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Overview of Battery Electric Vehicle Using Induction Motor

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Abstract

This paper presents an overview of electric vehicles (EV). Since conventional vehicles use gasoline or diesel engine which creates air pollution and greenhouse gas emissions, EVs runs on electric motors powered by batteries. The paper describes the outline of the system proposed for electric vehicles. The paper focuses on major components of EV which are Battery, Energy management system, motor controller and induction motor.

Keywords: *Battery, Energy Management System, 3-phase Induction Motor, PWM Inverter.*

1. Introduction

For mobility of human beings, IC engine vehicles have played a major role. But with the increase in population, vehicles have increased tremendously. Due to this, pollution has increased thereby causing adverse effect on living beings and environment. Also, fossil fuels are inadequate and hence we need to find an alternative to conventional IC engines. Researchers and developers are now focusing on Electric Vehicles (EV) which offers pollution-free operation, less maintenance and low cost energy. Electric vehicles may be classified as Battery electric vehicle (BEV), Hybrid electric vehicle (HEV) and Plug-in hybrid electric vehicle (PHEV). This paper purely focuses on Battery electric vehicle.

With the upcoming years, electric vehicles will completely supersede conventional IC engine vehicles. As per the present rate of extraction of crude oil, foretellers predict that the fuel will last for about next 50 years only. According to Indian Government Policy, the aim is to shift one-third of the petrol and diesel vehicles to electric fleet by 2030. All the security, safety and luxury features are been provided in the electric vehicle. The main sources of energy in electric vehicles are batteries. Batteries are easily rechargeable on charging stations provided in different areas. Many public parking lots or garages offer free charging [3]. Motor controller and AC motor are major components of propulsion system in EVs.

2. Overview of Electric Vehicles

The main components of electric vehicle are:

1. Battery
2. Energy management system
3. Three-phase PWM inverter

Fig. 1 shows the block diagram of electric vehicle. The energy management system is the heart of EV. When the ignition key is turned on, the energy management system energizes the other modules. The solenoid switch takes current from the battery and provides it to motor controller. The accelerator pedal is connected to pedal position sensor i.e. potentiometer. The position of the accelerator pedal determines the signal to be fed to motor controller and accordingly motor speed is controlled. The electric motor then converts electrical energy to mechanical energy. This mechanical energy drives the vehicle forward.

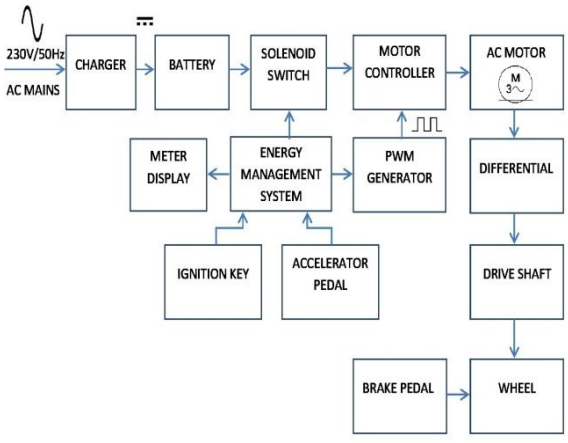

Fig 1: Block diagram of EV

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A power-transistorized PWM inverter and induction motor drive system with advanced controller for EV has the main merits of being robust, reliable, light weight, high efficiency, and almost maintenance free [5].

3. Charging System

3.1 Charger

Charger consists of full wave rectifier, capacitor filter and voltage regulator. The charger needed for the battery system for slow charging or fast charger are both required to handle high power [2]. It takes 230V AC mains and converts it into 48V DC to charge the batteries. Fig. 2 shows the general block diagram of charger.

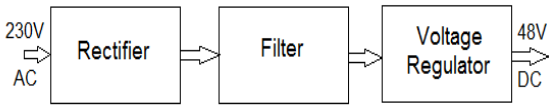

Fig 2: Charger

3.2 Battery

Battery is an electrochemical device which converts chemical energy to electrical energy. In electric vehicles, batteries have replaced the engine, which serves as energy storage system. Batteries are most expensive part of EVs which contribute to about 25 to 50% of the total EVs price. Rechargeable cells or secondary cells are mostly suitable for EVs.
The system consists of 8 lead acid batteries which are connected in series to form 48V. The nominal voltage of each battery is 6V and 3 cells per battery. Rated capacity of each battery is 200AH. The Lead acid battery offers long shell life, inexpensive as compared to other batteries. This battery is more reliable and the number of times the battery can be recharged without degrading its efficiency. The performance requirements of the lead acid battery are limited are therefore it need not possess a high energy density compared to newer battery technologies [3]. The lead acid batteries need to be replaced after 3 years approximately, beyond which it starts degrading. Fig. 3 shows the lead acid battery.

4. Propulsion System

4.1 Motor Controller

The controller takes power from the batteries and delivers it to the motor. The accelerator pedal is attached to a pair of potentiometers i.e. variable resistors, signals the controller how much power is to

Chemical reaction:

$$PbO_2 + 2H_2SO_4 + Pb \rightleftarrows PbSO_4 + 2H_2O + PbSO_4 (1)$$

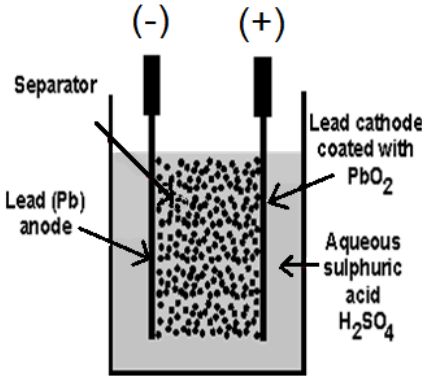

Fig 3: Lead acid battery

3.3 Solenoid switch

The system has used SW180 solenoid switch which is designed for direct current loads. The switch is made up of single pole single throw, double breaking main contacts with silver alloy tips, which are weld resistant, hard wearing and have excellent conductivity. The solenoid switch takes input from the battery

3.4 Energy Management System

The main function of the EMS is to monitor various vehicle parameters and to assist the driver in operating the vehicle, to ensure the electric motor operates with high efficiency [4]. According to driver's demand and state of vehicle, the EMS decides the energy to be delivered to various electrical components for achieving reference speed. The inputs to the EMS are:

- Speed of vehicle
- Motor RPM
- Motor temperature
- Battery Voltage
- Battery temperature
- Forward, reverse, neutral or boost state.

be sent to the motor. Motor controller in electric vehicles offers improved performance, efficiency and controllability [1].
The system has a motor controller which takes nominal battery voltage of 36/48V, armature current rating 350A and PWM operating frequency 16 kHz; it drives 3-phase induction motor. The motor controller consists of PWM generator and 3-phase PWM inverter. Fig. 4 shows 3-phase PWM inverter using IGBT.

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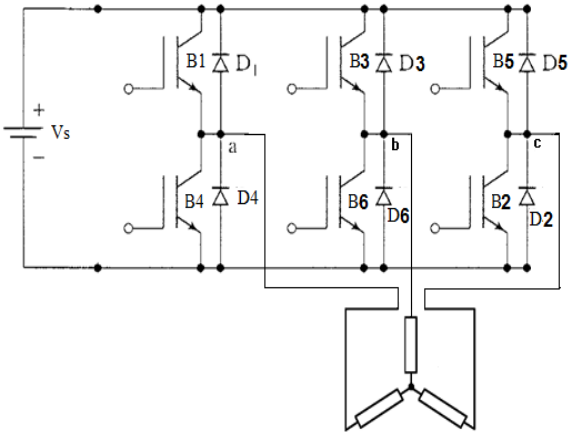

Fig 4: Three-phase PWM Inverter

4.2 Induction Motor

The three-phase PWM inverter takes DC voltage and converts it into AC voltage. This AC voltage is fed to three-phase induction motor. The basic working principle of induction motor is Faraday's Law of Electromagnetic Induction. The electric current is produced in rotor to produce torque due to magnetic field associated with stator. The direction of motion is given by Lenz's Law. Three phase induction motors offer high efficiency, good power factor, ruggedness, brushless, self-starting torque and hence are widely used in electric vehicles. The three-phase induction motor used operates on 125Hz, 28V AC and 13.1kW. Three phase induction motor provides efficiency more than 90% at peak load as well as at 10% load [1]. The speed of the motor is given by eqn (2);

$$N_s = \frac{120f}{P} \qquad (2)$$

Where N_s = Synchronous speed
f = Frequency
P = No. of poles of stator

The power flow diagram is shown in fig. 5. The output power is always reduced by some amount due to losses such as stator losses, rotor loss, friction, windage and stray losses.

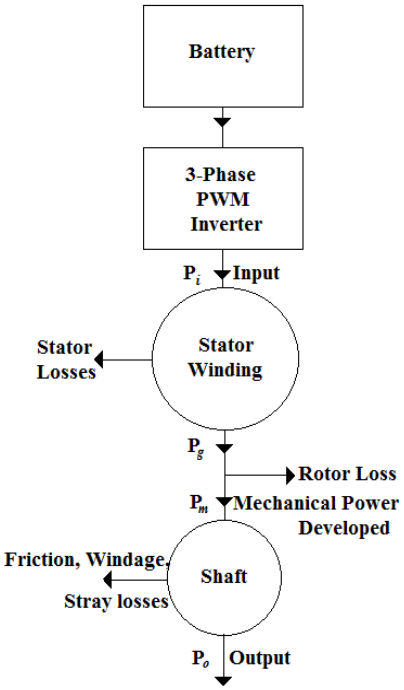

Fig 5: Power Flow Diagram

4.3 Differential and Wheels

The differential is a mechanical part which drives a pair of wheels and allows them to rotate at different speeds. The wheels in vehicles transform torque into tractive force from tires to road. This force is responsible for moving the vehicle.

4.4 Brakes

A brake is a mechanical device that forbids the motion of vehicle by means of friction. Brakes are applied to rotating wheels so as to slow down or stop the vehicle. Disc or drum brakes are used in vehicles. The braking method of an EV should be integrated with both mechanical and the electrical braking [2].

4.5 Ignition Switch

An ignition switch in the control system of the motor engine activates the main electrical systems including accessories like music system, power windows, navigation, etc. in the EV. Now these traditional mechanical keys have been replaced by keyless system, wherein the door lock which is located at or near driver's door is controlled by a keypad and activated by proximity. Recent cars have a smart key system also called as engine immobilizer in which a small chip is placed under the plastic key cover. When key is inserted into the ignition, the key sends its security code to the ignition. The ignition has its own security code. If it matches, the vehicle starts.

If the key codes do not match, the vehicle does not start when the key is turned on.

4.6 Accelerator Pedal

The accelerator pedal that consists of a pair of variable resistors sends signal to energy management system (EMS) which in turn gives signals to the motor controller how much power to take from the batteries. This regulates the vehicle's speed by changing the frequency of the AC power from the inverter to motor. When the accelerator pedal is pressed to ground fully, the EMS sends signal to the motor controller to take full power. When it is not pressed, the motor controller takes no power, and when in between it takes power accordingly. Fig.6 shows the accelerator pedal with variable resistor in EV.

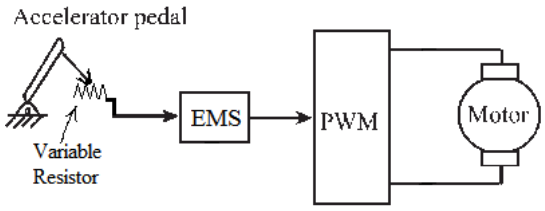

Fig 6: Accelerator pedal in EV

5. Other Accessories

5.1 Meter Display

Meter display gives information indication, combining indicating light, ampere meter, voltage meter, battery meter, speed meter and odometer into a single device panel. It is easy to read and battery meter shows the charge state of battery.

6. Conclusions

This paper discusses the overview of battery electric vehicle. It also gives the idea of general structure and component details used in the system. The system is designed using 3 phase PWM inverter and induction motor. Induction motor gives high efficiency, good power factor, ruggedness, brushless and self-starting torque. The batteries need to be replaced after every 3 years and therefore the maintenance cost of EVs increase. Advancements in the battery technologies can help reduce this cost. Since the refueling cost is very small as compared to conventional IC engine vehicles, switching to an electric vehicle can save a lot of money.

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