ISSN(Online): 2319-8753
ISSN (Print) : 2347-6710

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 7, Issue 6, June 2018

Closed Loop Speed Control of BLDC Motor using Microcontroller and LABVIEW Interface Monitoring

Vimal Kumar [1], Ravi Agarwal [2], Sanjiv Kumar [3]

P.G. Student, Department of Electrical & Electronics Engineering, S.I.T.E., S.V.S.U, Meerut, U.P., India[1]

Assistant Professor, Department of Electrical & Electronics Engineering, S.I.T.E., S.V.S.U, Meerut, U.P., India[2]

Associate Professor, Department of Electrical & Electronics Engineering, S.I.T.E., S.V.S.U, Meerut, U.P., India[3]

ABSTRACT**:** The speed control of a motor is frequently required in industrial applications, robotics, home appliances, etc. In this paper, we have implemented a BLDC motor speed control system. The idea of a speed control system is to maintain the speed of the motor at the desired value under various conditions. In practice, the DC motor is a nonlinear device and its speed varies because of change in load demand, disturbances. We have implemented the Tachometer algorithm which is a popular controller in industries. The motor speed is sensed by an optical switch and converted to feedback voltage. The controller acts on the error signal detected by IR sensor and generates appropriate control voltage. The PWM generator then varies the duty cycle of the voltage supplied to the motor to control its speed.

KEYWORDS: BLDC, Arduino, LABVIEW.

I. INTRODUCTION

Brushless DC motors are becoming more common in a variety of motor applications such as fans, pumps, appliances, robotic automation, and automotive drives. The reasons for their increased popularity are better speed versus torque characteristics, high efficiency, long operating life, and noiseless operation. In addition to these advantages, the ratio of torque delivered to the size of the motor is higher, making it useful in applications where space and weight are critical factors.

The stator of a BLDC motor is similar to that of an induction machine but the windings are distributed quite differently. The two different common distributions of the windings are distributed and sinusoidal. A distributed winding will have a trapezoidal back EMF while a sinusoidal winding will have a sinusoidal back EMF. This application note will focus on BLDC motors with distributed stator windings. The rotor of a brushless DC motor is different in the fact that the rotor contains permanent magnets instead of additional windings.

Unlike a brushed DC motor, the commutation of a BLDC motor in controlled electronically. To rotate the BLDC motor, the stator windings should be energized in a sequence. In order to make sure the motor controller is energizing coils in the correct sequence; IR Sensors must be used to detect the position of the rotor in the motor. When the rotor is spinning inside the motor either a North or South Pole will pass by the IR Sensors which will cause the sensor to output which section of the rotor is passed.

The main differences between BLDC motor controllers are the types of control algorithms that are implemented on their microcontrollers. The two main types of control algorithms are sensored and sensor less control. Sinusoidal and trapezoidal are the two different output types that must be picked from after a control method is selected. In this paper a sensored control algorithm uses IR sensor senses the speed of rotor at all times. The Arduino microcontroller uses the output of the IR sensors to know the present speed and varying the duty cycle to get the required speed of the rotor. Universal Serial Bus (USB) on some models, which are also used for loading programs from personal computers. The micro controllers are typically programmed using a dialect of features from the programming languages C and C++.

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II. RELATED WORK

A few examinations on BLDC motor are accounted for. In 2003, Padmaraja Yedamale [3], inferred that BLDC motors have focal points over brushed DC motors and acceptance motors. In 2009, Bhim Singh [7] completed a comprehensive diagram of PMBLDCM drives. In 2010, A. Ahfock and D. Gambetta [1] displayed a paper about sensorless recompense of BLDC motor by measure up to inductance technique. In 2006, Dae-Kyong Kim, Kwang-Woon Lee, and Byung-Il Kwon [10] proposed a torque swell decrease technique for a position sensorless BLDC motor drive. In 2011, Dawid Makiela [11] inspected sensorless fast PM BLDC motor control techniques for a specific target speed. In paper [4], [9], the speed control of position sensorless brushless DC motor is examined. In 2009, K. Wang et al [8] considered the plan of fast brushless DC motors furnished with surface-mounted magnets, for sensorless task in view of the third symphonious back-EMF. In 2010, A. Rahideh et al [4] displayed a technique for the ideal outline of a slotless PMBLDC motor with surface mounted magnets utilizing a hereditary calculation. Insight control like non specific control has cleared route for expanded control and exactness. In 2002, Bhim Singh and Sanjeev singh [6] exhibited another speed control system of a PMBLDC motor drive. In 2011, Cassio Luciano et al introduced a paper [9] on speed control for BLDC compressor utilizing a tedious module control with variable testing period. In paper [22] and [13], torque controller framework for a BLDC motor is broke down. Bogdan Alecsa and Alexandru Onea [8] exhibited a paper to actualize a computerized BLDC motor speed controller inside a FPGA gadget. In 2007, Eric Monmasson and Marcian N. Cirstea [12] displayed a paper on the commitments of FPGAs to the control of mechanical frameworks. In 2010, Wang Xing-gui and Liu Qi [5] recommended a powerful position control of the PMBLDCM. In 2011, Hao Chen, Song Sun, Dionysios C. Aliprantis, and Joseph Zambreno [14] introduced the FPGA execution of an acceptance machine dynamic reproduction, utilizing numerical joining calculation. In 1999, Z. M. Zhao, S. Meng and X N.Yue [3] created and actualized a virtual framework incorporating programming with equipment in circle and executed for motor drive applications.

In 2012, Jiancheng Fang, Haitao Li and Bangcheng Han [15] proposed another PWM current control technique. In 2006, Jianwen Shao [6] introduced the enhanced direct back-EMF-detecting plan that takes out obligation cycle restriction by including the alternative of detecting the back EMF amid the high-side-switch PWM on time. In 2006, Maurício Beltrão et al [21] exhibited a technique to create PWM signals for control of four-switch three-stage inverters. In 2004, Yen-Shin Lai, Fu-San Shyu, and Yung-Hsin Chang [7] introduced another PWM procedure for brushless dc motor drives nourished by MOSFET inverter, which altogether diminishes the conduction misfortunes and particularly turns out to be exceptionally encouraging for little influence applications. In 2010, An Albert Rajan et al [3] exhibited a plan to supplant the customary steady recurrence advanced PWM control strategy for speed variety in BLDC by factor recurrence and variable obligation proportion fluffy rationale technique. In 2003, J. X. Shen and K. J. Tseng [7] exhibited conditions to compute the mistake, which is identified with the motor parameters and load. In 2005, Mohamed A. Awadallah et al [1] exhibited two free plans for programmed blame conclusion and area of between turn short circuits on the stator twisting of CSI-nourished PM brushless dc motors. In 2010, K. Wang, M. A. Rahman and J. X. Shen [9] introduced a paper on correlated outline viewpoints identified with improving the third consonant back-EMF, for the most part from the stator topology. In 2007, WU Chun-hua, CHEN Guo-cheng and Sun Cheng [16] exhibited a plan to dispense with the costly corridor sensor technique to identify rotor position and presented wide-edge wave control strategy for the same. In 2011, M. V. Rameshet al [20] displayed a paper for CLOSED LOOP CONTROL and brushed rationale controller for speed control of BLDC motor.. In 2010, Baharuddin Ismail and Tan Chee Siong [5] thought about Proportional-Integral (PI) controller and fluffy rationale controller for speed control. In 2010, Ying Gao, Dedi Chen and Rong Wang [8] connected fluffy control hypothesis to the speed managing arrangement of BLDCM, in light of the scientific model. As studied, the most recent research needs assortment in speed controlling procedures. This paper incorporates the planning of CLOSED LOOP CONTROL as well as fluffy rationale smart control, with shifting burden torques and changing rate references. Three CLOSED LOOP CONTROL tuning techniques are endeavoured. The two Mamdani and Sugeno surmising models in fluffy are diagrammed. Fruitful execution of controller is finished with the assistance of microcontroller.

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M. Daniel pradeep,"a novel technique for speed and voltage control of BLDC motor" This paper displays the speed control of BLDC motor by the 3phase semiconductor connect by the flag detected by rotor position sensor. In the proposed technique the back emf of the motor is put away in the battery and the speed of motor is detected and is given the shut circle control controller which drives the semiconductor along these lines, by this proposed strategy the vitality utilization will be less and produced vitality can be put away and reused, and it has high, long working life, quiet operation, and rapid range [4].

Abhishek jain, "controlling of perpetual magnet brushless dc motor utilizing instrumentation technique "The paper portrays the controlling the lasting magnet brushless dc motor with sensor by means of instrumentation method. A lasting magnet brushless dc motor is picking up prevalence since its uses sensors rather than brushes and commutators. A brushless dc motor has been utilized as a part of this paper since it has high proficiency, solid and requires bring down upkeep cost. PWM strategy is utilized for the controlling of field programmable door exhibit gadget that computes the obligation cycle as required. The paper manages the examinations of speed control of the brushless dc motor which should be possible utilizing Sensor controller [5].

Yasser ali alm atheel, " speed control of dc motor utilizing fluffy rationale controller " Dc motor speed is controlled utilizing Sensor controller and fluffy rationale controller, Sensor controller requires a numerical model of the framework while fluffy rationale controller base on encounter by means of administer based information. Plan of fluffy rationale controller requires numerous outline choices, for instance administer base and fuzzification. The FLC has two information, one of these data sources is the speed blunder and the second is the adjustment in the speed mistake. There are 49 fluffy standards which are intended for the fluffy rationale controller. The focal point of gravity technique is utilized for the defuzzification. Fluffy rationale controller utilizes mamdani framework which utilizes fluffy sets in subsequent part. Sensor controller picks its parameters base on experimentation strategy. Sensor and FLC are explored with the assistance of MATLAB/SIMULINK bundle program re-enactment. It is established that FLC is more troublesome in configuration contrasting and Sensor controller, yet it has a progress to be more appropriate to fulfil non-straight attributes of dc motor. The outcome demonstrates that the fluffy rationale has least transient and relentless state parameters, which demonstrates that FIC more proficiency and adequacy than Sensor controller [16].

S.thamizmani , "plan of fluffy Sensor controller for brushless dc motor This brushless dc motors are broadly utilized for some modern applications as a result of their high productivity, high torque and low volume. This paper proposed an enhanced fluffy Sensor controller to control speed of brushless dc motor. The proposed controller is called proportional– integral– subsidiary controller and fluffy proportional– integral– subordinate controller. This paper gives a diagram of execution customary Sensor controller and fluffy Sensor controller. It is hard to tune the parameters and gain fulfilled power qualities by utilizing ordinary customary Sensor controller. As the fluffy can fulfilled control attributes and it is simple for registering, keeping in mind the end goal to control the BLDC motor, a fluffy Sensor controller is planned as the controller of the BLDC motor [17].

In 2015 Nikita Tiwari, Prof. Ritesh Diwan "Speed Control of Brushless DC Motor utilizing Fuzzy and Neuro Fuzzy "In this article the DC drive frameworks are regularly utilized as a part of numerous mechanical applications, for example, apply autonomy, incitation and controllers. The reason for this paper is to control the speed of Brushless DC motor by utilizing Fuzzy rationale controller (FLC) and Neuro-fluffy controller in MATLAB/SIMULINK demonstrate. The extension incorporates the displaying and recreation of Brushless DC motor, utilization of fluffy rationale controller to genuine DC motor. This paper will display the new limit of evaluating velocity and control of the Brushless DC motor. By using the Neuro fluffy controller, the rate can be tuned until the point when it get like the coveted yield that a client needs [18].

In 2015 Maloth Purnalal1, Sunil kumar T K2 "Improvement Of Mathematical Model And Speed Control Of BLDC Motor "In this article the electronically commutated Brushless DC motors are colossally utilized as a part of numerous modern applications which builds the requirement for plan of productive control system for these quiet motors. This paper manages a shut circle speed control of BLDC motor and execution of the BLDC motor is re-enacted. The

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Vol. 7, Issue 6, June 2018

obligation proportion is managed by CLOSED LOOP CONTROL controller, which oversees the obligation cycle of the PWM beats connected to the switches of the inverter to run the motor at enduring state speed [19]

III. PROPOSED METHODOLOGY AND BLOCK DIAGRAM

The proposed block diagram is shown in figure 1. The blocks of which and control strategies is explained in this section.

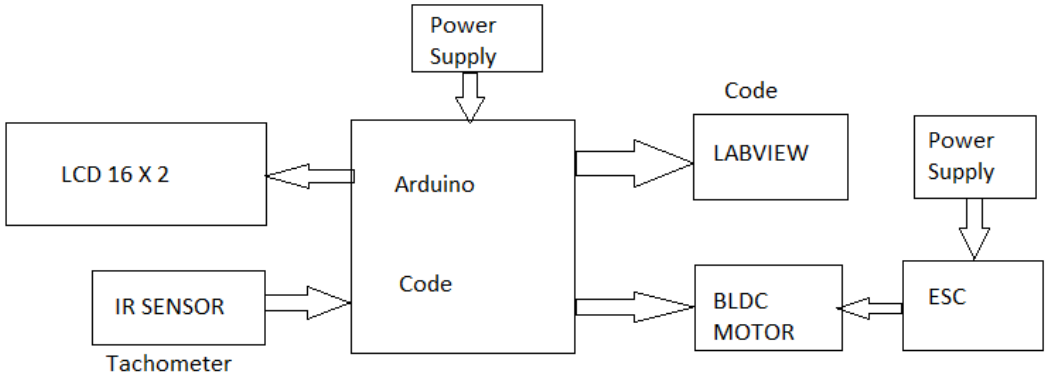

Figure 1: Block Diagram

BLDC and ESC

Brushless DC electric motor (BLDC motors also known as electronically commutated motors are synchronous motors powered by DC electricity via an inverter/ switching power supply which produces an AC/ bi-directional electric current to drive each phase of the motor via a closed loop controller. The motor structural elements of a brush less motor system is typically permanent magnet synchronous motor, but can also be a switched reluctance motor, or induction motor.

Regard less of the type used, an ESC interprets control information not as mechanical motion as would be the case of a servo, but rather in a way that varies the switching rate of a network of field effect transistors. ESC systems for brushed motors are very different by design; as a result brushed ESC's are not compatible with brushless motors. Brushless ESC systems basically create a tri-phase AC power output of limited voltage from an onboard DC power input, to run brushless motors by sending a sequence of AC signals generated from the ESC's circuitry, employing very low impedance for rotation.

Controlling Technique:

PWM technique is one of the most popular speed control techniques for BLDC motor. In this technique a high frequency chopper signal with specific duty cycle is multiplied by switching signals of VSI.

Therefore it is possible to adjust output voltage of inverter by controlling duty cycle of switching pulses of inverter. The disadvantages of analog methods are that they are prone to noise and they change with voltage and temperature change.

Also they suffer changes due to component variation .They are less flexible as compared to digital methods. The principle of generating PWM Counter is used to generate triangular wave. If the value of compare register is less than the value of triangular wave, then PWM is 1, else PWM is 0.

The supply voltage is chopped at a fixed frequency with a duty cycle depending on the current error. Therefore, both the current and the rate of change of current can be controlled. The two phase supply duration is limited by the two phase commutation angles. The main advantage of the PWM strategy is that the chopping frequency is a fixed parameter; hence, acoustic and electromagnetic noises are relatively easy to filter. There are also two ways of handling the drive current switching: hard chopping and soft chopping. In the hard chopping technique, both phase transistors

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are driven by the same pulsed signal: the two transistors are switched-on and switched-off at the same time. The soft chopping approach allows not only a control of the current and of the rate of change of the current but a minimization of the current ripple as well. In this soft chopping mode, the low side transistor is left ON during the phase supply and the high side transistor switches according to the pulsed signal. In this case, the power electronics board has to handle six PWM signals. The duty cycle determines the speed of the motor. The desired speed can be obtained by changing the duty cycle. The PWM in microcontroller is used to control the duty cycle of BLDC motor. An electronic Brushless DC Controller (also known as a Driver, or Electronic Speed Controller), replaces the mechanical commutation system utilized by a Brush DC Motor, and is required by most Brushless DC Motors to operate. In a Brushless DC Motor controller, either a IR Sensor or Back EMF (Electromotive Force) is used to identify the position of the rotor. Understanding the orientation of the rotor is crucial to operating the Brushless DC Motor. The Controlling Effect uses IR Sensor within the Brushless DC Motor to help detect the position of the rotor. This method is primarily used in speed detection, positioning, current sensing, and proximity switching.

ARDUINO Uno board type:
Arduino board designs use a variety of microprocessors and controllers. The boards are equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits. The boards feature serial communications interfaces, including Universal Serial Bus (USB) on some models, which are also used for loading programs from personal computers. The microcontrollers are typically programmed using a dialect of features from the programming languages C and C++.

LABVIEW Interface:
The GUI for monitoring was made on LABVIEW Software. Figure 2 gives front panel view of the LABVIEW Interface, and Figure 3 gives Block Diagram view of LABVIEW Interface for the proposed methodology.

IV. EXPERIMENTAL RESULTS

Figure shows the speed in rpm, in accordance with PWM duty ratio in figure 5 and 6, current of BLDC motor is shown under rpm measurements.

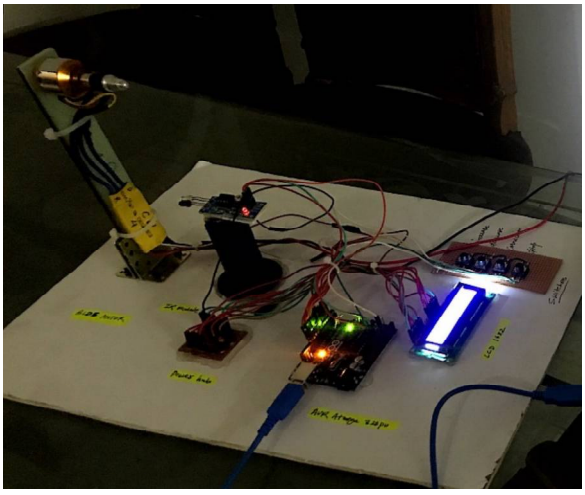

Figure 2: Experimental set-up

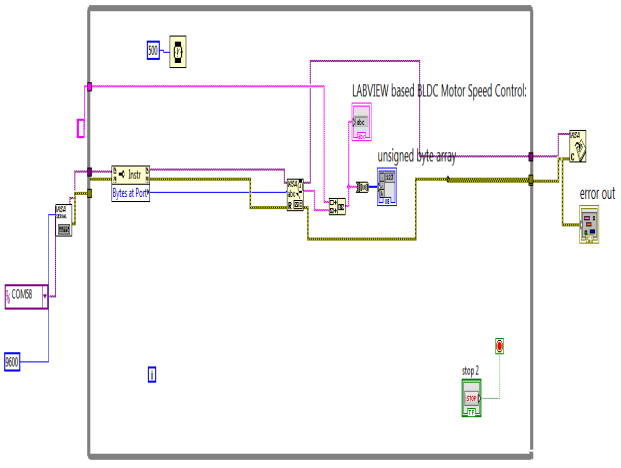

Figure 3: SIMULINK Model

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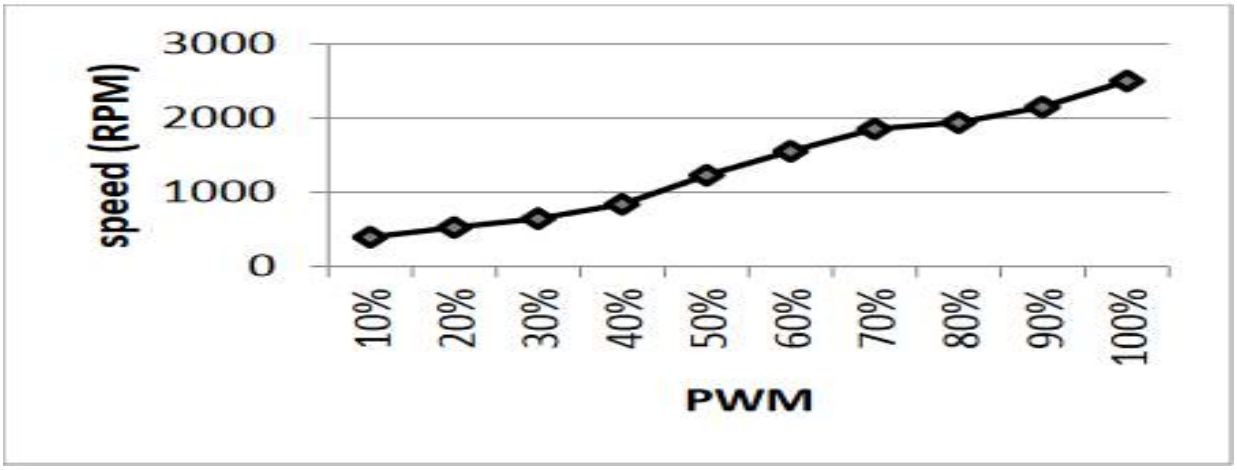

Figure 4: Speed vs PWM for BLDC motor

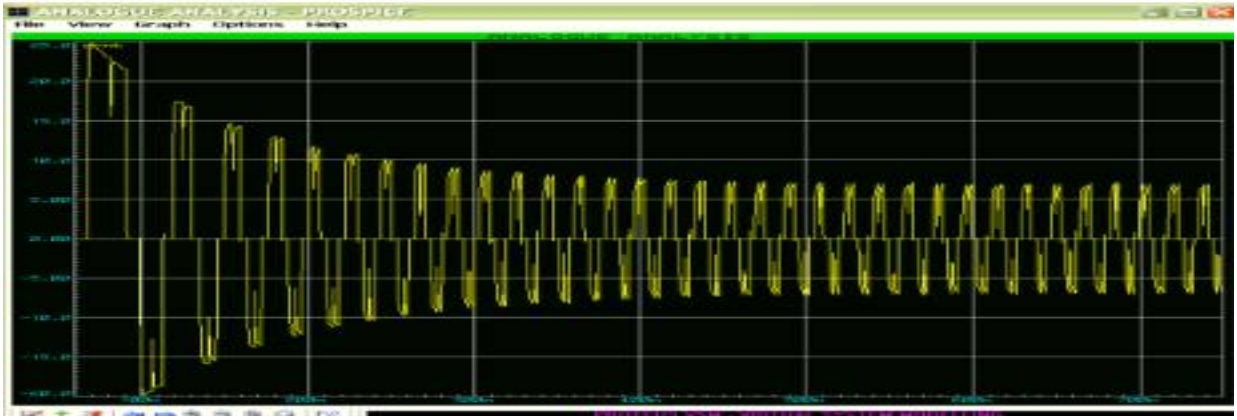

Figure 5: Current waveform for BLDC Motor

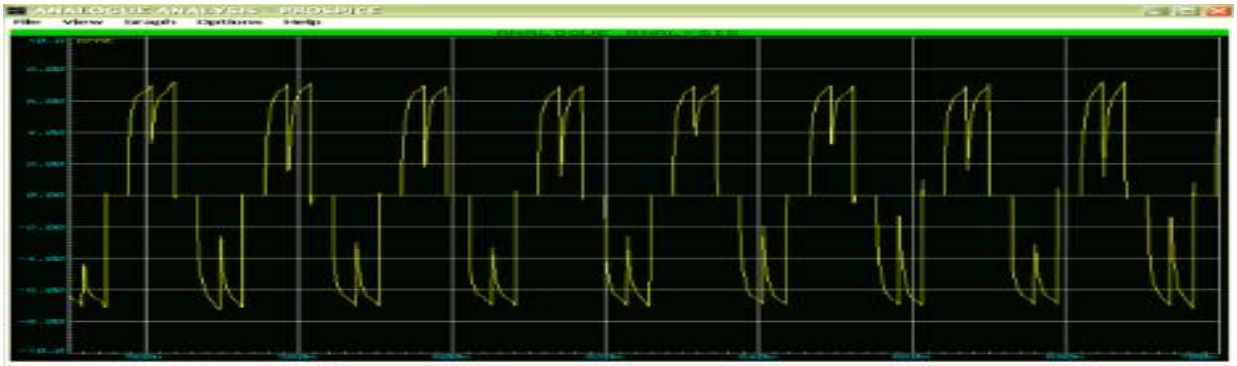

Figure 6: Current waveform (Magnified Output) for BLDC motor

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V. CONCLUSION

The framework once completely utilitarian will empower LABVIEW observing of the parameters of BLDC Motor. This paper shows the speed control technique for BLDC Motor through LABVIEW innovation. As the after effects of investigations, speed reaction and execution assessment has been confirmed with various speeds. Future extent of remote robotization incorporates use of adaptable systems of microcontroller based frameworks to control and screen a bank of electrical machines in mechanical and private fields. These systems would not be confined to LABVIEW but rather can likewise utilize Bluetooth, Wireless Fidelity (Wi-Fi), Radio Frequency Identification (RFID) and Zigbee and so on.

BLDC are continually supplanting DC motors in different applications. These applications fluctuate from fans, pumps, controlling haggle to give some examples. A common BLDC acts as a PM DC motor with straight speed versus torque attributes where the speed diminishes as the heap increments. A few applications, for example, a vehicle (Windscreen wiper), require the motor to have a genuinely consistent speed for various burdens. DC motors, for example, shunt and compound work sensibly well in these applications, however a BLDC with a CLOSED LOOP CONTROL controller enhances the execution.

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