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Forward Reverse Starter Motor Control With Internet Of Things (IoT)

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Abstract: The project aims to develop a motor control system integrated with IoT technology. The system utilizes an ESP8266 microcontroller as the main control unit, a current sensor for input monitoring, a relay for motor control, and an LCD display to visualize the motor's condition. The relay is connected to the contactor, allowing for seamless control of motor the operation. The Blynk application serves as the user interface, enabling remote motor control and real-time monitoring of the current value. The primary objective of the project is to provide convenient motor control and enhance safety through automatic motor shutdown in case of excessive current flow. The Blynk application empowers users to remotely switch the motor on or off based on their requirements. Additionally, users can monitor the real-time current value through the application, allowing for proactive identification of potential issues. The system employs the current sensor to continuously measure the motor's current consumption. If the current exceeds 6A, indicating a potential overload or fault condition, the system automatically shuts off the motor for protection purposes. This feature enhances the motor's operational safety and minimizes the risk of damage or accidents. The project combines the power of IoT technology, microcontroller-based control, and sensor integration to create a versatile motor control system. The integration of the Blynk application enables remote control and monitoring, making the system user-friendly and accessible from anywhere. As a result, user are able to turn on or off the motor by using Blynk Application and the current value measured by the current transformer almost the same with the value measured using a clamp meter. The project contributes to improved motor control efficiency, convenience, and safety in various applications, such as industrial and residential settings.

Keywords: Motor Control, IoT Technology, Remote Monitoring, Blynk Application

1. Introduction

The technology is moving towards data collection, analysis of the data, and controlling devices remotely via the Internet rather than just sharing information, and this results in a new technology called IoT [1] In the era of Industry 4.0, Internet of Things (IoT) has been a crucial component in shaping

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smart cities and advancing urbanisation [2]. IoT is a system of related sensors, computing and digital devices spread across the globe over the internet which can communicate amongst them to share and transfer information using unique id which is assigned to each and every device, as UIDs (Unique Identifiers) [3]. The Internet of Things is a new light of technology progression in the early stages of market growth. IoT has the potential to speed up the "sharing economy." So offering new techniques to manage and track minor things, it will also allow the sharing of new, minor and economic items outside the communities, aircraft, cars and motorbikes [4]. With the growth of IoT industries, various vertical IoT use cases have emerged, which require high bandwidth and reduced traffic delay in order to effectively support real-time IoT services. In this regard, the existing solutions based on a centralized IoT platform in the cloud have difficulty satisfying such needs [5].

IoT can assist real-time platforms in remotely monitoring and operating a complex production system with minimal intervention from humans. Hence it can be beneficial for hazardous industries, such as mining, by increasing the safety of personnel and equipment while reducing operating costs. However, a fully integrated automated system is challenging in practice due to infrastructural limitations in communication, data management and storage [6].

Many methods can be used to start large AC induction motors. Choosing the proper starting method for a motor includes an analysis of the power system as well as the starting load to ensure that the motor is designed to deliver the needed performance while minimizing its cost [7]. If a motor is to be driven in both forward and reverse, then it will need a Forward / Reverse motor starter. This type of starter has two contactors that are rated for three-pole horsepower, whereas a conventional starter only has one of these types of contactors. The motor is powered by both of the different motor starters, and each of them produces a different phase rotation. At the motor, power contacts are what connect line L1 to terminal T1, line L2 to terminal T2, and line L3 to terminal T3 when the forward contactor is activated. At the motor, the power contacts connect line L1 to T3, line L2 to T2, and line L3 to T1 when the reverse contactor is energized [8]. Figure 1 shows the connection of the forward reverse starter motor.

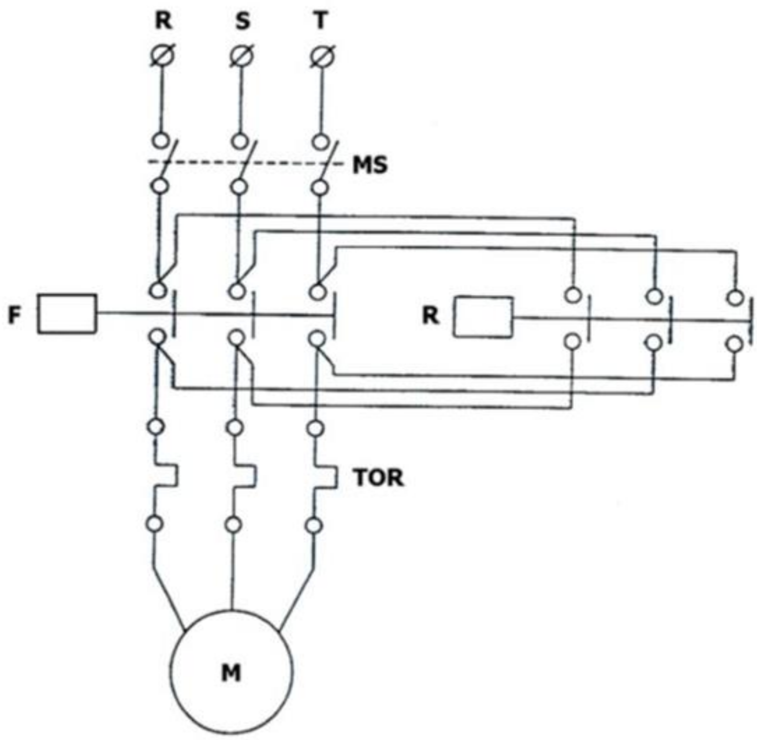


Figure 1: Connection for Forward Reverse Motor [8]

Take note that the two contactors need to be electrically and mechanically interlocked in order for there to be no possibility of both of them being energized at the same time. Interlocking prevents some action from taking place until some other action has been performed In the case of reversing starters, interlocking is used to prevent both contactors from being energized at the same time, This would result in two of the three-phase lines being shorted together. Interlocking forces one contactor to be de-energized before the other one can be energized. There are three methods that can be employed to ensure interlocking [9]. If both starter coils were to become energized at the same time, a short circuit would be created, which could have potentially dangerous consequences. Starters that can operate in both forward and reverse will come equipped with two separate sets of auxiliary contacts that can function as holding contacts in either direction. They will also come equipped with two sets of auxiliary contacts that are normally closed, which will serve as electrical interlocks [8]. Figure 2 shows the control circuit for the forward reverse starter.

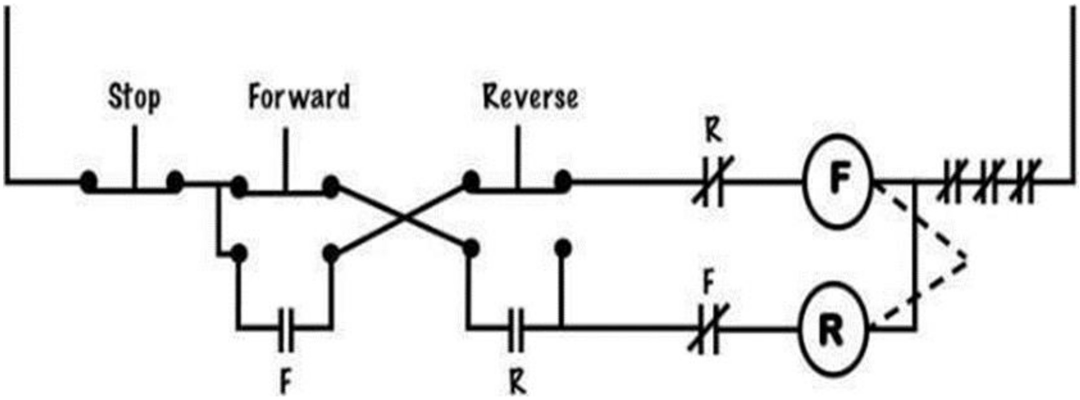


Figure 2: Control Circuit for Forward Reverse Starter [8]

This project is getting very close to managing the starter through the Internet. Therefore, high-rating motors require a secure way to operate. The most important goal of this project is to provide the appropriate level of protection for the motor as well as to provide management for the motor. We place a high priority on the safe operation of the motor because, in the scenario that it is unable to perform its primary functionality, this will result in increased costs associated with the motor's maintenance. As a result, this project was developed in order to ensure that the motor itself is safe. The user or operator will also have the power to turn on the motor and off by using the web that is created as part of this project.

2. Materials and Methods

2.1 Materials

All materials and equipment used in the project are :

a. Relay
b. Power Supply (5V)
c. Node MCU Esp 8266
d. Current Transformer (SCT-013)
e. 16x2 LCD I2C

a. Relay

The ESP8266 is connected into a 5V relay. Relay receives pulse from ESP8266, and contactor is connected to relay's output. ESP8266 receives a command to open the contactor via relay if it detects an abnormal state from the data it has collected. A relay with a single pole and one throw is employed here. The relay has a common pin, a 5V pin, a GND pin, a normally open pin, and a normally closed pin. ESP8266's internal power supply may power the relay without any additional external power source. The relay operates according to the laws of electromagnetic, when power is applied, the relay behaves like an electromagnet and causes the switch to toggle. Arduino's power supply doesn't depend on the power switch's output.

b. Power Supply 5V

The circuit wants 5V to work. DC 5V supply or a 5V battery refers to a direct current power source that provides a voltage output of 5 volts. It is commonly used in electronic devices and circuits that require a low-voltage power supply. This type of power source can be either a dedicated DC power supply unit or a battery with a voltage rating of 5V. The 5V supply or battery is typically used to power small electronic devices, microcontrollers, sensors, and other low-power components. It is a common voltage level in many electronic systems and offers a reliable and stable power source for various applications.

c. Node MCU Esp 8266

ESP8266 may be used to either host the application or to offload all Wi-Fi networking functions from another application processor through its self-contained Wi-Fi networking solution. ESP8266 has powerful onboard processing capabilities and sufficient storage that allow it to be integrated with minimal development up-front and minimal loading during runtime through its GPIOs(General Purpose input/output) with the sensor’s specific devices. ESP8266 has very low cost and high features which makes it an ideal module for the Internet Of Things (IoT). It can be used in any application that require it to connect a device to the local network or internet [10].

d. Current Transformer (SCT-013)

Current transformers are a type of sensor that can measure alternating current (AC) as well as direct current (DC). They are especially helpful for measuring the currents that are flowing in a cable wire in a non-intrusive manner, so this makes them very useful. In the fields of electrical and electronic engineering, a current clamp is a type of electrical device with jaws that can open to enable clamping around an electrical conductor. It is also sometimes referred to as a current probe. This makes it possible to measure the current that is flowing through a conductor without having to make physical contact with the conductor or disconnect it so that the probe can be inserted into it. Figure 3.9 show the current transformer and Table 3.2 show the specification of the current transformer.

e. 16x2 LCD I2C

An LCD I2C module combines the functionality of an LCD display with the convenience of the I2C communication protocol. LCDs are commonly used for displaying text and graphics in embedded systems, while I2C enables efficient communication between devices using a shared bus. By integrating an I2C interface into an LCD module, the LCD I2C module simplifies circuit design, reduces wiring complexity, and allows for easy integration into projects with limited available pins. It retains the fundamental LCD display features, while the I2C interface facilitates standardized communication, making it an efficient and practical solution for microcontroller based.

2.2 Methods

2.2.1 System Block Diagram

For this project, Esp8266 is used as a microcontroller, a current sensor as the input and LCD and relay as the output. The relay operation will be fully controlled by the Blynk application. Esp8266 manages to pull commands from the internet and sends control signals to the relay so that it can operate the motor. The information gathered by the sensors is presented graphically on the server.The control is handled by a circuit that consists of a relay and a contactor. When an abnormal value is detected, the on/off switch for the motor is triggered. Figure 3 shows the block diagram for the system.

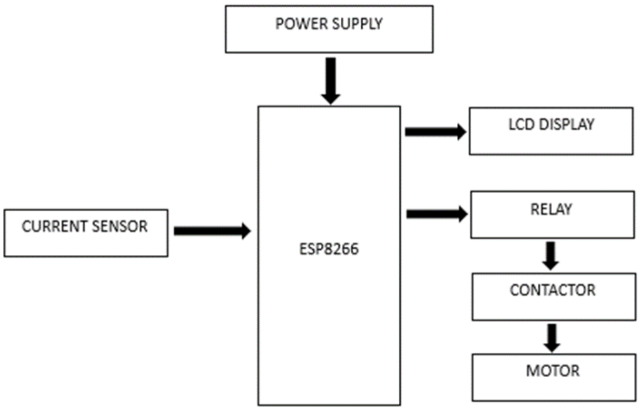


Figure 3: System Block Diagram

2.2.2 System Circuit Diagram

When the circuit is turned on with a smartphone, this starter motor control will function. After that, the contactor for the forward reverse starter motor will become energized thanks to the relay. The position of the coil relay will shift whenever the Esp8266 is given a signal to process. The contactor will become energized as a result of this action. Following that, the current sensor will function as feedback to the Esp8266. If the sensor determines that the current is higher than the exceeded value, then the relay and the contactor will both lose their electrical power. This happens when the relay detects that the current is higher than the value. That way, the motor won't keep running. The LCD will display the condition of the motor rotation. The connection between this system is shown in Figure 4.

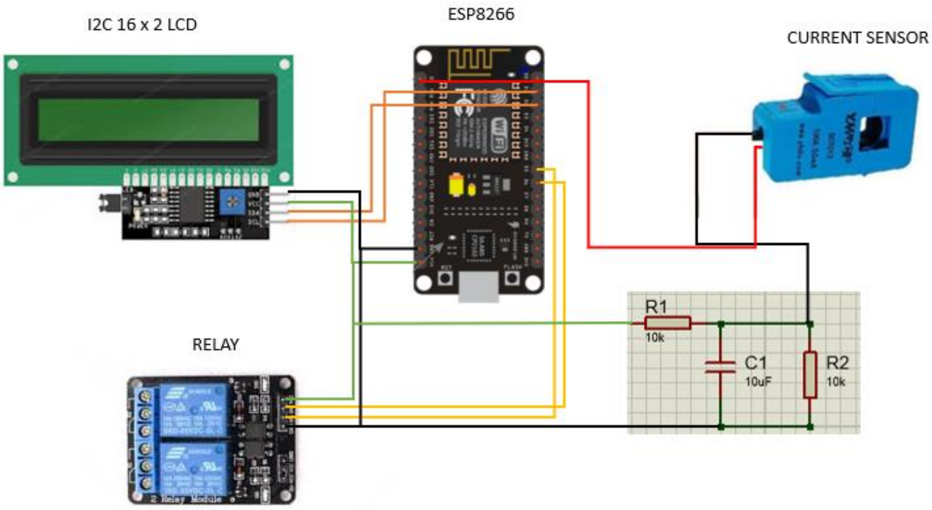


Figure 4: Circuit Diagram

3. Results and Discussion

3.1 Prototype Setup

For this project, the IoT system is connected with the forward reverse control circuit as shown in Figure 5. The IoT system consist of relay module, current transformer and ESP 8266 module. The complete control circuit with IoT system were connected with 3 phases motor. The Blynk interface is shown in Figure 6.

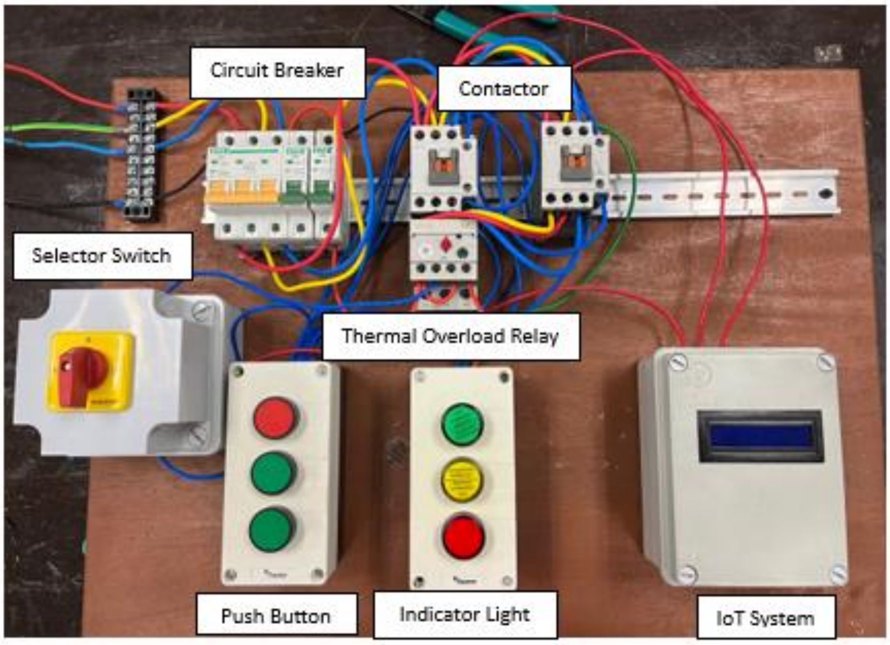


Figure 5: Prototype Setup

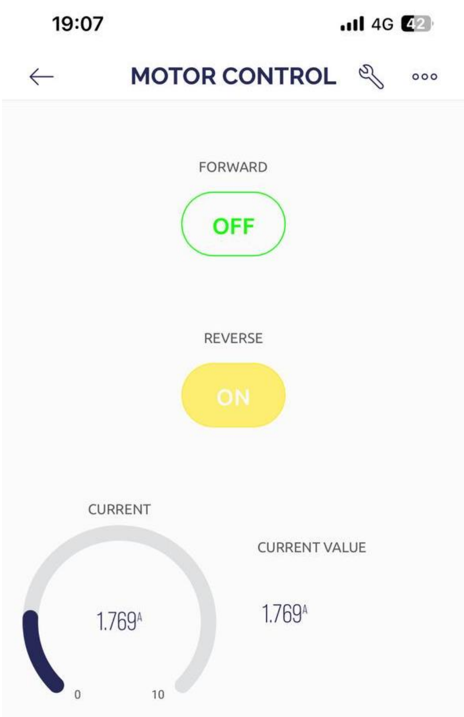


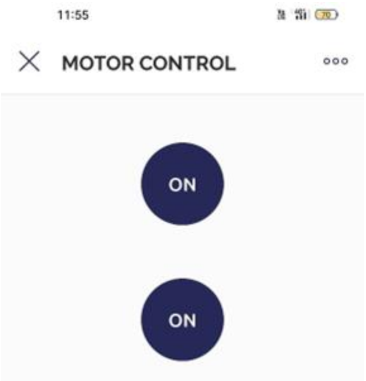
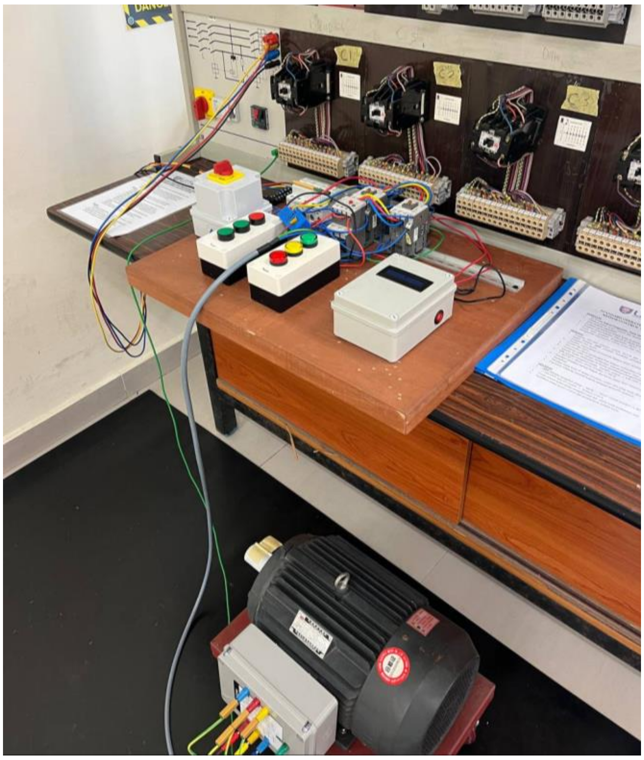
Figure 6: Blynk Interface

This chapter discusses the outcome of the project where analysis and experiments are being conducted in order to test the functionality and performance of this project that turn on and off the motor . This system is more focused on the turning on and turning off the motor that includes current value monitoring.

3.1 Control Motor by Using Blynk Application

The purpose of this test is to verify that the 3 phases can be fully controlled by using the Blynk application. Table 1 shows the hardware connection for this testing.

Table 1: Connection for Control Motor Using IoT System

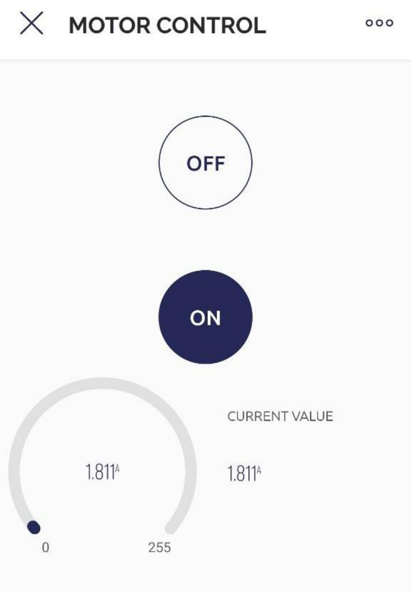
BLYNK APPLICATION	RESULT
	

As a result, when relay 1 receives a signal from the Blynk application, the relay switches to the high state and the forward contactor is activated. Then, the motor will begin to revolve forward. When relay 2 receives a signal from Blynk, it switches to the high state and activates the reverse contactor. The motor will rotate in reverse. At any one time, only one relay will be operational.

3.2 Monitoring Current Value Through Blynk Application

The purpose of this test is to verify that the current sensor can sense the current value and display the measured value in the Blynk application. Table 2 shows the result of this testing.

Table 2: Result for Current Value Monitoring Using Blynk

MOTOR CONDITION	RESULT
Forward	
Reverse	

As a result, when relay 1 is turned on, the motor will rotate forward and the gauge at the Blynk interface will display the current value measured by the current sensor. It also happens when relay 2 is turned on and the motor is in reverse rotation. The measured value will be displayed on the gauge in the Blynk interface. The results demonstrate that the user can monitor the data via the Blynk interface**.**

3.3 Measured Voltage Value

For this project, phase voltage was measured for both conditions which is, while the motor is fully controlled by the push button and also while the motor is fully controlled with IoT. Figure 7 shows the comparison of phase voltage measured while the motor in forward direction and the reverse direction is shown in Figure 8.

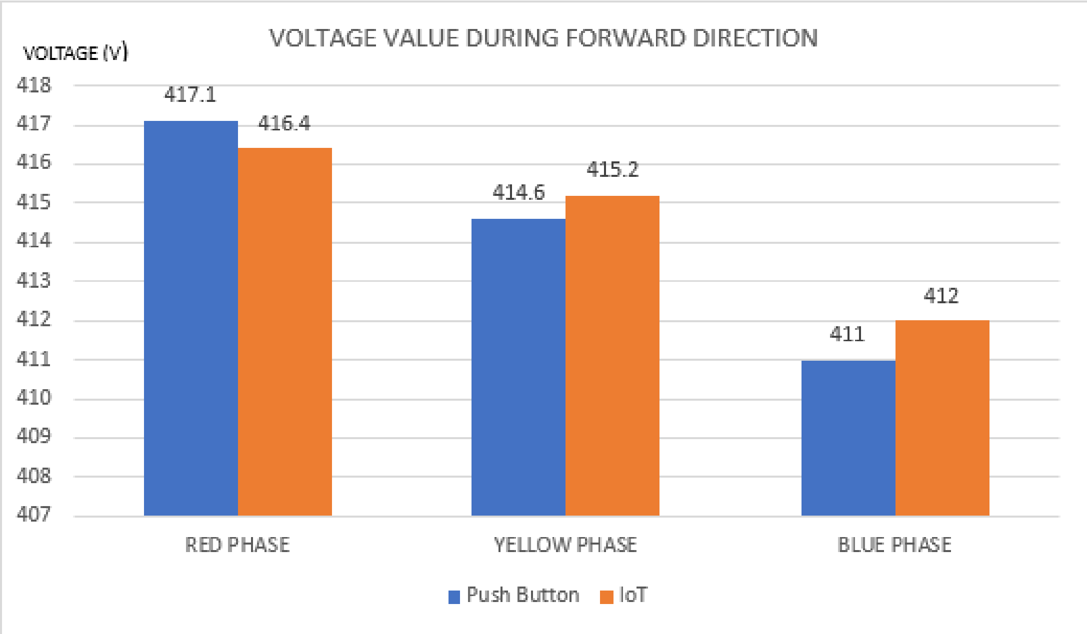


Figure 7: Measured Phase Voltage During Forward Direction

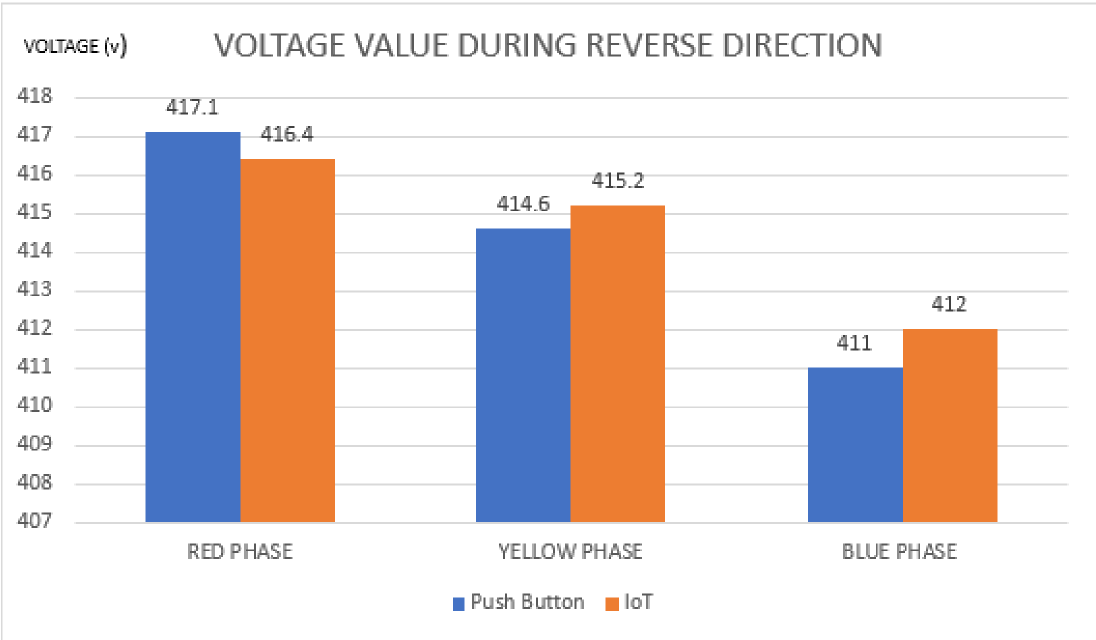


Figure 8: Measured Phase Voltage During Reverse Direction

From both graphs, the value for phase voltage during forward rotation and reverse rotation were the same. The measured value when the motor are controlled by push button is a bit different from the measured value when the motor is controlled fully by the IoT system. Small differences in phase voltage can occur due to factors such as load imbalances, system impedance, or variations in the power supply. These minor imbalances are often considered normal and do not cause substantial problems. Electrical systems and equipment are designed to operate within certain voltage tolerances to accommodate such variations.

3.4 Current Value Measured by Clamp Meter

Line current was measured using a clamp meter for this project, whether the motor was in forward or reverse rotation. The line current was measured in both conditions when the motor was controlled by a push button and when the motor was controlled by an IoT system. Figure 9 show the current value measured while motor in forward rotation and Figure 10 show the current value measured while motor in reverse rotation.

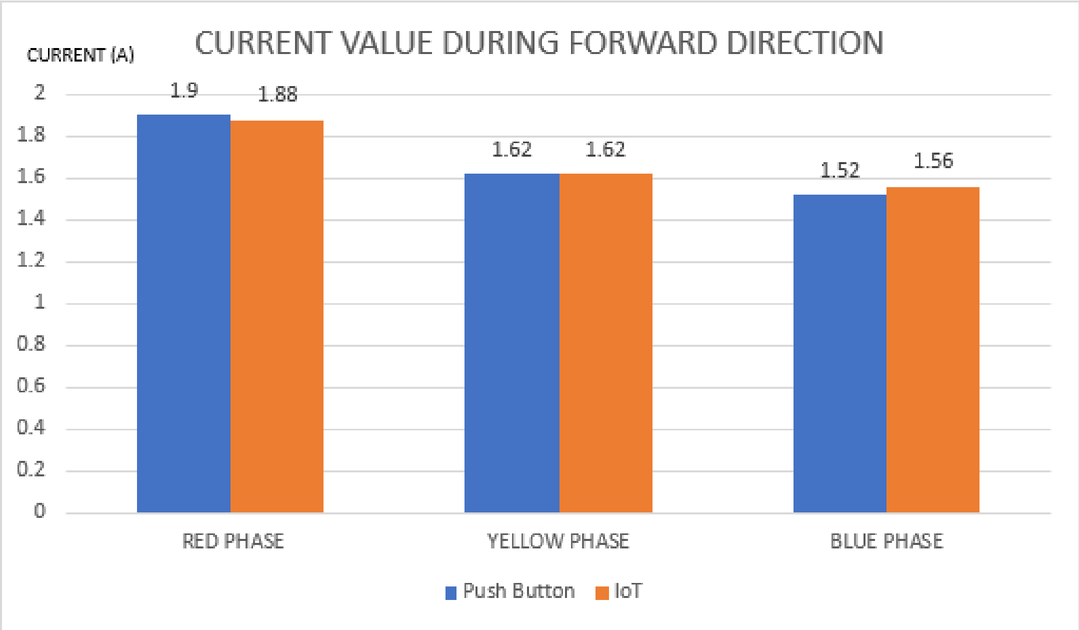


Figure 9: Line Current Measured During Forward Direction

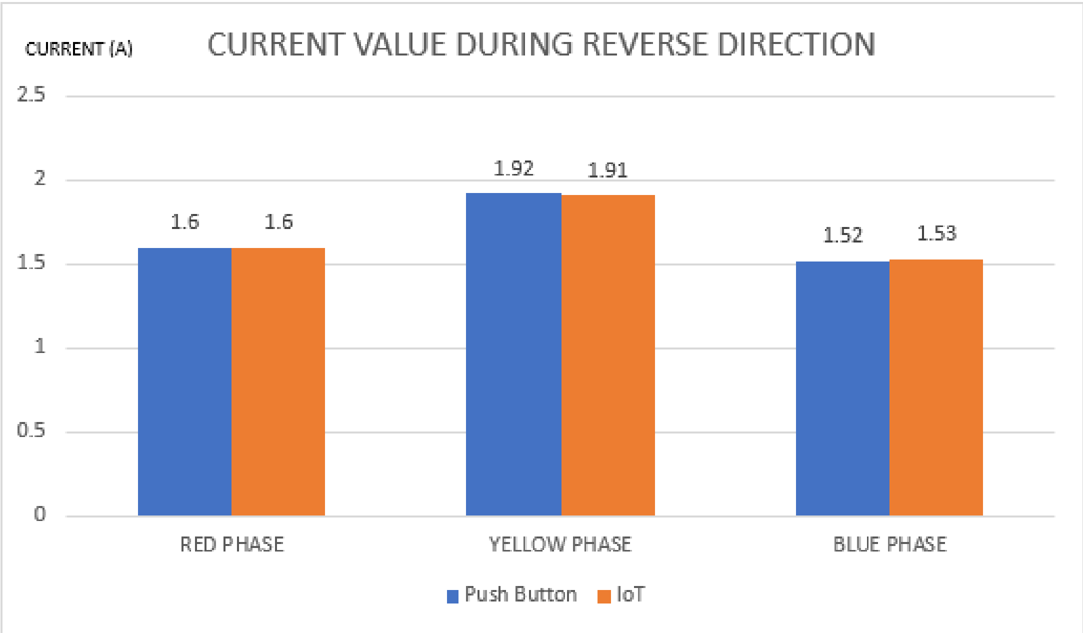


Figure 10: Line Current Measured During Reverse Direction

From the graph, during the forward rotation, the measured value of line current when motor is fully control by push button almost same with the measured value when the motor is fully control by IoT system. During the reverse rotation, the measured value for both control technique also almost the same. It is generally desirable for the line currents of a three-phase motor to be similar or balanced. Balanced line currents indicate that the electrical load is evenly distributed across the three phases of the motor.

3.5 Comparison Current Value Measured by Clamp Meter and Current Sensor

The line current was measured for this project using a clamp meter and a current sensor. This technique was carried out while the motor was totally controlled by the IoT system. The clamp meter value was compared to the value obtained from the current sensor. Table 3 shows all the measured values and also the difference in the measured reading values. Figure 11 show the measured value while motor in forward rotation and Figure 12 show the measured value while motor in reverse rotation.

Table 3 : Measured Current Value

CONDITION	PHASE	CLAMP METER	CURRENT TRANSFORMER	VALUE DIFFERENCE
FORWARD	RED	1.88 A	1.82 A	0.06 A
	YELLOW	1.62 A	1.74 A	0.12 A
	BLUE	1.56 A	1.59 A	0.03 A
REVERSE	RED	1.6 A	1.57 A	0.03 A
	YELLOW	1.91 A	1.66 A	0.25 A
	BLUE	1.53 A	1.59 A	0.06 A

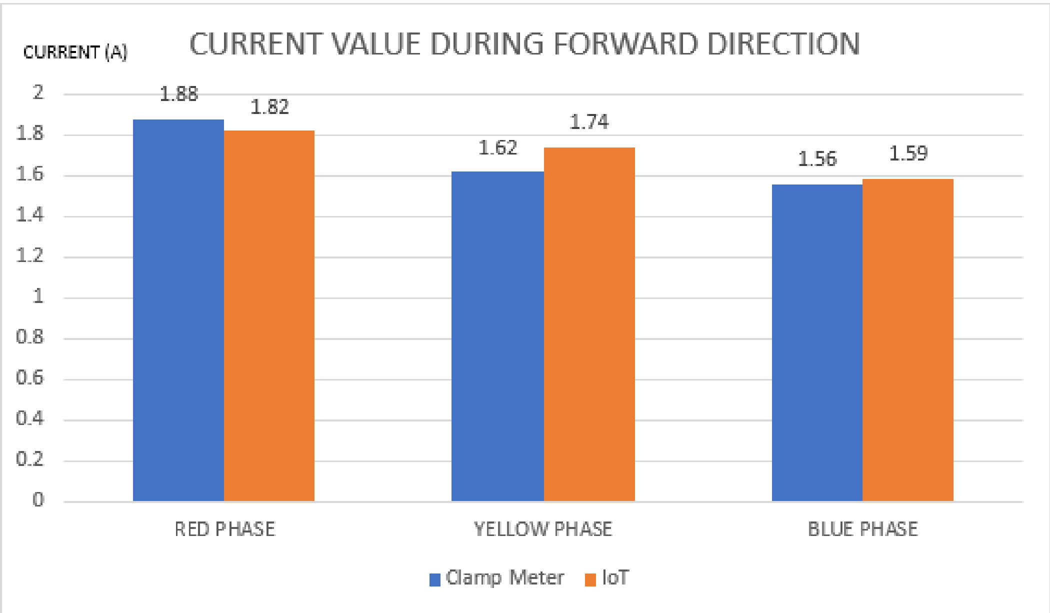


Figure 11: Line Current During Forward Direction

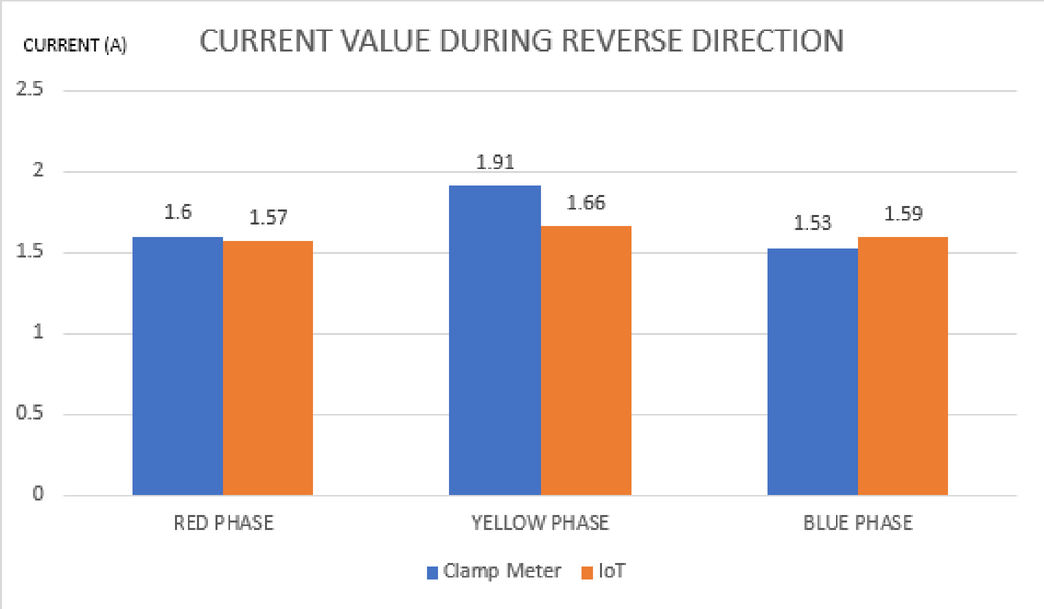


Figure 12: Line Current During Reverse Direction

As an observation from the result, it shows that the value measured by the clamp meter and current sensor during forward direction and reverse direction are almost the same. It only has a little bit different. This indicates that both measurement methods provide consistent and reliable results. Having matching measurements between the current sensor and the clamp meter is beneficial for accuracy. The fact that both instruments yield similar results indicates that both accurately measure the current. Accurate current measurements are crucial for assessing the electrical load, analysing power consumption, and ensuring the motor operates within its specified limits.

This result also shows that the current sensors are calibrated properly. Calibration is essential for ensuring that measurement instruments are accurate and reliable. Matching results from both the current sensor and the clamp meter indicate that the current sensor are properly calibrated and provides consistent measurements.

4. Conclusion

The development and implementation of the Forward Reverse Starter Motor Control with IoT project have reached significant milestones. The initial milestone involved the careful design of the IoT system's prototype using Google Sketchup. This resulted in a visually appealing representation of the physical implementation, providing a clear understanding of the system's layout and structure. Another important achievement was the integration of two module 2-channel relays connected to the contactors. This integration allows users to control the motor seamlessly in both forward and reverse directions, enhancing its operational flexibility and versatility. With the integration of the Blynk application, users can conveniently control the motor using their smartphones. This intuitive interface simplifies motor operation and improves the overall user experience. To enable comprehensive monitoring capabilities, a monitoring system was successfully implemented by incorporating a current transformer into the IoT system. This addition enables users to actively monitor and assess the precise value of the current flowing to the motor. Real-time performance evaluation and energy consumption analysis can be conducted, facilitating efficient motor management.

Overall, the Forward Reverse Starter Motor Control with IoT project has achieved remarkable milestones by combining motor control with IoT technology. It provides convenient control options and comprehensive monitoring capabilities, revolutionizing the way motor systems are operated and managed.

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