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DESIGN AND CONFIGURATION OF THE PLUMBING CONTROL SCADA NODE USING PROFICY HMI/SCADA-IFIX*5.5 EN SOFTWARE

Abstract: The paper presents the basic steps carried out when creating the SCADA node for plumbing control on the manufacturing shop floor. The truth table containing combinations of the valves states and an example of Karnaugh map for simplifying defined expressions were described at the beginning. Next, stages of hardware configuration, creation and verification of the program for PLC were depicted.

1. Introduction

Automation in technological processes becomes more common and the need for rapid and efficient information exchange between distributed control systems, analysis of events and conditions, and supervision of the whole process turn to be a key issues. For this purpose, SCADA systems (Supervisory Control and Data Acquisition) are used for machines and equipment control in many industries. Data acquired from PLCs, microprocessor controller devices are stacked in "master" computer system and presented in graphical form showing the state of the entire system (operations parameters, alarms, failures) and allow remote controlling of devices states and their parameters, and decision making in emergency situations. Presented work concerns water supply control system and is a part of the project of manufacturing shop layout reconfiguration that is realized in the Institute of Automation Processes Engineering and Integrated Manufacturing Systems of Silesian University of Technology. The project includes:

- assumptions concerning the operation method of water pumps and valves,
- truth tables containing all possible combinations of the valves states,
- minimization of logic functions using Karnaugh (K-map) method,
- hardware configuration using Simatic Step 7 software,
- control program for PLC controller using Simatic Step 7 software,
- verification of the PLC program in the WinCC software,
- connection of the PLC with iFIX environment via NETLink PRO PoE adapter,
- diagrams and descriptions of the electrical connection using Eplan software.

2. Basic assumptions

The manufacturing shop is equipped with an installation that supplies cold and hot water to the receivers (fig. 1). Water is supplied by four pumps driven by electric motors. Water shut-off valves and temperature controllers are located close to receivers. Pumps efficiency is as follows: P1 – 0,14 m^3/h, P2 – 0,07 m^3/h, P3 – 0,03 m^3/h, P4 – 0,02 m^3/h. The maximum water flow through the valves is as follows: Z4 – 0,06 m^3/h, Z5– 0,05 m^3/h, Z6 – 0,02 m^3/h, Z7 – 0,01 m^3/h. The control system should cover the total demand for water with optimal use of electricity that powers electric motors of pumps.

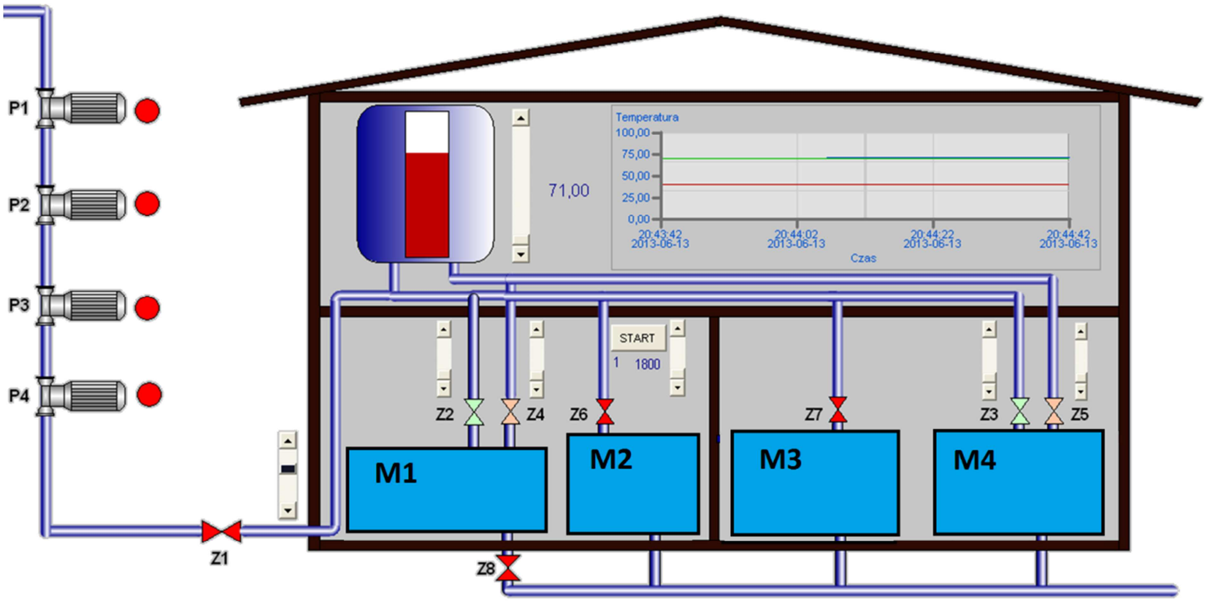

Fig.1. The scheme of the water system in manufacturing shop (iFIX visualization)

3. True table

Truth table (Tab. 1.) shows the zero-one combinations of all possible states of the valves. The combination of open valves Z4, Z5, Z6, Z7 causes start of the one or more pumps. In the column "value flow" values that can be obtained for fully opened valves are presented. The column "pump capacity" enables verifying the condition of the total coverage of the demand for water.

4. Simplifying expressions using Karnaugh method

Minimization of logic functions consists in reducing Boolean expression to it is the simplest possible form and it is very important for cost reduction of electronics and providing less reliable and higher speed of them. Minimization was performed using Boolean algebra.

For each pump, based on truth table, a Karnaugh map has been prepared. In tab. 2 the exemplary Karnaugh map for pump P4 shows fields which differ by the value of one variable. Below the table the canonical function is presented.

Tab. 1. The true table of the valves states

valves				flow value	pumps				pumps capacity
Z4	Z5	Z6	Z7		P1	P2	P3	P4	
0	0	0	0	0 [m³/h]	0	0	0	0	0 [m³/h]
0	0	0	1	0,01 [m³/h]	0	0	0	1	0,02 [m³/h]
0	0	1	1	0,03 [m³/h]	0	0	1	0	0,03 [m³/h]
0	0	1	0	0,02 [m³/h]	0	0	0	1	0,02 [m³/h]
0	1	1	0	0,07 [m³/h]	0	1	0	0	0,07 [m³/h]
0	1	1	1	0,08 [m³/h]	0	1	0	1	0,09 [m³/h]
0	1	0	1	0,06 [m³/h]	0	1	0	0	0,07 [m³/h]
0	1	0	0	0,05 [m³/h]	0	0	1	1	0,05 [m³/h]
1	1	0	0	0,11 [m³/h]	0	1	1	1	0,12 [m³/h]
1	1	0	1	0,12 [m³/h]	0	1	1	1	0,12 [m³/h]
1	1	1	1	0,14 [m³/h]	1	0	0	0	0,14 [m³/h]
1	1	1	0	0,13 [m³/h]	1	0	0	0	0,14 [m³/h]
1	0	1	0	0,07 [m³/h]	0	1	0	0	0,07 [m³/h]
1	0	1	1	0,09 [m³/h]	0	1	0	1	0,09 [m³/h]
1	0	0	1	0,07 [m³/h]	0	1	0	0	0,07 [m³/h]
1	0	0	0	0,06 [m³/h]	0	1	0	0	0,07 [m³/h]

Tab.2. The Karnaugh map for pump P4

		Z4 Z5 (a,b)			
		00	*01*	*11*	*10*
Z6 Z7 (c,d)	*00*		*1*	*1*	
	01	*1*		*1*	
	11		*1*		*1*
	10	*1*			

$$\boldsymbol{F(abcd) = a*b*\bar{c} + b*\bar{c}*\bar{d} + \bar{a}*\bar{b}*\bar{c}*d + \bar{a}*\bar{b}*c*\bar{d} + \bar{a}*b*c*d + a*\bar{b}*c*d}$$
$$\boldsymbol{= b*\bar{c}*\left(a+\bar{d}\right) + c*d*\left(a*\bar{b}+\bar{a}*b\right) + \bar{a}*\bar{b}*(\bar{c}*d + c*\bar{d})}$$

5. The PLC program

After the hardware configuration and creation of logical program with Simatic Step7 Manager Version V5.4 + SP1 environment the program to the PLC has been developed. PLC controller operates the actuators according to the data acquired from the Karnaugh maps. The part of the report from Simatic Manager software, showing the organization block in which is located the main program and exemplary network (pump P4), is shown in fig. 2.

SIMATIC MC\SIMATIC 300(1)\CPU 315-2 DP\...\OB1 - <offline> 09/25/2013 01:46:28 PM

OB1 - <offline>

"Blok główny"

Name: **Family:**
Author: **Version:** 0.1
Block version: 2
Time stamp Code: 09/25/2013 01:33:47 PM
Interface: 02/15/1996 04:51:12 PM
Lengths (block/logic/data): 00952 00806 00028

Name	Data Type	Address	Comment
TEMP		0.0	
OB1_EV_CLASS	Byte	0.0	Bits 0-3 = 1 (Coming event), Bits 4-7 = 1 (Event class 1)
OB1_SCAN_1	Byte	1.0	1 (Cold restart scan 1 of OB 1), 3 (Scan 2-n of OB 1)
OB1_PRIORITY	Byte	2.0	Priority of OB Execution
OB1_OB_NUMBR	Byte	3.0	1 (Organization block 1, OB1)
OB1_RESERVED_1	Byte	4.0	Reserved for system
OB1_RESERVED_2	Byte	5.0	Reserved for system
OB1_PREV_CYCLE	Int	6.0	Cycle time of previous OB1 scan (milliseconds)
OB1_MIN_CYCLE	Int	8.0	Minimum cycle time of OB1 (milliseconds)
OB1_MAX_CYCLE	Int	10.0	Maximum cycle time of OB1 (milliseconds)
OB1_DATE_TIME	Date_And_Time	12.0	Date and time OB1 started

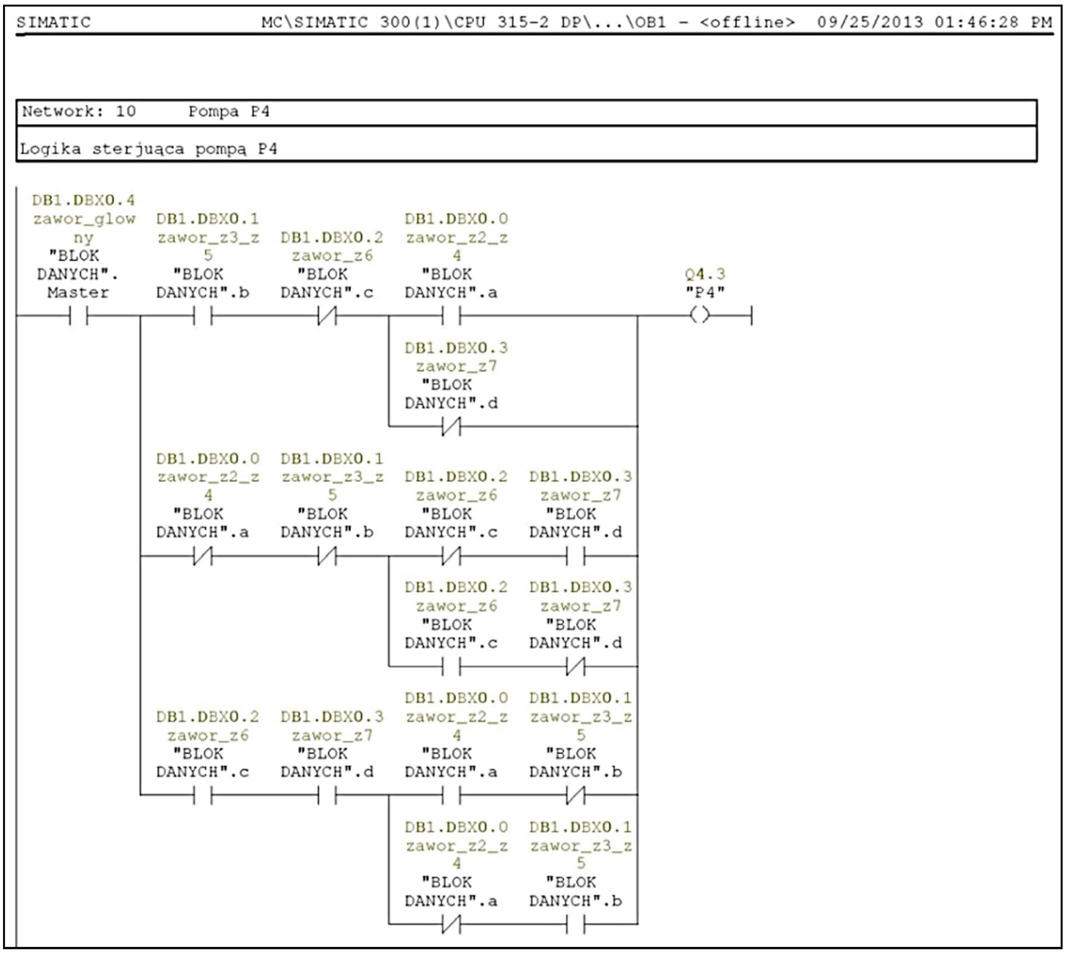

Fig.2. A part of the Simatic Manager report - organization block OB1

The combination of individual normally closed and normally open contacts, results directly from Karnaugh map. In order to verify the control algorithm an application in SIMATIC WinCC Flexible Runtime was developed. This application can also be used for remote control, e.g. by HMI - SIMATIC TOUCH PANEL. The fig. 3 shows the test panel. Control lamps P1, P2, P3, and P4 indicate the status of the pumps (a green light - the pump is running). Green color indicates also the “open” status of the valve.

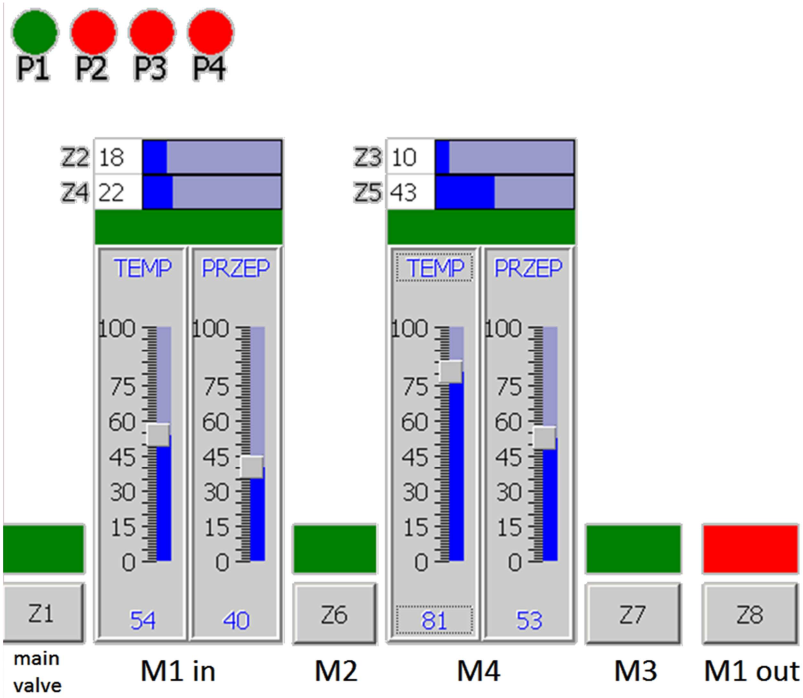

Fig.3. The test control panel (SIMATIC WinCC flexible Runtime)

Connection of the PLC controller with the iFIX environment is realized via Helmholz NETLink PRO PoE adapter using the Ethernet card in the PC with the SCADA application and MPI port. Applied hardware components are shown in fig. 4. Communication can be realized with using Siemens S7A for iFIX driver or IGS (Industrial Gateway Server) GE Intelligent Platforms driver.

6. Summary

Creating and configuring a SCADA node is a multi-threaded multi-stage process. In the presented example, covering the demand of water for production workshop, with optimal use of supply pumps electricity, was carried out using the logical functions minimization by Karnaugh method. The results of calculations have been used for creating the valves and pumps control application in the Siemens Step 7 environment. In the next step the hardware connection and drivers installation in an iFIX was taken. It was necessary for enabling the data exchange between SCADA node and actuators using the PLC controller. Program blocks migration from the controller to the iFIX speeds up the process of integration and validation of the system.

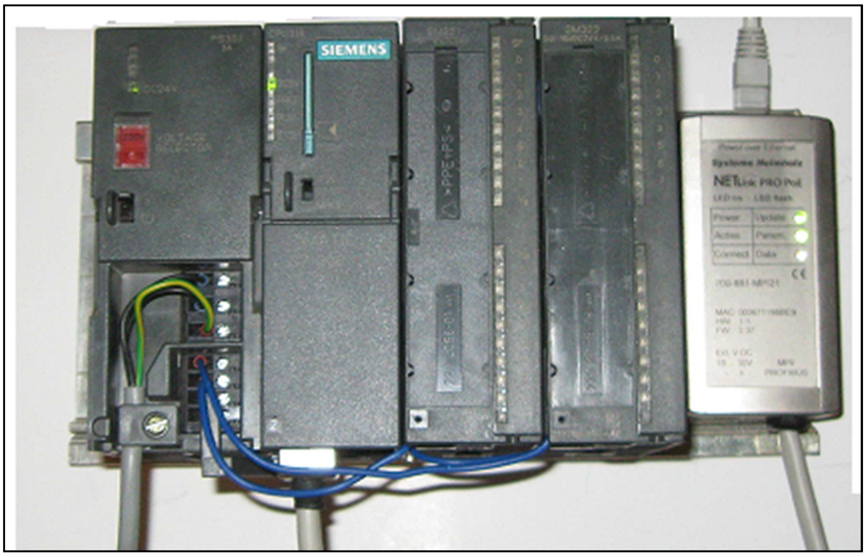

Fig.4. Hardware components: PLC controller and NETLink PRO PoE adapter

At the final step the electrical wiring diagrams were performed for all connections between PC, PLC controller and actuators. In addition, schemes include possibility of connecting a HMI panel and creating another access point for media control in the shop floor. The verification simulator made in STEP 7 can be installed in the touch panel and used for direct correction of the parameters. In this configuration, in order to avoid the simultaneous sending conflicting signals, the PLC program should be extended for enabling the master functionality to the SCADA node and slave functionality to the panel.

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