HYBRID ELECTRICAL VEHICLE TECHNOLOGIES

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The term hybrid electric vehicle has two kinds of energy sources which are an internal combustion engine and a battery pack. In this type of electric vehicle, internal combustion engine gets energy from fuel while electric motor takes energy from the battery. Three different types according to degree of hybridization and three types according to powertrain configurations are exist in HEVs [1].

Hybrid electrical vehicles are popular for their amplified efficiencies as compared to conventional vehicles. As said earlier, the electric motor and IC engine are mentioned propulsion systems for HEVs. The configurations of the HEV define how the electric motor works in conjunction with the ICE. The components can be connected by different architectures. Generally, three common design options of HEV architecture are exist [2]:

1. Series hybrid electric vehicle
2. Parallel hybrid electric vehicle
3. Series – parallel electric vehicle

1.1 Series hybrid electric vehicle configuration

The construction of series hybrid electrical vehicle is much simpler compared to other configurations. Series hybrid electrical vehicle is known as electrical coupling. The main components of series HEVs are IC engine, generator, converter, battery pack and an electric motor. The internal combustion engine is connected directly to the generator which the electric power is generated as well as the battery pack and generator connected to the electric motor which is mechanical power can be produced. In series hybrid vehicle, only the electric motor is responsible for vehicle driving. The difference with a pure electric vehicle is that the energy does not come exclusively from a battery recharged by the grid, but also the battery is charged partially or completely by an internal combustion engine.

In this type of the vehicle, the engine is used to generate only the electrical power it provides the engine works at its maximum efficiency. The control strategy is more straightforward when compare with other configurations because there is a mechanical coupling between engine and wheels.

Series hybrids may also be referred to as **extended-range electric vehicles (EREVs)** or **range-extended electric vehicles (REEVs)** since the gas engine only generates electricity to be used by the electric motor and never directly drives the wheels. Modern examples include the Cadillac ELR, Chevrolet Volt, BMW i3 and Fisker Karma [3].

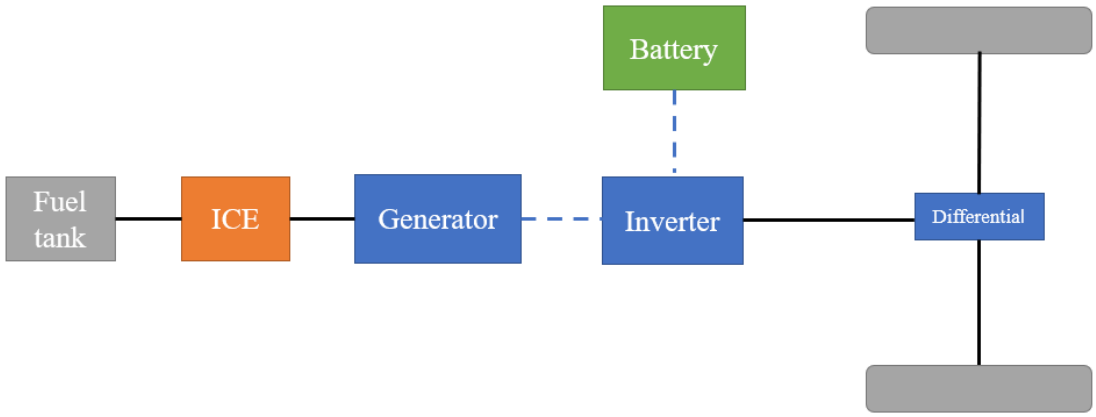


Figure 1. Series hybrid electric vehicle configuration

1.2 Parallel hybrid electric vehicle configuration

The hybrid electric vehicle with equipped parallel hybrid configuration can be moved by both an internal combustion engine and an electric motor connected to the wheel as shown in Figure 2. The powers from electric motor and ICE are merged together with the help of mechanical coupling. The electric motor can be used in low speed condition. Thus, at higher speed, this set up allows the engine to work in its ideal operating range with high efficiency [4]

When the vehicle is propelled only with the EM, the engine can be decoupled, whereas on the other hand, when the ICE is driving the vehicle, the EM is connected and it can be utilized as a generator to charge the battery by regenerative braking or by power provided by the ICE.

The parallel hybrid vehicles can divide into 4 classifications according to the placement of the electric motor in conventional powertrain:

1. Micro hybrids, the EM can be arranged as belt driven or crankshaft before ICE, for this reason, its speed is linked to the engine.
2. Pre-transmission parallel hybrids, the EM can be mounted between the engine and the gearbox.

3. Double-shaft parallel hybrids, the EM can be placed downstream of the gearbox

4. Double drive parallel hybrids, where the ICE can be placed on the other shaft separately from the EM.

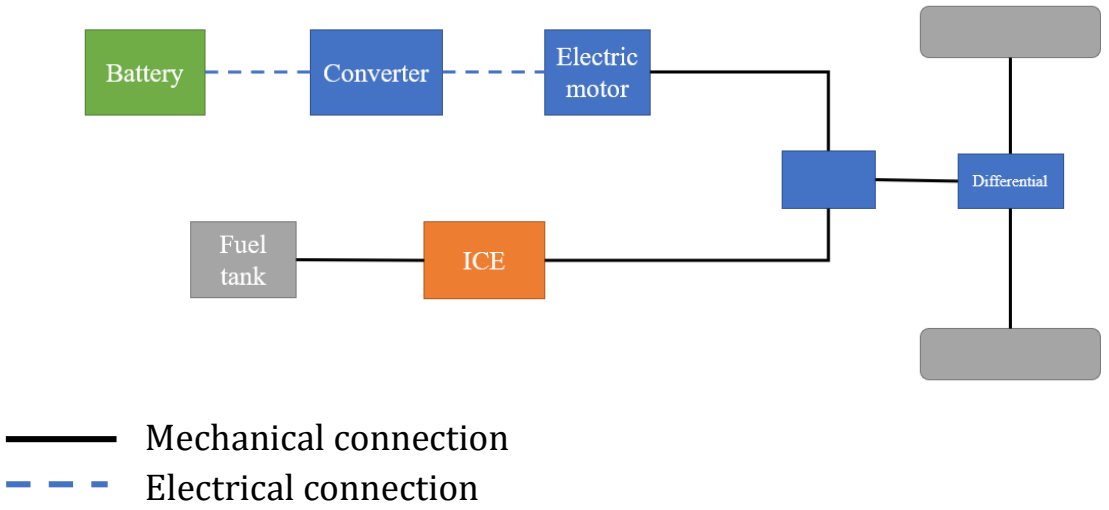
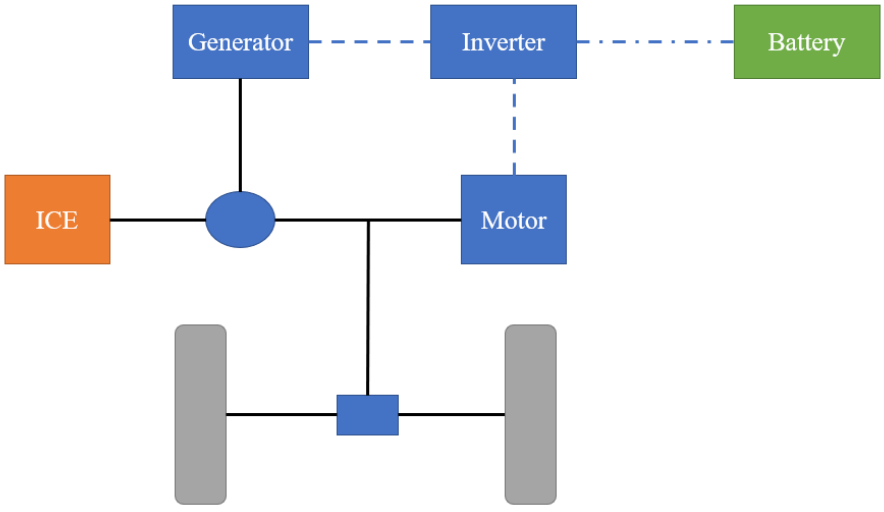


Figure 2. Parallel hybrid configuration

1.3 Series - parallel hybrid electric vehicle configuration

Series – parallel hybrid vehicles is also called power – split hybrids are parallel that include power-split devices. It allows for power paths from the ICE to the wheels on the mechanical or electrical way. This configuration combines the best aspects of series and parallel hybrids in order to create an extremely efficient system. In contrast with these technologies, power – split hybrid requires more components and a more complex control algorithm. The power which can be produced by the engine splits to the generator in order to generate electricity, on other hand to the mechanical gear system to propel the vehicle [5]. The architecture of power – split hybrids are shown in Figure 3.



Mechanical connection

Electrical connection

Figure 3. Series – parallel hybrid configuration

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