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Recent Development on Electric Vehicles

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Abstract – Here, we'll take a look at what's been happening recently in the world of electric vehicles. In this study, several components and their subcomponents are discussed and compared. Various aspects of battery and charger design, as well as the engine, steering, and braking, are discussed in detail. The paper concludes with a demonstration of an electric car prototype. Key words: electric car, AFS, steering system, ABS, braking system, BMS, inverter, battery management systems.

I. INTRODUCTION

Based on an electric propulsion system, an electric vehicle (EV). There is no internal combustion engine in operation here. Electricity is the primary source of power in the world today. The key benefit is the great efficiency of power conversion provided by the electric motor proposition system. Massive development effort has recently been reported in academia and business. There is also a commercial vehicle option. Many nations have lowered or exempted taxes, offered free parking, and supplied free charging facilities in order to encourage the usage of their services.

The hybrid electric vehicle (HEV) is an alternative, on the other hand. During the previous five years, it has seen a lot of usage. Almost every automaker offers at least one hybrid electric vehicle variant. So, we're left wondering: Which vehicle will be the most popular, and which one is most suited for the long term? It is the purpose of this article to review current developments in electric vehicle technology and provide recommendations for the field's future growth.

II. EV AND HEV

In the recent decade, HEVs have been widely publicised. One or more HEVs are available from almost every major automaker. At the time, it is meant to solve the battery energy storage issue. The electric power may be obtained from the engine by using a hybrid vehicle. There are two main types of hybrid electric vehicles (HEVs): series hybrids and series hybrids. The series hybrid's engine and batteries are completely intertwined. The battery powers the whole motor. The engine and the motor work together to propel the vehicle in a parallel hybrid. Both the motor and the engine contribute to the total torque. Aside from being a generator, the motor is also utilised to absorb the power from the engine. During braking or deceleration, either a series or a hybrid may regenerate power.

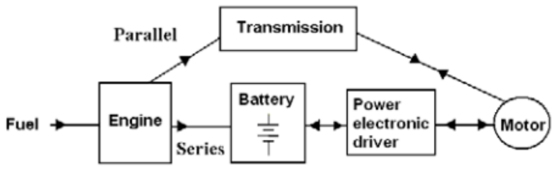

Figure 1. The series or parallel path of an HEV

However, HEVs still produce emissions. The advent of plug-in hybrid electric vehicles (HEVs) has helped alleviate some of these issues [2]. The battery is charged by plugging it into the mains. In other words, customers may use AC mains power to recharge the battery whenever they choose.

III. THE KEY COMPONENTS IN EV

The electric vehicle is rather simple in structure. The key components are the propulsion parts. Fig 2 shows the configuration.

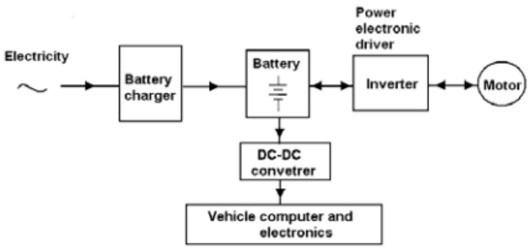

Figure 2. The key components of an Electric Vehicle

The battery serves as the primary source of power. Batteries may be charged by using a battery charger, which converts power from the mains. To power the motor, a power electronic inverter inverts the DC voltage of the battery to a switched-mode signal. Using a DC-DC converter, the battery pack's higher voltage may be stepped down to a lower voltage, such as 5V-20V, to power the vehicle's other electrical components.

IV. THE MOTOR

There are a variety of electric car motors on the market, including the following: Switched reluctance and permanent magnet synchronous are two types of DC motors, while induction and DC brushless are others.

1. DC motors:

It is a well-known motor and has been used for decades in motor control. The copper segments of the commutator are used to deliver all of the electromechanical conversion power to the rotor using fixed brushes. It has a limited lifespan and needs regular maintenance. However, it's best suited for low-power use. It has been used in electric wheelchairs, transporters, and micro-cars, among other uses. DC motors are now found in the majority of golf carts. The output power is below 4 kW.

2. Induction motor

It's a common kind of AC motor. Variable speed drive applications such as air conditioning, elevators, and escalators also use it extensively. When it comes to electric cars with more than 5 kW of power, induction motors are often used. Typically, a vector drive is used to manage torque and speed.

3. DC brushless motor

When a DC motor is used, the low power winding, or "field," remains motionless while the primary high power winding spins. Inside out [5]-[6]" the DC brushless motor. The high-power winding is located on the motor's stationary side, while a permanent magnet is used to excite the field on the rotor. Despite the fact that the motor is more costly, it has a longer lifespan than the DC motor. You may use brushless motors instead of DC ones in most cases, provided you have the right driver. Low-power electric vehicles (LEVs) now use it.

4. Permanent magnetic synchronous motor

The stator is comparable to that of an induction motor. Mounted on the rotor were permanent magnets. A permanent magnet creates the air-gap field, which is the same as in an induction motor. Pulse Width Modulation generates a sinewave driving voltage (PWM).

5. Switched reluctance motor

Because each phase is separated from the other, the machine has become popular lately because of its fault tolerance. There are some differences between this motor and the others we've already studied. In a fly-back circuit style, each phase winding is linked to each other.

V. DIRECT DRIVE AND IN-WHEEL MOTOR

The drive train's mechanical components lose less power while using direct drive. The transmission, clutch, and gear box are not required since the motor is directly attached to the shaft. Recently, researchers have been promoting the use of in-wheel motors. The rotor is turned inside out by the in-wheel motor, which is linked to both the rim and the tyre of the wheel. There are no gears or driving shafts in this model. See Fig. 3 for an illustration of the inside-wheel motor.

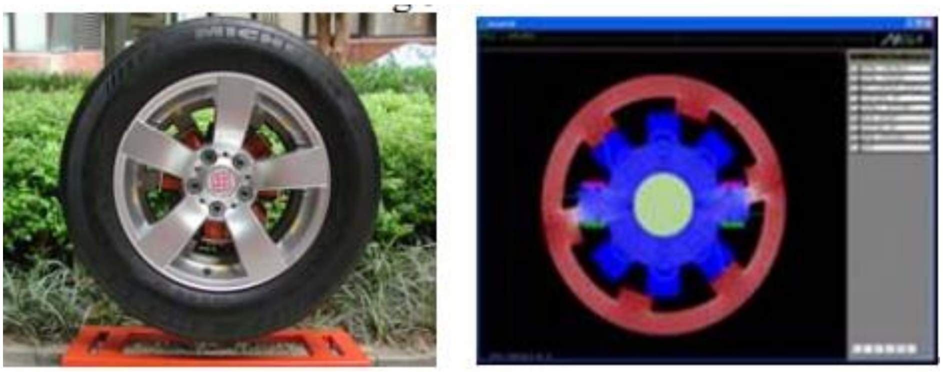

Figure 3. The in-wheel motor a) Hardware b) FEM model

Wheel-hub motor is another name for the motor. Its key benefit is that each wheel may be independently controlled. The four-wheel drive vehicle is shown in Figure 4. The wheels may move in any direction and at any speed. As a result, it is simple to produce parallel barking. Using today's technology, the anti-lock braking system can be simply deployed Preventing spinout has been shown to work. The car as a whole is a lot easier to put together. In-wheel motors may be powered by a variety of motors. Switched-reluctance kinds are the most common. Unlike the other, its phase-winding is completely independent of each other, making it much more tolerant of failures. Because the motor does not have a persistent magnetic field, there is less interference and fluctuation from permanent magnetic materials.

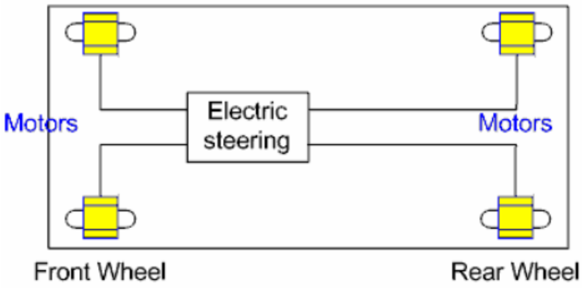

Figure 4. True 4-wheel drive vehicle

VI. ENERGY STORAGE

1. Batteries

The electric vehicle's battery is the primary source of energy storage. The electric vehicle's success is largely determined on its battery [9]. Massive battery development projects have recently come to light. Currently, a new generation of electric vehicles is powered by lithium-ion batteries. Many studies have looked at the dangers of battery instability. Because of its chemical stability and intrinsic safety, it seems that the LiFePO4 type is the best option. Some other Li-ion, such as LiCoO2, may have overheating and overcharging concerns [10]. [10, 11]. There is still a strong presence of lead-acid batteries in the market for low-cost solutions. There are several uses for the battery, such as a golf cart and a micro-car. The usage of NiCd batteries has also been banned by the latest RoHS regulations.

Fast battery charging is the focus of all current studies. MIT has announced [11] the development of a crystal structure that can charge a lithium-ion battery 100 times faster than a standard Li-ion battery. The usage of ultra-capacitors is another option.

2. Ultra-capacitor

A capacitor, on the other hand, is a purely static device. Components do not react chemically. It has lightning-fast charging and discharging rates. However, there is a limit to the amount of energy that can be stored. It has a lower energy density than a lead-acid battery by less than 20%. No matter how much denser future ultra-capacitors get, a complete solution for primary energy storage remains a difficulty. The temperature range and number of cycles are outstanding. There are several comparisons in Table 1.

Table 1: Comparison of different energy storage unit

	Lead-acid	NiMH	Li-ion	Ultra-capacitor
Energy density Whr/kg	40	70	110	5
Cycle life	500	8,00	1,000	500,000
Working temperature(°C)	-30 ~ +50	-40 ~+50	-40 ~ +60	-40 ~ +85
Cost $/kWhr	1,000	2,400	5,000	50,000

As a result, the ultra-capacitor is an excellent tool for applications requiring rapid response times or the temporary storage of large amounts of energy. It’s charging time may be shaved down to just a few minutes thanks to the high current it supports. The development of the ultra-capacitor is still in its infancy. In the next several years, it is projected that the cost will fall and the energy density will increase substantially.

VII. CHARGING SYSTEMS

1. General charger

Both a slow charger and a rapid charger are needed for the battery system to manage high power. A power converter, such as the H-bridge, is required. The converter is shown in Fig. 5. The converter is often used in chargers and DC-DC converters because of its efficiency.

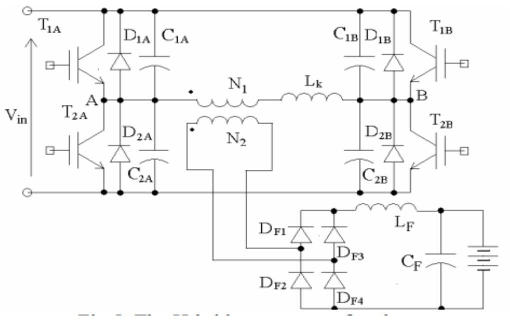

Figure 5. The H-bridge converter for charger

2. Ultra-capacitor charger

When the ultra-energy capacitor's storage goes from full to zero, the voltage on the ultra-capacitor varies from full to zero. The battery, on the other hand, barely fluctuates by around 25 percent. Users are not exposed to the capacitor voltage, which is located within the device. It is not essential to use a transformer isolated converter. [13] The use of tapped converters is recommended since they are more efficient at power conversion. The power converter has a better efficiency than the transformer-isolated variant. The design is straightforward.

3. Battery management systems

BMS is another name for it. Several battery ells make up the battery system. They may be linked in either series or parallel, depending on the layout. Each cell should be managed and monitored. Voltage, current, and temperature are all monitored as part of the conditioning monitoring. System control and protection are aided by the usage of parameters gathered from the system. In most cases, you'll have two options. the status of charge (SoC) and health (SOH) (SoH). In a similar way to an oil tank metre, the SoC delivers information on the battery's charging status. Voltage and current information are used to calculate it. The purpose of the SoH is to keep track of a person's health or ageing status. One of the most common definitions is:

$$\text{SoH} = \frac{\text{Nominal Capacity} - \text{Loss of Capacity}}{\text{Nominal Capacity}} \quad (1)$$

The purpose of cell balancing is to make certain that each cell is working under the same conditions, or to employ a regulation to charge or discharge each cell. This prevents the overflow of a specific cell.

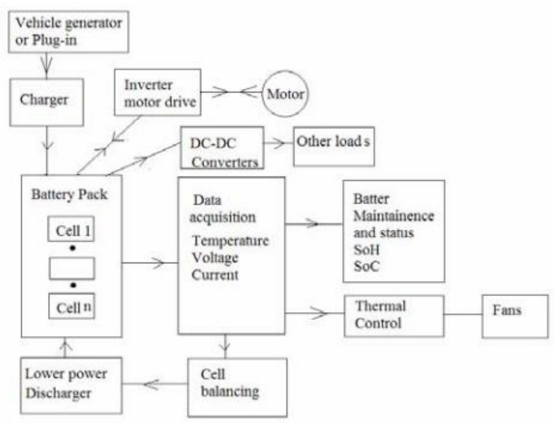

Figure 6. Schematic of the BMS

4. Energy management systems

Ultra-capacitor systems also rely on several capacitors or other energy storage devices like batteries to store energy. The same technology for monitoring and controlling the conditioning will be used again.

VIII. CHARGING NETWORK

1. Charging network

Because of the unpredictability of power requirements, location, and charging time, EV charging is a contentious topic. In a recent development, it has been stated that battery charging times have been shortened. The limitations of lead-acid batteries are due to their age-old design. This charger has a charging rate of less than 0.2C, which significantly reduces its lifespan. The suggested charging rate for other batteries, such as Li-ion, is 0.5C. In most cases, electric cars are equipped with a charger for their batteries. The car is plugged into a charging station through a power connection. Power outlets and an appropriate transaction software are necessary for a charging station to determine the fee. The charging station's power requirements are not a worry. In most cases, the usual charging power for a private automobile is less than 2.8kW. The power supply is a single-phase one. Every three days, an average car requires a charge. Even if all private vehicles in Hong Kong were charged to EV, it would only have a negligible impact on the city's power usage.

2. Fast charging station

Three-phase electricity is often utilised for quick charging because of the high current required. When designing a charging station, keep in mind that not all people are capable of using a 3-phase socket system. Discussed below are the following topics:

a. Magnetic contactless charging:

All power is transferred by magnetic induction, with no metal contact. Because the cable does not have to be in touch with the conductors, civilians using high-power cables have less need to be concerned.

b. High voltage power transfer:

High voltage connections may lower the weight and size of the 3-phase socket and cable. It is necessary to increase the voltage of the power source to several kV while simultaneously reducing the length of the cable. The high voltage is lowered to a lower level appropriate for charging the battery by another step-down converter in the car.

c. Battery rental:

As early as the first day of EV's advertising, this was mentioned. Users do not own any of the batteries; instead, they are renting them. To recharge their batteries, users visit the charging station. You may do the task in a matter of minutes. Such modifications should be included in the EV's design. Peak demand may be alleviated by valley supply adjustment by using the car battery charging station as an energy storage facility.

IX. BRAKING AND STEERING

1. Braking and power regeneration

Mechanical systems such as disc brakes were used for vehicle braking in the past. Electrical and mechanical brakes should be incorporated into an electric vehicle's braking system. Electrical power regeneration braking should be used in the first portion of the brake pedal. The vehicle's kinetic energy may be returned to the battery while slowing down or driving down a hill. Mechanical braking is employed in the last stages of braking. Energy conservation and safety are also taken into consideration.

In today's world, when we can manufacture motors with high regeneration power at the expense of their size, a trade-off is required between the weight, cost, efficiency, and safety of the motor. The motor should be built with acceptance of the high power design plugging mode, which provides strong reverse torque to stop the vehicle, to maximise the power regeneration area. High frequency decoupling capacitors should be used in conjunction with the motor drive in order to accommodate the quick transients of the reverse current.

2. Anti-lock braking (ABS)

Throughout order to minimise skidding and maintain a consistent braking performance, conventional ABS is fitted in the majority of the vehicle's body. The braking characteristics are influenced by the wheel slip and the road condition [14]. Continuous slip changing and discrete valve action, PID and finite state machine theories are used in the anti-lock braking system to provide discrete hydraulic pressure.

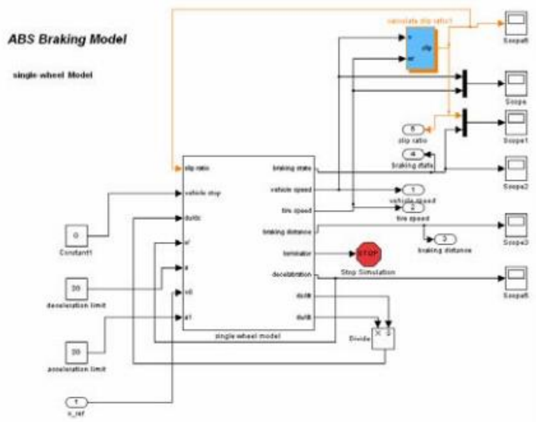

Figure 7. ABS braking system model

The goal of the ABS optimization is to maximise tyre forces regardless of the driving conditions. It is thus necessary to pinpoint the wheel slip ratio that is most closely associated with the highest possible level of tyre road adhesion. While these peak values vary greatly based on the road surface as well as the tyres used, the best wheel slip rate, which will be utilised as a control reference to optimise the braking force for all rolling situations. As seen in Figure 7, ABS is a system based on electrical motor drive technology.

3. Skid Steering

Yaw is done by altering wheel speeds on various sides to produce a yaw angle in the vehicle's direction of travel. As a means of ensuring that the turn radius is reached, a form of feedback on slip limiting is used in the simulation. Because to a decrease in the coefficient of road adhesion, the vehicle's drive wheels may slide while turning on a slick surface. The engine torque is reduced by the traction control system, which allows the sliding wheels to move into the desired skid range. Skid steering location for various turn radii is shown in Figure 8.

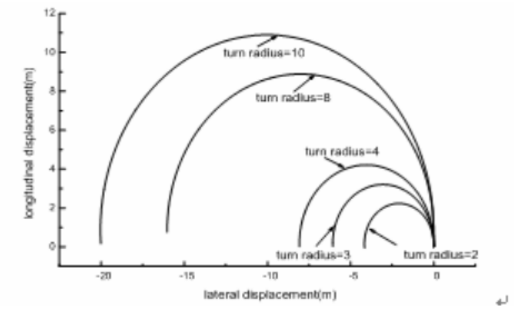

Figure 8. Locus of different turn radius achieved by skid steering

X. SUSPENSION

With a direct-drive linear motor actuator created for the active suspension systems of automobiles, the vehicle may be kept at a horizontal level while absorbing road shocks, suppressing roll and pitch movements, and improving both safety and comfort. Because a soft spring allows for too much movement, it is impossible to accomplish with traditional passive suspension systems, while a firm spring causes discomfort to passengers when driving on bumpy roads. In this way, the direct-drive linear switching reluctance actuator significantly improves suspension performance. Comparatively speaking, the direct-drive linear switching reluctance actuator-based active suspension system that was created requires fewer devices and mechanical components than hydraulic active suspension systems. This is an oil-free system since there are no hydraulics involved in its operation. In addition, the energy generated by the suspension might be included. There will be work on the actuator design, characterising it, and creating an active suspension system for a car as part of this project. The linear switching reluctance actuator requires a converter drive to be developed. We anticipate the drive's force, energy, and position controls to match those provided by the suspension system. A working prototype of an active suspension system is shown in Fig.9.

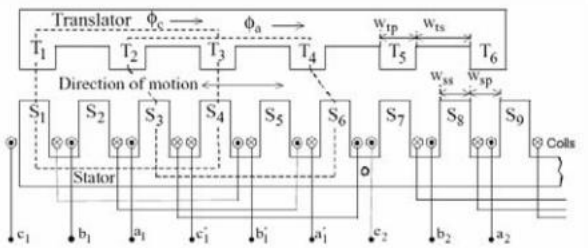

Figure 9. Active suspension based on linear motor

XI. OTHER ACCESSORIES

One of the most important aspects of a vehicle's interior and exterior illumination, especially at night, is the adaptive front-lighting system (AFS). When the vehicle's tilt state changes dynamically or in a stationary mode, the headlamp levelling subsystems are activated, which work to maintain light parallel to the road surface; the swivelling subsystem, which works to match the light distribution with the vehicle's turning angle in order to produce an optimal illumination effect for the driver, is also activated. The final system is a dimming system, which fades or dims lights when the ambient light and lane environment changes. Figure 10 depicts a front-light LED prototype.

Figure 10. AN LED front-lighting unit

XII. ELECTRIC VEHICL SHOW CASES

There have been a number of local and international firms and institutes working on electric vehicles recently. The development of electronic components and accessories for propulsion, safety, and control has been documented. The development of electric vehicles has lately been highlighted by a local institution. Figure 9 depicts a private vehicle, a security vehicle, a micro-vehicle, and a bicycle.

Figure 11. Electric vehicles developed

XIII. CONCLUSION

This article focuses on the latest advancements in electric car technology. Energy storage is first discussed in this paper's introduction. As a result, it expands to the parts of future vehicles. To provide an overview of the region's current EV efforts, this document presents a summary.

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