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Four Quadrant Operation and Control of Threephasebldc Motor for Electric Vehicles

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ABSTRACT

The authors of this study show the control of a brushless direct current (BLDC) motor in all four quadrants (forward/reverse motoring/braking) with the aid of a bidirectional DC-DC converter. The three-phase voltage source inverter (VSI), which functions as the motor's driver, receives the output of the DC-DC converter. When the system is operating in regenerative mode, mechanical energy is transformed into electrical energy and stored in the batteries. During the motoring mode, buck operation is accomplished by utilizing the battery's bi-directional converter. It will use the same rechargeable battery for the boost function. Since electric vehicles need to be started and stopped frequently, this is taken into consideration in the plan. It is suggested to use a system that recovers energy throughout each and every stopping process. by making use of the regenerative braking system. Additionally, the controlled speed on the downhill provides a source of energy replenishment for the battery in the case that the electric vehicle (EV) is currently descending a slope. Simulink/MATLAB Software is used in order to check the aforementioned operations.

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 worldrequireshighlyefficient electric vehicle drives for transportation needs. The BLDC motor has a longer lifespan,higher efficiency, and compact size making it the most sought after motor in electricvehicledriveapplications. The continuous attempt to reduce environmental pollution has given animpetustothemarket of electric vehicles (EVs). As the fuel resources are depleting, the energy efficient electricdrives are likely to replace vehicles running with fossil fuels. Being different fromtheICE(internalcombustion engine), EVs are the least burden to the environment. Any motor drive systemwhichcanbe 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 disadvantagesofEVdrives like overall lower efficiency, huge dimension, and the cost of storage devicesetc. Thetechnique of performing the four quadrant operation is proposed where its battery is chargedduringthe regenerative braking but the system here has two energy sources, one is drivingthemotorandotheris storing the energy using the rectifier during braking. It is proposed in this paper that onlyonebattery is enough to drive the motor and at the same time to recover the kinetic energyof themotorusing regenerative mode. This proposal reduces the cost of an extra rectifier andanadditionalbattery. In the four quadrant operation is performed without utilizing the kinetic energyofthemotor. During braking, the motor kinetic energy is wasted in

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resistive losses this makesthesystemhighly in efficient. In the world where there is fuel constraint, this systemis not helpinginthat cause.In four quadrant sensorless control of the electronically commutated motor is done without utilizingthe motor kinetic energy in regenerative braking. The battery capacity puts a limitationtotheEVsinthe form of mileage or distance covered. Regenerative braking is just one of the ways toincreasethe efficiency of the drive. During regenerative mode, the energy of the drive systemwhichisinthe form of kinetic energy can beused to charge the battery during deceleration anddownhill runtoslow down the vehicle.

2. LITERATURE SURVEY

1) P. Pillay and R. Krishnan The authors develop a phase variable model of the BDCM(brushless DCmotor) anduseittoexamine the performance of a BDCM speed servo drive systemwhen fed byhysteresisandpulsewidth-modulated (PWM) current controllers. Particular attention was paid tothemotorlarge-signal and small-signal dynamics and motor torque pulsations. The simulation includedthestate-space model of the motor and speed controller and real-time model of the inverter switches. Everyinstance of a power device turning on or off was simulated to calculate the current oscillationsandresulting torque pulsations. The results indicate that the small- and large-signal responsesareverysimilar. This result is only true when the timing of the input phase currents withthebackEMF(electromotive force) is correct. The large-signal and small-signal speed response is thesamewhetherPWM or hysteresis current controllers are used. This is because, even though the torquepulsationsmay be different due to the use of different current controllers, the average value whichdeterminesthe 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, tractionapplications. This makes the control of BLDC motor in all the four quadrants veryvital. Thispaperdeals with the digital control of three phase BLDC motor. The motor is controlledinall thefourquadrants without any loss of power; in fact energy is conserved during the regenerativeperiod.Thedigital controller dsPIC30F4011, which is very advantageous over other controllers, asit combinesthe calculation capability of Digital Signal Processor and controlling capabilityofPICmicrocontroller, to achieve precise control.
3) X. Nian, F. Peng and H. Zhang Amidst the ever-increasing advancements in the technological realm-the electrical vehicleindustry too has seen several leaps. This particularly owes to three primary factors one, thefactthatwe are running out of conventional resources like petrol and diesel; two, higher efficiencyofelectricvehicles; and finally, less pollution caused by them. This has led to a burgeoning intheuseofBLDCmotors with electronic commutation not only in EVs but also in industrial andcommercialapplications. This requires an enhanced driving and control mechanismto tap the efficiencythatsuchmotors provide to increase performance and to get better controllability and reliability. Thispaperpresents a controller for this EV motor driver with increased efficiency by combiningvariousstrategies.

3. PROPOSED SYSTEM

Brushless DC motors (BLDC) have been a much focused area for numerousmotormanufacturers as these motors are increasingly the preferred choice in many applications, especiallyin the field of motor control technology. BLDC motors are superior to

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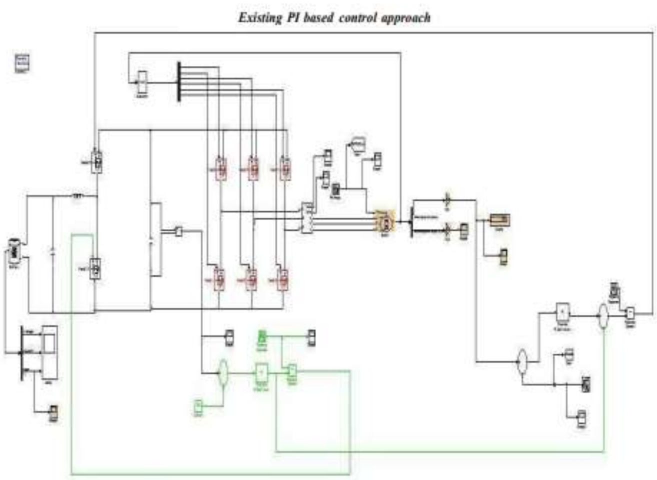
brushed DCmotorsinmanyways, such as ability to operate at high speeds, high efficiency, and better heat dissipation. Theyarean indispensable part of modern drive technology, most commonly employed for actuatingdrives,machine tools, electric propulsion, robotics, computer peripherals and also for electrical powergeneration. With the development of sensorless technology besides digital control, thesemotorsbecome so effective in terms oftotalsystem cost, size and reliability. A brushless DC motor (known as BLDC) is a permanent magnet synchronous electricmotorwhich is driven by direct current (DC) electricity and it accomplishes electronicallycontrolledcommutation system (commutation is the process of producing rotational torque inthemotorbychanging phase currents through it at appropriate times) instead of a mechanicallycommutationsystem. BLDC motorsare also referred astrapezoidalpermanent magnet motors. Unlike conventional brushed type DC motor, wherein the brushes make themechanicalcontact with commutator on the rotor so as to form an electric path between a DCelectricsourceandrotor armature windings, BLDC motor employs electrical commutation with permanentmagnetrotor and a stator with a sequence of coils. In this motor, permanent magnet (or fieldpoles)rotatesand current carrying conductors are fixed.

This electronic commutation arrangement eliminates the commutator arrangementandbrushes in a DC motor and hence more reliable and less noisy operation is achieved. Duetotheabsence of brushes BLDC motors are capable to run at high speeds. The efficiency of BLDCmotorsistypically 85 to 90 percent, whereas as brushed type DC motors are 75 to 80 percent efficient. Thereare wide varieties of BLDC motors available ranging from small power range tofractionalhorsepower, integral horsepower and large power ranges. ConstructionofBLDC Motor BLDC motors can be constructed in different physical configurations. Dependingonthestator windings, these can be configured assingle-phase, two-phase, or three-phase motors. However,three-phaseBLDC motors withpermanent magnet rotor are most commonly used. The construction of this motor has many similarities of three phase induction motor aswellasconventionalDC motor.This motor hasstator and rotor parts as like all other motors.

4. SIMULATION RESULTS



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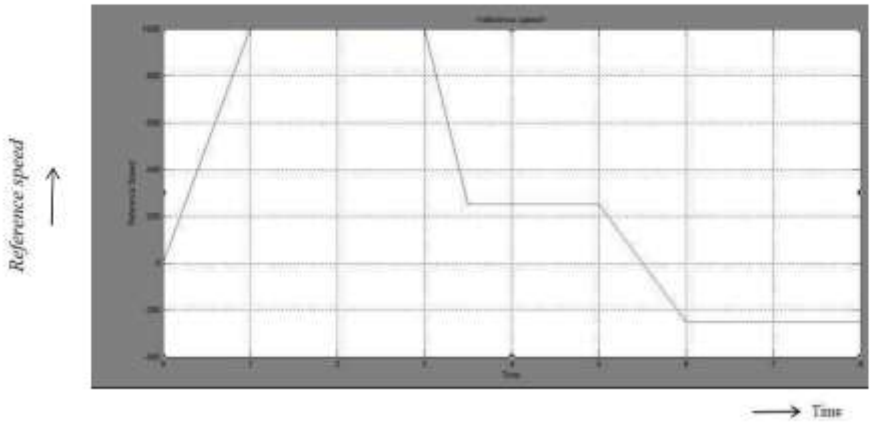
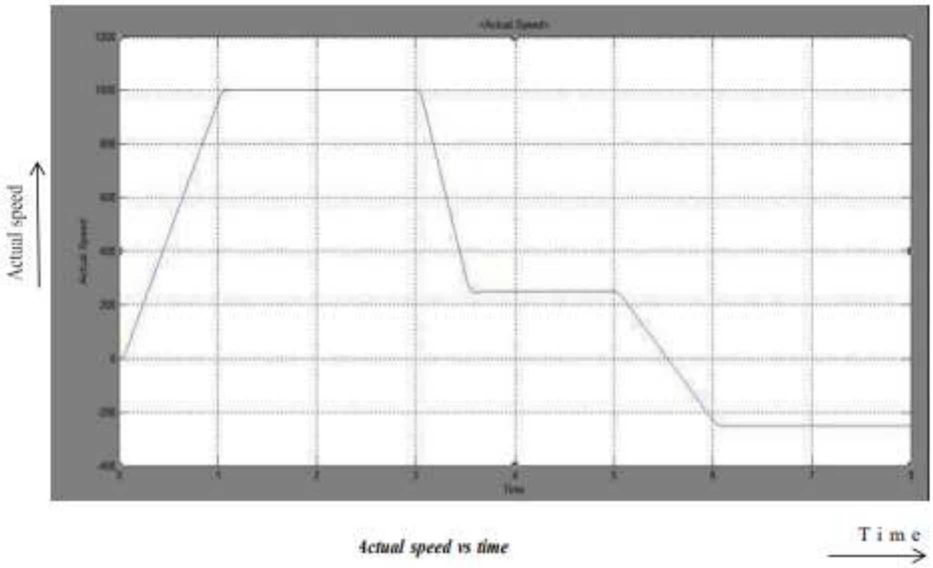
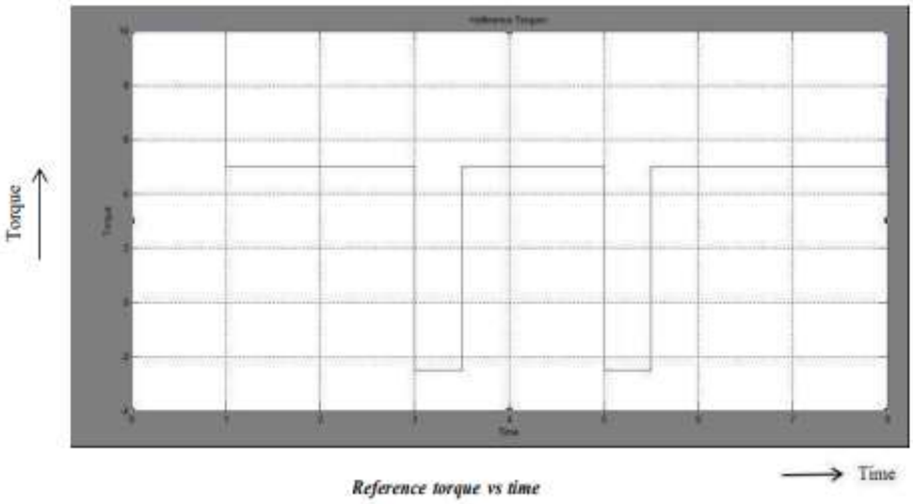


Reference speed vs time



Actual speed vs time



Reference torque vs time

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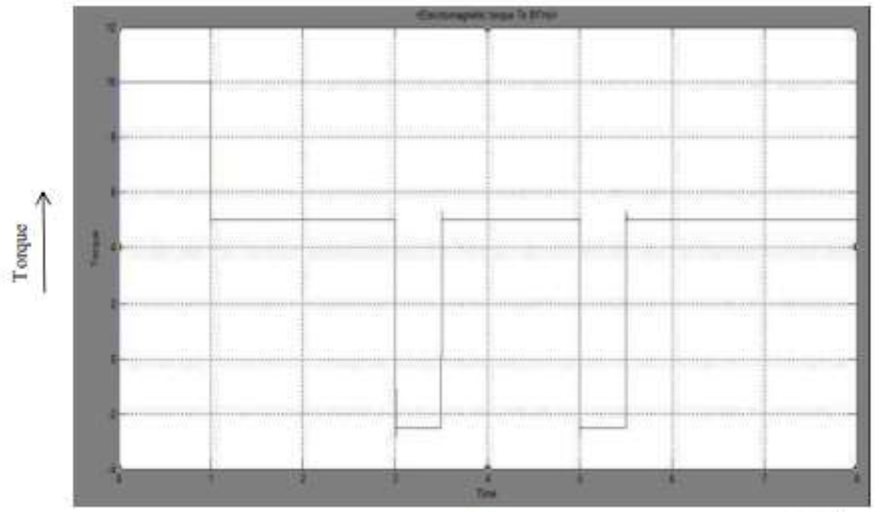
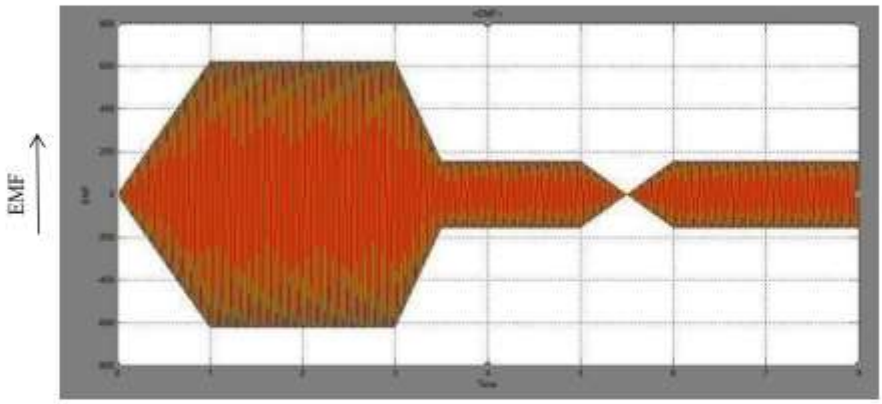
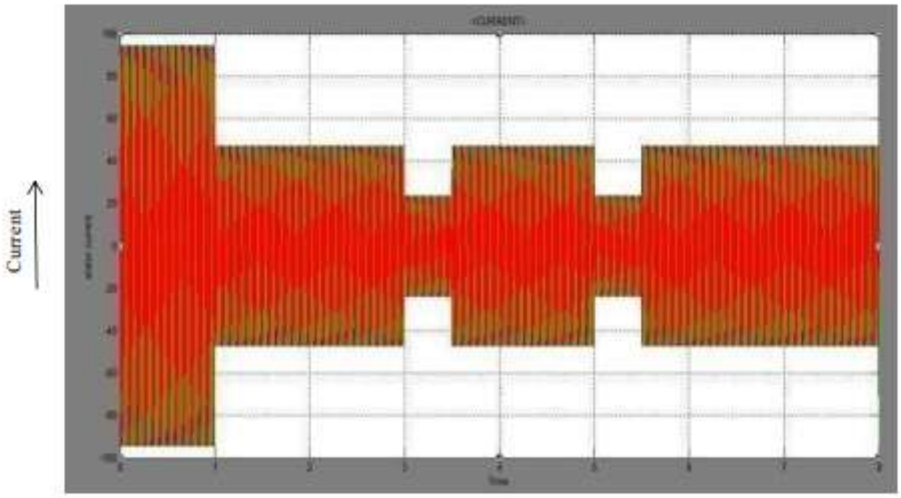


Electromagnetic torque



Back EMF vs time



Current vs time

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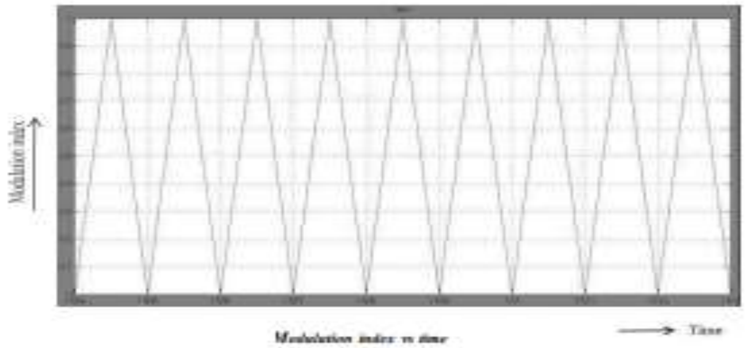
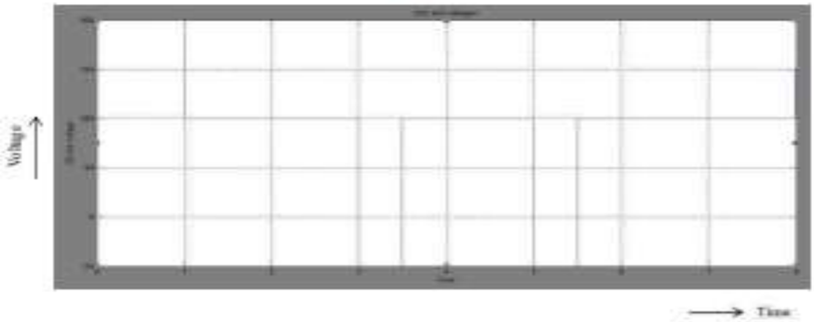
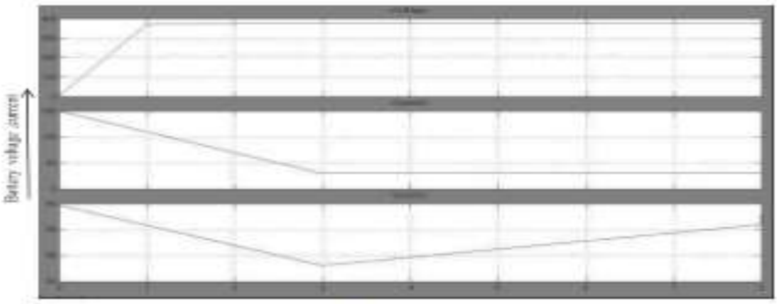


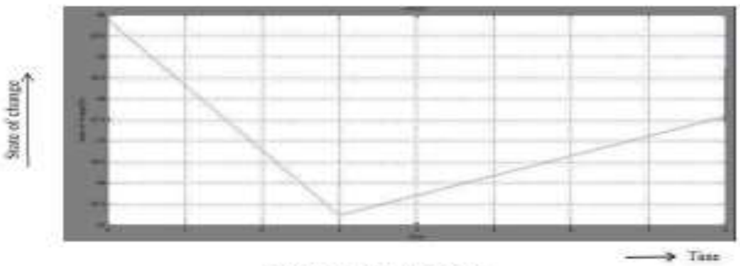
Modulation index vs time



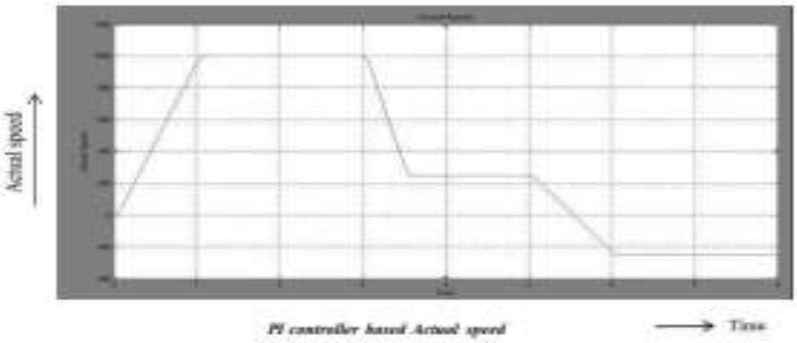
Dc link voltage vs time



Battery voltage, current, SOC vs time



SOC for PI based controller circuit



PI controller based Actual speed

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5. CONCLUSION

For the electric drive, the four quadrant operation is simulated with optimal efficiency while taking the fuel restriction into consideration. During the regenerative mode, the battery is charged, and closed loop control is used to control speed. The operation of the suggested method can be regulated in all four quadrants with the least amount of hardware required. The bi-directional converter uses the kinetic energy recovered during the regenerative mode to charge the battery. The aforementioned suggestion could be implemented in an electric vehicle during a downhill run by managing the speed in the gravitational force when the velocity surpasses the reference velocity. The suggested method's practical implementation is currently underway. In this work, a comparative analysis using PI and PID Controller is conducted using simulation results. We used convertible PI controlers in the current circuit arrangement, and that control had reduced settling, rise, peak, overshoot, and decision-making times.IOT-based controllers with features for quick operation and intelligent IOT.This study suggests a straightforward approach to quadrant functioning, where the battery is charged while the engine is braking.VSS and a bidirectional DC-DC converter can be used to achieve this efficient power usage technique. There is only 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 rectified voltage is increased and the VSI functions as a rectifier.

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