Increasing Driving Range In Battery Electric Vehicle

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Abstract: Electric vehicles are now developing as a replacement or alternative of a gasoline or diesel powered vehicle. As battery is the important part of battery electric vehicle, the other petroleum vehicles are becoming replaceable. This paper gives the solution to increase battery driving range by taken into account of two batteries. The electrical vehicle is designed using MATLAB/Simulink. The motor ratings and battery ratings are determined to design the electric vehicle. The two vehicles are designed one with lead acid battery and another with lithium ion battery. The permanent magnet synchronous motor is used, because of it has high efficiency than other motors. The speed of car, torque, power are determined and the distance is calculated. The comparison of vehicle with two different batteries are modelled and its distance were calculated.

Keywords: Lead-Acid, Lithium-ion, Driving range, Permanent magnet synchronous motor (PMSM).

1. Introduction

The electric vehicle were developing since 19th century. At first the power to the electric vehicle were generated by the fossil fuels such as coal and other non-renewable sources. By using the non-renewable sources first the fossil fuel is converted to electric and electric energy is converted to the kinetic energy. But these vehicles have disadvantage that its cost were very high. Then several replacements were made and the electric vehicles were developed. The electric vehicles are developing as a replacement of petroleum vehicles because of the polluting nature in petroleum vehicles. Now the electric vehicle is running with battery storage capacity and this stored power is used for driving the vehicle. The driving range is the major issue in the electric vehicle. The lithium-ion battery accept high current and prevents damages to the battery. Because of the acceptance of high current from regenerative braking, the efficiency of the vehicle is increased. This paper propose the simulation for increasing the driving range in battery electric vehicle by MATLAB/Simulink software.

The temperature released by the battery is stored and this energy is stored as power and increasing the driving range. Another author proposed about the remaining driving range prediction by using the algorithm. Wireless power transfers is used in battery electric vehicle, by transferring power in roadside while the vehicle is standing because of the traffic. In this system the vehicles cannot store more energy as possible and cannot increase the driving range. And also the existing system has the battery storage system but the driving range is very less compared to the driving range of the petroleum vehicles.

The existing block diagram of battery electric vehicle were discussed in this section. This existing system is now used for running the battery electric vehicle. In this the battery electric vehicle is charged, and the charge is stared in the battery for running the motor. This battery stores the DC power. This DC power is then converted to the AC power.

In the proposed system, the permanent magnet synchronous motor is used for running the electric vehicle because of its high efficiency and good speed regulation. It has higher efficiency than BLDC motor.

2. Proposed System

The proposed battery electric vehicle consists of Energy management system, Electrical system and vehicle dynamics. The block diagram for the battery electric vehicle is shown in Fig.1. The battery management system manages the power that is available in the vehicle and also manages the power to be given to the vehicle.

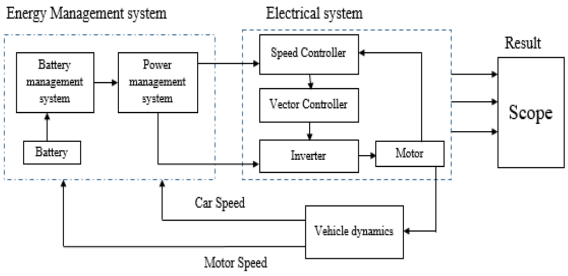

Fig.1 Block diagram of the proposed system

The power management system manages the power to be distributed to the motor. And also the torque signal is given to the speed controller. The speed is given as input to the speed controller. The vector controller controls the speed of the motor. The vector controller controls the stator current by giving a trigger signal to the inverter. The motor speed is given to the speed controller. The motor shaft is connected with vehicle dynamics where the vehicle wheels are placed and rotates based on the motor shaft. The speed is given to the vehicle dynamics, it considers the load of the vehicle and make the vehicle to according to the load.

3. Simulation

The electrical subsystem consists of

i. Permanent magnet synchronous motor with 2.5kW.
ii. Battery with 288V, 100Ah.
iii. Three phase inverter to convert DC power from the battery to AC power.

Motor

The permanent magnet synchronous motor is used in electric vehicle because of its high efficiency than other motors. The motor model is shown in the fig.2. The torque and power in motor obtained from simulation is shown in Fig.5.

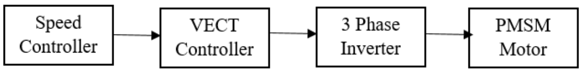

Fig.2. Simulation for motor model

The permanent magnet synchronous motor uses four main parts.

i. The electrical motor Permanent Magnet Synchronous motor is used. Its ratings include 288 Vdc, 2.5kW. There are 8 poles and magnet.
ii. The three-phase inverter receives the converts DC to AC and controls the power to be given to the motor.
iii. The Vector controller controls the stator current by giving trigger signal to the inverter. It also determine the 3 phase line current with respect to flux and torque and PWM signals are generated by current regulator.
iv. The speed controller receives the torque from the power management system. The motor speed is given to the speed controller. According to the torque it controls the speed in motor.

Table.1. Motor Ratings

Parameters	Ratings
Voltage	288V
Power	2.5kW
Speed	5000rpm
Torque	250Nm
d-axis inductance	0.000174H
q-axis inductance	0.000292H

Battery

There are many batteries in use such as Nickel-metal hydride battery, Nickel-cadmium battery, Lead-acid battery. Because of the low sellf-discharge, good temperature performance and high energy efficiency, the lithium ion battery is used for electric vehicle. The battery model in simulation is shown in fig.8.

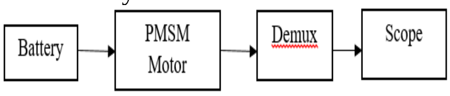

Fig.3. Battery model

The battery models 220V, 100Ah Li-ion battery connected to the motor load. When the State-of-Charge of the battery goes under 40%, a negative load is applied to the motor, so it acts as generator to recharge the battery. When the State-of-Charge is 80%, the power from battery is supplied to the load. The battery is modelled as given in Table.2.

Table.2. Battery Ratings

Parameters	Ratings
Voltage	288V
Rated capacity	100Ah
Resistance	0.028ohm

The power consumption of the vehicle with lead-acid battery is shown in Fig.5. The power consumption is less in lead-acid battery compared with lithium ion battery.

Vehicle structure

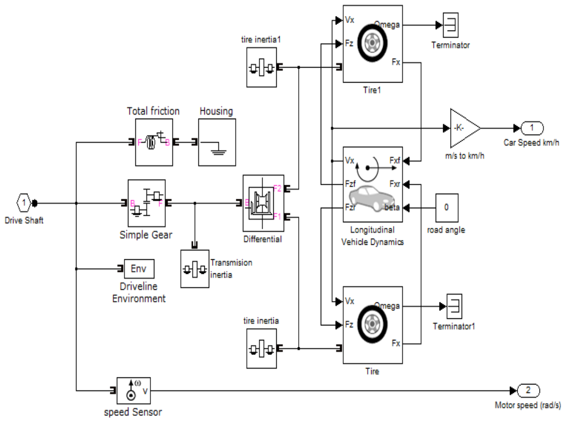

Fig.4 Vehicle model

The distance travelled by the vehicles depend on the loads like tire, weight, and all the parts in the vehicle. The parameters for modelling vehicle is given in table.3. The mechanical parts are modelled by the vehicle dynamics subsystem. The single reduction gear increase the torque and reduces the motor speed. The torque is splited into two equal torques by the differential split. Underground forces are applied by the tires. The overall system movement is monitored by the vehicle dynamics. The viscous friction demonstrates the losses in the mechanical system. The vehicle model is shown in fig.4.

Table.3.Vehicle Ratings

Parameters	Ratings
Weight	1695kg
Wheel radius	0.25m
Frontal area	2.71m^2
Coefficient of drag	0.35
Air density	1.29kg/m^3

4. Result

The two battery electric vehicle one with lead-acid battery and another with lithium-ion battery are taken into account. From manual calculation, the driving range of lead acid battery is 104km. And the driving range of lithium ion battery is 111km. As the acceleration increases the speed and torque of the vehicle is increased. When the acceleration is high the vehicle reaches its maximum speed. If the acceleration increases the torque and speed also increases and if the acceleration is decreased the speed and torque also decreases.

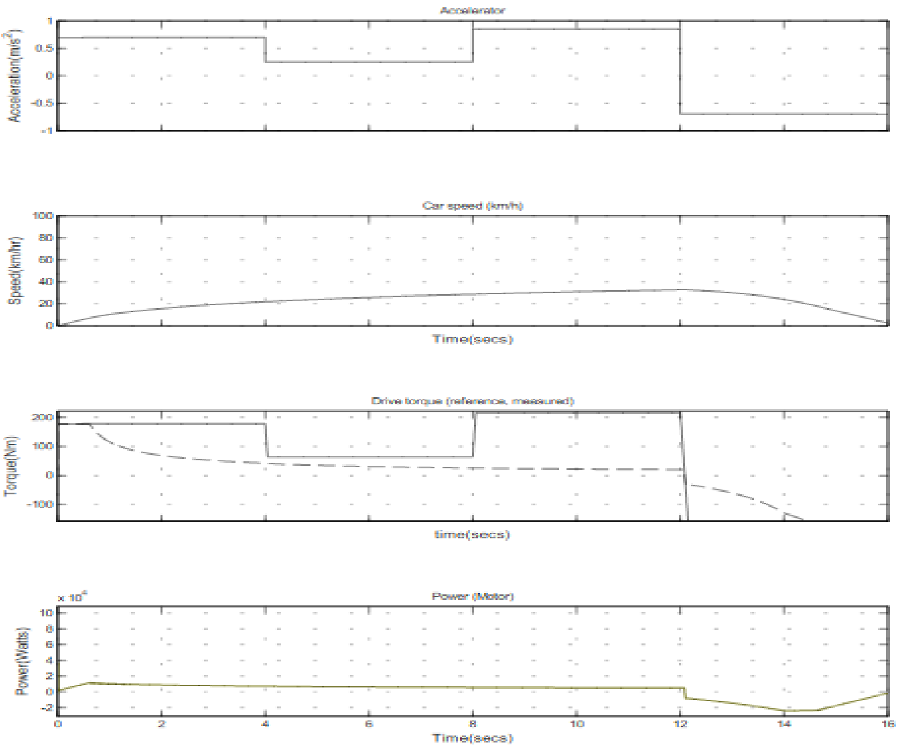

Fig.5 Accleration, Speed, Torque and power of vehicle with lead-acid battery

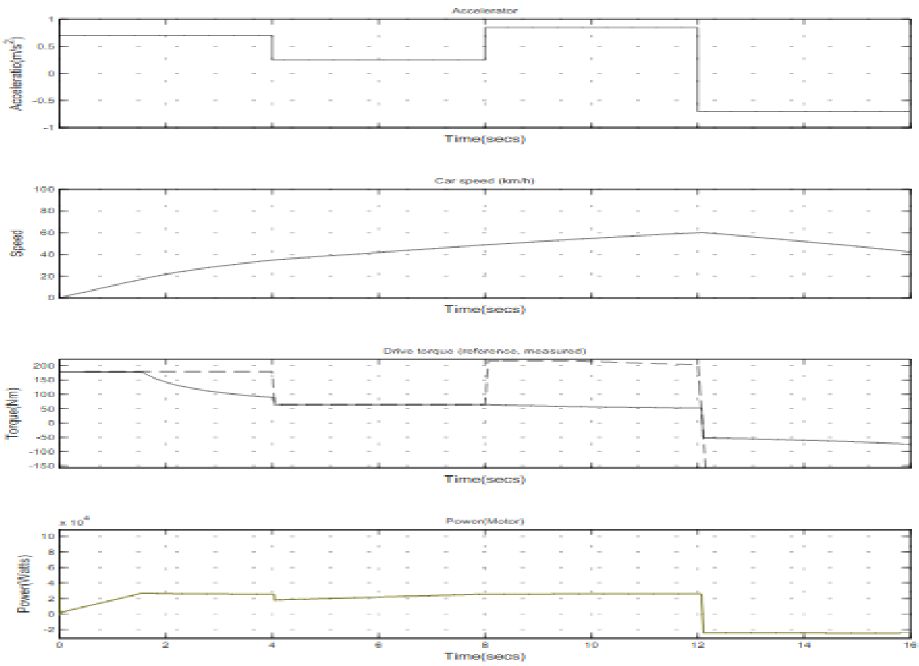

Fig.6 Acceleration, Speed, Torque and Power of vehicle lithium-ion battery

5. Conclusion

The project aims to give a solution for a battery to be used in electric vehicle with increased driving range. The lead acid battery and lithium ion battery are taken into account for comparing the driving range of the two different batteries. By using the power, torque and acceleration obtained by simulation the distance were calculated for two batteries. The lithium ion battery gives more distance than the lead acid battery. In this proposed system, the comparative analysis of electric vehicle efficiency with lead-acid and li-ion battery. The electric vehicle driving range are simulated and calculated using MATLAB platform.

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