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Wireless direction change of BLDC motor by Microcontroller and Radio

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ABSTRACT: BLDC (Brush-Less D.C.) motor have found application in most of the electro-mechanical actuators used now-a-days, especially in EVs and remote controlled robots since they have higher efficiency with respect to brushed D.C. motors and higher operating speed. But in the actual application of BLDC motors also needs to reverse the polarity of rotation. This can be achieved by reversing the polarity of D.C. supply. In BLDC motors, this is not as simple as DC motors. Here, considering the application of BLDC motor in remote controlled Robot, we can reverse the polarity of BLDC motor by using Arduino and H-Bridge.

KEYWORDS: Arduino, Electronic Speed Control, PWM, BLDC motor, Relay.

I. INTRODUCTION

Reversing the polarity of the BLDC motor includes the interconnection of Arduino microcontroller, 2 channel Relay board and radio receiver. The Radio receiver receives the PWM signal transmitted from the Radio transmitter. In general application, this PWM signal is directly fed to the BLDC motor. The speed control of the BLDC motor is done by varying the duty cycle of the PWM signal. And for direction control it can be done by interchanging the output phase of ESC (Electronic Speed Control) or by reversing the polarity of Hall-sensor used in BLDC. In general, this is done by manually changing the wires of output phase of ESC. The method including Hall-sensor is not practiced as the sensor is embedded to the motor and hard to access the wires of the motor.

The paper includes method to change the direction by electronics rather than by manually changing the wires. The PWM signal from Radio receiver is fed to Arduino microcontroller. The microcontroller reads the PWM signal duty cycle and operates the two-channel relay as programmed. The relays will be wired as H-Bridge between ESC and BLDC motor. The wiring will be shown later.

This is the typical practice followed by engineers to reverse the polarity of DC motor though. But practising the same method in the BLDC motor is not known in open source environment.

Paper is organized as follows. Section II describes the connection of electrical wiring and IDE programme. It will also include the reason for choice of particular components and overview of future possibility. The flow diagram and working of the project is described in Section III. Section IV presents experimental results showing the change of polarity of the motor. Finally, Section V presents conclusion.

II. RELATED WORK

A radio transmitter-receiver is used to control a remote controlled robot. Here a commonly available FSCT-6B computer transmitter receiver set is used. There are in total 6 channels that can be used for wireless communication. Each channel can independently send a PWM signal of user defined duty cycle from transmitter to receiver. This PWM signal is transmitted by radio waves at 2.4GHz after it is frequency modulated, which is decoded on the receiver side.

Generally the decoded signals are directly fed to the ESC for speed control of the BLDC motor. The output of the ESC generates a three phase voltage whose magnitude is directly proportional to the duty cycle of the PWM signal. Now here there is variation in our project from the general practice.

There are three wires in output of ESC, from which two will act as source while the remaining wire will be directly connected to the motor. Now let's name two wires for ease of understanding i.e. 'Aw' and 'Bw'. Also consider two electromechanical relays viz. 'Ar' and 'Br'. The 'Aw' wire will be connected to 'Normally Closed (NC)' terminal of 'Ar' relay and also to 'Normally Open (NO)' terminal of the 'Br' relay while the 'Bw' wire will be connected to 'Normally Open (NO)' terminal of 'Ar' relay and 'Normally Closed (NC)' terminal of 'Br' relay. The common terminal of both the relays ('Ar' and 'Br') will be connected to the remaining two wires of the motor input respectively. The input of the relays will be the digital signals from the digital output pins of Arduino microcontroller.

The input of the ESC consists of li-po battery source and a PWM signal. Along with the phased output for BLDC motor the ESC provides 5 volts D.C. output as it has Battery Eliminator Circuit (BEC) embedded on its circuit. The PWM

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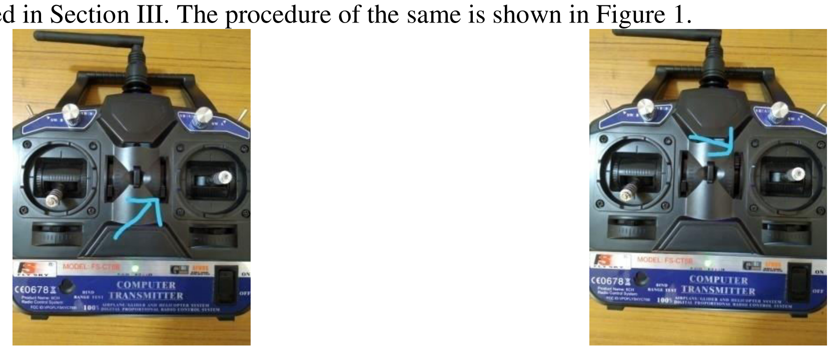
signal provided to ESC is applied to the 'Gate' terminal of the MOSFET in the ESC. This PWM signal for speed control is given by 'throttle' channel from the radio transmitter. For polarity of the rotation, another channel for 'elevator' from the transmitter is used. Now this may contradict the fact that the performance of whole system may drop by employing two channels of transmitter-receiver being used for single motor by our method. But this method might actually increase the performance of the whole system which will be discussed in Section IV.
Now when we have received the PWM signal from 'elevator' channel, it is directly fed to the Arduino microcontroller. The PWM signal has a certain value of duty cycle which can be read on serial monitor. For this the baud rate of the communication between Arduino and radio receiver is set to 115200 to observe the PWM duty cycle in decimal values. The Arduino is now programmed in an 'if' loop. The microcontroller reads the values of PWM signal and if the value matches the pre-programmed values, it generates a digital high signal which is fed to both relays and the relays triggers from 'NC' terminal to 'NO' terminal. This will reverse the polarity of the wires connected to the motor from ESC as the relays are setup in H-Bridge configuration.

III. METHODOLOGY

On the radio-transmitter that we own has a provision of sub-trim values for 4-channels. We are only concerned about the 'Elevator' channel. We first set the sub-trim value of 'Elevator' channel to lowest value. Note that this isn't the lowest value of the 'Elevator' channel. This value should be noted from serial monitor when we connect radio receiver to pre-programmed Arduino and run the code. Same procedure is to be followed when we set the highest value of sub-trim. Also note that the Arduino code should include 'Servo' library.
The Arduino code will first read the PWM signal duty cycle values. The microcontroller reads signal value from a range of certain values. This range will be decided after the experiment. The code will contain two set of range of the signal values. When the signal value from set containing lower values range is detected, the microcontroller sends a digital 'LOW' signal to relays and for detection of signal value from higher values range, a digital 'HIGH' signal is sent to relay. The digital 'LOW' and 'HIGH' signal to relay will connect the common terminal to 'NC' and 'NO' terminal respectively. The 'Red' wire of the motor is connected to common of 'Ar' relay and 'Black' wire to 'Br' relay. When both relays are fed digital 'LOW' signal they short 'NC' to 'Common' terminal, hence the 'Aw' and 'Bw' wires are connected to 'Red' and 'Black' wires of motor respectively. And when both relays are fed digital 'HIGH' signal they short 'NO' to 'Common' terminal disengaging the 'NC' terminal, hence the 'Aw' and 'Bw' wires are connected to 'Black' and 'Red' wires of motor respectively. Hence we can observe that the phase of the motor are interchanged and also the direction of rotation of motor by means of radio communication without physically changing the connections.

IV. EXPERIMENTAL RESULTS

The sub-trim value of 'Elevator' channel of radio transmitter is set to extreme values and their values is noted from the serial monitor as described in Section III. The procedure of the same is shown in Figure 1.



(a) (b)

Fig. 1 setting the sub-trim stick to extreme position (a) Lowest Point (b) Highest Point

After the experiments, the PWM signal values for both these extreme values lie in the range from 1415 to 1385 and from 1575 to 1545 for Lowest and Highest position respectively. Since the radio receiver is susceptible to noise, the values of PWM duty cycle varies about a fixed values hence a range of values is taken here as shown in Figure 2.

```
void setup() {
  pinMode(PWM1, INPUT);
  servo.attach(9);
  pinMode(relayAr, OUTPUT);
  pinMode(relayBr, OUTPUT);
  Serial.begin(115200);
}

void loop() {
  pwm1 = pulseIn(PWM1, HIGH);
  Serial.println(pwm1);
  delay(50);
  if (pwm1 <= 1575 & pwm1 >= 1545)
  {
  digitalWrite(relayAr, HIGH);
  digitalWrite(relayBr, HIGH);
  }
  if (pwm1 <= 1415 & pwm1 >= 1385)
  {
   digitalWrite(relayAr, LOW);
   digitalWrite(relayBr, LOW);
  }
}
```

Fig. 2 Arduino IDE code for 'if' loop for relay configuration

The setup for all the components is shown in Figure 3

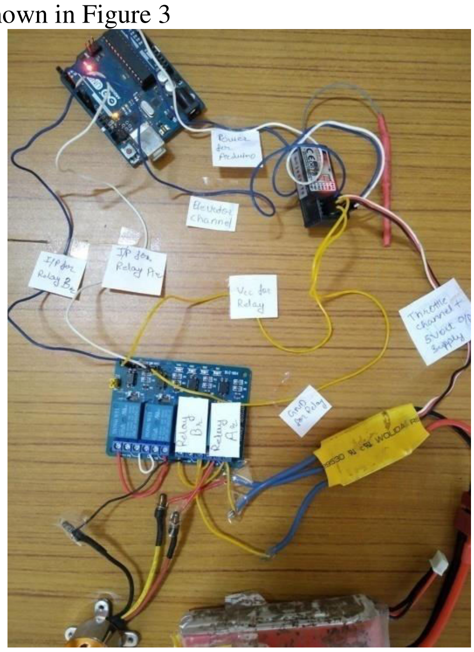
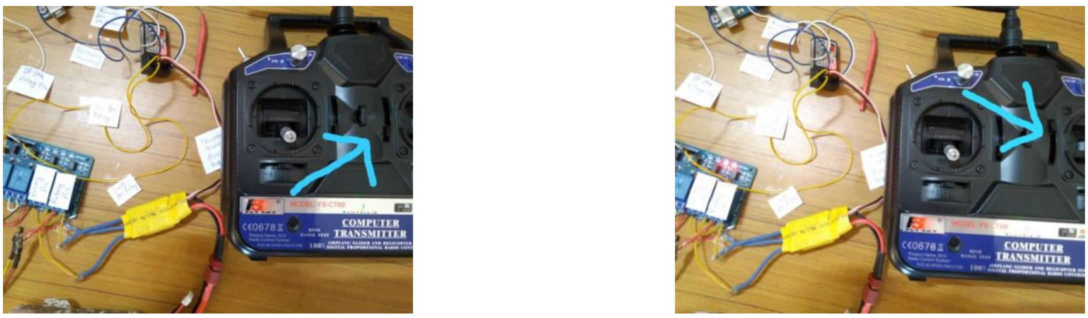


Fig. 3 Setup for the project

When sub-trim value hits the value between "1415 and 1385" and "1575 and 1545", the microntroller sends digital 'LOW' and 'HIGH' signal respectively to both relays. This can be seen in Figure 4 where the Red LEDs turn on and off when there is 'HIGH' and 'LOW' signal respectively.



(a) (b)

Fig. 4 (a) when sub-trim values hit lower range of values (b) when sub-trim values hit higher range of values

The rotation of motors in either direction is shown in Figure 5. (Because of the constraints of the photograph, the direction of rotation is not observable.)

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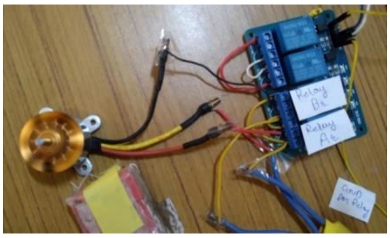
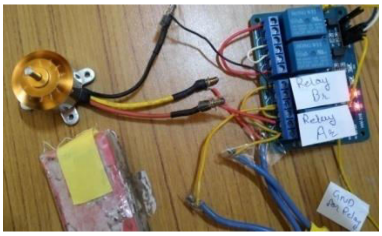


(a)



(b)

Fig. 4 (a) clockwise direction rotation (b) counter- clockwise direction rotation

Now the solution for contradiction that was observed in the Section II about the decrease in overall performance of the system, it is that the controller can be programmed for certain more functions when the PWM signal value hits the other values of the whole channel. Hence a single channel (here 'Elevator') can be used for optimum functions for the remaining values. Here we have considered the electro-mechanical relays for our operation, but according to availability, we can use solid state relays for smoother operation by the trade-off for separate bias circuit.

V. CONCLUSION

We have changed the direction of rotation of BLDC motor by using additional components rather than by manually disconnecting and interchanging the phase wires of ESC. We have accomplished the required work to be done by Radio Communication as it was expected to work. The application of this method can be in driving the radio controlled robots which needs to be driven in forward and backward direction.

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