Journal of Industrial Automation and Electrical Engineering
Vol. 02, No. 02, December 2025, pp. 29~35
ISSN: 3089-1159

Three-phase induction motor control using scalar control method based on the Internet of Things (IoT)

Nadila Rahma Putri[1], Muldi Yuhendri[1]
[1]Department of Electrical Engineering, Faculty of Engineering, Universitas Negeri Padang, Padang, Indonesia

Article Info

Article history:

Received July 17, 2025
Revised September 12, 2025
Accepted October 19, 2025

Keywords:

Induction motor
VSD
PLC CP2E-N
Modbus RTU
Internet of Things

ABSTRACT

The induction motor is one of the most widely used types of electric motors in the industrial sector due to its simple structure and high reliability. However, speed control of induction motors often requires an advanced control system to ensure both efficiency and flexibility. This final project presents the design and implementation of a three-phase induction motor control system using the scalar control method (V/f), integrated with Internet of Things (IoT) technology. The system enables users to monitor and control the motor's frequency and direction of rotation in real-time through a web-based interface developed using Node-RED. The system design involves the integration of hardware components, including a three-phase induction motor, an Omron 3G3JX-A Variable Speed Drive (VSD), and an Omron CP2E-N Programmable Logic Controller (PLC), which communicate using the Modbus RTU protocol. The PLC is programmed using CX-Programmer to implement the appropriate control logic, while the IoT interface enables users to send commands and monitor operational data remotely. Test results indicate that the system is capable of regulating motor speed linearly in response to input frequency without causing current surges, and it provides accurate, real-time motor parameter data through the dashboard interface.

Corresponding Author:

Nadila Rahma Putri
Department of Electrical Engineering, Faculty of Engineering, Universitas Negeri Padang
Kampus UNP Pusat, Jl. Prof. Hamka, Air Tawar, Padang 25131, Indonesia
Email: nadilarahmaputri2019@gmail.com

1. INTRODUCTION

The industrial world requires a system that works effectively, efficiently and reliably. Therefore, industry requires automatic technology [1]. Various industrial equipment operates based on mechanical motion, either rotational or linear. Generally, this motion is generated by electric motors. In industrial environments, a variety of electric motors are used as sources of driving power, including asynchronous motors, DC motors, servo motors, and others [2]. Induction motors can be implemented through various approaches, one of which is by automating the system as a strategy to enhance product quality, cost efficiency, and time effectiveness in order to meet the continuously growing demands of human life [3]. The asynchronous motor is one of the most commonly used types of electric motors as a driving power source in the industrial sector. Its main advantage lies in its simple design, making it more cost-effective to produce and easier to maintain compared to DC motors, which still utilize carbon brushes [4].

However, induction motors operating at constant speed require higher power, which can lead to increased electrical energy consumption [5]. In addition, excessive electricity usage often occurs during the starting process of induction motors, especially because many systems still rely on conventional methods. To address this issue, a solution is needed to reduce electricity consumption, particularly in the operation of electric motors [6]. One way to save electrical energy in motor operation is by using a Variable Speed Drive (VSD), also known as a Variable Frequency Drive (VFD). A Variable Speed Drive (VSD) or Variable Frequency Drive (VFD) is a device used to control the speed of an AC electric motor by adjusting the frequency of the power supplied to the motor [7]. The use of induction motors in industrial production processes requires an optimal control system to ensure production outcomes meet the desired targets [8]. With the current industrial advancements, induction motor control can now be automated using a Programmable Logic Controller (PLC), which can be monitored and operated through an interface known as a Human Machine Interface (HMI) [9]. This enhances communication between users and machines, while also improving the efficiency of electrical energy usage. Moreover, in today's technological landscape, an IoT (Internet of Things)-based interface is essential—an interface technology that enables devices to connect to the internet [10]. The integration of HMI with IoT in remote control and monitoring systems can enhance operational efficiency. Devices can be monitored and analyzed in real-time to ensure system performance remains within acceptable tolerance limits [11]. Several previous studies have discussed three-phase induction motors, such as IoT-based remote control of three-phase induction motors [12], speed control and monitoring of three-phase induction motors using PLC with HMI expansion [13], design of voltage control and monitoring systems for three-phase motors based on the Internet of Things using the Blynk application [14], and constant torque control of induction motors using variable frequency drive based on the Internet of Things [15].

This research presents the development of a control and monitoring system for three-phase induction motors based on the Internet of Things (IoT), utilizing a Variable Speed Drive (VSD). The system enables users to control and monitor motor performance remotely via smartphone or computer. The control system employs an Omron 3G3JX-A VSD and an Omron CP2E-N Programmable Logic Controller (PLC), which communicates using the Modbus protocol as the core control components. The IoT framework is implemented using CX-Programmer and Node-Red software, with one device functioning as a web server and another as a client for real-time control and monitoring. To improve operational efficiency, a scalar control strategy with a constant torque configuration is applied through the VSD. The proposed system was implemented on a 0.75 kW three-phase induction motor and validated through laboratory experiments to evaluate its performance and functionality. The findings demonstrate that the system effectively controls and monitors motor speed and direction. This approach is expected to enhance the efficiency and reliability of induction motor control, particularly in industrial applications where such motors are widely used.

2. METHOD

The design and development of a control and monitoring system for induction motor speed based on a Variable Speed Drive (VSD) with a constant torque configuration in this study was carried out using an experimental research method. The research stages included system design, hardware assembly, programming, and system testing through various scenarios to comprehensively evaluate the device's performance.The components used consist of hardware such as the Omron CP2E-N PLC, Omron 3G3JX-A VSD, and an induction motor, while the software was developed using CX-Programmer and Node-Red. The three-phase induction motor is controlled using a scalar method with a constant torque configuration, which allows variable speed control via the Modbus communication terminal on the PLC connected to the VSD, with input frequencies adjustable up to 50 Hz.In addition, the motor's direction of rotation can also be controlled, both forward and reverse. This system enables remote motor control through IoT connectivity using a smartphone, as illustrated in Figure 1.

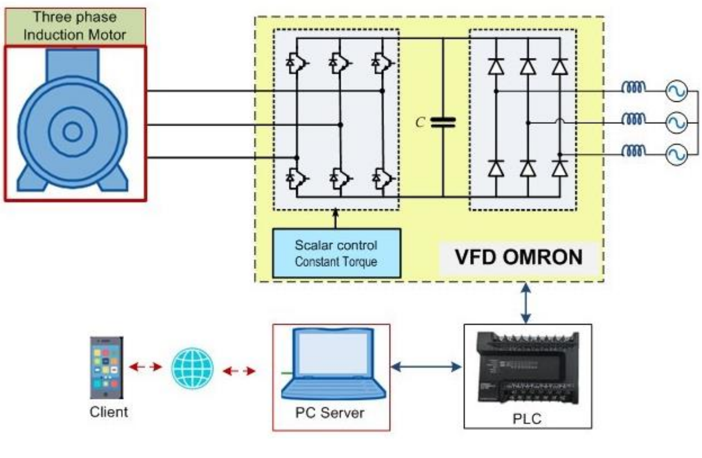

Figure 1. The scheme of proposed system

The speed control system for three-phase induction motors using an Omron VSD with the scalar control method can be implemented through several approaches, one of which is the constant torque method. This method is applied when the motor operates at a power level lower than its rated power as indicated on the motor nameplate. Under these conditions, the motor speed can be varied by adjusting the voltage or frequency below the motor's nominal frequency, as illustrated in Figure 2.

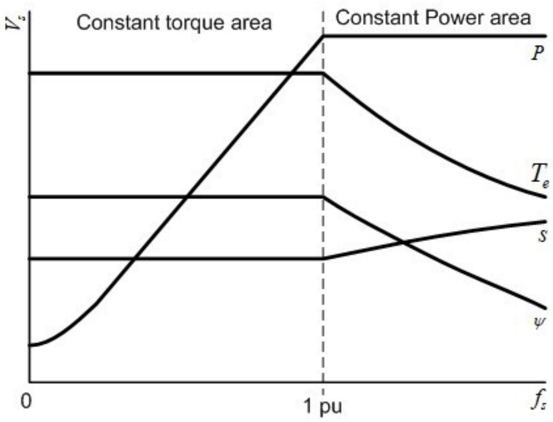

Figure 2. Operation zone of induction motor based on scalar control

The entire control process is managed through the Omron CP2E-N Programmable Logic Controller (PLC). To regulate the motor frequency, the Variable Speed Drive (VSD) is activated via the Modbus communication terminal on the PLC, which is connected directly to the VSD, as illustrated in Figure 3. Two Modbus output terminals on the PLC are utilized to vary the motor frequency and to control the direction of rotation. All terminal operations are controlled through the Human-Machine Interface (HMI) and the IoT system, allowing users to set frequency inputs and motor rotation directions. These controls are visualized and accessible via a control interface displayed on both smartphones and PC servers.

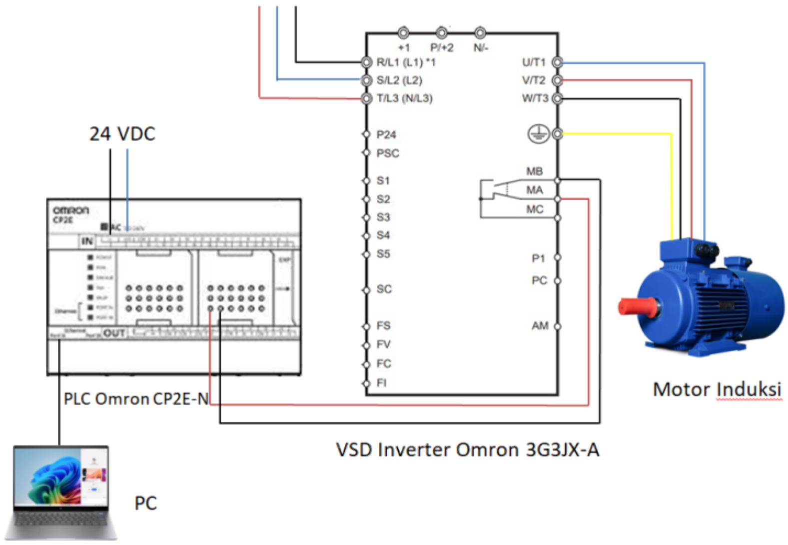

Figure 3. PLC circuit for VSD

Figure 4 illustrates the design of the control screen interface on a PC or smartphone, developed using Node-Red software. The control interface includes a main menu to start and stop the control system, configure the motor's rotation direction (forward or reverse), and set the motor's frequency input. The motor frequency input can be varied from 1 Hz to 50 Hz, which will automatically display other parameters such as motor speed, voltage, and output current. This control screen can be accessed via the Human-Machine Interface (HMI) and the internet network, using either a PC or a smartphone.

Figure 4. Display of control screen with node-red application.

3. RESULTS AND DISCUSSION

The design of the three-phase induction motor control and monitoring system using a constant torque method based on a Variable Frequency Drive (VFD) has undergone testing and validation in a laboratory setting. The testing was conducted on a 0.37 kW three-phase induction motor. This IoT-based system was operated using one PC as the server and one smartphone as the control device. The hardware installation used during the testing process is shown in Figure 5.

Figure 5. Hardware installation

The initial test was conducted by operating the motor at a low frequency with both forward and reverse rotation directions. The frequency was set to 15 Hz. The motor was operated using both the PC server and a smartphone. Figure 6 shows the control screen display when the motor is running at a frequency of 15 Hz with forward and reverse rotation directions.

Figure 6. PC server screen at first test

The control interface shown in Figure 6 demonstrates that the control and monitoring of the induction motor via the PC server were successfully carried out. The displayed frequency value corresponds accurately to the input frequency. A similar condition was also observed when the motor was operated using a smartphone and HMI, as illustrated in Figure 7.

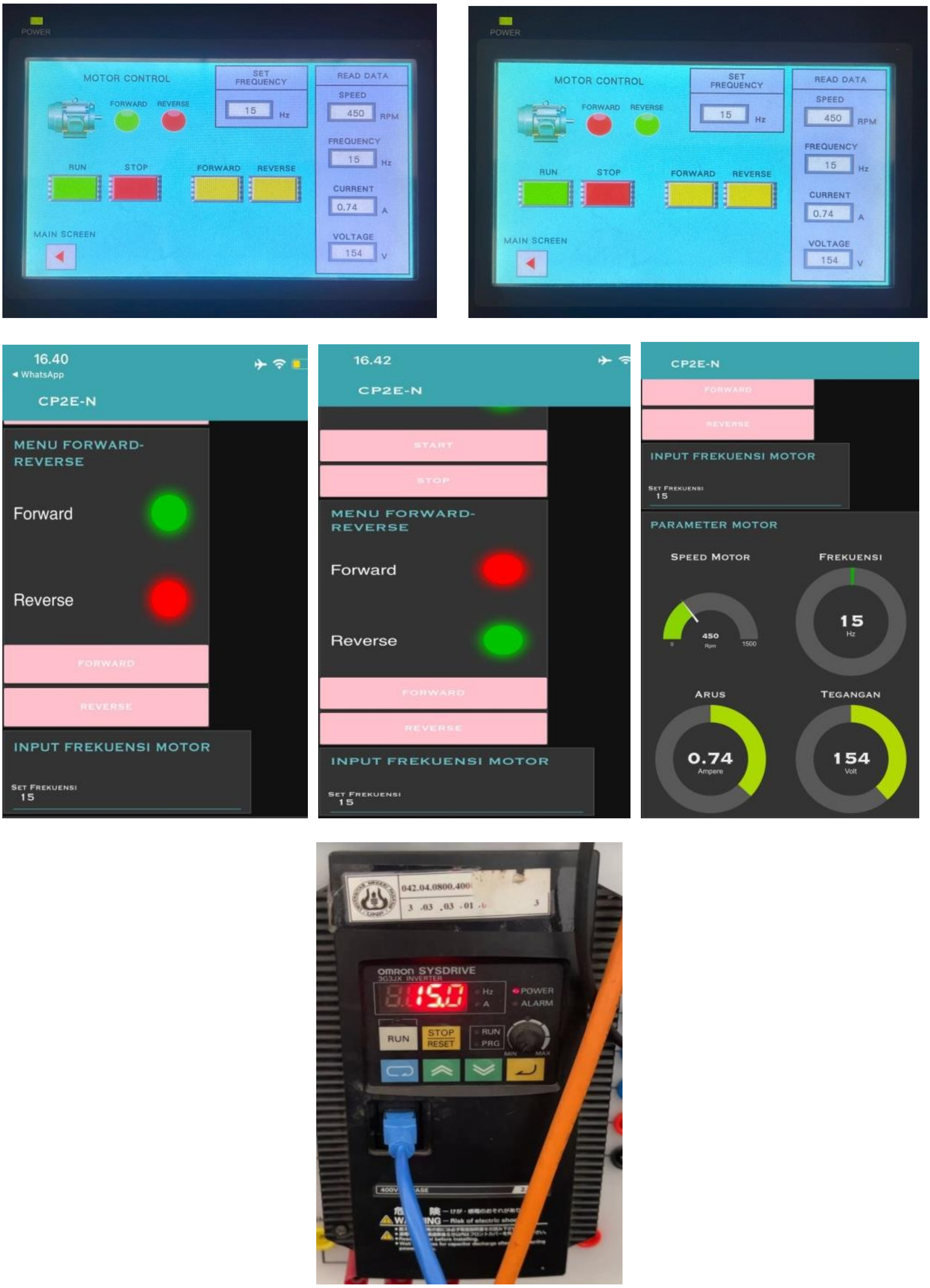

Figure 7. Smartphone screen at first test

When the motor speed is set with a frequency of 15 Hz, the motor operates at a speed of 450 rpm with a stator voltage of 154 Volts and a current of 0.74 Amperes. These results indicate that the motor is operating at a rotational speed below its nominal speed of 1500 rpm. Additionally, the motor voltage is also below its rated voltage. This confirms that the motor is operating within the constant torque zone. Subsequently, testing was carried out with variations in frequency and rotation direction. The frequency was varied from 1 Hz to 50 Hz. The test results are summarized in Table 1.

Table 1. Experimental Results

Frequency	Speed (rpm)	Voltage (Volt)	Current (A)
15	450	154	0,74
30	900	286	0,66
50	1500	462	0,61

The data in Table 1 shows that when the speed is increased to a frequency of 30 Hz, the motor reaches a speed of 900 rpm with a voltage of 286 Volts. Meanwhile, the motor current is recorded at 0.66 Amperes. These results indicate that as the frequency setting increases, the motor speed also increases. The same trend applies to the voltage value. This demonstrates that the motor speed control is achieved by varying both the voltage and frequency, which are directly proportional. On the other hand, the ratio between voltage and frequency is inversely proportional, as indicated in Table 1. At the maximum frequency of 50 Hz, the motor operates at a speed of 1500 rpm with a voltage of 462 Volts. This indicates that the motor is operating at its rated speed of 1500 rpm. These results confirm that the motor is functioning as expected.

Based on all test results, the three-phase squirrel cage induction motor control system using an IoT-based VSD and constant torque control method has successfully regulated the motor frequency and direction of rotation as intended. The motor can be effectively operated and monitored through the HMI, PC server, or smartphone connected to the internet. These findings demonstrate that the induction motor control system with an IoT-based constant torque approach has performed in accordance with the established.

4. CONCLUSION

This study developed a control and monitoring system for three-phase induction motors using a Variable Speed Drive (VSD) that utilizes the Modbus communication protocol with a PLC and is integrated with Internet of Things (IoT) technology. The control features include speed regulation, starting, braking, and direction control of the motor. All of these functions can be executed through the Omron 3G3JX-A VSD.The IoT-based system is implemented using a PLC, with a user interface accessible via HMI, PC, and smartphone. The IoT architecture was designed using the Node-Red application. The motor control system applies a scalar control method with a constant torque approach. Speed control is achieved by varying the frequency set point.Test results show that the developed system successfully controls and monitors the induction motor through HMI, PC, and smartphone. These findings demonstrate that the proposed system has operated effectively and as expected.

REFERENCES

[1] Y. Siregar, Y. R. O. Siahaan, N. N. B. Mohamed, D. C. Riawan, and M. Yuhendri, "Design of starting a three phase induction motor using direct on-line, variable frequency drive, soft starting, and auto transformer methods," *Indones. J. Electr. Eng. Comput. Sci.*, vol. 37, no. 2, pp. 700–714, 2025, doi: 10.11591/ijeecs.v37.i2.pp700-714.

[2] S. M. Goda, Y. S. Elkoteshy, A. N. Ouda, and A. E. Elawa, "Scalar Control Technique for Three Phase Induction Motor for Electric Vehicle Application," *2018 20th Int. Middle East Power Syst. Conf. MEPCON 2018 - Proc.*, no. February, pp. 705–711, 2018, doi: 10.1109/MEPCON.2018.8635187.

[3] S. Vadi, R. Bayindir, Y. Toplar, and I. Colak, "Induction motor control system with a Programmable Logic Controller (PLC) and Profibus communication for industrial plants — An experimental setup," *ISA Trans.*, vol. 122, pp. 459–471, 2022, doi: 10.1016/j.isatra.2021.04.019

[4] G. Mamatha and A. H. Thejaswi, "Induction Motor Condition Monitoring and Controlling Based on IoT," *Int. J. Res. Eng. Sci. Manag.*, vol. 4, no. 9, pp. 220–225, 2021.

[5] R. Azizipanah-abarghooee, S. Member, M. Malekpour, and S. Member, "Smart Induction Motor Variable Frequency Drives for Primary Frequency Regulation," *IEEE Trans. Energy Convers.*, vol. PP, no. c, p. 1, 2019.

[6] M. Yuhendri, Y. Siregar, D. Candra Riawan, N. Nabila Mohamed, Taali, and F. Hanifah, "Vector Control of Three Phase Squirrel Cage Induction Motor based on Internet of Things," *Eng. Technol. Appl. Sci. Res.*, vol. 15, no. 3, pp. 22312–22318, 2025, doi: 10.48084/etasr.9790.

[7] M. Dwiyaniti., Y. E. S. Situmorang., Y. D. Handoyo., H. Setiana and A. K. Wardhany, "Implementation of IoT on PLC-Based Induction Motor Speed Control," in *2023 Int. Con. on Converging Technology in Electrical and Information Engineering (ICCTEIE)*, 25-26 October 2023.

[8] D. Kalel and R. R. Singh, "IoT integrated adaptive fault tolerant control for induction motor based critical load applications," *Eng. Sci. Technol. an Int. J.*, vol. 51, no. July 2023, p. 101585, 2024.

[9] P. M. Akotkar, V. S. Karale and A. U. Jawadekar, "Condition monitoring of three phase induction motor based on IoT",

International Journal of Electrical Engineering and Ethics, vol. 3, no. 4, pp. 1-7, August 2020.

[10] F. Hanifah, M. Yuhendri and N. Faradina, "Variable Speed Drive of Three Phase Induction Motor Based on Internet of Things," *2024 FORTEI-International Conference on Electrical Engineering (FORTEI-ICEE)*, Badung, Indonesia, 2024, pp. 119-123, doi: 10.1109/FORTEI-ICEE64706.2024.10824496.

[11] M. A. Luthfi, "Pengaturan Kecepatan Motor Tiga Fasa Dengan Arah Putar Reverse Menggunakan Variabel Speed Drive (VSD)," *Indones. J. Electr. Eng. Renew. Energy*, vol. 2, no. 2, pp. 64–69, 2022, doi: 10.57152/ijeere.v2i2.394.

[12] Z. A. Shehzad, M. A. Shaikh, M. Ariz, M. Zakariya, and A. Hussain, "IoT & ML-Based Parameter Monitoring of 3-φ Induction Motors for Industrial Application," in *2023 International Conference on Emerging Power Technologies (ICEPT)*, 06-07 May 2023, pp. 1-6.

[13] S. Madakam, R. Ramaswamy, and S. Tripathi, "Internet of Things (IoT): A Literature Review," *J. Comput. Commun.*, vol. 03, no. 05, pp. 164–173, 2015, doi: 10.4236/jcc.2015.35021.

[14] F. Hanifah and M. Yuhendri, "Kontrol dan Monitoring Kecepatan Motor Induksi Berbasis Internet of Things," *JTEIN J. Tek. Elektro Indones.*, vol. 4, no. 2, pp. 519–528, 2023.

[15] U. Syarah and M. Yuhendri, "Constant Torque Control of Induction Motor Using Variable Frequency Drive Based on Internet of Things," *Journal of Industrial Automation and Electrical Engineering.*, vol. 1, no. 1, pp. 7–12, 2024.