):

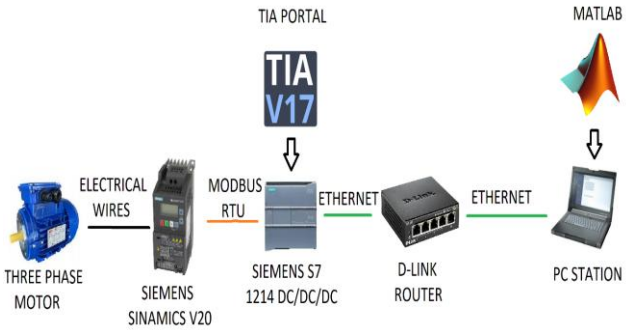

Figure 3 Diagram of the Connected Workstation

Simply connecting the station is not enough, you must additionally configure the controller and the PC for proper data exchange. For this purpose, the TSEND_C and TRCV_C blocks must be added and configured in the controller (Fig.4, Fig.5, Fig.6, Fig.7).

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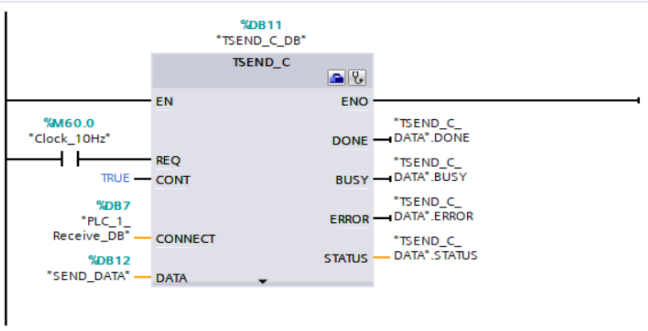

Figure 4 TSEND_C Block for Sending Data to Matlab Via Tcp Protocol

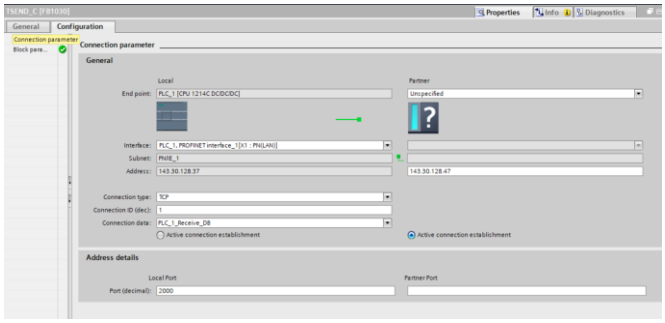

Figure 5 TSEND_C Block Configuration

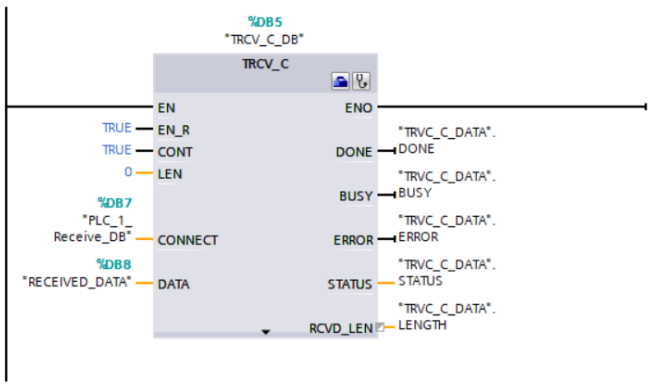

Figure 6 TRCV_C block used to receive data from Matlab via TCP protocol

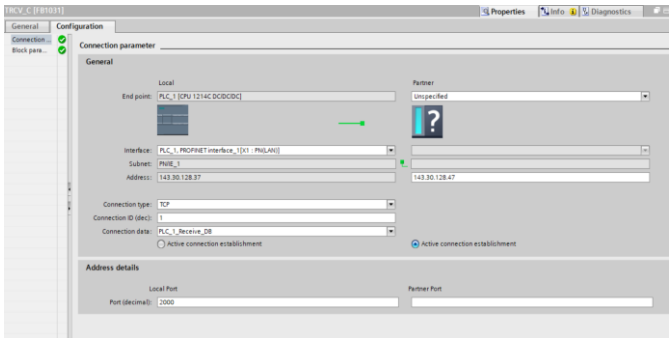

Figure 7 TRCV_C Block Configuration

When configuring the TSEND_C and TRCV_C blocks, ensure that the IP address is entered correctly and that the Unspecified device is selected. Next, select TCP connection [11] and set the PORT value to 2000. Once one of blocks is configured, the other can be configured based on the first one. The last thing to do in the controller program is to add the function of sending and receiving individual data bits. The solution is original and can be done in many ways. We used the following (Fig.8, Fig.9, Fig.10, Fig.11).

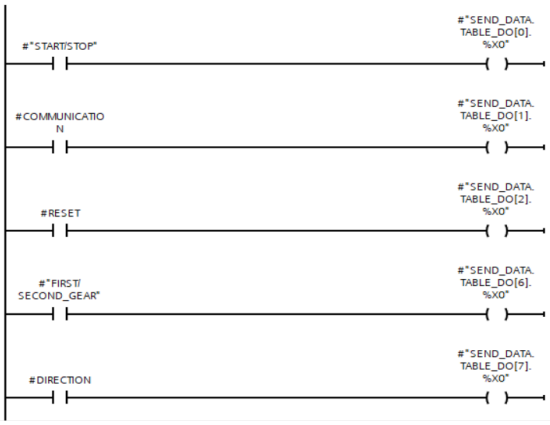

Figure 8 Program Responsible for Sending Digital Values to Matlab

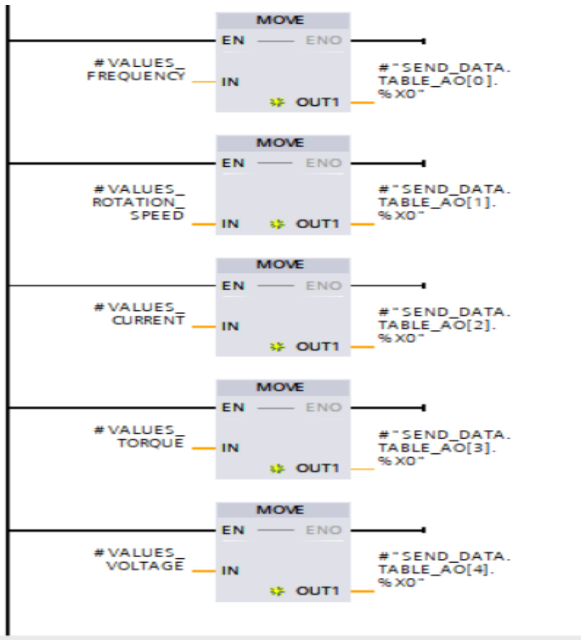

Figure 9 Program Responsible for Sending Analog Values Read from Motor to Matlab

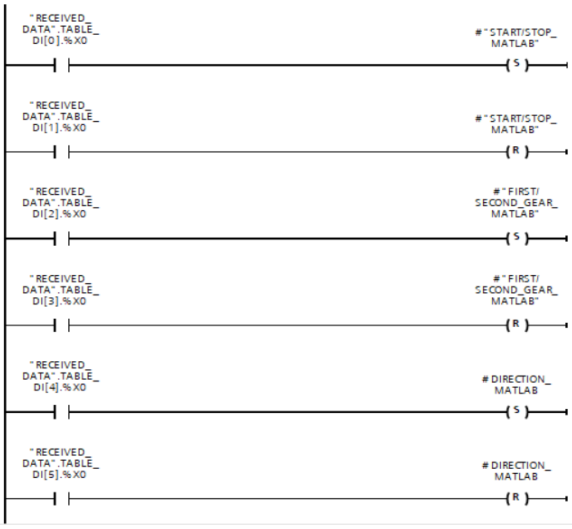

Figure 10 Program Responsible for Receiving Digital Values from Matlab to The Controller

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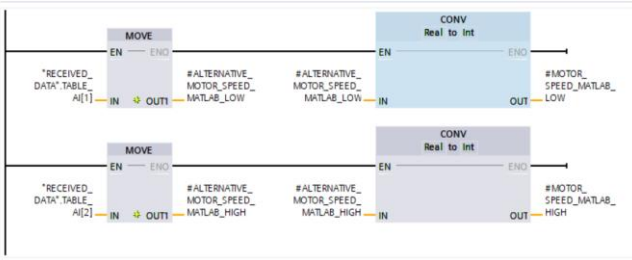

Figure 11 Program Responsible for Receiving Analog Values from Matlab to The Controller

The data from the SEND_DATA and RECEIVED_DATA arrays are sent through the TSEND_C and TRCV_C blocks to Matlab. To receive or send information from Matlab, you must also add a function block (Fig.12).

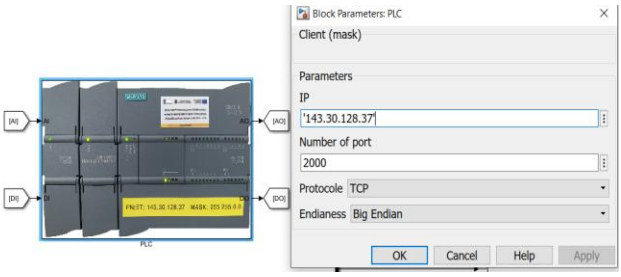

Figure 12 Function Block Configuration in Matlab

The function block used is a proprietary block, it uses built-in Matlab functions to communicate over TCP protocol. The way of sending and receiving data was also created for a specific object control project and is shown in (Fig.1)

V. COMPARISON OF OBJECT CONTROL METHODS

Comparing our original idea of alternative object control using Matlab with PLC we can see that there are more elements to configure, requires skill in using Matlab and basic knowledge of TCP protocol. In return we get much more extensive interface, which can be freely programmed, the ability to process data in any way and connect additional device because Matlab is compatible with more devices than TIA Portal. Detailed comparison of both ways of object control is presented in the table (Table. 1)

Table 1 Comparison of object control methods

CONTROL FROM TIA PORTAL	CONTROL FROM MATLAB
Reduced complexity of connection and configuration	Higher complexity of connection and configuration
Need to know only one programming environment	Knowledge of two programming environments
Data exchange only via MODBUS protocol	Data exchange via TCP and MODBUS protocol
No data processing possible	Possibility of data processing in any way
Limited number of devices compatible with the controller	Possibility of connecting any other device to the system via PC
No possibility of using data for further research	Possibility of making mathematical simulations based on received data

As we can see both ways of controlling the object have their advantages and disadvantages. Our solution requires knowledge of additional protocols, software and ways of communication, while it gives us much more possibilities and we are able to use received information in more ways. Each production process is different so it is impossible to unequivocally state which solution is better. The choice of how to control the object should be chosen wisely beforehand so that it fulfills its purpose.

VI. CONCLUSION

The project was made as an idea for an alternative way of controlling an object through a controller. It was carried out in the laboratory of the Gdynia Maritime University, where a stand was created, the diagram of which was presented earlier. The control operates on Siemens S7-1200 controller, Siemens Sinamics V20 inverter and three-phase induction [4] electric motor. An innovation solution is the use of additional software Matlab with Simulink extension which was installed on a PC station. The TCP protocol was used for data exchange, the controller was connected to the PC station via Ethernet cable using a switch. Program logic was created in TIA Portal V15 and Matlab Simulink environments. The controller was programmed to collect information regarding motor output voltage, phase current and torque, it was send to Matlab through TSEND_C function blocks. Matlab received the data and stored it and displayed it in graphs, which could be edited in any way . In addition, it was possible to send feedback from Matlab and control motor speed and his direction from Matlab. For this purpose, we used the TRCV_C function blocks to receive the information sent from Matlab to the controller. Finally a comparison of the discussed control method with the most commonly used method in industry is presented. From the comparison results obtained, it is difficult to determine which solution is better. Both solutions have their advantages and disadvantages and the choice is very dependent on the task that the control has to perform, what we want to read the data and how. Our solution aims to show that there is another way to control the object.

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