

# The motion control of three-phase motor using wireless communication: design and experimental works

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**Abstract.** This study presents an investigation on the motion control of 3 phase motor using wireless communication. The wireless communication network used is Bluetooth which supports Arduino Uno, so that the motor rotation can be controlled via a smartphone. Control system is used to adjust 3 phase motor rotation. The method used in the development of 3 phase motor rotation control system are analysis of needs, control system design, development of systems, testing and performance measurement, and improvement the system. The results of this study indicate that the 3 phase motor rotation control system can work according to the design. When Bluetooth HC-06 module receives a signal from a smartphone via Bluetooth Electronics, then the signal is sent to Arduino Uno and forwarded to DC Relay and proceed to Omron MKP3-I Relay. When using 3.0 version of bluetooth, the farthest distance that can be received by the Bluetooth HC-06 module without an obstacle is 21 m, whereas if there is an obstacle, the signal can only be received in 16 m. Meanwhile, when using 4.1 version bluetooth, the farthest distance that can be received by the Bluetooth HC-06 module without an obstacle is 26 m, whereas if there is an obstacle, the signal can only be received in 19 m.

## 1. Introduction

It is necessary important for studying motion control of 3 phase motor especially in the industrial implementation like stirring machine, grinding machine, conveyor and other liquid pump supplied [1]. Nowadays, the use of electric energy increases. Industrial Revolution 4.0 (IR 4.0) has given impetus to the industry to create a fast, safe and efficient production process. Control system plays an important role in achieving this. The control system makes production activities more efficient, faster and safer. The control system is needed in electricity centers that use many electric motors in production processes [2].

Electric motors become industrial daily necessities in all production work processes. There are many types of electric motors in the industry. 3 phase motor is a type of electric motor that is widely used by industry because it has several advantages, including simple, inexpensive and easy to maintain [1]. The objectives of the power electronics system were to control the speed of motor and also for improving the steady state characteristics and motor's dynamic [3]. Otherwise, simulation works by using MATLAB/SIMULINK model for two level inverter has been studied for solving three phase



induction motor and space vector modulation, the study through Space Vector Pulse Width Modulation technique with stepwise understanding of v/f speed control method [4].

Moreover, designing open loop system using V/F scheme to control the speed of a three-phase Induction Motor (IM) through Field Programmable Gate Array (FPGA) based Sinusoidal Pulse Width Modulation (SPWM) for a three-phase Voltage Source Inverter (VSI) with Variable Voltage Variable Frequency (VVVF) [5]. Several various techniques are implemented to control the speed of three phase induction motor, namely v/f speed control, rotor resistance control, frequency control, and stator voltage control [6].

In the control sector, currently there are still users who use conventional control systems that are carried out manually by the operator [8]. In the conventional control system, only a few plant control systems can be carried out remotely [9]. In practice, problems often occur that hinder the control process. If the controlled plant is made of hazardous materials and the operator must always monitor from a short distance, of course there is a very negative effect on the operator.

Therefore, this study is a solution for controlling the plant with a 3 phase motor actuator that can be controlled remotely. So that the control system operator will be able to monitor the plant from the desired distance according to the specified control system specifications. This study presents the design and implementation of a motion control of 3 phase motors using bluetooth signals. Operators can control it using a smartphone.

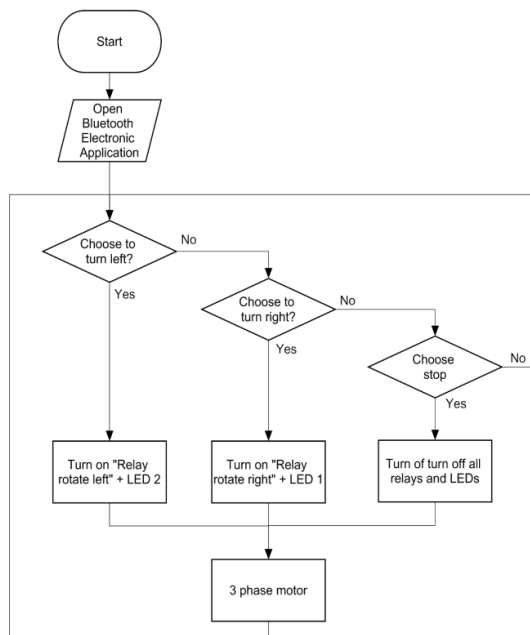
## 2. Method

In this study, an investigation on the 3 phase motor control was carried out on motion namely turn right and turn left. In this control system, processing data is processed by Arduino Uno. Meanwhile, the Bluetooth HC-06 module is used as an intermediary for communication between 3 phase motors and smartphones. Several stages are carried out in this design and implementation, namely analysis and identification of needs, system design through eagle software, development of 3 phase motor control system using Arduino IDE software, and system testing. All of these stages will be repeated until the design and implementation of the 3 phase motor control system reaches the target.

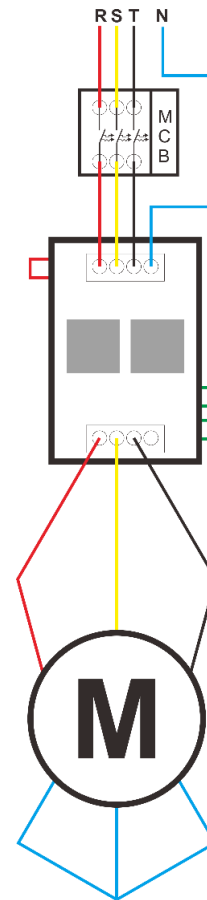
This 3-phase motor control system requires several main components, namely (a) Arduino Uno microcontroller, used to process reading data from the Bluetooth HC-06 module that receives signals from smartphones with Bluetooth Electronics application, instructs relays as outputs and ordered the 3 phase motor to turn on, turn right or left and turn off. (b) Bluetooth HC-06 module, used to receive signals from the Bluetooth Electronics application and forward them to Arduino Uno. The application is used to send signals from an Android smartphone to the Bluetooth HC-06 module. (c) Relay, as an output to rule the 3 phase motor to turn on, turn left and right turn. The relays used are DC 2 channel Relay and Omron Relay MK3P-I 220V 10A.

Figure 1 presents the 3 Phase Motor control design using Arduino Uno and Bluetooth HC-06 Module that are connected to the application on Android smartphone. The user interface on the smartphone has been developed, so that operators can control via smartphone.

Steps of testing the 3 phase motor control system using Arduino Uno and HC-06 bluetooth module. The testing steps carried out are as follows: (a) Testing the response of the Bluetooth HC-06 module using 2 different smartphones in the bluetooth version to determine the reliability of the performance of the Bluetooth HC-06 module. (b) Preparing supporting tools, namely 2 different versions of bluetooth smartphones (the author uses smartphones Xiaomi Redmi 3x and Andromax C2), distance measurer, and power supply.



**Figure 1.** Flowchart of 3 phase motor control system



**Figure 2.** Wiring diagram of tool testing

Next is (c) connecting a DC 9V 2A power supply with a 3 Phase Motor Control device using Arduino Uno and Bluetooth HC-06 Module. Followed by (d) Turn on bluetooth on smartphone and open Bluetooth Electronics application. Then (e) connect the smartphone via the Bluetooth Electronics application with the 3 Phase Motor Control tool using the Arduino Uno and HC-06 Bluetooth Module. After that, (f) Measure the distance between the tools with a distance of 1-2 meters and get away. Next, (g) Test the connection between the two devices by pressing the "Right" or "Left" button repeatedly until the connection is lost and the device cannot receive signals from the smartphone. Then, (h) Record the measured distance and input it into the recording table. (i) After finishing, replace with another smartphone device, then do the same steps as above. In the end, (j) If all have been done, then unplug the power supply and proceed to the next test.

### 3. Results and discussion

This section presents the results of testing 3-phase motor control system. Tests were carried out to determine the performance of the 3 phase motor control system with distance variation to prove whether the control system has worked as expected or not, so that in the end the system can work according to the design of the 3 phase Control Motor using the Arduino Uno and Bluetooth HC-06 Module.

There are 2 problems encountered when the 3 phase starting motor: large initial current and initial torque that is often too small. If it is turned on directly, the starting current can surge up to 7 times the nominal current of the motor. To avoid this, usually an induction motor is started with lower voltage level than its nominal voltage.

Testing of all performance of Motor Control 3 Play Phase Using Arduino Uno and Bluetooth HC-06 Module so that it works properly. The testing steps are as follows: (a) Prepare support device and a 3 phase motor that will be controlled.

Furthermore, (b) Connect the power supply and the 3 Phase Motor Control device Rotate Right-Left Using the Arduino Uno and HC-06 Bluetooth Module to 220V electricity. Next, (c) Observe the red power indicator LED. When it is on, it means the device is operating. After that, (d) Turn on bluetooth on the smartphone and open the Bluetooth Electronics application. Then, (e) Connecting the smartphone via the Bluetooth Electronics application using the 3 Phase Motor Control tool Rotating Right-Left Using the Arduino Uno and HC-06 Bluetooth Module. Furthermore (f) Assembling 3 Phase Motor Control devices Turn Right-Left Using Arduino Uno and HC-06 Bluetooth Module with 3-phase power source and 3-phase motor as shown in Figure 2. Make sure the 3-phase electric MCB is off.

After the circuit is correct, test the motor rotation by pressing the "Right" and "Left" buttons alternately. Make sure when you want to reverse the direction of rotation of the motor, the motor in the condition actually stops. Next make an observation of the indicators, namely LED 1, LED 2, and the direction of rotation of the motor.

The test that conducted by trying the connection from the closest distance until the connection is both disconnected and the bluetooth module cannot receive commands to move the relay. The first test was carried out indoors without an obstacle between the two devices.

The second test is carried out by giving obstacles, the HC-06 bluetooth module is placed in a closed room. The testing steps are carried out the same as in the first test, namely by trying the connection from the closest distance until until the connection is both disconnected and the bluetooth module cannot receive commands to move the relay. This test aims to determine the performance of the Bluetooth HC-06 module in receiving signals from Bluetooth Android smartphones with obstructed conditions. So that in its application, 3 Phase Motor Control Turns Right-Left Using Arduino Uno and Bluetooth HC-06 Module can work well. Table 1 and Table 2 present the performance of the system controller for 3 phase motor.

**Table 1.** Distance testing data on the bluetooth hc-06 module with Android smartphone's 3.0 version Bluetooth

No	Without Obstacle		With Obstacle	
	Distance (m)	Connectivity	Distance (m)	Connectivity
1	0	√	0	√
2	2	√	2	√
3	4	√	4	√
4	6	√	6	√
5	8	√	8	√
6	10	√	10	√
7	12	√	11	√
8	14	√	12	√
9	16	√	13	√
10	18	√	14	√
11	19	√	15	√
12	20	√	16	√
13	21	√	17	X
14	22	X	-	-

**Table 2.** Distance Testing Data on the Bluetooth HC-06 module with Android smartphone's 4.1 version Bluetooth

No	Without Obstacle		Without Obstacle	
	Distance (m)	Connectivity	Distance (m)	Connectivity
1	0	√	0	√
2	2	√	2	√
3	4	√	4	√
4	6	√	6	√
5	8	√	8	√
6	10	√	10	√
7	12	√	12	√
8	14	√	14	√
9	16	√	16	√
10	18	√	17	√
11	20	√	18	√
12	22	√	19	√
13	24	√	20	X
14	25	√	-	-
15	26	√	-	-
16	27	X	-	-

Based on the Bluetooth HC-06 module connectivity testing using Android smartphone's 3.0 version Bluetooth, if without an obstacle, it can be connected from 0 to 21m, and if there is an obstacle, it only can be connected from 0 to 16m. Whereas when using Android smartphone's 4.1 version Bluetooth, if without an obstacle, it can be connected from 0 to 26m, and if there is an obstacle, it only can be connected from 0 to 19m.

Based on the performance test of 3 Phase Motor Control using Arduino Uno and Bluetooth HC-06 Module, it can be concluded that this tool is able to work as expected and works well, marked with the suitability of the 3 phase motor rotation with the button pressed. When the button in the Bluetooth Electronics application is pressed "Right", the bluetooth HC-06 module receives a signal from the Android smartphone, then the signal is forwarded to Arduino Uno, and Arduino Uno sends a signal to the DC relay to activate "Relay 1" and turn on "LED 1", then the 3 phase motor rotates to the right. If the "Left" button is pressed while the 3 phase motor is still rotating, the 3 phase motor will stop 10 seconds before the 3 phase motor reverses its rotation direction by turning on "Relay 2 and" LED 2 ", and so on.

#### 4. Conclusion

This study presents the development of 3 Phase Motor Control using Arduino Uno and Bluetooth HC-06 modules and DC relays, and Omron MKP3-I relays. Performance of 3 Phase Motor Controls Rotate Right-Left Using Arduino Uno and Bluetooth HC-06 Module can control the direction of rotation of a 3 phase motor over a Bluetooth network from a considerable distance. In an open room (without an obstacle), this tool is able to connect and can control the direction of the 3 phase motor rotation as far as 26 m. As well as if this device is placed in a closed room (with an obstacle), this tool is able to connect and can control the direction of rotation of the motor 3 phase as far as 19 m.

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