FOUR QUADRANT OPERATION AND CONTROL OF THREE PHASE BLDC MOTOR FOR ELECTRICVEHICLE USING ZETA CONVERTER

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Abstract— The paper introduces a control strategy for Brushless Direct Current (BLDC) motor in an electric vehicle (EV). The approach uses a bidirectional DC-DC converter and a three-phase voltage source inverter (VSI) to drive the motor. During normal operation, the bi-directional converter of the battery conducts buck operation. However, during regenerative braking, the mechanical energy is converted into electrical energy and stored in the same chargeable battery through boost operation. This design optimizes energy recovery from EV's frequent start/stop operations. When the EV is moving downhill, the controlled speed provides energy return to the battery. MATLAB/Simulink software is employed to validate the operations and verify their efficiency. Overall, the paper presents a comprehensive approach to controlling BLDC motors in electric vehicles.

Index Terms— - Back electromotive force (EMF), Brushless dc motor (BLDC), Electric vehicle (EV), Proportional integral-derivative Controller (PID), Voltage Source Inverter (VSI).

INTRODUCTION

This chapter deals with the Problem Statement taken up for this project, Existing system for the problem, Demerits of the existing system, Objective of this Project, Proposed solution for the problem statement, advantages of the proposed system and also the Literature survey is also discussed with proper data from reliable source.

This project aims to enhance the speed control of Brushless DC (BLDC) motors. The key attributes of BLDC motors will be emphasized, including their reliability and efficiency. The boost converter will be integral in elevating the DC voltage input. The project scope includes exploring the three-phase inverter's role in transforming the boosted voltage into three-phase AC voltage for optimal BLDC motor performance. The objective is to achieve precise and efficient speed control tailored to applications that prioritize reliable motor performance. The project will encompass the study of BLDC motor dynamics, boost converter functionality, and practical considerations for hardware implementation in diverse settings.

2. LITEATURE SURVEY

1. Those that incorporate voltage boosting and power factor correction. This segment emphasizes the practical relevance of this technology within personal affirmation thaw applications.

2. Proposed Device for Bi-flyback DC-DC Converter: This section discusses a novel device that can enhance the performance of bi-flyback DC-DC converters for LED drivers. By implementing readiness caliber parameters, this device ensures reliable operation in a variety of applications.

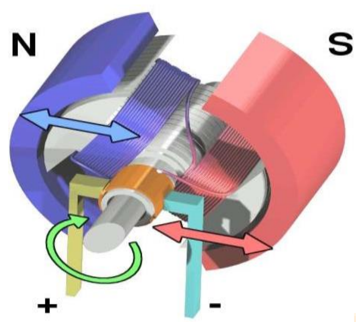
2. Power Factor Correction for BLDC Engines: This section introduces a notable contribution that presents a BLDC engine drive with power factor correction (PFC). By offering adaptability and efficiency across a spectrum of low-power

3. Induction Heating Systems: The survey explores induction heating systems, including Controlling DC Brushless Motors: This section delves into the complexities of controlling DC brushless motors, detailing various techniques such as sensor-less approaches and comprehensive control strategies implemented through advanced circuit systems

4. Adaptive Power Control for PM Brushless DC Engine Drives: This segment discusses the implementation of adaptive power control for PM brushless DC engine drives. By adjusting conductivity edges to optimize

power development, this approach showcases a nuanced technique for enhancing efficiency.

5. Pulse Width Modulation (PWM) Switching Strategies for Brushless DC Motors: This section reviews PWM switching strategies for brushless DC motors, offering a detailed assessment of measurement plans and their implications for motor response.
6. Applications of Simulation Software in Electrical Machine Design: This section explores the pivotal role of accurate simulation, particularly in magnetic force and heat, to achieve optimal machine performance. The wealth of insights gathered underscores the interconnectedness of these advancements and shapes the landscape of contemporary power electronics and motor control.



3 Existing system
3.1 Introduction

The current BLDC motor control relies on traditional methods lacking a boost converter. This absence may result in suboptimal voltage levels, impacting efficiency. The motivation for introducing a boost converter is to enhance DC voltage input, addressing efficiency gaps and improving motor performance. The proposed integration aims to overcome existing challenges, making it a promising solution for industries prioritizing reliable and efficient BLDC motor control.

3.2 Techniques

The current BLDC motor control technique involves traditional methodologies that primarily use pulse width modulation (PWM) and closed-loop control systems to regulate motor speed. These methods often face challenges in achieving precise control, especially during variations in load and voltage. The reliance on open-loop systems can result in limited adaptability to dynamic operating conditions, impacting overall motor efficiency. The absence of advanced features, such as a boost converter, might restrict the system's ability to optimize voltage levels for improved performance. The proposed enhancement aims to address these limitations by introducing a boost converter, promising a more sophisticated and efficient approach to BLDC motor control.

4 WORKING

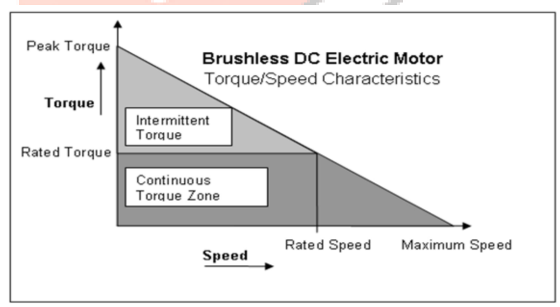
3-Phase Brushless DC (BLDC) Motors

BLDC motors consist of three phases and use brushless motors instead of traditional brushes. They offer numerous advantages over traditional brushed DC motors, such as improved efficiency, reliability, and performance.

In this figure 4.1 3 phase brushless motors.

Speed-Torque Characteristics

The speed-torque characteristics of a BLDC motor describe the relationship between the motor's rotational speed and the torque it produces. In general, as the BLDC motor speed increases, the torque typically decreases, forming a negative correlation between speed and torque. This



behavior is influenced by the motor's design, the applied voltage, and the magnetic field strength.OPERATION OF A 3-PHASE VSI

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A 3-phase VSI, or Variable Speed Inverter, can be considered as three single-phase half-bridge inverter circuits put across the same dc bus. The output from this inverter is to be fed to a 3-phase balanced load.To achieve this, we can follow the below steps:

1. The fundamental principle of a VSI is the PWM (Pulse Width Modulation) of the switching transistors. By adjusting the duty cycle of the PWM signal, we can modulate the voltage at the dc bus of the VSI.

2. In the case of a 3-phase VSI, the output waveforms are generated by modulating the switching of six transistors in such a way that they form a 3-phase bridge type VSI.

3. The three pole voltages of the 3-phase square wave inverter are generated by PWM modulation of three pairs of transistors, such that each pole voltage is formed by switching between 0 V and a voltage determined by the PWM duty cycle.

4. The three pole voltages of the 3-phase square wave inverter are shifted in time by one third of the output time period to form the 3-phase bridge type VSI.

5. The PWM modulation signals of the switching transistors are typically generated by using microcontrollers or dedicated power electronics devices, such as PWM controllers or gate drivers.

6. The waveforms in Fig. 35.2 are generated by using simulation tools or data acquisition systems that sample the voltage at the dc bus of the VSI at different time points and display the waveforms.

7. By analyzing the output waveforms of the 3-phase VSI and the relevant parameters, such as the power factor, efficiency, and dynamic response, we can obtain valuable insights into the performance of the VSI and the efficiency of the power electronics devices used in its operation.

8. It is important to note that the performance of a VSI is highly dependent on the design and operating conditions of the VSI and the specific requirements of the application. Therefore, thorough testing and validation of the VSI and its associated control algorithm are essential to ensure optimal performance.

5. HARDWARE DESCRIPTION

5.1 DRIVER CIRCUIT:

It is used to provide 5 to 12 volts to switch the MOSFET Switches of the inverter. Driver amplifies the voltage from microcontroller which is 5volts. Also it has an optocoupler for isolating purpose. So damage to MOSFET is prevented.

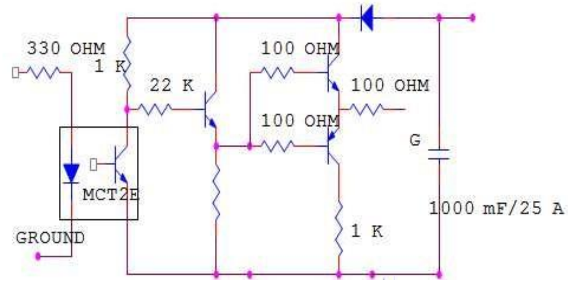


Fig 5.1 Driver Circuit

5.2 DRIVER CIRCUIT OPERATION:

The driver circuit forms the most important part of the hardware unit because it acts as the backbone of the inverter because it gives the triggering pulse to the switches in the proper sequence. The diagram given above gives the circuit operation of the driver unit. The driver unit contains the following important units.

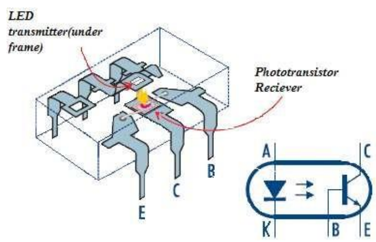
- Optocoupler
- Totem pole
- Capacitor
- Supply
- Diode
- Resistor

5.3 OPTOCOUPLER:

Optocoupler is also termed as optoisolator. Optoisolator a device which contains a optical emitter, such as an LED, neon bulb, or incandescent bulb, and an optical receiving element, such as a resistor that changes resistance with variations in light intensity, or a transistor, diode, or other device that conducts differently when in the presence of light. These devices are used to isolate the control voltage from the controlled circuit.

Optocouplers typically come in a small 6-pin or 8-pin IC package, but are essentially a combination of two distinct devices: an optical transmitter, typically a gallium arsenide LED (light-emitting diode) and an optical receiver such as a phototransistor or light-triggered diac. The two are separated by a transparent barrier which blocks any electrical current flow between the two, but does allow the passage of light. The basic idea is shown in Fig.1, along with the usual circuit symbol for an optocoupler. Usually the electrical connections to the LED section are brought out to the pins on one side of the package and those for the phototransistor or diac to the other side, to physically separate them as much as possible. This usually allows optocouplers to withstand voltages of anywhere between 500V and 7500V between input and output. Optocouplers are essentially, digital or switching devices, so they're best for transferring either on-off control signals or digital data. Analog signals can be transferred by means of frequency or pulse-width modulation.

Fig 5.2 Optocoupler



5.4 PIC 16F877A MICROCONTROLLER:

We are using PIC 16F877A for producing switching pulses to multilevel inverter. So as to use those vectors which do not generate any common mode voltage at the inverter poles. .This eliminates common mode voltage Also it is used to eliminate capacitor voltage unbalancing. The microcontroller are driven via the driver circuit so as to boost the voltage triggering signal to 9V.To avoid any damage to micro controller due to direct passing of 230V supply to it we provide an isolator in the form of optocoupler in the same driver circuit.

5.5 FEATURES OF PIC MICROCONTROLLER:

- High-Performance RISC CPU
- Peripheral Features
- Analog features
- CMOS Technology.

6. SIMULATION RESULT:

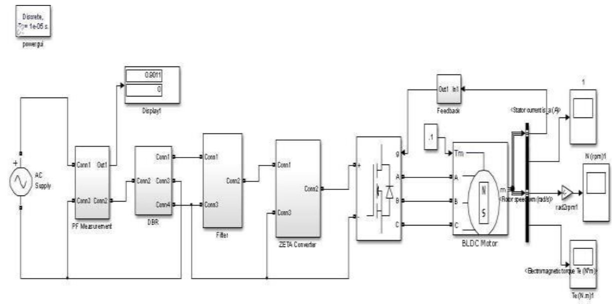


Fig 6.1 BLDC Drive with Zeta Converter

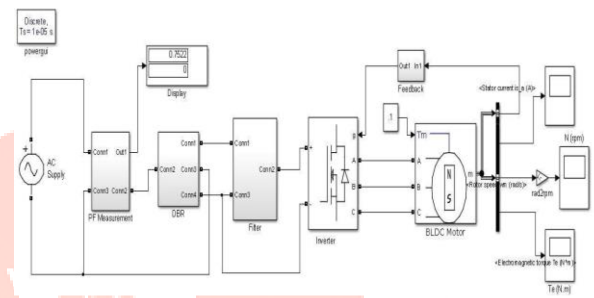
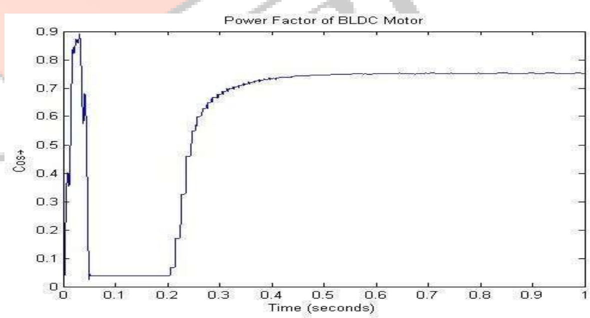


Fig 6.2 Conventional BLDC Drive

Fig 6.3 Conventional BLDC Drive Graph



5 CONCLUSION

The electric drive with maximum efficiency operates in all four quadrants, thanks to regenerative energy recovery and a closed-loop control system. By controlling speed in gravitational action, the system prevents excessive energy consumption and optimizes performance. This proposed method reduces energy consumption, enhances system efficiency, and can be applied to a wide range of electric drive systems, including those in electric vehicles. By integrating an innovative energy management approach with cutting-edge hardware, the proposed method paves the way for more sustainable and efficient transportation solutions. Remember, for any essay, it is essential to cite the source and format the work accordingly to maintain academic integrity.

6 FUTURE SCOPE

Advancements in brushless dc (bldc) motor control technologies are driving significant improvements in motor efficiency, reliability, and overall performance. by employing sophisticated control algorithms, integrating advanced power electronics, and adopting novel materials for motor construction, bldc motors are poised to revolutionize a wide range of applications, including electric vehicles, renewable energy systems, industrial automation, and robotics. as the demand for compact, powerful, and energy-efficient motors continues to grow, ongoing research in this field holds the promise of even greater advancements and contributions to the global landscape of electrification, automation, and sustainable energy solutions.

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