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Design of Scada-Based Motor Monitoring System

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ABSTRACT

Industrial progress triggered by the development of science and technology is centered towards the era of industrial automation. Industrial automation gives the industry the opportunity to develop production output. SCADA (Supervisory Control and Data Acquisition Systems) is a system that works on supervisory control of certain devices from a remote location and human operators can monitor and control devices from a computer screen by not being physically near the device. The purpose of this research is to find out how to solve problems in the control program on the Schneider PLC for motor control to improve the efficiency and reliability of system performance, with consideration of various technical, operational, and safety aspects. The initial step of this research is the design of a series of tools on SCADA-based motor monitoring that will facilitate the assembly process. The next step is to connect the HMI with the PLC, whether the HMI can work properly or not. After the HMI and PLC can be confirmed to work properly, the next process is to assemble the tool. After the tool is assembled, the researcher conducts experiments and measurements and records the results and analyzes whether the tool made can work properly or needs improvement again. Based on the results of the process of designing, making, and testing the design of a SCADA-based motor monitoring system, it can be concluded that the error of PZEM 004T in measuring voltage is 0.0198% in measuring current is 0.612%. In this test, for the three PZEM 004 T as slave 1, slave 2, and slave 3 connected to the RS485 converter and directly connected to the HMI, will experience data reading errors on the HMI because the data retrieval time is too fast and not in rhythm which results in some data not being recorded.

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INTRODUCTION

Industrial development in the 4.0 era, industrial automation systems are very important things to pay attention to. Indonesia, a developing country, has several industries and is divided into large-scale industries, medium-scale industries, and small-scale industries. Advances in science and technology have a positive effect on the development of the industrial world. Industrial progress triggered by the development of science and technology is centered towards the era of industrial automation. Industrial automation provides an opportunity for the industry to develop production results. (Irvawansyah & Rahmansyah, 2018).

SCADA (Supervisory Control and Data Acquisition Systems) is a system that performs supervisory control of certain devices from a remote location and human operators can monitor and control devices from a computer screen by not being physically near the device (Soleh Uddin et al., 2023).

The purpose of vocational education is to prepare students to enter the world of work. Industrial automation system is one of the advances in the industrial sector that needs to be considered by the education community. Therefore, it is necessary to provide students with a fundamental understanding of industrial automation. The SCADA-based motor monitoring system is one illustration of the automation system. Here, the system provides an overview of how to regulate the on and off of an electric motor.

LITERATURE REVIEW

SCADA (Supervisory Control and Data Acquisition)

Supervisory Control and Data Acquisition stands for SCADA which refers to a group of devices that work together and form a unit, communicating with each other to perform tasks such as measurement, control, and data request/submission. SCADA is used to assist in achieving the best operating system while still considering the advantages and disadvantages that exist in real-world systems. Software and hardware make up SCADA (Ta'ali & Eliza, 2020)

1. PLC (Programmable Logic Controller)

An electrical device known as a Programmable Logic Controller (PLC) is digitally operated, has programmable memory, and stores instructions to carry out specific tasks such as arithmetic, logic, counting, sequencing, and timing to control various types of motors or processes using analog or digital input output modules. Electronic circuits that can operate are contained within the PLC. For example, contact relays (both NO and NC) can be used repeatedly for all basic commands other than output instructions (Yudamson et al., 2013).

Figure 1. PLC Schneider

2. Human Machine Interface (HMI)

Human Machine Interface is a software interface between machines or factories and operators or observers. Usually HMI consists of a central computer or several separate computers that have functions for monitoring and controlling machines, plants or processes in a factory (Soleh Uddin et al., 2023). The purpose of using HMI is to collect and

Figure 2. Human Machine Interface

3. Induction motor

3-phase induction motors are the prime movers for most machines. These motors can be operated either directly from a power source or from a frequency converter. Modern industrialized countries, more than half of the total electrical energy used is converted into mechanical energy through AC induction motors (Adam et al., 2021). The application of this motor covers almost every stage of manufacturing and processing. Its application also extends to commercial buildings and domestic environments. These induction motors are usually used to drive pumps, fans, compressors, mixers, conveyors, cranes, and so on.

Figure 3. Motor Induksi

4. Contactor

Electrical equipment based on electromagnetic induction is known as contactors. In contactors can be found coils that when electrified will produce a magnetic area in the iron core, which results in the resulting magnetic force attracting the contacts. This tool is divided into main contacts found in power circuits and auxiliary contacts found in control circuits. (Indrihastuti et al., 2021)

Figure 4. Kontaktor

5. MCB (Miniature Circuit Breaker)

Miniature Circuit Breaker (MCB) is an important part of the electrical installation protection system in case of overcurrent. MCB serves to protect overload and short circuit because overcurrent causes overload and short circuit. The expansion principle says the bimetal strip bends and cuts off the flow of electricity when the current passing through it exceeds its nominal nominalnya (Sahmul1, 2023). In short-circuit protection, electromagnetic induction occurs. When the coil is induced, the surrounding magnetic field affects the movement of the shaft and the working of the breaker lever. Disconnection and trip times are faster with shorter short-circuit currents. Short-circuit currents can cause sparks that can lead to fire.

Figure 5. MCB

6. TOR (Thermal Overload Relay)

As a load protector against overcurrent, TOR is a protective device. Temperature sensitivity affects the TOR. The TOR will trip in case of overcurrent and high temperature, protecting the load. The way the TOR works is that a high current flowing through the bimetal will cause it to expand and break the current. (Akhir & Sudrajat, 2023)

Figure 6. Thermal Overload Relay

METHODOLOGY

Stages of research

The stages of this research flow are as follows.

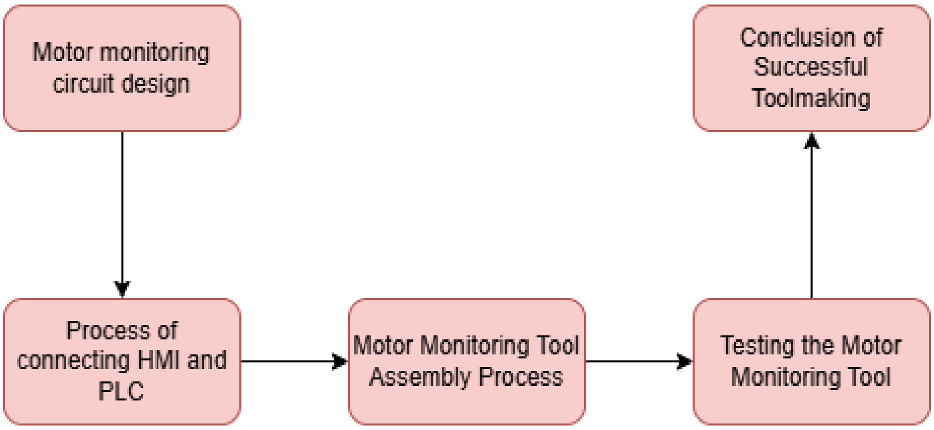

Figure 7. Research Design Flow

The diagram above shows the stages of research with the whole or outline that will be carried out by researchers. The initial step of this research is the design of a series of tools on SCADA-based motor monitoring that will facilitate the assembly process. The next step is to connect the HMI with the PLC, whether the HMI can work properly or not. After the HMI and PLC can be confirmed to work properly, the next process is to assemble the tool. After the tool is assembled, the researcher conducts experiments and measurements and records the results and analyzes whether the tool made can work properly or needs improvement again.

Monitoring System Circuit Diagram Design

Figure 8 illustrates how the design of a SCADA-based motor monitoring tool can be put together using several parts. PZEM as a slave is used to read voltage and current data from the motor, PLC as a slave is used to control the on and off of the motor, and USB to record the data that has been read. Can be seen in the following picture.

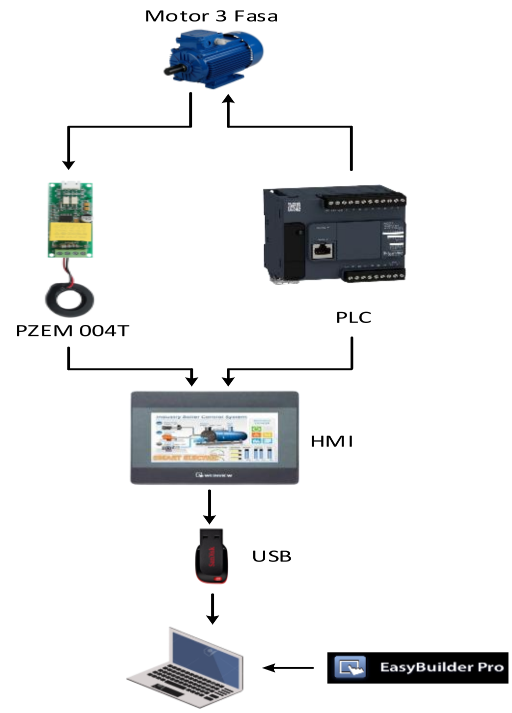

Figure 8. Monitoring System Circuit Diagram

RESEARCH RESULT

Line to Line Voltage Measurement

Table 1. Line to Line Voltage Measurement

Date	Time	Voltage R-S	Voltage R-T	Voltage S-T
14/09/2024	17:41:33	0	0	0
14/09/2024	17:42:38	0	0	0
14/09/2024	17:43:41	0	0	0
14/09/2024	17:44:00	393,3	396,1	398,9
14/09/2024	17:44:57	393,3	396,1	398,7
14/09/2024	17:45:31	393,7	396,1	398,9
14/09/2024	17:46:51	394,4	396,5	398,9
14/09/2024	17:47:49	394,2	396,6	399,1
14/09/2024	17:48:12	394,2	396,5	398,9
14/09/2024	17:48:57	394,2	396,5	399,2
14/09/2024	17:49:53	393,9	396,1	399,1
14/09/2024	17:50:53	394,0	396,1	399,1
14/09/2024	17:51:53	394,0	396,1	399,1
14/09/2024	17:52:53	394,2	396,1	399,2
14/09/2024	17:53:58	394,4	395,9	399,1
14/09/2024	17:54:58	394,2	395,4	399,1

Date	Time	Voltage R-S	Voltage R-T	Voltage S-T
14/09/2024	17:55:40	394,0	395,3	398,5
14/09/2024	17:56:53	393,7	395,3	398,7
14/09/2024	17:57:22	393,9	395,4	398,7

From table 1, a graph can be made as shown in the following graph.

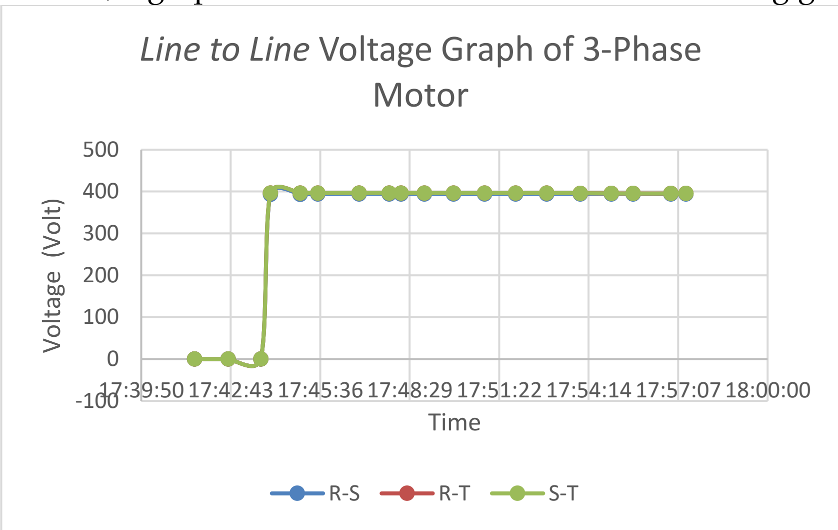

Figure 9. Line to Line Voltage Graph of 3-Phase Motor

Line to Neutral Voltage Measurement

Table 2. Line to Neutral Voltage Measurement

Date	Time	Volatge R-N	Voltage S-N	Volatage T-N
14/09/2024	17:41:33	0	0	0
14/09/2024	17:42:38	0	0	0
14/09/2024	17:43:41	0	0	0
14/09/2024	17:44:00	227,1	228,7	230,3
14/09/2024	17:44:57	227,1	228,7	230,2
14/09/2024	17:45:31	227,3	228,7	230,3
14/09/2024	17:46:51	227,7	228,9	230,3
14/09/2024	17:47:49	227,6	229	230,4
14/09/2024	17:48:12	227,6	228,9	230,3
14/09/2024	17:48:57	227,6	228,9	230,5
14/09/2024	17:49:53	227,4	228,7	230,4
14/09/2024	17:50:53	227,5	228,7	230,4
14/09/2024	17:51:53	227,5	228,7	230,4
14/09/2024	17:52:53	227,6	228,7	230,5

Date	Time	Volatge R-N	Voltage S-N	Volatage T-N
14/09/2024	17:53:58	227,7	228,6	230,4
14/09/2024	17:54:58	227,6	228,3	230,4
14/09/2024	17:55:40	227,5	228,2	230,1
14/09/2024	17:56:53	227,3	228,2	230,2
14/09/2024	17:57:22	227,4	228,3	230,2

From table 2, a graph can be made which looks like the following.

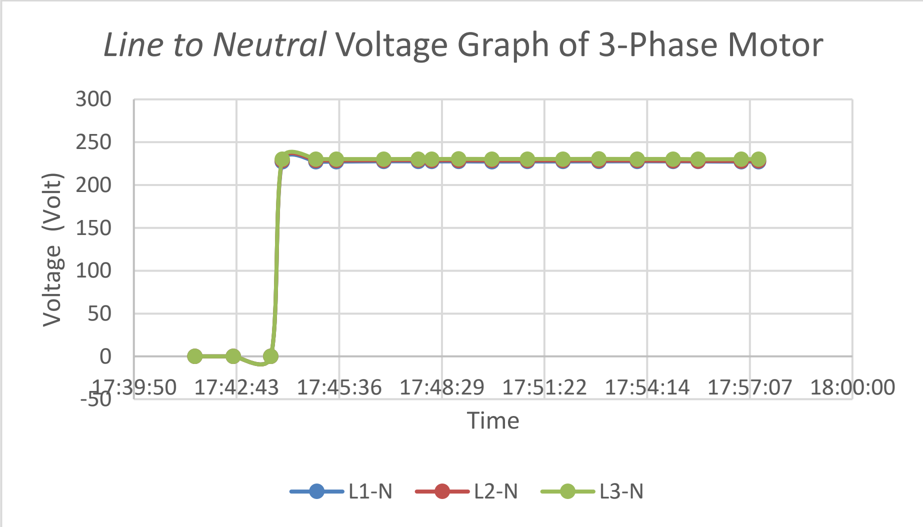

Figure 10. Line to Neutral Voltage Graph of 3-Phase Motor

3-Phase Motor Current Measurement

Table 3. 3-Phase Motor Current Measurement

Date	Time	R-Current	S-Current	T-Current
14/09/2024	17:41:33	0	0	0
14/09/2024	17:42:38	0	0	0
14/09/2024	17:43:41	0	0	0
14/09/2024	17:44:00	0	0	0
14/09/2024	17:44:57	1,012	0	1,087
14/09/2024	17:45:31	1,016	0,975	1,087
14/09/2024	17:46:51	1,015	0,975	1,088
14/09/2024	17:47:49	1,013	0,974	1,089
14/09/2024	17:48:12	1,013	0,974	1,089
14/09/2024	17:48:57	1,011	0,973	1,085
14/09/2024	17:49:53	1,01	0,969	1,086
14/09/2024	17:50:53	1,01	0,969	1,085
14/09/2024	17:51:53	1,01	0,969	1,085

Date	Time	R-Current	S-Current	T-Current
14/09/2024	17:52:53	1,01	0,97	1,084
14/09/2024	17:53:58	1,01	0,979	1,084
14/09/2024	17:54:58	1,011	0,978	1,083
14/09/2024	17:55:40	1,014	0,977	1,093
14/09/2024	17:56:53	1,013	0,975	1,094
14/09/2024	17:57:22	1,013	0,974	1,094

From table 3, a graph can be made which is shown in the following figure.

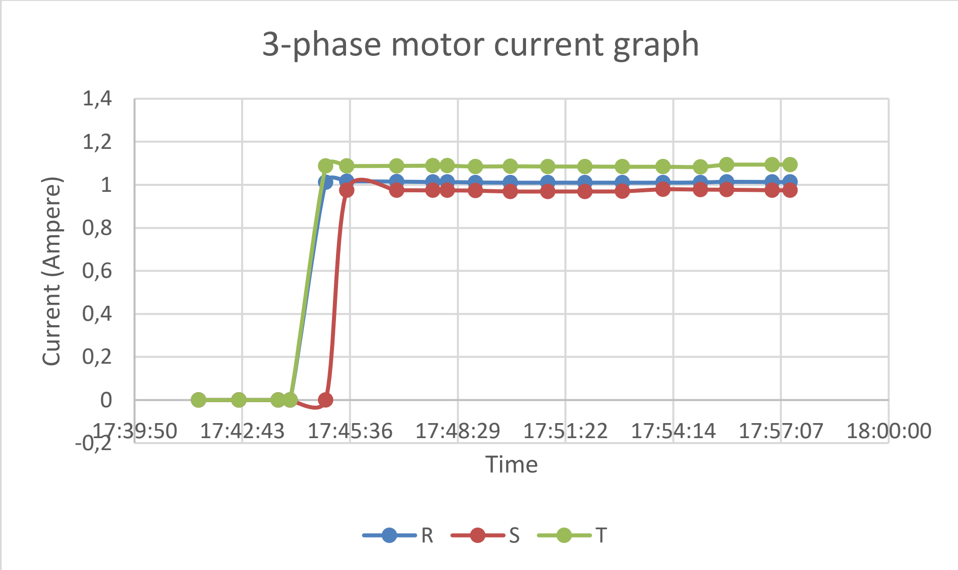

Figure 11. 3-phase motor current graph

DISCUSSION

1. *Line to Line Voltage Measurement*

It can be seen from the data in Table 1 that the highest voltage between phase R and phase S was 394.4 V at 17:46:51. The highest voltage between phase R and phase T was 396.6 V at 17:47:49. And the highest voltage between phase S and phase T was 399.2 V at 17:48:57.

From table 1, we can convert it into a graphical form which can be seen in Figure 9 that the voltage between phase to phase has a difference that is not too large. It can be seen that the voltage spike occurred when starting the motor at 17:43. The above results show the voltage between phases during the operation of a 3-phase induction motor for 20 minutes.

2. *Line to Neutral Voltage Measurement*

From table 2, it can be seen that the voltage between phase and neutral that the highest voltage between phase R and neutral is 227.7 V at 17:46:51. The highest voltage between phase S and neutral was 229 V at 17:47:49. And the highest voltage between phase T and neutral was 230.5 V at 17:48:57. From the three voltage data, it can be seen that the highest average voltage is found in the T voltage with Neutral.

From the graph in Figure 10, it can be seen that the voltage between phases has a difference that is not too large. It can be seen that the voltage spike occurs when starting the motor at 17:43. The above results show the voltage between phases during the operation of a 3-phase induction motor for 20 minutes.

3. *3-Phase Motor Current Measurement*

From table 3, it can be seen that the highest current in phase R was 1.014 A at 17:55:40. The highest current for phase S was 0.979 A at 17:53:58. And the highest current for phase T was 1.094 A at 17:56:53. From the three current data, it can be seen that the highest average current is in the T phase.

It can be seen from Figure 11 that with a value of 1.094 A, phase T recorded the highest electric current, in accordance with the measurement results mentioned earlier. This shows that, compared to the other phases, phase T has the highest current load. Meanwhile, phase S had the lowest current, reaching only 0.974 A. This difference indicates that phase S has a lower load than phase T, which is reflected in its lower current.

CONCLUSIONS

Based on the results of the design, manufacture, and testing of the SCADA-based motor monitoring system design, it can be concluded that the error of PZEM 004T in measuring voltage is 0.0198% in measuring current is 0.612%. In this test, for the three PZEM 004 T as slave 1, slave 2, and slave 3 connected to the RS485 converter and directly connected to the HMI, will experience data reading errors on the HMI because the data retrieval time is too fast and not in rhythm which results in some data not being recorded.

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