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SCADA Monitoring Design Using Multiple Siemens PLCs Based on a LAN Network

Wahidah[1,a], Asyraful Insan[2,*,b], Muhammad Rasul[3,c]
[1,2,3] Department of Automated Mechanical System, Politeknik ATI Makassar, Jl. Sunu No. 220 Makassar, 90215, Indonesia
[a]wahidah@atim.ac.id, [*,b]asyraful@atim.ac.id(Corresponding Author), [c]20osp498@atim.ac.id

***Abstract*— In In the DCS SCADA practicum at ATI Makassar Polytechnic's PLC laboratory, there were connection issues between the PLC and PC, including damaged cables, loose connectors, or communication port interference. This research aimed to design a SCADA monitoring system using multiple PLCs over a LAN network. Three display modules were developed to detect connection problems for three PLCs, each assigned a different IP. When a connection issue occurred with PLCs A, B, or C, the LED on the PLC_S7-1200 text would flash. Network connections were tested using the PING command to measure round trip times. Additional tests included network connection checks via accessible devices that flash on the PLC, tag tests on Kepserverex, Factory I/O tests, and PLC communication tests with Factory I/O. System testing showed average round trip times of 2.4 ms for both PCs and PLCs, with durations of 1, 2, 5, 10, and 20 minutes. The network connection test via flash LED accessible devices functioned correctly, indicating connection status with a light indicator. Kepserverex tag tests displayed tags and their quality, Factory I/O tests showed access names and tags used, and the HMI display module functioned as intended. Finally, PLC communication tests with Factory I/O successfully connected the software with the PLC.**

Keywords*— *PLC Siemens S7-1200, Factory I/O, Kepserverex, LAN Network, Multiple PLC, Monitoring, SCADA

I. Introduction

DCS SCADA is one of the new courses at ATI Makassar Polytechnic in the Machinery Systems Automation study program. The focus is to increase students' understanding in designing human user interfaces (HMI), connecting controllers such as PLCs to HMIs with Open Protocol technology such as Modbus and OPC, as well as understanding the connection between HMIs and databases.

In the SCADA system practicum in the ATI Makassar Polytechnic campus laboratory, there are activities that involve the use of a PLC (Programmable Logic Controller) and PC connected to each other via ethernet cable. The connection between the PLC and PC is very important, because it is used to control and unite the automation system via the HMI (Human Machine Interface) display. In this context, the use of the user interface (HMI) in the SCADA system during the practicum becomes very important.

HMI plays an important role in presenting data and information collected by SCADA systems in a visual and easy to understand manner. HMI allows users, such as students or practicum participants, to view and control ongoing system operations. However, in this practice, problems often occur with the network cable that connects the PLC to the PC. These problems can vary, such as damaged cables, loose connectors, or problems with the communication port on the PC or PLC [1].

When this problem occurs, the HMI display on the PC cannot display the necessary data and information, so the practical cannot be carried out smoothly. To overcome this problem, designing a SCADA system using Multiple PLCs that can be monitored using HMI is the proposed solution. This research is a development of previous research which was still monitoring 1 PLC and to develop a practicum module in implementing communication between PLCs.

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II. Research Methodology

This research was carried out from June 2023 to July 2023 at the ATI Makassar Polytechnic campus. In this research, three modules were used, namely the Siemens S7-1200 PLC Trainer module, four PCs and switches as well as several application tools to make wiring easier. Devices that use a cross type Ethernet LAN cable will connect the PLC using a PC/Monitor then the PC will be connected to applications such as Factory I/O as an I/O module, Virtual Plant Factory I/O as a Virtual button panel, Kepserverex as a link between HMI and Tia Portal, and Tia Portal as applications that program and assign addresses to the PLC so that communication can be established. Then Aveva Intouch HMI as the HMI display.

In this research, 3 display modules were created that detect connection problems on 3 PLCs. Each module focuses on 1 PLC with a different IP and if there is a problem with the PLC A, B, & C connection, the LED in the PLC_S7-1200 text will flash. Then testing the PC and PLC network connections using the PING statistical command via estimated round trip time. Next, test the network connection via a device that can be flashed on the PLC, test the tag on Kepserverex, test the Factory I/O, and test the PLC communication with the Factory I/O, with test times of 1, 2, 5, 10, 20 minutes.

III. Results and Discussion

The I/O Trainer module is made in Factory I/O software with 2 push buttons and indicator lights. Next, IP configuration is carried out using the Factory I/O Software, two push buttons are connected as the start button and stop button and a light is used as a run indicator from the Factory I/O Software to the PLC Trainer module. After checking the IP, the PLC trainer module is connected to the PC using a cross type LAN ethernet cable and also connected to the 220VAC supply using a power cable. By using the PING command, the PC connection to the PLC trainer module is confirmed to be connected and then with the help of the TIA Portal application, the ladder diagram along with the I/O List (Tag) is transferred to the PLC.

The ladder diagram and tags can be seen in pictures 1 and 2 below:

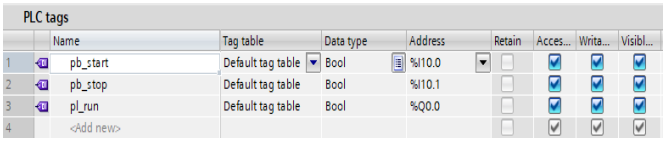

Figure 1. PLC tags or I/O list used for PLC A, B, & C

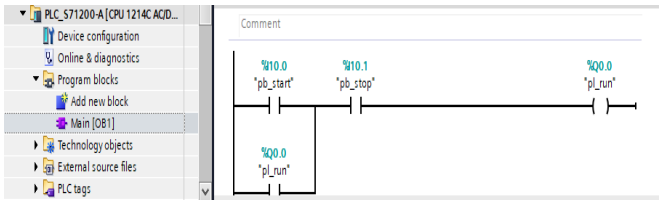

Figure 2. Ladder diagram for PLC A, B, & C

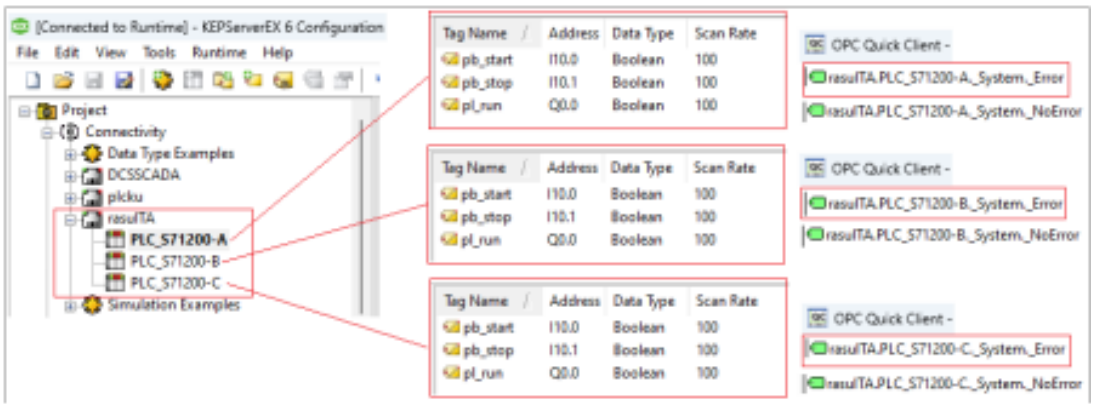

Figure 3. Tag settings in Kepserverex 6.0

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Once the ladder diagram is downloaded or transferred to a Siemens PLC, the Kepserverex software is opened and the device and tag are created. Next, name tags and modules were created in the Aveva Intouch HMI Software and a SCADA display was created.

Figure 3 shows that each PLC is colored red, indicating that the PLC has its own tag which is used in the Kepservex software and shows good quality results and green shows the system error tag of each PLC tag which functions as a connection marker. connected to the disconnected computer can be seen via the SCADA display.

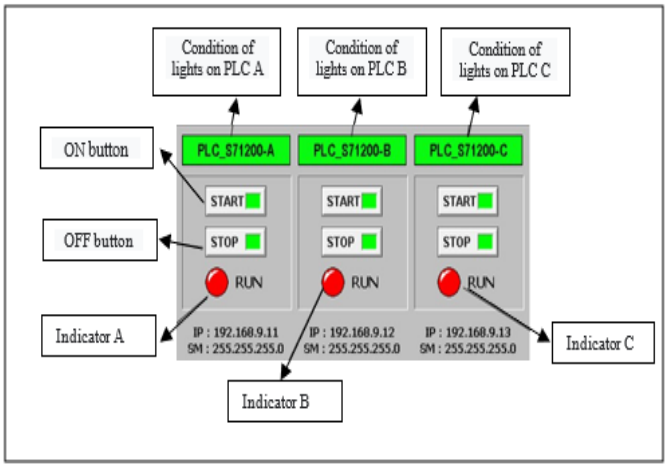

Figure 4. Aveva Intouch HMI SCADA Display Module (Application Manager)

When the START button on the S7-1200A PLC panel is pressed, the RUN light is active and when the STOP button is pressed the RUN light will be deactivated. Likewise, the second and third panels work the same way. When the PLC S7-1200A connection is not connected to the PC, the green light on the display name PLC_S7-1200A will flash, which means the PLC is not connected to the PC, the same as with the PLC S7-1200B and PLC S7-1200C.

Table 1. PING statistical test results on PLC 1, 2, 3

No	*Devices*	*Duration of time (Minutes)*	*Round trip times (ms)*		
			Mini mum	*Maxi mum*	*Aver age*
1.	PLC 1 192.168.9.11 255.255.255.0	1	1	3	2
2.		2	2	3	2
3.		5	2	4	3
4.		10	3	4	3
5.		20	2	3	2
Average value					2,4
6.	PLC 2 192.168.9.12 255.255.255.0	1	1	3	2
7.		2	3	4	3
8.		5	2	3	2
9.		10	2	3	2
10.		20	3	4	3
Average value					2,4
11.	PLC 3 192.168.9.13 255.255.255.0	1	1	3	2
12.		2	2	3	2
13.		5	2	3	2
14.		10	3	4	3
15.		20	3	4	3
Average value					2,4

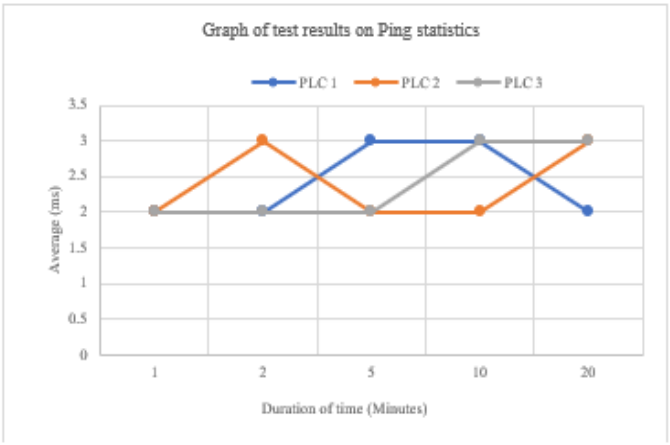

Figure 5. Graph of test results on PLC 1, 2, 3

Each experiment uses the Ping command and time statistics are analyzed in the form of round trip time for minimum, maximum and average values in milli seconds (ms). From table 1 and figure 5 you can see the results of the Ping statistics test on PLC 1, PLC 2 and PLC 3 with five trials for a time duration of 1 minute, 2 minutes, 5 minutes, 10 minutes and 20 minutes and obtained an average round trip time of 2.4 ms.

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Table 2. PING statistical test results on PC 1, 2, 3

No	*Devices*	*Duration of time (Minutes)*	*Round trip times (ms)*		
			Minimum	*Maximum*	*Average*
1.	PC 1 192.168.9.7 255.255.255.0	1	2	3	2
2.		2	2	4	3
3.		5	2	3	2
4.		10	3	4	3
5.		20	2	3	2
Average value					2,4
6.	PC 2 192.168.9.8 255.255.255.0	1	2	3	2
7.		2	2	3	2
8.		5	3	4	3
9.		10	2	4	3
10.		20	2	3	2
Average value					2,4
11.	PC 3 192.168.9.10 255.255.255.0	1	2	3	2
12.		2	3	4	3
13.		5	3	4	3
14.		10	2	4	3
15.		20	2	3	2
Average value					2,6

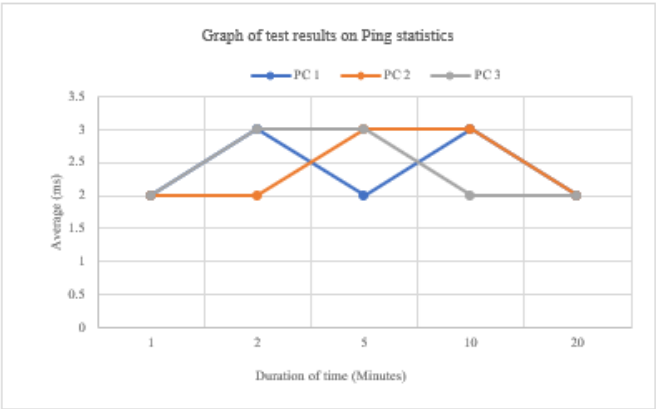

Figure 6. Graph of test results on PC 1, 2, 3

In table 2 and figure 6, you can see the Ping statistics test results for PC 1, PC 2 and PC 3 devices with five trials for a duration of 1 minute, 2 minutes, 5 minutes, 10 minutes and 20 minutes and obtained an average round trip time of 2.4 ms.

IV. Conclusion

In this research, a SCADA monitoring system has been designed and created using multiple PLCs based on a LAN network with 3 display modules that detect connection problems on 3 PLCs. Each module focuses on 1 PLC with a different IP. Based on the results of system testing carried out, it can be concluded that SCADA Monitoring with Multiple PLC based on LAN Network was successfully implemented.

1. Testing the PC and PLC network connections using the PING statistics command shows the results of round trip times an average of 2.4 ms on PC 1, 2, 3, and an average of 2.4 ms on PLC 1, 2, 3 with testing time 1, 2, 5, 10, and 20 minutes.
2. Testing the network connection via "accessible devices flash" on the PLC is functioning properly. If a problem occurs with the PLC A, B, and/or C connections, the LED on the PLC_S7-1200 will flash.
3. Testing tags on Kepserverex displays a table containing the tags used and shows good quality.
4. Testing the Factory I/O displays the access name and tags used and the HMI display module being tested runs in accordance with the system that has been implemented, as well as testing PLC communication with Factory I/O to connect the Factory I/O software with PLC.

This research can be further developed with a better HMI display, adding cases to the Virtual Plant Factory I/O, combining different types of PLC, as well as automating the switch to the next PLC module when one of the HMI display modules of the PLC experiences an error.

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