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Hadrware Implementation of Boost Converter for BLDC

Srinivasan S[1], Logavani K[2]

PG Scholar, Department of Power Electronics and Drives, GCE, Salem, Tamil Nadu, India[1]

Assistant professor, Department of EEE, GCE, Salem, Tamil Nadu, India[2]

ABSTRACT: This project of the Dc-Dc Converter is Hardware Implemented for brushless Dc Motor (BLDC) and Open-loop speed control using potentiometer. The three phase (BLDC) Motor is operated in ac supply which is supplied to this machine for six step inverter or ESC Circuit by the source of Dc-Dc Boost Converter and Dc battery. To minimize the harmonics to improved sinusoidal pulse width modulation. This type of commutation reduced the torque ripple of motor. Whose switching state is controlled by PWM signal which is generated and controlled for arduinoUno.The purpose of the project application of EV vehicle

KEYWORDS: potentiometer controller, BLDC motor, electronic speed controller

I. INTRODUCTION

The DC motor considered as having good torque and speed characteristic and efficiency. The DC motor are preferable than AC motor in any area like aircraft, robotics, industries and home appliances. But the brushed dc motor has some disadvantage which lead to introduce the brushless dc motor instead of the brushed-dc machine. The operation and maintenance cost of the dc motor is too high due to the presence of the commutator brushes and the brush gear and cannot operate in huge hazard conductions because sparks may occur and may lead to the fire. The speed will change as the load changes, as there is variable speed not only by controlling the resistance but also by the load current.

The speed control could be impossible for rapidly changing loads. Brushless dc motor does not any brushes, so they don't undergo any commutation, Brushless dc motor has a significantly higher efficiency and performance and compareto that it also has a very low susceptibility to mechanical parts than their brushed counter parts. Due to advantage of BLDC motor over dc motor and other ac motor control of BLDC motor is very essential. Many control techniques of BLDC motor are in the use but to improve the performances of the motor we are going to deal with the Potentiometer control method.

II. METHODOLOGY

BLOCK DIAGRAM OF THE PROPOSED SYSTEM

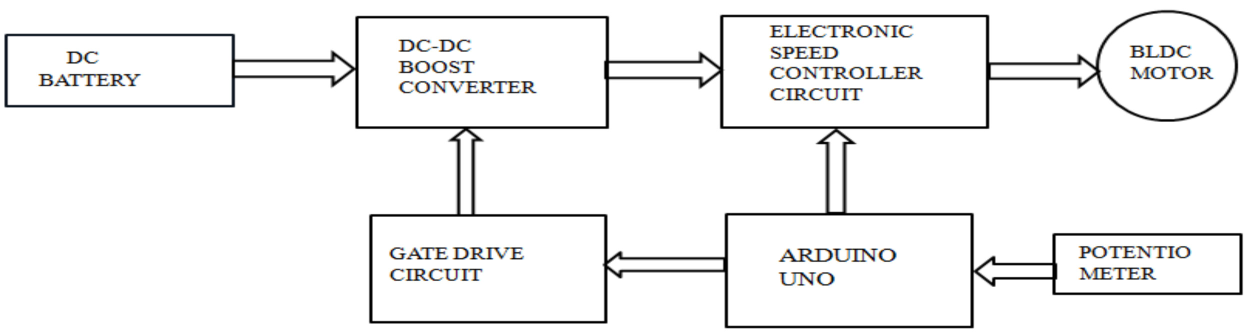

Figure1.1 Block diagram of open loop control for BLDC

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BOOSTCONVERTER

Boost converters are used in electronics to generate a DC output voltage that is greater than the DC input, therefore boosting up the supply voltage. Boost converter are often used in power supplies for white LEDs, battery packs for electric auto mobiles, and many other applications. Boost converters are a type of DC-DC switching converter that efficiently increase (step-up) the input voltage to a higher output voltage. By storing energy in an inductor during the switch-on phase and releasing it to the load during the switch-off phase, this voltage conversion is made possible. Boost converters are widely used in portable electronic devices, such as smartphones, tablets, and laptops, where they step up the battery voltage to required levels. These devices often require multiple voltage levels for different components, and boost converters efficiently provide these higher voltages from a single battery source. Their high efficiency and compact size make them ideal for extending battery life and reducing the size of power management circuits in portable electronics.

TOPOLOGY

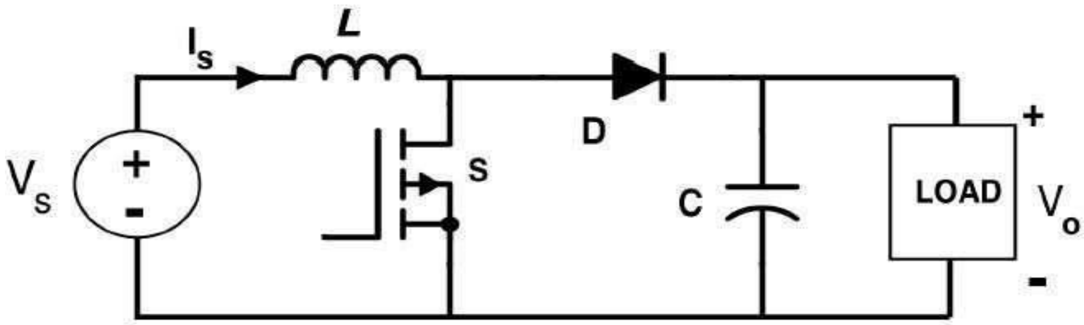
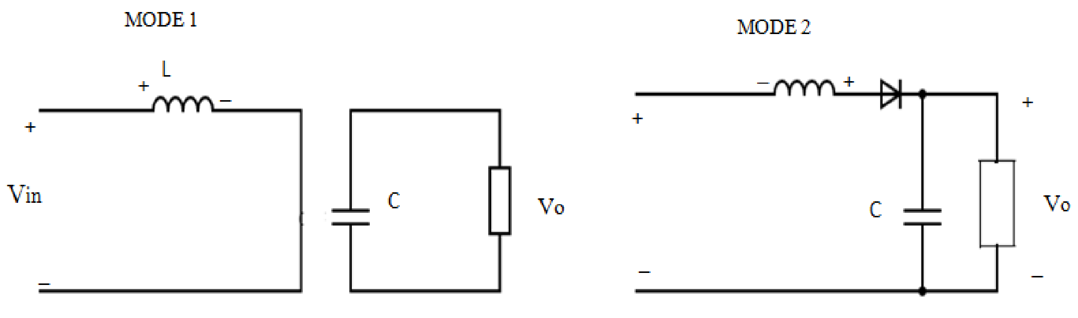


Figure2.1 BoostConverter

A boost converter is a type of DC-DC converter that steps up the input voltage to a higher output voltage. It begins with a DC voltage source that provides a lower input voltage. An inductor is connected in series with the input voltage source and the switch, storing energy when the switch is closed. The switch, typically a transistor, alternates between open and closed states, controlled by a pulse-width modulation (PWM) signal. When the switch is closed, current flows through the inductor, causing it to store energy in its magnetic field. Diode is placed in series with the output and prevents the backflow of current from the capacitor to the inductor when the switch is open. When the switch opens, the inductor releases the stored energy, which adds to the input voltage, thereby boosting the voltage. A capacitor connected across the output terminals smooths the output voltage by storing and supplying energy. The output voltage is higher than the input voltage and is maintained by the combined action of the inductor and capacitor. In continuous conduction mode, the inductor current never falls to zero, providing a continuous output voltage. The output voltage is regulated by adjusting the duty cycle of the PWM signal, which controls the proportion of time the switch is closed versus open.

MODE OF OPERATION:



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MODE-1

The switch is closed, causing the inductor to store energy as the current through it increases linearly. The diode is reverse biased, preventing current from flowing to the output, and the input voltage is directly applied across the inductor.

MODE-2

The switch is open, causing the inductor to release its stored energy. The inductor voltage reverse, forward biasing the diode, and allowing current to flow to the output. The inductor current decreases, transferring energy to the output capacitor and load. To obtain the input–output voltage relationship, apply the volt-second balance rule to the inductor. This implies that the area under the inductor voltage curve in one period under steady state conditions should be zero.

III. BOOSTCONVERTER DESIGN CALCULATION

$$\text{Duty cycle } D = 1 - \frac{V_{IN} \times \eta}{V_{out}} \eta = 100\%$$

$$\text{maximum swiutch current } i_{max = 14 \text{ Amps}}$$

$$\text{inductance } L = \frac{V_{in} \times (V_{out} \_ V_{in})}{\Delta_{IL \times f_S \times} V_{out}}$$

$$\text{capacitance } c = \frac{I_{out} \times D}{\Delta V_{out} \times fs}$$

$$D = 0.62 \text{ or } 62\%$$

$$\text{inductance value } L = 4.1\text{mH}$$

$$\text{capacitor value } C = 380\mu F$$

$$v_i = 12v \; , I_{in} = 15amp$$

$$v_o = 24v, I_o = 7amp, f_s = \text{Switching frequency Hz}$$

$$f_s = 10 \text{ Khz}$$

IV. THREE PHASE INVERTER

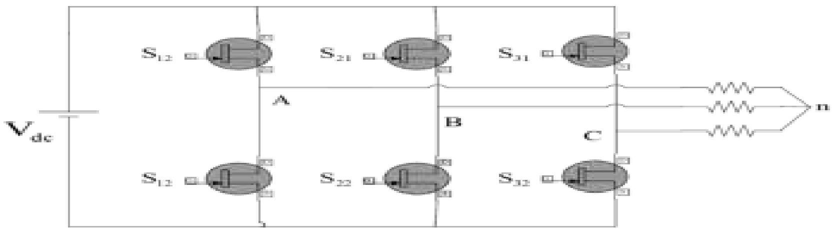

Figure3.1Voltage Source Inverter

BLDC motor drives are mostly used three-phase bridge inverters for supplying power to it. The circuit diagram of a six-step VSI isas shown in Figure, it comprises of three half- bridges, and these three phase shifted by120degree to produce the three phase voltages.

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PWM TECHNIQUES

Pulse-width modulation is a technique in which the ON-OFF time of switches is controlled by reference wave. In this the intersection between a reference wave and a carrier wave produces the pulses according to which the switches are switched ON and OFF.PWM have a wide field of applications such as motor speed control, converters, communication, etc. For example, PWM is used to control the switches of inverter to control the power supplied to the motor. By controlling the ON-OFF time of the switches we can control the speed of the motor. When we Need more speed we increase the ON time of the switches similarly when we need to slow down the motor we decrease the OFF time of the switches. Higher switching frequency for the switches so that the power losses is in significant as compare to the power supplied by the source. There are different PWM techniques used for motor control application.

We use the following techniques:

1) Sinusoidal PWM
2) Space Vector PWM

V. BRUSHLESSDIRECTCURRENTMOTOR

A BLDC motor is a permanent magnet synchronous motor. Position sensors are used to sense the rotor position according to the rotor position inverter control the stator currents thus the speed of motor. The term dc comes in the name of BLDC because its torque speed characteristics are similar to that of dc motors. BLDC requires an electronic commutation circuit instead of mechanical or brushed commutation used in dc motor.

BLDC motor is divided into mainly two types based on the shape of back-emf waveform induced in the stator are sinusoidal type and trapezoidal type. Sinusoidal motor has a sinusoidal shaped back-emf and it require phase current to be sinusoidal for torque ripple free operation on the other hand trapezoidal motors need rectangular shaped current for torque ripple free operation. The trapezoidal motor requires position sensors to sense the position of rotor at every instant of time. It’s requiring a complex hardware for smooth operation.

The trapezoidal motor is more popular for most of the application due to its simple operation, low price and high efficiency. Many different configurations of BLDC motor exist three phase motors with star connected windings are most popular in use today because of its high efficiency and lower torque ripple. Brushless DC motor has the rotor containing a permanent magnet and its stator consists of three solenoids connected in a star topology and positioned 120° from each other. The rotor electromagnetic field changes with the rotation so that in order to keep the load angle as close to 90° as possible, the stator electromagnetic field is constantly changed according to the position of the rotor below show the structure and working principle of a brushless DC motor.

VI. SIX-STEPALGORITHM

The six-step algorithm is a driving operation of three-phase BLDC motors. In six- step, there are six current directions running through two of the three phases, which created six discrete directions of magnetic field for the stator .To acquire the position of the rotor, the hall-effect sensors are used for sensor BLDC motors and EMF feedbacks are used for the sensor less counter- parts. Eventually, the correct step is applied accordingly to the known rotor position and the intended rotation direction.

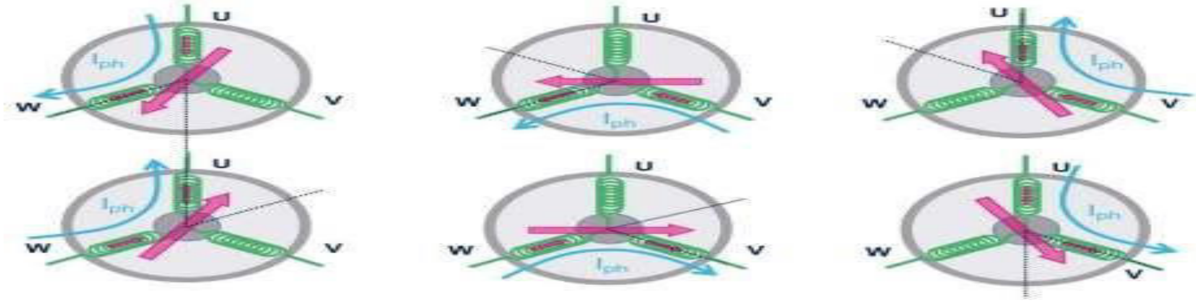

Figure3.2 Six combinations in six-step algorithm

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Principle of Operation of Brushless dc motor

The three phase BLDC motor is operated by energizes two phases at a time, i.e. the only two phases are energized at an instant of time while the third phase is off to produce the highest torque. The two phases which are energized determine by an electronic commutation circuit. depends on the output of the sensors. Hall-effect sensors are most commonly used to sense the rotor position and feed it to the controller. The signal from the sensors changes every 60° (electrical degree) as shown in figure. Each interval starts with the rotor and stator flux is 120° apart and ends when they are60°apart.Highest torque is reached when the field are perpendicular to each other. Commutation is done by a Voltage source inverter. The switching devices used are MOSFET or IGBT.

VII. ELECTRONIC SPEED CONTROLLERS

Electric unmanned aerial vehicles (UAVs) are increasingly being operated in a range of civilian and military applications. Within the powertrain of all these UAVs is an electronic speed controller (ESC) that provides a link between the power source and the motor. The ESC converts the direct current (DC) electricity from a battery to 3-phase AC to drive a brushless DC motor. This is achieved via high frequency electronic switching, which could yield considerable efficiency losses. However, despite the importance of the ESC, limited data is available on the performance of ESCs and the impact on electric UAV propulsion systems. Performance of ESCs is especially important for advanced fuel-cell propulsion systems where power is limited and the voltage can change significantly under load.

ESC SPECIFICATIONS

ESC	Voltage Range (V)	Maximum Current(A)
TurnigySuperBrain40	6-13	40
TurnigyAerostar30	6-17	30
TurnigyAerostar50	6-26	50
TurnigyAerostar80	6-26	80

VIII. POTENTIOMETER CONTROLLER

The most crucial manual tool for regulating speed in the planned BLDC motor control system is the obedient hand potentiometer. The user may even adjust the motor's rotational speed by rotating the hand potentiometer, which is a very easy and straightforward method to utilize when controlling the motor's operation. The primary goal of adding a potentiometer to an Arduino system is to add variable resistance. The potentiometer's position corresponds to the digital signal output value of 1024, which is measured by Arduino as an analogue voltage between 0 and 5 volts. To find a PWM (pulse width modulation) width that allows the motor to run at the required speed, the Arduino takes this data and converts it to an appropriate value.

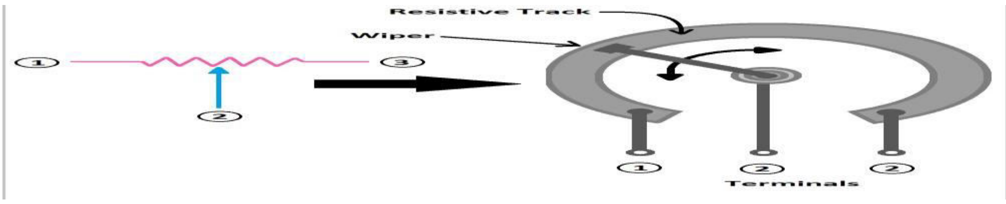

Figure 6.1 potentiometer

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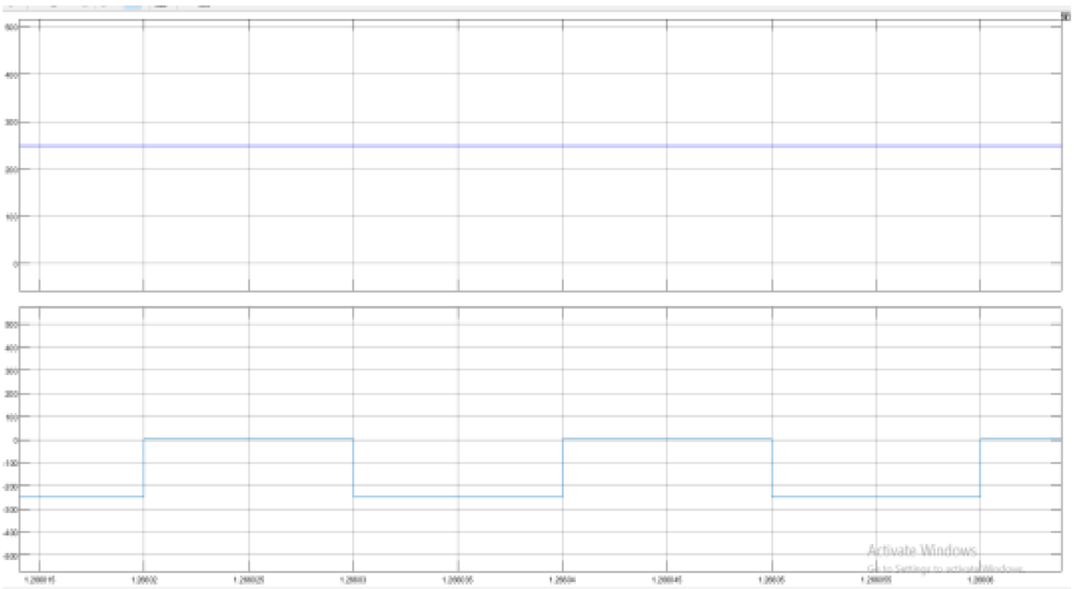
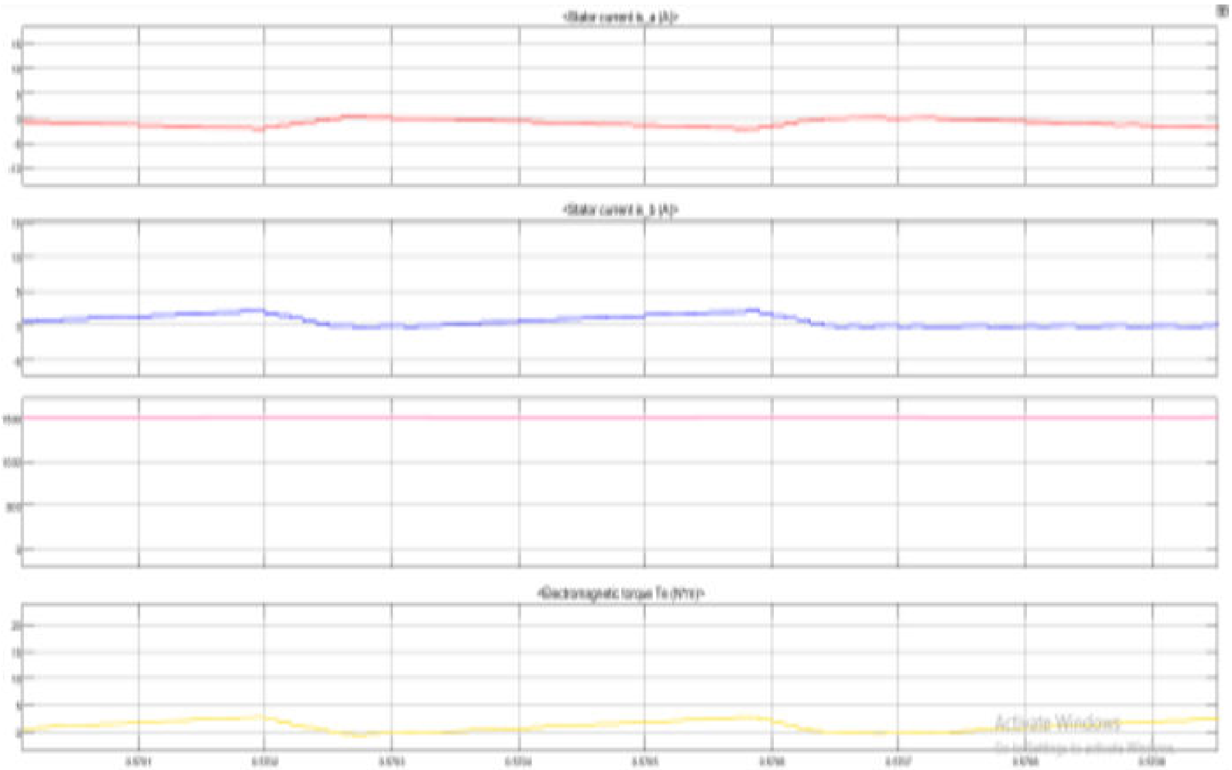
IX. SIMULATION DIAGRAM

Simulation diagram of proposed system

WAVEFORM FOR BOOST CONVERTER OUTPUT AND INVERTER OUTPUT



WAVEFORM FOR SIMULATION OUTPUT



Figur waveform for simulation output

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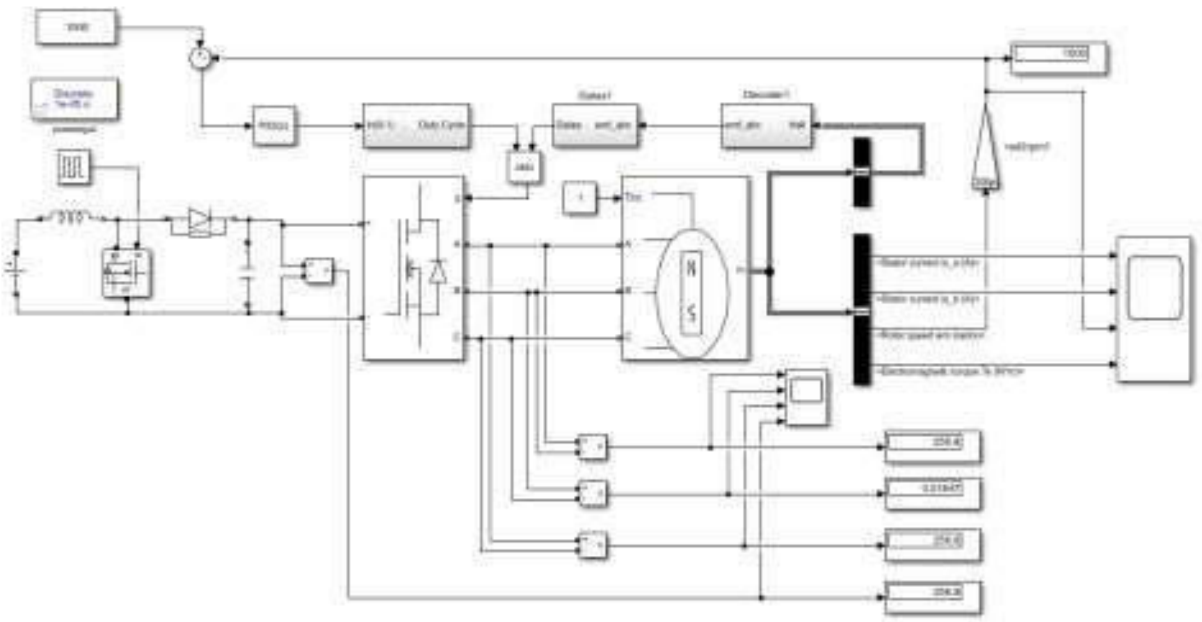
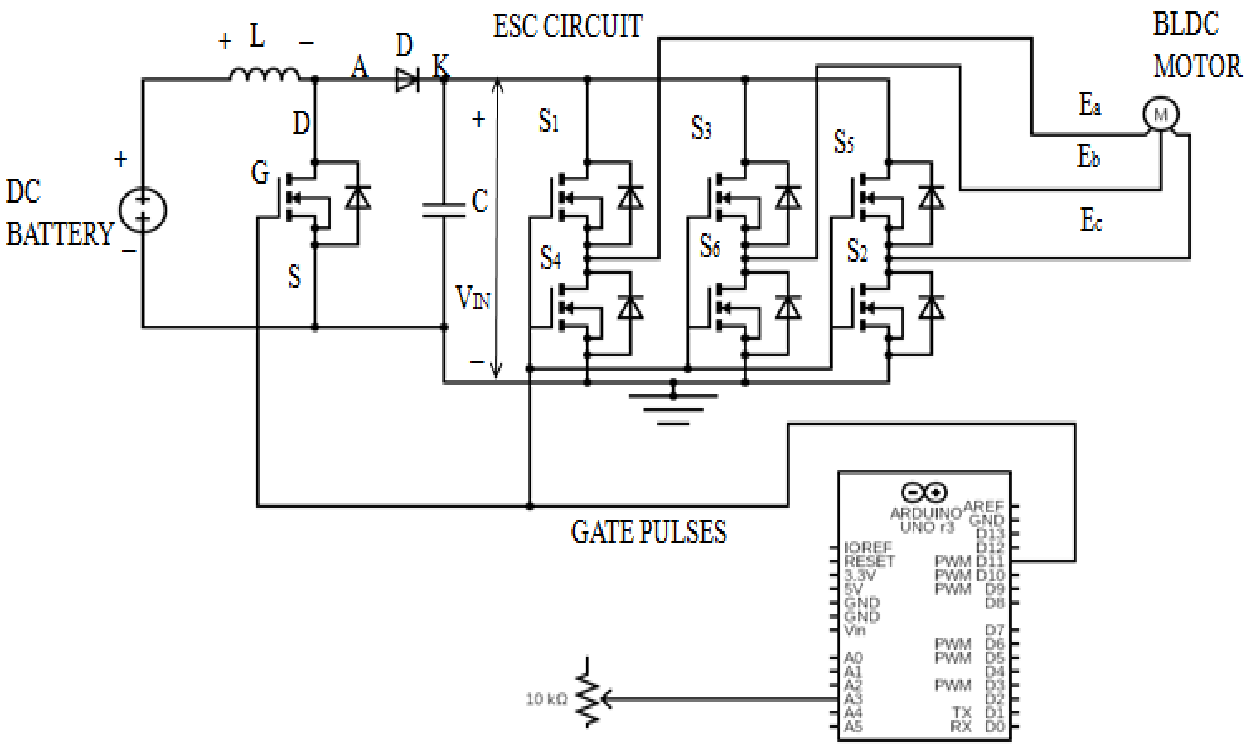
HARDWARE CIRCUIT AND IMPLEMENTATION



9.1CIRCUIT DIAGRAM



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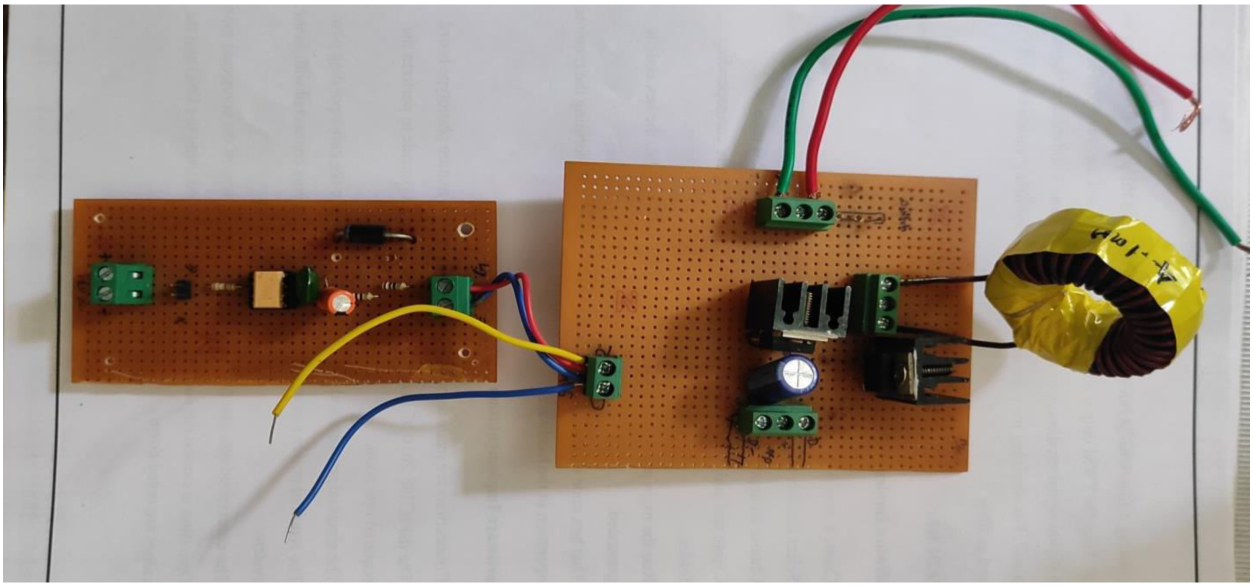
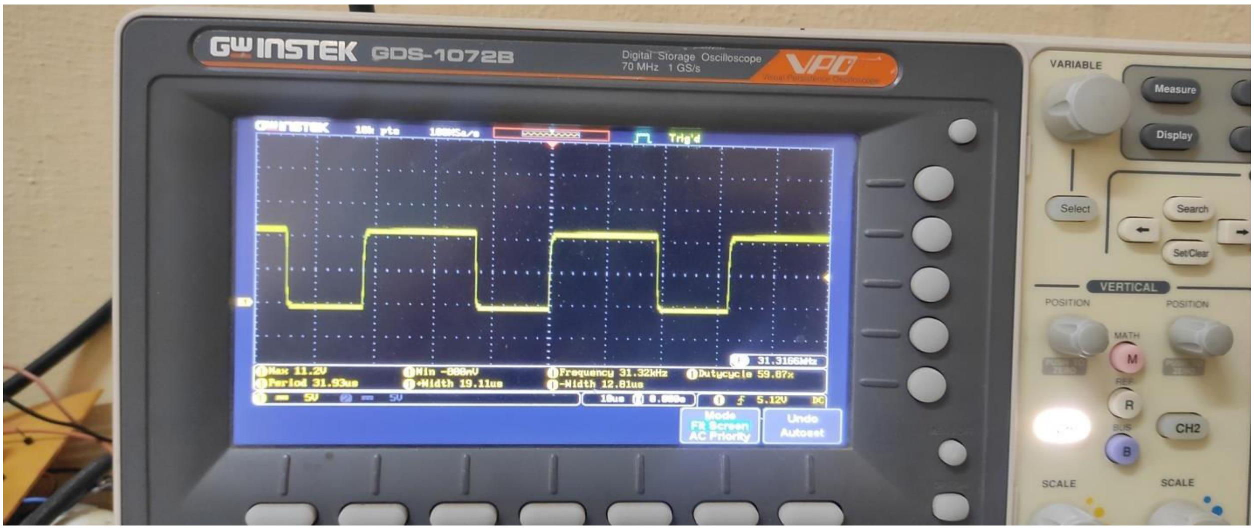
9.2 HARDWARE SPECIFICATION

DC Battery = 12V, 15AH
Diode: U860 (30V. 8A)
N- Channel MOSFET: IRF 3205, Vds= 55V, Vgs=20V, ID=110A
L= 4.5mH
C= 320µF
ESC= 24V, 7A
BLDC Motor: 170W, 1500rpm.

9.3GATE DRIVE CIRCUIT



9.4 GATE DRIVE PULSE



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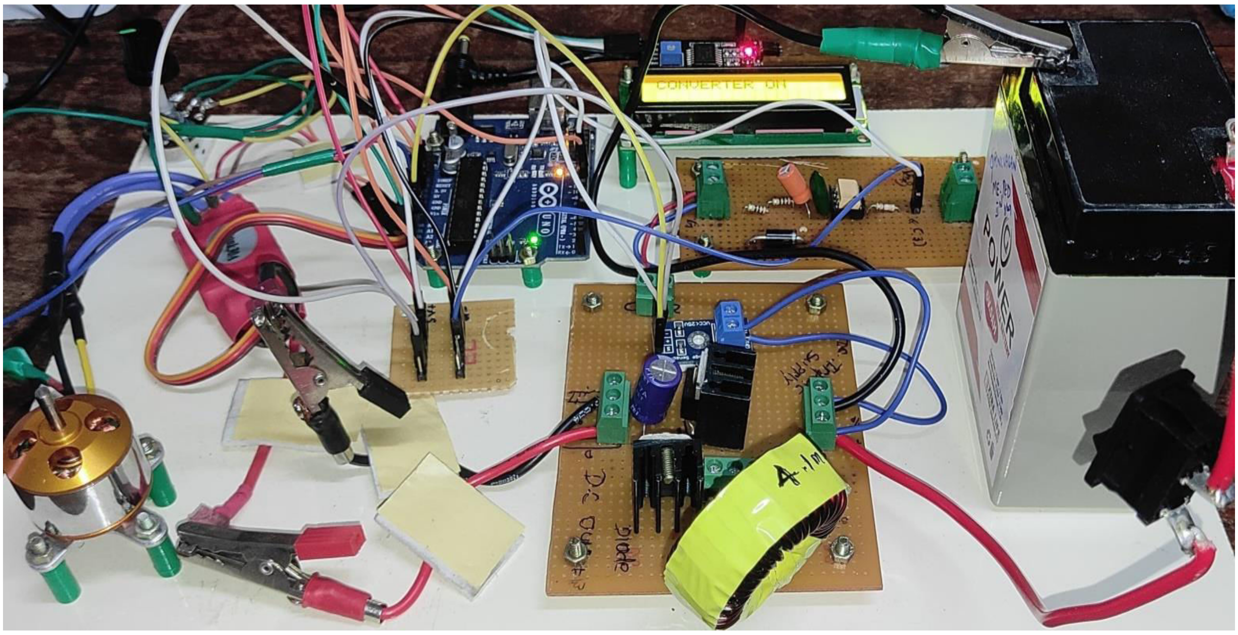
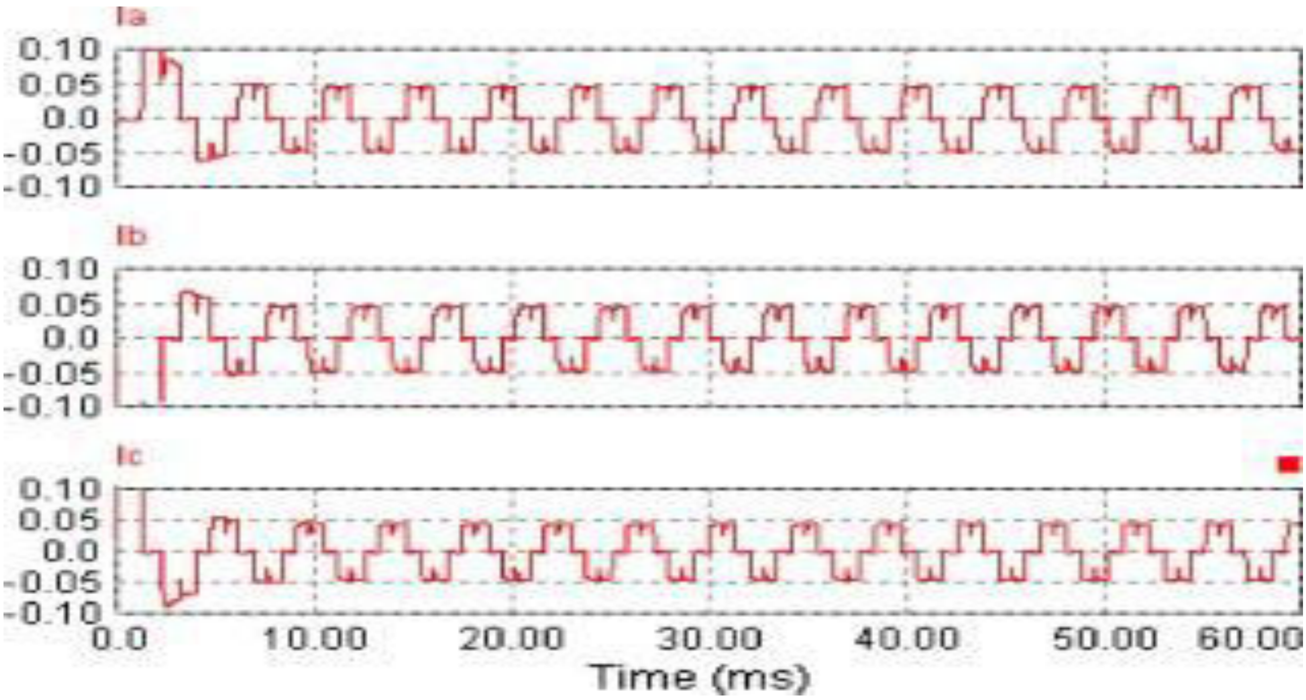
9.5 HARDWARE POWER CIRCUIT



9.6 POWER CIRCUIT WAVEFORM



X. CONCLUSION

This project of design and implementation of boost converter for bldc motor. Which hardware implementation is built and run successfully by a proper design calculation.

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