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Robust Controll of Variable Speed BLDC Motor Drive Using PID Controller

Shuaib Mhammed T A*[1], Fathima Nazar[1], Nivya Dileep[1], Sreethu G[1]
[1]*Mar Athanasius College of Engineering , Kothamangalam ,Kerala, India*
*Corresponding Author:*shuaibmuhammedta@gmail.com*

Abstract
Brushless direct current (BLDC) motors have become very attractive in many applications due to its low maintenance cost and compact structure. The BLDC motors can be substituted to make the industries more dynamic. To get better performance, BLDC motor requires a control drive facilitating to control its speed and torque. The project describes the design of BLDC motor control system using Proportional integral derivative(PID) controller that can efficiently improve the speed control and reliability. The project provides an overview about the functionality and design of the PID controller and an interleaved boost converter.The whole control system has been successfully simulated using MATLAB/SIMULINK. The output results show that the back electromotive force and output speed,whose closed loop control, can give rise to a robust speed control system. The interleaved boost converter is formed by the paralleling of two boost converters. This increases the overall output current along with a wider voltage range.The complete hardware of the project will also be implemented in printed circuit boards. The design of converter is done such that voltage varies between 12 and 22 volts for an input of 12 volts. The motor stator is excited through a voltage source inverter whose switches are fired corresponding to the hall effect sensor output signal from the motor. A microcontroller is employed to take the hall effect signal at the input and produce switching sequences according to a given set of conditions.Another microcontroller is used in the interleaved converter circuit to implement the switching of two mosfets. Thus, the circuit in a whole forms a robust motor speed controller.

Keywords:*PID, Interleaved Boost Converter, PWM,BLDC Motor, Voltage Source Inverter.*

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I. INTRODUCTION

The BLDC motor is usually a synchronous motor composed of a trapezoidal back EMF waveform and a permanent magnet. The current trend shows that high-performance BLDC motor technologies are widely used for global industrial applications and variable speed drives in electric vehicles. In fact, these types of motors depend on its control circuit. In fact, these types of motors rely on its control circuit and still developing a high performance circuit is a challenging task for researchers. A basic control system is shown in Fig. 1 for the BLDC motor. The BLDC motor is accompanied by tuning block and closed loop control model. The design structure of a BLDC motor is a complex task and depends on many issues such as project selection, modeling, simulation, etc. In terms of the rapidity framework of the BLDC motor, a host of modern control solutions have been proposed. The key features of a conventional PID controller algorithm are it is easily adjustable, steady operation and its simple design, which makes it widely used for controlling system. For practical reason, common speed control structure is applied in the PID controller. The mathematical model and speed control of the BLDC motor have been proposed and validated using fuzzy logic and PID controller [4]. Most of the cases a different finding is seen in terms of practical utility experiences where the volatility of well-structured prototype, different units of nonlinear, low variability have been at work. For tuning a PID controller parameters are not that simple, hence, getting the optimal position under the examined circumstances is challenging. This project designs a PID controller to increase the speed range of BLDC motor. In this case parameters can be tuned at the actual moment under PID controller operation. For the better functioning of the PID controller scheme, it is required to optimize the values of tuning constants. At the same time, a set of values are applied for the PID controller's constant coefficients Kp, Ki and Kd. By employing these values, the proposed modified controller would be restructured to any adjusting dimension. The purpose of the project is to show the dynamic response to the rapid tuning results of the proposed modified PID controller; which can help to control the speed of the motor and to maintain constant speed during load changes. Thus, the PID regulator can increase the overall performance of the BLDC motor. The simulation results showed that the functions of the PID controller could be provided with a better control performance. In addition to the speed controller design, a dc-dc converter design is also conceived. The converter that is going to be implemented is an interleaved boost converter. Interleaved boost converter is a boost converter in which two boost converters are connectedin parallel such that the overall output current is improved with reduced ripples.

II. METHEDOLOGY

The speed controller used for the bldc motor used here is of closed loop type. The complete block diagram is shown in figure 3.1. The important blocks other than the motor are the interleaved boost converter, PID controller, and the voltage source inverter. In this figure, two control loops are indicated. The first one takes speed as the motor as feedback while the other takes back emf as feedback

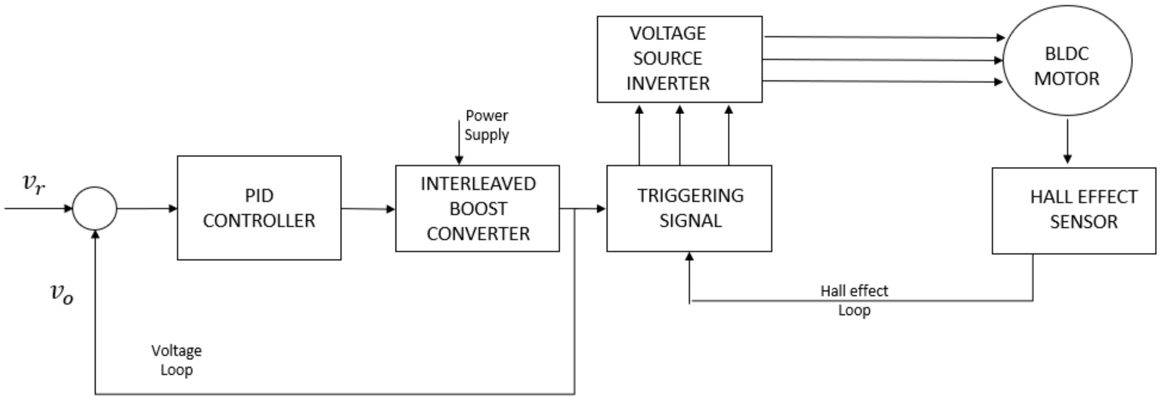

Figure 1: Speed control block diagram

The dc-dc converter used here is an interleaved boost converter. Interleaved boost converter is a converter where boost converters are connected in parallel. Interleaving adds additional benefits such as reduced ripple currents in both the input and output circuits. The advantages of interleaved boost converter compared to the classical boost converter are low input current ripple,faster transient response,reduced electromagnetic emission and improved reliability. As seen in the block diagram, we have a closed loop control of the output voltage of the converter. An error signal resulting from the difference between reference voltage and output voltage is applied to the converter which then boosts the voltage at the output according to the duty ratio. As seen in the block diagram, the output of the motor is taken through the hall effect sensor pins. A hall effect sensor is essentially a transducer based on the principle of hall effect.Typically,a bldc motor has three hall effect sensors placed 120 degrees apart from each other.In six steps, these hall effect sensors are able to give the motor position. The other use of these sensors is the speed calculation. Speed calculation is done by calculating the periods of the hall effect sensor signal. Only one hall effect sensor is enough for calculating the speed. The output from the hall effect sensors is used for comparing speed as well as the rotor positions. The hall effect signal, usually three bit is then used to control the switchingof the six mosfets in the voltage source inverter. The firing pulses for the mosfets is given with the help of a boolean logic which can be programmed using a microcontroller.

III. THE SIMULATION

The MATLAB simulation of theVoltage Source Inverter ,Interleaved BoostConverter and Input Voltage Controll and Motor Speed Controllare shown in figure 2, figure 3 and figure 4 respectively.

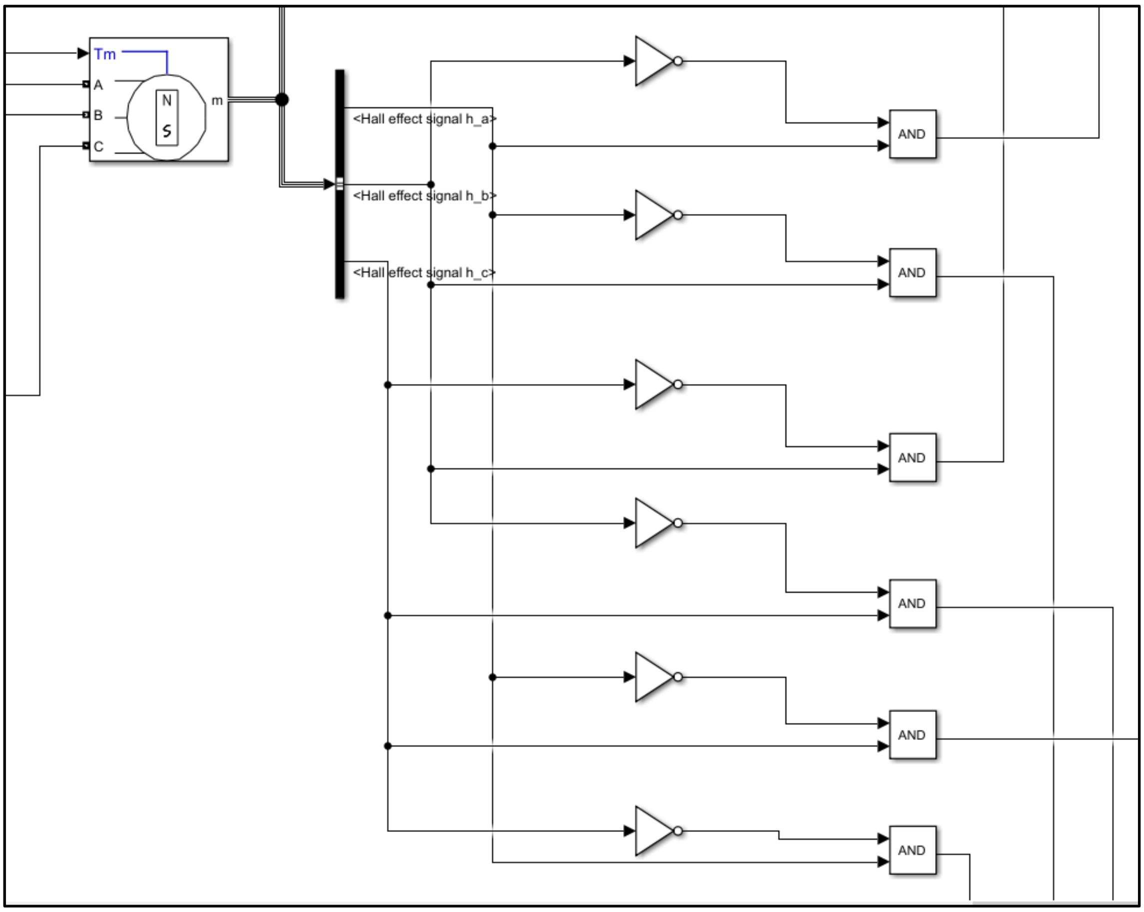

Figure 2:Inverter with SPWM

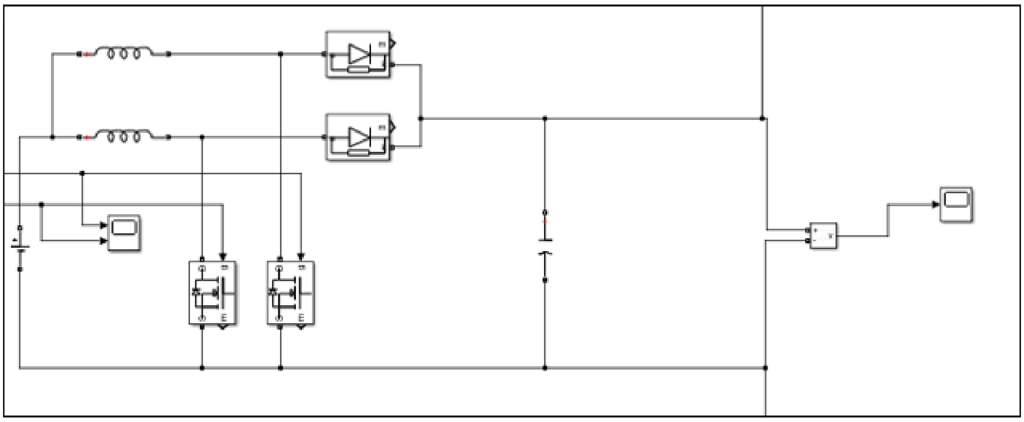

Figure 3: Interleaved Boost Converter

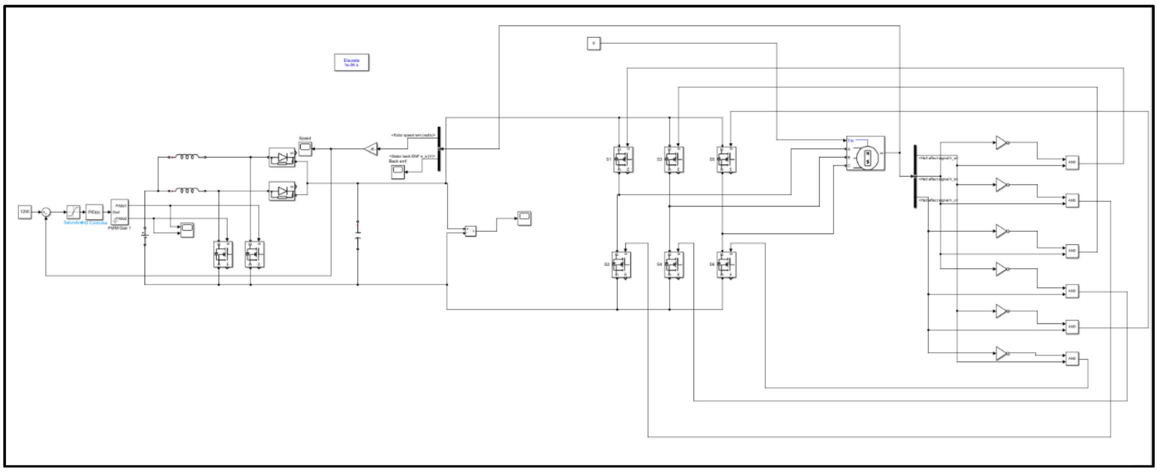

Figure 4:Interleaved Boost Converter and Input Voltage Controll and Motor Speed Controll

IV. SIMULATION RESULTS

The simulation results as Output Back EMF and Output speed in rpmare shown in the figure 5 and figure 6 respectively.

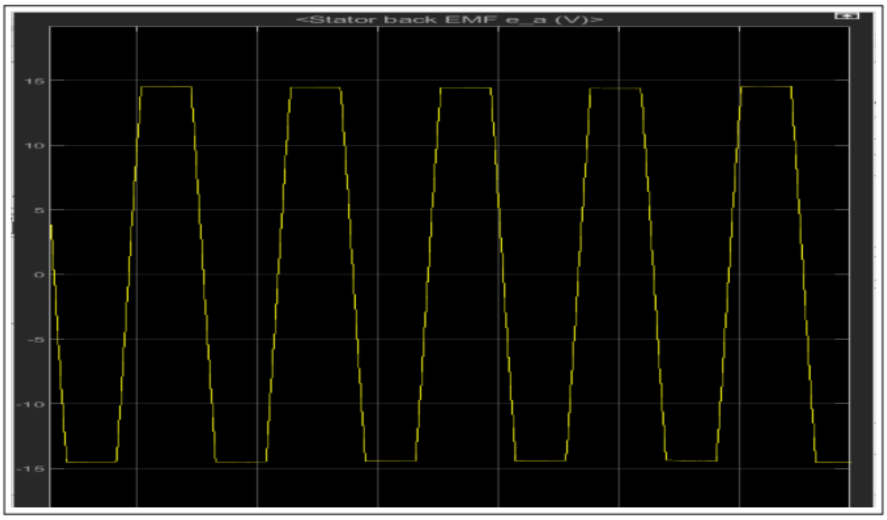

Fig.5:Output Back EMF

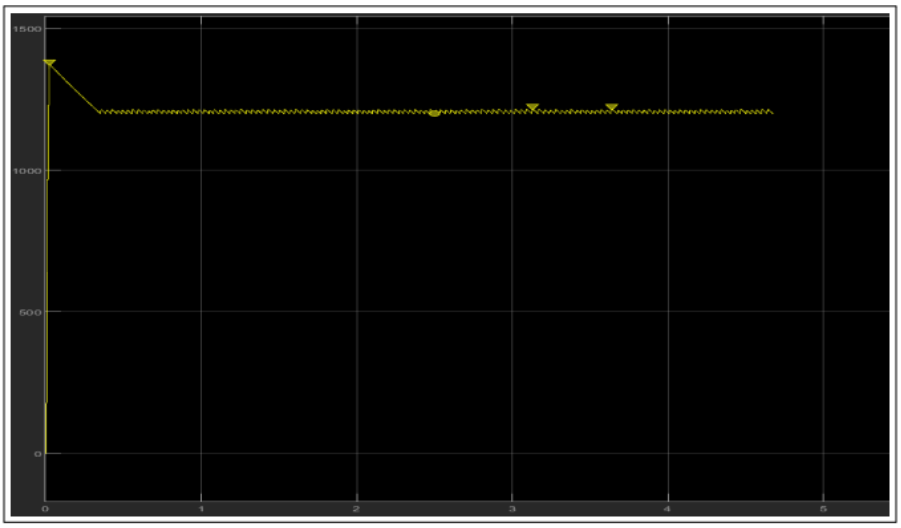

Figure 6: Output speed in rpm

HARDWARE IMPLIMENTATION

Hardware has been implemented as two parts, that is , in two separate printed circuit boards(pcb). The first part is of the interleaved converter and the second part has the voltage source inverter.The dc-dc converter is the first part of the motor control system. As mentioned earlier, we are implementing an interleaved boost converter for varying or developing the suitable supply for the motor with reduced ripples. Interleaved converter is actually aconverter in which two boost converters are connected in parallel. The input voltage of our circuit is 12 volts and with the set duty ratio of the converter ,we are getting an output voltage at around 24 volts. With the assistance of a rheostat at the output of the converter, we vary the output voltage of the converter which is nothing but theinput of the voltage source inverter connected to the motor. Thus, by varying the converter voltage the supply to the motor also gets varied, which in turn varies the speed of the motor.hile we implement the interleaved converter in the printed circuit board, we employ a microcontroller and a driver ic chip. The microcontroller we are using here is dsPIC30F2010. The adequate programming for controlling the switching of mosfets in the converter is written in the microcontroller. The microcontroller controls the mosfets through a driver ic chip. The driver ic chip used here is IR2110 ic.The IR2110 ic is a high voltage, high-speed power mosfet driver with independent high and low side referenced output channels. The voltage comparison as well as the voltage limit conditions can be programmed in the microcontroller suiting our purpose.

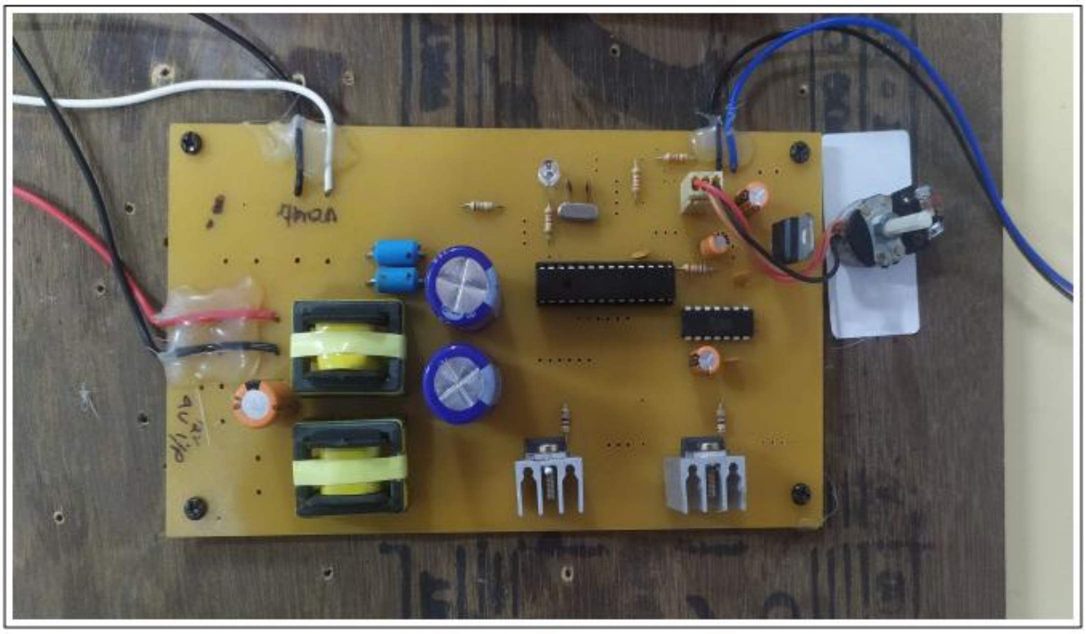

Figure 7:Interleaved Converter Hardware

The voltage source inverter has also been implemented in a separate printed board. circuit. In the inverter we employ six switches for controlling the output waveform or pulses. The switches are implemented with six mosfets driven by three driver ic chips. The switching of the mosfets are programmed in the microcontroller which thus controls the driver ic chips. The hall effect signal is the input to the voltage source inverter. The logic for creating the six different switching sequence for the mosfets is already programmed in the microcontroller before integrating them. Thus forms a closed loop control of the bldc motor. The microcontroller chip used here is also dsPIC30F2010 and the drive ic chip is IR2110. Three such driver ic chips are required to control the six mosfets. A 12 regulator ic is also used to control the voltage at the output of the driver ic to 12 volts which is to besupplied to the mosfets.

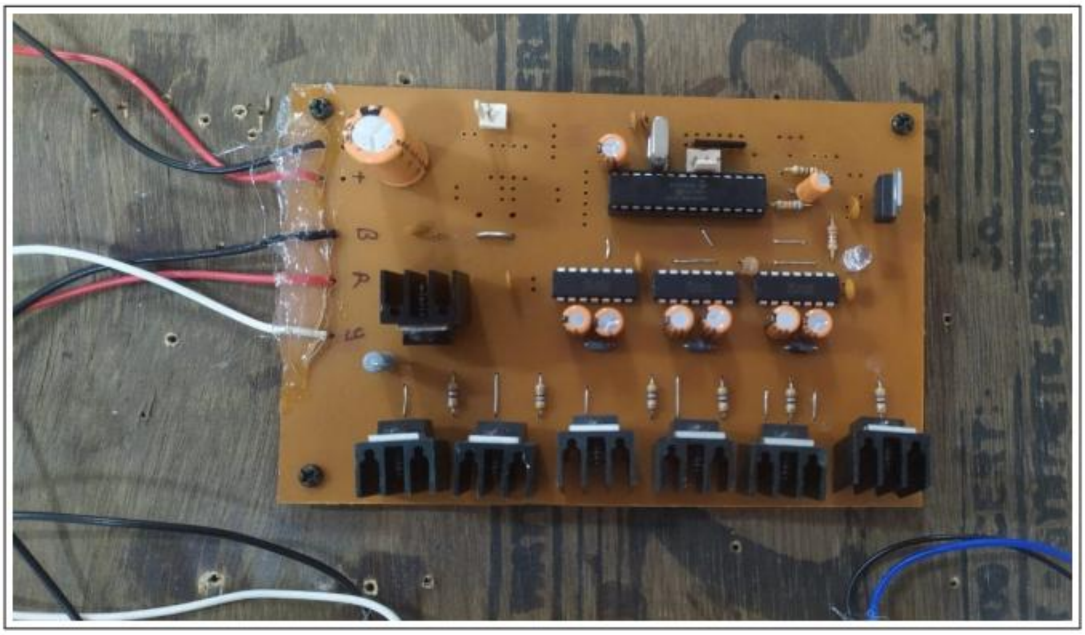

Figure 8:Voltage Source Inverter

The dc voltage from the interleaved converter is then fed to the voltage source inverter having six mosfet switches. The inverter provides a three phase ac voltage which forms the input for the motor. The bldc motorused is also shown in the figure. Input for the hall effect sensor is also taken from the inverter circuit. The three bit output of hall effect sensor is also given to the microcontroller, which then uses this signal for firing the mosfets in the inverter. Thus, a closed loop control of motor speed is achieved.

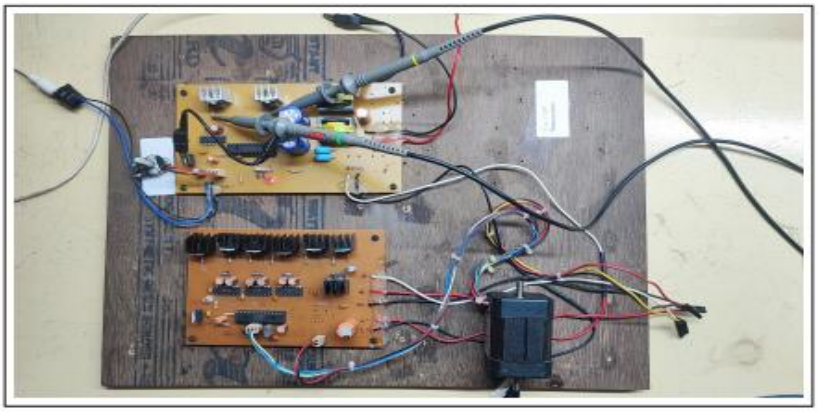

Figure 11:Complete Hardware

V. CONCLUSION

A BLDC motor controller has been successfully designed based on proportional-integralderivative (PID) controller scheme.The interleaved boost controller that was simulated has been realized on the printed circuit board. The supply to the converter is controlled by using a rheostat and thus the speed of motor is varied between maximum and minimum. The variation of voltage also has been observed using a cathode ray oscilloscope. The oscilloscope result shows that the speed of the motor varies in direct proportion to the change in reference voltage to the converter. The use of interleaved converter helped to yield the required current for smooth running of the motor. In addition, it also helped to reduce the ripples in supply to the motor.The pid controller has made improvements in the time and frequency responses of the motor output with added stability. The voltage source inverter was implemented using six mosfets to provide appropriate switching in accordance with the six rotor positions of the motor. Three driver ic chips were used for effectively controlling the pulses to the mosfets and ensure seamless switching. The switching pulses in the six mosfets of inverter ,The switching pulses of mosfets and the dc output voltage range were observed using the cathode ray oscilloscope. The switching of driver ic chips, the error signal calculation logic and the pid control algorithm were programmed using two microcontrollers.

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