

## ENHANCED PERFORMANCE AND EFFICIENCY IN ELECTRIC VEHICLES THROUGH FOUR-QUADRANT CONTROL OF THREE-PHASE BLDC MOTORS

<sup>1</sup>Dr.B.DIVYA, <sup>2</sup>K.MANIKANTESWAR

<sup>1</sup>Professor, <sup>2</sup>Assistant Professor

*Department Of Electrical and Electronics Engineering*

*Indira Institute Of Technology And Sciences, Markapur*

### ABSTRACT

The authors of this paper demonstrate how a bidirectional DC-DC converter may be used to operate a brushless direct current (BLDC) motor in all four quadrants (forward/reverse motoring/braking). The DC-DC converter's output is sent to the three-phase voltage source inverter (VSI), which drives the motor. Mechanical energy is converted to electrical energy and stored in the batteries while the device is in regenerative mode. Buck operation is carried out in the driving mode by making use of the battery's bidirectional converter. For the boost feature, it will make use of the same rechargeable battery. Since electric cars need frequent starts and stops, this is accounted for in the design. It is advised to use a system that uses the regenerative braking system to collect energy throughout each and every halting procedure. In addition, if the electric vehicle (EV) is now descending a slope, the regulated speed on the downhill serves as a source of energy replenishment for the battery. Software called Simulink/MATLAB is used to verify the above listed procedures.

### 1. INTRODUCTION

Brushless DC motors are gaining a lot of popularity whether it is aerospace, military, household or traction applications. Due to the constraint of fuel resources, the world requires highly efficient electric vehicle

drives for transportation needs. The BLDC motor has a longer life span, higher efficiency, and compact size making it the most sought after motor in electric vehicle drive applications. The continuous attempt to reduce environmental pollution has given an impetus to the market of electric vehicles (EVs). As the fuel resources are depleting, the energy efficient electric drives are likely to replace vehicles running with fossil fuels. Being different from the ICE (internal combustion engine), EVs are the least burden to the environment. Any motor drive system which can be recharged from any external electricity source is known as a plug-in electric vehicle (EV). The complete electric vehicle drive model is described. There are still some disadvantages of EV drives like overall lower efficiency, huge dimension, and the cost of storage devices etc. The technique of performing the four quadrant operation is proposed where its battery is charged during the regenerative braking but the system here has two energy sources, one is driving the motor and other is storing the energy using the rectifier during braking. It is proposed in this paper that only one battery is enough to drive the motor and at the same time to recover the kinetic energy of them regenerative mode. This proposal reduces the cost of an extra rectifier and an additional battery. In the

four quadrant operation is performed without utilizing the kinetic energy of the motor. During braking, the motor kinetic energy is wasted in resistive losses this makes the system highly in efficient. In the world where there is fuel constraint, this system is not helping in that cause. In four quadrant sensor less control of the electronically commutated motor is done without utilizing the motor kinetic energy in regenerative braking. The battery capacity puts a limitation to the EVs in the form of mileage or distance covered. Regenerative braking is just one of the ways to increase the efficiency of the drive. During regenerative mode, the energy of the drive system which is in the form of kinetic energy can be used to charge the battery during deceleration and down hill run to slow down the vehicle.

## 2. LITERATURE SURVEY

1) P. Pillay and R. Krishnan The authors develop a phase variable model of the BDCM (brushless DC motor) and use it to examine the performance of a BDCM speed servo drive system when fed by hysteresis and pulse width-modulated (PWM) current controllers. Particular attention was paid to the motor large-signal and small-signal dynamics and motor torque pulsations. The simulation included the state-space model of the motor and speed controller and real-time model of the inverter switches. Every instance of a power device turning on or off was simulated to calculate the current oscillations and resulting torque pulsations. The results indicate that the small- and large-signal responses are very similar. This result is only true when the timing of the input phase currents with the back

EMF (electromotive force) is correct. The large-signal and small-signal speed response is the same whether PWM or hysteresis current controllers are used. This is because, even though the torque pulsations may be different due to the use of different current controllers, the average value which determines the overall speed response is the same.

2) C. Joice, S. Paranjothi and V. Kumar Brushless DC (BLDC) motor drives are becoming more popular in industrial, traction applications. This makes the control of BLDC motor in all the four quadrants very vital. This paper deals with the digital control of three phase BLDC motor. The motor is controlled in all the four quadrants without any loss of power; in fact energy is conserved during the regenerative period. The digital controller dsPIC30F4011, which is very advantageous over other controllers, as it combines the calculation capability of Digital Signal Processor and controlling capability of PIC microcontroller, to achieve precise control.

3) X. Nian, F. Peng and H. Zhang Amidst the ever-increasing advancements in the technological realm-the electrical vehicle industry too has seen several leaps. This particularly owes to three primary factors one, the fact that we are running out of conventional resources like petrol and diesel; two, higher efficiency of electric vehicles; and finally, less pollution caused by them. This has led to a burgeoning in the use of BLDC motors with electronic commutation not only in EVs but also in industrial and commercial applications. This requires an enhanced driving and control mechanism to tap the efficiency that such

motors provide to increase performance and to get better controllability and reliability. This paper presents a controller for this EV motor driver with increased efficiency by combining various strategies.

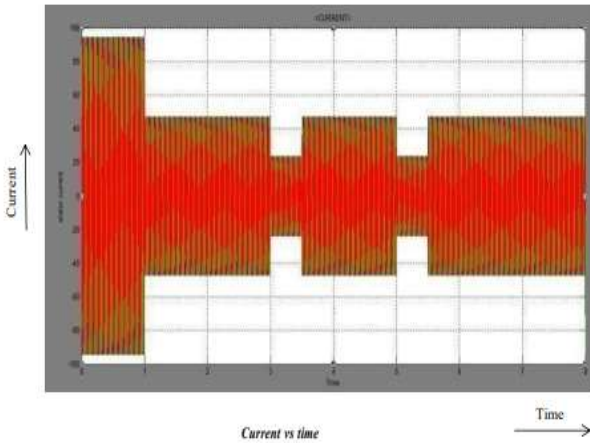
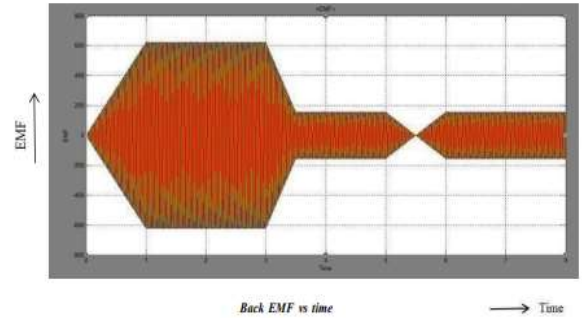
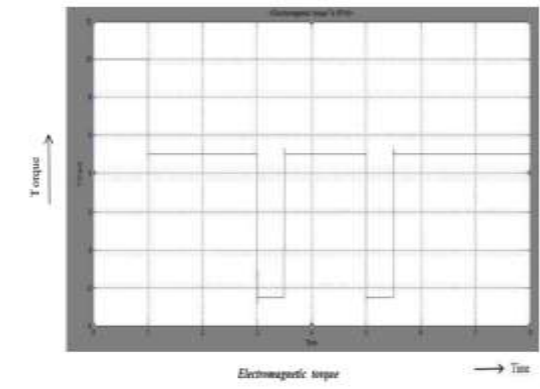
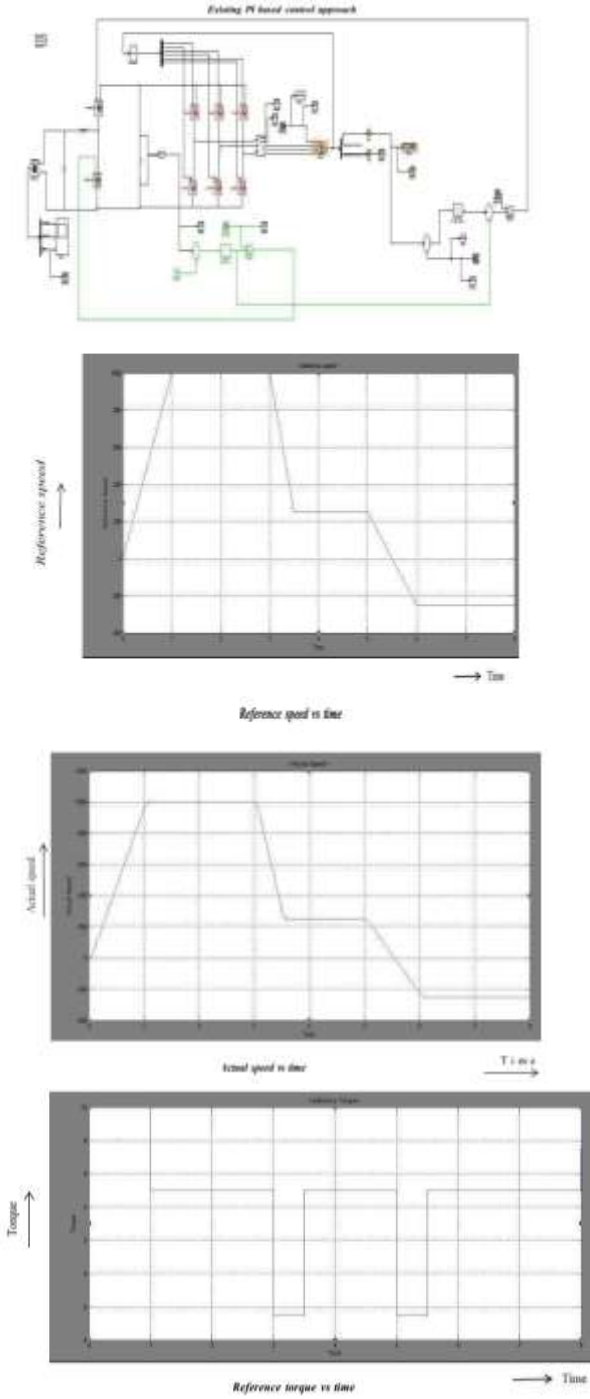
### 3. PROPOSED SYSTEM

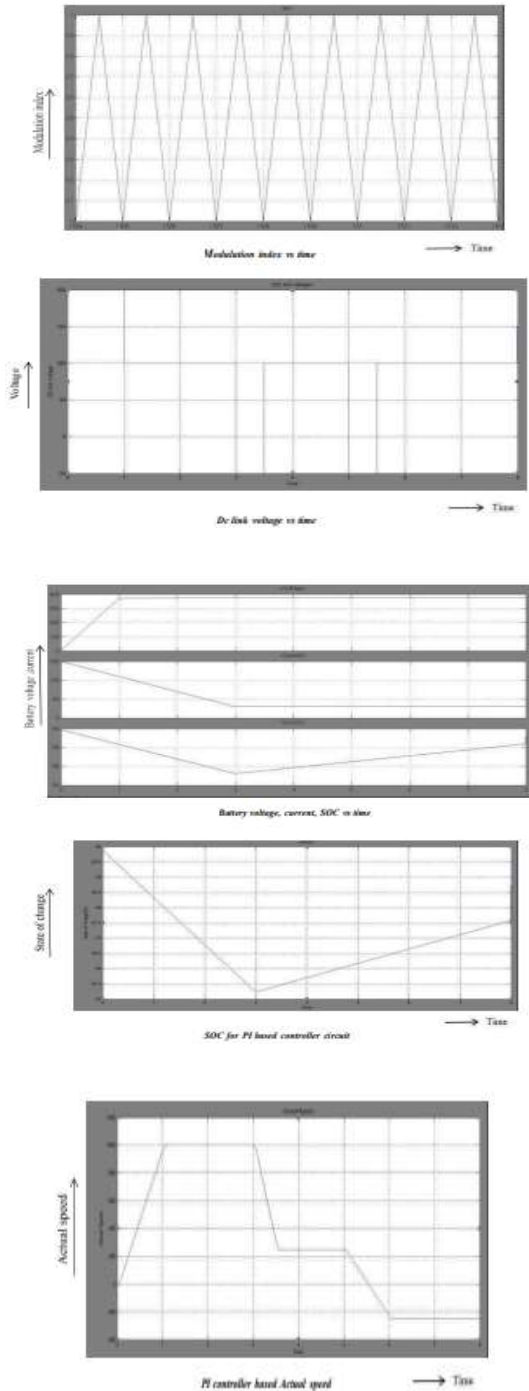
Brushless DC motors (BLDC) have been a much focused area for numerous motor manufacturers as these motors are increasingly the preferred choice in many applications, especially in the field of motor control technology. BLDC motors are superior to brushed DC motors in many ways, such as ability to operate at high speeds, high efficiency, and better heat dissipation. They are an indispensable part of modern drive technology, most commonly employed for actuating drives, machine tools, electric propulsion, robotics, computer peripherals and also for electrical power generation. With the development of sensor less technology besides digital control, these motors become so effective in terms of total system cost, size and reliability. A brushless DC motor (known as BLDC) is a permanent magnet synchronous electric motor which is driven by direct current (DC) electricity and it accomplishes electronically controlled commutation system (commutation is the process of producing rotational torque in the motor by changing phase currents through it at appropriate times) instead of a mechanically commutation system. BLDC motors are also referred as trapezoidal permanent magnet motors. Unlike conventional brushed type DC motor, wherein the brushes make the mechanical contact with commutator on the rotor so as to form an electric path between a DC electric source and rotor armature

windings, BLDC motor employs electrical commutation with permanent magnet rotor and a stator with a sequence of coils. In this motor, permanent magnet (or fieldpoles) rotates and current carrying conductors are fixed.

This electronic commutation arrangement eliminates the commutator arrangement and brushes in a DC motor and hence more reliable and less noisy operation is achieved. Due to the absence of brushes BLDC motors are capable to run at high speeds. The efficiency of BLDC motors is typically 85 to 90 percent, whereas as brushed type DC motors are 75 to 80 percent efficient. There are wide varieties of BLDC motors available ranging from small power range to fractional horsepower, integral horsepower and large power ranges. Construction of BLDC Motor BLDC motors can be constructed in different physical configurations. Depending on the stator windings, these can be configured as single-phase, two-phase, or three-phase motors. However, three-phase BLDC motors with permanent magnet rotor are most commonly used. The construction of this motor has many similarities of three phase induction motor as well as conventional DC motor. This motor has stator and rotor parts as like all other motors.

### 4. SIMULATION RESULTS





## 5. CONCLUSION

With consideration for the fuel limitation, the electric drive's four quadrant functioning is simulated for optimal efficiency. During the regenerative mode, the battery is charged, and closed loop control is used to regulate the speed. The suggested approach

can be managed in all four quadrants and needs the least amount of gear. The bi-directional converter returns the kinetic energy to charge the battery when the system is operating in regenerative mode. The aforementioned suggestion might be implemented in an electric vehicle during a downhill run by managing speeding when there is a gravitational pull and the speed exceeds the reference speed. The suggested strategy is now being put into practice. In this study, a comparison analysis using simulation results is conducted between PI and PID Controller. We used convertible PI controllers in the current circuit layout, and those controls had shorter settling, rising, peak, overshoot, and decision-making times. IOT-based controllers are included to enable quick and intelligent IOT. This research suggests a straightforward off-our-quadrant functioning strategy that uses the motor's energy to charge the battery while braking. VSI and a bidirectional DC-DC converter may be used to achieve this efficient power use technique. There is just one energy source, and it uses the motor's kinetic energy to charge the battery with the VSI in an efficient manner. In the braking mode, the VSI functions as a rectifier, increasing the rectified voltage.

## REFERENCES

1. P. Pillay and R. Krishnan, Modeling, simulation, and analysis of permanent-magnet motordrives. II. The brushless DC motor drive. IEEE Transactions on Industry Applications, 25(2), pp.274-279, Mar./Apr. 1989.
2. R. Krishnan, "Electric Motor Drives Modeling, Analysis and Control",

- Prentice Hall of India, First Edn, 2002, Chapter 9, pp 513- 615.
3. R. Krishnan, Permanent Magnet Synchronous and Brushless DC Motor Drives, CRC Press, 2010.
  4. C. Joice, S. Paranjothi and V. Kumar, "Digital Control Strategy for Four Quadrant Operation of Three Phase BLDC Motor With Load Variations". IEEE Transactions on Industrial Informatics, 9(2), pp.974-982. May 2013.
  5. U. Vinatha, S. Pola., K.P Vittal, "Simulation of four quadrant operation & speed control of BLDC motor on MAT LAB / SIMULINK", IEEE Region 10 Conference TENCN2008, pp.1-6, 19-21 Nov. 2008.
  6. P. Damodharan., K. Vasudevan., "Sensorless Brushless DC Motor Drive Based on the Zero-crossing Detection of Back Electromotive Force (EMF) From the Line Voltage Difference," IEEE Transactions on Energy Conversions, vol.25, no.3, pp.661-668, Sept. 2010