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Original Research Paper

Engineering

RECENT DEVELOPMENT ON ELECTRIC VEHICLES

Aniket Garge BE Mechanical Engineer, 3/8, Vidarbha housing society, Shastri nagar, Amravati-444602.

Sushant Rahangdale* BE Mechanical Engineer, Qtr no.106, Central Jail, Quarters, Wardha Road, Nagpur, 440020. *Corresponding Author

ABSTRACT This paper provide an overview of the recent work of electric vehicle in the region. The paper describes the development and the comparison of different part of components. The major components in battery technology, Charger design, motor, steering and braking are examined.

KEYWORDS : Electric vehicle, AFS, steering system, braking system, ABS, battery management systems, BMS, Inverter. Hybrid Electric Vehicle.

INTRODUCTION

Electrical vehicle (EV) based on electric propulsion system. No internal combustion engine is used. All the power is based on electric power as the energy source .The main advantage is the high efficiency in power conversion through its proposition system of electric motor. Recently there has been massive research and development work reported in both academic and industry. Commercial vehicle is also available. Many countries have provided incentive to users through lower tax or tax exemption, free parking and free charging facilities. On the other hand, the hybrid electric vehicle (HEV) is an alternative. It has been used extensive in the last few years. Nearly all the car manufacturers have at least one model in hybrid electric vehicle. The questions come to us: Which vehicle will dominate the market and which one is suitable for future? This paper is to examine the recent development of electric vehicle and suggest the future development in the area.

EV AND HEV

HEV has been promoted extensively in the last decade. Nearly each manufacturer has at least one HEV in the market [1]. It is supposed to rescue the battery energy storage problem at that time. Using hybrid vehicle it allows the electric power can be obtained from engine. The HEV is broadly divided into series hybrid and series hybrid. The engine power of the series hybrid is connected totally to the battery. All the motor power is derived from the battery. For the parallel hybrid, both the engine and motor contribute the propulsion power. The torque is the sum of both motor and engine. The motor is also used as a generator to absorb the power from engine through the transmission. Bothe series or hybrid can absorb power through regeneration during braking or deceleration. Nevertheless, HEV still has emission. The introduction of plug-in HEV that solves some of the problem [2]. It accepts the electric power to battery through plug in from the mains. Therefore when convenient, users may charge the battery using AC from the mains.

THE KEY COMPONENTS IN EV

The electric vehicle is rather simple in structure. The key components are the propulsion parts. Fig 1 shows the configuration

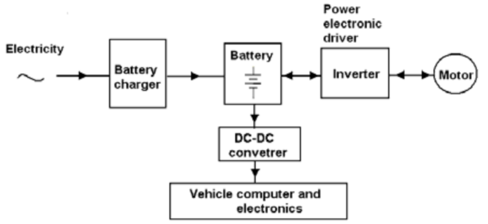

Fig 1: The key components of an Electric Vehicle.

The battery is the main energy storage. The battery charger is to convert the electricity from mains to charge the battery [3]. The battery voltage is DC and I is inverted into switched-mode signal through power electronic inverter to drive the motor. The other electronic components in a vehicle can be supplied to the battery through DC-DC converter that step down the voltage from the battery pack to lower voltage such as 5V-20V.

THE MOTOR

There are a number of motors available for electric vehicle: DC motors, Induction motor, DC brushless motor, permanent magnetic synchronous motor and Switched reluctance motor. Limit switch is one type of "Contact Sensor", In that there is Normally Open Contact & Normally Close Contact. Limit Switches is used mainly for Safety Purpose.

1. DC motors

It is a classical motor and has been used in motor control for a long time. All the power involved in electromechanical conversion is transferred to the rotor through stationary brushes which are in rubbing contact with the copper segments of the commutator. It requires certain maintenance and has a shorter life time. However, it is suitable for low power application. It has found applications in electric wheel-chair, transporter and micro-car. Today, most of the golf-carts are using DC motors. The power level is less than 4kW.

2. Induction motor

It is a very popular AC motors [4]. It also has a large market share in variable speed drive application such as air-conditioning, elevator or escalator. Many of the higher power electric vehicles, for more than 5kW, uses induction motor. Usually a vector drive is used to provide torque and speed control.

3. DC brushless motor

The conventional DC motor is poor mechanically because the low power winding, the field, is stationary while then main high power winding rotates. The DC brushless motor is "turned inside out [5]-[6]. The high power winding is put on the stationary side of the motor and the field excitation is on the rotor using a permanent magnet. The motor has longer life time than the DC motor but is a few times more expensive. Most of the DC motor can be replaced by the brushless motor with suitable driver.

Presently, its applications find in low power EV.

4. Permanent magnetic synchronous motor

The stator is similar to that of an induction motor. The rotor us mounted with permanent magnets. It is equivalent to an induction motor but the air-gap filed is produced by a permanent magnet. The driving voltage is sinewave generated by Pulse Width Modulation (PWM)

5. Switched reluctance motor

It is a variable reluctance machine and its famous recently because of the fault tolerance because each phase is decoupled from other. The power stage is different from other the motor discussed in 2-4. Each phase winding is connected in a fly back circuit style [7].

1. Batteries

The battery is the main energy storage in the electric vehicle. The battery in-fact governs the success of the electric vehicle [8]. Recently there are massive works being reported in battery development. The battery such as Li-ion is now being used by new generation of electric vehicle. The danger of the instability of the battery has been studied by many reported. It seems that the LiFePO4 type is preferable because of its chemically stable and inherently safe. Other Li-ion such as LiCoO2, LiMn2O4 and Li (Ni1/3Mn1/3Co1/3) O2 may has the thermal and overcharge concern [9]. For low cost solution, the lead-acid battery is still dominant part of the market. The battery has found applications in electric wheel chair, Golf-cart, micro-car and neighbourhood town air. The recent RoHS has also stopped the use of NiCad battery. All the research is looking towards the fast charging for batteries. MIT reported [10] the technology of a crystal structure that allows 100 times of charging speed than conventional Li-ion battery. Other alternative is to use ultra-capacitor.

2. Ultra-capacitor

Capacitor is basically a static component. There is no chemical reaction in the components. Its charging and discharging speeds are very fast. However, the energy storage is limited. Its energy storage density is less than 20% of the lead-acid battery. Although the expected ultra-capacitor density will go up in next few years, its total solution for main energy storage is a challenge. The number of cycles and the temperature range is excellent. Therefore ultra-capacitor is useful for fast speed or transient energy storage. As it allows high current charging, it's charging time can be shortened to within a few minutes. The ultra-capacitor is still in the initial stage of development. It is expected that the cost will be going down and the energy density will go up rapidly in next few years.

CHARGING SYSTEMS

1. General charger

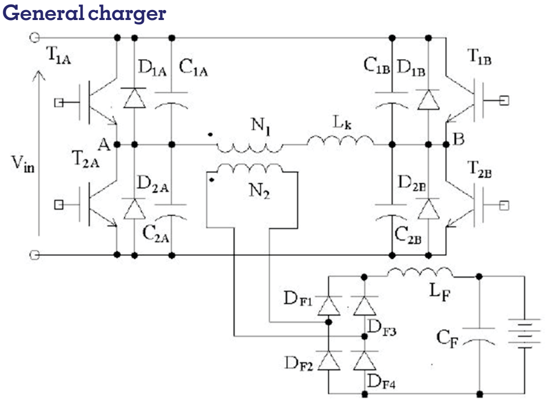

Fig 2: The H-bridge converter for charger

The charger needed for the battery system for slow charging or fast charger are both required to handle high power. The H-bridge power converter is needed [11]. Fig 2 shows the converter. The converter is famous for its efficiency and has found application in charger and DC-DC converter.

2. Ultra-capacitor charger

The voltage on the ultra-capacitor various from the full-voltage to zero when nits energy storage varies from full to zero. This is different from the battery as its voltage will only varies within 25%. The capacitor voltage is internal point and is not in contact with users. The transformer isolated converter is not necessary. A tapped converter should be used as it will have higher efficiency for power conversion [12]. The efficiency of the power converter is higher than the transformer-isolated version. The structure is simple.

CHARGING NETWORK

1. Charging network

The charging method of EV is controversial because of the uncertainty of the power needed, location and the charging time. The charging time of batteries has been reported to be shorter in the recent development. The lead-acid batteries are restricted by its technology. The charging rate is less than 0.2C and quicker charging rate seriously shortens its life time. Other battery such as Li-ion has recommended charging rate of 0.5C.

Usually most of the electric vehicles have an on-board battery charger. A power cable is connected from the vehicle to a charging point. A charging station should provide a number of power points and a suitable transaction program to calculate the tariff.

The power needed for the charging station is not a concern.

Usually for private car, a standard charging power is less than 2.8kW. Single-phase power line is used. In average a vehicle is needed to be charged every 3 days. Using Hong Kong as an example, it will only affect the power consumption of less than 2% even all the private cars are charged to EV.

2. Fast charging station

For fast charging, a high current is needed, therefore three-phase power is usually used. The charging station should consider the method to connect the 3-phase socket to users as not all the civilian can handle the use of 3-phase socket system. The following has been discussed:

a. Magnetic contactless charging: There is no metal contact, all the power transfer is through magnetic induction. This reduce the concern when a civilian to handle high power cable and he/she does not need to contact the conductors.

b. High voltage power transfer: The heavy and large

3-phase socket and cable can be reduced in size by high voltage connection. The power source is stepped up to high voltage of several kV, and the cable is reduced. There is another step-down converter in the vehicle that reduced the high voltage to suitable lower voltage to charger the battery.

The design of the EV should be made for such changes. The vehicle battery charging in the station can also be used for energy storage to ease peak demand through valley supply compensation.

BRAKING AND STEERING

1. Braking and power regeneration

The braking of a vehicle in the past based on mechanical system such as disc brake. The braking method of an EV should be integrated with both mechanical and the electrical braking. In the initial region of the braking pedal, it electrical power regeneration braking should be applied. This is usually for deceleration or going down a slope, the kinetic energy of the vehicle can be returned to the battery. The final region of the braking, mechanical braking is used. This provides a compromise of the energy saving and safety.

Today, we can make motors with high power of regeneration that is in the expenses of the motor size, a compromise between the motor weight, cost, power regeneration efficiency and safety are needed. To increase the region of the power regeneration, the motor should be made with acceptance of the high power design plugging mode which is to provide high reverse torque to stop the vehicle. The motor drive should also be implemented with high frequency decoupling capacitor to absorb the fast transient of the reverse current.

2. Anti-lock braking (ABS)

Conventional ABS is installed in most of the vehicle to prevent skidding and to obtain a stable braking performance.

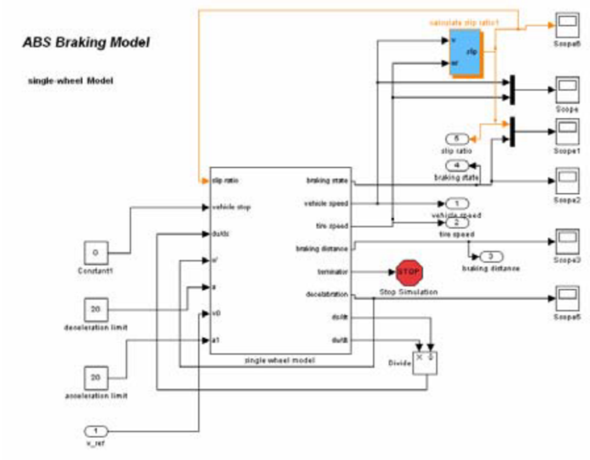

Fig 3: ABS braking system model

The ABS optimization consists to maximize the tire forces whatever the conditions of the road. Therefore, it must to localize the wheel slip ratio which corresponds to the peak tire road adhesion characteristic. The location and the value of these peak values varies in large range depending on the road, tire and many other different factors, For any rolling conditions, the optimal wheel slip rate, which will be used as control reference to optimize the braking force.

3. Skid Steering

Steering is achieved by differentially varying the speeds of the lines of wheels on different sides of the vehicle in order to induce yaw. To satisfy the requirement of the turn radius, the longitudinal slip must be controlled, so a method of slip limitation feedback is used in the simulation. When the vehicle is turning on a slippery surface, because of the drop at the coefficient of road adhesion, the drive wheels may slip. The traction control system reduces the engine torque and brings the slipping wheels into the desirable skid range.

SUSPENSION

The developed direct-drive linear motor actuator for the automobile active suspension systems can generate control forces to absorb road shocks rapidly, suppress the roll and pitch motions, and ameliorate both safety and comfort, while maintaining the vehicle at a horizontal level. For conventional passive suspension systems, it is difficult to be achieved, since a soft spring allows for too much movement and a hard spring causes passenger discomfort due to road irregularities. Thus, significant improvement of suspension performance is achieved by the direct-drive linear switched reluctance actuator. Comparing with hydraulic active suspension systems, the developed active suspension system based on the direct-drive linear switched reluctance actuator is simpler since it needs fewer devices and mechanical parts. Due to no hydraulic devices, this is an oil-free system. Furthermore, it can include the energy generation from the suspension. The development includes the design of direct-drive linear switched reluctance actuator, its characterization, and the design of the automobile active suspension system. The converter drive is also needed to develop to match with the linear switched reluctance actuator. The drive is expected to fit the driving pattern of the suspension system and to provide suitable force control, energy generation control and position control.

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