An Encyclopedic Review on Fuel Cell based Architecture and DC Chopper for Hybrid Electric Vehicle

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Abstract – *Electric vehicles are attractive widespread and are achieving more attention due to various parameters, primarily subsiding rates and high eco-friendly attentiveness. This paper discusses about intense summary combination of fuel cells (FC) and hybrid exciting vehicle (HEV) which jointly known as Fuel Cell Hybrid Electric Vehicle(FCHEV.) The routine of FCHEV is prejudiced by proficiency of power converter controller, as well as technological competence of the power sources. FCHEV's requires to elaborate energy management system (EMS) to task successfully, EMS is the chief demand in growth of fuel cell based vehicles prepared with many energy storing system. This paper shows a energy organization for battery depends on fuel cell electric vehicle works conducting mode A valuation of future scenario of fuel cells based power resources geology and various power input DC-DC converter classification used in hybrid electric vehicle is proposed and energy management strategies are advisable to implement in electric vehicles to improve its efficiency and outcomes.*

Keywords – battery, DC converter, Fuel cells (FC), Hybrid electric vehicle (HEV).

1. INTRODUCTION

The planet transportation presently count on greatly on remnant fuels as its major cause, this tends to air contamination and reduction of the ozone layer and exhaustation of global heating and too much use of fossil fuels in transport and shipping leads to the weakening of subversive gasoline capital in 2014, the data collected from the US energy vigilence shipping business calculated as 55% of international energy utilization and 30.9% of CO_2 excretion[1]. which leads to Global warming and weather alteration are caused by pollution due to extensive burn of diesel and petroleum based vehicles [2]. This study shows that we urgently need to shift on renewable energy resources to protect our environment therefore by seeing present scenario of excessive transmission of carbon dioxide and other harmful gases, there is urgent need to banned diesel and petroleum-based vehicles. A vehicle made up of fuel cell as an alternative of battery or the hybridization of fuel cell with different energy ingredients like ultracapacitor (UC), battery, lunar photocell, superconducting magnetic energy storage (SMES) flywheel, are also comes under FCHEVs[3-5] and can be implemented in designing hybrid vehicles.

As seen now a days, electric vehicles are great options to traditional gas-powered vehicles because they are clean, quiet, smooth and release negligible emissions and at the same time they are more efficient than conventional cars that are based on internal combustion engines. Therefore, as technology upgrades, number of charging stations increases electric vehicles will get more popular in terms of sustainable transportation

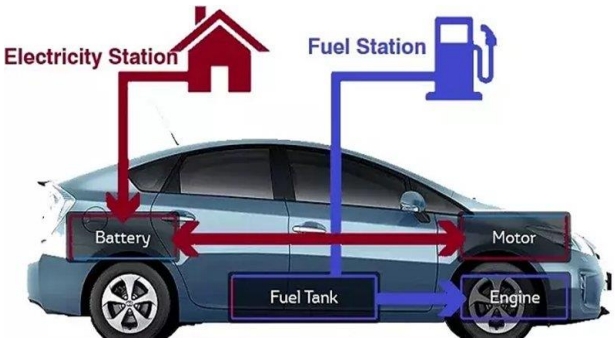

Fig. 1. Electric and Hybrid Technologies available in market.

The FCEV utilizes an electrical motor motorized by power full by a blend of FC and a battery. The fuel cell (FC) uses hydrogen to produce electrical energy instead of depiction electricity from a battery. The fuel cell hybrid electric vehicles (FCHEV's) are intended so as to recollect decelerate energy for the aspect of additional power all through speeding up process. FCEV are filled with pure hydrogen gas stored in container of the vehicle, just same as conventional internal ignition engine vehicles, they can fuel in approx 5 minutes and have a dynamic range of more than 300 miles. Since the chief ingredient of fuel is hydrogen, therefore magnitude of energy that system is resolute by the amount of the hydrogen gas storage capacity accessible on project [6].

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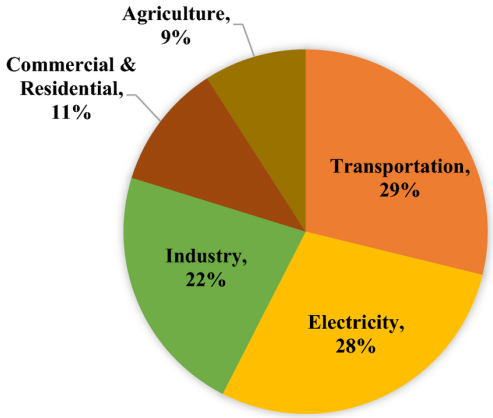

Fig. 2. Green House emission various sectors.

The current reading aims to improve the understanding of FCHEVs geographies, differenti-input DC–DC control converter geographies, and the upcoming expectations are aspects by analyzing the present writing. The FC's is organized with the motor with restricted power electronic elements [6-8]. The main factor of FCHEVs is a fuel cell, and then minor factor is power source, power electronic converter, and the working motor component. There are various compositions and factors are available in market to be linked elements with the energy management design, to impove its performance, Fuel cell hybrid electric vehicle are classified as mentioned by the power coach formation [9-11].And is used as a multiple input system DC to DC power control converter is used to blend with supplementary sources with the fuel cell [12]. The main and supplementary ground for FCHEV and power translation study with different methods and strategies are discussed in this paper. The major factors in EV that are available in market are explained. The combinations are battery, flywheel, FC and UC [13]. Energy management system participates a important role in the presentation and effectiveness of FCHEV [14]. Its chief motive is distributing energy between various sources while attaining two major aims the first one is mentioning to reduce hydrogen utilization or to minimize the similar energy consumption [15].And the second goal is to, expand fuel cell shelf life, which explains the inclining escalating the financial system of the market of hybrid system worldwide [16]. A huge count of EMSs is paid on these two improved intelligence objective. The first type of Engine management system is the hit and trial rule-based technique. This generally needs attaining the power graph of the fuel cell is to get the maximum output in service position. The three types of electrified vehicles are classified as 1.HEV (hybrid electric vehicle) which uses petrol and battery 2. FCEV (fuel cell electric vehicle) which produced from chemical energy 3.BEV (battery electric vehicle) which is battery powered electric drive train 4.PHEV (plug in hybrid electric vehicle), this have both engine and motor It can also regulate the control allocation of the fuel cell and the energy containing space that can be a ultacapacitor or power bank, according to the power organization system [17].

2. WORKING PRINCIPLE OF FUEL CELL

2.1 Basics of fuel cells.

A fuel cell behaves like power banks and generate electricity and warmth as much as fuel is given. A fuel cell is electro-chemical cell that transforms chemical energy and corrosion agent into valuable electrical energy. A FC is made up of positive ions, negative ions, and an electrolyte. A usual FC works by using series of redox reactions, the fuel cell produces electricity by going through a chemical reaction between H_2 and H_2O. At the negative electrode i.e anode side, hydrogen is supplied. The permeable electrolyte is proton based working membrane that passes only protons to go by, while jamming electrons. The catalyst majorly used as platinum to accelerate the reaction of electrodes. And at the positive electrode (cathode) end, the protons, electrons, and oxygen combine to generate water particles. The conversion is conducted via indisposed & oxidized reactions to produce electricity [18]. The source of input for the electrochemical reaction are H_2 and O_2, which is going to be applied by the positive electrode and negative electrode [19-20]. In the process of chemical response, H_2 is decayed on anode side in negative and positive ions. The ions carrying positive charge tries to reach the top of the cathode plate through electrolyte and allows to surpass only positive carrying charges [21-23]. Negative carrying charges mixes with positive carrying charges to reach the negative electrode's side, and pass to the positive electrodes side via an exterior track.

The chemical reactions are as follows

$$2H_2 + O_2 = 2H_2O + energy \quad (1)$$

$$H_2 = 2H^+ + 2e^- \quad (2)$$

$$\frac{1}{2}o_2 + 2H^+ + 2e^- = H_2O \quad (3)$$

The speculative rate of voltage came by a chemical response of oxygen (O_2) and hydrogen (H_2) is 1.23 V, other than the realistic rate be low because of the losses taking place in the circuit just as resistive loss, foundation loss, and shipping loss, while the present value spikes up [24]. At constant current, the voltage value rated is of 0.6–0.7 V is created through a fuel cell unit for realistic purposes. The working characteristic of the fuel cell is used for the evaluation of the system's measurement for a various uses. Fuel cell can occupate at elevated efficiencies than ignition engines and transfer that chemical energy into electrical energy through capacity of exceeding 60%. So, it is important to attain the I-V curve of a fuel cell in terms of characteristic plot. The routine characteristic of a general FC is mention below in given figure number 3.

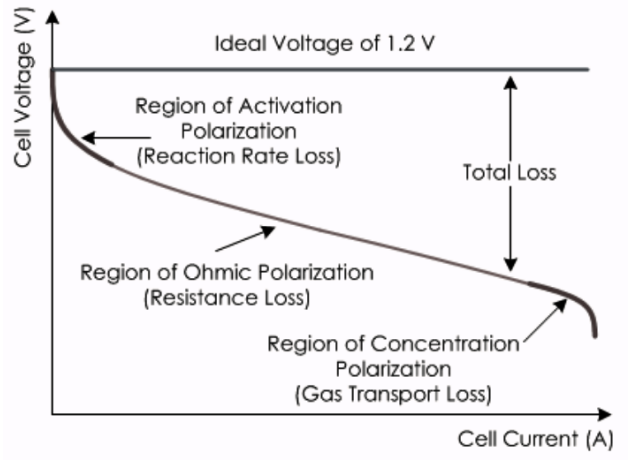

Fig. 3. General characteristic of a fuel cell.

3. TYPICAL TOPOLOGIES OF FCHEVs

3.1 General Classification

Fuel cells are frequently united with various renewal energy sources to figure out hybrid structure to provide source to HEVs. Hydrogen fuel cells release only water, challenging critical environment starategies as there is no carbon dioxide (co_2) emissions and no air pollution that creates health issues. These secondary energy sources are ultacapacitors, superconducting magnetic energy storage (SMES), batteries, solar photocells and gearwheels etc. When there is a need of high capacity, the gearwheel can discharge a ratio of mechanical energy and transforms it into ratio of electrical energy to provide energy source to the given respective circuit [26-27]. The power unit used in-vehicle puposes compulsory have the quality to switch high intake energy with compact size and reasonable price. There are two different varieties of batteries that are obtainable in market, the first one is non-rechargeable and second one is rechargeable (reusable). Therefore, a lead-acid battery is a kind of rechargeable battery which is made-up by French scientist in 1859. This is the very frequently used batteries used in electric vehicles, in this type of batteries the cathode consists of lead peroxide, and the anode consists of lead which is soft sponge. The electrolyte is sulphuric acid-based used to construct electricity by sinking these plates into solution. The operational reactions at two different plates are given as below

At anode end-

$$Pb + SO_4^{2-} = PbSO_4 + 2e^-$$

At cathode end

$$PbO_2 + SO_4^{2-} + 4H^+ + 2e^- = PbSO_4 + 2H_2O$$

In fully charged condition, the chemical energy of battery is restored in potential difference between metallic lead at anode and PbO_2 at cathode.

The lead acid containing batteries are easily installable, low charging time, low safeguarding and high efficiency. These few advantages make their availability in market great.

Table 1. Review of common topologies of FCHEV's.

Classifications	Advantages	Disadvantages
Fully FCEV	1. easy arrangement 2. Simple to apply control conditions	not capable to restore energy
FC+ Battery Classification	1. prominent energy concentration of battery 2. capable to restore energy	sluggish dynamic reply
FC+UC Classification	1. Quick dynamic reaction 2. Capable to pick up energy	UC is costly than power input short energy mass(UC)
FC+battery+UC Classification	1. great battery energy concentration. 2. Quick dynamic input (UC) 3. Capable to boost energy	Conditional strategies are complicated and hard to apply.

3.2 Fully FCEV

FCEVs are powered by hydrogen, they apply fuel cells to stimulate communication arrangement with no supporting energy input. Its easy collection made up of fewer elements of a FC stack, UDPC, fuel tank, inverter, and motor [28]. The Fuel cell load calculates the response from the fuel tank, air and produces DC output excitement voltage. Without the help of combining of Fuel cell with any other secondary excitement fully FCEV is less consistent, expensive, and therefore reduced transient response. On positive note they do not generate harmful gases, there is only a presence of water vapour and hot air, So generally used upcoming uses are mainly in small velocity vehicles such as two-wheelers, forklift, electric buses, e-rickshaws and underwater vehicles [14].

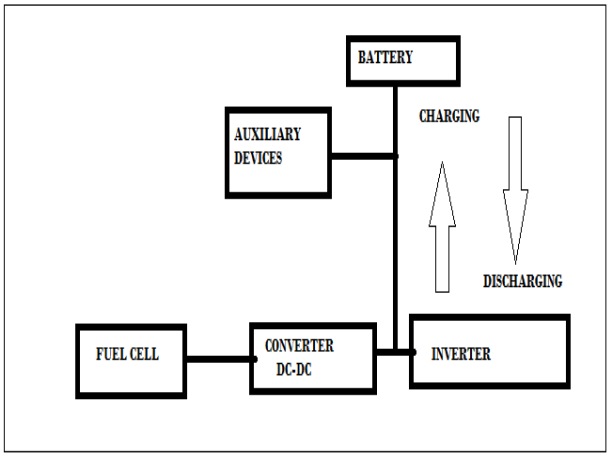

Fig. 4. Fully FCEV block diagram.

3.3 FC +Battery Classification.

The mixed power connected method made up of batteries and fuel cells, this is the most regular classification as of now. The advantages of this combination are that batteries comes with prominent power density, usually short safeguarding and reasonable cost. The normal life span of a battery is nearly 4 to 6 years. Hence, this type of classification is extensively used in manufacturing [30].

FC and battery are interrelated with DC bus with UDPC and BDPC The bi-going nature of the converter is maximized for the power unit for the reason that its going to help to transfer energy to connect load to the battery, and wires the operation and in the last, the electric motor gains response from the inverter part [31]

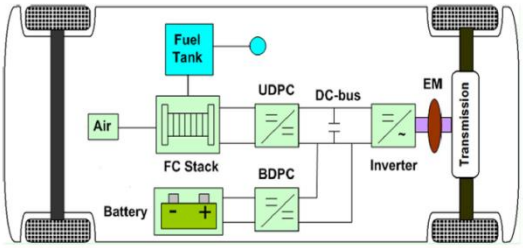

Fig. 5. FC + Battery Topology System.

3.4 FC+ UC Classification

This is the classification where**,** UC is coupled with the DC bus with the help of BDPC. UC is used as the supplementary cause instead of the battery [31]. The standard life span of UC is approximately 12-20 years [32]. FC is taken as primary source connected to DC bus via UPDC. This arrangement has a reward of getting more powerful energy revival and better active response to immediate excess-power command. And at the same time It also has some drawbacks of expensive cost and short energy concentration, and short span time. Therefore, it is not used for vast area as hybrid combined systems with fuel cells and combination with batteries and power banks.

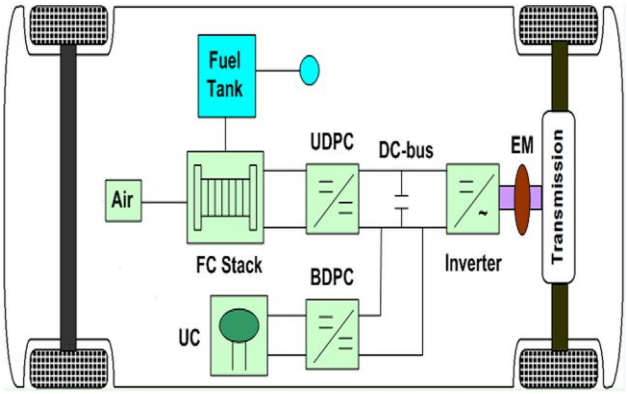

Fig. 6. FC + UC hybridization Topology System.

3.5 FC + UC + battery classification

For this hybrid scenario, FC's are the chief power ingredient to supply normal power requirement of the consignment. The properties of batteries and ultra capacitors are taken broadly due to this, its easy to compliment this classification in vast areas.

This classification has compensation of FC with UC and FC with battery. It supplies nonstop energy and increases the rapid performance of FC during momentary working operation of the system [33].

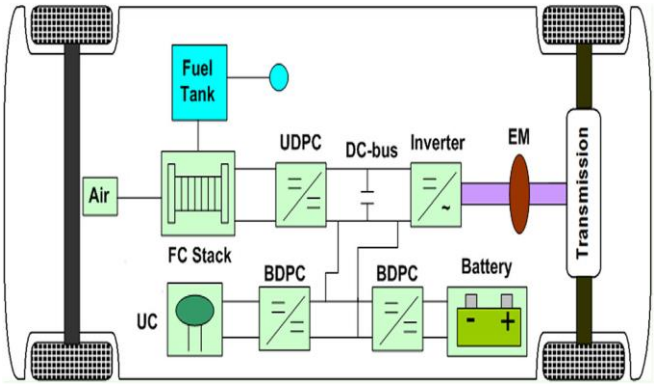

Fig 7. FC+UC + Battery hybridization.

3.6 FC + Battery +SPV Classification.

In this classification, the solar photovoltaic cell is measured as one of the most well-known renewable energy sources for improving environment conditions. This is the classification where, FC is considered as the most important input source, and the supplementary energy source is Solar photovoltaic cell. A UDPC is essential to unite with the FC and SPV with the help of DC bus [34]. Power produces all the way through SPV relies on the solar inclination(the intensity of solar light falls on the earth surface), warmth, and direction, so that the statuary power is established with the SPV model [35]. Therefore, power produced by solar Photo voltaic is given to the motor to allege the battery, hence overall efficiency of FCHEV is improved.

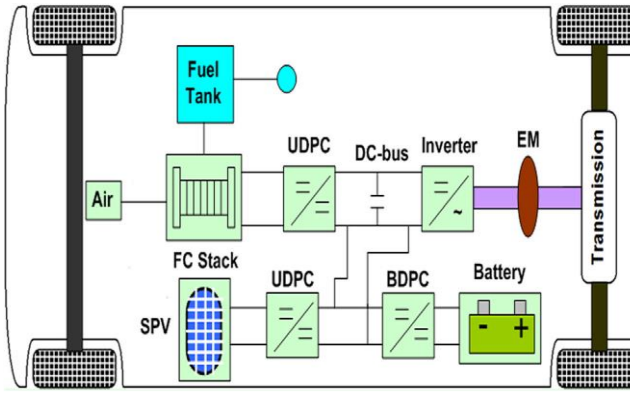

Fig. 8. FC +Battery+ SPV Topology System.

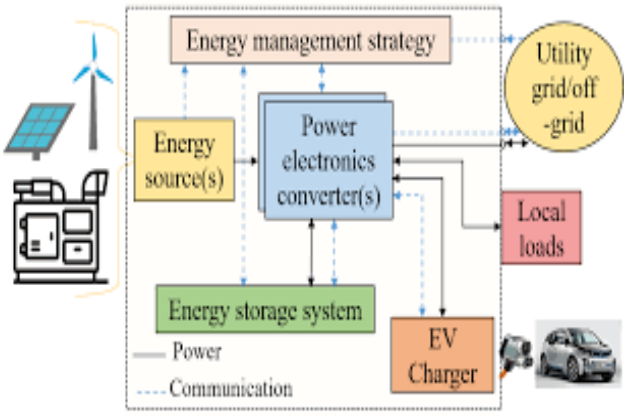

Fig. 9. Block diagram of EMS.

3.7 FC + SMES Topology

This type of classification is not yet implemented for FCHEV, but this is likely to be proposed for FCHEV. Its principle is that when nonstop current flowing in a superconducting loop, it generates the magnetic field and SMES stores the energy. Superconducting Magnetic Energy System has elevated prospective of fast input response and great incoming and outgoing power resonance and on the other side hydrogen has a great capacity of outsized storage and sluggish reaction and therefore both systems have storing capacity which equalizes each other, and can be combined together for further applications [36]. In this kind of hybrid arrangements superconducting magnetic energy system and Electrolyte elements H_2 fuel cell (EL-H_2-FC) plans are loaded to closest to liquid hydrogen (LH_2) station for vehicles.

4. ENERGY MANAGEMENT STRATEGIES

To recover the routine of FC hybrids, scheming and mounting capabilities of energy management system strategies (EMS) is an vital requirement for present automobile dealers. Energy Management strategies (EMS) are presently equipped to recover the action of HEV from mutually indulging in two aspects of the energy utilization perception and the stability of the apparatus. From the outlook of energy consumption, the chief object is to slow down hydrogen expenditure and stabilize component stability, therefore it aims on rescuing the deprivation of fuel cells, ultra capacitor and batteries. The various types of energy management system are as follows-

a) Rule base energy management strategy
b) Optimization based energy management strategy
c) Learning based energy management strategy

These management strategies help to design the vehicle more precise and specific according to the requirement and specifications.

5. CONCLUSION

This paper discusses about various topologies took stand in designing of fuel cell hybrid electric vehicle and reduces the conventional technique to utilize fossil fuels at the same time it shows the potential of renewable energy. There are various topologies and methods are available to reduce air pollution by reducing conventional vehicles which are based on diesel and petroleum ground. The hybrid vehicles are techniques to overcome air, noise pollution and global warming to some extent. This initiative provides employments in automobile industries and aware humans about upcoming environment disasters. The government also plays a satisfactory role in market by providing subsidiary policies which impresses costumers to buy electric vehicles.

ACKNOWLEGEMENT

I hereby acknowledge to Dr. Pawan Kumar Pathak for his immense Support and time in writing this paper. this could not be possible without his contribution. Thank you for your valuable time and information.

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