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Speed Control of BLDC for Electric Vehicle

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ABSTRACT: Brushless DC Motor overcomes many problems of the brushed DC Motor and has been widely applied in various fields. The development of BLDCM control system requires reliable operation, excellent performance of control algorithm, low cost and short development cycle. This paper proposes the speed control of BLDC motor for an electric vehicle. The flexibility of the drive system is increased using digital controller. The 3-phase inverter is implemented using Smart Power Module for feeding BLDC motor. The proposed system accepts Hall sensor signals from the motor and is programmed for desired speed. Experimental results verify the effective developed drive operation.

I.INTRODUCTION

Electric motor technology involves machine constructions, materials, electronics, sensors and control technologies. A suitable converter and control techniques need to be developed for different kind of motors in order to generate a high performance drives. The important aspect of various converter designs is the converter efficiency and its dynamic response. Low power loss in converters is due to high efficiency. The 3rd harmonic and its corresponding multiples component are eliminate d in the output due to this feature three phase power system is used in DC drive systems. Comparing 1-phase system with that of 3-phase, the ripple voltage is significantly less.

Now a days we are facing lot of different crisis caused by high oil prices and obsolete designs which have prompted the search for more efficient road vehicles, possibly based on environment friendly sources located in politically stable areas. This has led to the development of electric vehicles [1].Compared with a DC motor, the BLDC motor uses an electric commutator rather than a mechanical commutator, so it is more reliable than the DC motor. In a BLDC motor, rotor magnets generate the rotor’ s magnetic flux, so BLDC motors achieve higher efficiency [2]. It has become possible because of their superior performance in terms of high efficiency, fast response, and weight, precise and accurate control, high reliability, maintenance free operation, brushless construction and reduced size, Torque to motor size ratio is high, Thermal overload & under load protection is provided. [3, 5, 8] Microcontroller has more advantages than microprocessors. These ICs are cost effective and can be used for any applications ranging from appliances to automobile engines to text or data processing equipment. Because of their higher performance; they perform higher solution control and minimize control loop delays . These efficient controls make it possible to reduce torque ripples and harmonics and to improve dynamic behavior in all speed ranges. The motor design has optimized due to lower vibrations and lower power losses such as harmonic losses in the rotor. Smooth waveforms allow an optimization of power elements and input filters. Overall, these improvements result in a reduction of system cost and better reliability. Switching electric machines from ordinary digital control to microcontroller significantly improves operating efficiency, saving energy while allowing the use of smaller, less expensive motors.

Since the advancement in battery technology has been relatively sluggish, compared with the power electronics area, the handicap of short range associated with EV still remains. With this technology limitation, the EV seems to be the viable alternative to the ICE automobile at the present.[7] The aim of this project is to design microcontroller-based BLDC motor drives for electric vehicle. Based on several PWM switching schemes the performance of converter parameters will be tested and observed. Open loop and closed loop speed control of the system is done and the results are tabulated which verify the effective developed drive operation.

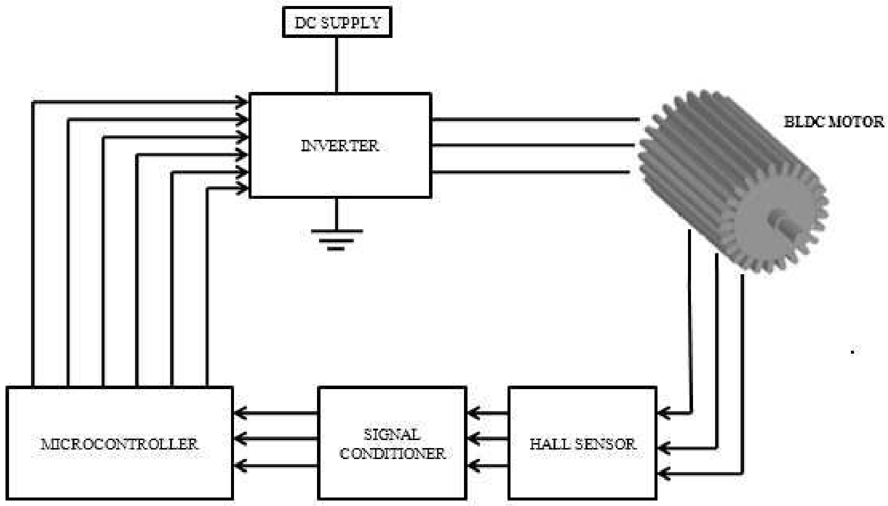

Figure 1 : Block diagram of BLDC drive system

II.LITERATURE REVIEW

Alireza Tashakori Abkenar Thesis submitted for the degree of Doctor of Philosophy BLDC Motor Drive Controller for Electric Vehicles[2014] Performance of the brushed DC, induction, BLDC and switched reluctance motors are compared according to the in-wheel technology requirements through simulation. Faster dynamic response of the BLDC motor is seen compared to the other motors.

Mrs. S. D. Joshi, Prof. Dr. (Mrs.) N.R.Kulkarni International Conference on Electrical Machines- ICEM Brushless Direct Current Motors Topologies and its Applications[2017] Deals on simulation using Mat lab / Simulink for mathematical model of the PMBLDC motor for electrical applications.

Anna Joy , Aparna Jose, Jithin Joseph International Journal of Advanced Research in Electrical Engineering Development of a In-Wheel Brushless D.C. Motor Drive for an Electric Scooter[2021] Design of a direct drive, Brushless DC motor is presented. Many constraints have been considered, such as the size of the motor, maximum driving current and maximum output power.

III.METHODOLOGY

It consists of a three phase inverter, position sensors, signal conditioner and a digital controller. The inverter along with the position sensor arrangement is functionally analogous to the commutator of a dc motor. The commutation of a BLDC motor is controlled electronically. The stator windings should be energized in a sequence in order to rotate the motor. Rotor position should be known in order to switch the winding in sequence. A permanent magnet brushless dc motor incorporates some means of detecting the rotor position.

The BDLC motor detects the position of the rotor using Hall sensors. Three sensors are required for position information. With three sensors, six possible commutation sequences could be obtained. In the Hall sensor technique, three Hall sensors are placed inside the motor, spaced 120 degrees apart. Each Hall sensor provides either a High or Low output based on the polarity of magnetic pole close to it. Rotor position is determined by analyzing the outputs of all three Hall sensors. Based on the output from hall sensors, the voltages to the motor's three phases are switched.

The advantage of Hall sensor-based commutation is that the control algorithm is simple and easy to understand. Hall sensor-based commutation can also be used to run the motor at very low speeds.

BLDC motor control is to have only one current at a time. Because of which current sensor is not advised to be placed on each phase of the motor; one sensor placed in the line inverter input is sufficient to control the current of each phase. Insulated systems are not required when sensor is on the ground line. The torque and speed of motors is managed by microcontroller. A sufficient amount of processing power is required to solve the algorithms needed to generate Pulse Width Modulated (PWM) outputs for motor. By simply varying the voltage across the motor, one can control the speed of the motor. When using PWM outputs to control the six switches of the three-phase bridge, variation of the motor voltage can be achieved easily by changing the duty cycle of the PWM signal.

The three-phase BLDC speed control is done by using both open loop and closed loop configurations. Open-loop control is used to control the speed of the motor by directly controlling the duty cycle of the PWM signal that directs the motor-drive circuitry. The duty cycle of the PWM signal controls the ON time of the power switches in the half bridges of the motor-drive circuit and this in turn controls the average voltage supplied across the motor windings. Closed loop control regulates the speed of the motor by directly controlling the duty cycle of the PWM signals that direct the motor-drive circuitry. The major difference between the two control systems is that the open-loop control considers only the speed control input to update the PWM duty cycle, whereas, the closed-loop control considers both speed-input control and actual motor speed (feedback to controller) for updating the PWM duty cycle and, in turn, the motor speed. A PID controller is a closed-loop control implementation that is widely used and is most commonly used as a feedback controller.
The actual motor speed is calculated by tracking the time period between successive Hall events, which represents a part of the mechanical cycle of the motor. In a 3-phase BLDC motor control, one electrical cycle has six Hall states and, depending on the number of poles pairs in the motor, the electrical angle measured between successive Hall state changes can be translated to a respective mechanical angle.

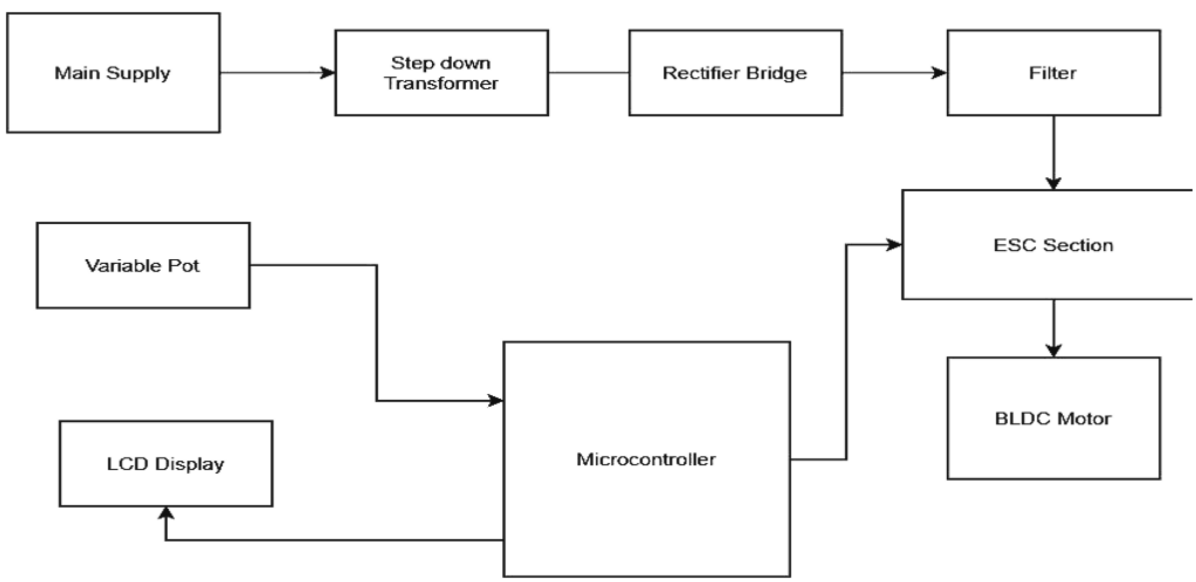

Figure 2 : BLOCK DIAGRAM

IV.RESULTS

The proposed scheme is first simulated and then implemented in the laboratory. The simulations are carried out using MATLAB 7.13. The control scheme is implemented by DSC (dsPIC30F4011). Software program is written in C language. Programming is done using MPLAB Integrated Development Environment (IDE) tool. For execution of C code MPLAB C30 compiler is used.

- We could conclude that the Speed of a brushless dc motor can be controlled by controlling the input dc voltage.
- Tuning the controller for speed control of DC motor will optimize the best result.

- The limitation is that it can only be used in medium to high speed applications of BLDC motor. At low speeds the accuracy isn't sensible.

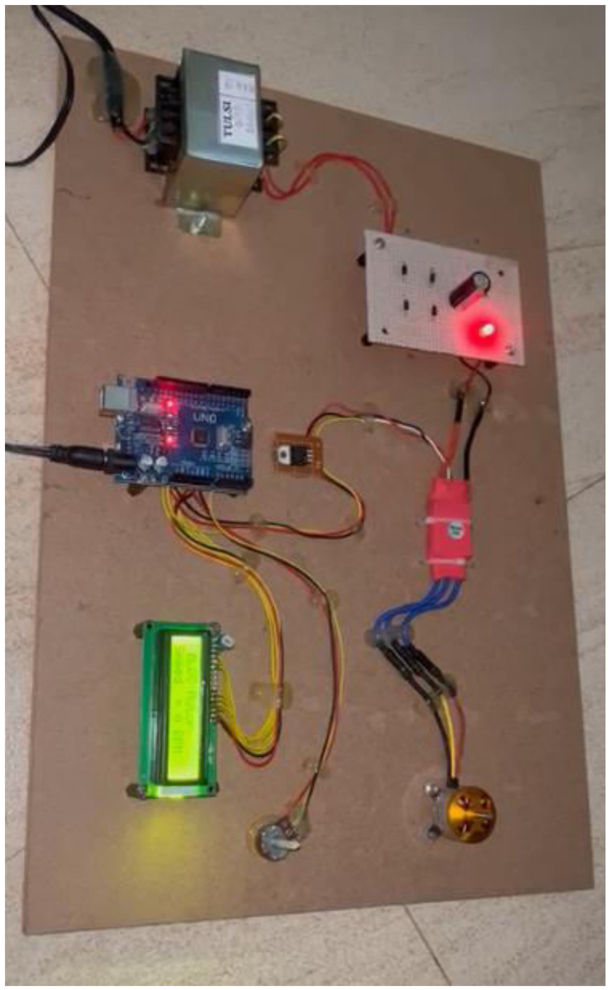

Figure 3 : Results of Speed Control of BLDC for Electric Vehicle

V.CONCLUSION AND FUTURE WORK

The proposed algorithm has been implemented, and it generates the firing pulses required to drive the IGBTs of three phase fully controlled bridge converter. The generated PWM signals for driving the power inverter bridge for BLDC motor have been successfully tested using a dsPIC30F4011 Digital Signal Controller. The output from the converter is fed to the three phase stator winding of 48V, 250 W, 3850 rpm BLDC motor and the motor is found to run at constant speed which is set by the external potentiometer connected to the microcontroller circuit. The program is found to be efficient and the results with the designed hardware are promising. The developed control and power circuit functions properly and satisfies the application requirements. Experimental results justify effectively the developed drive designs.

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