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Optimize Power Flow Between the HEB, HPB, Based on the Battery SOC and Driving Conditions Using Buck- Boost Converter Topology

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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 electrochemically independent continuously variable DC-DC converter to connect separate DC voltage bus and pass energy back backward and forwards. In this paper a battery connected induction motor drive is proposed with charging and discharging capabilities converter in motoring mode and regenerative breaking mode. Three bidirectional switches are used to charge and discharge the batteries 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. This paper presents the design and development of a bi-directional DC/DC converter integrated with a dual-battery energy storage system for HEVs. The proposed system aims to enhance energy management, improve system efficiency, and extend the lifespan of the batteries.

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

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increase the motivation for using Electric vehicles in transportation. This change will help in making our planet greener and cleaner environment. [2]

1.1DC-DCConverter

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]

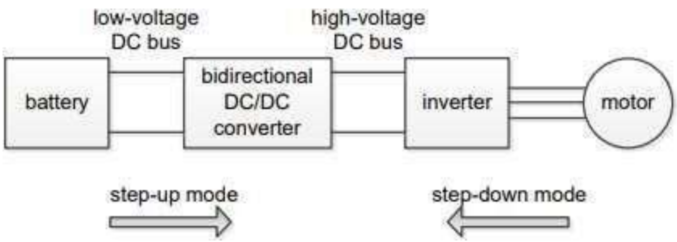


Figure1:DC-DC converter in an electric vehicle

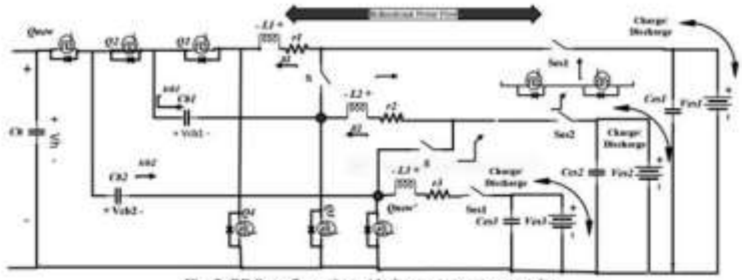


Fig 2 BDC configuration with three energy storage units

Table 1 Conduction status during different modes of operations.

Operating Modes	ON	OFF	Control switch	Synchronous Rectifier
Low-Voltage Battery-Source Powering/Motoring mode	SES1,SES2,SES3	S1,S2	Q1, Q2, Qnew	Q3, Q4, Qnew'
High-Voltage Regeneration mode	SES1,SES2,SES3	S1,S2	Q3, Q4, Qnew'	Q1, Q2, Qnew
Main source Buck/Boost Mode (VES1 to VES2/VES2 to VES1)	SES1,SES2,SES3	S2, Q1, Q2, Q4, Qnew, Qnew'	S1/Q3	Q3/S1
Auxiliary Source Buck/Boost Mode (VES1 to VES2/VES2 to VES1)	SES1,SES2,SES3	S1, Q1, Q2, Q3, Q4,Qnew	S2/Qnew'	Qnew'/S2
System Shutdown	-----	SES1, SES2, SES3 Q1,Q2,Q3,Q4,Qnew,Qnew'	-----	------

Figure3: Internal Block Diagram of Fuzzy Control

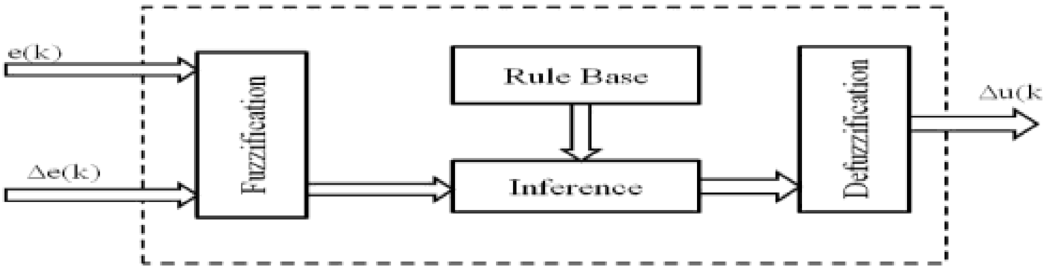
II. METHODOLOGY

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
- De fuzzification



III. 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.

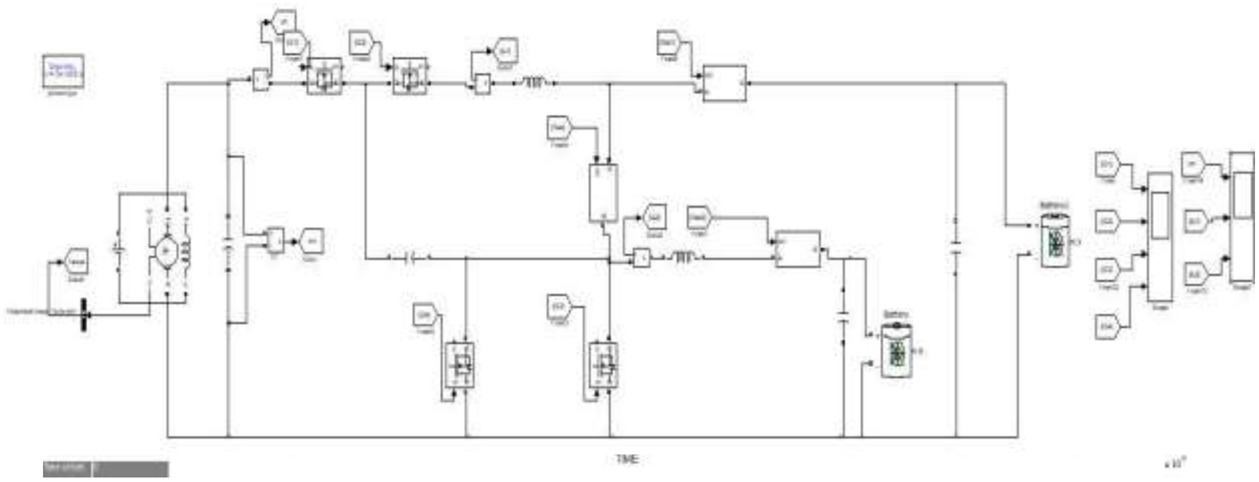


Figure4:Proposed bidirectional converter

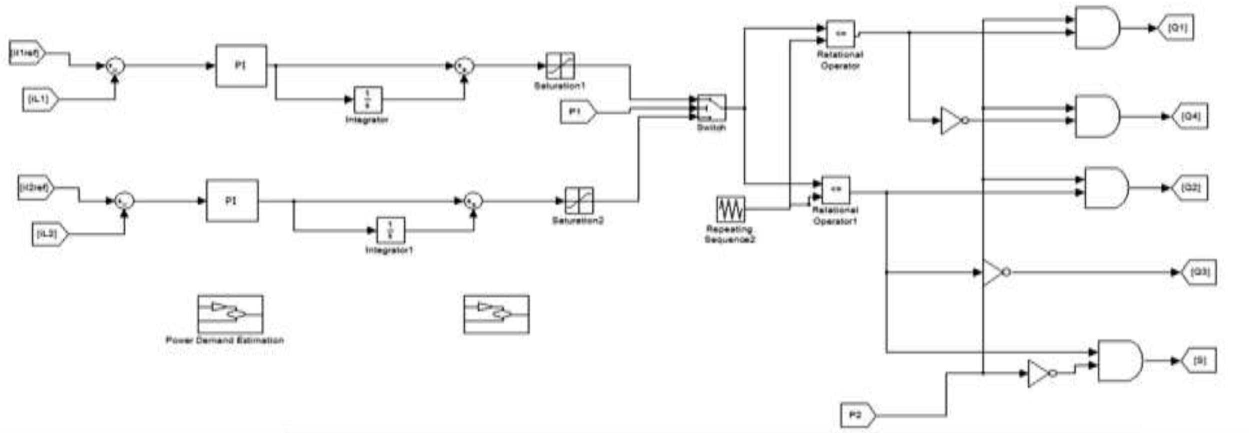
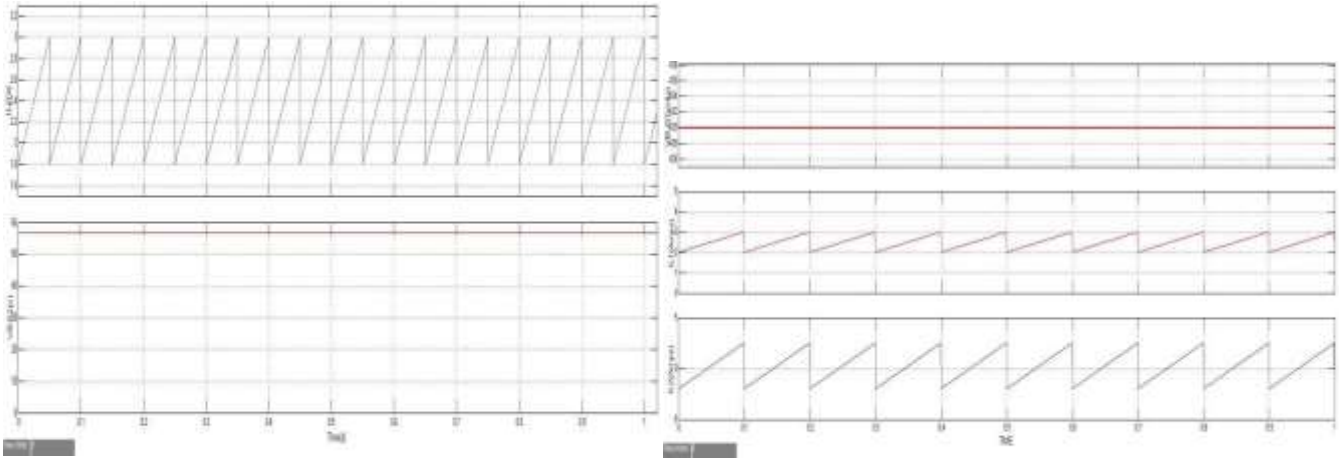


Figure5: a)Proposed controller

Figure5: b)Gate signals Q1,Q2,Q3,Q4.

In the above Proposed bidirectional converter show in figure 4. 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).

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 switches Q1Q4 and Q2Q3 are complimentary switches which operate alternatively. The duty ratio is generated by PI controller with comparison of reference value with measured value. The below are the operating characteristics graphs of the devices during all modes.



6 a) 6 b)

Figure6: a) power boost b) boost

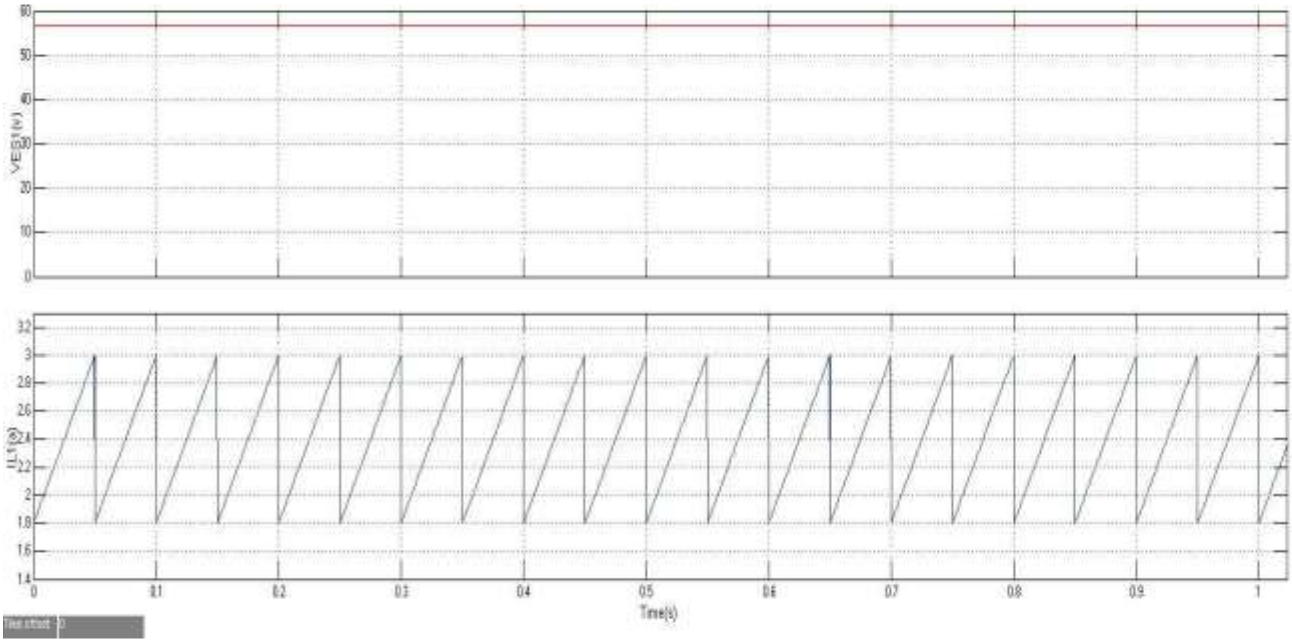


Figure7: power buck

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,

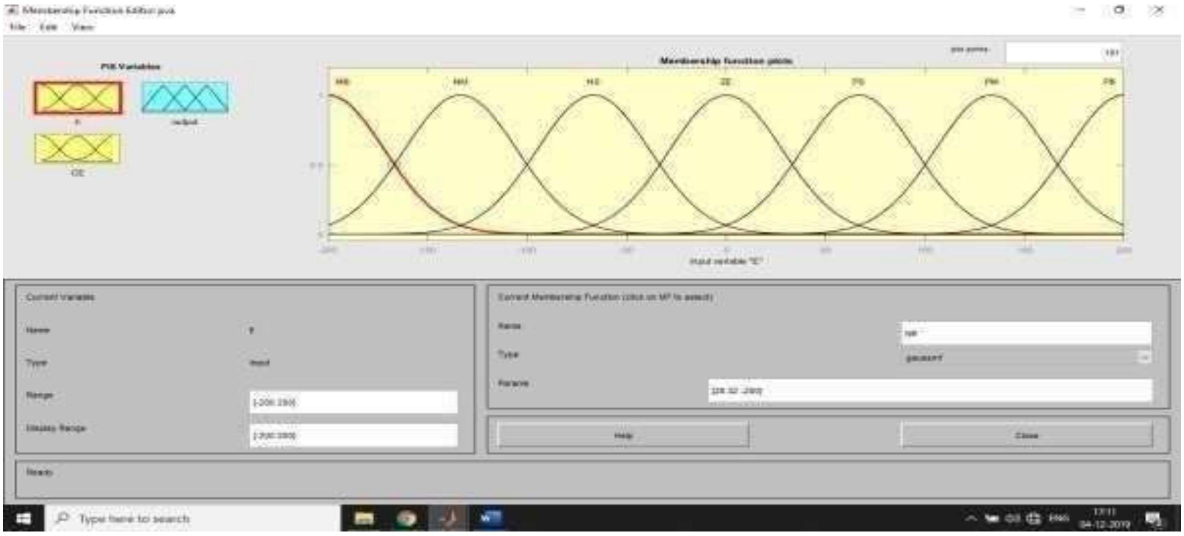


Figure 8:Error input membership function

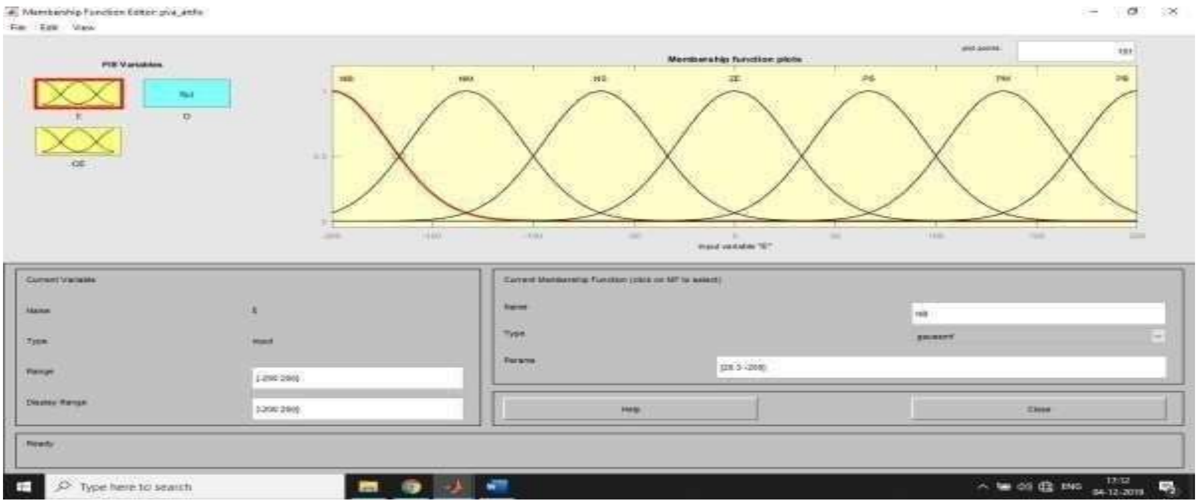


Figure9:Change in error input member ship function The output membership functions are of triangular format.

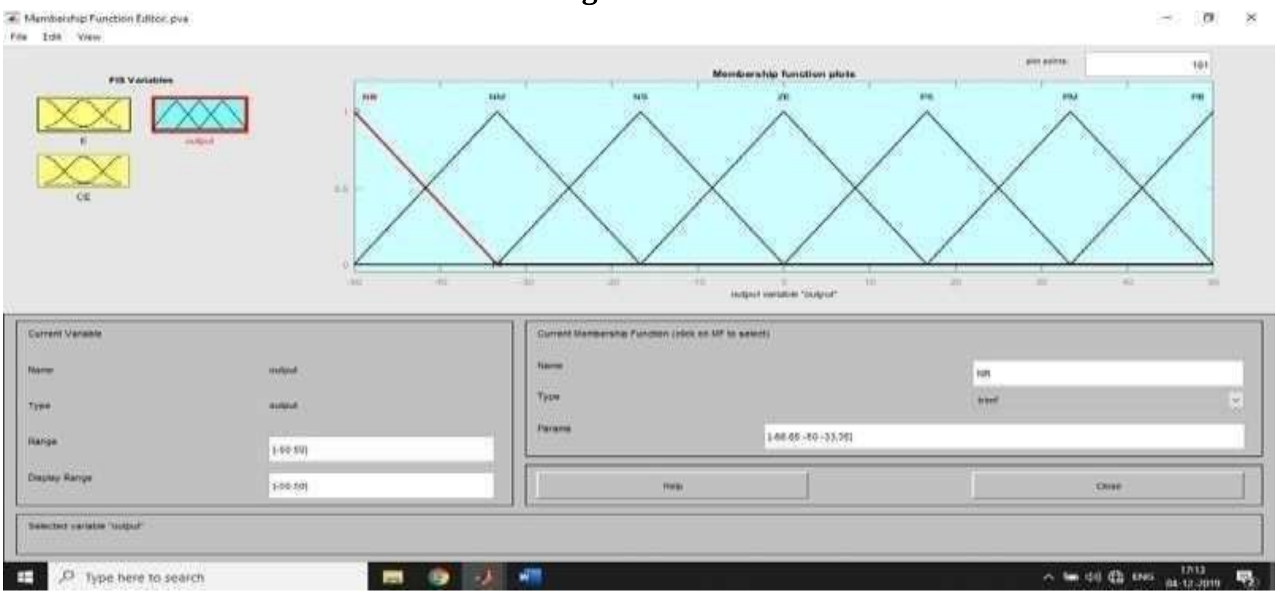


Figure10:Output member ship functions

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 M files related to your research work on internet or in some cases these can require few modifications .Once these M files are uploaded in software, you can get the simulated results of your paper and it easies the process of paper writing.

IV. 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 characteristics are compared with different controllers (PI and fuzzy). All the graphs are generated with respect to time with torque of the motor in positive (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. Three bidirectional switches are used to charge and discharge the batteries 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 calculates the duty ratio for the switches connected in the converter. A PWM pulse is generated at very high frequency for the switches at different modes run using MATLAB Simulink software. The output 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.

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```
clc; clear; close all;
% Battery Parameters
V_batt = 300;   % Battery voltage (V) SOC_batt = 0.8;  % Initial State of Charge P_batt_max = 50; % Max battery power (kW)
% Supercapacitor Parameters
V_sc = 48;               % Supercapacitor voltage (V) SOC_sc = 0.5;   % Initial SOC
P_sc_max = 20;   % Max supercapacitor power (kW)
% Fuel Cell Parameters
V_fc = 400;              % Fuel cell voltage (V) P_fc_max = 80;   % Max fuel cell power (kW)
% Load Demand
T = 0:1:100;             % Time (seconds)
P_load = 40 + 20*sin(0.1*T); % Dynamic load profile (kW)
% Power Sharing Logic P_batt = zeros(size(T)); P_sc = zeros(size(T)); P_fc = zeros(size(T));
for i = 1:length(T)
if P_load(i) <= P_fc_max
P_fc(i) = P_load(i); % Fuel cell supplies all power else
P_fc(i) = P_fc_max; % Fuel cell supplies max power remaining_power = P_load(i) - P_fc_max;
if remaining_power <= P_batt_max
P_batt(i) = remaining_power; % Battery supports extra load else
P_batt(i) = P_batt_max; % Battery supplies max power
P_sc(i) = remaining_power - P_batt_max; % Supercapacitor covers remaining demand end
end end
% Plot Power Distribution figure;
plot(T, P_load, 'k', 'LineWidth', 1.5); hold on;
plot(T, P_fc, 'r', 'LineWidth', 1.5);
plot(T, P_batt, 'b', 'LineWidth', 1.5);
plot(T, P_sc, 'g', 'LineWidth', 1.5);
legend('Load Demand', 'Fuel Cell Power', 'Battery Power', 'Supercapacitor Power');
xlabel('Time (s)'); ylabel('Power (kW)');
title('Power Distribution in Three-Port DC-DC Converter'); grid on;
```