Implementation of induction motor control and monitoring system for blower drive based on Internet of Things

Habibi Muhammad Zein[1], Muldi Yuhendri[1]
[1]Department of Electrical Engineering, Faculty of Engineering, Universitas Negeri Padang, Padang, Indonesia

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ABSTRACT

Induction motors are widely used in industrial applications, particularly as blower drives, due to their simplicity, durability, and high efficiency. However, when operated at constant speed without considering load conditions, these motors often cause excessive energy consumption and reduced operational lifespan. This study develops an Internet of Things (IoT)-based control and monitoring system for a three-phase induction motor driving a blower by integrating Siemens Sinamics G120 Variable Speed Drive (VSD), Simatic S7-1200 PLC, SIMATIC KTP 700 HMI, and a web interface based on Node-RED. The system supports manual and automatic operation modes, with the automatic mode controlled by real-time ambient temperature readings from an LM35 sensor. The automatic control logic ensures the motor operates only when the temperature is within the range of 20°C to 37°C, automatically shutting down the motor if the temperature falls outside this range to prevent damage and inefficient operation, while the motor speed is proportionally adjusted according to the temperature within the specified range. Monitoring and control can be performed remotely via PC or smartphone using Ethernet communication based on the Profinet protocol. Testing results show that motor speed and direction can be accurately controlled and monitored in real time, with consistent data among the HMI, VSD, and external measuring instruments. This solution offers a reliable, user-friendly, and energy-efficient method for blower control in industrial environments, making a significant contribution to industrial automation by combining conventional control systems with IoT technology.

Corresponding Author:

Habibi Muhammad Zein
Department of Electrical Engineering, Faculty of Engineering, Universitas Negeri Padang
Kampus UNP Pusat, Jl. Prof. Hamka, Air Tawar, Padang 25131, Indonesia
Email: hzein013@gmail.com

1. INTRODUCTION

Industrial environments increasingly demand efficient, reliable, and intelligent systems to support automation and process optimization. Blowers are one of the most common components used in industries for ventilation, cooling, drying, and other essential applications. These blowers are typically driven by three-phase induction motors due to their robustness, simplicity, low cost, and high efficiency [1], [2]. However, when operated at constant speeds, induction motors can lead to excessive energy consumption, especially under partial load conditions, and contribute to premature equipment wear due to the use of conventional starting methods [3],[4]. To address such issues, industries have widely adopted Variable Speed Drives (VSD) such as the Siemens Sinamics G120. These devices enable dynamic control of motor speed and torque by adjusting the frequency and voltage supplied to the motor, leading to significant improvements in energy efficiency and motor longevity [5],[6]. Additionally, Programmable Logic Controllers (PLCs) and Human-Machine Interfaces (HMIs) have become integral components of industrial control systems, offering intuitive control and real-time visualization [7]. With the advent of the Internet of Things (IoT), industrial control systems are undergoing a paradigm shift. IoT technologies enable remote monitoring and control of equipment via web-based platforms, enhancing operational flexibility, predictive maintenance, and safety [8],

[9]. Node-RED, a flow-based development tool, has been proven effective for creating web-based control systems due to its modularity, ease of integration, and real-time communication capabilities [10],[11]. Prior studies have implemented IoT for motor monitoring, but most lack integration of complete control logic with temperature-based automation and real-time bidirectional feedback between VSDs and user interfaces [12],[13].

This study proposes a comprehensive IoT-based control and monitoring system for a three-phase induction motor driving a blower, utilizing Sinamics G120 VSD, a Siemens S7-1200 PLC, HMI, and the Node-RED platform. The system features both manual and automatic control modes, the latter based on real-time ambient temperature readings from an LM35 sensor. The PLC executes logic control while data visualization and remote access are facilitated through Node-RED dashboards accessible via PC and smartphones. The innovation of this research lies in its holistic integration of VSD, PLC, HMI, and IoT technologies into a seamless system for controlling motor speed and direction with real-time feedback and temperature-dependent automation. Unlike previous implementations, this system enables real-time control and monitoring with high accuracy, robustness, and practical deployment potential. The results demonstrate that this integrated approach significantly enhances the operational flexibility and energy efficiency of industrial blower systems.

2. METHOD

The research implements a control and monitoring system for an induction motor based on the Internet of Things (IoT), designed through a system architecture that involves several key components, including a temperature sensor, Programmable Logic Controller (PLC), inverter, Human Machine Interface (HMI), and a visualization platform based on Node-RED. The system aims to control an induction motor used as a blower drive while simultaneously monitoring ambient temperature conditions in real time via the internet. Figure 1 below illustrates the block diagram of the implemented system.

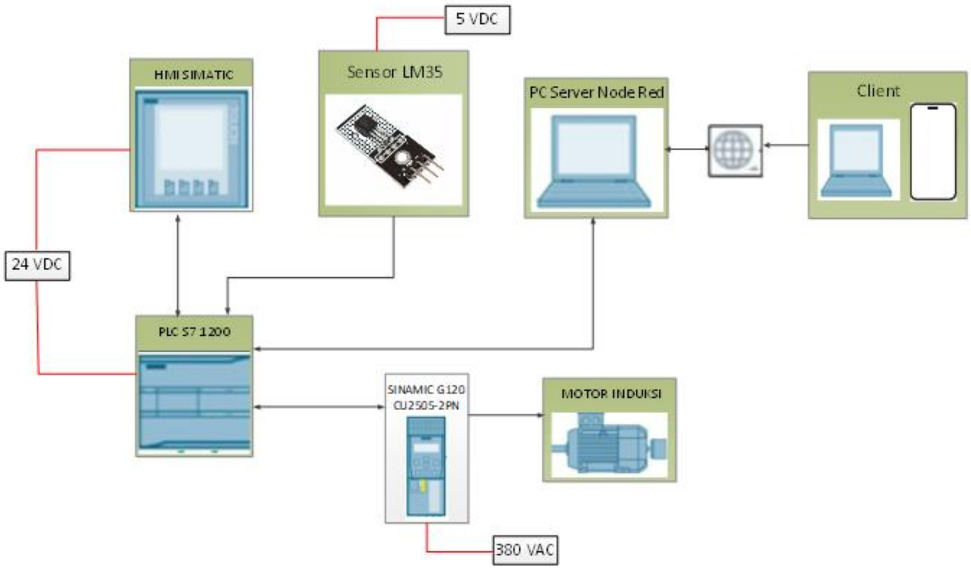


Figure 1. Block diagram system

In Figure 1, the architecture of the induction motor control and monitoring system based on the Internet of Things (IoT) is presented. The LM35 temperature sensor functions as an analog input that provides ambient temperature data to the Siemens S7-1200 PLC. This temperature data is processed by the PLC to determine the speed of the induction motor, which is controlled via the SINAMICS G120 CU250S-2PN inverter. The inverter receives control signals from the PLC to regulate the frequency and voltage supplied to the three-phase induction motor, allowing for flexible control of the blower's speed and rotation direction. The SIMATIC HMI system serves as a local interface that displays temperature, motor speed, and operational status in real time to the operator. To support remote control and monitoring, the PLC is also connected to a Node-RED-based PC server via an Ethernet network using the Profinet protocol. Node-RED acts as an IoT visualization server, providing an interactive dashboard accessible to users (clients) via laptops or smartphones through an internet connection [10].

The utilization of Node-RED as a visualization platform is highly effective, as it provides an intuitive flow-based programming interface to connect data from the PLC to the user interface. The integration of Node-RED with the induction motor control system enhances flexibility and facilitates remote monitoring. Moreover, an IoT-based control system can reduce delays in the decision-making process by enabling real-time monitoring [11]. The reliability of the temperature monitoring system is also essential to maintain motor performance and plays a crucial role in displaying temperature data and system status [12]. The use of IoT-based sensors can also be further developed to integrate current or vibration sensors to support early fault detection [13]. By combining PLC control technology, inverters, HMI interfaces, and IoT-based visualization through Node-RED, the system can provide an effective and efficient solution for the operation of blower drive induction motors, either automatically or manually, both locally and remotely [14],[15].

In the implementation of the control and monitoring system for the blower drive induction motor based on the Internet of Things (IoT), a Siemens S7-1200 PLC, SIMATIC HMI, and the Node-RED platform are used. The system is designed to operate in two modes: manual and automatic, with a control interface accessible via HMI, PC, or mobile devices. The general system workflow is illustrated in three main flowcharts as follows.

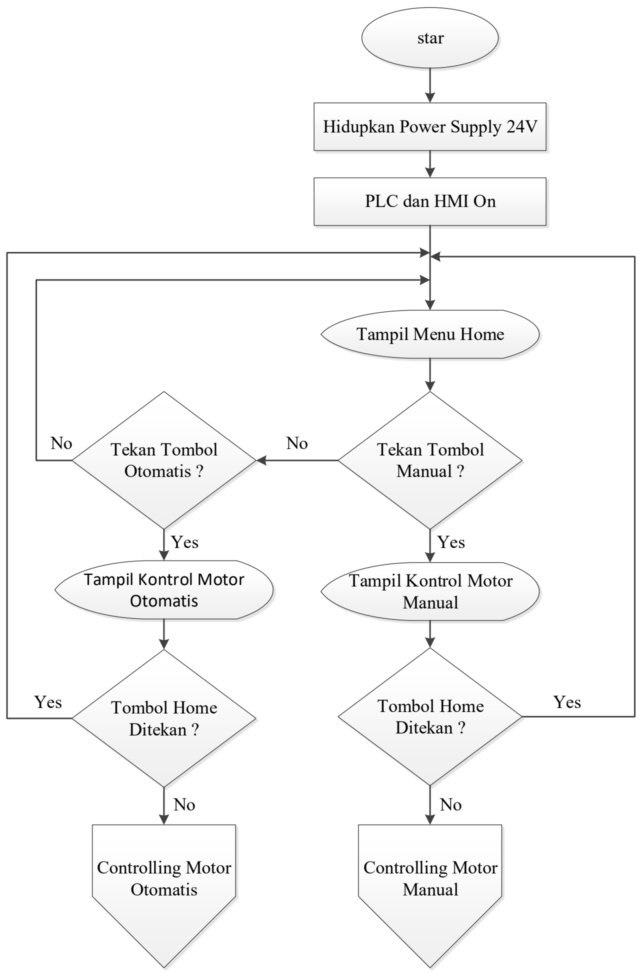


Figure 2. HMI/PC/Smartphone Monitoring Flowchart

Figure 2 illustrates the main system flow, which begins with the activation of the 24 VDC power supply, subsequently powering up the PLC and HMI. Once the system is active, the user is directed to the main menu, which displays two control options: automatic mode and manual mode. The user can select either mode and, if needed, return to the main menu by pressing the Home button. This process ensures flexibility in navigation and smooth transitions between operating modes. The manual operation mode of the system is shown in Figure 3 below.

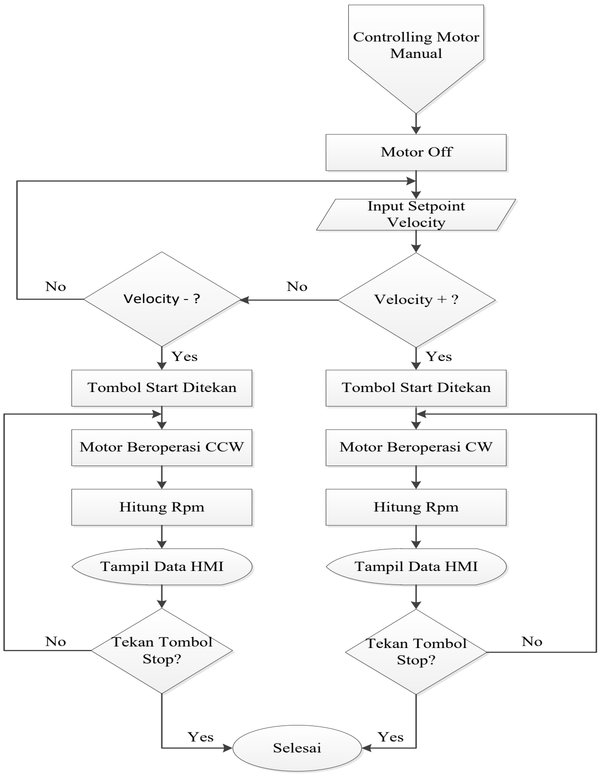


Figure 3. Manual Induction Motor Control Flowchart

Figure 3 illustrates that in manual mode, the system waits for an input in the form of a velocity value from the user. The direction of the motor's rotation is determined by the sign of the velocity value: a positive value will drive the motor clockwise (CW), while a negative value will drive the motor counterclockwise (CCW). Once the Start button is pressed, the motor will operate in the specified direction, and the system will calculate the rotational speed (RPM) to be displayed on the HMI screen. The operation will stop when the Stop button is pressed. The automatic operation mode of the system is shown in Figure 4 below.

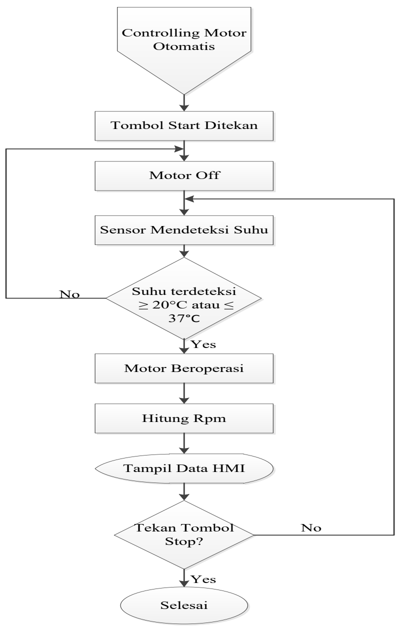


Figure 4. Automatic Induction Motor Control Flowchart

Based on Figure 4, it can be seen that in automatic mode, the system uses input from the LM35 temperature sensor to determine the motor's operating speed. After the Start button is pressed, the system reads the ambient temperature and adjusts the motor speed according to a preprogrammed temperature range between 20°C and 37°C. If the temperature falls outside this range, the motor will automatically shut off for safety and energy efficiency. The calculated speed is displayed in real-time on the HMI interface, PC, and mobile devices via the Node-RED dashboard.

3. RESULTS AND DISCUSSION

The control and monitoring system for the induction motor speed in this study was tested and verified using a trainer available in the laboratory. To observe the motor speed data displayed on the HMI and PC (Personal Computer) screens. The physical appearance of the device that has been developed can be seen in Figure 5 below.

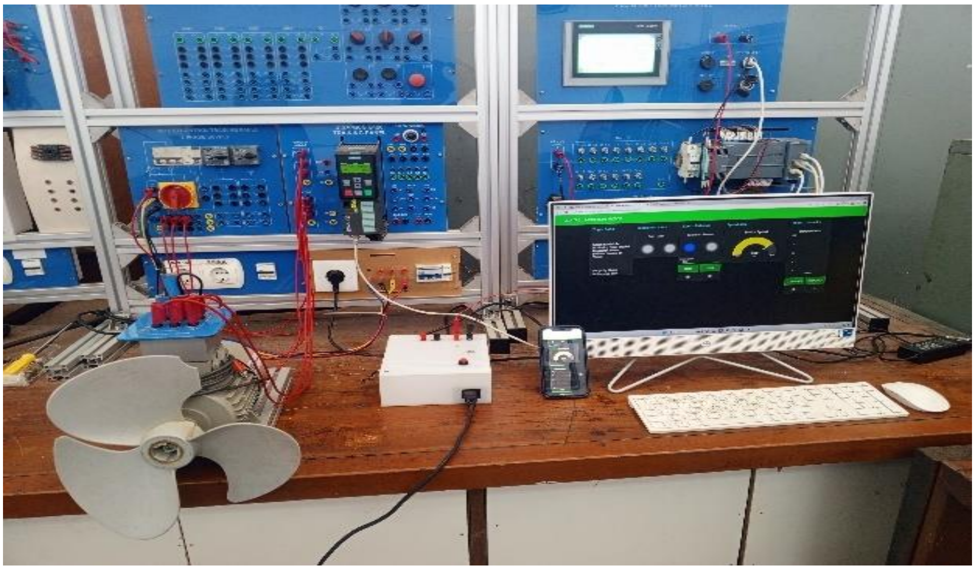
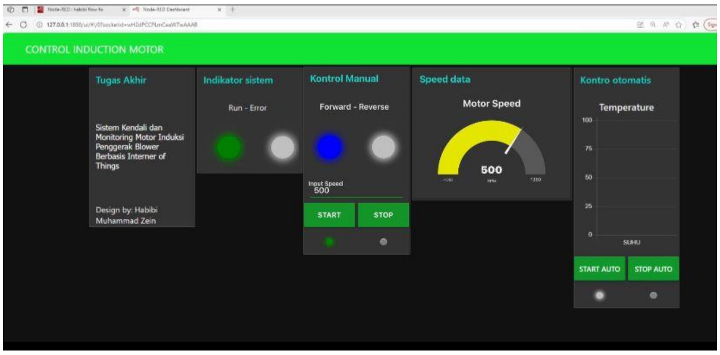


Figure 5. IoT-Based Induction Motor Control and Monitoring System for Blower Drives

The control system testing was conducted in both manual and automatic modes. In the manual mode, variations in motor rotation direction were applied, namely clockwise (CW) and counterclockwise (CCW), with a velocity value of 500 rpm. For the automatic control test, there is no need to input a velocity value; simply pressing the Start button will cause the motor to operate automatically if the detected temperature is greater than or equal to 20°C and less than 37°C. Conversely, if the detected temperature is below 20°C or above 37°C, the motor will automatically turn off. The first test was conducted in manual mode with a speed input of 500 rpm and clockwise (CW) rotation by adding a positive (+) sign in the motor setting feature, as shown in Figure 6 below.

(a)

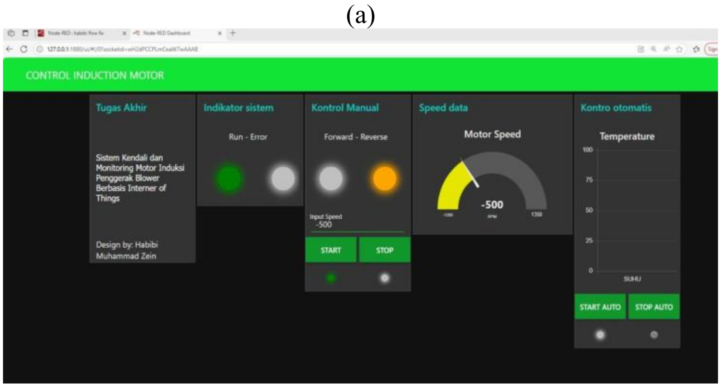


(b)

Figure 6. Manual system operation forward mode (a) HMI and (b) PC

The results of the first test shown in Figure 6 indicate that the motor can operate according to the reference values, namely at a speed of 500 rpm with clockwise (CW) rotation. This can be seen from the data displayed on the HMI screen, which matches the display on the PC. The second test was also conducted in manual mode with a speed input of 500 rpm and counterclockwise (CCW) rotation, as shown in Figure 7. The speed input set in the motor setting feature was -500 rpm, with the negative sign indicating the motor's rotation direction is counterclockwise (CCW).

(a)

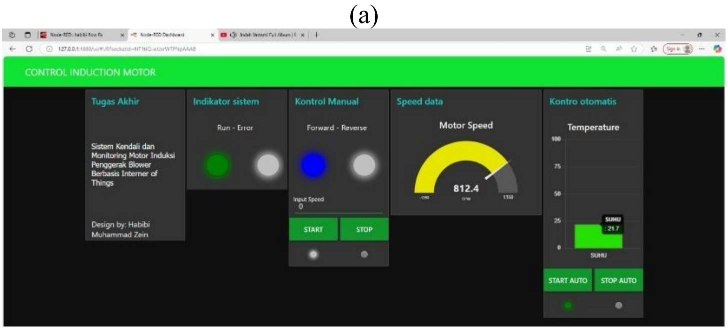


(b)

Figure 7. Manual system operation reverse mode (a) HMI and (b) PC

The results of the second test shown in Figure 7 indicate that the motor can operate according to the reference values, namely at a speed of 500 rpm with counterclockwise (CCW) rotation. This is evident from the data displayed on both the HMI and PC screens, which are consistent and show the value of -500 rpm. The third test was conducted in automatic control mode by heating the LM35 sensor so that the measured temperature reached 22°C, as displayed in the temperature feature shown in Figure 8. When the Start button is pressed, the motor operates at a speed of 812.7 rpm to maintain the temperature at no more than 22°C. If the measured temperature rises further, the motor's rotational speed will increase accordingly.

(a)

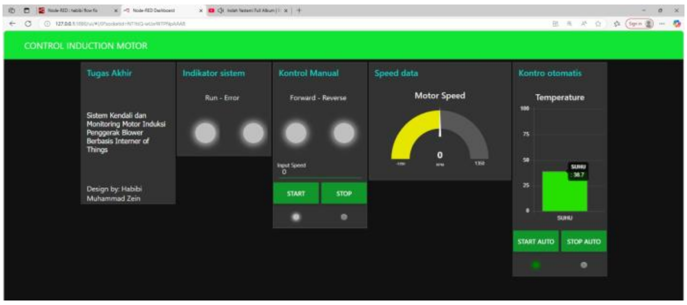


(b)

Figure 8. Automatic system operation with a temperature of 22˚C (a) HMI and (b) PC

The results of the third test show that the motor can operate according to the reference value from the measured temperature, namely at 22°C with a speed of 812.7 rpm. The fourth test was also conducted in automatic control mode, where the LM35 sensor was heated to a temperature above 37°C, specifically 39°C. The measured temperature data is displayed in the temperature feature, as shown in Figure 9 below.

(a)



(b)

Figure 9. Automatic system operation with a temperature of 39˚C (a) HMI and (b) PC

These results also indicate that the motor can operate automatically according to the reference temperature value, meaning the motor turns off when the detected temperature exceeds 37°C. The motor speed used in this test is limited to a maximum of 1350 rpm, which occurs when the sensor detects a temperature of 37°C. This limitation is set to keep the motor safe and prevent overspeed. The four test results show that the motor speed data displayed on the HMI and PC screens are nearly identical. This demonstrates that the hardware and software designed for IoT-based control and monitoring of the induction motor speed and rotation direction for the blower drive have worked well, allowing accurate motor speed measurement. The differences in speed data obtained from measurements and those displayed on the HMI screen remain within tolerance, which may be caused by external influences during testing.

4. CONCLUSION

The implementation of an IoT-based control and monitoring system for a three-phase induction motor driving a blower has proven effective in improving operational flexibility, energy efficiency, and ease of access. The system enables two modes of operation: manual mode, which allows the user to set motor speed and direction manually, and automatic mode, which adjusts motor operation based on real-time ambient temperature inputs from an LM35 sensor. Integration of the Siemens S7-1200 PLC, SINAMICS G120 VSD, SIMATIC HMI, and Node-RED platform allows for seamless real-time data acquisition, control, and visualization. System testing demonstrated that both control modes function accurately, with motor speed and direction responding as expected and data readings consistent across the HMI and external devices. The automatic control logic ensures safety by stopping the motor when temperatures fall outside the programmed range of 20°C to 37°C, while proportionally adjusting speed within that range to maintain optimal blower performance. This research contributes to the advancement of industrial automation by offering a scalable and modular solution that combines conventional PLC-based control with modern IoT capabilities. Future development may include integration of additional sensors (e.g., vibration, current) and the implementation of predictive maintenance algorithms using AI and machine learning to further enhance system intelligence and reliability.

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