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# A Review on Power Conversion Topologies for Fuel Cell in Hybrid Electric Vehicles (FCHEV)

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**ABSTRACT:** Car manufacturers have shifted their focus to new technologies connected to electric/hybrid vehicles and electric fuel cell vehicles as a result of technological advancements in recent decades and the application of international standards to minimize greenhouse gas emissions. The employment of fuel cells (FC) in vehicle technology has grown in popularity in recent years. The power sources in a Fuel Cell Hybrid Electric Vehicle (FCHEV) are typically a fuel cell, a battery, and/or an ultra-capacitor (UC). The hybrid FC system is formed by integrating the power converter with the power sources. This compensates for the disadvantages of individual power sources. The numerous power conversion topologies for fuel cells in hybrid electric vehicles are discussed in this paper.

**KEYWORDS:** Fuel Cell Hybrid Electric Vehicle (FCHEV), power conversion Topologies, greenhouse gas emissions.

## I. INTRODUCTION

Hybrid vehicles have a drive system that incorporates two or more power sources [1]. Ordinary internal combustion engine (ICE) cars, on the other hand, employ a single power source that consists of a reciprocating engine that is commonly fueled with gasoline and drives a complex transmission system that is then attached to the drive wheels. Low energy efficiency, toxic chemical emissions, high noise level, and heavy reliance on a single fuel source are all downsides of ICE vehicles. One of the proposed solutions to address the perceived concerns related with the energy crisis and global warming is hybrid electric automobiles. Hybrid cars [2, 3] smoothly integrate two or more power sources into a single propulsion system. Fuel cell hybrid vehicles combine the technologies of a hybrid vehicle and hydrogen gasoline cells to substitute conventional fuel, reduce CO<sub>2</sub> emissions, and improve fuel efficiency [4, 5]. Due to the following advantages of the fuel cell and the battery, the fuel cell/battery hybrid vehicle has been targeted as an alternative engine to the existing internal-combustion engine. To begin with, the fuel cell is both efficient and environmentally benign. Second, the battery provides a quick response time for changing power demands. However, the hybrid fuel cell vehicle's competitive efficiency is required to successfully replace conventional automobiles with fuel cell hybrid vehicles. The relative engine sizing between the fuel cell and the battery [4] is the most important aspect that determines the overall efficiency of the hybrid fuel cell vehicle.

## II. ARCHITECTURE OF HEV [7]

An electric motor (EM), battery, converter, internal combustion engine (ICE), gasoline tank, and control board are the main components of a HEV. These elements can be divided into three categories:

1. Drivetrains—physically connect the internal combustion engine (ICE) with the electric motor.
2. Energy storage system (ESS)—focuses on large or small energy storage and power capabilities.
3. Control system—directs electric systems/ICE and oversees the hybrid energy storage system (HESS).

These components can be combined in a variety of ways and sizes, resulting in a variety of vehicle designs. Drive trains are classified as series, parallel, or power split based on component integration.

## III. POWER CONVERSION TOPOLOGIES [6]

The configurations of fuel cell vehicle propulsion systems can be divided into two types based on the power conversion stages: There are two types of power conversion: multiple stage power conversion and single stage power conversion.



A. Multiple stage power conversion

A hybrid vehicle's power conversion is split into two stages: DC-DC conversion and DC-AC conversion. Low voltage DC power sources are first transformed into high voltage DC, and then the high voltage DC is inverted into AC. As illustrated in Figure 1, the topologies of multiple stage power conversion studied in various literatures can be categorized into six categories.

- (T1) floating DC bus: is the most basic, in which the FC communicates directly with its storage device without the use of a converter, and the combined DC bus communicates with the motor inverter.
- (T2) Controlled FC with floating battery/ultra capacitor: The storage system is connected to the DC bus via a DC/DC converter, whereas the FC system is connected directly to the DC bus. Because the power flow via the DC/DC converter is bidirectional in this configuration, it has a higher loss than the second. As a result, the power electronic loss in this architecture is greater.
- (T3) Floating FC with controlled battery/ultra capacitor: A DC/DC converter connects the storage system to the DC bus, whereas the FC system is directly connected to the DC bus. Because the power flow through the DC/DC converter is bidirectional in this configuration, it suffers from higher losses than the second. As a result, this architecture has a larger power electronic loss.
- (T4) Controlled DCbus with Controlled FC, battery/ultra capacitor: is a popular choice among searchers. This design allows you to control both the FC and storage power flows. A careful control on both source converters is required because the power of the sources must meet the required power and the voltage level of the DC bus must be stable.
- (T5) Controlled FC with controlled battery and floating ultra capacitor: A propulsion system comprising a battery and an ultra capacitor with a fuel cell is depicted. The fundamental benefit of this topology is that it combines the advantages of both UC and battery technology, resulting in great power and energy density. However, the system's complexity is a disadvantage.
- (T6) Controlled FC with controlled battery and ultra capacitor: FC, UC, and battery are all connected through DC-DC converters. The DC bus voltage is better controlled in this design than in the preceding five topologies. In comparison to topologies 3, 4, and 5, it allows the super capacitor to manage greater power and the battery to store energy more efficiently.

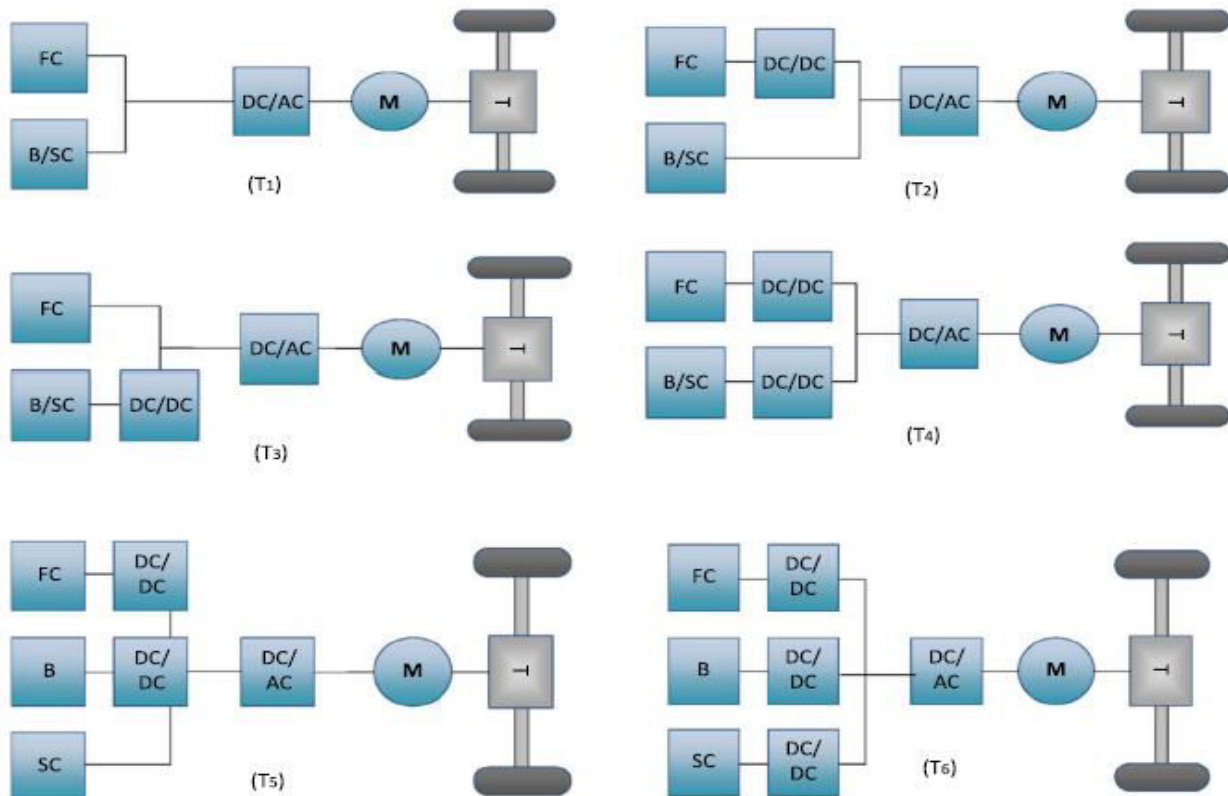


Figure 1 Power conversion Topologies of FCHEV



#### IV. CONCLUSION

Hybrid-electric vehicles (HEVs) combine the advantages of internal combustion engines and electric motors, and can be customized to achieve a variety of goals, including increased fuel economy, increased power, and additional auxiliary power for electronic devices and power tools. This paper discusses the various power conversion topologies for fuel cells in hybrid electric vehicles.

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