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POWER CONVERTERS IN ELECTRIC VEHICLES

Gandi Likhitha, M Rambabu*, Dhoda Venkatesh *,Arumalla Anil kumar **

* Department of Electrical and Electronics Engineering, GMR Institute of Technology, Vizianagaram District, A.P, India

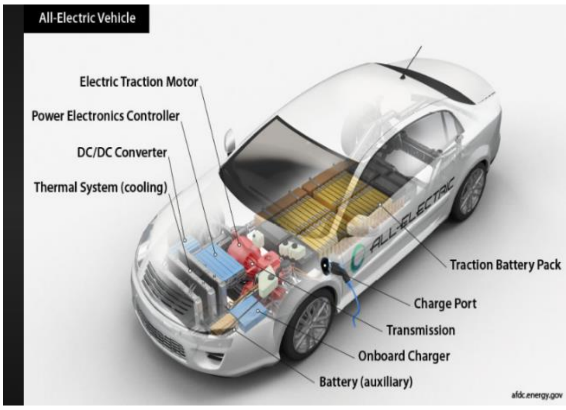
ABSTRACT:

Electric motors are gradually replacing Internal Combustion Engines (ICE), resulting in higher efficiency and lower greenhouse gas emissions. The electrical energy generated by batteries and ultracapacitors is used entirely or partially by the electric vehicle. In a hybrid electric vehicle, the hyper or battery is charged by ICE, whereas in a converter electric vehicle, the hyper or battery is charged by an AC power connected to the grid line. A hybrid vehicle known as a plug-in engine with just an electric engine (PHEV) uses a charger to generate electricity its electric engine and gets recharge from the grid. Using this hybrid technology, PHEVs can significantly outperform conventional vehicles in terms of fuel efficiency and pollution output.

INTRODUCTION:

Because of excessive use in the traditional vehicular system, fossil fuel is gradually depleting. Similarly, as transportation infrastructure improves, demand for fossil fuels rises gradually. The typical ICE is only about 20% efficient. The remaining energy after combustion is lost as heat as well as Gas Emissions (GHG) as a byproduct. Both the general public and the automotive industry now demand hybrid technology. Diesel engines can significantly increase fuel efficiency while emitting far fewer emissions than conventional vehicles . This type of hybrid car connects to the grid thanks to a large battery and motor (120Vrms). PECs and variable speed drives have become increasingly important in new advances in automotive technology. PECs and dc motor drives in EVs regulate the electrical energy flowing to and from the vehicle, as well as from the external fast charger or grid. As a result, EVs become cleaner, more efficient, and more powerful, and their durability improves.

1.General classification of Electric Vehicles:



Power windows, powerful headlights, and auto update are a few examples of modern automotive extras that require more power and different voltage ratings to function. Trying to design the power transmission system is more challenging than simply connecting the battery to the grid. The battery must be built to specific specifications in order to be protected from damage. The battery may blow up or catch fire if none of these requirements are met.

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Even if a suitable system is used, the battery will remain enclosed to protect anyone working on it or the framework self. In the case of PHEVs, the large charger pack must be charged from an AC outlet via a Power Factor Adjustment (PFC) controller.

2. Electrical vehicle types and the function of power electronics converters:

Electric vehicles (EVs) require electricity to power their electrical appliances as well as to propel the vehicle forward .A hybrid electric vehicle (HEV) is one that uses a number of energy sources, a storage device, and a converter to drive the vehicle, provided at least one of those sources is supplying electrical energy, according to the International Electro-Technical Commission's Technical Committee (IETCTC).

2.1. Battery-powered automobile

2.1.1. Battery electric vehicle architecture

A BEV's drive train is powered by the battery. The storage unit for rechargeable batteries in a BEV also serves as a fuel tank. After fully charging, the BEV typically travels between 100 and 250 kilometres. A BEV does not have an internal combustion engine (ICE) because it is propelled by an electric engine. BEVs are seen in two operating modes. In the battery-operated mode, an inverter and a DC-DC converter transfer the energy from the battery to the vehicle. In energy recovery mode, the rectifier and DCDC converter transfer the traction motor's power to the battery as shown in Fig 2(a).

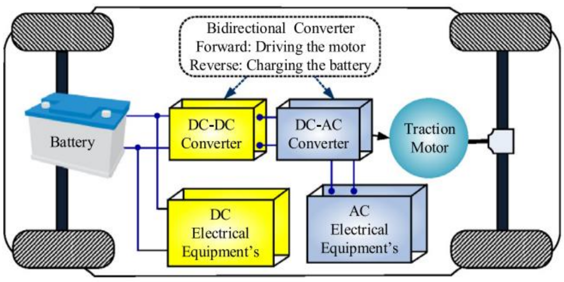
2.1.2. PEC's function in battery-powered vehicles

In BEVs, the single direction phasing DC-DC transformer is used to continue increasing voltage in response to the propulsion system's requirements and the electrical load.The step-up converter converts the battery's direct current voltage to a high voltage direct current bus. Projector lamps and other rated equipment are powered by the DC high-voltage bus. The battery's DC power supply is used as fuel to power the vehicle and other electronic devices as shown in Fig 2(b).

2.2. Vehicle powered by fuel cells

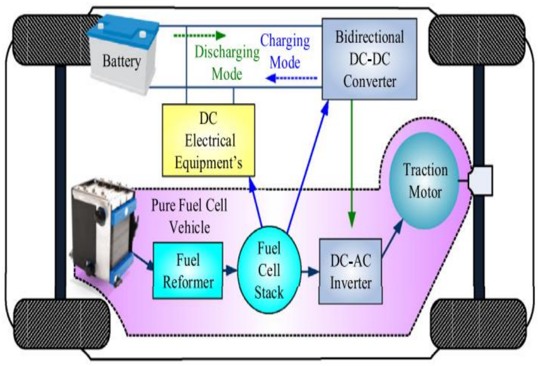
2.2.1. Design of a fuel cell electric vehicle

In an FCEV, stored hydrogen and airborne oxygen combine to produce energy that powers the electric motor. A fuel tank's hydrocarbon gas is transformed by the fuel reformer into true hydrogen gas, then it is kept in the fuel-cell stack for storage. When electricity is required, oxygen from the air and liquid fuels for fuel layers of cells are combined to produce electricity. Any extra electricity is stored in battery packs or ultra-capacitors.



(a)

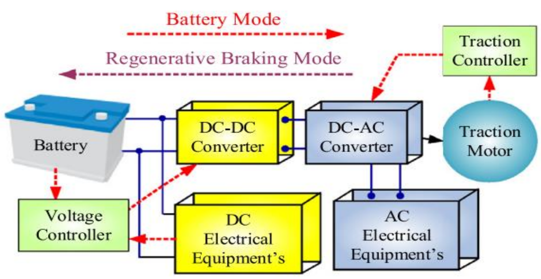
Fig.2.Typical structure of BEV



(a)

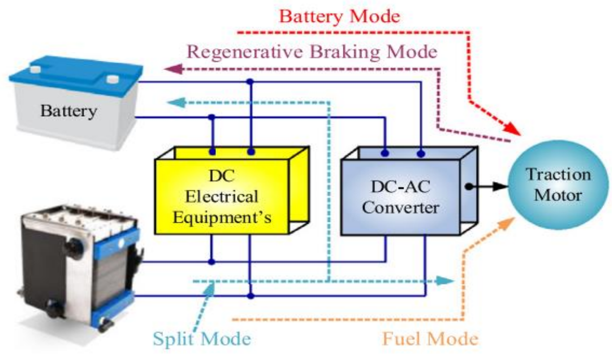
Fig.3. Typical structure of FCEV

Molten carbonate fuel organisms, fuel cells, renewable fuel cells, reformed ethanolic hydrogen fuel, polymer electrolyte fuel cells, and polymer automated membrane (PEM) fuel cells are all on the market. In fuel mode, the same fuel cell provides the energy required to power each individual train vehicle. When train is in battery mode, the battery serves as a power source to keep it running. A "combined mode" is one in which both the battery and the energy supply are present. The fuel cell powers the vehicle in split mode while using any excess energy to recharge the battery. In a renewable mode, as shown in Fig.3, the traction engine serves as a power source to recharge the battery as shown in Fig.3(b).



(b)

Fig.2. BEV operating modes and control scheme



(b)

Fig.3.Operating modes of FCEV

2.2.2. PEC's function in fuel-cell electric vehicles

The primary goal of FCEVs is to convert electrical power from fuel cells into usable power for a variety of loads on the vehicle in order to increase efficiency and performance. Batteries and fuel cells supply direct power to DC low voltage equipment such as mobile chargers and car starters. By changing the frequency and magnitude of the inverter output, the suction controller is altered to keep the car travelling at the desired speed.A bi-directional Power supply converter is required in the FCEV electrical grid to manage the power flow from the fuel cell to the traction motor when the vehicle is in motor configuration and from the motor to the battery when the vehicle is in hybrid FCEV configuration. Voltage and traction controllers are used to manage the flow of energy in the input and output DC-DC power converters.

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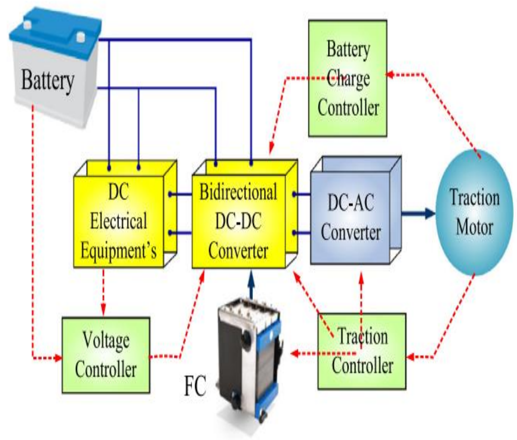


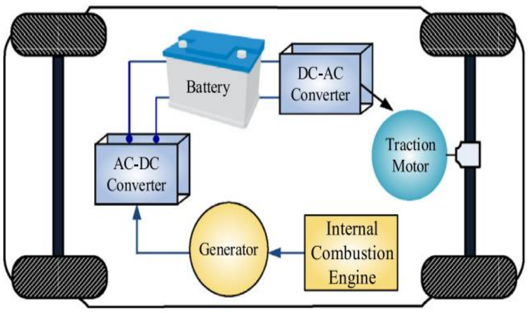
Fig. 4. FCEV's control scheme

2.3. Electric hybrid vehicles (HEVS)

The ICE provides the necessary propulsion to move the vehicle convoy. The battery is charged through a regenerative mechanism, which improves the vehicle's economy and efficiency by storing braking energy. Series hybrid electric vehicles (SHEV) and parallel electric hybrids are the two main types of hybrid and electric vehicles (PHEV). A third hybrid car (SPHEV), which combines the advantages of SHEV and PHEV, was introduced to increase power, effectiveness, and fuel efficiency.

2.3.1. Electric vehicle series hybrid

The mechanical work from ICE is converted into electrical energy in SHEV via a generator. An AC-DC rectifier is used to convert the produced AC power into DC power that can be used to charge the battery. To run the train, SHEV requires three propulsion systems. The traction motor converts electrical energy into mechanical energy for propulsion, while the ICE generates mechanical energy, the generator converts mechanical energy into electric, and the generator converts electrical energy into mechanical energy. As a result, SHEV is less efficient. The ICE drives and charges the generator and charger at the fastest possible speed. When the Condition of Charge (SOC) is as low as possible, the ICE begins charging the battery. Because the train is powered by a battery, it consumes less fuel and emits less carbon dioxide. When the need for frequent starting but also stopping of something, such as a vehicle, arises, as in city rides, the SHEV is a viable option. SHEV has three operating modes. According to the battery's SOC, the battery is first charged using ICE in the fuel mode. In battery mode, the battery provides propelling power. The traction motor also serves as a source when the vehicle is braking in a process known as regenerative braking mode as shown in Fig.5(b).



(a)

Fig.5. Typical structure of SHEV

2.3.2. Electric parallel hybrid vehicle

Figure depicts how the ICE and battery can each power the train independently, as shown in Fig.6(a). Two clutches connect the electrical motor and the ICE to the driving shaft. The vehicle can be propelled thanks to a direct connection between the ICE and the mechanical shaft of the drive train. In comparison to SHEV, the

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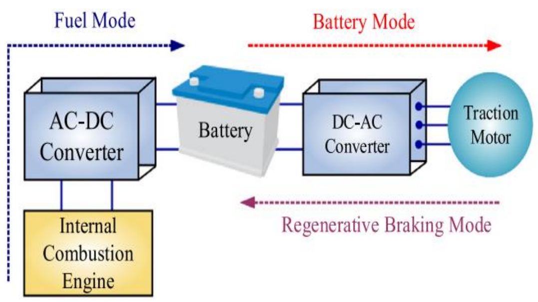
efficiency of PHEV is higher due to the absence of intermediate converter phases between the ICE and the drive train. A PHEV is a good choice for long-distance travel because it does not require an intermediate conversion state like a SHEV. As a result, the car consumes little energy. As shown in Fig. 6(b), there are three ways to use the ICE but also the battery in a PHEV (b). For lower speeds, the battery is used in motor mode to power this same train, which is a viable solution. The ICE performs best in fuel mode to propel the train at top speed. The three phase inverter's job is to keep the traction motor's torque and velocity constant by converting the constant output voltage into and out of variable AC frequency and voltage.

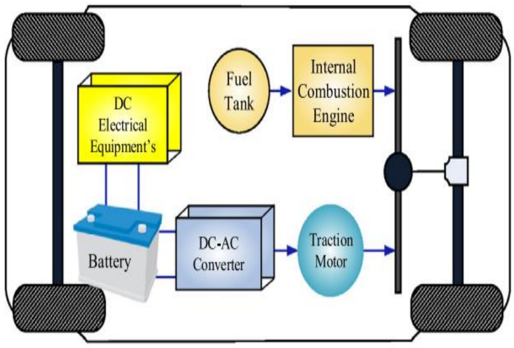


(b)

Fig.5.Different operating mode of SHEV

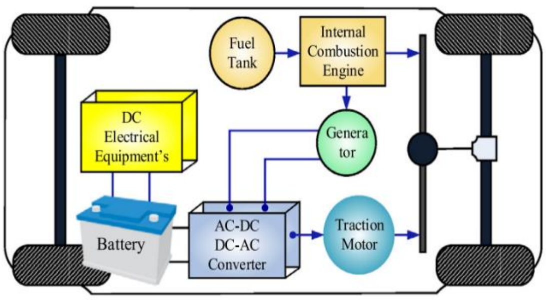
2.3.3. Series-Parallel hybrid electric vehicle

The Series-Parallel Hybrid Rechargeable Vehicle (SPHEV) design combines SHEV and PHEV features. The architecture clearly shows that SPHEV is more expensive and complex than the other two HEVs. When the car is in fuel mode, the ICE works to power it. In battery mode, however, the battery provides propulsion power. During split mode, the traction motor receives power from the ICE, while the battery is charged with the extra power. The traction motor is powered in combine mode by both the ICE and the battery. While the vehicle is slowing down and braking, the traction motor acts as a power source, feeding energy to a battery in energy recovery mode. The most common method for utilising the charger and ICE in SPHEVs is to use the battery to start the vehicle and provide low-speed propulsion before the ICE works by itself to provide high-speed propulsion.



(a)

Fig.6.Typical structure of PHEV



(a)

Fig.7. Typical structure of SPHEV

2.3.4. PEC's function in hybrid electric vehicles

As previously stated, HEVs run on kinetic motion from the ICE, electric energy

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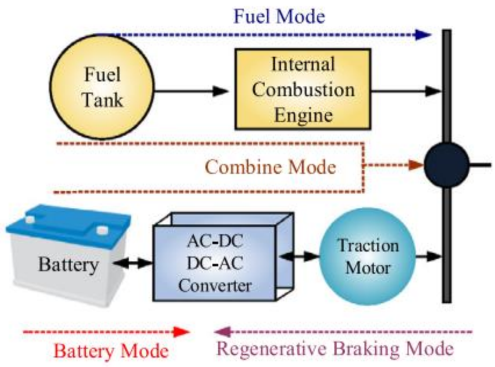
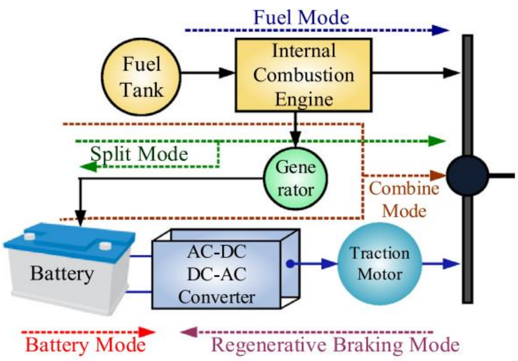
generated by the battery, or a combination of the two. PECs use a voltage and traction controller to maintain and limit the energy flow from the power supply or ICE to the motor drive and from the motor drive to the battery. The negative voltage from the battery is supplied for low voltage regarded DC equipment such as cell phone chargers and auto start-up. When the vehicle is in regenerative braking mode, the AC-DC rectifier converts the variable AC voltage to a constant DC voltage.



(b)

Fig.6.Different operating mode of PHEV



(b)

Fig.7.Different working mode of SPHEV

2.4. Plug-In electric vehicles

A PEV is a type of HEV that uses an external source to charge its battery. The vast majority of the energy converted during conversion is converted into heat. PEV's typical structure is depicted in and is comparable to SHEV. The batteries are recharged at the rechargeable battery charging station, and the PEV runs on power energy. The charging station could be in your home or on the grid.

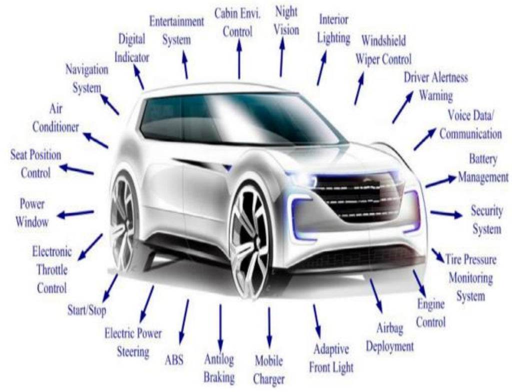


Fig. 8. Electrical appliances of EVs.

A three-phase converter serves as an inverter in the fuel, battery, split, and combine modes of a modern vehicle, as well as a rectifier in the renewable mode. The complex converter mode selection process is managed by the traction control system. The voltage control board manages the battery's SOC at both the maximum and lowest levels. The voltage regulator continuously receives the battery's SOC level signal, compares it to the source voltage signal, and generates a controlled pulse for the DC-DC converter.

3. Power electronics converter classification

As discussed in the section preceding this one, each converter has a distinct function or role. This section will go over the non-isolated bi-directional Switching devices for EVs that are currently available.

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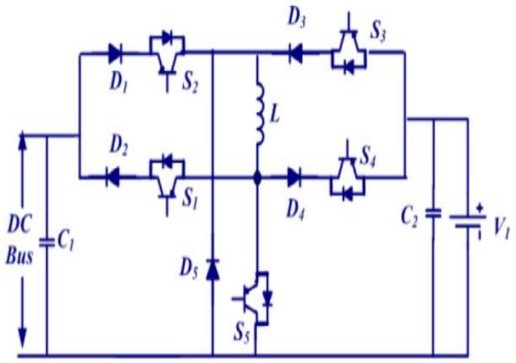

Fig.9.Universal Bidirectional DC-DC Converter

Figure 9 depicts an all-purpose bidirectional DC-DC converter. With non-inverting output, the converter can operate in both buck and boost modes. The various operating modes are described in Table 3. It is composed of two engaged and two passive parts, resulting in less electrical and thermal stress. The disadvantages of this boost mode include higher ripple current, which harms batteries, and discontinuous output current, which increases output capacitor size.Buck boost converter with cascaded bidirectional conversion. The converter supports both buck and boost modes. The CUK converter reduces input and output current ripple.

4.Power electronics vehicle system problems

4.1. Boost performance

To begin, an electric motor replaces the mechanical and hydraulic shafts that traditional vehicles use to propel themselves. HEV efficiency can be increased by carefully combining the optimal amounts of ICE, fuel cell, and battery. PECs are critical for increasing efficiency in rechargeable batteries or fuel methods by selecting the appropriate power converter.When selecting a transformer, the total load and input supply are taken into account. The effectiveness of PEC is influenced by the number of components, control methods, and EMI effects.

4.2. Improve the resilience of EVs

The lifespan of the electric motor inside EVs determines how long they will last. PEC cannot function without semiconductor devices. The converter must be able to withstand high vibration levels as well as extremely hot temperatures. The difficulties arise from selecting a converter that is high in efficiency, rigid, affordable, and small in size.

4.3. Improve the efficiency of EVs

The auto manufacturing system necessitates quick and powerful industrial motion control. To maximise EV performance, the PE technique and Digital Signal Processing (DSP) are combined.

4.4. Increase the opulent element

The primary focus of today's advanced EVs is the development of high-comfort EVs. Figure 20 depicts a few high-comfort applications. The voltage rating required to run each application varies. The three-phase inverter powers the alternating current load.

4.5. Raising EV safety standards

In addition to power conversion and propeller control, it is critical to monitor the traction motor's health for failures such as stator, rotor, and bearing issues. ABS and airbags necessitate high-power actuators in EVs ahead of time. In the future, the PEC with DSP technique could be used to improve EV safety features.

CONCLUSION:

This paper summarised the effects of PECs on the price, effectiveness, and performance of EVs. According to an EV analysis, the SPHEV has the ideal pairing of two types of energy for propulsion and other functions. The demand for various supply ratings grows as the electrical system for vehicles evolves; however, a single battery or a two-battery structure cannot meet this demand. The bi-directional DC-DC converter is essential in EV power converters. The current non-isolated bi - directional DC-DC different topologies are thoroughly reviewed, compared, and discussed, as are the benefits and drawbacks of PEC in the current vehicular system. Face in improving their effectiveness, dependability, performance, and cost-cutting.

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