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Full Length Research Paper

A research on SCADA application by the help of OPC server for the water tank filling system

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This study deals with the data exchange issues based on object linking and embedding for process control (OPC) server in industrial automation systems. OPC server is a software developed to solve the driver device problem, where the first-tier visualization and supervisory control and data acquisition (scada) applications needed to have a standard way for reading and writing data from devices on the factory floor in process control. In this paper, the aim of the study was to control the water tank filling system through the programmable logic controller (PLC) and to observe the procedure by the help of SCADA The connection between the PLC and SCADA is maintained by the OPC server. With OPC server, the exchange of digital and analogue data obtained from sensors in the system can be realized with low cost and maximum performance. This paper illustrates the use of OPC server in industrial automation systems and the necessary PLC algorithms. A practical application of the design of the system is described.

Key words: OPC server, SCADA, PLC, fluid level control.

INTRODUCTION

With the development of the industrial automation system, in industrial applications, new machines, instead of more human workforce, have been improved. Mechanization and automation technologies have brought fast and reliable production techniques along with themselves. As that is the case, machines and processes that find a life by the microchip-based control methods have started to be an undeniable part of the industry (Crispin, 1990; Olsson and Pianni, 1992; Yucelen et al., 2005).

In this study, water tank filling system was applied by the programmable logic controller (PLC), and by this way, SCADA process changes were able to be monitored with the quality of interfering those changes.

THE WORK-PRINCIPLE OF THE SYSTEM

In the system shown in Figure 1, by a speed control of DC motor and with the Pals Width Modulation (PWM), the water in the water tank was made to reach to the tank by being pumped. If desired, by turning off the by-pass (Valve 1), it can be possible to let the water pass through cooler. The water that reaches to the water tank is heated by the water dimmer circuit and a temperature-changeable electrical resistance by which the desires temperature set value is obtained. In order to enable the homorganic temperature distribution in the water, the mixer motor is controlled in the on/off mode. Those processes are carried out by the information that is sent to PLC and their interpretation of the program that is written in the PLC and the arrangement of the feedbacks accordingly.

To watch and to control the occurrences that happen in the system, the variables used in PLC should be addressed symbolically, and the addressed variables should be related with the appropriate tags that are in SCADA software.

PLC PROGRAMMING

PLC is an industrial computer, designed to maintain the

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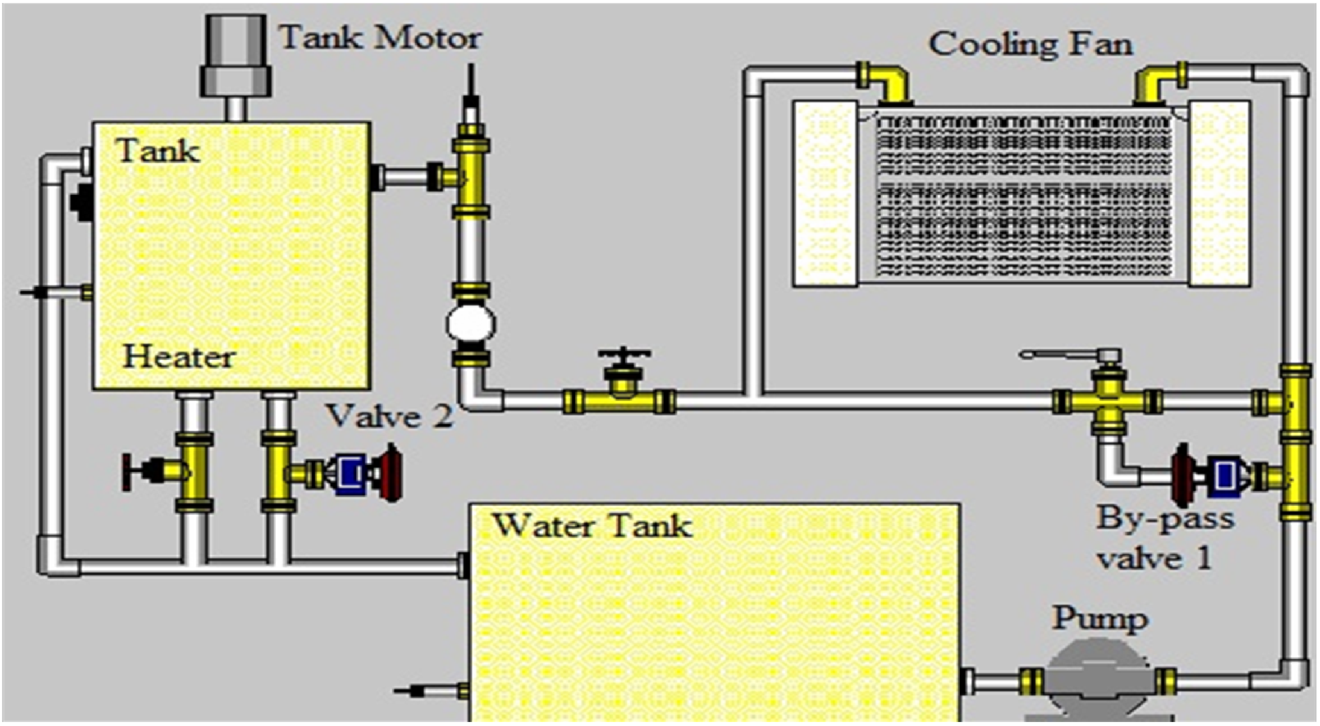

Figure 1. The process period of the water tank filling system.

functions such as timing, counting, control in a row, doing arithmetic's, data channeling, communication etc by a program that is installed in it. The PLC, which was formerly designed to take over the function of relay and timer relay etc, it is now possible to realize the complex control procedures (Beyazit, 2005).

PLCs are generally used in the industrial process applications and production. The basic advantage of the PLC is that it helps to enable flexible, reliable and simple system configuration and it has lower cost of care therefore complex systems moves toward PLC control systems (Aydogmus, 2009).

In the system, the PLC equipment with the model of CPU224 that belongs to the Siemens S7-200 family was used. There are 14 digital inputs (DI) and 10 outputs (DQ) terminals located in the system with 2 analog inputs and 1 analog output. The program prepared by STEP7 Micro/Win4.0 software was installed to PLC by the RS232-RS485 PC/PPI wire. Ladder-LAD was chosen as the programming language.

The program addresses that belong to the PLC input and output units are (Figures 2 and 3):

AQW0 = isitici_kontrol *(Heater Control)*
AIW0= kazan_sicaklik *(Tank Temperature)*
AIW2= kazan_seviye *(Tank Level)*
M0.0 = start
M0.1 = start_button
M0.2 = Emergency Stop button
M0.3 = Valf_1 on *(Valve 1 on)*
M0.4 = Valf_2 on *(Valve 2 on)*
M0.5 = Sogutucu_on *(Cooling Fan on)*
M0.6 = kazan_motor *(Pump)*
M0.7= TD_200
Q0.3 = Valf_1*(Valve 1)*
Q0.4 = Valf_2*(Valve 2)*
Q0.5 = Sogutucu *(Cooling Fan)*
Q0.6 = Kazan_motor *(Pump)*

There are VW100 and VW210 variables in the program. They are 16 byte addresses where the data sent over SCADA are stored. A symbolic addressing was made to all input, output and changeable memories that are on the PLC stair-diagram.

CONTROL CIRCUITS

Dimmer heater circuit

PLC analogue output will be in control of the heater. No external PLC analog module, an analog input, two analog outputs on the CPU 224XP model is used. Depending on the value 0-32760, analog output varies between 0-10V.

PLC analog output is between 0-10V. If we want to control the heater (220V/100W 50Hz), connecting PLC output directly to the output of the heater will cause the problem. Therefore, a simple dimmer circuit is designed for control.

In the circuit, a 12 V lamp that can be controlled by the

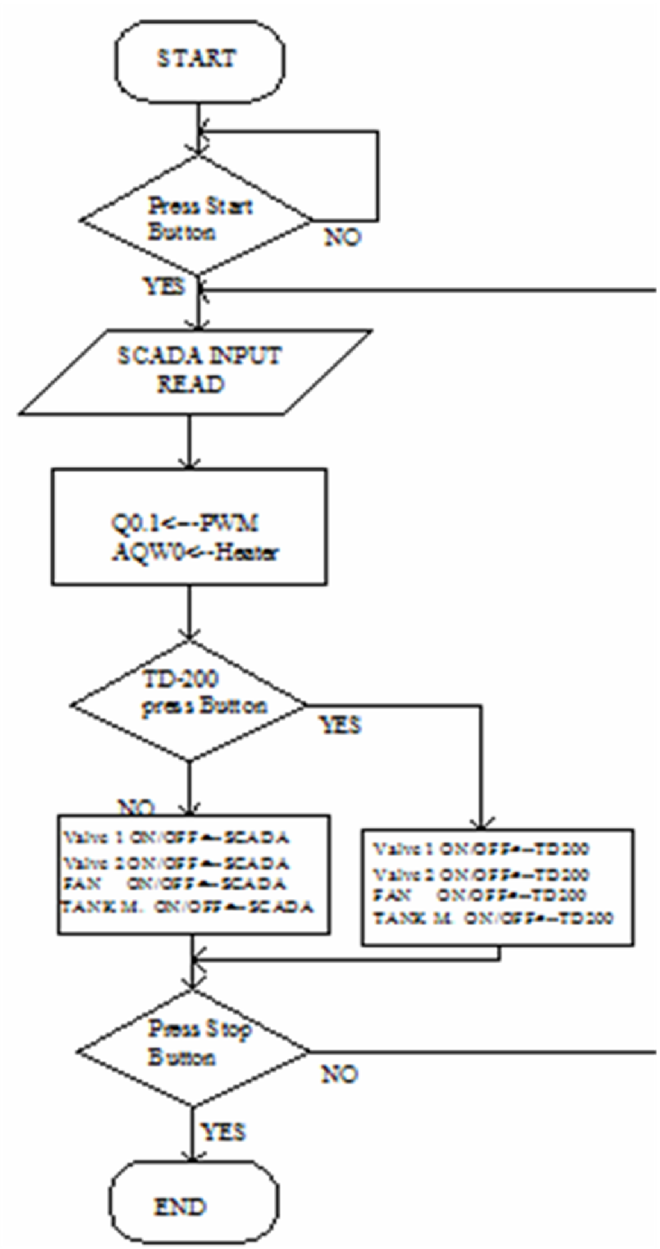

Figure 2. PLC flow chart.

analogue output of PLC has been put against LDR. The lamb will be connected to the collector pin of the transistor and to the base pin of the transistor the voltage will be let by analogue output of PLC. According to the voltage change on analogue output of PLC a linear change will be monitored in the light intensity of the lamp and the temperature of the both heater (Figures 4 and 5).

PWM DC motor control

PWM (pulse width modulation), as it applies to motor control, is a way of delivering energy through a succession of pulses rather than a continuously varying (analog) signal.

PWM uses a rectangular pulse wave whose pulse width is modulated resulting in the variation of the average value of the waveform. If we consider a pulse waveform $f(t)$ with a low value y_{min}, a high value y_{max} and a duty cycle D, the average value of the waveform is given by:

$$\bar{y} = \frac{1}{T}\int_0^T f(t)\,dt \qquad (1)$$

As $f(t)$ is a pulse wave, its value is y_{max} for 0< t <D.T and y_{min} for D.T <t <T. The above expression then becomes:

$$\bar{y} = \frac{1}{T}\left(\int_0^{DT} y_{\max}\,dt + \int_{DT}^{T} y_{\min}\,dt\right)$$

$$= \frac{D.T.y_{\max} + T.(1-D)\,y_{\min}}{T}$$

$$= D.y_{\max} + (1-D)\,y_{\min} \qquad (2)$$

This latter expression can be fairly simplified in many cases where y_{min} = 0 as $\bar{y} = D.y_{\max}$. From this, it is obvious that the average value of the signal ($\bar{y}$) is directly dependent on the duty cycle D.

The Model of S7-200 PLC has built-in functions to generate the PWM. S7-200 PLC has two PWM output pin (Q0.0 and Q0.1).

The PWM1_RUN instruction allows you to control the duty cycle of the output by varying the pulse width from 0 to the pulse width of the cycle time. The cycle input is a word value that defines the cycle time for the PWM output.

The Duty_Cycle input is a word value that defines the pulse width for the PWM output. The important point in PLC selection is to use PLC with transistor output, because high frequency switching is required (Figure 7).

OPC SERVER

OPC Server is based on Microsoft's OLE/COM technology. Microsoft's COM in a nutshell is software architecture. This technology allows applications to be built from binary software components. The OLE/COM specification is extensible, so the OPC Specification is useful for the process control and manufacturing automation industries.

Technical representatives from several major automation companies met together to provide a standard mechanism for communicating to numerous data sources, either devices on the factory floor, or a

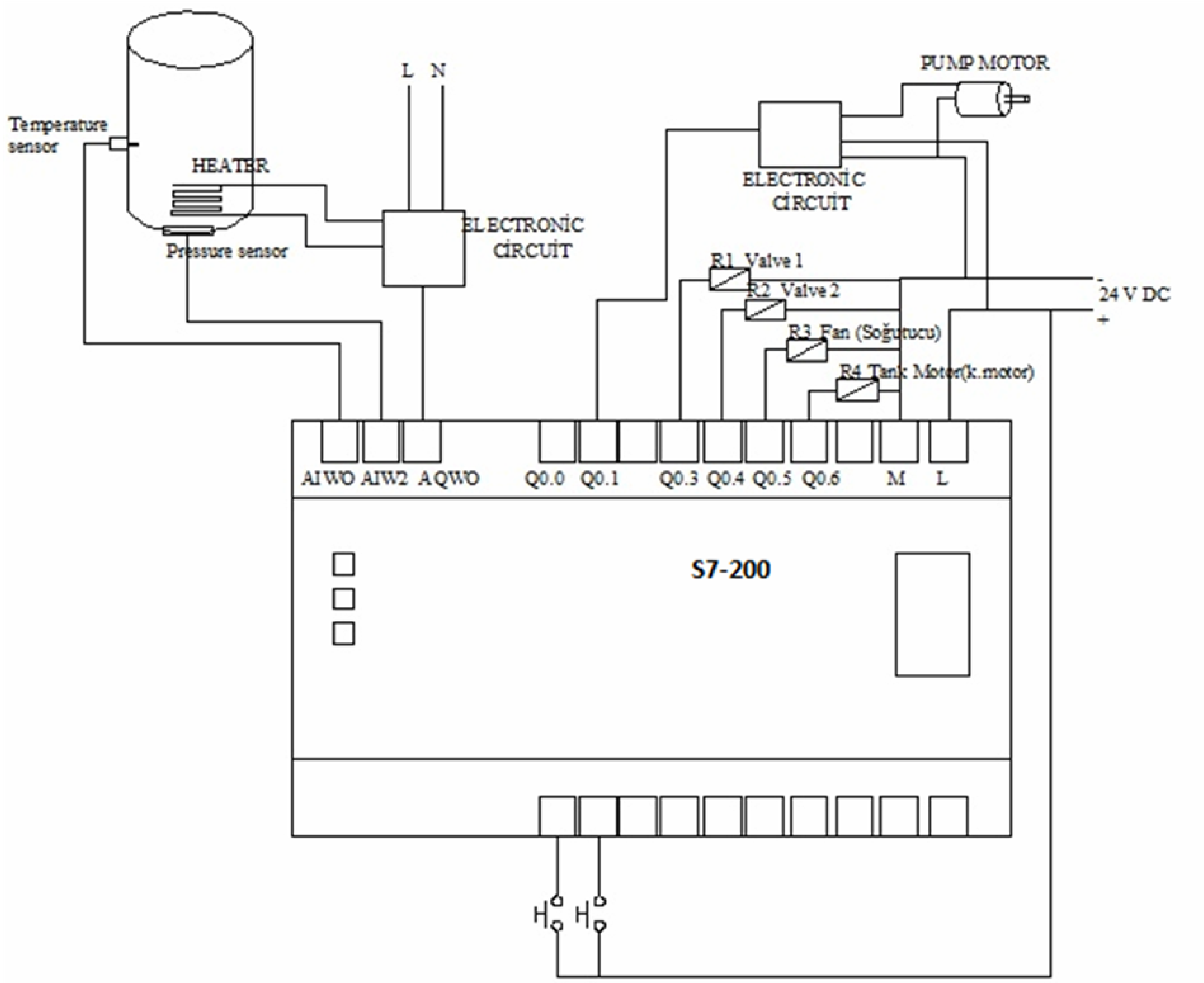

Figure 3. PLC wiring diagram.

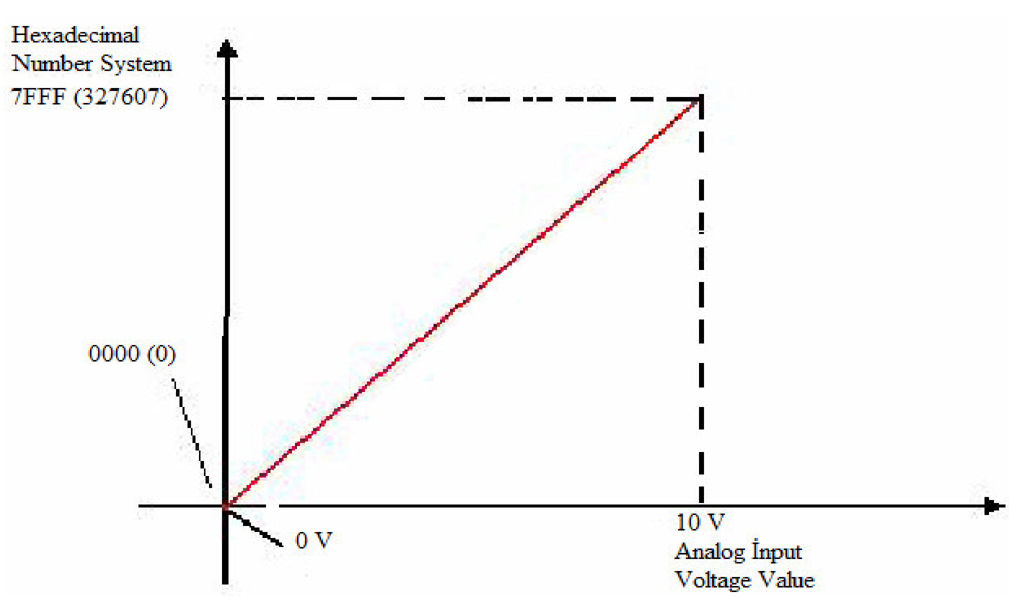

Figure 4. Analog output curve.

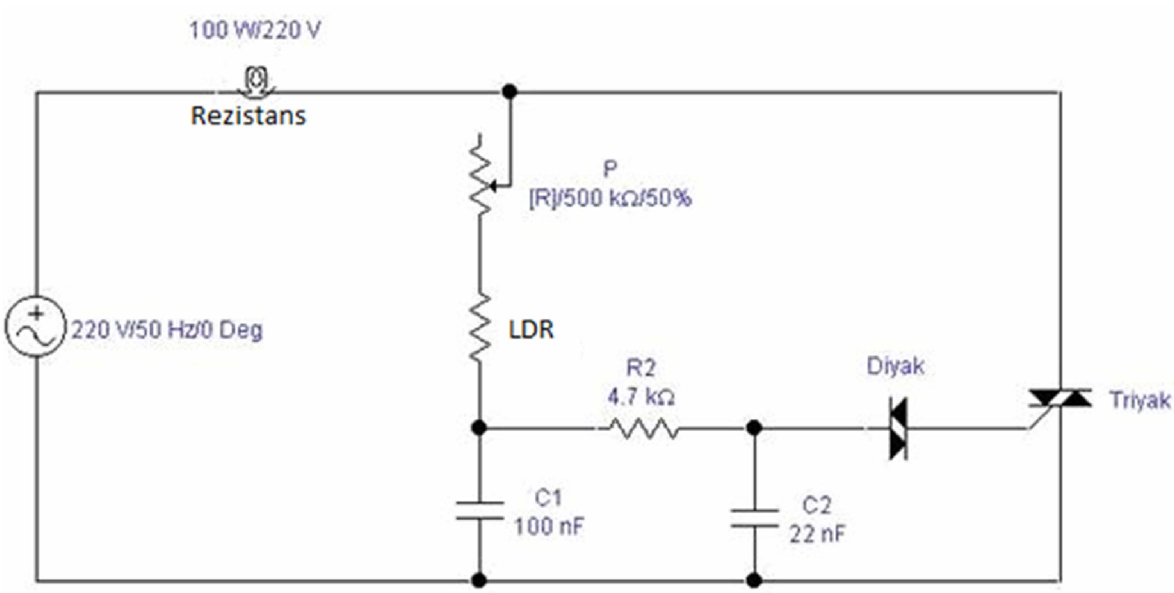

Figure 5. Dimmer heater circuits.

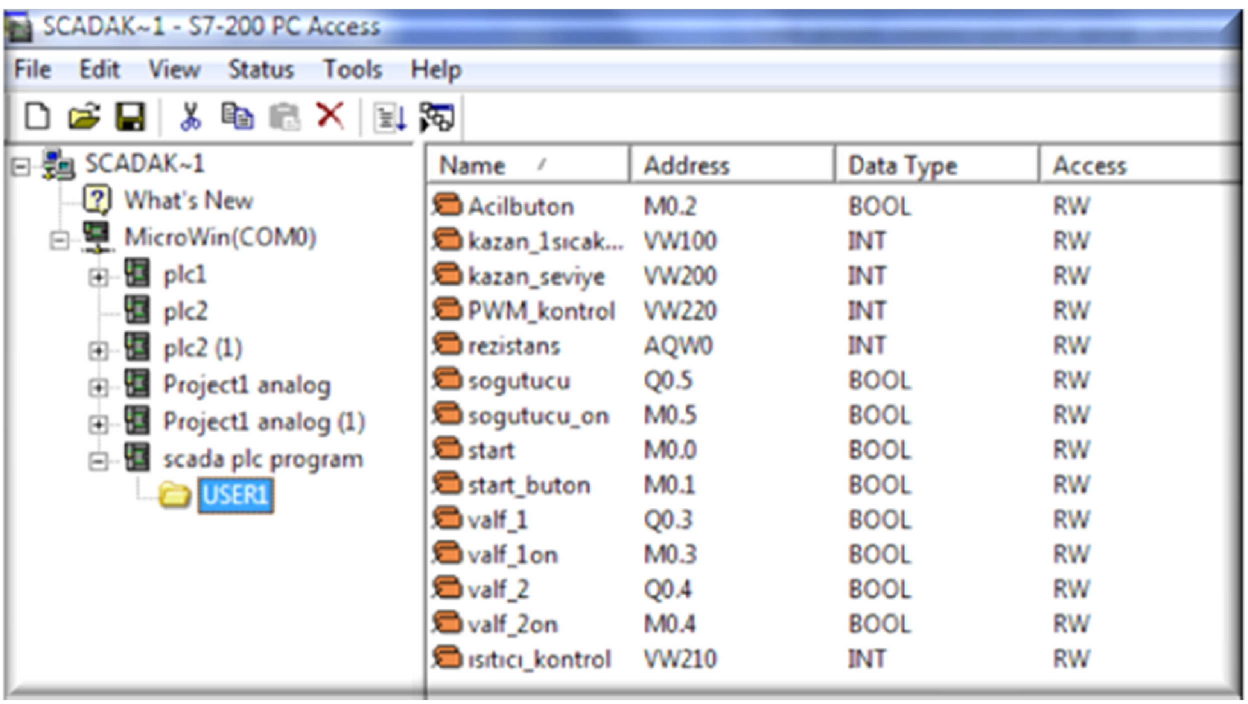

Figure 6. Tags taken into the PC Access.

database in a control room (Hong and Jianhua, 2006; Al Chisholm, 1998).

Through the OPC standard, users can image the various equipment in different brands and models on the OPC that they are using and also can control them. Since it has a significant lower price compared to the standard SCADA packet software and as it removes the problem of monopoly, OPC has become highly advantageous for the imaging and monitoring systems (Sahin et al., 2007). In the study conducted, we make use of the PC Access Program, which is an OPC server that creates the connection with S7200 PLC in any way (Figure 6). S7-200 PC Access supports all S7-200 protocols. With its help, symbolic addresses that are in the microWIN

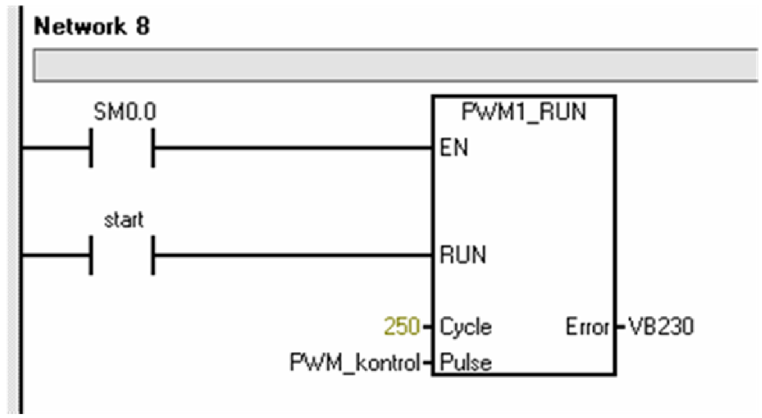

Figure 7. PWM control with PLC.

Table 1. Analog voltage that corresponds to the output pulse.

Cycle	Pulse	Analog output
250	250	24 V
250	200	22.1 V
250	150	19.2 V
250	125	17.3 V
250	75	13. V
250	25	7.8 V
250	0	0 V

program are tagged and then sent to WinCC above the OPC server. When the connection between the WinCC and microWIN is maintained, WinCC and S7-200 Siemens PLC are easy to control.

SCADA (supervisory control and data acquisition)

The word SCADA is the shortened form of the English word "supervisory control and data acquisition". Work operators monitor, control and command the system by using the SCADA. SCADA systems are used in industrial processes (concrete production, iron-steel industry, chemical industry etc.) in telecommunication, transport, power plants and in the control of scientific experiments such as fusion. SCADA systems can control input/output processes of up to one hundred thousand (Daneels and Salter, 1999).

A SCADA system allows an operator to make a set point changes on remote controllers, to open/close valves/switches, to monitor alarms, and to gather instrument information from a local process to a widely distributed process, such as oil/gas fields, pipeline systems, or hydroelectric generating systems (Boyer, 1999; Horng, 2002).

In the project, the WinCC V7.0 Demo version with the SCADA software has been created so as to control the system from the main computer. After the creation of the system control screen in the WinCC programs graphical design as it is shown in Figure 8, tags are sent to the appropriate picture on the graphic screen so as to relate the MicroWIN program with the pictures.

System can be controlled on the control screen and all the changes happening are easy to monitor. The way that the water uses to reach the water tank through the by-pas valve can be seen from the color of the pipes as it is shown in Figure 8. In addition to this, tank water level can be watched from the scale as real time. To exemplify this is the arrangement of the pump speed in which a slider with the 0-100 scale on a pump is used. Below are the configurations that can be controlled from the screen;

Tank Temperature; *The scale was 0-100*
Pump speed control; *DC motor PWM control*
Cooling fan control; *On-Off*
Agitator Motor; *On-Off*
By-pass valve and evacuation valve; *On-Off*
Authorization to use operator panel
Starting System
Emergency Stop

RESULTS AND DISCUSSION

This study deals with the data exchange issue in industrial automation. One of the most important results of the study is that OPC helps the data exchange between SCADA and PLC and shows the reliability of the low cost and the maximum performance in software and hardware relation in the system and in the industrial automation systems. Thus OPC eliminates the need for costly custom software integration

As it is shown in Table 1, PWM pulse outputs are successfully sent from SCADA to Ladder diagram programme in PLC via OPC server. Meanwhile data gained from heat and pressure sensors are sent to SCADA system from OPC server. OPC specifications being developed in industrial automation fields, such as

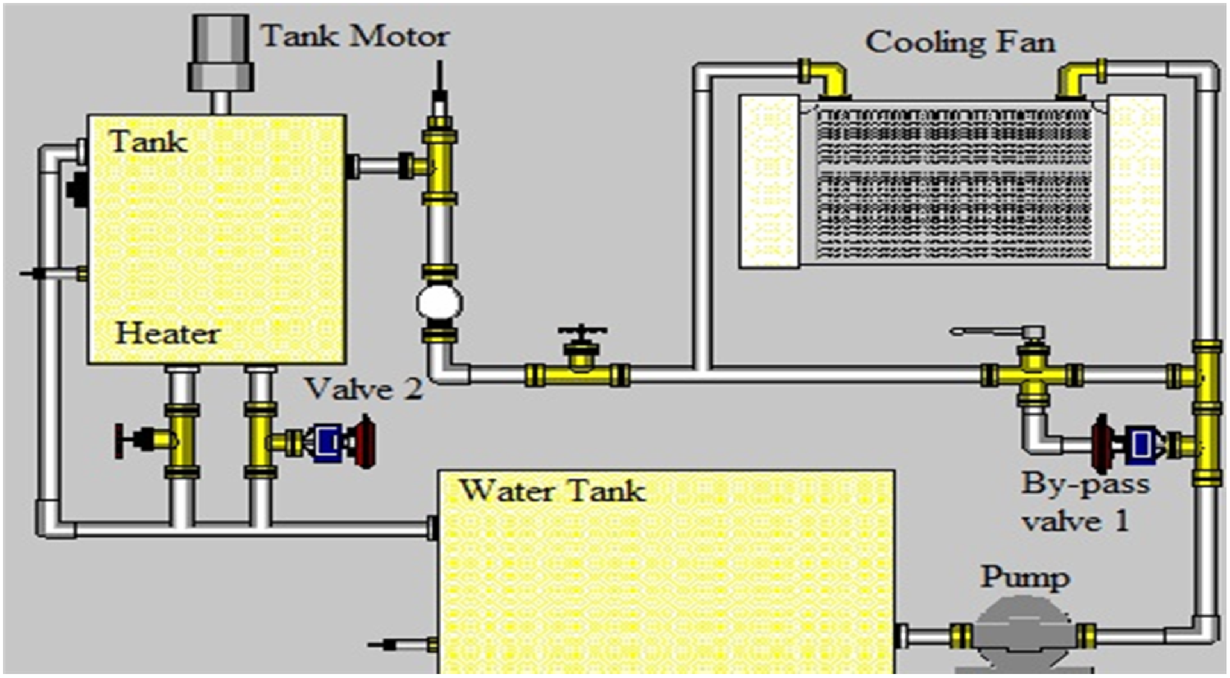

Figure 8. SCADA screen.

data access, alarms and events, historical data access, batch, security, XML etc. process can be done.

In future many hardware developments or solutions can be found with the step to OPC server and some programmes working together. For example, artificial intelligence can use algorithms for the system by Matlab software programme. Data gained can transfer distributed control systems, supervisory control and data acquisition systems and PLC etc. automation field equipment with the help of OPC. In this way extra modules in automation systems will decrease and capability of the system will increase.

Conclusion

In this study, an appropriate Programmable Logic Control (PLC) ladder diagram for a water tank filling system automation was created. Additionally, appropriate SCADA software within the WinCC program to control and monitor the system from a central point was realized. The communication amongst OPC server that is capable of controlling and displaying the various devices with different models and marks, and the used PLC and SCADA program was realized. The messaging between the analogous and digital data, SCADA and PLC was achieved successfully. The practical application of tank filling system, as a sample of the use of OPC servers in industry, was realized.

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