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BLDC Motor Drive for Electric Vehicles

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ABSTRACT: Nowadays electric vehicles are replacing conventional vehicles because of their environment friendly operation and less maintenance. Most of the electric vehicles use three phase induction motors. In this project BLDC motor drive is proposed as it exhibit high torque, high efficiency, easy speed control, reduced noise and longer life time. Retrofitting conventional vehicles to electric vehicles by replacing a brushless dc motor will have a great scope in future as it is economical.

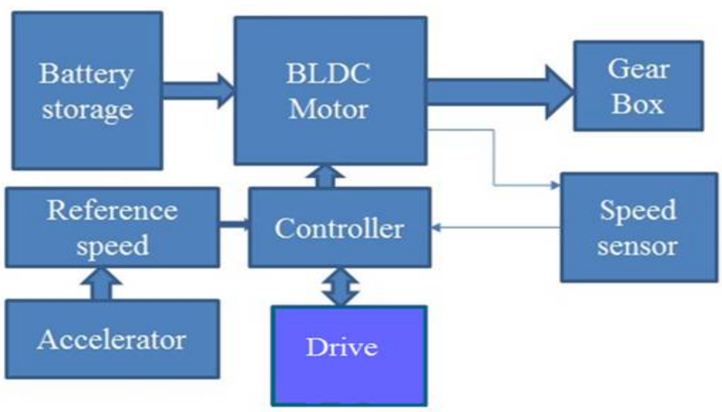
KEYWORDS:BLDC motor

I.INTRODUCTION

Electric vehicles are at least twice as efficient as conventional vehicles. So we are encouraging more electric vehicles than conventional vehicles. Inthis system an idea of retrofitting the conventional vehicles to electric vehicles is proposed. A BLDC motor drive and its controller can be designed as per the weight and torque specifications on existing conventional vehicles. This will reduce the costbecause existing conventional vehicles are transformed to electric vehicles with required specification. BLDC motor is proposed because it has high torque, high efficiency, reduced noise, easy speed control and longer lifetime. As the name suggests brushless dc motor does not have brushes and they are commuted electronically.

BLDC motors are known for their high durability due to simplicity in design and high rpm capabilities. They have both small and large applications. The motor is controlled by a motor controller . The motor controllers need rotor position to control the motor. Some type of controllers use hall effect sensors or rotary encoder to sense the rotor position. Others measure the back emf in the undriven coils to infer the rotor position. It contains three output terminals which are controlled by logic circuits. Advanced controllers use microcontroller to manage acceleration and speed.

II.MAIN BLOCK DIAGRAM



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The BLDC motor is energized by lead- acid battery. Accelerator consist of a varistor. The varistor output wills according to the acceleration and this output will fed to the controller. The signal from the accelerator is the reference signal. The hall sensors mounted on the BLDC Motor will provide the actual speed of the motor. These two signals are compared in the controller and the power output from the chopper drive is varied. The signal from the chopper is fed back to the motor.According to the power output from the chopper drive the motor speed can be controlled.

III.BLDC MOTOR CONTROLLER AND DESIGN

Growing need for high productivity is placingnew demands on mechanisms connected with electrical motors.The demand for low cost Brushless DC (BLDC) motor has increased in industrial applications. A simple BLDC motor control algorithm for low cost motor drive applications using general purpose microcontrollers has been created and presented in this paper. Proposed design will allow the user to rotate the motor either clockwise or counter clockwise direction. Depending on the rotor position the sensor will give response to the controller circuit. Then the controller circuit will fix the direction of current following to the stator. The design controller circuit is also implemented. The overall design consists of microcontroller circuit, logic gates, switching devices (MOSFET/BJT), BLDC motor, sensors.A brushless dc (BLDC) motor is a synchronous electric motor which is powered by direct-current electricity (DC) and which has as electronically controlled commutation system, instead of a mechanical commutation system based on brushes. In such motors, current and torque, voltage and rpm are linearly related. In BLDC motor the electromagnets do not move, instead the permanent magnets rotate and the armature remains static. This gets around the problem how to transfer current to a moving armature. In order to do this, the brush systems assembly is replaced by an electronic controller. The controller performs the same power distribution found in abrush dc motor, but using a solid state-static circuit rather than a commutator/brush system.

The equation for design of rotor torque is as follows:

TTE [lb] = RR [lb] + GR [lb] + FA [lb]

Where:

TTE = total tractive effort [lb]

RR = force necessary to overcome rolling resistance [lb]

GR = force required to climb a grade [lb]

FA = force required to accelerate to final velocity [lb]

Step1:Determine Rolling Resistance

Rolling Resistance (RR) is the force necessary to propel a vehicle over a particular surface. The worst possible surface type to be encountered by the vehicle should be factored into the equation.

RR [lb] = GVW [lb] x Crr [-]

where:

RR = rolling resistance [lb]

GVW = gross vehicle weight [lb]

Crr = surface friction

Step2:Determine Grade Resistance

Grade Resistance (GR) is the amount of force necessary to move a vehicle up a slope or “grade”. This calculation must be made using the maximum angle or grade the vehicle will be expected to climb in normal operation.

To convert incline angle, α, to grade resistance:

GR [lb] = GVW [lb] x $\sin(\alpha)$

where:

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GR = grade resistance [lb]

GVW = gross vehicle weight [lb]

α = maximum incline angle [degrees]

Step3:Determine Acceleration Force

Acceleration Force (FA) is the force necessary to accelerate from a stop to maximum speed in a desired time.

FA [lb] = GVW [lb] x Vmax [ft/s] / (32.2 [ft/s2] x ta [s])

where:

FA = acceleration force [lb]

GVW = gross vehicle weight [lb]

Vmax = maximum speed [ft/s]

ta = time required to achieve maximum speed [s]

Step4:Determine Total Tractive Effort

The Total Tractive Effort (TTE) is the sum of the forces calculated in steps 1, 2, and 3. (On higher speed vehicles friction in drive components may warrant the addition of 10%-15% to the total tractive effort to ensure acceptable vehicle performance.)

TTE [lb] = RR [lb] + GR [lb] + FA [lb]

Step5:Determine Wheel Motor Torque

To verify the vehicle will perform as designed in regards to tractive effort and acceleration, it is necessary to calculate the required wheel torque (Tw) based on the tractive effort.

Tw [lb-in] = TTE [lb] x Rw [in] x RF [-]

where:

Tw = wheel torque [lb-in]

TTE = total tractive effort [lb]

Rw = radius of the wheel/tire [in]

RF = “resistance” factor [-]

Step6:Reality Check

The final step is to verify the vehicle can transmit the required torque from the drive wheel(s) to the ground. The maximum tractive torque (MTT) a wheel can transmit is equal to the normal load times the friction coefficient between the wheel and the ground times the radius of the drive wheel.

MTT = Ww [lb] x μ [-] x Rw

where:

Ww = weight (normal load) on drive wheel [lb]

μ = friction coefficient between the wheel and the ground (~0.4 for plastic on concrete) [-]

Rw = radius of drive wheel/tire [in]

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Interpreting Results:

Total Tractive Effort is the net horizontal force applied by the drive wheels to the ground. If the design has two drive wheels, the force applied per drive wheel (for straight travel) is half of the calculated TTE.

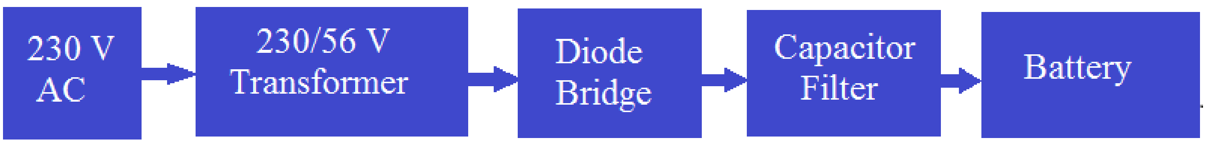
The Wheel Torque calculated in Step Five is the total wheel torque. This quantity does not change with the number of drive wheels. The sum of the individual drive motor torques (see Motor Specifications) must be greater than or equal to the computed Wheel Torque.

The Maximum Tractive Torque represents the maximum amount of torque that can be applied before slipping occurs for each drive wheel. The total wheel torque calculated in Step Five must be less than the sum of the Maximum Tractive Torques for all drive wheels or slipping will occur. By considering the weight and required driving torque we have used a 2Kw, 48V, 3000 rpm BLDC Motor which will provide 7 Nm continuous torque at 40A and a peak torque of 17 Nm at 70A.This motor is coupled to the gear box and the gear are as follows;

First gear = 1:15, Second gear = 1:12, Third gear = 1:9.

IV.CHARGING

The lead-acid battery can be charged using plug-in power and also renewable energy sources like solar energy, wind energy etc.In foreign countries they have charging points for charging the electric vehicles. By 2030 we can also expect a large variety of electric vehicles and also charging stations. In this project we have made a charger for charging lead-acid batteries.



V.BATTERY

Lead-acidbatteries use a chemical reaction to do work on charge and produce a voltage between their output terminals.The reaction of lead and lead oxide with the sulphuric acid electrolyte produces a voltage. The supplying of energy to and external resistance discharges the battery. To charge the lead-acid battery a voltage from a charging source is applied to reverse the discharge reaction. This batteries are reliable over 140 years of development. They are robust and tolerant to overcharging. The world's most recycled product is lead-acid battery and they have an attractive advantage of being cheap.

Some of the applications where we can find this type of batteries are automotive and traction applications,back up for electrical installations, submarines, UPS, lighting and high current drain applications. This can deliver high currents. Wide range of capacities and sizes are available for this batteries. Sealed battery types are available for use in portable equipment. Flooded lead- acid cells are one of the least expensive sources of battery power available .In this project for the required electrical energy we are using four 12V lead-acid batteries connected in series.

VI.CONCLUSION AND DISCUSSIONS

BLDC Motor of high power rating is not available easily. When compared with other motor, cost of BLDC motor is really high. BLDC Motor and it's controller should be matched to each other. Coupling the motor with thegear box of the existing vehicle was tiresome and time consuming.

Thus by providing BLDC drive we can achieve smooth operation with high efficiency, high torque and easy speed regulation. As per the weight and required torque of the vehicle we can convert the conventional vehicles to pollutant free, highly efficient electric vehicles. For further enhancement of this project we can have solar power to charge the batteries thus making the electric vehicle more efficient.

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VII.FUTURE SCOPE

By 2030 we are expecting only electric vehicles on our roads and if we can convert the existing conventional vehicles to electric vehicles that will more cost efficient. Furthermore the storage capacity and charging time can also be improve the entire reliability and efficiency of the system.

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