Design and Construction of A Motor Control Center Panel Based on PLC and VSD for Controlling Two Induction Motors

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Article Info **:**	**ABSTRACT**
Article History : Received : 12-12-2022 Revised : 25-12-2022 Accepted : 02-01-2023 Available Online : 06-01-2023 **Keyword :** **MCC Panel,** **PLC,** **VSD**	*Motor Control Center (MCC) Panel is a control panel that functions as the control center of two or more induction motors in buildings and the industrial world. However, the induction motor control panel in PNJ electrical engineering is still a control to control one VSD, not yet to control two VSDs for two three-phase induction motors. Therefore, we need an MCC panel that implements modern industrial control using PLC and VSD so that it can be used for practical application of three-phase induction motor control in the industrial world for PNJ electrical engineering students. The method used is literature study, MCC panel design with VSD and PLC, data retrieval, and data analysis. The results obtained from this study are that two VSDs were successfully controlled from a PLC using the Modbus RTU RS-485 communication protocol. There are differences in the actual measurement results of voltage and current using measuring instruments with VSD readings up to 91.1% for voltage and 48.68% for current caused by two factors, namely human error and measuring instrument error.*

1. INTRODUCTION

In the era of industrial automation 4.0, the use of PLCs and VSDs as controllers of induction motors has become an integral part of the system because their use is able to simplify complex and expensive conventional control systems. The large number of three-phase induction motors in the industrial world means that these motors can be controlled by a centralized panel called the motor control center (MCC) panel. This panel functions to control and monitor the performance of induction motor parameters such as voltage and current (Harahap, 2016).

However, the motor control panels and MCC panels found in PNJ electrical engineering are still conventional controls. Apart from that, the control of this motor is still in the form of control for one VSD and one induction motor, not yet towards the control of two VSDs and two induction motors, because on the MCC panel there are two or more three-phase induction motors that must be controlled. Apart from that, this panel still does not yet implement industrial developments where each component is integrated or communicates with each other, so that to control it, it still requires a lot of cables to connect the components. Like the module previously created by David regarding the Design and Development of Motor Speed Monitoring and Control Systems, this module still does not utilize integration between each process component, namely PLC and VSD (Febrinaldo, 2021).

Another research was also carried out by Sevira which discussed motor speed control using the ATV610U75N4 VSD with the drawback that there was no data communication from the PLC with the VSD, so monitoring the performance of the three-phase induction motor was not possible

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(Sevira, 2021). The same research was carried out by Rais using a different VSD, namely the ATV12H075M2, which still has the same shortcomings, namely not being able to implement communication between the PLC and VSD (Rais, 2021).

There was other research conducted by Sonya using the ATV610U75N4 VSD to control the motorbike using the preset speed method from the VSD. In this research, communication between the PLC and VSD has been utilized using the Modbus RTU communication protocol. However, the supervision or monitoring carried out in this research was only motor speed, while important parameters such as voltage and current were not included in the monitoring (Sanrivo, 2021).

Therefore, it is necessary to have an MCC panel to control two three-phase induction motors using two VSDs which are controlled using a PLC. Apart from controlling, this panel is also capable of supervising or monitoring the voltage and current parameters of a working three-phase induction motor using integration between the PLC and VSD.

2. RESEARCH METHODS

The Motor Control Center panel designed in this research is designed in such a way that it is mounted on a C profile frame measuring 1 x 1 m and installed on the wall of the PNJ Electrical Engineering SCADA Room. On this panel there are two VSDs which are used to control two three-phase induction motors. Apart from control using VSD, in this panel there is also a motor starter using direct on line and star-delta methods.

The stages carried out in the motor control center panel research are as follows, as shown in Figure 1:

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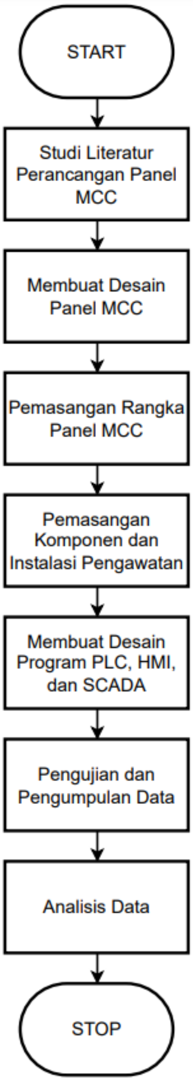

Figure 1. Flowchart of Research Stages

The process flow diagram on the MCC panel is as follows. First, the input component provides an input signal to the process component. The input components in this panel are the emergency button, thermal overload relay, VSD relay, HMI, and SCADA. To connect the HMI and SCADA with the PLC, you must use a communication protocol, namely Modbus TCP/IP which is connected via a switch hub. This input signal will be processed by process components, namely PLC and VSD. There are two VSDs used, namely ATV610U75N4 and ATV12H075M2 which are connected to the PLC using the Modbus RTU RS-485 protocol. The signal that has been processed will move or turn on the output components in the form of a contactor, buzzer and three-phase induction motor. This flow is visualized in Figure 2.

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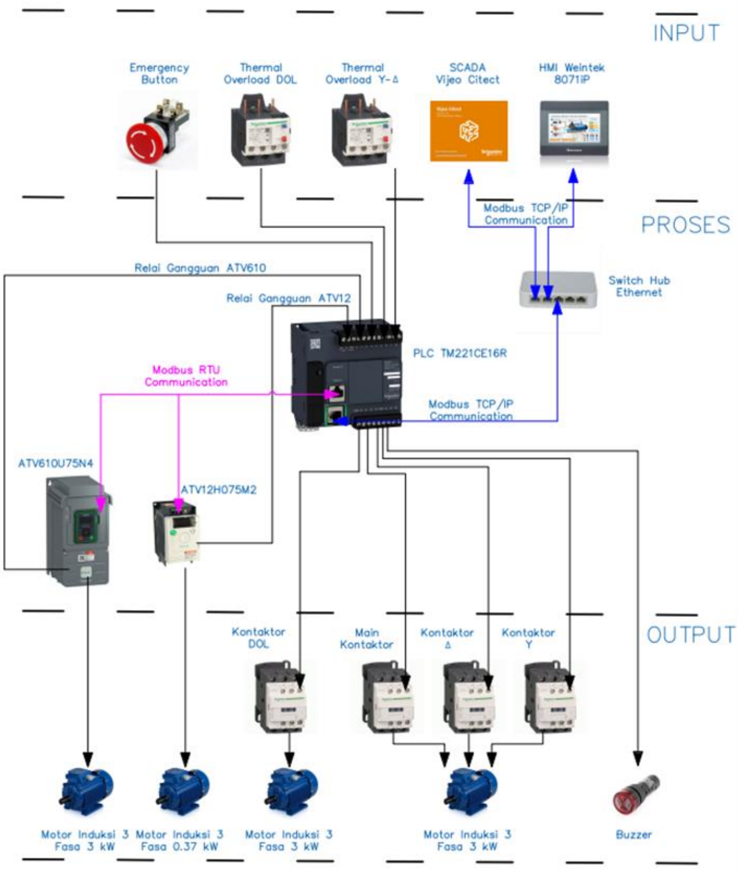

Figure 2. Block Diagram of Relationships Between MCC Panel Components

The way this panel works is that it is operated via a SCADA system or via an HMI screen connected to a PLC. There are four controls on this panel, namely direct on line, star-delta, and soft starting using VSD ATV610U75N4 and ATV12H075M2 which can be visualized in Figure 3-5.

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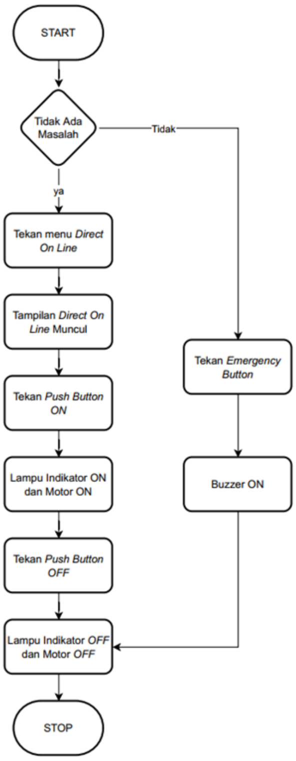

Figure 3. Direct On Line Starter Control Flow Chart

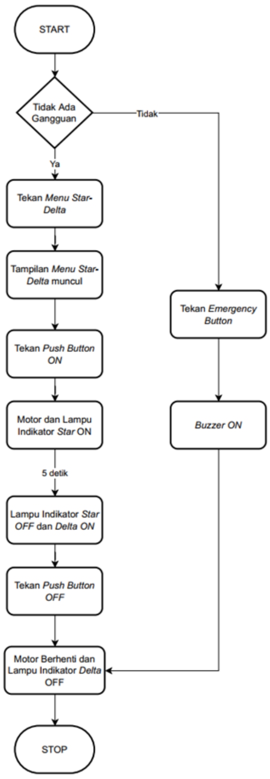

Figure 4. Star-Delta Starter Control Flow Chart

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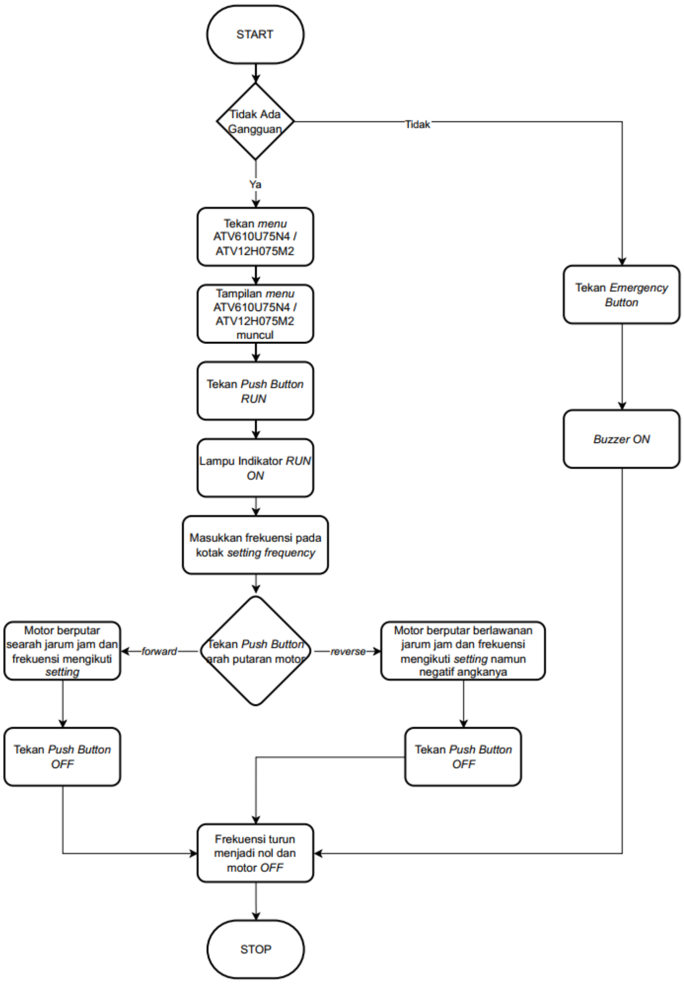

Figure 5. Soft Starting Starter Control Flow Chart for ATV610U75N4 and ATV12H075M2

3. RESULTS AND ANALYSIS

Based on the MCC panel design that has been carried out, there are two tests carried out. The first is testing the motor control center panel which aims to find out that the designed panel is working and functioning properly according to the way it works. The second is a measurement test of the suitability of the actual value which aims to determine the difference in measurement results between the VSD and the measuring instrument.

3.1. Motor Control Center Panel Testing

This test is carried out when the designed MCC panel is installed and ready to run. This test is carried out to find out that the control system created is in accordance with the way it works. Below in Figure 6 is the result of the panel design that was made.

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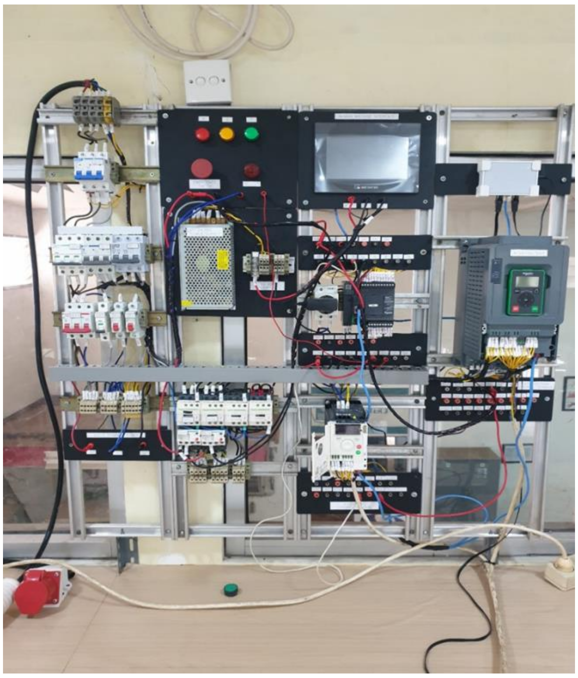

Figure 6. Realization of Motor Control Center Panel Design

Testing the motor control center panel is carried out by pressing the push button available on the HMI screen or SCADA system. From the input provided, the output or reaction given by the system can be seen according to the way it works. The results of the test can be seen in Table 1-3.

Table 1. Direct On Line Control Test Results

No.	***Input***	***Output***	**Keterangan**
1.	Pressing the ON Push Button	Motor works	Work well
2.	Press the OFF push button	Motor stops	Work well

Tabel 2. Hasil Pengujian Kontrol *Star-Delta*

No.	***Input***	***Output***	**Keterangan**
1.	Pressing the ON Push Button	The motor works in star connection	Work well
2.	After five seconds	The motor works in delta connection	Work well
3.	Press the OFF push button	Motor stops	Work well

Table 3. VSD Control Test Results

No.	***Input***	***Output***	**Keterangan**

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1.	Pressing the RUN Push Button	VSD is in RUN state	Work well
2.	Enter the frequency value	Input is received by the PLC	Work well
3.	Press the forward push button	The motor moves forward with the previous input frequency	Work well
4.	Press the STOP push button	Motor stops	Work well
5.	Press the reverse push button	Motor moves in *reverse*	Work well
6.	Current reading	Read when the motor is rotating	Work well
7.	Voltage reading	Read when the motor is rotating	Work well

Based on the data from the motor control center panel testing results that have been obtained, both the design and control program created are in accordance with the work description and the panel is ready to be used.

3.2. Actual Value Conformity Measurement Testing

In testing the conformity of the actual value with the readings made by the VSD, two measurement methods are required to be used. The actual values for current and voltage measurements are measured using a voltmeter and amperage pliers attached to the motor, while measurements made by VSD can be seen directly on the VSD screen or HMI screen. This test is carried out within 10 seconds. The results obtained from both are in the form of error percentages calculated using the equation:

$$\text{Error} = (\text{difference in measurement value})/(\text{measuring instrument measurement}) \times 100\% \quad \textbf{(1)}$$

The results obtained from this test are shown in Tables 4 and 5.

Table 4. Voltage Measurement Test Results

Parameter	**Time (s)**	**Measuring Instrument**	**VSD**	***Error***
	0	3,21 V	6,14 V	91,1%

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Voltage	2	53,1 V	93,6 V	76,38%
	4	349,9 V	327,1 V	6,53%
	6	400 V	392,9 V	1,79%
	8	399,6 V	392,3 V	1,83%
	10	399,7 V	392,4 V	1,83%

Table 5. Current Measurement Test Results

Parameter	**Time (s)**	**Measuring Instrument**	**VSD**	***Error***
Current	0	0,76 A	0,39 A	48,68%
	2	1,05 A	1,03 A	1,9%
	4	1,44 A	1,52 A	5,56%
	6	1,61 A	1,68 A	4,35%
	8	1,6 A	1,68 A	5,62%
	10	1,6 A	1,68 A	5,62%

Based on voltage and current measurement data obtained from measuring instruments and VSD, there is a very large difference in measurement results at the initial time, up to 91.1% and 48.68%. However, as time goes by, this error value gets lower. The very large difference is caused by two main factors, namely human error and measuring instrument error.

The human error factor causes differences in measurement results because the data recording time is not appropriate between the measuring instrument and the VSD, so that the recording time can differ even if only by a fraction of a second. Apart from that, clamping ampere pliers on a conductor wire that is not ideal can also reduce the level of accuracy of current measurements.

The next factor is the measuring instrument, both voltmeters and ammeters have a lower sample rate or speed of converting analog data to digital, namely 2-3 times per second compared to VSD which is four thousand times per second. Apart from that, the voltmeter used does not have a low pass filter, so it is unable to read the maximum output voltage of the PWM (Pulse Width Modulation) type VSD.

4. CONCLUSION

After testing the motor control center panel and measuring the actual values, it can be concluded that:

1. Control of two three-phase induction motors with two VSDs can be controlled and monitored by a PLC because it is connected to the Modbus RTU communication protocol;
2. Differences in actual value measurements using measuring instruments and VSD readings are caused by human error and measuring instrument errors.

5. DECLARATION OF COMPETING INTEREST

We declare that we have no conflict of interest.

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6. REFERENCES

Atmam, Abrar Tanjung, Z. (2018). Analisis Penggunaan Energi Listrik Motor Induksi Tiga Phasa Menggunakan Variable Speed Drive. *Jurnal Sains, Energi, Teknologi, & Industri*, *2*(2), 52–59.

Fauzan, S. H. (2021). Penggunaan PLC Pada Sistem Pengendalian Kecepatan Motor Listrik Dengan VSD. *Politeknik Negeri Jakarta*.

Febrinaldo, D. (2021). Rancang Bangun Sistem Pengendalian dan Pemonitor Kecepatan Motor. *Politeknik Negeri Jakarta*.

Harahap, P. (2016). *Pengaruh Jatuh Tegangan Terhadap Kerja Motor Induksi Tiga Fasa Menggunakan Simulink Matlab*. *9*(2).

Ibrahim, A. W., Widodo, T. W., & Supardi, T. W. (2016). Sistem Kontrol Torsi pada Motor DC. *IJEIS (Indonesian Journal of Electronics and Instrumentation Systems)*, *6*(1), 99–104. https://jurnal.ugm.ac.id/ijeis/article/view/10775/8070

Joko Prihartono, P. B. B. (2016). *Analisa Kinerja Mesin Bensin Berdasarkan Perbandingan Pelumas Mineral dan Sintetis* (pp. 95–104).

Rais, M. (2021). Pemrograman PLC Pada Sistem Pengendali dan Pemonitor Kecepatan Motor. *Politeknik Negeri Jakarta*.

Sevira, A. (2021). Pengaturan Parameter Inverter Sebagai Kecepatan Motor Induksi Tiga Fasa. *Politeknik Negeri Jakarta*.

Shihab, M. K., Nrartha, I. M. A., & Suksmadana, I. M. B. (2018). Analisis Arus Starting Dan Torsi Pada Motor Induksi Tiga Fasa Terhadap Pemasangan Kapasitor Secara Real Time Berbasis Atmega 2560. *Dielektrika*, *5*(2 Agustus), 99–107. http://dielektrika.unram.ac.id/index.php/dielektrika/article/view/167

Sonya Desy Sanrivo. (2021). *Pengaturan Variable Speed Drive (VSD) Pada Sistem Pengendali Kecepatan Motor*. *021*, 21–22.

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