LCAMP

Learner Centric Advanced Manufacturing Platform

BASICS OF AUTOMATION WITH PLC (EXERCISES)

WP6 COLLABORATIVE LEARNING FACTORY

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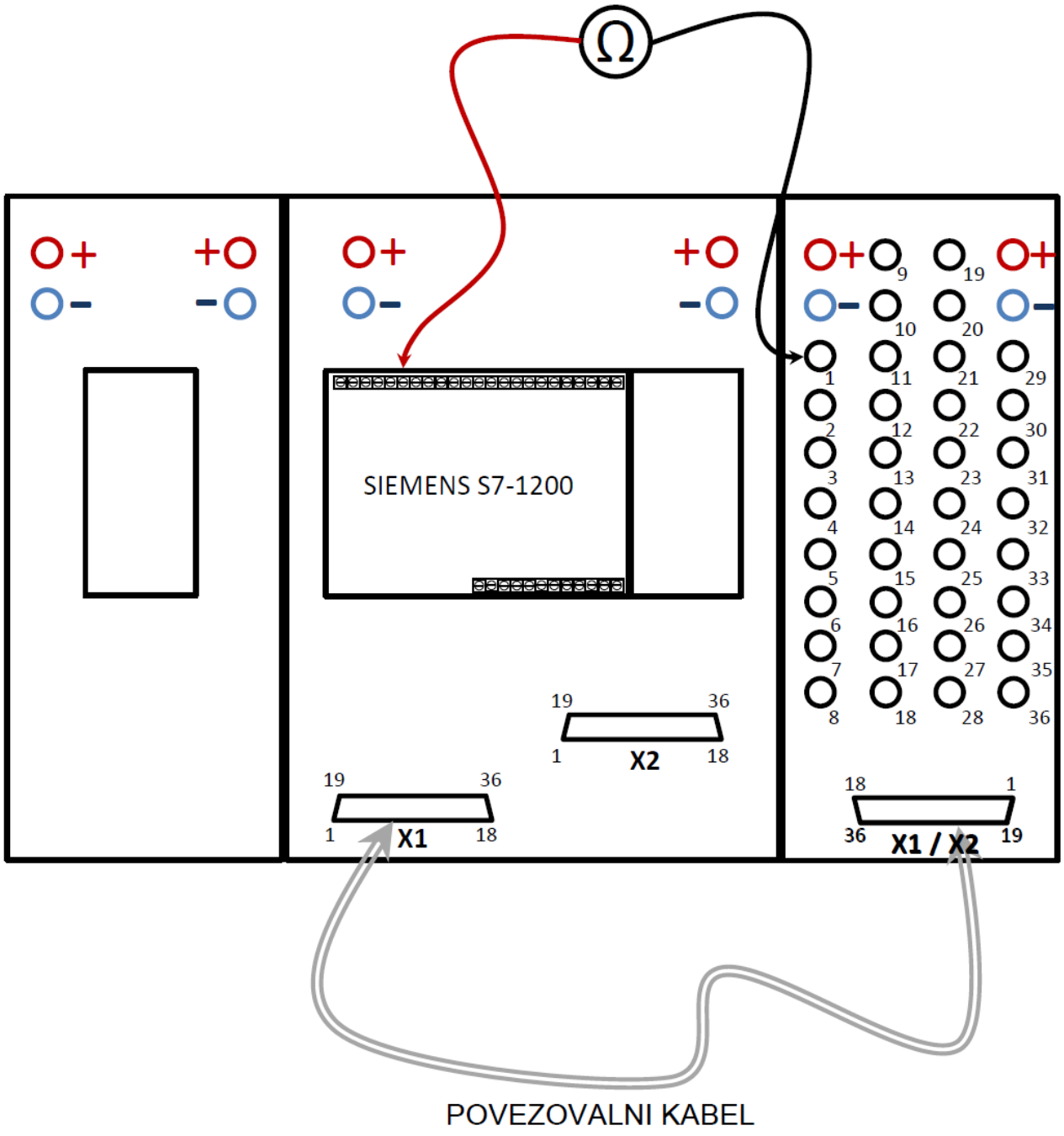
CONTENT TABLE

EXECUTIVE SUMMARY

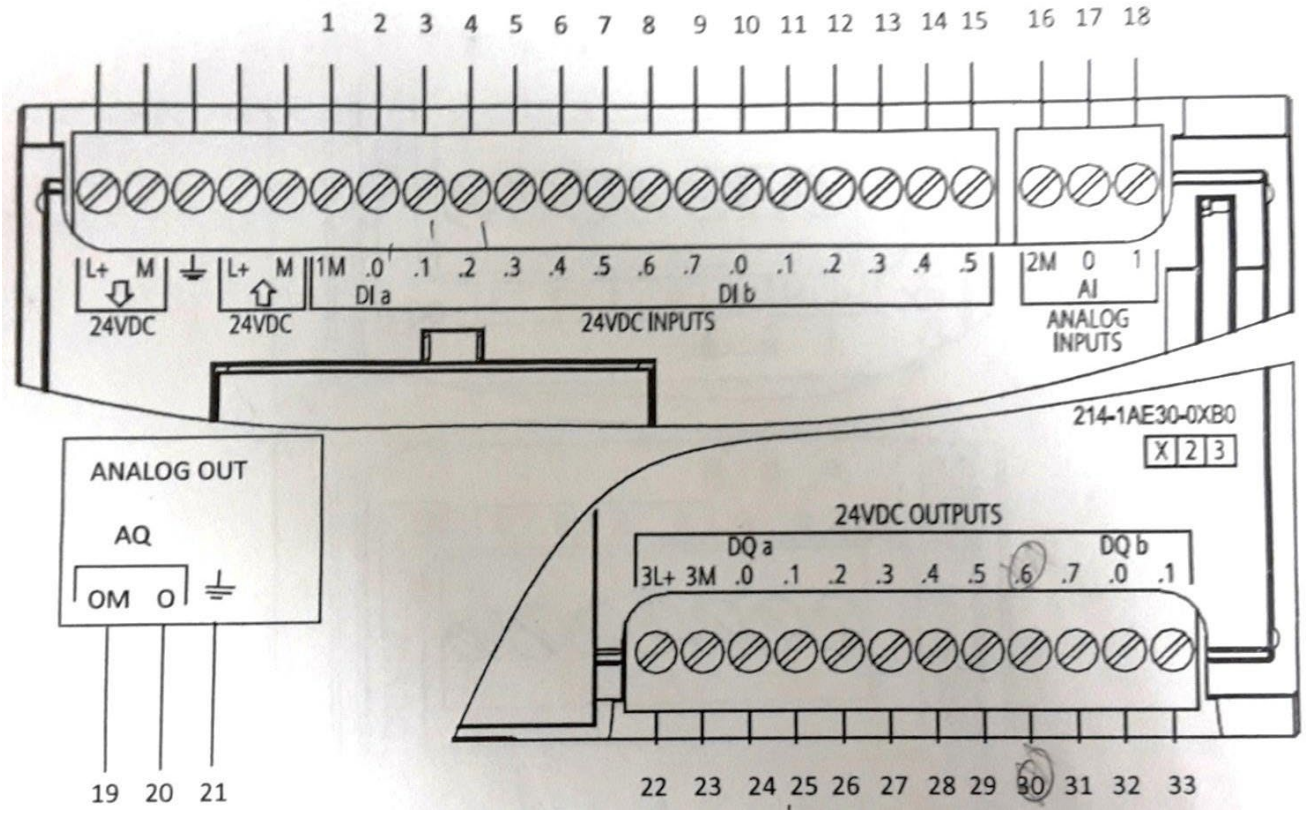
In this course we provide participants with knowledge about configuration of PLC automation and programming hardware, advantages of using PLC in process automation, optimal selection of PLC and extension modules for automation of a specific process, the basic functions of PLC programming, PLC programming on the example of a practical task (basic combination and stepper control).

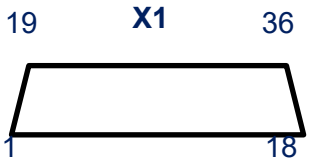
EXERCISE 1

1. Transcribe PLC code: _____
2. On the sketch of the arrangement of the components on the PLC board, it numbers the connectors and indicates the connection of the supply voltage (voltage 24 V DC or 230 V AC). On (ob) PLC, number the connectors when connecting connector X1 under PLC and X1 on the banana connector part (using the connecting cable).
3. It checks the connections with a resistance meter (Ω - meter) and on the next page indicates which connections match (where the contact is, or where which connector is connected).



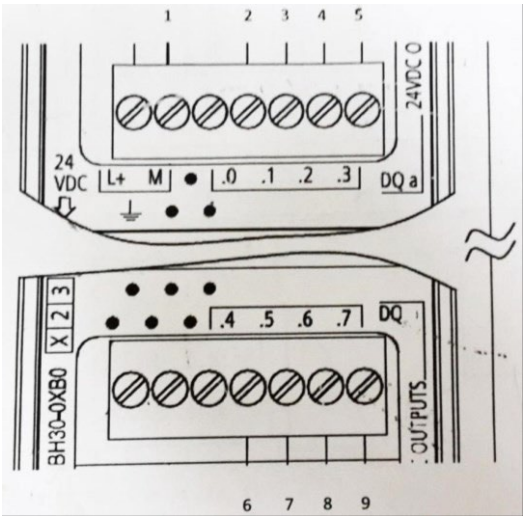
CONNECTOR X1





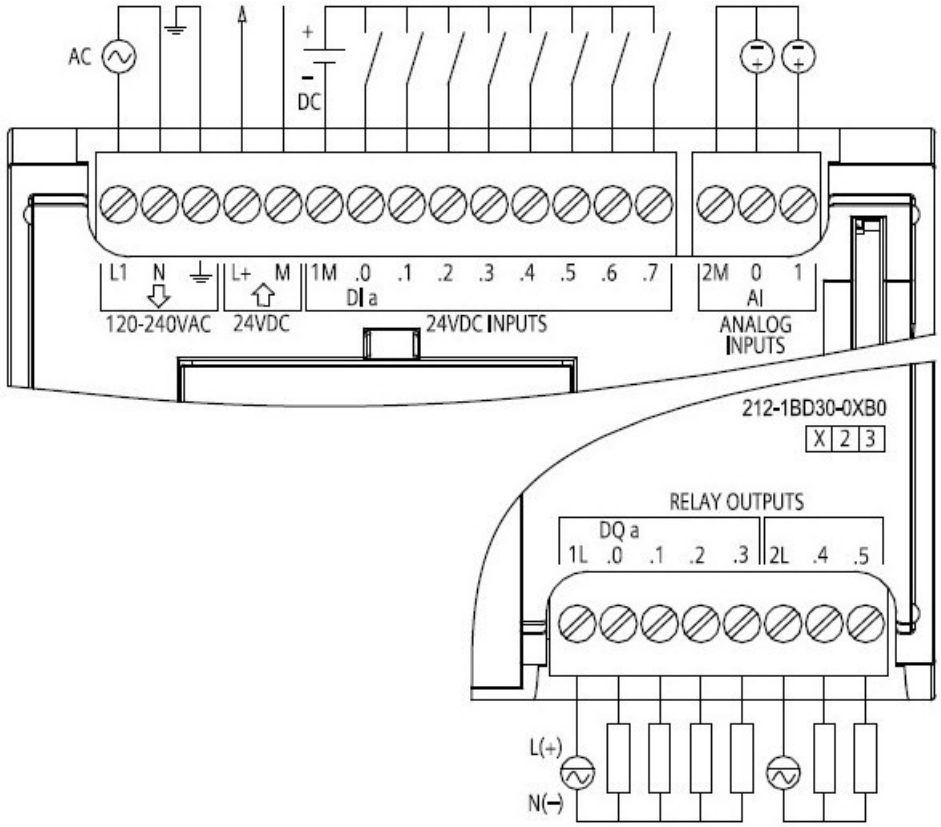
4. Using a universal instrument, it checks the correctness of electrical connections (if the electrical plans and connections on the board match - it measures each connection and indicates the correctness of the connection next to each number).

CONNECTOR X2:

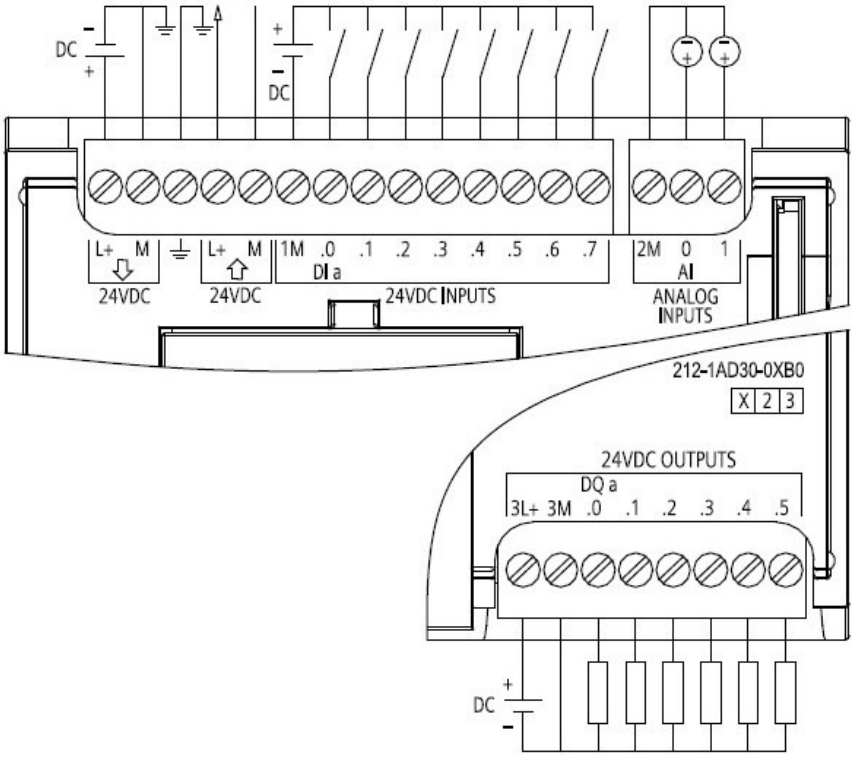


Connecting power, inputs and outputs

SIEMENS S7-1200, CPU 1214C, AC/DC/RLY:



SIEMENS S7-1200, CPU 1214C, DC/DC/DC:



SIEMENS SIMATIC S7-1200

Compact CPU 1214C

Device versions				
Version	Supply voltage	Input voltage DI	Output voltage DO	Output current
• DC/DC/DC	24 V DC	24 V DC	24 V DC	0.5 A, transistor
• DC/DC/relay	24 V DC	24 V DC	5 … 30 V DC / 5 … 250 V AC	2 A; 30 W DC / 200 W AC
• AC/DC/relay	85 … 264 V AC	24 V DC	5 … 30 V DC / 5 … 250 V AC	2 A; 30 W DC / 200 W AC

Answers questions:

1. Meaning of DC/DC/DC?
2. Meaning of AC/DC/relay?
3. CPU 1214C – how many inputs and outputs does this controller have and what type are they?
4. Plot the electrical connection I0.0 to logic 1 (logical input and power supply).
5. What kind of power supply does the DC/DC/DC type PLC have and what kind of AC/DC/relay?
6. What voltage, current and power can be connected to the digital outputs (PLC S7-1200 1214C)?
7. What does the number 6ES7 214-1AG31-0XB0 mean next to CPU1214C DC/DC/DC?

EXERCISE 2: CONNECTING PLC AND INTRODUCTION TO PROGRAMMING

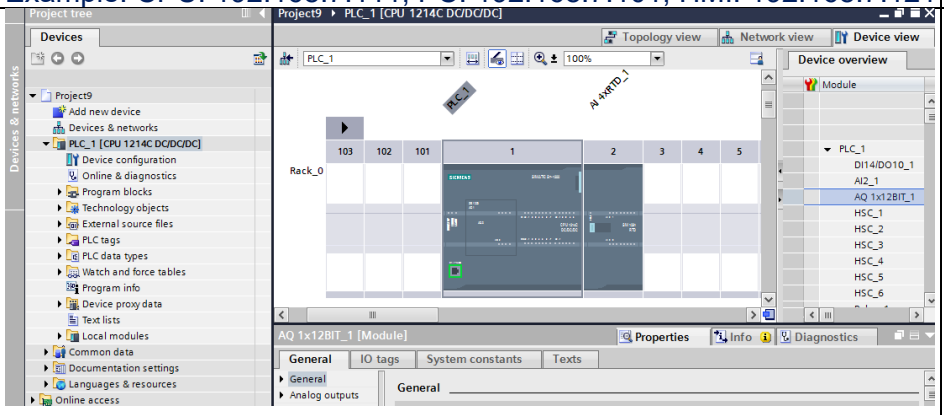
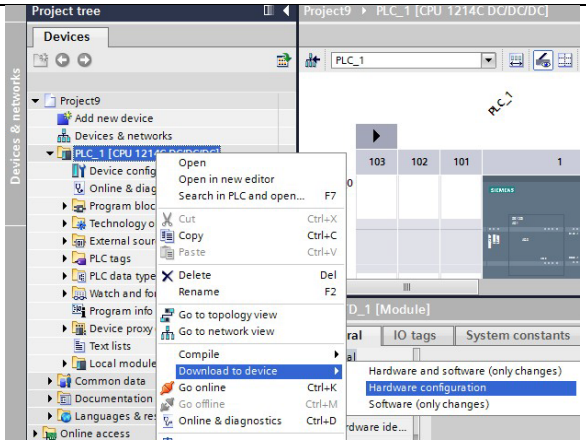
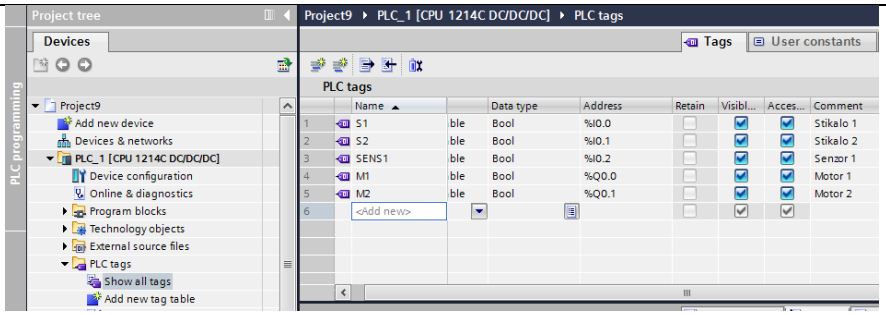
A) Transcribe PLC code: _____

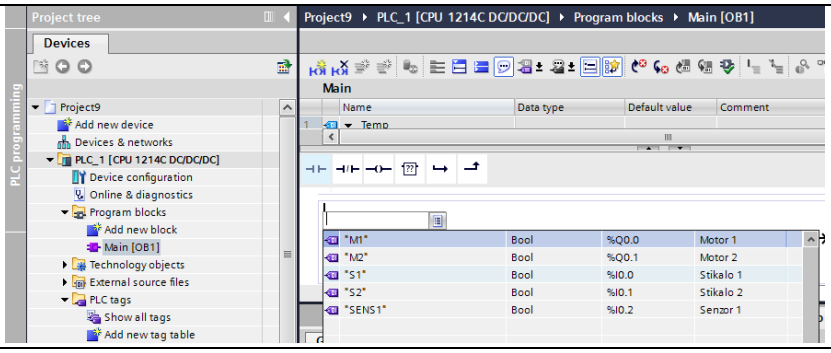
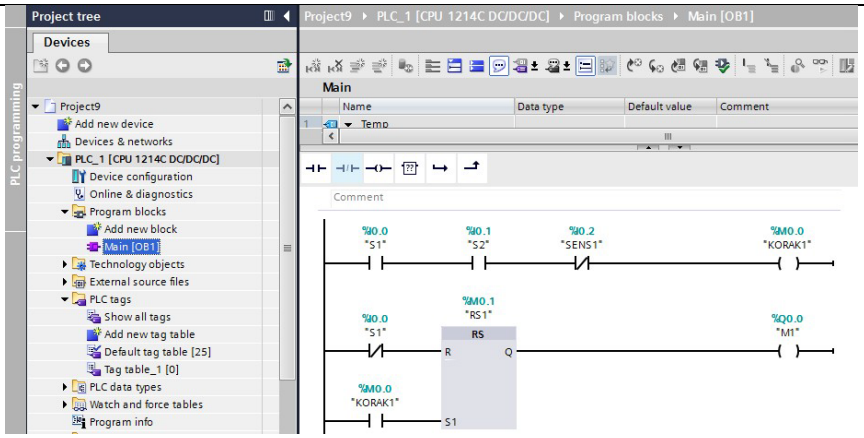
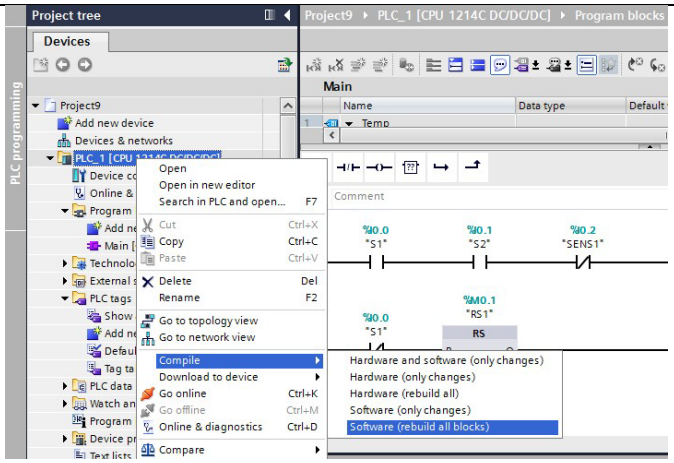
B) Before starting to use the PLC SIEMENS SIMATIC S7-1200, we need to get acquainted with the structure: on the basis of the PLC marking, find out the characteristics (in the file S7_1200_getting_started_en-US_en-US.pdf or S7-1200.pdf or s71200-Manual.pdf – you can in the online classroom INK) or on the official website of http://www.siemens.com/automation/support-request_support :

Power	
Number and type of inputs	DIGITAL: ANALOG:
Number and type of outputs	DIGITAL: ANALOG:
What does DC/DC/DC mean	
What voltage can be connected to the outputs?	
What current can be connected to the outputs?	
What power can be connected to the outputs?	

C) Once you have completed point B, follow the sequence of steps in programming the PLC SIEMENS SIMATIC S7-1200. In the TIA Portal, write down a simple program (AND, ALI, NEIN, and NEALI) using a scale diagram by following these steps:

1.	Connect PLC to power supply, connect UTP (PLC –LT)	Turn on the power
2.	Starting TIA Portal V15 (TIA – Totally Integrated Automation)	Double-click the shortcut on Desktop: TIA V13 (V15)
3.	Open a new project – Create new project On the C drive, first create a folder for your projects in the C:\SIEMENS folder: C:\SIEMENS\Priimek1_Priimek2 Name the projects: VAJA2_Priimek1_Priimek2	Specify name Path (folder), author and description
4.	At the bottom left, follow the Project view path	

5.	Hardware configuration: • Add new device • CPU selection (PLC record – bottom right under the hood) ○ VERSION (required to select): ▪ Table 1, 3, 4, 5, 6 -> Version: V 2.2	Example: CPU1214C DC/DC/DC 6ES7 214-1AG31-0XB0 Double-click on the selected CPU (overwrite the tag from PLC)
	▪ Table 2 -> Version: V 2.0 ▪ Table 7, 8 -> Version: V 4.2 You can also select the unknown and recognize the CPU itself	
6.	Set fixed IP (double-click on PLC and on network connection / Ethernet addresses) Example: CPU: 192.168.7.111, PC: 192.168.7.101, HMI: 192.168.7.121	This point is mandatory when let's add PLC!
7.		After detecting it, he found these devices. It is necessary to download the hardware configuration. First compile and then load!
8.		To download the configuration: Compile first and then LOAD! **LOAD:** (if there are any errors, we disable the components we don't need) **Start All** **Finish**
9.		Defining input and output variables: **PLC tags**

10.		Programming with software blocks: **Program blocks / Main [OB1]**
11.		Build a program in **Main (OB1)** (scale diagram – according to the requirements of the task – do not redraw this example)
12.		Binding inputs / outputs to the digital simulator
13.		Translate the program
14.	To download the program: Right-click on the PLC_.../Download to device,.... Load	
15.		Testing

Redraw programs (scale diagram) for each created function:

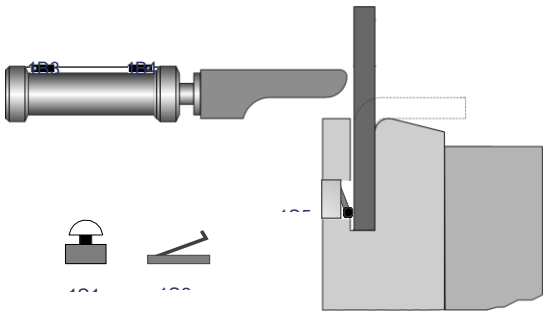
AND	OR
NOAND	NOOR
EXCLUSIVE OR – ANTIVALENCE (XOR)	EXCLUSIVE NOR – EQUIVALENCE (XNOR)

EXERCISE 3: ELECTROPNEUMATIC CONTROL OF A DEVICE FOR BENDING METAL STRIPS

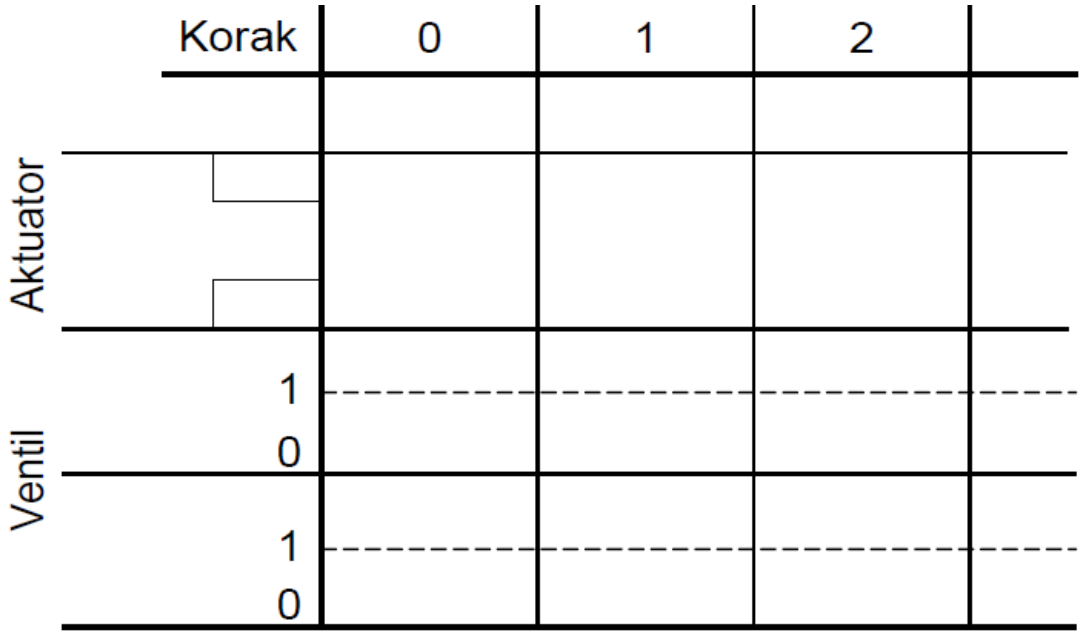
Design **the electropneumatic** control of the device for bending metal strips with the help of a two-way cylinder 1A**,** which is controlled by a solenoid bistable valve.

To perform **the working movement** (extension), cylinder 1A must be retracted (1B3), a metal strip must be inserted (1S5) and the worker must press the start button (1S1). **The return movement** is performed automatically when the cylinder reaches its final position (1B4), and at any time the return of the cylinder can also be initiated using the foot pedal (1S2).

The solenoid travel valve is controlled **indirectly** via a relay, the magnetic (Reed) sensors 1B3 and 1B4 are in **a two-wire** version, the speed of the feed movement should be **adjustable**, and the feedback movement should be carried out **as quickly as possible**.

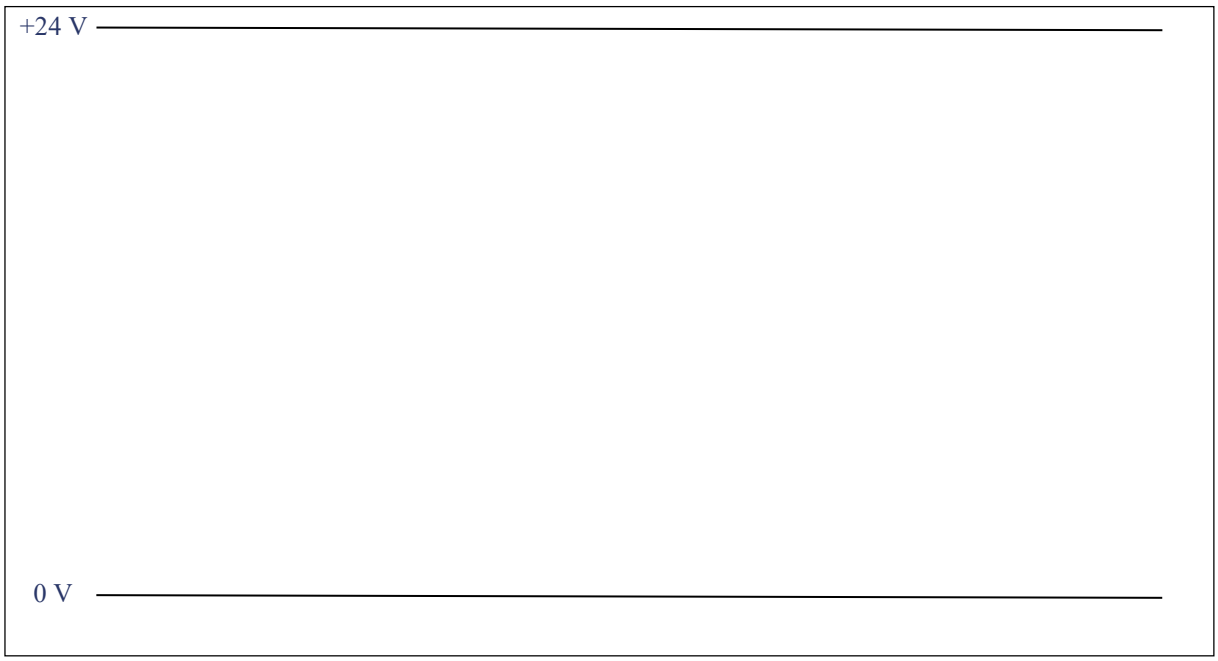


Route diagram – step (it is necessary to mark all actuators, valves and indicate trigger signals with arrows!)

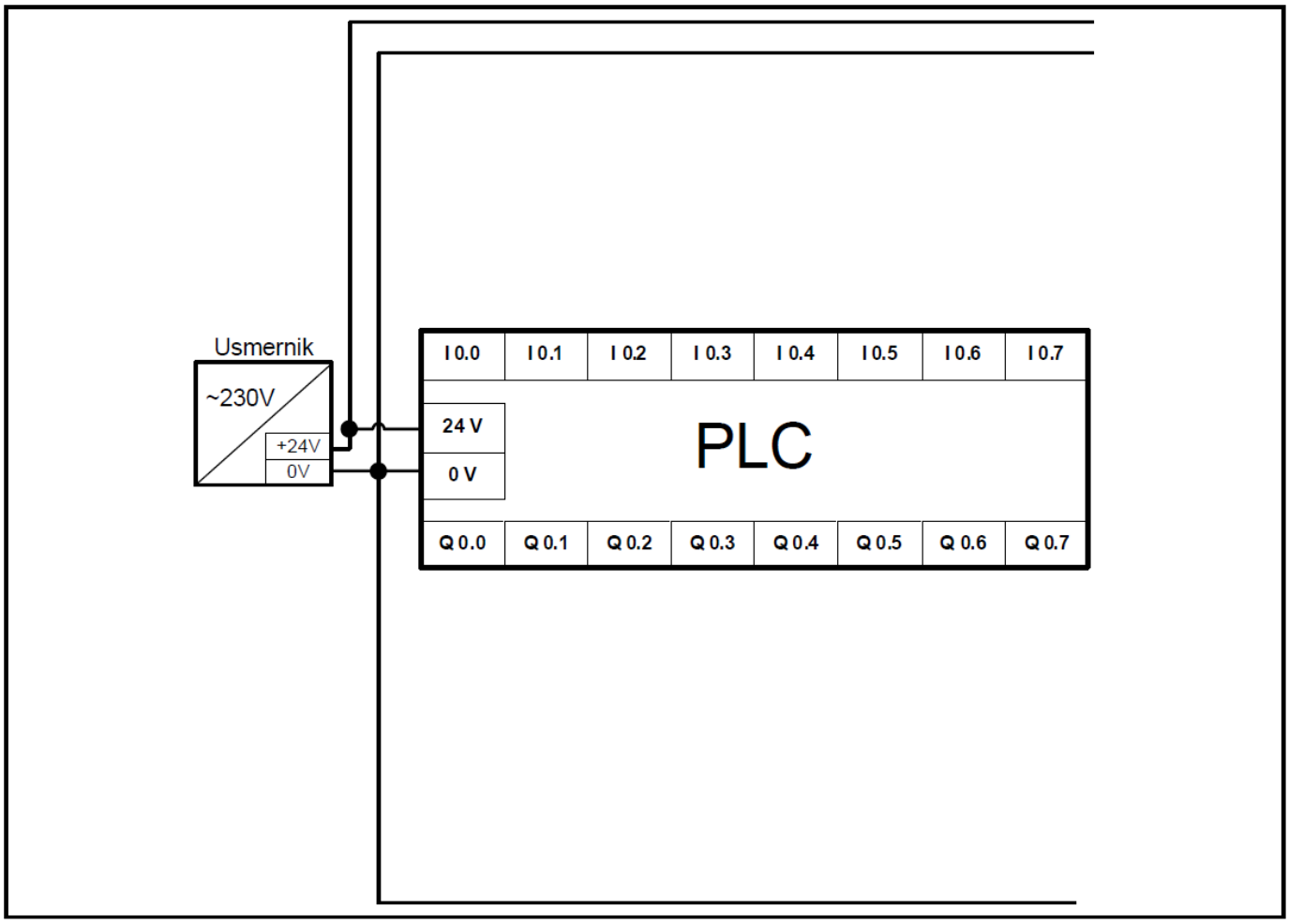


Electrical plan of the control part

- label all components and their connectors – control scheme



Electrical plan of connection to PLC



The program is written in the form of a scale diagram:

EXERCISE 4: USING AN ANALOG SIMULATOR

Design **the electric** controls to demonstrate the use of the analog simulator and the comparison functions of the TIA Portal.

Connect the output of the analog simulator to the analog input A 0.0. On an analog simulator, use an output range between 0 V and + 10 V.

We do not connect the output connectors to the executive links. Control LEDs on individual outputs are used to indicate (display) the output state (control of the correctness of program operation).

Create a progam that will work according to the following requirements:

1.

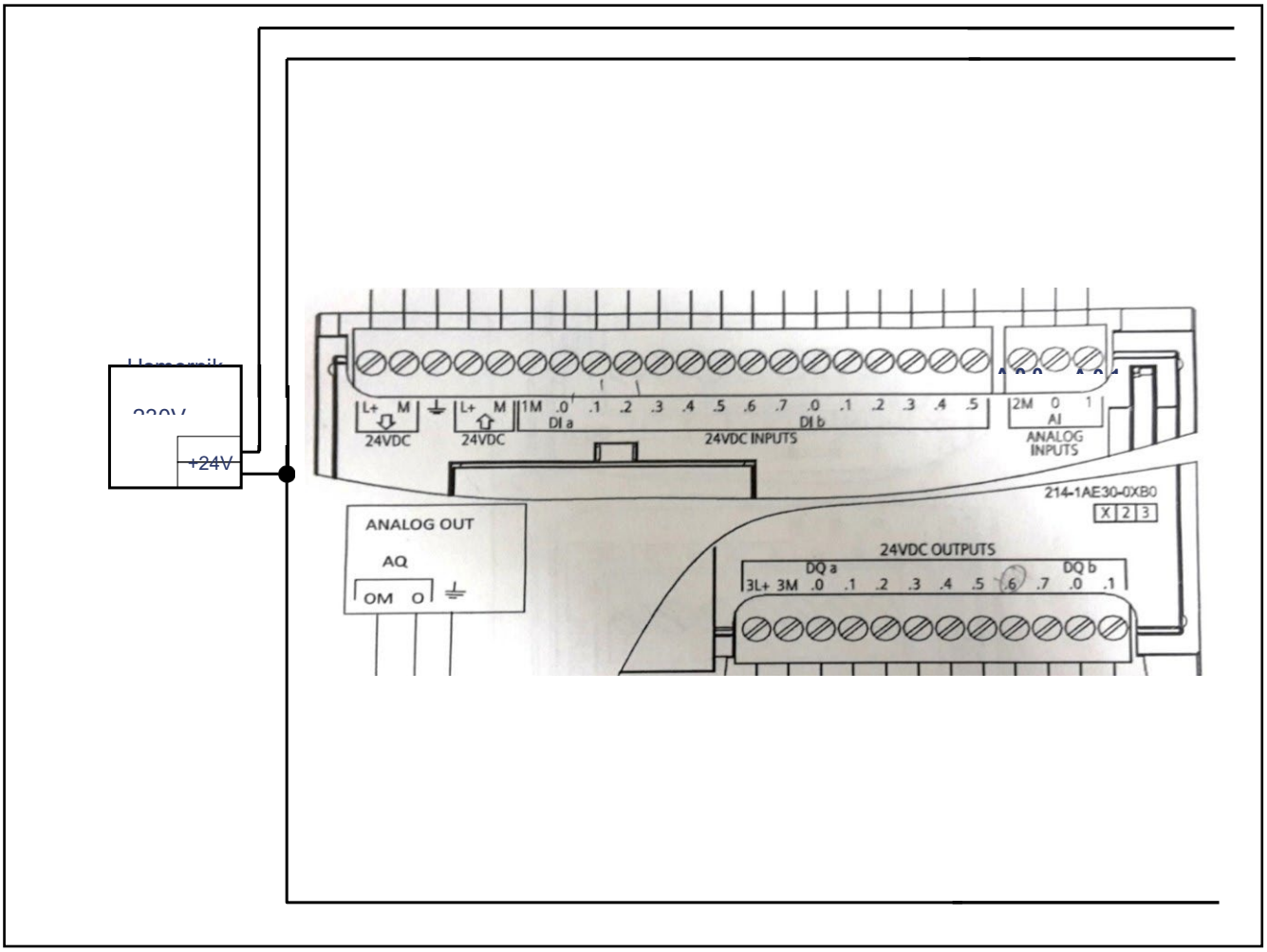
No.	Condition	Description (function) of operation
1	Uvh < 1 V	Output Q 0.0 is at logical 1, others at 0
2	Uvh > 1 V	Output Q 0.0 and Q 0.1 are on logical 1, the rest are on 0
3	Uvh > 2 V	Output Q 0.0 to Q 0.2 are on logic 1, the rest on 0
4	Uvh > 3 V	The output of Q 0.0 to Q 0.3 are on logical 1, the rest on 0
5	Uvh > 4 V	Output Q 0.0 to Q 0.4 are on logical 1, others on 0
6	Uvh > 5 V	Output Q 0.0 to Q 0.5 are at logical 1, the rest at 0
7	Uvh > 6 V	Output Q 0.0 to Q 0.6 are on logical 1, the rest on 0
8	Uvh > 7 V	Output Q 0.0 to Q 0.7 are at logical 1, the rest at 0

2.

No.	Condition	Description (function) of operation
1	0 V < Uvh < 1 V	Output Q 0.0 is at logical 1, others at 0
2	1 V < Uvh < 2 V	Output Q 0.1 is at logical 1, others at 0
3	2 V < Uvh < 3 V	Output Q 0.2 is at logical 1, others at 0
4	3 V < Uvh < 4 V	Output Q 0.3 is at logical 1, others at 0
5	4 V < Uvh < 5 V	Output Q 0.4 is at logical 1, the others at 0
6	5 V < Uvh < 6 V	Output Q 0.5 is at logical 1, others at 0
7	6 V < Uvh < 7 V	Output Q 0.6 is on logical 1, others on 0
8	7 V < Uvh < 8 V	Output Q 0.7 is on logical 1, others on 0

ELECTRICAL PLAN

If the connectors are used on the PLC, be sure to write the connection number on the connection board (with sockets for BANANA connection cords).



The program is written in the form of a scale diagram:

1.

2.

EXERCISE 5: ELECTRIC TRAFFIC LIGHT CONTROL

Make a control that will simulate the operation of a traffic light
The control option should be:

a) manually:

when pressing the NEXT button, switch to the next traffic light combination.

b) automatic

The traffic light switches automatically. The time of the green light should be 10 s. Other combinations are adjusted to the time when the green light is switched on. Use the emergency shutdown key. At the moment of activating the key, the yellow color should flash.

With the ST1 switch, we switch between AUTOMATIC and MANUAL operation. Table of designations and functions of steering components:

No.	*Tag*	*Connector*	*Description (function) of the component*
1	ZI	I 0.0	EMERGENCY OFF button
2	ST1	I 0.1	MANUAL/AUTOMATIC switch (0 = MANUAL, 1 = AUTOMATIC)
3	NAPREJ	I 0.2	Button that switches the position of the traffic light (switch to the next combination of outputs in MANUAL mode)
4	RD	Q 0.0	Red traffic light (LED)
5	RU	Q 0.1	Yellow traffic light (LED)
6	ZE	Q 0.2	Green traffic light (LED)

You can connect the individual lights of the traffic light simulator directly to the DC outputs of the controller.

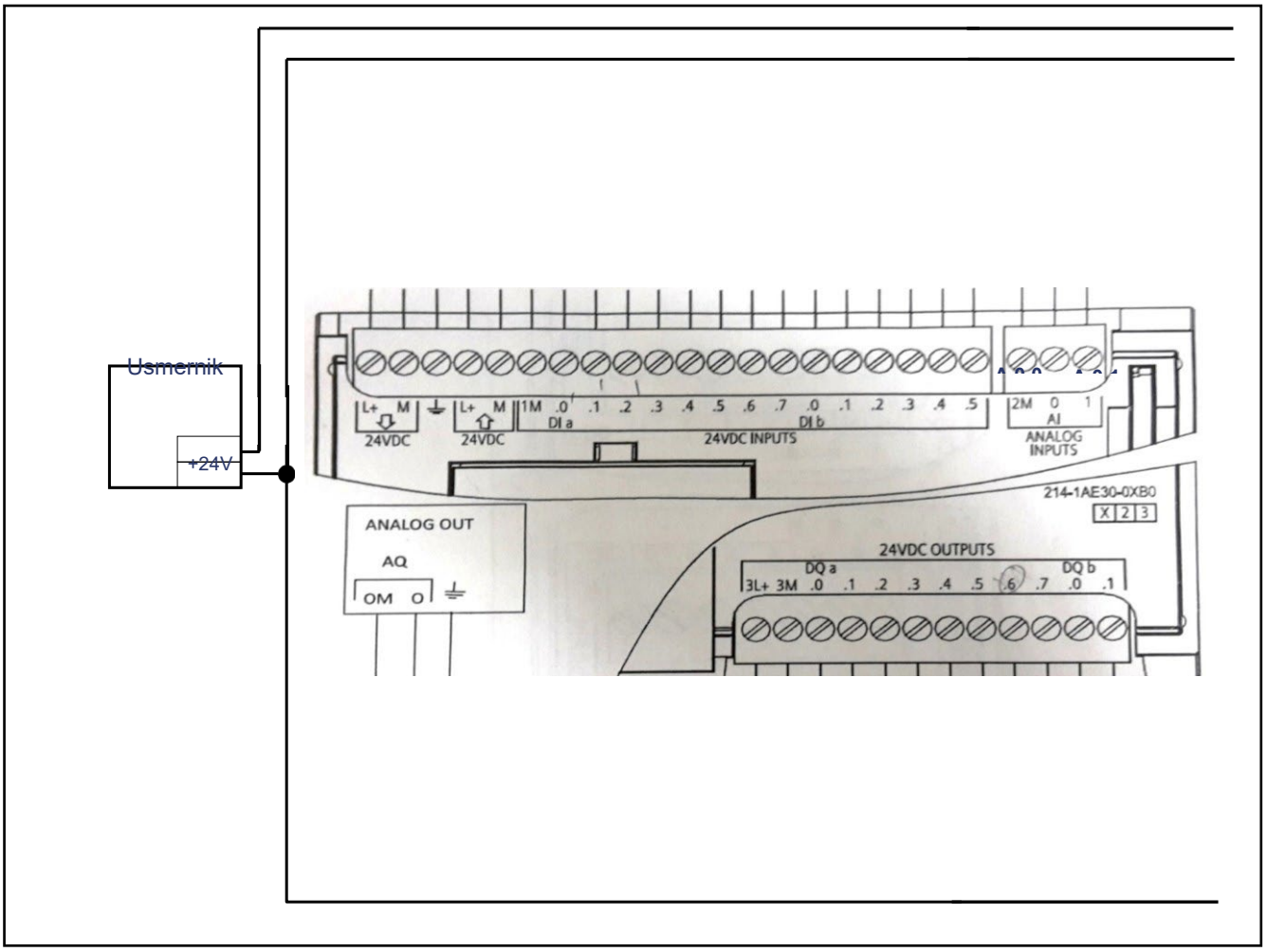
The sequence of traffic lights turned on:

No. step	*Turn on colors*
1	Red
2	Yellow and red
3	Celery
4	Green flashes (this step is mandatory for an excellent grade, the rest can be omitted)
5	Yellow

After step 5, we return to the first step

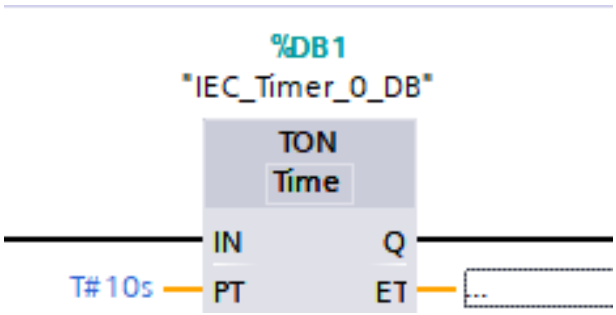
ELECTRICAL PLAN

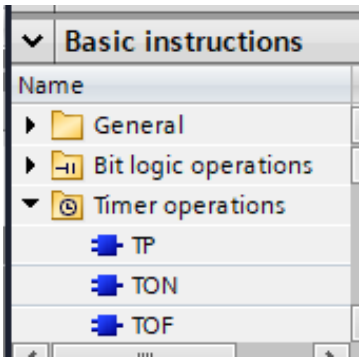
In the case of used connectors on the PLC, be sure to write the connection number on the connection board (board with sockets for BANANA connection cords).



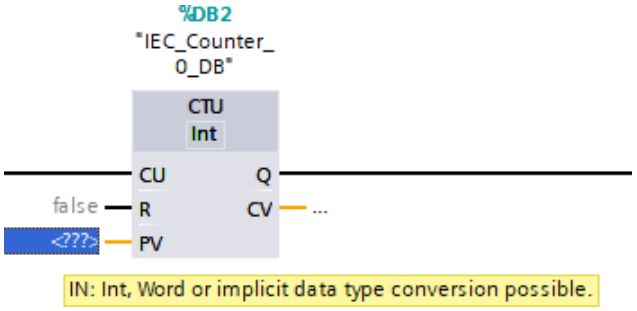
When designing the program, help yourself with the following elements:

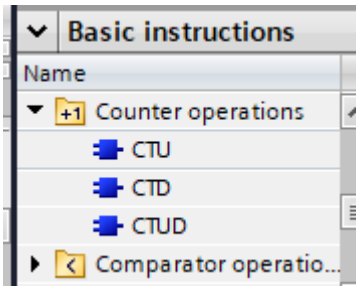
1. **Switch-on delay:**





2. Numerator



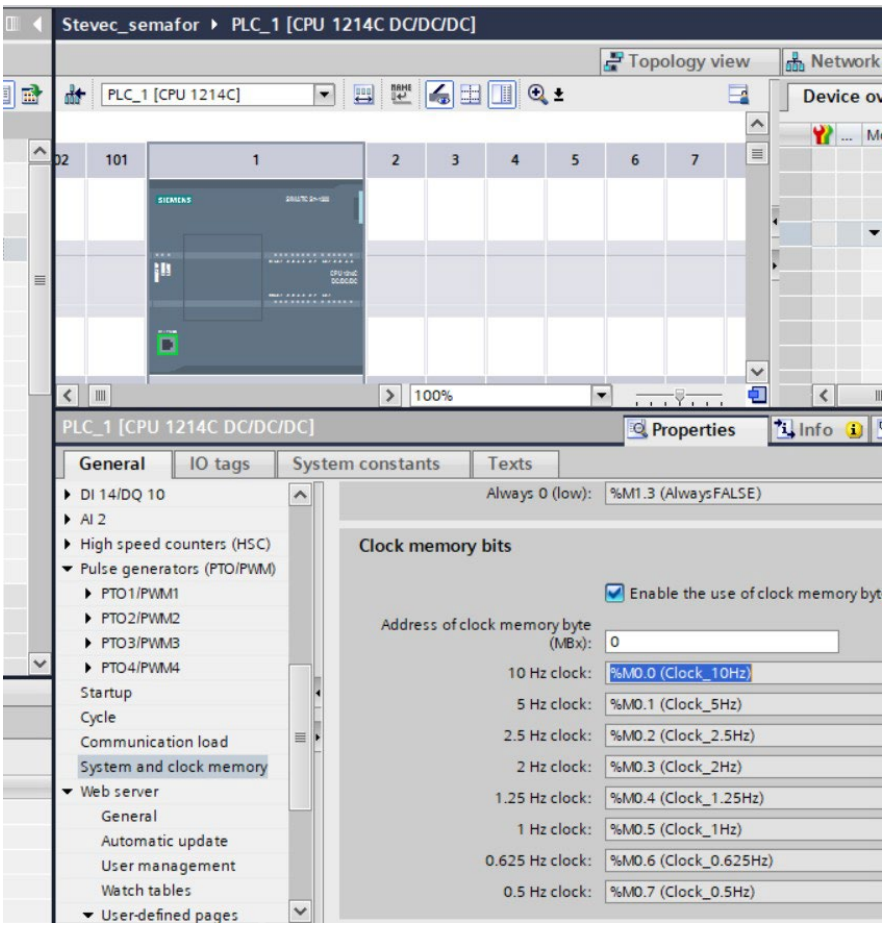


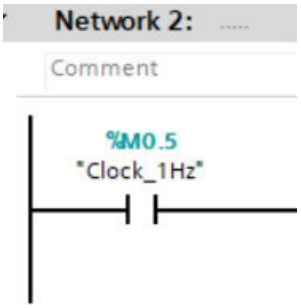
CU – adding values when we go from 0 to 1 (first front)
PV – setting value (number) – when the state of this value is reached, the value 1 appears at the output Q
CV – a counter value that can be used anywhere in the program
R – reset the counter, when we go from state 0 to 1 (when we get to a certain CV value we can reset by comparing the output value of the counter), the counter is set to 0.

https://tiaportal.weebly.com/siemens_plc_programming/how-counter-up-ctu-in-siemens-tia-portal-plc-programming-works
https://tiaportal.weebly.com/siemens_plc_programming/counter-function-in-tia-portal

3. System and clock memory / Clock memory bits

In the device configuration (PLC), enable system timers (MBx move to another address in the memory table!! – towards 100):





The program is written in the form of a scale diagram:

EXERCISE 6: CONVEYOR BELT, INDUCTIVE SENSORS

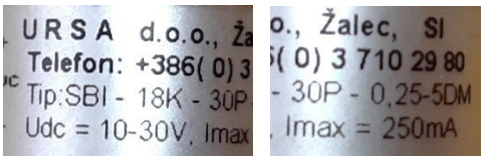
In the factory, we need to automate the control of the conveyor belt.

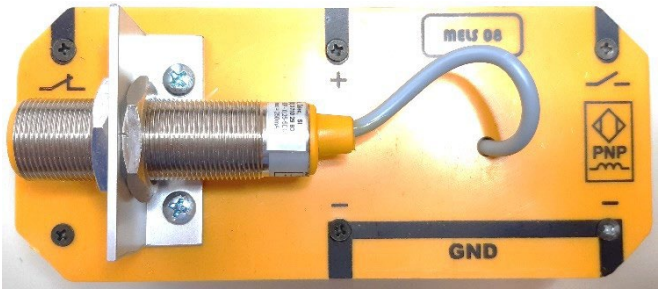
1. The metal workpiece must move from one end of the conveyor belt to the other end and back.
2. At each end (at the sensor), the workpiece is processed for 5 seconds and then returned to the other end (to the other sensor).
3. For the left and right extreme positions, we use an INDUCTIVE PNP sensor (mounted on the demonstration board).
4. The electric motor for moving the conveyor belt is controlled by two digital outputs.
5. To show the direction of movement of the conveyor belt, a traffic light simulator is used. Connect the GREEN bulb to the LEFT output, and connect the YELLOW bulb to the RIGHT output. Use the RED light bulb to show the error when the emergency shutdown button is pressed (no other light bulb should be lit at that time).
6. The process is initiated by two-hand switching on (two switches, where in the first phase we do not take into account the time component – a maximum of 500 ms during the switching on of each switch) and with one of the inductive sensors active.
7. The ribbon moves as long as both switches are activated.
8. When both switches are not active, both outputs must be deactivated (turned off).
9. If the workpiece is removed from the conveyor belt (ERROR) or none of the inductive sensors is active for more than 20 seconds (falls off the belt or has been manually removed), the tape stops and the red control signal (RED light bulb) starts to light up.
10. In the event of an ERROR referred to in point 9, the red control signal starts flashing with a time of 500 ms on and 500 ms off (RED bulb).

Table of designations and functions of steering components (fill in table):

No.	Label	IN/OUT	Description (function) of the component
1	OFF	I0.	
2	ST1	I0.	
3	ST2	I0.	
4	IND_L	I0.	
5	IND_D	I0.	
6	IZHOD_L	Q0.	
7	IZHOD_D	Q0.	
8	ERROR	Q0.	

Inductive Sensor Data:



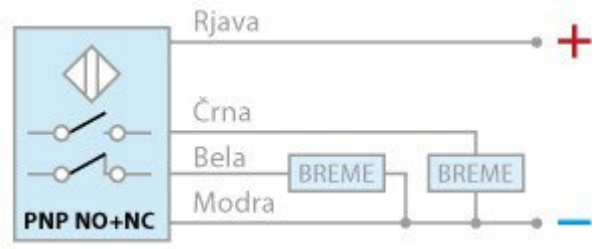


Sensor Information:

1. Inductive switch SBI-18K-30P-0,25-5DM
2. dimensions M18x1, length 60 mm
3. PNP output (in the presence of metal to output +), NO working output, NC peace output, NO signaling with LED
4. power supply from 10 to 30 VDC
5. maximum load flow 250 mA
6. IP67 degree of protection
7. switching distance 5mm +-10%, in the entire temperature spectrum +-20%
8. temperature range of action from -25 to 70 degrees. Celsius
9. LIYY Connection Cable 4 x 0.25 mm^2

Connect:

10. + brown,
11. - blue
12. output NO black,
13. output NC white

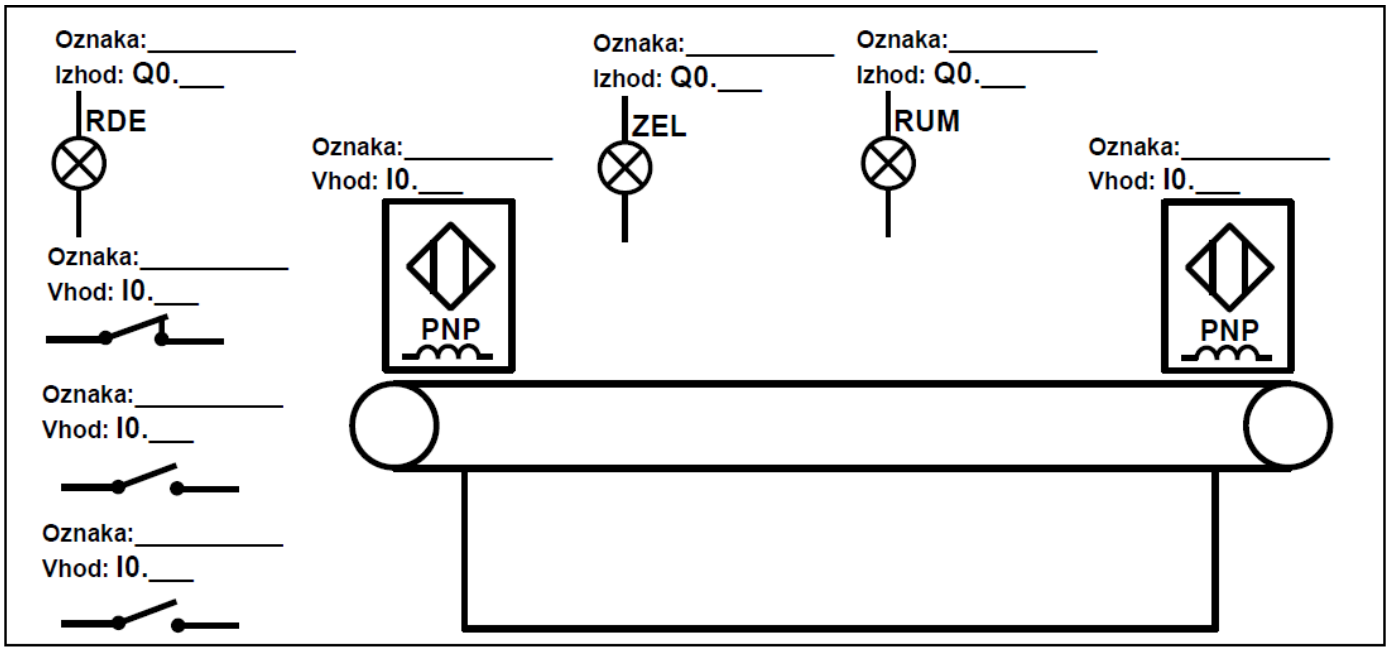


Manufacturer:

URSA, company for electronics, d.o.o.
Web: ursa-doo.si, ecopulse.eu

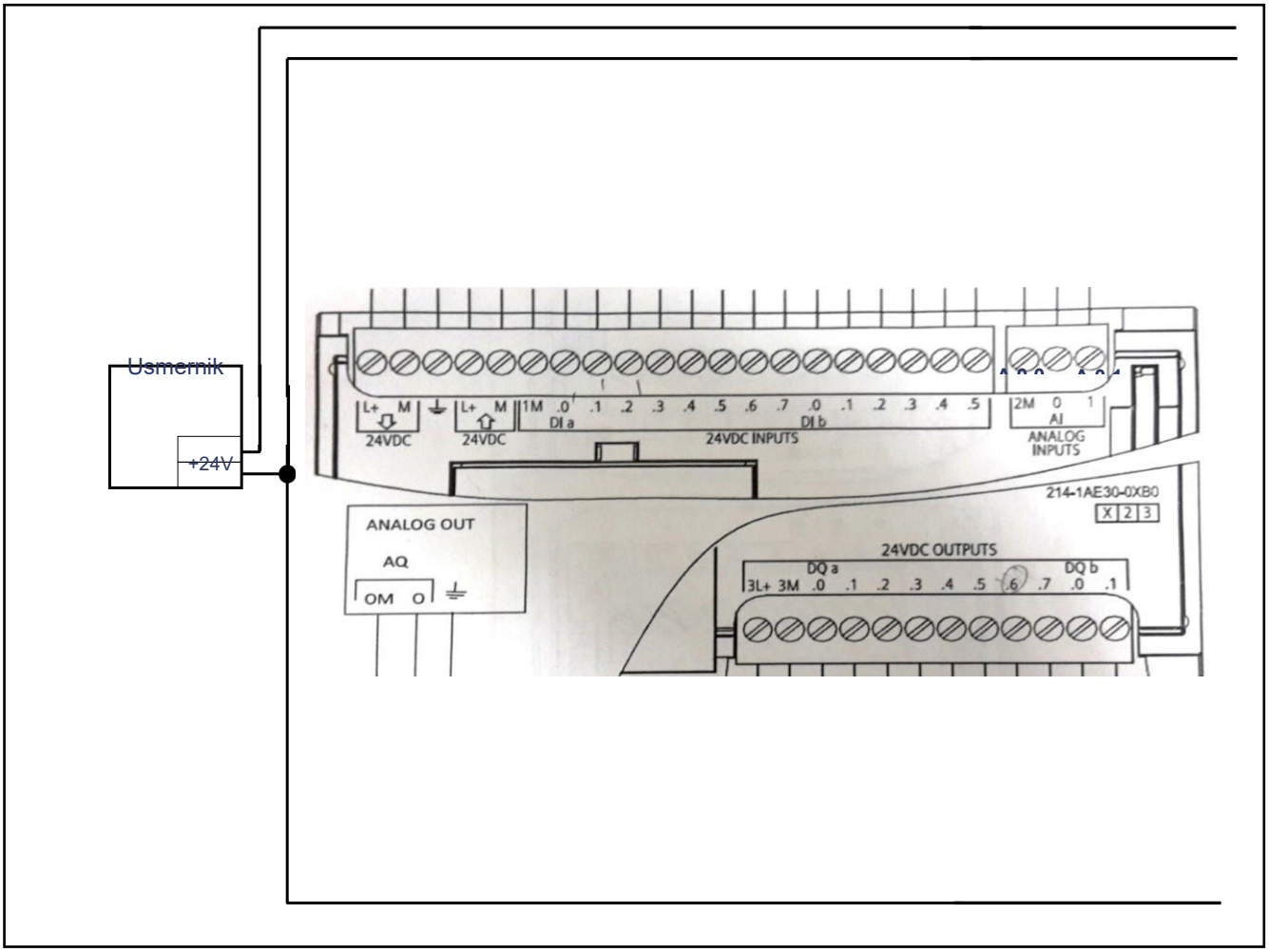
SKETCH OF THE DEVICE:

From the text of the task, complete the sketch of the device:



ELECTRICAL PLAN

In the case of used connectors on the PLC, be sure to write the connection number on the connection board (board with sockets for BANANA connection cords).

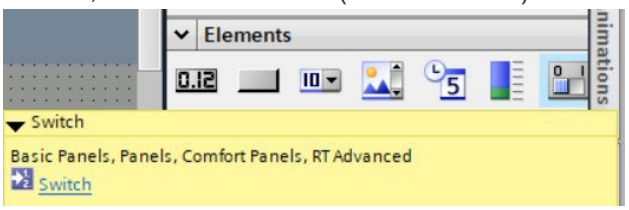


The program is written in the form of a scale diagram:

EXERCISE 7: TOUCH SCREEN (TP), AND, OR, NOAND, NOOR PORTS

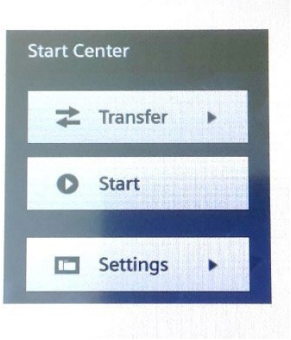
Use the touch screen to realize the logical port.

1. Connect the PLC, TP, network switch and laptop to the local network using UTP connections and complete the "PROFINET Network Plan".
2. Draw a plan of electrical connections and connect the equipment to the power supply.
3. Open a new project in the TIA portal.
4. Add PLC SIEMENS S7-1200.
5. Add the TP (KTP600 basic – table 1 to 6 or KTP700 basic – table 7 and 8) and connect it to the SIEMENS S7-1200 PLC via the PROFINET connection (Select PLC and select the added SIEMENS S7-1200 PLC).
6. On the main TP screen, change the existing text "Welcome to HMI_1 (KTP700 Basic+ PN)!" with your last name and first name and date.
7. Translate software and hardware for PLC and TP and download and test the operation of the connections.
8. Build a program for the AND ports (scale diagram).
9. Translate the software solution and download it to PLC.
10. On TP, add two switches (IN 1 and IN 2) to the basic input screen:

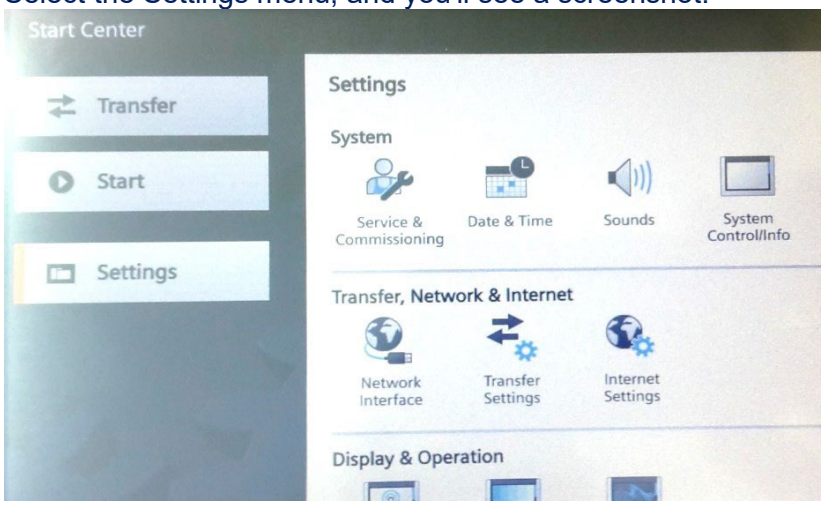


11. Next to the buttons, write down AND 1 and which AND 2.
12. Connect the buttons to the merkers from the table of variables from PLC (right click on Switch, Properties, General and select Tag:....).
13. Compile the TP software solution and transfer it to the hardware.
14. Test the operation (check if the Q output correctly shows you the AND status of the function).
15. Repeat the process for the other required functions (OR, NEIN, NEALI).
16. Add the output signaling to the touchscreen (the light is red for logic 0 and green for logic 1).
17. Connect the simulator (switches) and enable the display of the operation of the logic port with lights on the touch screen (also for the inputs).
18. Include port input selection: ON-SCREEN SWITCHES/KEYS so that you can choose to trigger logic ports by selecting (or operating via SWITCHES or via touchscreen keys) and displaying the operation of inputs and outputs.

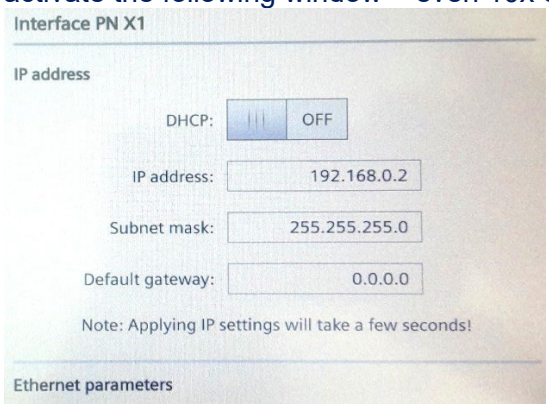
First of all, it is necessary to set the IP number on the KTP700 Basic. After turning on the power, a menu will appear on the screen:



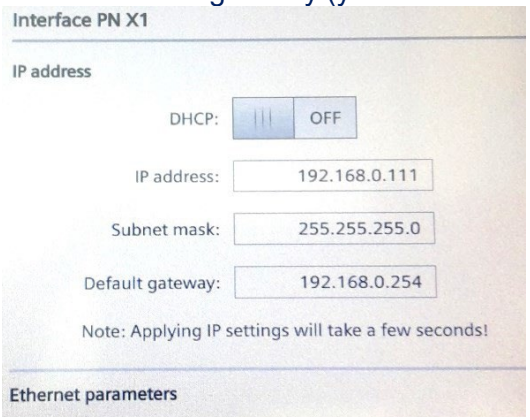
Select the Settings menu, and you'll see a screenshot:



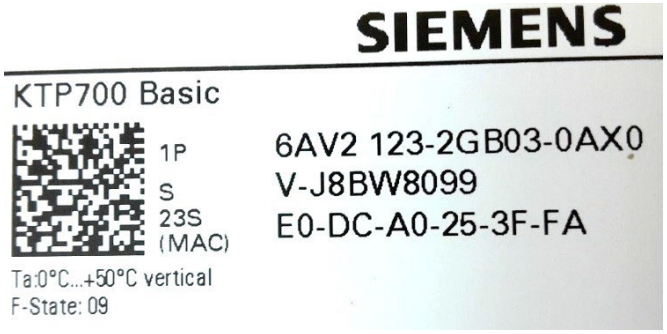
Select Network Interface (you need to press the Network Interface field several times to activate the following window – even 10x or more...) and a window will open:



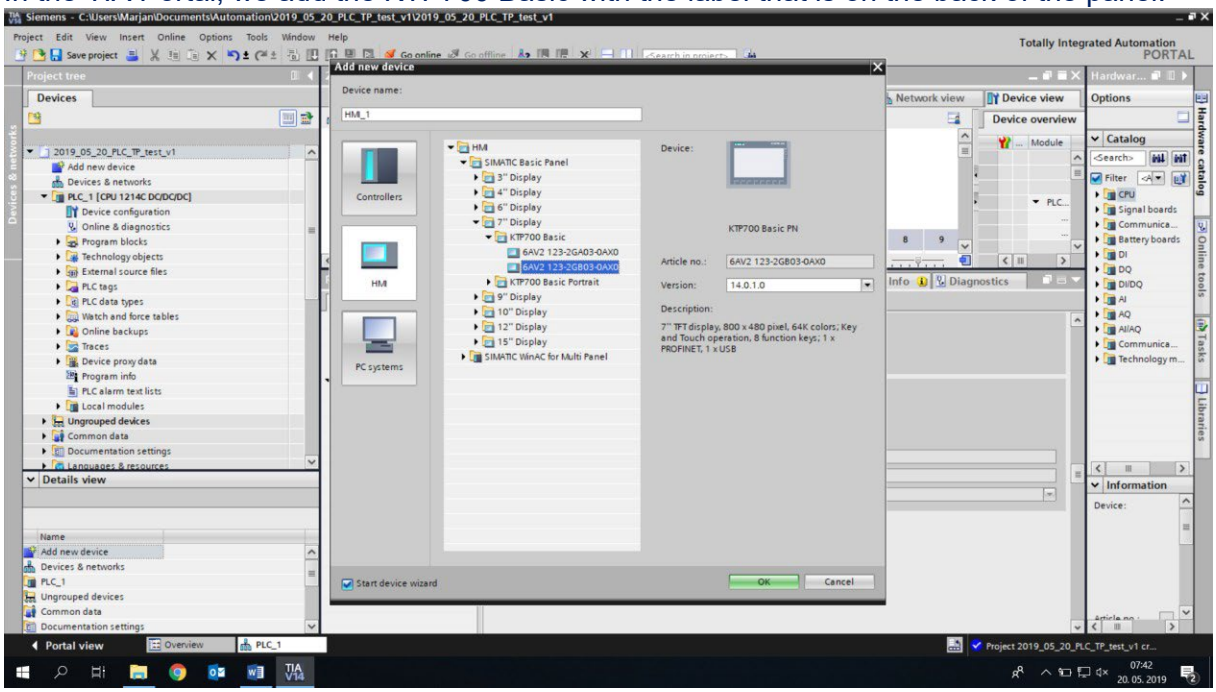
You enter the IP address (each panel has its own number, see the first page of this document) and the Default gateway (you all have the same number):



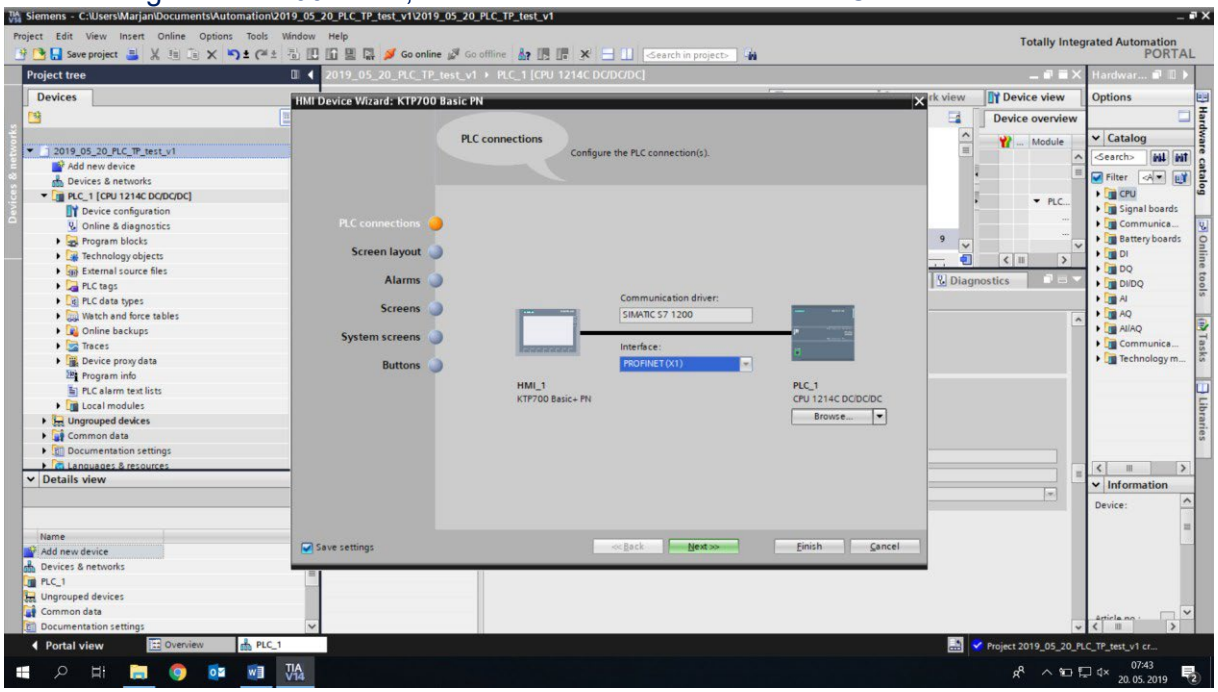
When adding TP, we first need to look at the exact designation of the type KTP700 Basic that we use:



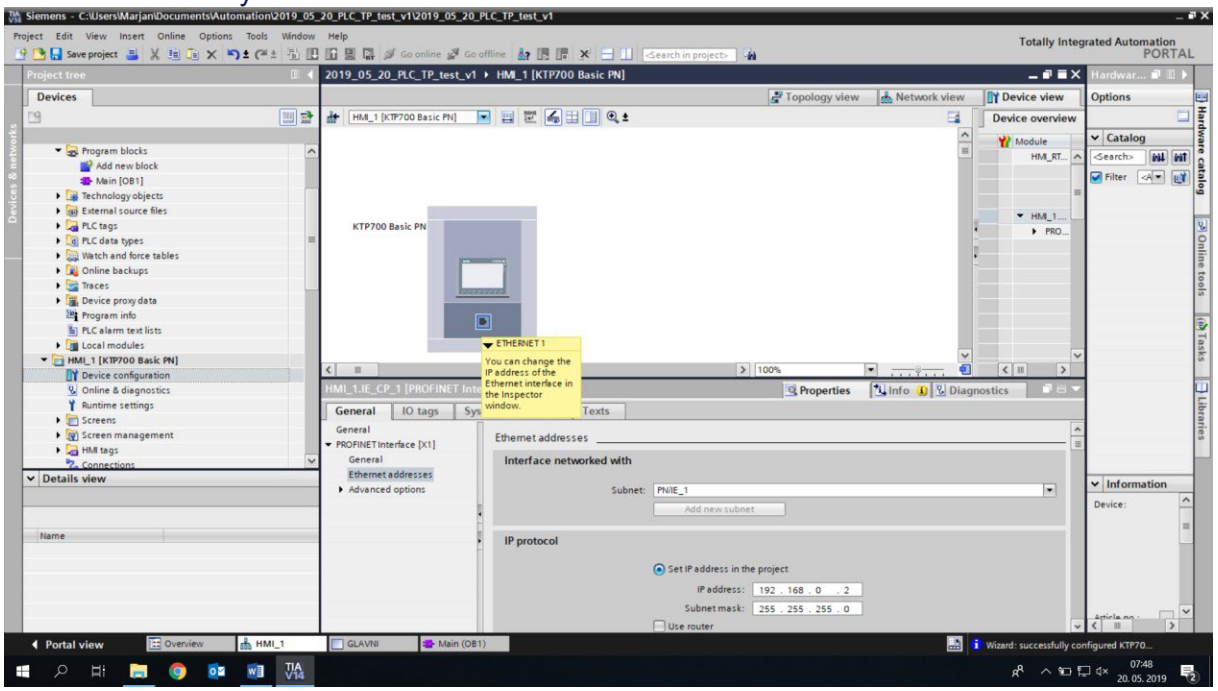
In the TIA Portal, we add the KTP700 Basic with the label that is on the back of the panel.



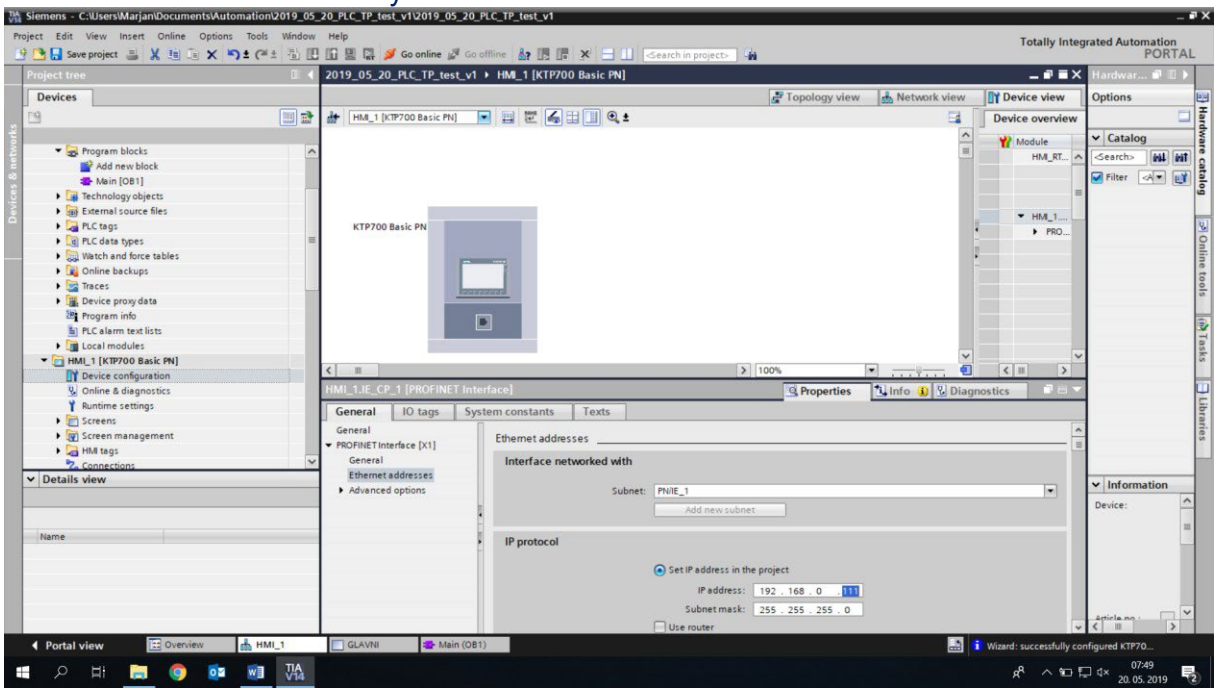
After adding the KTP700 Basic, we still need to determine the PLC and communication:



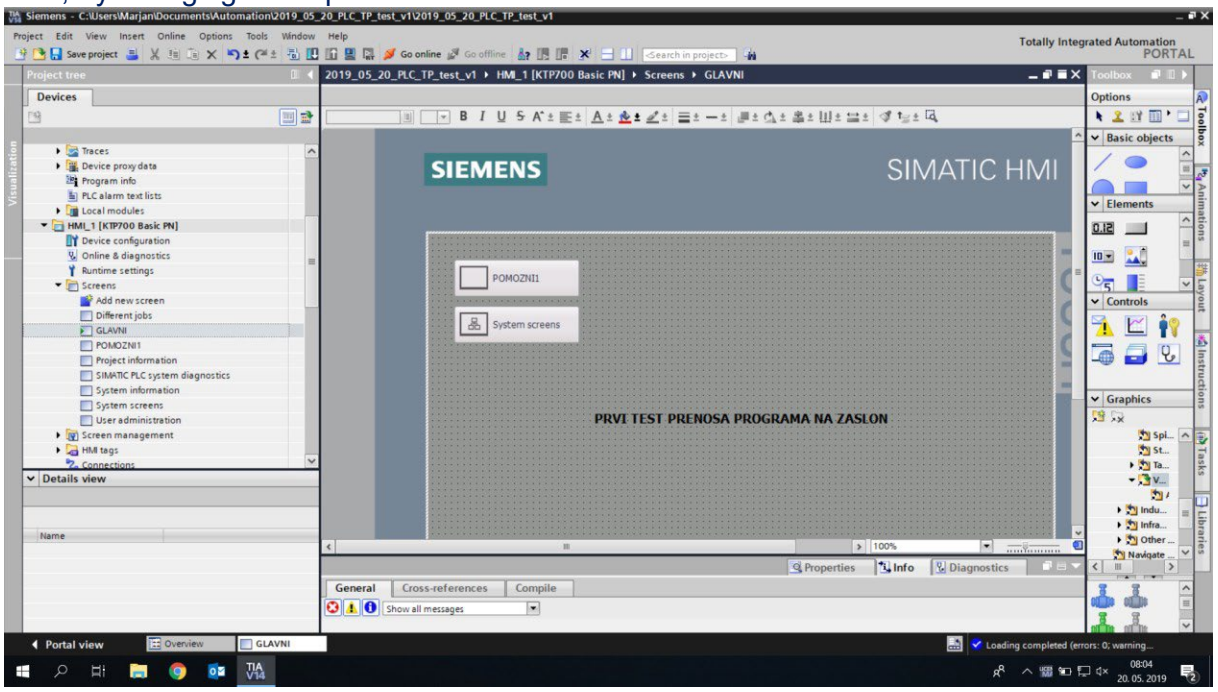
It is also necessary to set the IP number:



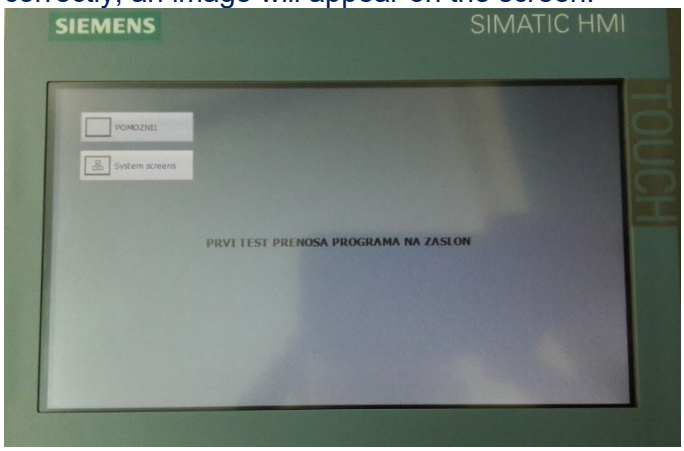
You enter the IP number that you set to TP.



First, try changing the caption on the home screen:



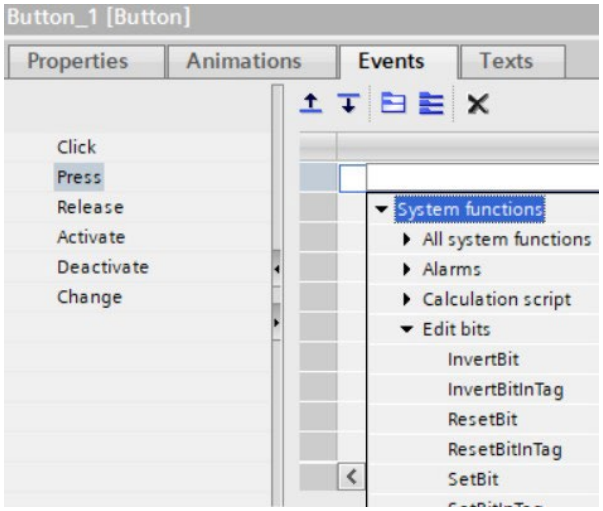
Translate and download both and check the operation. If you performed the procedure correctly, an image will appear on the screen:



This is followed by the addition of buttons and signal elements that will show us the functionality of our MPS station. First of all, it is necessary to write a simple program (use the START button on the MPS station to move the executive link (electric motor, cylinder,...).

This is followed by adding on the screen (double-clicking on the screen) and connecting the keys on the screen with the controls in the program.

1. ADD NEW SCREEN
   - Root Screen in Screen 1
   - We add a button
     - Right-click, Properties.
     - Events -> Click, Activate Screen (select Screen 1)
2. Add a button and connect to the inputs
     - Change color depending on state
3. You add a display element (light) and connect it to the outputs
   - Change color depending on state
4. If you want to set (activate) or delete bits when pressing a key, you need to choose the following when you right-click on the placed button:
   - Events / Press or Releasse or ... / System function / Edit bits / SetBit or ResetBit ...
   - It is mandatory to change **the MERKER memory cells (M0.0, M0.1 ...)** that are defined in the Default Tag Table



To change network settings:

First of all, it is necessary to connect everything according to the electrical plan. It is necessary to set the correct IP address on the computer:

1. Click on networks (bottom right of the screen),
2. In the pop-up list, select the Network & Internet Settings link,
3. On the left, select Ethernet
4. On the right, select the Change network adapter option link
5. Choose the right Ethernet card (Realtek PCIe GBE Family Controller)
6. Right click / Properties
7. Select Internet Protocol IPv4 (TCP/IPv4) / Properties
8. You set the right IP and confirm
9. When you return to Network Connections, right-click on the right network connection and Disable
10. Right-click on the right network connection and Enable
11. In CMD, it checks the PING to the desired device
12. In CMD, you can use the arp command to check what you have connected

To work in the 192.168.7.xxx subnet, we must first move the IP number to PLC from the current 192.168.0.xxx network in order to move it to the 192.168.7.xxx subnet, and only then move the IP number on the computer on the network card.

Photo of the wallpaper of the touch screen from table 2 (we have 6 such screens):

KTP600 Basic color PN

6AV6 647-0AD11-3AX0

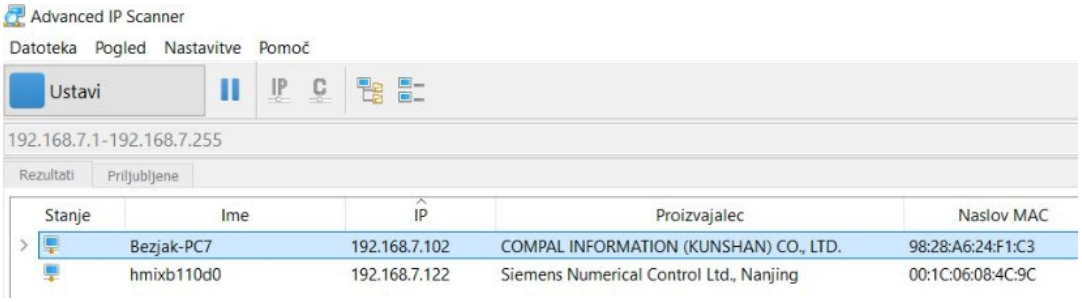
S ZVBOYUBO30743

MAC-ADD.: 00-1C-06-08-4C-9C

When searching for IP numbers on the network, we can help ourselves with:

1. Command interpreter (enter CMD and <ENTER> on the WIN command line) with PING and ARP –A

2. The Advanced IP Scanner program, where we enter the desired search area of IP numbers. Programmatically, you can download for free and just run from the website https://www.advanced-ip-scanner.com/ Example of a search result when we have 2 active devices on the network (computer and touch screen):



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