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Internet of Things (IoT) implementation through Node-RED to control and monitoring induction motors

Faisal Bahri[1], Ta ali[1], Ayu Hendra[1]
[1]Department of Electrical Engineering, Faculty of Engineering, Universitas Negeri Padang, Padang, Indonesia

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ABSTRACT

The Internet of Things (IoT) is a technology that plays an important role in the contemporary era, especially in the industrial sector. The Internet of Things allows remote access of physical objects at any time and from any location, simply by establishing an internet connection. Thus, in the control and monitoring of motors remotely, IoT allows adjusting the speed and direction of rotor rotation. The motor used is a 0.75 kW Siemens induction motor. To adjust the speed and direction of rotor rotation of the motor, a Sinamic G120 programmable logic controller S7-1200 VSD is programmed via TIA Portal to serve as the central controller for all induction motor control. A multi-interface system consisting of a KTP 700 Comfort HMI, a PC server, and clients in the form of PC and smartphone clients was used for control and monitoring of the induction motor. The visual interface of the HMI interface was designed using TIA Portal, while the visual interface of the server and client was designed using Node-RED. The PC server, PLC, HMI, and VSD are all connected via Ethernet. At the same time, the connection of the Internet of Things (IoT) client, which is integrated with the server, is connected via the Internet network. Research on IoT-based control and monitoring of induction motors through the Node-RED proposal has been successful and works as intended.

Corresponding Author:

Faisal Bahri
Department of Electrical Engineering, Faculty of Engineering, Universitas Negeri Padang
Kampus UNP Pusat, Jl. Prof. Hamka, Air Tawar, Padang 25131, Indonesia
Email: faisal21012001@gmail.com

1. INTRODUCTION

The industrial world is inseparable from the control system that controls the production process, both small and large scale. The control system is generally used to control the actuators that are combined to create a machine or production tool that is integrated with each other [1]. The actuator that dominates the industrial process is the Electric motor. The application of electric motors is widely used in industry as an electric drive for various production processes, including pumps, compressors, conveyors, blowers, and other drives [2]-[3]. This is because most industrial equipment requires quite a lot of power to operate industrial equipment or machines. Thus, the induction motor is the right solution to meet industrial operations [4]. Induction motors are classified as Alternating Current (AC) motors and it is a little difficult to control the rotor rotation speed [5]. Induction motors are used to convert three-phase AC power into mechanical power. When the load on the induction motor increases, the percentage of slip increases, so that the reduction in the speed of the induction motor while the speed is constant in industry is very important [6]-[7]. However, with the development of semiconductor technology, the frequency converter method, or soft starter which includes power electronic elements such as IGBT, Thyristor, and MOSFET is used as a solution to control motors and the variable speed drive (VSD) was created [8]-[9].

PLC and VSD are two components that play an important role in the motor control system to achieve more sophisticated and efficient control over the operation of the induction motor. The PLC system is used to control three-phase induction motors with the control method mentioned V/f [10]-[11]. Using VSD provides a great opportunity to control the operation of the induction motor in terms of speed, [12] soft starting, motor rotation direction, and braking [13]. Controlling the constant speed of an induction motor using PLC and VSD provides the benefits of power savings, reducing motor starting current, and reducing mechanical stress on the motor, especially during the start interval [14]-[15]. However, the application of induction motor control in industry still uses a lot of on-site control methods or local controllers [16]. Local control requires the operator to go directly to the field to operate it [17].

This research focuses on the development of IoT that can control and monitor motors. Through the Internet of Things (IoT) is the right solution to operate electric motors, especially induction motors [18]. This provides a way to create a widely connected infrastructure to support innovative services and promises better flexibility and efficiency [19]. This means that through an induction motor control device connected to the internet, we can control the induction motor anytime and anywhere we are just by connecting to the internet [20]-[22]. In terms of advantages, IoT has many advantages for industry in terms of time, cost, and production efficiency. And the most important thing is that with the application of IoT, it means that it has supported the ease of the industrial process. Therefore, the application of IoT to induction motor control can facilitate the operation and monitoring of induction motor operations [23]-[27].

2. METHOD

Research and development of IoT-based induction motor control systems using two types of materials, namely hardware and software materials. Hardware-based materials consist of induction motors as controlled objects. PLC S7-1200 as a controller. VSD Sinamic G120 acts as an inverter that will send output according to instructions from the PLC so that the motor operates based on the wishes of the VSD G120 as in Figure 1. The software type materials used include TIA Portal to manage ladder diagrams including designing, editing, and compiling. Using Node-RED to manage flow nodes and visualization of the IoT Dashboard. And using Ngrok as a third device to make IoT accessible via an external network.

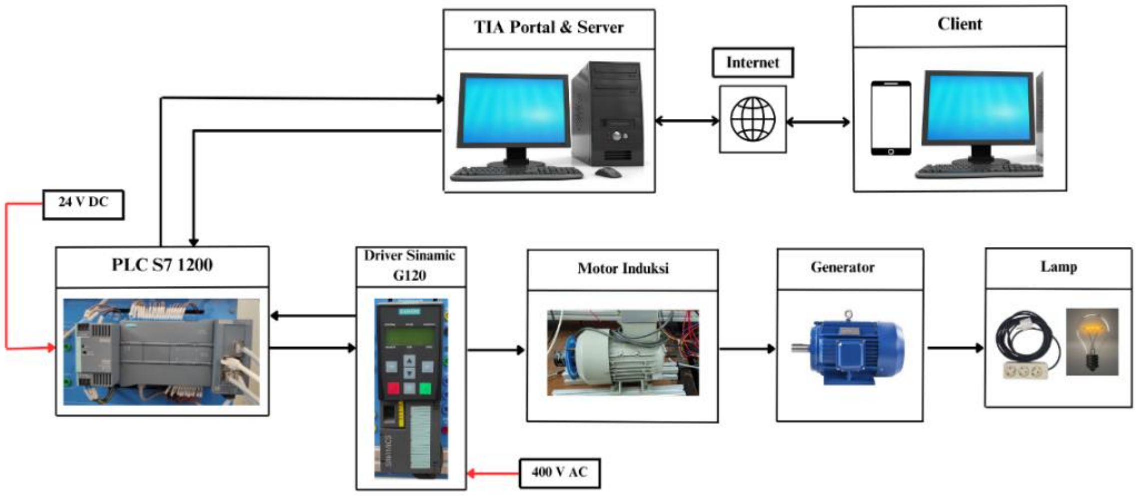


Figure 1. Diagram block of proposed system

The concept or method in the research of IoT-based induction motor control system development is in the form of direct trials using the concept of trial and error testing. In the context of hardware testing, it will be installed as in Figure 1. There are four interfaces that will control the induction motor that is integrated with the PLC S7-1200. The interfaces implemented are HMI Simatic KTP 700 Comfort, PC server, PC client, and also a smartphone as a client. Meanwhile, to create a visual IoT interface, it is made through Node-RED as in Figure 2. The nodes that make up the IoT interface consist of S7 in, S7 out, UI Pushbutton, UI LED, Function, and timer. S7 in or S7 out is the addressing in the ladder diagram. The node is adjusted to the addressing and settings in the PLC. The IoT visual interface can be seen in Figure 3. The visual interface consists of several groups. The first group tab is settings. This section contains three LED indicators. In standby mode, the LED is set with a silver background. The input speed in the settings section is where we input the motor speed value according to the motor rpm range. The last in the settings group section are three buttons, namely start, stop, and reset. The third group tab is an indicator consisting of two LEDs. The run LED on the left indicates that the system is operating and the error LED on the right indicates that the system is in error or interference so that it must be reset..

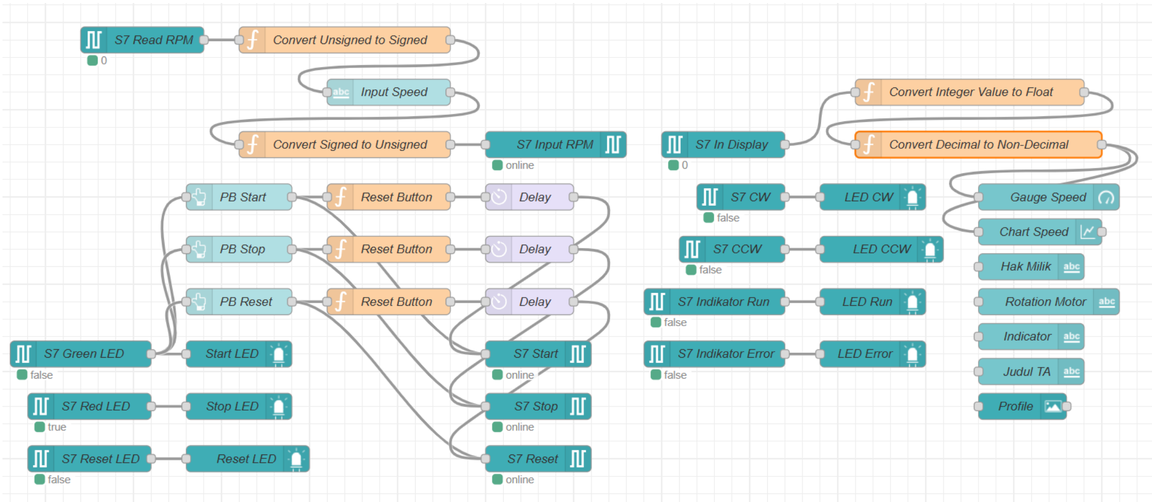


Figure 2. IoT interface flow structure

The fourth group tab is a display of motor speed in the form of gauges and graphs. The last or fifth group tab is an indication of the direction of rotation of the motor rotor. On this tab there are two indicator LEDs that indicate the direction of rotation of the rotor in forward and reverse. When the motor operates in forward condition, the right LED will be on, while when the motor operates in reverse condition, the right LED will be on.

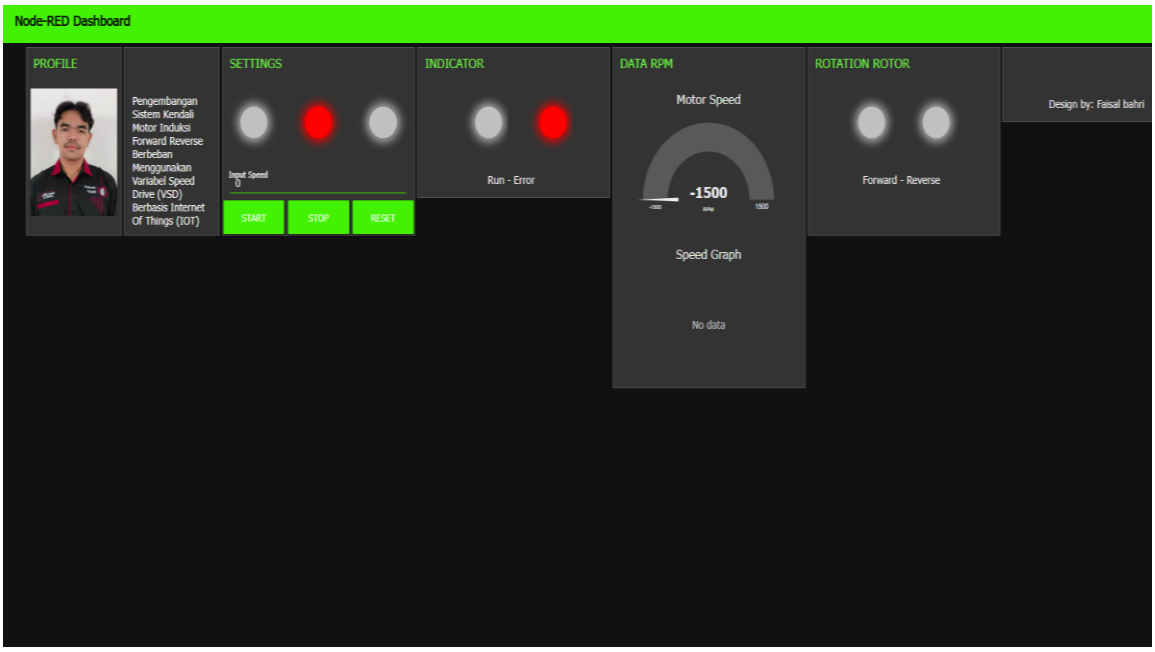


Figure 3. Visual display of the IoT interface

The working principle or flowchart of the entire control and monitoring system of 3-phase induction motor using Nodered-based IoT proposed in this study is presented in Figure. The control system process starts from the start. In this condition, the Driver or VSD Sinamic G120 and the three-phase induction motor with a cage rotor are still off. Furthermore, the rotor rotation speed value is input at the setpoint on the display with a negative rule for reverse operation and a positive value is forward operation. When the rotor rotates, the generator will also follow the same operation or in other words the generator is on. At the same time, the VSD obtains rotor speed data. Data from the VSD will be calculated by the PLC. The calculation results are then transferred to four interface displays. The next process is to press the stop button on the interface and the motor operation will end.

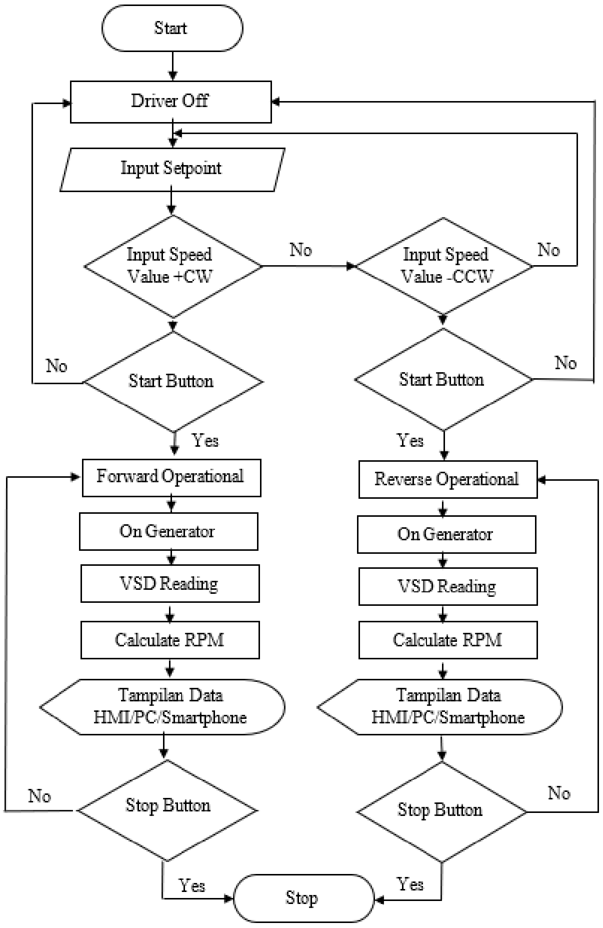


Figure 4. Flowchart of induction motor control and monitoring based on IoT

3. RESULTS AND DISCUSSION

IoT-based induction motor control and monitoring testing using Node-RED was carried out in various experiments. Namely, constant and varying load experiments, varying speeds, and so on. Figure 5 shows the test circuit schematic.

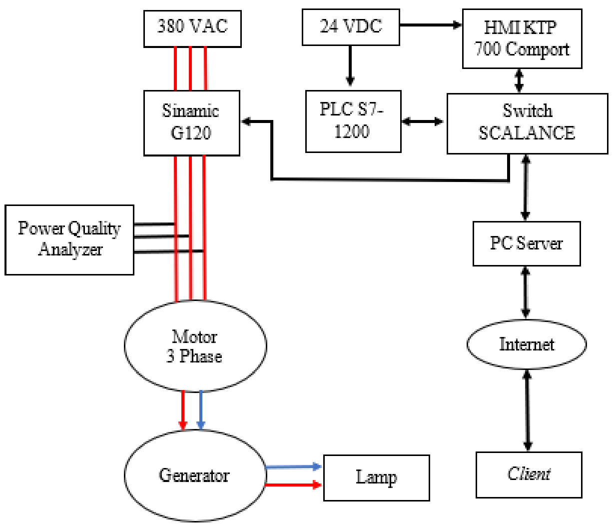


Figure 5. Experimental scheme

The trainer in the laboratory is a medium and place for testing and verification in this study. Figure 6 shows the test installation. Meanwhile, IoT testing is carried out with reciprocal testing from HMI/server to client and from client to HMI/server. HMI/server-to-client testing is testing that is carried out by controlling the speed or direction of the rotation of the motor rotor from HMI/server to client. While client-to-HMI/server testing is the opposite of HMI/server-to-client testing, which is carried out by controlling the speed or direction of the rotation of the motor rotor from client to HMI/server. Testing is carried out by controlling and monitoring the motor remotely via a different network between the server and client. The purpose of testing is to validate whether remote control and monitoring using different networks are able to control the motor and display the same rpm data on all interfaces..

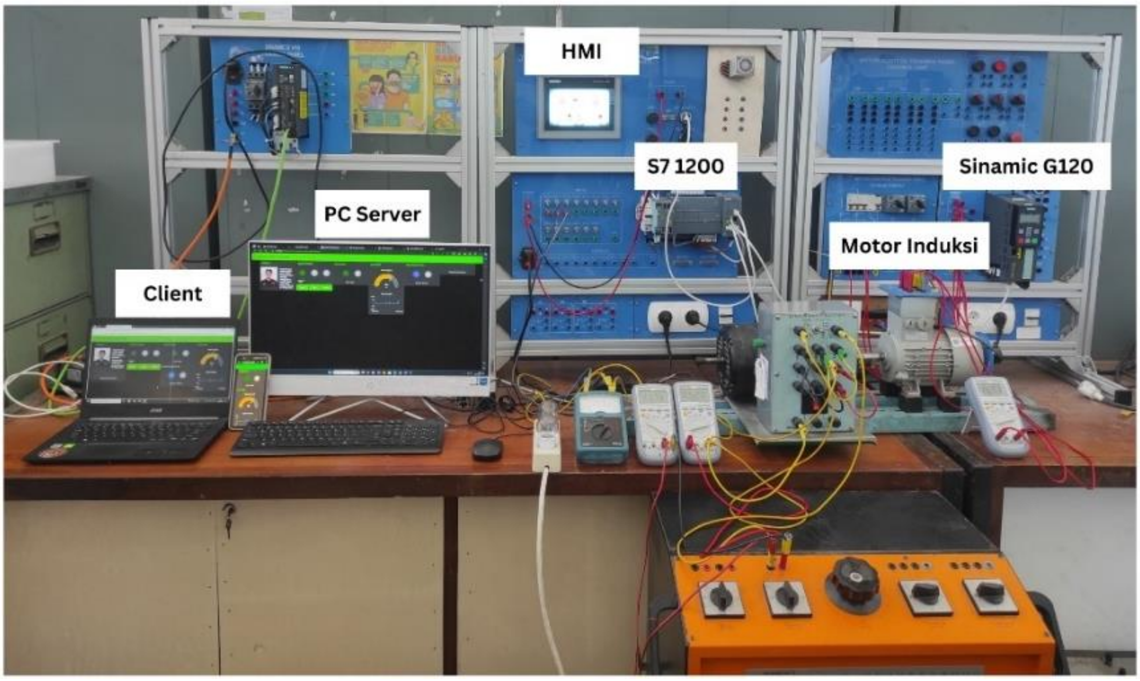


Figure 6. Hardware setup

The first test was conducted with a motor speed of 750 rpm in forward and reverse directions. Figure 7 shows the HMI display in this test. The test results show that the motor control from the HMI has worked well. The HMI has also successfully displayed the monitored motor data.

(a)	(b)

Figure 7. HMI display at first experiment, a) forward operation, b) reverse operation

Figure 8 shows the display of the server PC, client PC and smartphone which function as IoT devices in the first test. Figure 8 shows that all displays of the interface work well. The PC server, PC client and smartphone can control and monitor the operation of the induction motor.

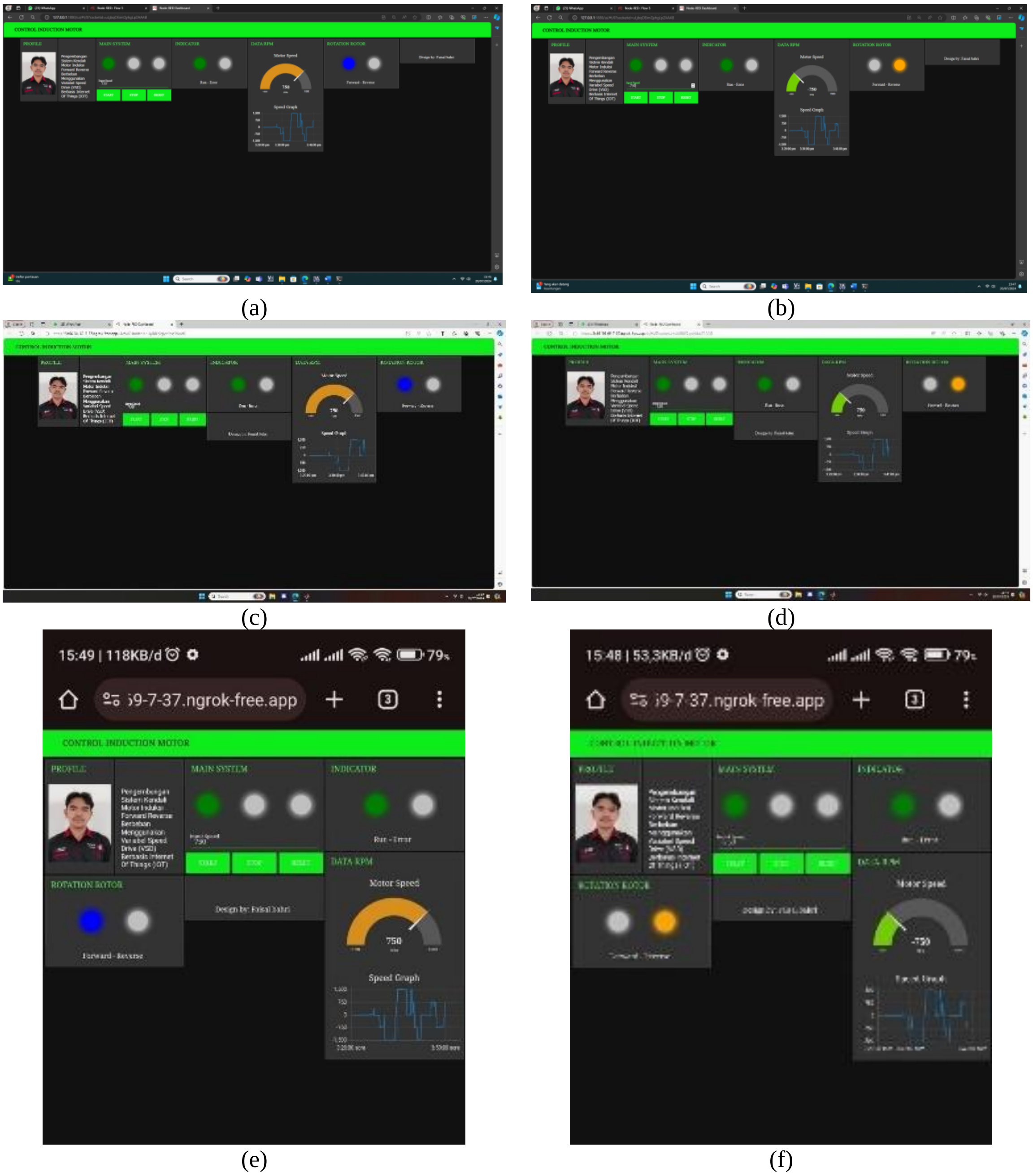
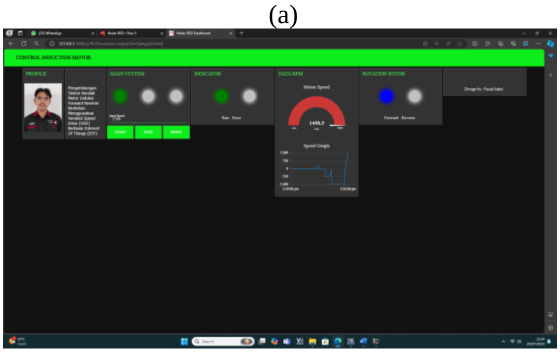


Figure 8. Diplay of IoT interface at 750 rpm, a) forward operation in PC server, b) reverse operation in PC server, c) forward operation in PC client, d) reverse operation in PC client, e) forward operation in smartphone, f) reverse operation in smartphone

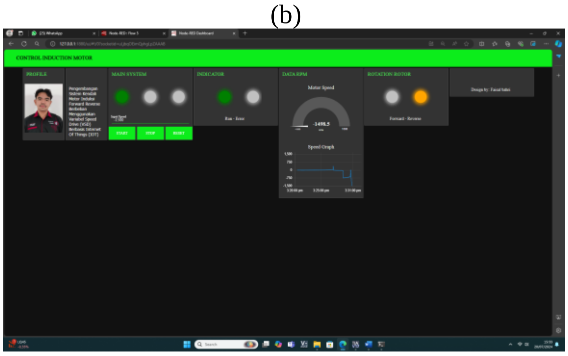
Testing from HMI/server to client in Figure 7-8 shows that remote motor control using different networks between server and client can control the motor in terms of rpm and rotor rotation direction. Operation with an rpm value of 750 makes the motor operate in forward condition and is marked by the active LED forward. While for operation with an rpm value of -750 makes the motor operate in reverse condition and is marked by the active LED reverse. This phenomenon also applies to the client interface display. Next is the communication test from client to HMI/server presented in Figure 9 with a rotor speed of 1500 rpm which includes forward and reverse operations.

(a)

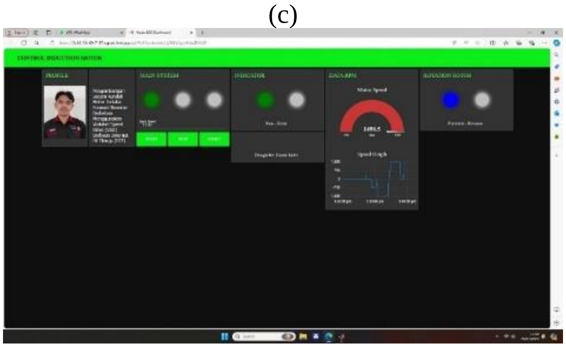
(b)



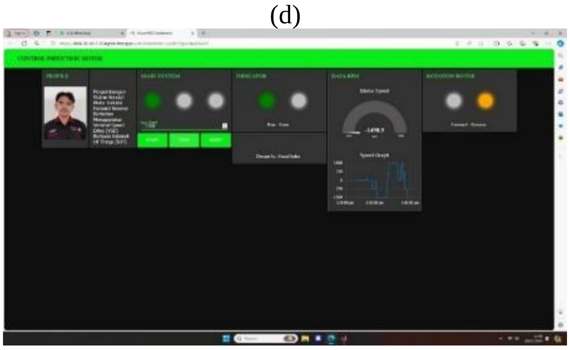
(c)



(d)



(e)



(f)

(g)

(h)

Figure 9. Diplay of IoT interface at 1500 rpm, a) forward operation in HMI, b) reverse operation in HMI, c) forward operation in PC server, d) reverse operation in PC server, e) forward operation in PC client, f) reverse operation in PC client, g) forward operation in smartphone, h) reverse operation in smartphone

Testing from client to HMI/server in Figure 9 with operational rpm 1500 makes the motor operate in forward condition and is marked by the active LED forward. While for operation with rpm value -1500 makes the motor operate in reverse condition and is marked by the active LED reverse indicator. This phenomenon also applies to the HMI/server interface display. Testing also shows that remote motor control using different networks between the server and client can control the motor in terms of rpm and rotor rotation direction.

4. CONCLUSION

Controlling induction motors using IoT via Node-RED proposed in this study using the S7-1200 controller and Sinamic G120 as induction motor drivers has been successful as expected, IoT in this study can be accessed from client to HMI/PC server and from HMI/PC server to client via external or non-local networks anywhere and anytime. The research results obtained have proven that induction motors can be controlled remotely via IoT. The control and monitoring system is made with three interfaces that are integrated with each other. The interfaces are HMI, PC server, and client. The interface also successfully displays data on rotor speed and direction of rotation of the induction motor.

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