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Speed Control of BLDC Motor using Zeta Converter

M.Suneetha, M.Leela Mounika, N.G.Sai Ram, A.K.Pavan Kumar, K.Thirumala Venkatesh, P.Vokki

Department of Electrical and Electronics Engineering, Narayana Engineering College, Nellore, Andhra Pradesh, India

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ABSTRACT

Traditionally inexpensive analog components are used for the design purposes of Motor drives. The weakness of analog systems is their susceptibility to temperature variations and component aging. Another drawback is the difficulty of upgrading the systems. Digital control structures eliminate drifts and, by using a programmable controller, the upgrades can be easily accomplished by software. The high performance of digital signal controllers allows them to perform high-resolution control and minimize control loop delays. These efficient controls make it possible to reduce torque ripples, harmonics and improve dynamic behavior in all speed ranges. The motor design is optimized due to lower vibrations and lower power losses such as harmonic losses in the rotor . Moreover designers have recognized the opportunity to redesign existing systems to use advanced algorithms. For improved efficiency and torque performance, brushless DC (BLDC) motors require a phase advance circuit. Because of the problem of controlled phase advance in BLDC motor we need digital control methodology instead of conventional analog control for the speed control of PMBLDCM. By applying direct digital control it will substantially increase the effective speed range and facilitates a constant power profile. Here the DSP controller is designed to meet the needs of control-based applications of Brushless DC Motor. BLDC motors are becoming popular in Aerospace applications due to better speed v/s torque characteristics, higher efficiency, and high power to frame size, silent operation and reliability.

KEYWORDS: BLDC MOTOR 1, DSP Controller 2, Motor drives 3

INTRODUCTION

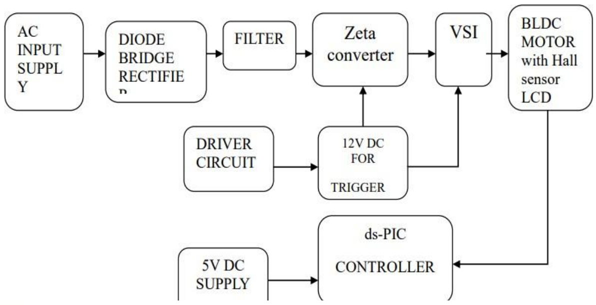
The DC-DC converter exhibits the advantages over the conventional buck, boost, buck–boost converter when employed in SPV-based applications. The boost converter dc voltage is applied to three phase inverter circuit. Three phase inverter converts the dc voltage into three phase ac voltage. The boost converter operates to increase the output voltage.

This project is proposed to control the speed of bldc motor by employing boost converter. The AC supply is applied to the bridge rectifier, the bridge rectifier converts ac supply into dc supply. That dc supply is applied to boost converter, the boost converter is boost the input voltage (i.e) if input 15v dc means boost converter output voltage is greater than 15v dc voltage. That dc voltage is given to the three phase inverter ,it converts the dc voltage into three phase ac voltage. Three phase ac voltage is connected to the BLDC motor. The bldc motor have hall sensor. The hall sensor output is feedback to the controller. The three phase inverter Pulse depends on the hall sensor of bldc motor. The DSPIC controller key functions [1] are used to control the bldc motor speed. DSP-Based Speed Control of Brushless DC Motor Drive Using Sliding Mode Control" (2019) by N.

D. Shah, M. K. Zaveri, and R. J. Shah: This paper presents a DSP-based speed control technique for a BLDC motor using a sliding mode control approach. The performance of the system is evaluated through simulation and experimental results.[2] DSP-Based Speed Control of BLDC Motor Using Model Predictive Control" (2020) by M.H. Naeem and M. R. M. Khan: This paper presents a DSP-based speed control technique for a BLDC motor using a model predictive control approach. The performance of the system is evaluated through simulation and experimental results.[3] DSP-Based Speed Control of BLDC Motor Using Model Predictive Control" (2020) by M.H. Naeem and M. R. M. Khan: This paper presents a DSP-based speed control technique for a BLDC motor using a model predictive control approach. The performance of the system is evaluated through simulation and experimental results. This paper proposes a novel Zeta converter topology for brushless DC motor drives with an active power factor correction (PFC) technique.[4] In another study by Nagaiah et al. (2018), a hybrid Zeta converter topology was proposed for BLDC motor drives. The topology combined the Zeta converter with a flyback converter to improve power quality and efficiency. The system was implemented and tested experimentally, and the results showed that the hybrid Zeta converter improved power quality and reduced EMI.[7] Another study published in the Journal of Power Electronics (Volume: 17, Issue: 5, September 2017) investigated the use of a Zeta converter with a novel active power factor correction (PFC) technique for brushless DC motor drives. The proposed PFC technique involved adding an additional switch to the Zeta converter circuit to control the input current waveform. The results showed that the proposed PFC technique improved the power quality of the Zeta converter by reducing the THD of the input current and improving the power factor.

COMPONENTS:

Block diagram



Working Principle:The speed control of a BLDC (Brushless DC) motor using DSPIC30F4011 processor typically involves the following steps:

1. Sensing: The position and speed of the motor are measured using Hall-effect sensors or encoder feedback. The DSPIC30F4011 processor reads these signals and determines the position and speed of the rotor.
2. Computation: The processor computes the required drive signals based on the measured position and speed. This involves the use of complex algorithms for commutation and pulse- width modulation (PWM) to control the motor's speed.
3. Control: The computed drive signals are used to control the power electronics that drive the motor. The processor generates signals to control the gate of the MOSFET or IGBT switches in the inverter circuit, which in turn control the current flowing through the motor windings.
4. Feedback: The processor continuously monitors the motor speed and adjusts the drive signals to maintain the desired speed. If the motor speed deviates from the desired speed, the processor adjusts the drive signals to bring it back to the desired value.

In summary, the DSPIC30F4011 processor reads the position and speed of the BLDC motor, computes the required drive signals using complex algorithms, controls the power electronics to drive the motor, and continuously monitors the motor speed to maintain the desired speed.

Components

- BLDC motor
- LCD display
- MOSFET
- capacitor
- resistor
- opto coupler

BLDC MOTOR

A BLDC (Brushless DC) motor is a type of electric motor that uses a permanent magnet rotor and a stator with windings to generate rotational motion. Unlike conventional DC motors, BLDC motors do not use brushes to transfer electrical power to the rotor, which makes them more reliable and efficient.
The working principle of a BLDC motor can be explained as follows:

1. Electromagnetic fields: The stator of the BLDC motor has three-phase windings that are energized in a sequence by an electronic commutation circuit. When a current flows through a winding, it generates an electromagnetic field. The direction of the magnetic field is determined by the direction of the current flow.
2. Rotor magnet: The rotor of the BLDC motor has permanent magnets mounted on it. The magnetic poles of the rotor magnets are arranged in a specific pattern, such as a north-south- north-south configuration.
3. Commutation: The electronic commutation circuit senses the position of the rotor using sensors, such as Hall-effect sensors or encoder feedback. Based on the position of the rotor, the commutation circuit energizes the appropriate phase windings in a specific sequence. This generates a rotating magnetic field that interacts with the permanent magnets on the rotor, causing it to rotate.

Rotation: As the magnetic field generated by the stator rotates, it pulls the rotor magnets along with it, causing the rotor to rotate. The speed and direction of the motor are controlled by varying the frequency and amplitude of the current supplied to the stator windings. Overall, the working principle of a BLDC motor is based on the interaction between the rotating magnetic field generated by the stator windings and the permanent magnets on the rotor. The electronic commutation circuit ensures that the phase windings are energized in the correct sequence to generate a rotating magnetic field that causes the rotor to rotate. This makes BLDC motors more efficient, reliable, and durable compared to conventional brushed DC motors.

Fig. BLDC motor Cross section

HARDWARE IMPLEMENTATION AND ITS RESULTS

BEFORE IMLEMEMNTATION

Block diagram for control for BLDC motor

The proposed control for BLDC motor control using DSP controllers of MICROCHIP with device name DSPIC30F4011.The system consists of following blocks are1ф Bridge rectifier, BLDC motor, hall sensor, signal conditioner, DSP- DSPIC30F4011, opto-coupler, MOSFET driver, keypad. Fig 1 Block diagram of speed control of BLDC motor using DSP The system takes 1ф, 230v supply; this supply is converted into 24V, DC supply through bridge rectifier. The 24V, DC supply gives to MOSFET Bridge. MOSFET bridge consists of six MOSFET (IRF640) connected in bridge format. According to the sequence these MOSFETs are Switch ON and OFF. Rotor position senses by hall sensor. The output of hall sensor is amplifying through signal conditioner, this signal given to DSP processor. DSP processor takes input from keypad if we want to change speed and from signal conditioner. In DSP processor compare current speed with reference speed and according to that gives output which control MOSFET Bridge. In MOSFET Bridge switching transistors and flow current through two windings of stator winding and the other winding is inactive and hence commutation is done electronically and hence rotor starts rotating. This is closed loop system. The base drive to the MOSFETS in the Inverter circuit is given by the DSPIC30F4011controller through driver (IR2101).The Hall signals from the motor are fed as inputs to the

DSPIC30F4011 device and based on the Hall position and the direction of rotation of the motor specified by the manufacturer the corresponding gate drive is made active by the microcontroller and fed to the stator of the BLDC motor. The commutation sequence for rotating the motor in clock wise direction when viewed from the non driving end.

Hall Sensor Code			Phase Sequence	Driver Transistor Activating sequence		Phase Current		
A	B	C				A	B	C
0	0	1	1	Q1 (PWM1)	Q6 (PWM6)	+DC	OFF	-DC
0	0	0	2	Q1 (PWM1)	Q4 (PWM4)	+DC	-DC	OFF
1	0	0	3	Q5 (PWM5)	Q4 (PWM4)	OFF	-DC	+DC
1	1	0	4	Q5 (PWM5)	Q2 (PWM2)	-DC	OFF	+DC
1	1	1	5	Q3 (PWM3)	Q2 (PWM2)	-DC	+DC	OFF
0	1	1	6	Q3 (PWM3)	Q4 (PWM4)	OFF	+DC	-DC

fig. Driver triggering

Based on the Hall sensor input to the DSP controller, the corresponding transistors are made active and current flows through two windings and the other winding is inactive and hence commutation is done electronically with the use of a DSP controller.[4] Thus by properly exciting the corresponding winding based on the hall signal, the motor is commutated and is made to run at the desired speed. Initially irrespective of the rotor position, the windings are excited in the given sequence and once the motor starts rotating, rotor position is sensed by the Hall sensor and then the motor is excited based on the Hall signal and according to the direction of rotation of the motor. The speed can be controlled in a closed loop by measuring the actual speed of the motor. If the speed is greater than the desired rated speed, then all the transistors are turned off for a short duration and then again excited based on the Hall position and accordingly speed can be adjusted to get constant speed. The demand of PMBLDC motors in high power servo applications is increased because of its High efficiency due to reduced losses, low maintenance and low rotor inertia. Also the invention of modern solid state devices like MOSFET, IGBT and high energy rare earth Permanent Magnets have widely enhanced the applications of PMBLDC motors in variable speed drives. As the opto- coupler (HPCL817) provides the electrical isolation between circuits, it is called opto-isolator. In KEYPAD SET SPEED key sets the speed of motor and direction of motor clockwise/anticlockwise. RUN/STOP key runs the motor and stop the running motor. INC key increments the set speed by 100 rpm. DEC key decrements the set speed by 100rpm.

BLDC MOTOR WORKING

BLDC motors are basically inside-out DC motors. In a DC motor the stator is a permanent magnet. The rotor has the windings, which are excited with a current. The current in the rotor is reversed to create a rotating or moving electric field by means of a split commutator and brushes. On the other hand, in a BLDC motor the windings are on the stator and the rotor is a permanent magnet. Hence the term inside-out DC motor

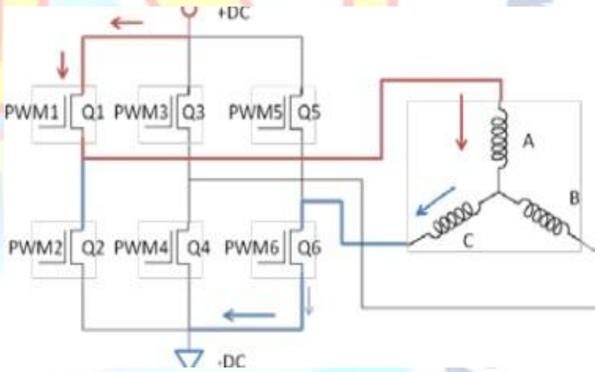


Fig. BLDC Motor with Drives position1

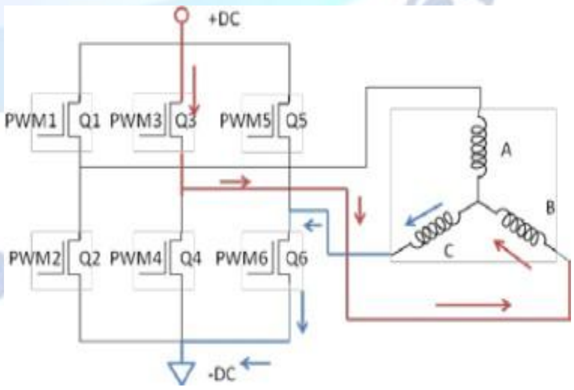


Fig. BLDC Motor with Drives position2

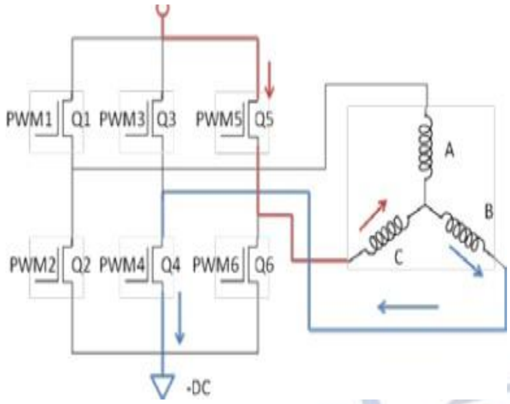


Fig. BLDC Motor with Drives position3

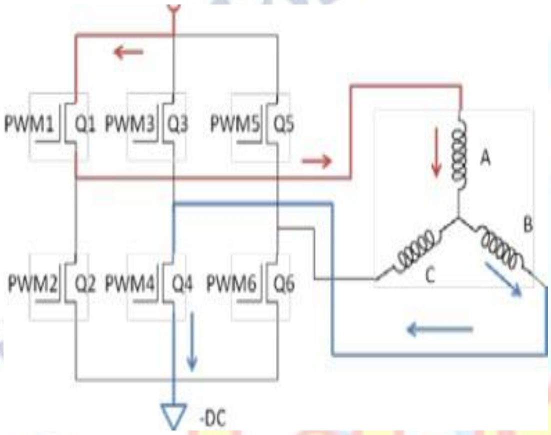


Fig. BLDC Motor with Drives position4

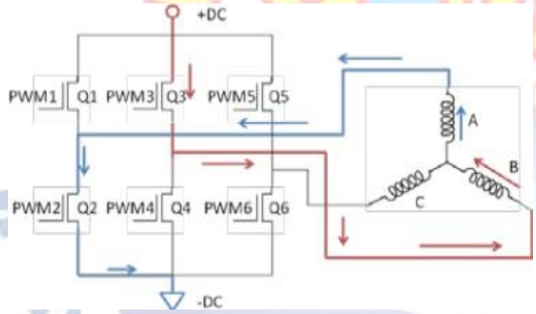


Fig. BLDC Motor with Drives position5

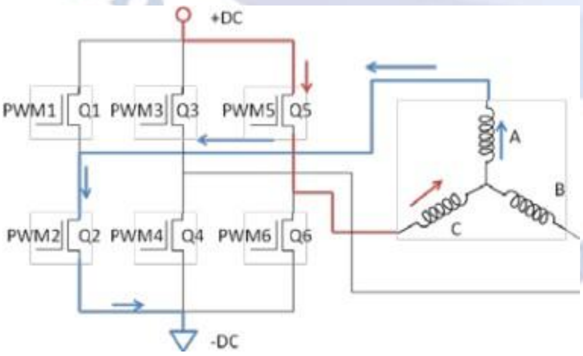
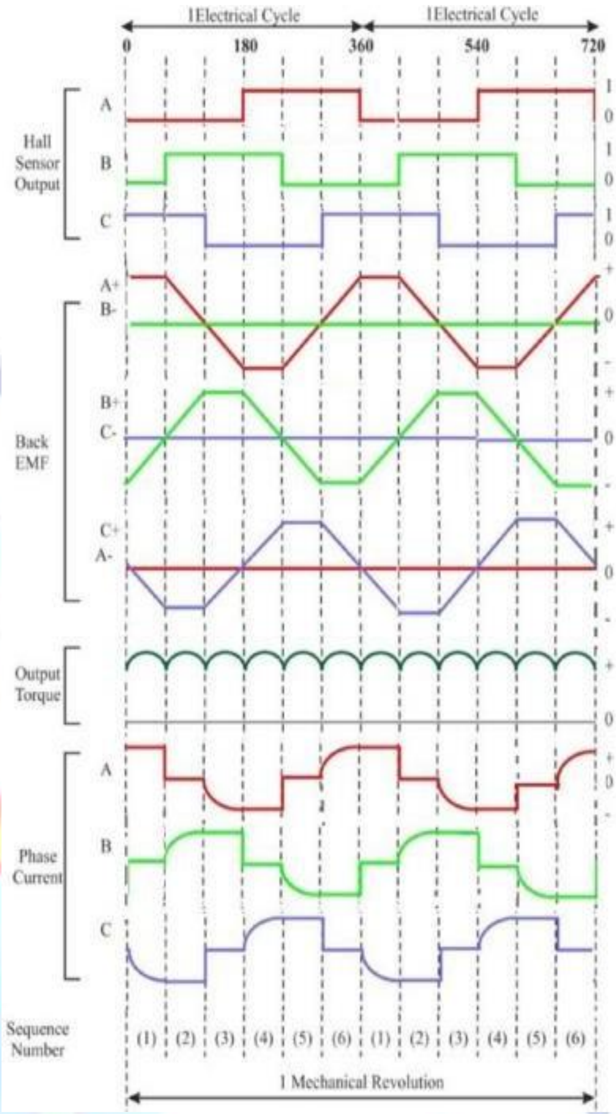


Fig. BLDC Motor with Drives position6



hall sensor waveforms

AFTER IMPLEMENTATION:

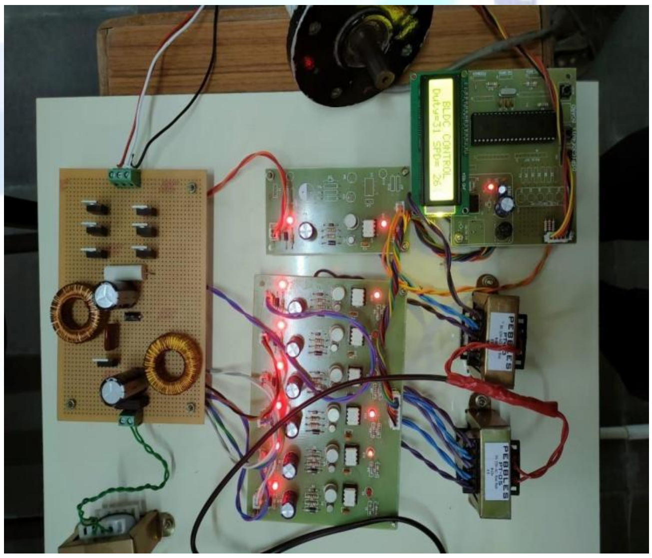


fig After implementation

Implementing speed control of a BLDC motor using a Zeta converter involves the following steps:

Design the Zeta Converter: The Zeta converter is a DC-DC converter that can regulate the voltage across the load by varying the duty cycle of the switch. The design of the Zeta converter involves selecting the appropriate values of the inductor, capacitor, and switch. The output voltage of the Zeta converter should be equal to the maximum voltage rating of the BLDC motor.

Connect the Zeta Converter to the BLDC Motor: Connect the output of the Zeta converter to the input of the BLDC motor. The motor should also be connected to a speed sensor that can provide feedback on the actual speed of the motor.

Speed Control Algorithm: The speed control algorithm determines the required duty cycle of the Zeta converter switch based on the difference between the desired speed and the actual speed of the motor. The algorithm can be implemented using a microcontroller or a digital signal processor.

Test and Optimize: After implementing the speed control algorithm, test the system and optimize the parameters of the algorithm to achieve the desired performance. This can involve adjusting the PI gains, the switching frequency of the Zeta converter, and the motor parameters

.Protection Circuitry: Finally, it is essential to include protection circuitry in the system to protect the motor and the Zeta converter from overcurrent and overvoltage conditions.

Overall, implementing speed control of a BLDC motor using a Zeta converter is a complex process that requires careful design and optimization. However, with the proper implementation, a Zeta converter-based speed control system can provide precise and efficient control of BLDC motor speed.

RESULT

- CASE-I

The input with duty cycle 31 then the output of the motor rotated at a speed of 271rpm

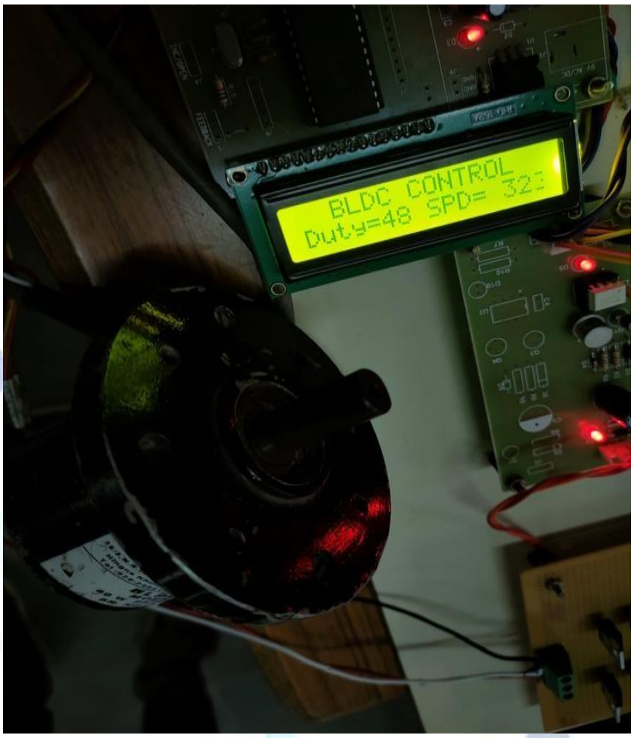


fig output Speed is323rpm

- Case-II

The input with duty cycle 48 then the output of the motor rotated at a speed of 323rpm.

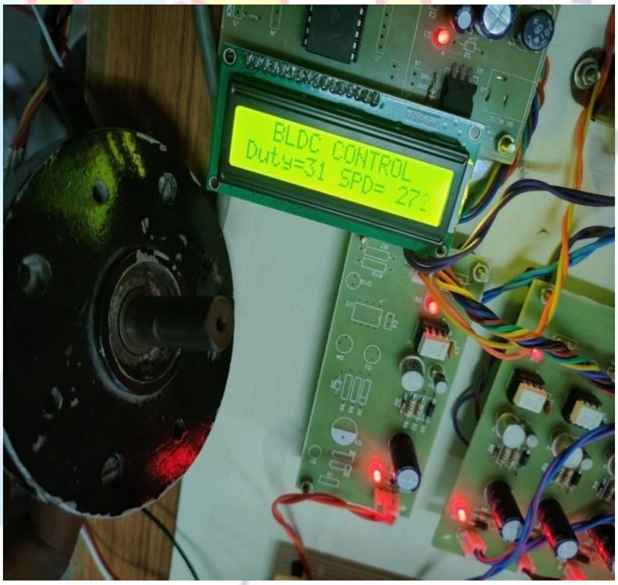


fig .output Speed is323rpm

Case-III

- The input with duty cycle 57 then the output of the motor rotated at a speed of 336rpm.

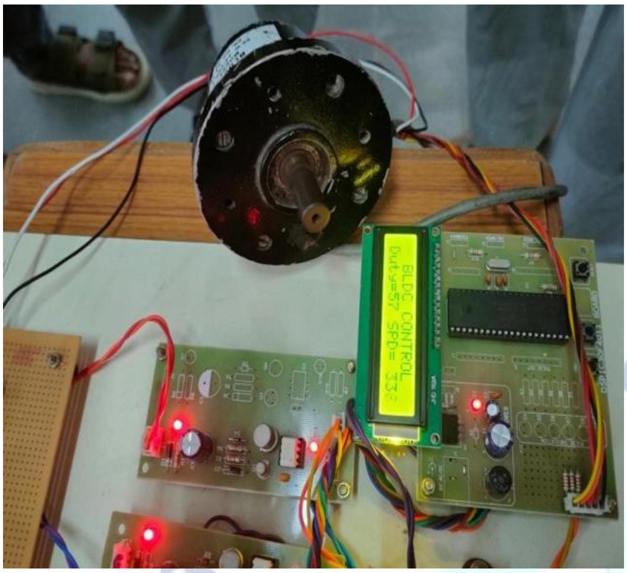


fig . output Speed is 336rpm

CONCLUSION

A greenhouse emission alphabetic character convertor nourished BLDC engine drive has been planned for a good scope of speed management with UPF at air-conmains. The speed of BLDC engine has been affected by differing th edc-interface voltage of VSI through the green house emission alphabetic character converter. The greenhouse emission alphabetic character converter has been supposed to figure in DICM, that needed a voltage follower for dc- connect voltage management. A solitary voltage detector has been needed for the whole drive, which makes it a sensible arrangement. Additionally, low-recurrence exchanging beats are used for electronically commutating the BLDC engine that offers diminished exchanging misfortunes within the VSI standard arranges of PWM-based exchanging of VSI. The intense problems with this drive r the voltage & current weights on the nursery emission converter transposition, which restricts its activity for low power applications programme. Decrease of those burdens utilizing delicate exchanging procedures has to be compelled to be accomplished for raising the operating force run. Additionally, a decrease of Hall-Effect position detector is used utilizing the detector less management of BLDC engine drives for utilization of those drives in unsafe condition

FUTURE OF SCOPE

The future scope of speed control of BLDC motors using Zeta converters is vast and promising. Here some potential areas of development and improvement:

Efficiency: Researchers can focus on developing more efficient Zeta converters that can deliver higher power density and minimize power loss. This can be achieved by optimizing the converter's components, such as the inductor and capacitor, and implementing advanced control techniques.

Integration: Zeta converters can be integrated with other power electronics components, such as inverters and power factor correction circuits, to create more complex and sophisticated control systems. This can lead to improved motor performance, reduced energy consumption, and lower system costs.

Control Algorithms: The speed control algorithm used in Zeta converter-based systems can be further optimized to achieve more precise and stable control of BLDC motors. Advanced control algorithms, such as model predictive control and adaptive control, can be used to improve the motor's response to changing load conditions.

Motor Design: BLDC motor design can also be improved to enhance performance and efficiency. For instance, researchers can develop motors with higher torque density and lower cogging torque to reduce motor noise and vibration.

Applications: The use of BLDC motors is increasing in various applications, such as electric vehicles, drones, and robotics. The future scope of Zeta converter-based speed control systems is significant in these areas, as the demand for high- performance, efficient, and reliable motors continues to grow.

In conclusion, the future of speed control of BLDC motors using Zeta converters is exciting and offers ample opportunities for innovation and development. With further advancements in converter design, motor technology, and control algorithms, Zeta converter-based systems can become more efficient, reliable, and cost-effective, making them an attractive solution for various industrial and consumer applications.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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