International Journal of Engineering Applied Science and Management
ISSN (Online): 2582-6948
Vol. 3 Issue 8, August 2022

Dual Input DC-DC Converter for Hybrid Electric Vehicle: A Review

Nirbhay Kumar[1], Dr. Prabodh Khampariya[2]
MTech Scholar, Department of Electrical Engineering Sri Satya Sai University of Technology & Medical Science, Sehore, Bhopal[1]
Asso. Professor, Department of Electrical Engineering Sri Satya Sai University of Technology &Medical Science, Sehore, Bhopal[2]

Abstract: *Hybrid Electric Vehicles (HEV) have gained much attention, in the context of growing concerns about increasing pollution and resulting global warming. The main characteristics of HEV is that is powered either solely by a battery or in combination with fuel engine. HEV and other vehicles configurations such as Battery Electric Vehicles (BEV), Plug-in Hybrid Electric Vehicles (PHEV) also gaining importance with growing concern towards the environment. This leads to the initiation of researchers and scientists to think for the improvement of the Hybrid Vehicles technology. The paper reviewed the work done in the technology to design and analyse the dc-dc converter for HEV. This paper provides a review of the technology aspects, the current state of the research and development in the field.*

Keywords: *Renewable energy DC-DC bidirectional converter Electric vehicle Battery electric vehicle.*

1. Introduction

HEVs are attracting the attention of an increasing number of nations due to growing environmental awareness. Investing much on cars powered by internal combustion engines is a common occurrence. There is a strong desire to move away from ICE cars and toward HEVs as a result, but this is complicated by technical and commercial challenges. There are several benefits to using a HEV over a conventional car. Fossil fuel-based transportation is the primary mode of transportation for most people in today's society. As cities, industries, and countries become more industrialized and globalized, the number of personal autos will rise. As a result of this trend's dependence on oil, there are a number of challenges to consider. In addition to the finite supply of oil on Earth, the emissions from burning oil products have contributed to climate change, poor air quality in metropolitan areas, and political tension.[1] There seems to be a change happening in the automotive industry toward hybrid electric cars, and it seems that power electronics are a key enabler of that transition. Some people refer to the HEV's bidirectional DC-DC converter as an energy management converter. This powerful DC-DC converter connects the high-voltage battery to the high-voltage DC bus at a lower voltage.

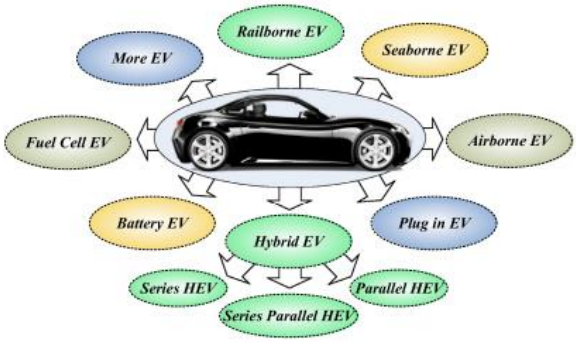

Fig. 1: General classification of EV

A battery pack's normal voltage range is between 300 and 400 volts. For motors and inverters, the ideal operating voltage is 600 volts. The voltages of the battery system and the motor system are matched by this converter. This converter also helps to improve the performance of the powertrain system, reduce battery ripple current, and maintain DC link voltage, all of which contribute to the high-power output of the powertrain. As a result, researchers are focusing on improving the bidirectional dc-dc converter technology. The DC-DC converter's

architecture and state space modelling for bidirectional operation were studied in this work.[2]

1.1 DC-DC Converter

A DC-DC converter is an electrical circuit that transforms a DC source into a different voltage level. As indicated in Figure, the converter can be divided into two types: (1) linear regulators and (2) switching regulators. The switching regulator can be divided into different types based on the use of inductors: (a) inductor-based switching regulators; and (b) inductor-less switching regulators (switched capacitor).[3]

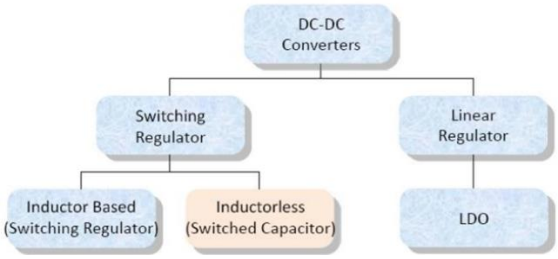

Figure 2: Classifications of DC-DC Converters

Power electronic circuits that transform a dc voltage to a different voltage level are known as DC–DC converters. Electronic, linear, switching mode, electromagnetic, and capacitive conversion methods are only a few examples. Switched mode DC-DC converters are the type of circuits mentioned in this paper. These would be electronic devices that have been utilised whenever DC electrical power needs to be changed from one voltage level to another. The usage of a switch or switches for the purpose of efficient conversion is referred to as an SMPS in general. When humans talk about DC-DC converters in the future, we'll talk about them in terms of SMPS. DCDC converters are useful in situations where 5V DC on a computer motherboard needs to be stepped down to 3V, 2V, or less for one of the latest CPU chips, and wherever 1.5V from a single cell needs to be stepped up to 5V or more to power electronic equipment.[4]

1.2 Advantages of HEV

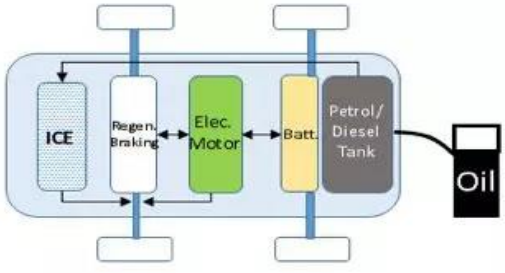

Fig. 3: General diagram of HEV

Environmentally Friendly: One of the main reasons that public and private organisations are moving to hybrid vehicles is that they have been cleaner and provide better gas mileage than traditional gasoline-powered vehicles, offering them ecologically beneficial options. When the electric motor as well as the gasoline engine operates together, they save energy by reducing fuel consumption.
Economical: The government has approved many subsidies and incentives for those who want to switch to a hybrid vehicle in order to encourage hybrid vehicles. In addition to low fuel expenses, they are immune from congestion charges and have significantly lower annual tax expenditures.
Less Fossil Fuel Dependent: A hybrid car with an electric motor runs cleaner and uses less fossil fuel, resulting in lower pollutants and less reliance on fossil fuels. This will result in a decrease in fuel costs as a result of this.
Regenerative Braking System: The intriguing thing about hybrid automobiles is that the electric battery recharges a little more every time you press the brake while driving. On longer excursions, the energy released as a result of applying the brakes is caught by an internal system and also used to replenish the battery, reducing the need to stop frequently to recharge the battery.
Light Build: When hybrid vehicles are built, lighter materials are employed, which means they consume less energy to operate. The engine's lower size and lighter construction also saves energy.

2. Literature Review

(MEHRDAD EHSANI & SINGH, 2021)[5] For a safe sustainability and environmental transportation, electric and hybrid electric vehicles (EV/HEV) are potential alternatives for fossil fuel conservation as well as pollution reduction. In this review, published recommendations and suggestions are examined and assessed. To evaluate the strengths and shortcomings of different methods, the results of extensive research are presented in tabular form. Additionally, difficulties in present research are explored, and recommendations for technology advancement are made. This article examines current research in the subject of electric vehicles and hybrid electric vehicles, as well as the obstacles and scope of future research. It can be used as a reference for anyone working in this topic.
(Alam et al., 2019)[6] A pulse-width modulated (PWM) dual-input DC-DC buck converter with tiny signal modelling and voltage-mode control is presented in this study. For a multi-input buck converter, a brief compensator design is presented. A new variable is added to correlate the duty cycles in the closed loop control to the output voltage transfer function in order to regulate the duty cycles of many switches as well as control the output voltage. LTSpice is used to simulate the analysis and controller design.

(Chakraborty et al., 2019)[7] The development & assessment of several DC-DC converter topologies for Battery Electric Vehicles (BEVs) as well as Plug-in Hybrid Electric Vehicles (PHEVs) are discussed in this article (PHEVs). The output power, component count, switching frequency, electromagnetic interference (EMI), inefficiencies, effectiveness, dependability, as well as cost of different converter topologies are described, studied, and evaluated. The architecture, benefits, and drawbacks of converter topologies (AC-DC and DC-DC) for Fast Charging Stations are also discussed in this study.

(YILDIRIM & AKDEMİR, 2018)[8] Multiple energy storage systems for electric vehicles (EV) and hybrid electric cars can be used with DC/DC converters (HEV). As per the energy needs of the loads, these power converters can manage the power flow to or from each storage element. This study provides a system architecture as well as performance comparison of two DC/DC converter topologies for connecting an energy storage system with a hybrid Lithium ion battery as well as super capacitor to the DC connection. A recommended set of requirements is used to construct traditional and three-level (TL) DC/DC converter topologies. The Hybrid Energy Storage System (HESS) design considerations are determined, as well as the various DC/DC converter topologies are evaluated.

(Alzgool, 2018)[9] A revolutionary Multi-Input Multi-Output (MIMO) step-up DC transformer is constructed and described for use in high voltage renewable energy sources. Even without an internal AC transformer, this design topology can give a high step-up conversion gain to supply diverse DC output voltage levels from the incorporation of multiple input power sources. MIMO DC transformers enable flexibility in terms of power source selection and availability, and also a decrease in the amount of power lines required to transport power to pre-determined locations as well as improved system performance.

(Liu, 2016)[10] The researcher analyses, designs, and studies the Boost type power factor correction technologies, that is used in the in-board two-stage battery charger, based on the previous research on power factor correction technology. The active power factor corrector's essential functioning principle was first investigated. The average current control (ACM) boost power factor corrector was chosen as the study goal after examining various distinct topologies of PFC converter main circuit as well as control approaches. After that, the author calculated as well as constructed the PFC circuit as well as the ACM controller used in EV first-level charging. In Simulink, the investigator runs the model and examines key features such as power factor, input current waveform, output DC voltage, THD, as well as higher harmonic magnitude.

(Chen, 2016)[11] The idea of composite converter architectures is suggested in this study. This technique targets all prominent loss mechanisms by highlighting the direct / indirect power path directly, leading in fundamental efficiency improvements over a wide variety of operating situations. The DC Transformer (DCX) converter, which is a major component of the composite converter technique, is fully addressed in this paper, and significant enhancements are offered. It improves DCX performance over the whole power range, with a loss minimization of more than ten times at no load. Various composite converter prototypes are shown, with rated power ranging from 10 kW to 60 kW.

(Shah, 2015)[12] With the support of a Fuzzy logic controller (FLC) as well as MATLAB / Simulink, the whole study compares closed loop speed control of a separately excited using IGBT Chopper. For the speed control of a DC motor, conversion of a constant voltage DC source into a variable voltage or variable current is necessary in several industrial processes. A converter characterized as a chopper is utilised for this type of activity. The creation of a PI controller and a fuzzy tuned PI controller for DC motor speed control is described in this study. This study presents and analyses the simulation findings.

3. Conclusion

Enough power can only be provided by renewable energy technologies such as solar photovoltaic (PV) and hydrogen fuel cell (FC). Power converters are necessary for the utilisation of renewable energy. The study provides an overview of the latest achievements in hybrid electric vehicle power converter architecture and bidirectional operation modelling. With an understanding of the previous work, the dc-dc converter may be designed in accordance with the study findings. To design and implement improved converters for electric vehicles, the above-mentioned ideas might have significant impact. For academics and automotive engineers, this review may provide a clear notion and information on converter setups, control and optimization. Ultimately, this analysis serves to pave the road for future EV expansions that are more environment friendly.

Reference

[1] MEHRDAD EHSANI and K. V. SINGH, “State of the Art and Trends in Electric and Hybrid Electric Vehicles,” vol. 109, no. 6, 2021.

[2] M. M. Alam, D. C. Lu, and Y. Siwakoti, “Small signal analysis of dual input buck converter,” pp. 8–16, 2019, doi: 10.12720/sgce.9.1.8-16.

[3] S. Chakraborty, H. Vu, M. M. Hasan, D. Tran, M. El Baghdadi, and O. Hegazy, “DC-DC Converter Topologies for Electric Vehicles , Plug-in Hybrid Electric Vehicles and Fast Charging Stations : State of the Art and Future Trends,” 2019.

[4] M. A. YILDIRIM and M. AKDEMİR, “Performance Comparison of Different Converters combined with DC Motors,” 2018.

[5] M. Alzgool, “Design and Analysis of a Novel Multi-Input Multi-Output High Voltage DC Transformer

Model," no. September, 2018.
[6] Z. Liu, "DESIGN OF SINGLE PHASE BOOST POWER FACTOR CORRECTION CIRCUIT AND CONTROLLER APPLIED IN," no. June, 2016.
[7] H. Chen, "Advanced electrified automotive powertrain with composite DC-DC converter by," 2016.
[8] M. Shah, "International Journal of Research (IJR) A Comparative Study on Different Speed Control Methods of D . C . Drives for Electric Vehicle," no. August, 2015.
[9] A. R. Pravin, P. M. Kumar, and E. Karthick, "Dual-Input Isolated Full-Bridge Boost DC-DC Converter based on the Distributed Transformers," vol. 3, no. 22, pp. 1–6, 2015.
[10] R. İ. Kayaalp, T. Demirdelen, and M. Tümay, "Modelling and Analysis of Bidirectional DC-DC Converter 2 . Modelling of Bidirectional DC-DC Converter," no. December, pp. 16–30, 2015.
[11] N. Xue, "Design and Optimization of Lithium-Ion Batteries for Electric-Vehicle Applications," 2014.