DEVELOPMENT OF A BIDIRECTIONAL DC/DC CONVERTERWITH DUAL-BATTERY ENERGY STORAGE FOR HYBRIDELECTRIC VEHICLE SYSTEM

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Abstract- Hybrid electric vehicles (HEVs) offer many benefits, such as high fuel efficiency, reduced emissions, and noisy service. Two or three frequency buses are available in HEVs for various operating purposes. There are requirements of an electrochemical ally independent continuously variable DC-DC converter to connect separate DC voltage bus and pass energy back backward and forwards. In this report a battery connected induction motor drive is proposed with charging and discharging capabilities converter in motoring mode and regerative breaking mode. Three bidirecational switches are used to charge and discharge the battries connected in the topology. The topology consists of two batteries with different voltage levels, one at 96V and other at 48V which discharge or charge with respect to the reference value given in the controller. The controller is a PI gain controller which calcualtes the duty ratio for the swiches connected in the converter. A PWM pulse is generated at very high frequency for the switches at diffent modes run using MATLAB Simulink software. The ouput voltage from the converter is used to run an induction motor and charteristics of the machine are observed by graphs generated with respect to time. All of the critical specifications for DC-DC converters for electric and hybrid vehicles are high performance, small size, lightweight and durability.

Keywords- Hybrid electric vehicles, MATLAB, Dc/Dc Converter, PI gain controller

I. INTRODUCTION

A concern has been developed all over the world because of rise in global warming as well as rise in pollution. There is a need to look for alternatives because of various reasons like increasing rates of fuel, increased dependency over conventional fuel and change in driving trends. Normal climate meetings have been held everywhere in the world, along with the most prominent, i.e. The Kyoto Protocol discusses major concerns related to environmental impacts due to global warming and industrial and automobile pollution. There are various regulations to be imposed by governments to reduce the impact of reducing the emission of toxic gases like carbon dioxide and other lead replacements due to the combustion of fuel for automotive applications. In this study, the recent and future possible trends are also discussed about Hybrid Electric Vehicle Industry. [1]

. Depletion of conventional resources, rise in price of oil and rise in carbon emission are the major concern in the present world. These concerns are especially faced in developing nations like India because of growing cities, rapid economic developments and increasing traffic. Among all these reasons of concern, power grids and ICE vehicles are the major source of carbon emission. All such concerns increase the motivation for using Electric vehicles in transportation. This change will help in making our planet greener and cleaner environment. [2]

DC-DC Converter

By using voltage source inverter, both electric vehicle and hybrid electric vehicles get charged from the battery. It's really useful to keep the battery voltage rating pretty low for vehicle performance improvement, as this implies using

fewer series-connected cells. Although from the perspective of the engine, since the voltage rating and the power supplied by the engine are completely dependent, it is important to have a high-voltage DC bus. In addition, in the case of permanent magnet synchronous machines, moving the flux-weakening region to the high-speed region is particularly convenient for a high-voltage DC bus. A controlled DC voltage is an additional advantageous feature of the implementation of a DC/DC converter, which results in greater motor drive output. As a result, in order to balance the various voltage ratings of these two components, a DC/DC bidirectional converter is normally inserted between both the battery as well as the inverter. [3]

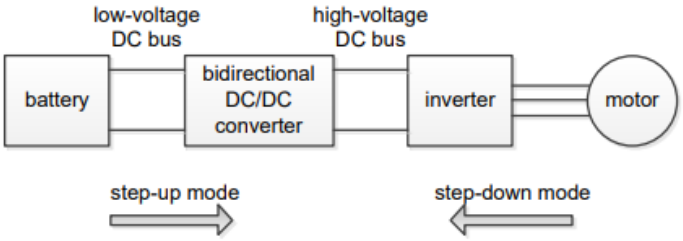

Figure 1 DC-DC converter in an electric vehicle

II. LITERATURE REVIEW

(Sonar, 2020)[1] Recently, Hybrid Electric Vehicles (HEV) has seen enormous development around the world. HEV's growth in this field has been huge. Because of rising emissions from traditional cars, rising fuel costs, and global warming environmental issues, the automotive sector is turning its attention towards developing HEVs. The HEVs have various configurations depending on the hybridization degree to provide simultaneous traction efficiency for the IC engines and electric batteries.. There are a physical description and simulation of hybrid fuel vehicles. In this article, the bidirectional complete bridge dc-dc converter, and the implementation of this converter in Series-Parallel HEV is discussed. The topology of the transforming converter accounts for motoring as well as regenerating breaking operations. The value of the dc-dc converter is suggested.

(Sowmya et al., 2017) [2]It was proposed to promote recovery of energy before and during braking downhill travel by using a bi-face DC-DC converter between the power source and traction engine. This integration will also increase traction driving performance and improve the range by 25 percent. Now the right bidirectional DC-DC converter heading can be used to maximize architecture efficiency in order to decrease weight, size, and system expense. This paper reviews and explores the fundamental bidirectional topology of the DC-DC converter and describes the comparative benefits for making the right electric car design decision.

(Chakraborty et al., 2019) [4]This paper discusses the scientific implications, the state of the world of research and development. In the sense of increasing alarm over increased emissions and the resulting global warming, Hybrid Electric Vehicles (HEV) has earned considerable interest. HEV is driven by a battery or mixed with electricity. HEV is primarily driven by a bacterium. HEV and other vehicle configurations such as Battery Electric Vehicles (BEV), Plug-in Hybrid Electric Vehicles (PHEV) is also gaining importance with growing concern towards the environment.

(SaiTeja et al., 2019) [5] Highlighted that "a bidirectional chopper (BDC) is the only element which can interface main source (HVS), auxiliary source (LVS), and a DC Bus voltage at different levels which is implemented in Hybrid Electric Vehicle (HEV)". This transformer process is composed of different mechanisms: double operation and refurbishing function in both dimensions with voltage regulation. And the autonomous supply voltage regulates two outlets (i.e., the dual-source buck-boost mode). Simulated results have included the regulation of the loop and the contrast between PI and ANN regulation, as well as the closed neural artificial network (ANN).

(de Melo et al., 2020) [6] Submitted that electric hybrid cars and pure electric vehicles, where successful conservation of energy is critical, rely on energy storage systems (ESDs) and electronic transformers. In this paper, a

proposed EV architecture is explored based on super condensers (SCs) and packs for a safe and rapid electrical transition. The transfer of power according to the above sources of energy to the EV occurs through the DC-converter link. The topology reveals the small number and high reliability of modules over a wide spectrum of loads suitable for high-performance, high-current values. The systematic modeling method includes the evaluation of the transformer and operation of the control system by a fundamental approach, namely the average current mode function.

(Devi Vidhya&Balaji, 2020) [7]The electronic power interface, with its powerful control system, has an important role in the use of energy sources to use electric cars. For this reason, a multiple-input converter (MIC) topology hybrid fuzzy pi-based control scheme is suggested. Include a traditional solid PI controller and fluid transfer PI in the proposed hybrid fuzzy PI controller. The proposed control design also supports the monitoring of a pre-defined speed profile to complete electric vehicle development. Detailed simulation and efficiency analyses are carried out with traditional controllers. The results show that the device is resilient and offers two-way power control, fast monitoring capability with less stable state error, increased dynamic response by improving flexibility and proper use of energy sources. A simulation of the output of the multi-input converter in the MATLAB/SIMULINK environment with the built control system is performed.

(Antony &Rajitha, 2020) [8] Announced that a range of applications such as electric vegetables, renewable sources, and UPS have been transformed by DC-DC converters. These converters are useful to transform the direct current to various voltage levels. A two-way DC-DC converter (BDC) is a DC-DC converter which, with its high power transmission and reduced dimensions, is used to flow power in both directions and dominates unidirectional converters. Therefore the industrial and testing areas of these transformers obtain more attraction. In two key modes, these converters operate. Buck or low-stress mode, while the other is high tension or boost mode. The output voltage in buck mode is lower than the input, and in boost mode, the output is higher than the specified input. These papers propose a two-way DC-DC converter that functions in buck and boost modes and is being tested in its use in battery-powered vehicles. The added value of this converter is the ability to charge the grid.

(Jagadeesh&Indragandhi, 2019) [9] Paper with a variety of DC-DC converters such as sepic, boost or bi-directional converter is reported. Integrating the booster, the sepic, two-way DC-DC converter helps you to define the required converter with an exact power rating for renewable energy applications. On the basis of this analysis, the efficiency of the non-isolated converter is evaluated. So the converter is used to move up/down the voltage stage, so the conversion efficacy of PV is low. This paper aims to carry out an analysis of the performance and voltage and current tension on the converters of the DC-DC converters. The simple electric photovoltaic vehicles and electric fuel cells are discussed in depth.

III. METHODOLOGY

A. Bidirectional DC tO DC converter

The Bidirectional DC/DC converter feature consists of interfacing with the DB bus of the driving inverter with dual-battery energy storage.

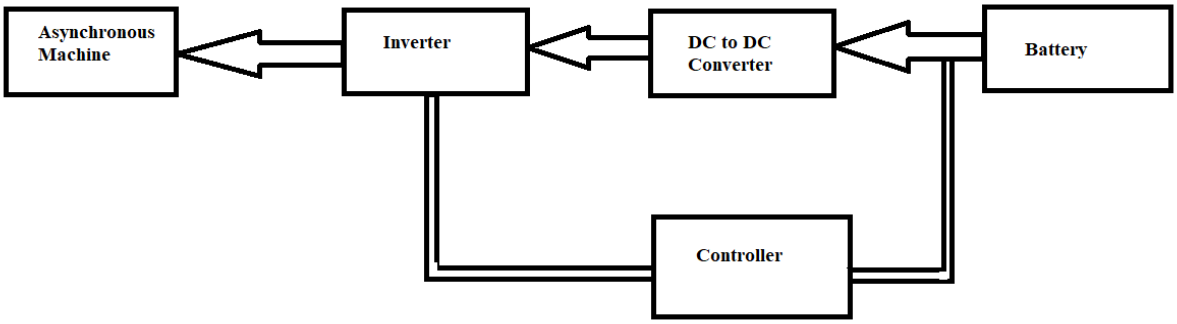

Figure 2 Block Diagram of DC to DC Convertor

B. Basic components of Fuzzy Controller

Regulation of logic fuzzy relies largely on the laws of language variables. Unlike other approaches, Fuzzy logic control is free of complex numbers. The model is only tracked using basic mathematical equations. It offers good performance in a control scheme despite relying on simple mathematical analysis. This approach is, therefore, one of the better and much easiest methods for managing a plant.

Logic control Fuzzy is based on the principle of the Fuzzy series. In the theory of fuzzy, each element is associated with a certain extent of association. We may say that fuzzy sets, without finer borders, are like classic sets. When accuracy is mild, and the plant is devoid of sophisticated mathematical analysis, the Fuzzy Logic Controller (FLC) is used most.

"The three main components of a Fuzzy Logic controller are

- Fuzzification
- Fuzzy Rule base and interfacing engine
- Defuzzification."

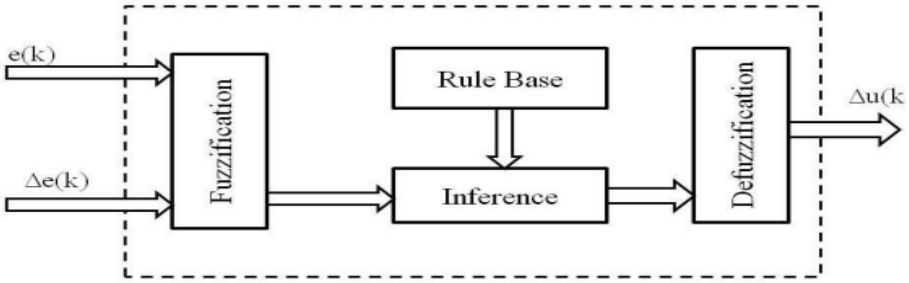

Figure 3 Internal Block Diagram of Fuzzy Control

IV. RESULTS AND DISCUSSION

The strategy implementation stage provides an assessment of the need for electricity as well as a power and voltage management facility for the car. The global management findings have to optimize the usage of the source, which better meets the demand for power from the driver and the lane. The DC-bus voltage is regulated and driven by the FC stack by means of a dc- DC converter in FCV/HEV power systems. So the boost converter current iL1 or iL2 is identified and matched with the reference current for regulating the system frequency instead of monitoring the transformer output voltage of each operating mode. The motor fuel & power & voltage monitoring unit in the converter control structure specifies the BDC mode in compliance with vehicle operating conditions such as various moving power specifications (Pdem) and the double source voltages (VES1, VES2). The present references iL 1, refer or iL2, réf can be chosen, and the active switches (S, Q1~Q4) can be regulated with a proportional-integral system (PI) or more advanced.

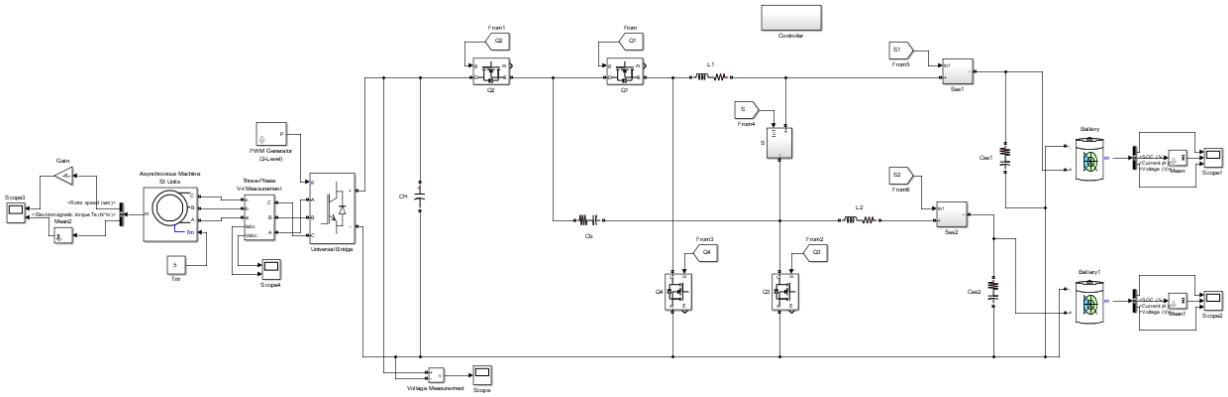

Figure 4 Proposed bidirectional converter

In the above proposed converter there are three bidirectional switches and four MOSFETs for changing the mode of operation of the circuit. The modes are changed with respect to the state of the charge of the battery and the induction

machine operation (motoring mode or generator mode).

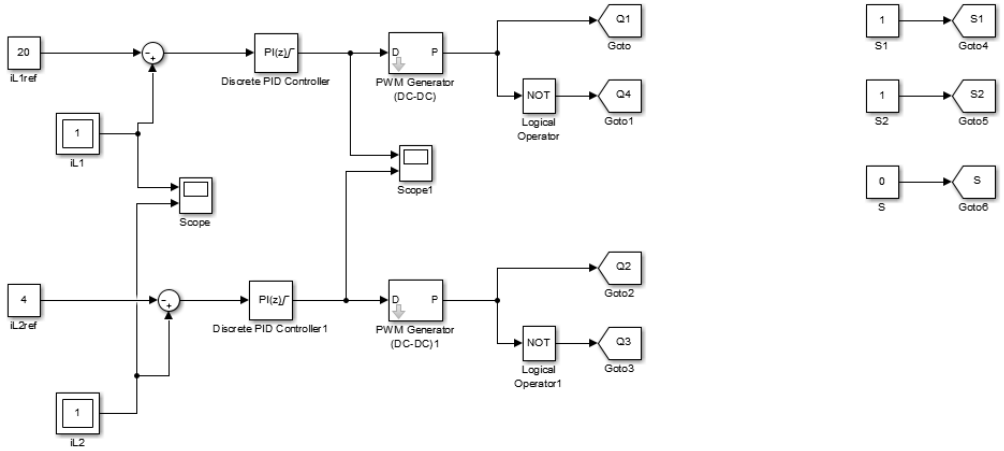

Figure 5 Proposed control srtucture

The above is the controller in mode A for operating swithcesQ1Q2Q3 and Q4. In mode A the swithcesS1 and S2 are ON and S is in OFF states. The swithcesQ1Q4 and Q2Q3 are complimetary switches which operate alternatively. The duty ratio is generated by PI controller with comprison of reference value with measured value. The below are the operating characteritics graphs of the devices during all modes.

The PI controller is replaced with fuzzy controller with 49 rule base with two input variables and one output variable.

The fuzzy controller uses two input membership variables error E and change in error dE. There is only one output for the fuzzy function. The function considered is ‘mamdani’ function with seven membership functions in each variable. The input membership functions have gauss format and are shown below.

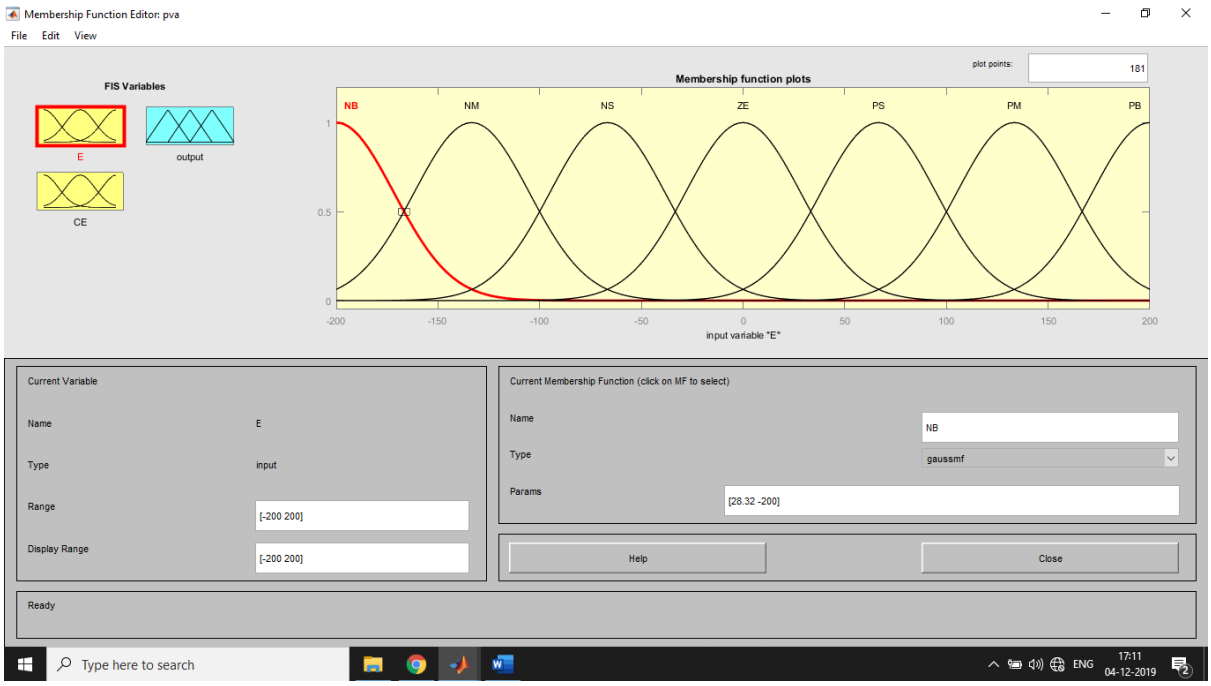

Figure 6 Error input membership function

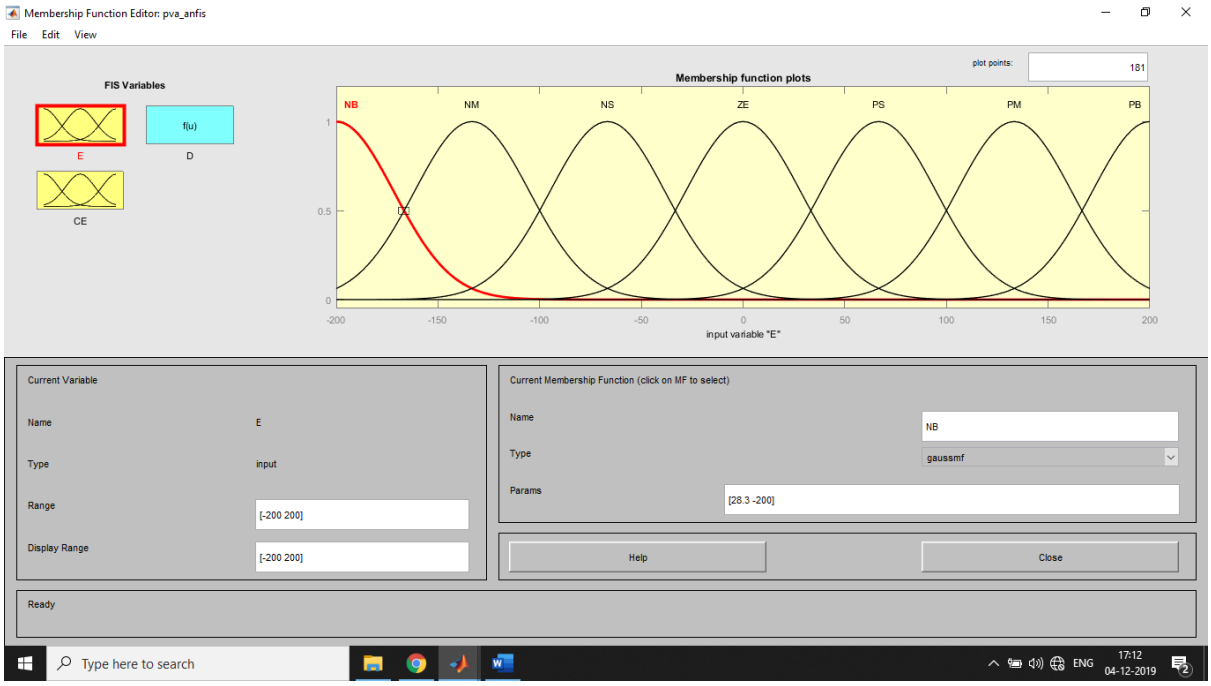

Figure 7 Change in error input membership function

The output membership functions are of triangular format.

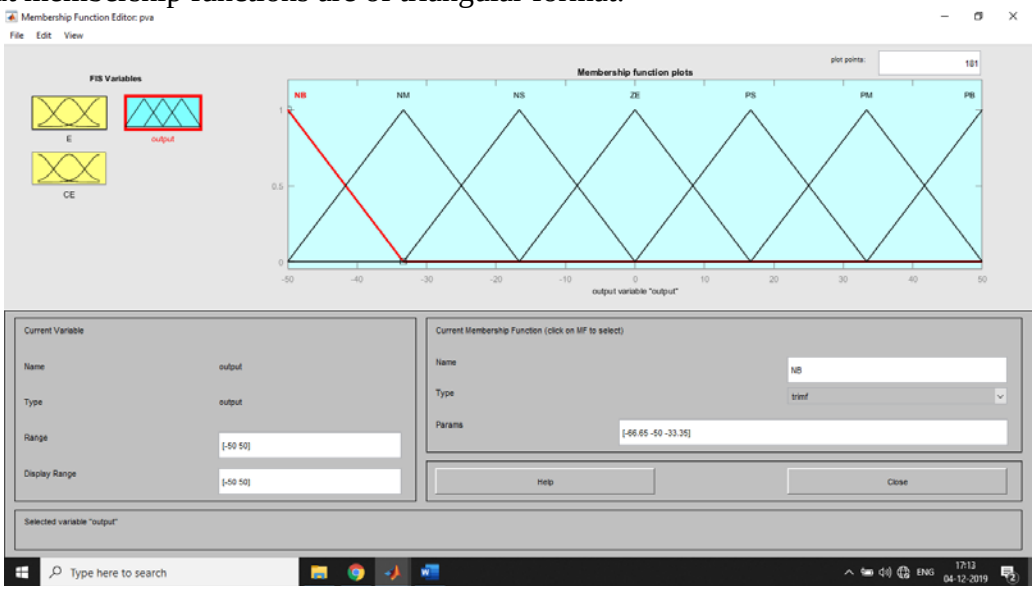

Figure 8 Output membership functions

There are numbers of software available which can mimic the process involved in your research work and can produce the possible result. One of such type of software is Matlab. You can readily find Mfiles related to your research work on internet or in some cases these can require few modifications. Once these Mfiles are uploaded in software, you can get the simulated results of your paper and it easies the process of paper writing.

V. CONCLUSION

As per the graphs generated the batteries are charged and discharge with respect to mode of operation (Mode A or B or C) and the charateristics are compared with different controllers (PI and fuzzy). All the graphs are generated with repect to time with torque of the motor in postive (motoring mode) and negative (generation mode). The DC link voltage of fuzzy control system is stable and settles faster as compared to PI controller model.

In this case, the importance of Fuzzy logic in some areas is often taken into account and understood various forms of speed modulation for a separately excited DC motor. Several concepts have been observing and researching the Fuzzy logic as well as the Fuzzy set theory. The DC engine's speed-torque properties are

also studied. This paper has introduced a new soft-switched, independent two-way dc-dc converter. It explained the process, analytical functionality, and architecture concerns. The working theory was tested by simulation and experimental findings for the 1KW prototype.

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