

DESIGN OF CONTROL AND MONITORING OF BRUSHLESS DIRECT CURRENT (BLDC) MOTOR ON CONVEYOR USING BLUETOOTH BASED ON STM 32

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Abstract

DC motors are one of the most popular motors used in the industrial world. In operation, DC motors use a direct current (DC) source. In its application, the BLDC motor is combined with a method to make it easier to control the BLDC motor to match what is desired, one example is the Proportional Integral Derivative (PID) method, which is a control consisting of a standard configuration of K_p , K_i , and K_d whose values are determined in order to get the desired result or speed, namely speed with good stability with a small error rate and overshoot. The control system for the BLDC stepper motor nema 17 on the conveyor uses the STM32 Nucleo F030R8 module as a microcontroller and the HC-05 bluetooth module as a remote control interface on the conveyor motor. To send commands from the microcontroller to the motor, a driver is needed which is used as a data receiver and control setting from the microcontroller, namely the L298N motor driver. The monitoring system on the miniature conveyor uses an LM393 speed sensor as a stepper motor rotation speed reader and an INA219 sensor as a current and voltage reader. Sensor readings will be processed on the microcontroller and the results will be displayed on the 1.3-inch LCD screen that has been installed. In this study, it is still in prototype form, so the miniature conveyor cannot receive too heavy a load. The load is adjusted to the torque capacity of the BLDC stepper motor used, which is 0.36 N.m. In other words, the maximum miniature conveyor receives a load with a stable speed of less than or equal to 2 kg, because the load on the conveyor belt will affect the speed of the BLDC motor. With this research, it is hoped that it can be a lesson about control and monitoring systems on BLDC motors. The maximum Bluetooth range is 9 meters.

Keywords: BLDC motor, STM32 Nucleo F030R8, HC-05 bluetooth module, LM393 speed sensor, INA219 current and voltage sensor

INTRODUCTION

In today's industrial era, automation is needed to help create conditions so that people can work more efficiently and productively.... For this reason, a driving machine or motor is needed which is used as a driving medium. DC motor is one of the popular motors used in the industrial world. In operation, DC motors use a direct current (DC) direct current source.

DC motors have two types, namely brushed and brushless. In a DC motor there is a set of electromagnets whose charge can change when rotation occurs, so there will always be permanent magnets with opposite charges moving towards it and the load. The same load that the solenoid coil experiences when changing can push the coil. Brushed DC motors use brushes or charcoal brushes as a medium for transmitting power from a DC power source to the rotor. Due to contact between shafts, brushes and commutators can wear or erode. Meanwhile,

brushless motors use a permanent magnet configuration as an external rotor. In addition, brushless motors also use a three-phase drive winding as well as a special sensor that monitors the position of the rotor (Hall sensor). As the sensor tracks the rotor position, it sends a reference signal to the controller, which in turn activates the windings in a structured manner, phase by phase.

Therefore, the brushless DC motor requires an electric controller that functions as a motor motion regulator and motor rotation speed. Using digital control with a microcontroller is the right solution at this time. In its application, the BLDC motor is combined with a method to make it easier to control the BLDC motor to match what is desired, for example, the proportional integral derivative (PID) method is a control consisting of a standard configuration of K_p , K_i and K_d whose values are determined to achieve the desired result or rate, namely the speed has good stability with a small error and overshoot rate.

Previous research (Rohiman, 2013) mentioned using Arduino Atmega 2560 to determine the rotation speed of a BLDC motor using a U-shaped optocoupler, the data results are displayed on a PC / Laptop connected to the Arduino Atmega 2560 microcontroller via USB to serial port connection.

The next study (Jago, 2019) investigated DC motor speed control with the Ziegler-Nichols PID controller parameter setting method to achieve good PID mode feedback. Indeed, this method has advantages over the classical method. One of the advantages is that there is no emphasis on reducing the mathematical model of the tuned component (Factory).

Based on some of these studies, this research will create a tool that will be the development of BLDC motor control with the title "BRUSHLESS DIRECT CURRENT MOTOR CONTROL AND MONITORING (BLDC) ON CONVEYOR USING STM 32-BASED BLUETOOTH".

The Prototype method is a system development technique that uses a prototype to describe the system so that the system creator or owner has a clear picture of the system to be built by the development team. When using this type of model, errors can often be detected more quickly and feedback from users is faster to offer better solutions. In this method, a working model of the system is provided. This method can work well for defining requirements, saving system development time and making it easier to implement because it already knows what is needed.

METHODS

The research design is the method used by the author to compile the report. The method used by the author is divided into several steps as shown in Figure 1.

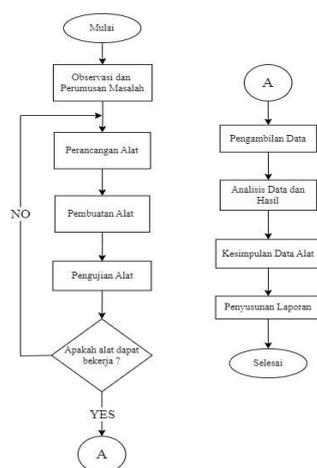


Figure 1 Research design

This research starts from observation and formulation of previous problems to find references, after obtaining references so that problems are known, followed by

problem formulation to find out how the design of this tool will be made. After formulating the problem, design and manufacture are carried out starting from the tool design method. The tool design aims to clearly describe how the tool design will be made. Enter the tool testing stage which is intended to find out how this tool design works and can find out the shortcomings and advantages of the tool. After testing this tool the data taken or that has been obtained is analyzed so that we get the results and conclusions.

In designing a tool for speed control on BLDC motors, this tool uses the PID method as a tool speed regulator. This tool uses the Bluetooth HC-05 module as a control on the BLDC stepper motor nema 17, then the data will be processed on the STM32 Nucleo F030R8 module and forwarded to the L298N motor driver. After that the command will run the BLDC stepper motor nema 17. On the BLDC stepper motor nema 17, an LM393 speed sensor is installed which functions as a speed reader on the motor, installing an INA219 current and voltage sensor used as a current and voltage reader on the BLDC motor. Then the reading results from the sensor will be displayed on the LCD installed.

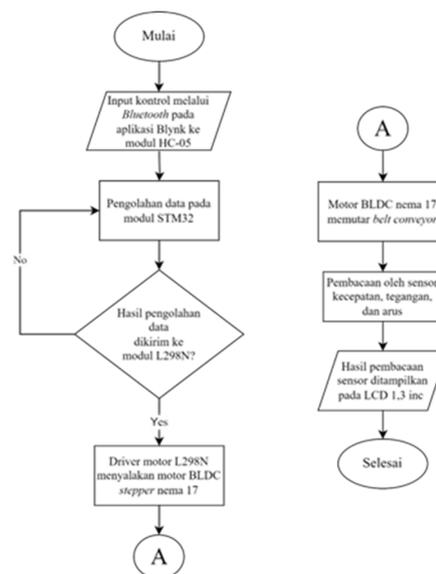


Figure 2 Flowchart of How the Tool Works

Figure 2 is the flow of the control and monitoring interface through the Blynk application which is displayed from the HC-05 module output. Then the data is managed by the STM32 Nucleo F030R8 module and forwarded to the L298N motor driver to run the BLDC nema 17 motor which is connected to the miniature conveyor as a conveyor belt drive. Then reading the motor speed using the LM393 speed sensor, reading the current and voltage of the motor using the INA219 module, and processed on the STM32 Nucleo F030R8 then displayed on a 1.3inch OLED LCD.

Tool Components

Laptop as a medium for the module programmer used. Used in this research is a Lenovo G40 laptop with AMD A8 6410 processor specifications with speeds up to 1.9Ghz, 500 GB Hardisk capacity, 2 GB RAM, equipped with Windows 10 operation.

Mobile phone used as a medium to control the BLDC stepper motor nema 17 through the Blynk application.

Power Supply In this tool design, a power supply is needed which is used to supply the STM32 Nucleo F030R8 module with a voltage value of 5volt DC, because the source from PLN is AC 220V voltage.

STM 32 Nucleo F030R8 is a microcontroller that uses an ARM Cortex M0 processor. Used as a data manager for the L298N motor driver and the installed module modules.

L298N Motor Driver

Figure 3 shows the motor driver circuit. The motor driver is used as a controller for stepper motor nema 17. The input of this motor driver is 12volt. This motor driver receives commands from the STM 32 microcontroller.

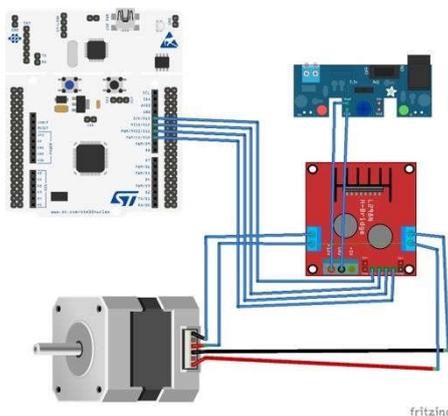


Figure 3 Motor driver circuit

Stepper motor nema 17HS4401S Figure 4 shows the stepper motor circuit. The nema 17 stepper motor is one of the BLDC motors that must work with microcontroller control to turn it on. The input voltage is 12volt.

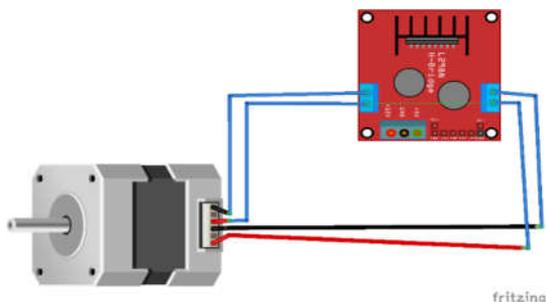


Figure 4 Stepper motor circuit

Bluetooth HC-05 module in Figure 5 displays the Bluetooth module circuit. Used as communication on the conveyor motor using Bluetooth media.

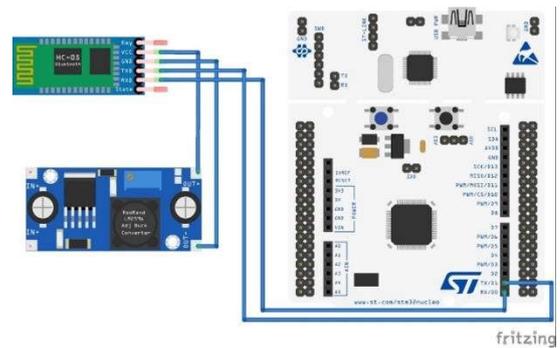


Figure 5 Bluetooth module circuit

LM393 module In Figure 6 displays the LM393 speed sensor circuit. Used as a speed reader sensor on the conveyor motor.

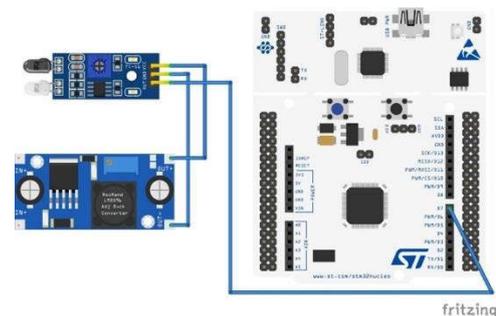


Figure 6 Speed Sensor Circuit

INA219 module In Figure 7 shows the INA219 sensor circuit. Used as a current and voltage reader sensor on the Stepper motor nema 17.

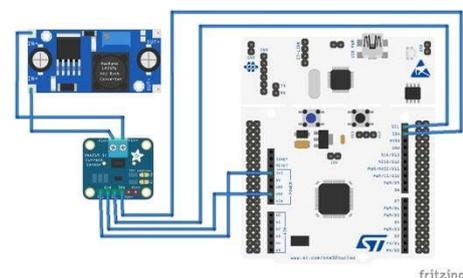


Figure 7 INA219 Sensor circuit

1.3inc OLED LCD In Figure 8 displays the LCD circuit. Used as a medium for monitoring speed, current and voltage on motors that are already installed on the conveyor.

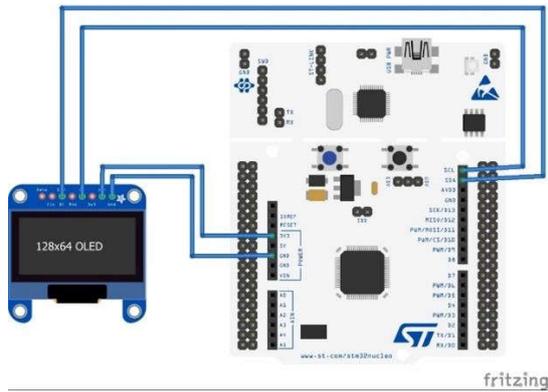


Figure 8 LCD circuit

Conveyor In Figure 9 displays a conveyor design that the author will make. Used as a medium to move goods from one place to another.

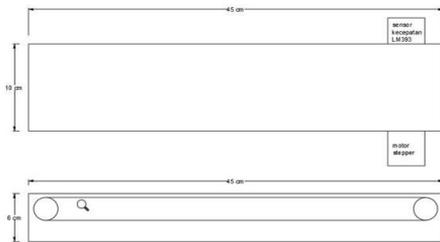


Figure 9 Conveyor design

RESULTS AND DISCUSSION

The 12V power supply in this tool design is used as a source of input to the motor driver. And installed with a Buck Converter LM2596 with 5V output to provide supply to the STM 32 Nucleo microcontroller.



Figure 10 Power Supply

This driver receives a source from a power supply of 12 volts, for pin enable A and enable B get input from the microcontroller PWM pin that has been set in the program. In this design using a motor driver type L298N.



Figure 11 L298N Motor Driver

This BLDC motor is a component that functions as a conveyor belt drive. This BLDC motor is regulated by a motor driver which is controlled using a microcontroller. For this type of BLDC motor using Stepper nema 17 HS4401S with 12V supply.



Figure 12 Nema 17 BLDC Stepper Motor

Buck Converter LM2596 functions as a step down module or voltage reducer from the 12V DC voltage power supply output to the 5V DC voltage used as a supply to the microcontroller.



Figure 13 Buck Converter LM2596

This STM 32 Nucleo module functions as a reader and sends data from speed sensors, current and voltage sensors which are then displayed on the LCD. This microcontroller is also a communication data processor from the Bluetooth module which functions to turn the motor on and off. In addition, this microcontroller also functions as a motor speed setting programmed through the Arduino IDE application. The type used is STM 32 Nucleo F030R8.

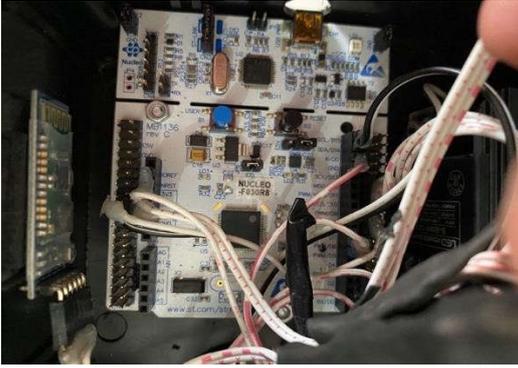


Figure 14 STM 32 Nucleo F030R8

This bluetooth module functions as a communication medium to turn on and off the conveyor from a cellphone through the blynk application. This Bluetooth module requires a supply of 5 volts. For the type used, namely the HC-05 type Bluetooth module.

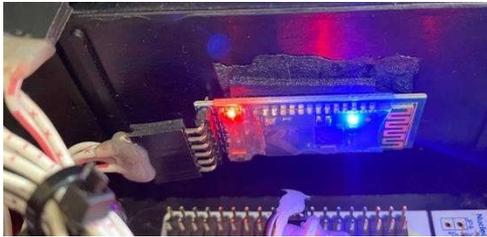


Figure 15 HC-05 Bluetooth Module

The current and voltage sensors in this final project function to read the voltage and current at the BLDC motor input which will be controlled by the STM 32 Nucleo and we can see the display on the LCD. The type used is INA219.

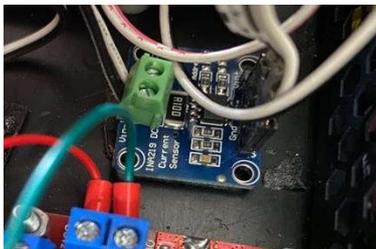


Figure 16 INA219 sensor

This speed sensor functions as a speed reader on the conveyor motor rotation. To perform the command, the speed sensor is connected to the STM 32 Nucleo module and the sensor reading results will be displayed on the LCD. The type of speed sensor used in this design is LM393.

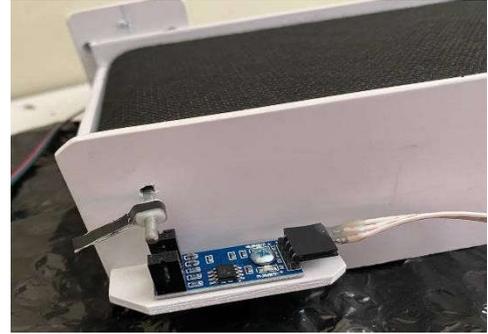


Figure 17 LM393 Speed Sensor

Conveyor is a tool that functions as a goods mover by placing objects on a conveyor belt which will then move according to the user's wishes. In this tool design the author uses a conveyor with a length of 45 cm and a width of 10 cm which is then driven by a BLDC stepper motor nema 17.



Figure 18 Conveyor

Arduino IDE is a software program that is used to create commands or can be called an application for coding that aims to translate or command from a microcontroller device. In this case the software helps to make commands carried out by sensors or components on the tools made. In Figure 19 is a display for board selection that is adjusted to the hardware. Using the Nucleo-64 board.

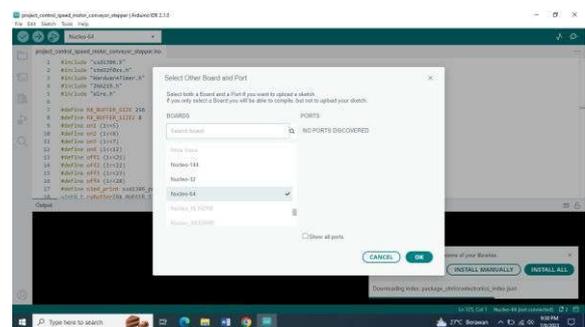


Figure 19 Nucleo-64 Board Selection

In Figure 20 After programming or entering the coding is complete, the process of compiling or uploading the coding results to the STM 32 Nucleo microcontroller device is carried out.

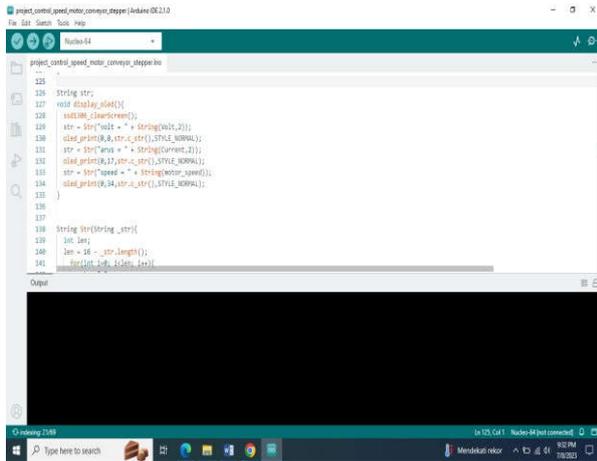


Figure 20 Compiling Coding Process

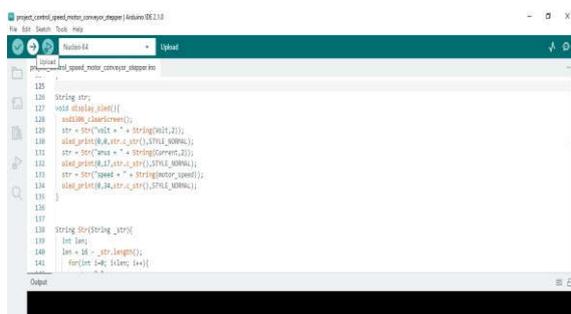


Figure 21 Coding Upload Process

Analysis: Figure 21 shows the process of uploading coding from the Arduino IDE application to the microcontroller. From the above process, it is obtained that the program in the Arduino IDE application works normally, and is ready to be uploaded to the STM 32 Nucleo board used in this tool.

The Blynk application functions as a data communication interface from the cellphone and the HC-05 Bluetooth module. Where in this application the ON and OFF buttons appear as controls for the conveyor. In Figure 22 is the initial appearance of the blynk application that has not been connected to the HC-05 bluetooth module.

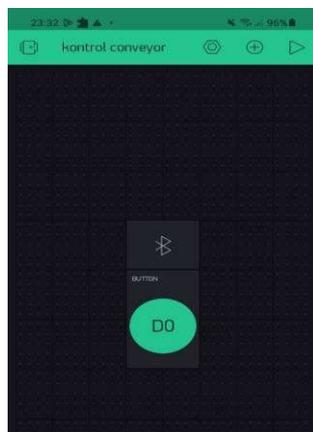


Figure 22 Blynk App View

Figure 23 shows the process of connecting Bluetooth between the cellphone and the HC-05 module and then pressing the ok button. As shown in the picture.

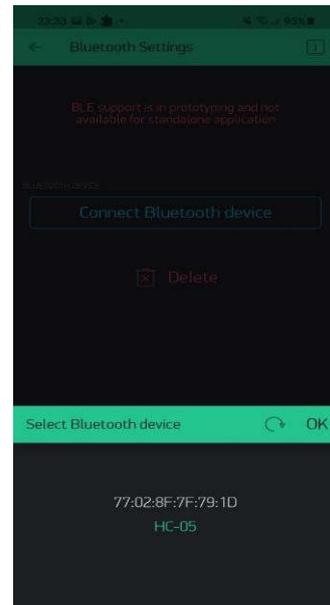


Figure 23 Bluetooth Connection View

After connecting, a connected sign will appear on the screen. The following display if Bluetooth is connected can be seen in Figure 24.

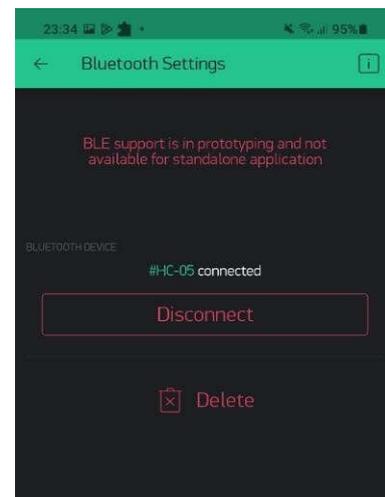


Figure 24 Bluetooth Connected Display

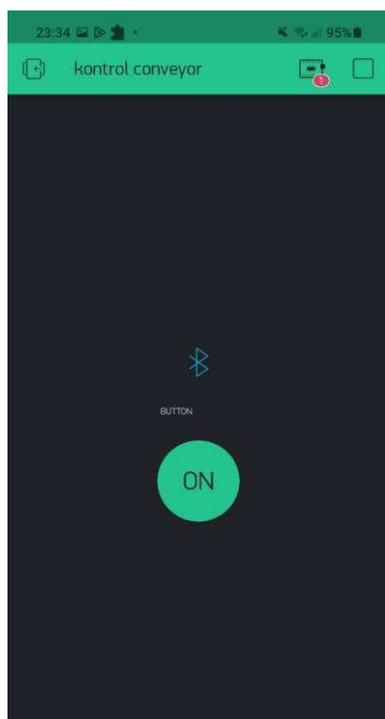


Figure 25 Control display ready for use

In Figure 25 the blynk application is ready to become a communication medium in this tool design.

Table 1. Conveyor testing

Load (Kg)	Speed (Rpm)	Voltage (Volt)	Current (Ampere)	Motor Torque (N.m)
4	455	11,50	0,89	0,20
3	480	11,51	0,96	0,21
2	550	11,70	1,16	0,23
1	550	11,72	1,16	0,23

This experiment was carried out by giving different loads to the conveyor belt. For the first experiment a load of 1kg was given and the LCD showed a speed value of 550 Rpm, voltage 11.72 volts, current 1.46 amperes, torque 0.23 N.m. for the second experiment a load of 2kg was given and the LCD showed a speed value of 550 Rpm, voltage 11.70 volts, current 1.16 amperes, torque 0.23 N.m. for the third experiment a load of 3kg was given and the LCD showed a speed value of 480 Rpm, voltage 11.51 volts, current 0.96 amperes, torque 0.21 N.m. for the third experiment given a load of 3kg and the LCD shows a speed value of 480 Rpm, voltage 11.51 volts, current 0.96 amperes, torque 0.21 N.m. for the fourth experiment given a load of 4kg and the LCD shows a speed value of 455 Rpm, voltage 11.50 volts, current 0.89 amperes, torque 0.20 N.m. Giving a load on this conveyor belt can affect the rotation speed of this conveyor. From the above tests it can be concluded that

when the conveyor belt is given a load of 1kg and 2kg the conveyor speed is still stable. When given a load of 3 kg the conveyor speed starts to be slower than the given setting.

CLOSING

Conclusion

Based on the test results and data analysis entitled "Design of Control and Monitoring of Brushless Direct Current (BLDC) Motors on Conveyors Using Bluetooth Based on STM 32" the following conclusions are obtained:

1. The control design on this tool uses Bluetooth as a communication medium between the user and the conveyor so that it can run. For the maximum Bluetooth connection distance is 9 meters.
2. This conveyor has the capacity to accommodate a maximum load of 4 kg.
3. The stable setting speed used on this conveyor is 550 Rpm. The conveyor speed remains stable at a

minimum load of 1kg and a maximum of 2 kg. When given a load of 3 kg the conveyor speed starts to become slower than the given setting.

Advice

Constructive suggestions needed to improve this final project include the following:

1. The use of a better speed sensor so that the reading of the motor rotation speed can be read accurately.
2. Monitoring voltage, current, and speed can use applications or use IOT.

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