Development of an Electric Vehicle Using PWM Control Technique

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Abstract - *In the last few years, almost every automotive manufacturer has announced the development of some sort of electric vehicles. Many of those have already been shown to the public, either as concept vehicles, or as pre-production demonstration vehicles .The government has also announced the complete electrification of automotive field within 2030. We are developing an electric vehicle using a much efficient PWM control technique. A Brushless DC Motor is used to power the wheels, which is free from pollution compared to that of the conventional internal combustion engines. The main aim is to make possible the electrification, in an economical manner.*

Key Words: Brushless DC Motor(BLDC), Switching Devices, PWM control Technique, Inverters, Parameters

1. INTRODUCTION

The development of automobile with heat engines is one of the greatest achievements of modern technology. However, the highly developed automotive industry and the large number of automobiles is use around the world have caused serious problems for society and human life. Deterioration in air quality, global warming, and a decrease in petroleum resources are becoming major threats to human beings. The major components of an electric vehicle system are the motor, controller, power supply, charger and drive train . Controller is the heart of an electric vehicle, and it is the key for the realization of a high-performance electric vehicle with an optimal balance of maximum speed, acceleration performance, and traveling range per charge. Control of Electric Vehicle (EV) is not a simple task because the operation of an EV is essentially time-variant. Therefore, the controller should be designed to make the system robust and adaptive, improving the system on both dynamic and steady state performances. Another factor making the control of EV unique is that EV's are really "energy-management" machines. Hence, beside controlling the performance of vehicle, significant efforts have to be paid to the energy management of the batteries on the vehicle. However, from the viewpoint of electric and control engineering, EV's are advantageous over traditional vehicles with internal combustion engine. The remarkable merit of EV's is the electric motor's excellent performance in motion control, which can be summarized as (1) torque generation is very quick and accurate, hence electric motors can be controlled much more quickly and precisely; (2) output torque is easily comprehensible; (3) motor can be small enough to be attached; (4) and the controller can be easily designed and implemented with comparatively low cost

1. DEVELOPMENT OF ELECTRIC VEHICLE

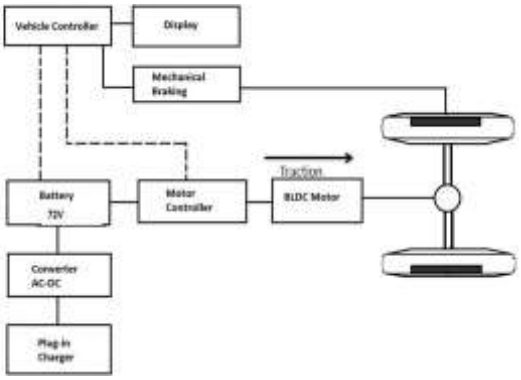

Figure 1: Block Diagram

The structure of the proposed system is shown in **Figure 3.**The electric drive system of the presented vehicle consists of three main elements, i.e pack of 72v lead acid battery, BLDC motor of 4.5 Kw of output mechanical power and an appropriate controller to run the motor. The BLDC motor is powered using the lead acid batteries. Six 12v lead acid batteries are connected in series to achieve 72v to run the motor. Plug-in charger is used to charge the batteries. In order to convert the alternating current an Analog to digital converter is used. The overall system is controlled using the vehicle controller.

2. BRUSHLESS DC MOTOR

BLDC motor is a brushless motor. The name itself implies that there are no brushes and commutator. In BLDC Motor the

commutation is performed with the help of electronic circuit, which reduces the mechanic losses and improves the efficiency. Replacing the inefficient motors with more efficient BLDC motors will result in substantial energy savings. A BLDC has several advantages over other machine types. Most notably they require lower maintenance due to the elimination of the mechanical commutator. It also has high power density. Compared to induction machines, BLDC motors have lower inertia, allowing for faster dynamic response to reference commands [2]. The major disadvantage with permanent-magnet motors is their higher cost and relatively greater degree of complexity introduced by the power electronic converter used to drive them. The speed of the motor is directly proportional to the applied voltage. By varying the average voltage across the windings, the speed can be altered.

2.1 CONTROL OF BLDC MOTOR

The BLDC motor is characterized by a two phase ON operation to control the inverter. In this control scheme, torque production follows the principle that current should flow in only two of the three phases at a time and that there should be no torque production in the region of Back EMF zero crossings. The following figure describes the electrical wave forms in the BLDC motor in the two phases ON operation. The principle of the BLDC motor is, at all times, to energize the phase pair which can produce the highest torque. To optimize this effect the Back EMF shape is trapezoidal. The combination of a DC current with a trapezoidal Back EMF makes it theoretically possible to produce a constant torque. In practice, the current cannot be established instantaneously in a motor phase; as a consequence the torque ripple is present at each 60 degree phase commutation.

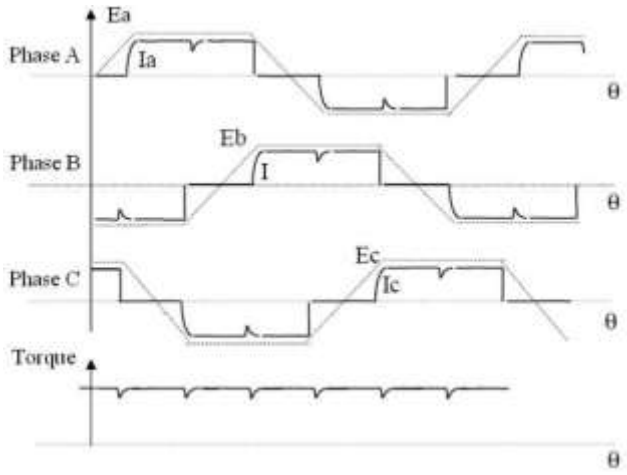

Figure 2 : Control of BLDC Motor

2.2 MOTOR CONTROLLER

The Motor controller mainly consists of two parts i.e., Controller part and the inverter part. dsPIC30F2010 is used as the IC. The Driver IC is chosen as IR2110.The driver IC is used to drive the gate of the MOSFETs.And also its act as a protection for the controller. BLDC motor is controlled using PWM techniques

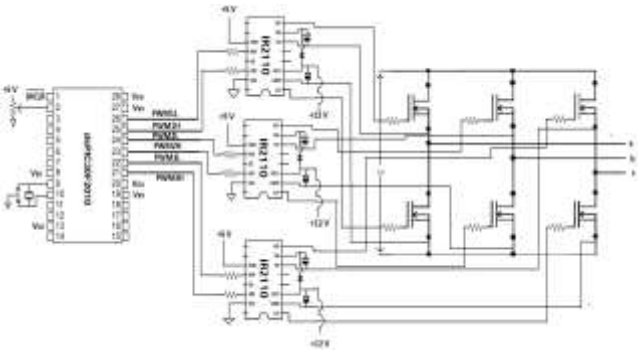

Figure 3:Motor Controller

3. PWM Technique

Pulse width modulation control works by switching the power supplied to the motor ON and OFF very rapidly. The DC voltage is converted to a square wave signal, alternating between fully on (nearly 12v) and zero, giving the motor a series

of power "kicks". Pulse width modulation technique (PWM) is a technique for speed control which can overcome the problem of poor starting performance of a motor. PWM for motor speed control works in a very similar way. Instead of supplying a varying voltage to a motor, it is supplied with a fixed voltage value (such as 12v) which starts it spinning immediately. The voltage is then removed and the motor 'coasts'. By continuing this voltage on/off cycle with a varying duty cycle, the motor speed can be controlled.

Pulse-width modulation (PWM) or duty-cycle variation methods are commonly used in speed control of DC motors. The duty cycle is defined as the percentage of digital 'high' to digital 'low' plus digital 'high' pulse-width during a PWM period.

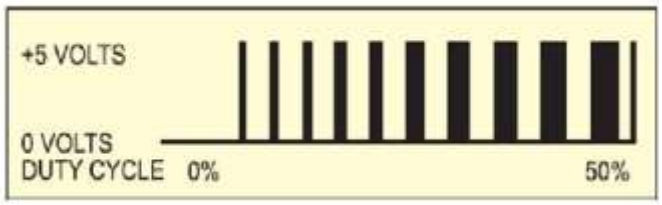

Figure 4: PWM Technique

Fig. 2 shows the 5V pulses with 0% through 50% duty cycle. The average DC Voltage value for 0% duty cycle is zero; with 25% duty cycle the average value is 1.25V (25% of 5V). With 50% duty cycle the average value is 2.5V, and if the duty cycle is 75%, the average voltage is 3.75V and so on. The maximum duty cycle can be 100%, which is equivalent to a DC waveform. Thus by varying the pulse-width, we can vary the average voltage across a DC motor and hence its speed. The average voltage is given by the following equation:

$$y' = D. Ymax + (1- D) Ymin$$

But usually minimum equals zero so the average voltage will be:

$$y' = D. Ymax$$

4. CONCLUSIONS

The construction of an electrical vehicle has been presented and tested. The vehicle is powered by the brushless DC motor (BLDC) of 4.5 kW of nominal power which seems to be the best solution for this type of construction. The use of BLDC motor in such a construction makes the vehicle relatively fast and powerful. And also it results in,

- Better fuel economy
- Reduced carbon emissions
- Better control

Further Improvements

- Implementation of Solar Energy source
- Using Lithium Ion Cells
- Implementation of Super capacitors

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