BLDC Motor Speed Control with RPM Display

Project Exhibition -1

Submitted in partial fulfilment for the award of the degree of

Bachelor of Technology
In
ELECTRICAL AND ELECTRONICS ENGINEERING

Submitted to

VIT BHOPAL UNIVERSITY (M.P.)

Submitted by
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Under the Supervision of

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MAY - 2021

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CANDIDATE'S DECLARATION

I hereby declare that the Dissertation entitled "BLDC MOTOR SPEED CONTROL USING RPM DISPLAY" is my own work conducted under the supervision of Dr. Om Prakash Pahari, Assistant Professor, Electrical and electronics department at VIT University, Bhopal.

I further declare that to the best of my knowledge this report does not contain any part of work that has been submitted for the award of any degree either in this university or in other university / Deemed University without proper citation.

Prashasti Singh Gautam
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This is to certify that the above statement made by the candidate is correct to the best of my knowledge.

Date: 08 May 2021

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Designation: - Assistant professor

Digital Signature of Guide

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CERTIFICATE

This is to certify that the work embodied in this Project Exhibition -1 report entitled "**BLDC MOTOR SPEED CONTROL USING RPM"** has been satisfactorily completed by **Ms. Prashasti Singh Gautam** Registration no: **19BEE10028** in the School of Electrical & Electronics Engineering of at Electrical & Electronics Engineering VIT University, Bhopal. This work is a Bonafide piece of work, carried out under my/our guidance in the School of Electrical and Electronics Engineering for the partial fulfilment of the degree of Bachelor of Technology.

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Approved by
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EXECUTIVE SUMMARY

The importance of BLDC motor is increasing day by day because it has been mostly used in industries for different applications such as spinning, drilling and elevators. Similarly, its speed control is also too much important. A new generation of microcontrollers and advanced electronics has control factions making BLDC motor more practical for a wide range of use.

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CHAPTER -I

INTRODUCTION

A Direct Current machine has developed, especially for small devices, including as a control motor, or servo motor. The favorite electrically powered drive engine is a brushless direct current motor (BLDC motor) because it has advantages compared to other types of electrically powered propulsion engines. The power of a BLDC motor is that its efficiency is higher than that of an induction motor, the dimensions are smaller than conventional direct current motors. Also, in the absence of a brush, maintenance becomes light, almost no noise, and can be operated in a flammable environment.

Another advantage of induction machine is that the response is faster, longer service life, and has a wide speed range. The brushless dc motor is a three-phase dc motor which requires a controller to power its 3 phases. This controller is called an ESC (Electronic Speed Controller). This topic shows how to drive a BLDC motor using Arduino where the speed is controlled with a potentiometer.

The brushless DC (BLDC) motor is a 3-phase motor which we do with sensor. BLDC (Brushless DC) motor speed control with rpm display system is a system, that offers the BLDC motor to run at different speeds and display this speed on LCD display. The importance of BLDC motor is increasing day by day because it has been mostly used in industries for different applications such as spinning, drilling and elevators. Similarly, its speed control is also too much important. Different companies are making their motor drive circuits with different types of controllers. But their cost is so much high and its operating system is quite difficult. Here we are offering a system that is called a BLDC motor speed control with RPM display system with the help of Aurdino and ESC.LCD display bridge rectifier , voltage regulator and IR sensors.

In this system, the speed of BLDC motor is controlled by changing the duty ratio of supplying voltages. This system is less costly, quite simple and control the speed of BLDC motor more precisely with displaying of on LCD display. So here we use Aurdino and ESC to control the speed of BLDC motor with the help of potentiometer.

Since these motors have the ability to work with the available low voltage sources such as 12v DC supply. It makes the brushless DC motors fans convenient for use in electronic equipment computers, mobile equipment, vehicles and spindle drives for disk memory, because of its high reliability, efficiency and ability to reverse rapidly. The speed control ofthe BLDC motors is archived by varying the duty cycles (PWM Pulses) from the keypad and delivers the desired output to switch the motor driver so as to control the speed of the BLDC motor. The speedsensed by the ‘IR’ sensor is given to the microcontroller to display it on the (LCD) display

OBJECTIVE

The objective of our project is to control the speed of a brushless DC (BLDC) motor with the help of a microcontroller. We will be using Arduino in our project for the speed control and RPM monitor that offers the BLDC motor to run at different speeds and displays this speed on LCD display.

PROPOSED METHODOLOGY

- In this project Controlling the motor can be done accurately.
- It displays its speed using IR method of speed sensor mechanism.
- This system provides an efficient mechanism for increasing or decreasing the speed.
- To control the rotation, adjust the magnitude and direction of the current into the coils in the BLDC motor

BLOCK DIAGRAM

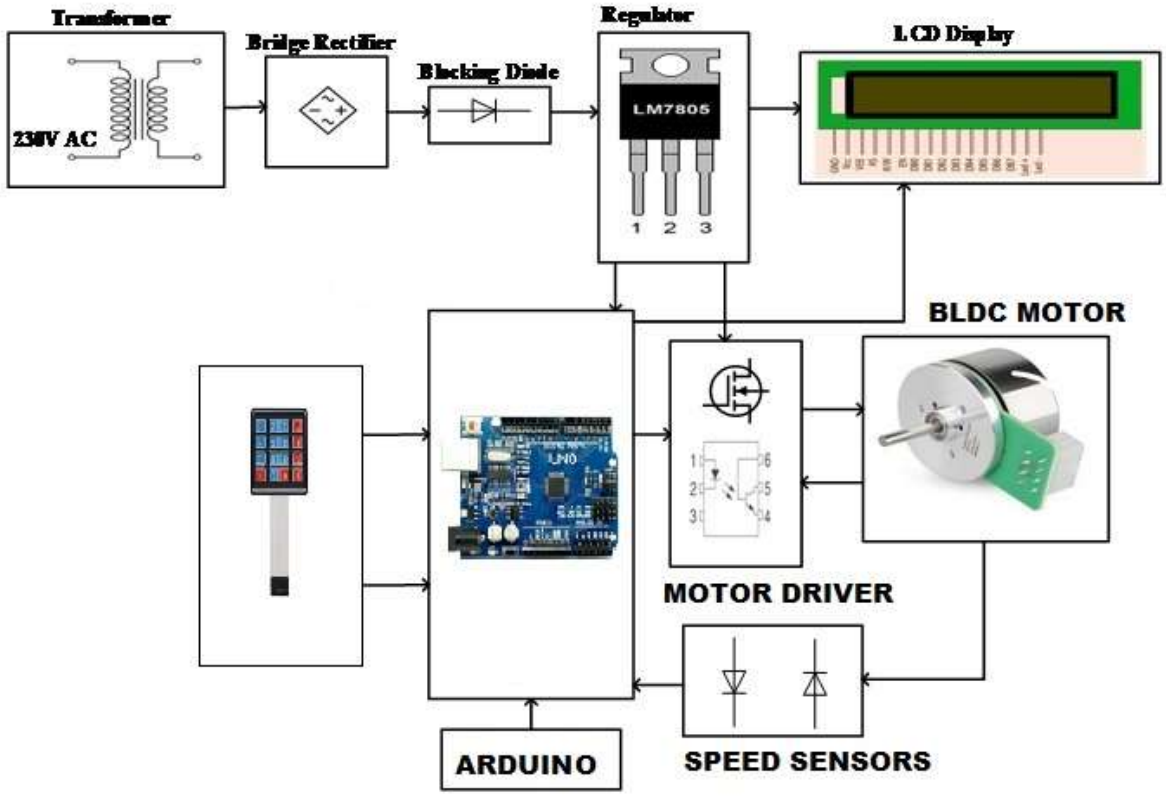

Figure 1: Block Diagram of BLDC Motor Speed Control with RPM using Arduino

CHAPTER - Ⅱ

LITERATURE REVIEW

The research papers which we have used are: -

- BLDC (Brushless DC) motor speed control with **RPM DISPLAY** system is a system, that offers the BLDC motor to run at different speeds and display this speed on LCD Display The importance of BLDC motor is increasing day by day because it has been mostly used in industries for different applications such as spinning, drilling and elevators. Similarly, its speed control is also too much important. Different companies are making their motor drive circuits with different types of controllers such as **VFD (variable frequency drive)** but their cost is so much high and its operating system is quite difficult. Here we are offering a system that is called a BLDC motor speed control with RPM display system with the help of Arduino, LCD display, transformer, voltage regulator, ESC and IR Sensors. In this system, the speed of BLDC motor. This system is less costly, quite simple and control the speed of BLDC motor more precisely with displaying of on LCD display.

- 1st Paper

  This paper raises the design of BLDC motor speed control using rpm. The Outcome of literature survey was that we were able to collect ideas and information about our desired system and details about each component of it.

- 2nd Paper

  It helped us in planning the Framework of our desired system. It helped us in designing our circuit by arranging all the components and do the required Arduino coding

- 3rd Paper
- It helped us in running our system and to check whether it is giving desired results or not

CHAPTER -III

LIST OF COMPONENTS

1. BRIDGE RECTIFIER
2. BLOCKING DIODES
3. VOLTAGE REGULATOR
4. LCD DISPLAY
5. KEYPAD
6. ARDUINO (UNO)
7. ELECTRONIC SPEED CONTROL
8. SPEED SENSORS
9. 5V BLDC

KEY PARTS

Bridge Rectifier: Bridge rectifier is used for converting the ac voltages into dc voltages for supplying the power to whole components of this system. It consists of four diodes

Blocking Diodes: In this system, the blocking diode is used only for blocking reverse polarity current, in other words it protects the transformer. It is connected at the output of bridge rectifier.

Voltage Regulator: Voltage regulator is used for regulating the 9V dc into 5V dc for supplying the voltages to microcontroller and motor drive circuit.

LCD Display: The LCD display is used for displaying the rpm (revolution per minute) of BLDC motor. It is a 16 pins LCD display and is powered up with 5V dc supply. It is interfaced with microcontroller.

Keypad: The Keypad helps us to get the desired output RPM from the BLDC motor. It is interfaced with microcontroller.

Arduino UNO: It is used for the intelligent control of this system. It is powered up with 5V dc and is interfaced with LCD display, Keypad, speed sensors and motor drive circuit.

Electronic Speed Control: In this BLDC motor speed control with rpm display system, the ESC acts as the motor driver circuit which is used for driving the BLDC motor.

Speed Sensor: In this BLDC motor speed control with rpm display system, two ir sensors are used for measuring the speed of motor. One is transmitter is for sending the infrared light and second one is receiver for receiving the infrared light after the collision from the shaft of BLDC motor.

5V BLDC : The brushless dc motor, which is powered up through switching dc supply. Here we would be powered up through switching dc supply.

CHAPTER - IV

PRACTICAL IMPLEMENTATION

BLDC motors were developed from conventional BLDC motors with the availability of solid state power semiconductors. BLDC motors are similar to AC synchronous motors, the major difference is that synchronous motor develops a sinusoidal back EMF, as compared to a rectangular, or trapezoidalback EMF for BLDC motors both have stator created rotating magnetic fields producing torque in a magnetic rotor.

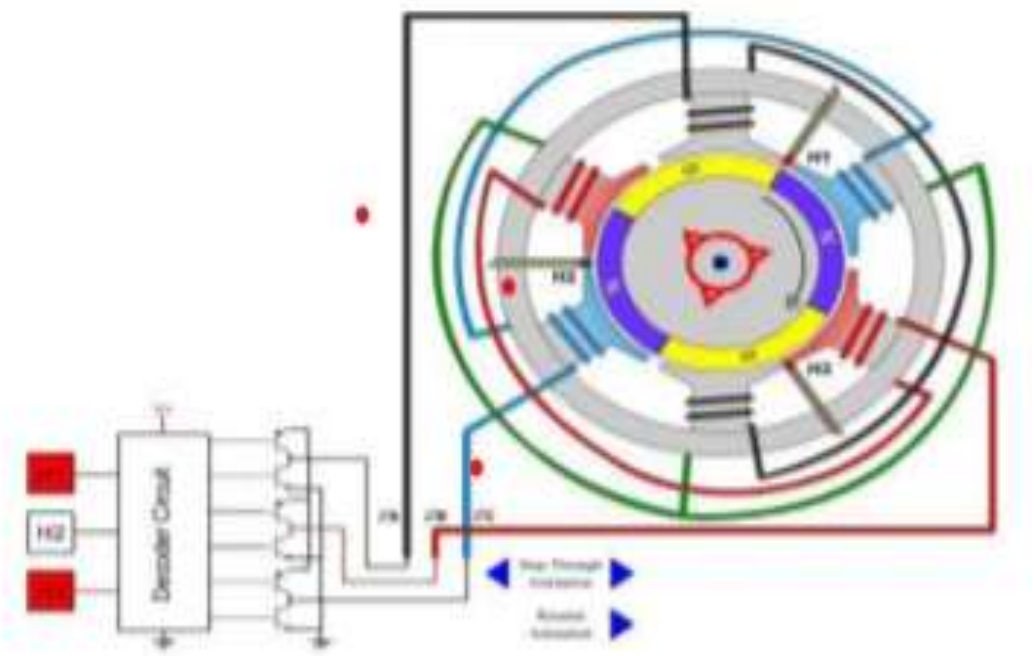

Figure 2: Implementation of BLDC motor

The basic construction of a BLDC consists of a fan blade attached to a permanent magnet rotor that surrounds the electromagnetic coils of the stator and associated control electronics.

The **speed control** of the **BLDC motors** is archived **by** varying the duty cycles (PWM Pulses) from the keypad and delivers the desired output to switch the **motor** driver so as to **control** the **speed** of the **BLDC motor**. The **speed** sensed **by** the 'IR' sensor is given to the microcontroller to display it on the (LCD) display.

Let us consider the configuration in the brushless dc motor, and represent the equations of voltages at each phase then

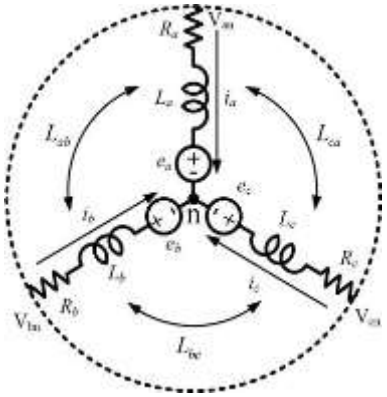

Figure 3: Configuration of BLDC motor

$$V_{an} = R_a i_a + L_{aa}\frac{di_a}{dt} + L_{ab}\frac{di_b}{dt} + L_{ac}\frac{di_c}{dt} + e_a$$

$$V_{bn} = R_b i_b + L_{ba}\frac{di_a}{dt} + L_{bb}\frac{di_b}{dt} + L_{bc}\frac{di_c}{dt} + e_b$$

$$V_{cn} = R_c i_c + L_{ca}\frac{di_a}{dt} + L_{cb}\frac{di_b}{dt} + L_{cc}\frac{di_c}{dt} + e_c$$

R_a, R_b, and R_c represents phase resistance for each phase,

L_{aa}, L_{bb}, and L_{cc} represent the self-inductance for each phase,

L_{ab}, L_{bc}, and L_{ca} represent the mutual inductance between either of two phases,

e_a, e_b, e_c represent the back EMF for each phase.

TORQUE:

The electromagnetic torque is expressed as $\mathbf{T_e = K_t * ia}$, indicates that it can be controlled by the stator current with the torque constant Kt.

The effective voltage is proportional to the PWM duty cycle when properly commutated.The variable voltage can be used to control the speed of motor and available torque

ha	hb	hc	emf_u	emf_v	emf_w	Q1	Q2	Q3	Q4	Q5	Q6
0	0	0	0	0	0	0	0	0	0	0	0
0	0	1	0	-1	+1	0	0	0	1	1	0
0	1	0	-1	+1	0	0	1	1	0	0	0
0	1	1	-1	0	+1	0	1	0	0	1	0
1	0	0	+1	0	-1	1	0	0	0	0	1
1	0	1	+1	-1	0	1	0	0	1	0	0
1	1	0	0	+1	-1	0	0	1	0	0	1
1	1	1	0	0	0	0	0	0	0	0	0

PHASE COMMUTATION

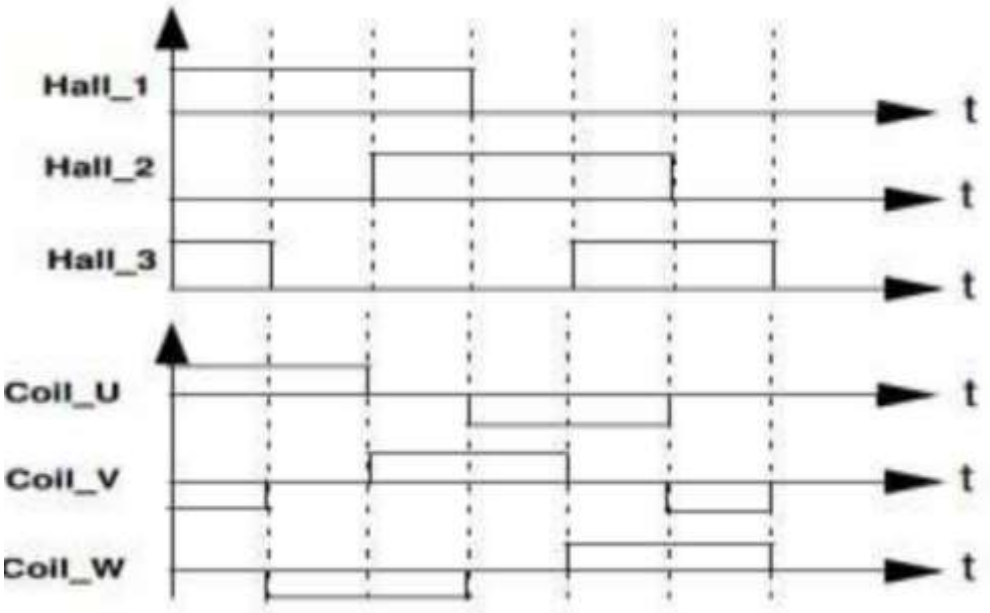

Figure 4: Phase commutation

The commutation of power transistor energies the appropriate windings in the stator to provide optimum torque generation depending upon the rotor position

SIMULATION DIAGRAMS

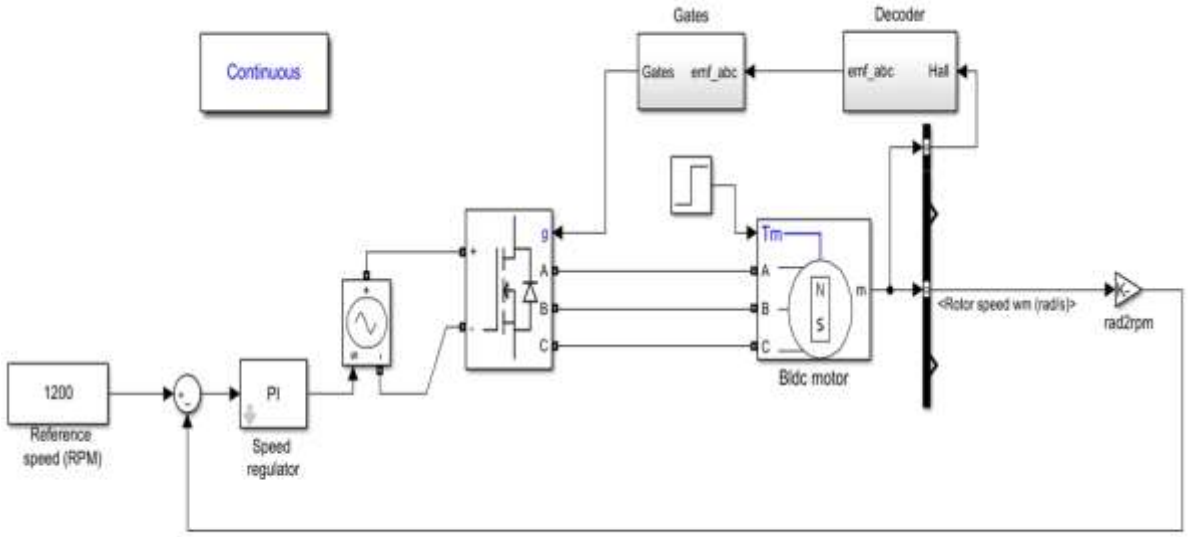

Figure 5: Circuit diagram of BLDC motor speed control using Arduino.

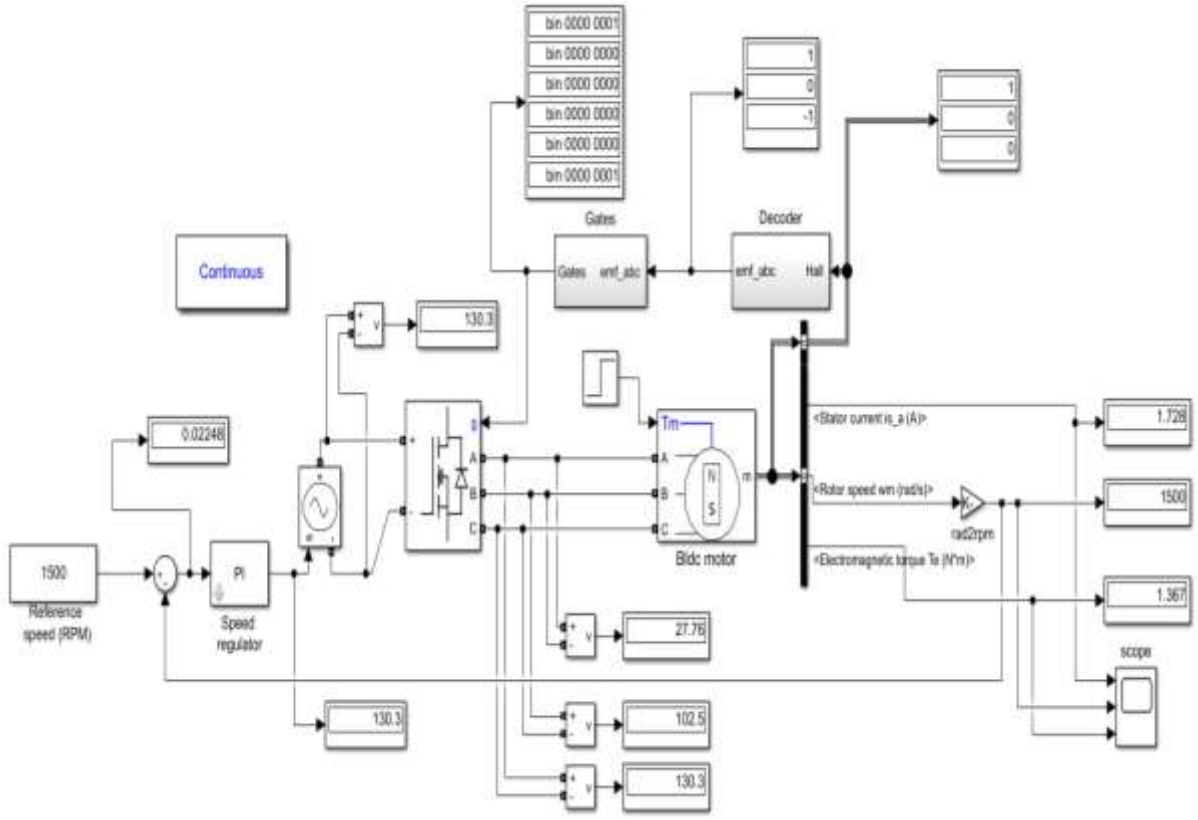

Figure 6: Output values of the BLDC speed control using arduino with rpm.

CHAPTER - V

RESULT AND DISCUSSION

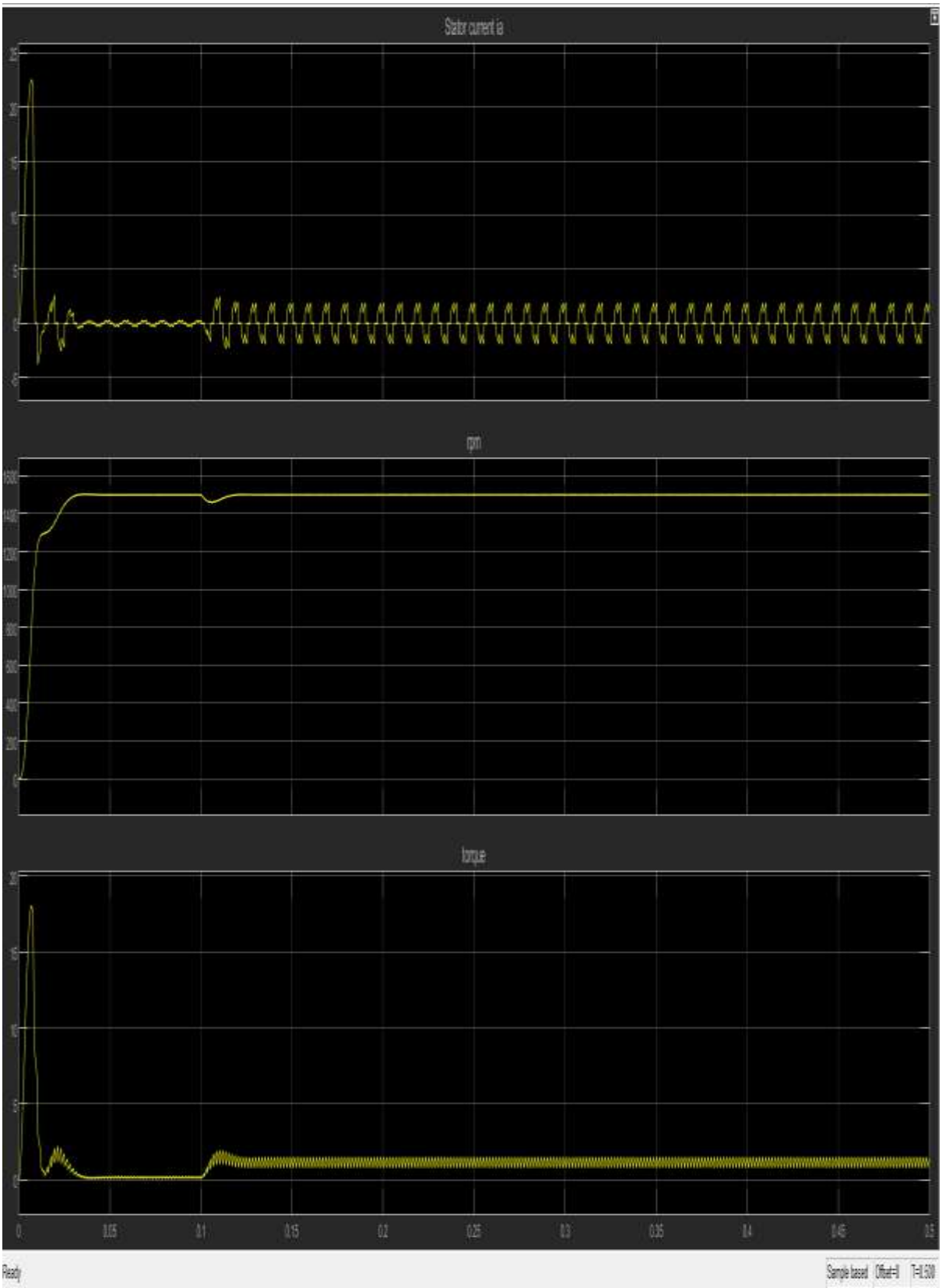

Figure 7: Waveform output of bldc motor speed control using arduino with RPM display

The current wave form for each winding is a staircase from zero to positive current to zero zero and the negative current. This produces the current space vector that approximates the smooth rotation and it steps among six distinct direction as rotor runs.

The time variant petribution to the current control loop causes the lag and the gain error in the motor current. And higher speed results in the larger errors .so it causes its to shift away from the quadrature direction.

When it happens less torque is produced by a given amount of current is required to maintain the torque. So this degradation continuous as speed increases.At the same point motor current phase shift cross through 90 degrees.When this happen torque is reduced to zero.With sinusoidal commutation speed above gthe point results in negative torque.

PRESENT AND FUTURE SCOPE OF PROJECT

By 2030 we are expecting only electric vehicles on our roads and if we can convert the existing conventional vehicles to electric vehicles that will more cost efficient. Furthermore, the storage capacity and charging time can also be improve the entire reliability and efficiency of the system.

Figure 8: Future scope of BLDC motor

CONCLUSION

BLDC Motor of high-power rating is not available easily. When compared with other motor, cost of BLDC motor is really high. BLDC Motor and its controller should be matched to each other. Coupling the motor with the gear box of the existing vehicle was tiresome and time consuming. Thus, by providing BLDC drive we can achieve smooth operation with high efficiency, high torque and easy speed regulation. As per the weight and required torque of the vehicle we can convert the conventional vehicles to pollutant free, highly efficient electric vehicles. For further enhancement of this project we can have solar power to charge the batteries thus making the electric vehicle more efficient.

REFERENCES

http://www.troindia.in/journal/ijcesr/vol2iss2/182

https://www.renesas.com/us/en/support/engineer-school/brushless-dc-motor-01-overview

https://www.arrow.com/en/research-and-events/articles/which-dc-motor-is-best-for-your-application

https://robu.in/brushless-dc-motor-working-principle-construction-applications/#:~:text=BLDC%20motor%20works%20on%20the,an%20equal%20and%20opposite%20force

BOOKS

1)Electric Motor Control, 1st Edition , DC, AC, and BLDC Motors by Sang-Hoon Kim

2) Exploring Arduino: Tools and Techniques for Engineering Wizardry by Jeremy Blum

[1] Lin Bai, "Electric Drive With BLDC Motor" Department of Electrical and Computer Engineering,978-1-4244-8039-5/11/$26.00 ©2011 IEEE. [2] WU Chun-hua, CHEN Guo-cheng, SUN Cheng-bo, "A wide-angle wavecontrol method of reducing torque ripple for brushless DC motor",Journal of Shanghai University (English Edition), 2007, 11(3): 300– 303, Digital Object Identifier(DOI): 10.1007/s 11741-007-0323-1. ShanghaiKey Laboratory of Power Station Automation Technology, Shanghai University, Shanghai 200072, P. R. China, [3] V. N. Savoy, Zh. D. Georgiev, E. S. Bogdanov. "Analysis of cage induction motor by means of the finite element method