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Design of Intelligent Based Control of DC-DC Converter Fed DC Drives

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ABSTRACT: This paper presents a unique model for the simulation of buck-boost converter fed DC drive implemented with smart control technique. The ultimate aim of this paper is to achieve high power factor and achieve a faster settling of the output. This paper introduces the method of intelligent regulation of speed of the dc drives using fuzzy logic control technique. It also proposes the model of implementing IGBT as the switch with integrated double buck-boost converter. Here we use an EMI filter which filters the disturbances. An explanation about fuzzy logic controller is given. Fuzzy logic is getting increased emphasis in control application. The variation of output is smaller and settles faster than other control techniques.

KEYWORDS: Fuzzy Logic controller, DC-DC Buck-Boost Converter,Simulink MATLAB,IGBT,Power factor.

I.INTRODUCTION

DC to DC converters are controlled by analog integrated circuit technology and linear system design techniques. The aim of power electronics is to process and control the flow of electrical energy by supplying voltages and current. Direct current motor drives have been used where accurate speed control is required. As AC motors are rugged, cheaper and lightered motors controlled by a converter is still a very popular choice in specific applications. In this paper we present a case of using fuzzy logic control for regulating DC-DC converters. Here we describe the use of fuzzy control scheme. Computer simulations are used to verify the proposed fuzzy control [1-5].

It uses output voltage of the converter as feedback for significantly improving the dynamic performance of Buck-Boost DC-DC converter by using MATLAB/SIMULINK.As compared to open loop system the idea to have a control system in DC-DC converter is to ensure desired voltage level of the output. This paper also uses IGBT for switching purpose in the Buck-Boost converter circuit for better performance and reduced losses.

Crucial to the performance of power converters is the choice of control methods. Traditional frequency domain analog methods are predominantly used in controller design, which are based essentially on an equivalent linear small-signal model of the converter concerned. Performance is usually traded off for simplicity since linear small-signal models have rather restricted validity, especially for systems with strong nonlinearity. There are two possible routes of escape from the conventional framework of linear control. First one is is to develop more accurate nonlinear models on which high performance controller design can be based. The disadvantage about taking this route is that complex mathematical derivations are often involved which, with very few exceptions, lead to very complicated control algorithms that are not suitable for practical implementation.

The second for escape is to employ heuristic reasoning based on human experience of the plant. Such experience is usually collected in the form of linguistic statements and rules. In this case, no modeling is at all required, and the whole business of controller design reduces to the “conversion” of a set of linguistic rules into an automatic control algorithm [6-9]. Here, fuzzy logic comes into play as it provides the essential machinery for performing the said conversion. Fuzzy variables are preferred since we can frame any number of rules as per our requirement based on the If..Then conditions. They are known as smart control techniques since they replace complex mathematical calculations

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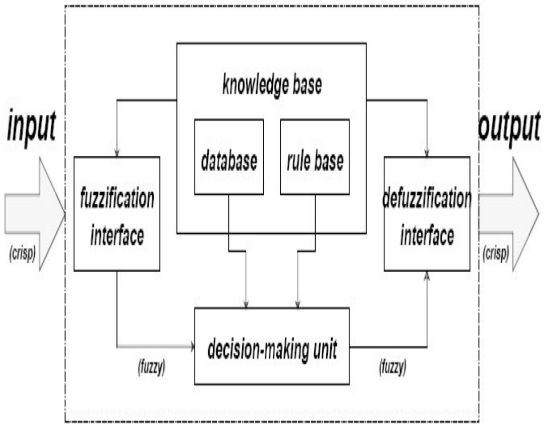
which are involved in other control techniques and prove themselves a better one. Fuzzy controllers are very simple conceptually. They consist of a processing stage, and an output stage which is discussed here.

II.DESIGN OF FUZZY LOGIC CONTROLLER



Conventionally, PD, PI and PID controller are most popular controllers and they are widely used in most power electronic closed loop appliances. In the recent years there are many researchers who have reported successfully and adopted the Fuzzy Logic Controller (FLC) to become one of the intelligent controllers. This paper uses fuzzy logic controller with feedback of voltage output. The voltage output in the circuit will be fed to fuzzy controller to give appropriate measure on steady state signal. This technique can be applied to many dc-dc converter topologies such as Buck, Boost and Buck-Boost. Based on the human reasoning fuzzy logic control is built up by a group of rules of system behavior. For the dynamic behavior of dc-to-dc converter and performance of proposed controllers we use Matlab simulation. The design of fuzzy logic controller can provide desirable both large signal and small signal dynamic performance , which is not possible in linear control technique. The basic scheme of the controller consists of four basic components such as: a Fuzzification, which converts input data value into suitable linguistic values; a knowledge base, which consists of control rule set and a data base with the necessary linguistic definitions ; a Decision-Making logic ,which is use to simulating a human decision process and infer the fuzzy control action from the knowledge of the control rules and linguistic variable definitions; And a Defuzzification interface, which yields non fuzzy control action from an inferred fuzzy control action. It also provides the storage energy information in the converter [10-12].

III.FUZZY LOGIC TABLE RULES

Fuzzy controller rules which are play a very important role for controller simulation are obtained from the analysis of the system behavior. In their formulation it must be considered that, By using this controller we improve the converter performances in terms of dynamic response and robustness. when the output voltage is far from the set point i.e. error (e) is NB or PB, the controller must be do the strong corrective action i.e. duty cycle close to zero or have the dynamic response as fast as possible, obviously taking into account current limit specifications of the system. Here in this paper we have taken seven fuzzy logic variables thereby we end up in 49 rules. The rule table of Fuzzy Logic Table is shown below.

Table1: Rule Table of FLC

c* / e	NB	NM	NS	ZE	PS	PM	PB
NB	NB	NB	NB	NB	NM	NS	ZE
NM	NB	NB	NM	NM	NS	ZE	PS
NS	NB	NM	NS	NS	ZE	PS	PM
ZE	NB	NM	NS	ZE	PS	PM	PB
PS	NM	NS	ZE	PS	PS	PM	PB
PM	NS	ZE	PS	PM	PM	PB	PB
PB	ZE	PS	PM	PB	PB	PB	PB

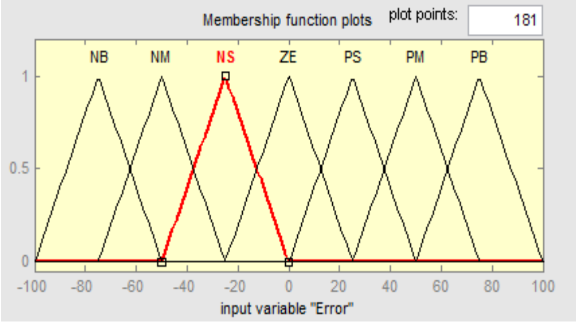


Fig.1.Membership Function Editor for Error(e)

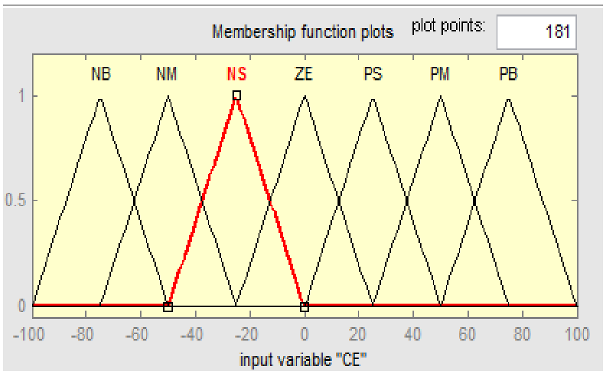


Fig.2.Membership Function Editor for Change in Error(ce)

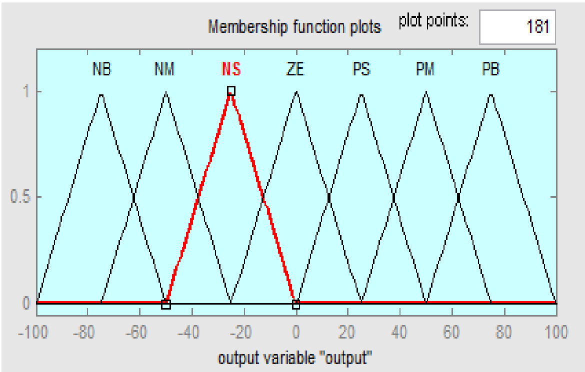


Fig.3.Membership Function Editor for Output

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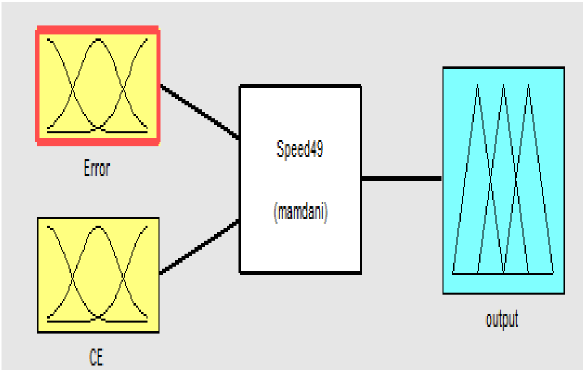

Fig.4.Fuzzy Inference System(FIS)

1. If (Error is NB) and (CE is NB) then (output is NB) (1)
2. If (Error is NM) and (CE is NB) then (output is NB) (1)
3. If (Error is NS) and (CE is NB) then (output is NB) (1)
4. If (Error is ZE) and (CE is NB) then (output is NB) (1)
5. If (Error is PS) and (CE is NB) then (output is NM) (1)
6. If (Error is PM) and (CE is NB) then (output is NS) (1)
7. If (Error is PB) and (CE is NB) then (output is ZE) (1)
8. If (Error is NB) and (CE is NM) then (output is NB) (1)
9. If (Error is NM) and (CE is NM) then (output is NB) (1)
10. If (Error is NS) and (CE is NM) then (output is NB) (1)
11. If (Error is ZE) and (CE is NM) then (output is NM) (1)
12. If (Error is PS) and (CE is NM) then (output is NS) (1)
13. If (Error is PM) and (CE is NM) then (output is ZE) (1)
14. If (Error is PB) and (CE is NM) then (output is PS) (1)
15. If (Error is NB) and (CE is NS) then (output is NB) (1)
16. If (Error is NM) and (CE is NS) then (output is NB) (1)
17. If (Error is NS) and (CE is NS) then (output is NM) (1)
18. If (Error is ZE) and (CE is NS) then (output is NS) (1)
19. If (Error is PS) and (CE is NS) then (output is ZE) (1)
20. If (Error is PM) and (CE is NS) then (output is PS) (1)
21. If (Error is PB) and (CE is NS) then (output is PM) (1)
22. If (Error is NB) and (CE is ZE) then (output is NB) (1)

Fig.5.Rule Editor for FIS

IV.BUCK-BOOST CONVERTER

Buck-boost DC-DC converter is an important element, since buck-boost converter is able to regulate the output voltage that may be less or greater than the input voltage. Buck-boost converter allows more flexibility in modulating the energy transfer from the input source to the load by varying the duty cycle D[13-14]. The operation of the buck-boost converter can be divided into two modes, namely ―on state and ―off state. During the on state the IGBT is turned on and the diode Dm is reverse biased. The input source flows through the inductor L. When IGBT is turned off during off state, the energy stored in the inductor L will be transferred to the load until the next on state. By varying the duty cycle D, the output voltage is changed accordingly. In buck-boost converter, the output polarity is opposite to the input polarity. Thus, the mean input power *Pg* can now be calculated, taking into account that both input waveforms will be sinusoidal is given as follows,

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$$P_g = \frac{1}{2} V_g \langle i_g \rangle_{\text{peak}} = \frac{D^2 V_g^2}{4 L_i f_S}$$

The input inductance *Li* can be calculated for a given output power assuming 100% efficiency as,

$$L_i = \frac{D^2 V_g^2}{4 P_O f_S}.$$

The output inductance and capacitance *LO* and *CO*
are obtained using the well-known expressions for a buck–boost converter operating in CCM as follows,

$$L_O = \frac{D V_B}{0.5 \Delta I_{Lo\_\text{HF}} f_S}$$

$$C_O = \frac{D I_O}{\Delta V_{O\_\text{HF}} f_S}$$

Then, assuming 100% efficiency, by equaling above equation, the output voltage is finally obtained as follows,

$$V_O = \frac{D V_g}{2\sqrt{K}}$$

The Duty Cycle for the Buck-Boost Converter can be given by,

$$D = \frac{V_o}{V_o - V_i}$$

V.SIMULATION RESULTS

The model was simulated with both PID control and Fuzzy Logic Control. A comparison was made between the results of both the techniques. It is observed that Fuzzy technique proves to be more efficient and distortion free than PID control Technique.PID control technique includes some complex mathematical calculations where as fuzzy logic technique fully includes usage of linguistic variables.

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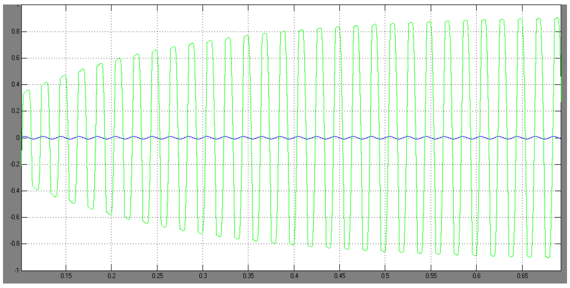

Fig.6.Input Powerfactor Waveform

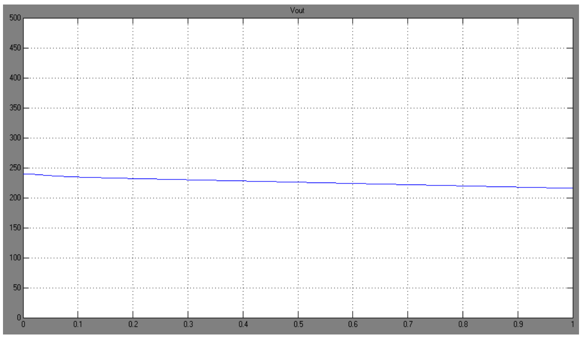

Fig.7. Output Voltage with PID Control

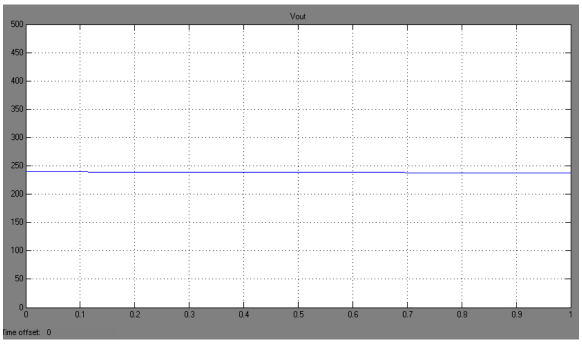

Fig.8. Output Voltage with Fuzzy Logic Control

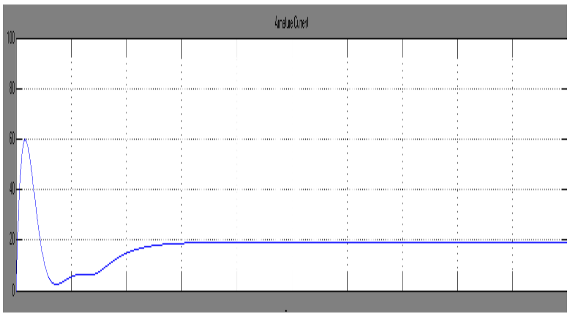

Fig.9. Armature Current Waveform with PID Control

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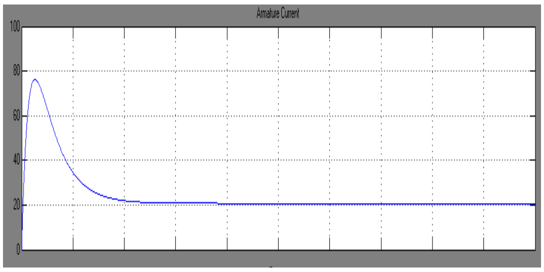

Fig.10. Armature Current Waveform with Fuzzy Logic Control

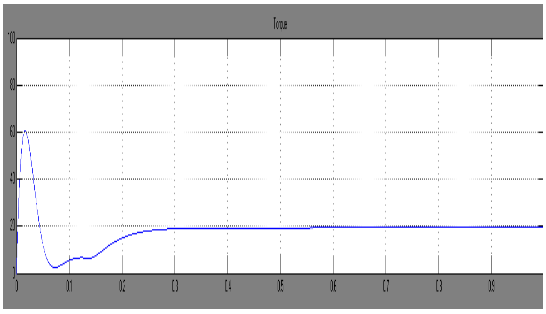

Fig.11.Torque Response Waveform with PID Control

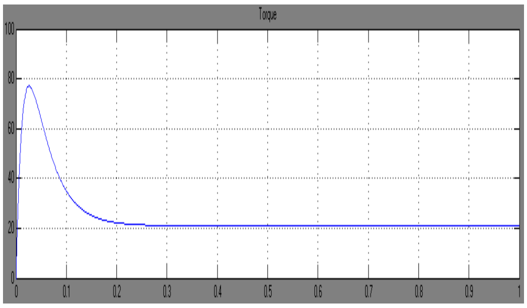

Fig.12. Torque Response waveform with FuzzyLogic Control

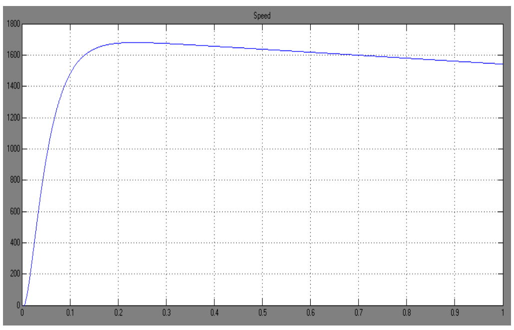

Fig.13. Speed Response Waveform with PID Control

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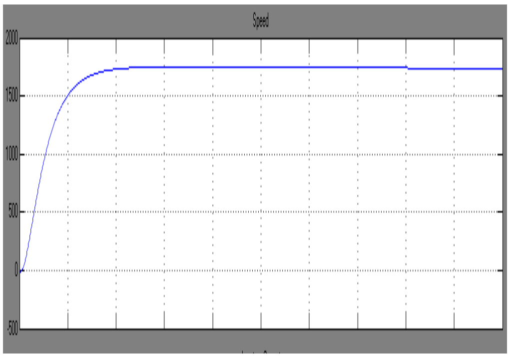

Fig.14. Speed Response waveform with Fuzzy Logic Control

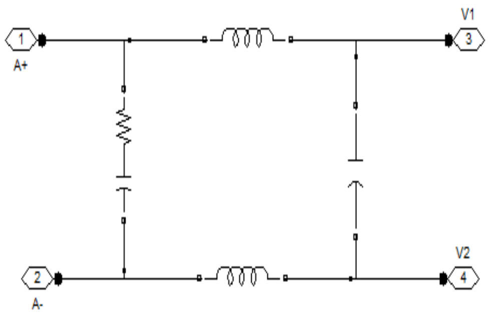

Fig.15. Simulink Diagram for EMI Filter

VI.CONCLUSION

In Conclusion, fuzzy logic controller is much better in overall performance and also provides high power factor, robustness and lesser settling time as compared to other control techniques. An output voltage of 240V was obtained with an input of 100V AC supply. Design of the fuzzy logic controller on Buck-Boost DC-DC converter by using MATLAB/SIMULINK has been successfully achieved. It is also observed that the circuit performs well on any kind of Voltage value either lower or higher and proves itself a Buck-Boost converter and also regulates the speed of the DC drive. Also the use of IGBT as a switching device in Buck-Boost converter circuit produces high power output with reduced switching losses. The health of the power system is maintained as it approaches a high power factor. Hence the circuit satisfies and provides the needed output.

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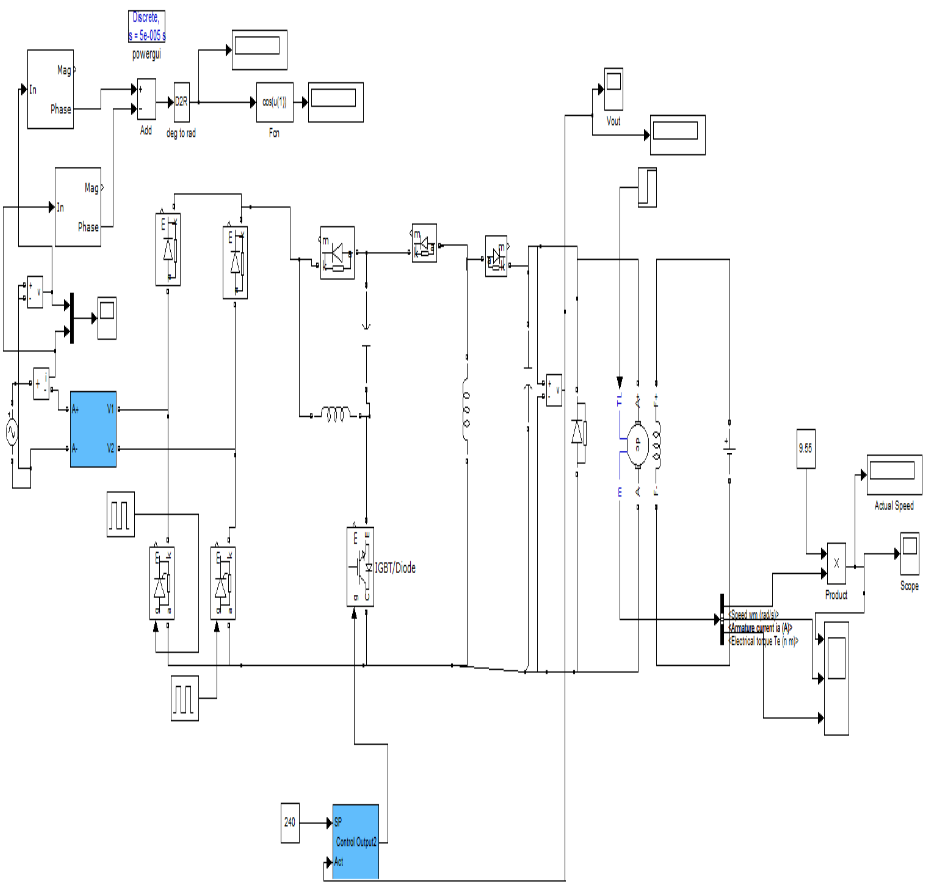

Fig.16. Simulink Diagram For Proposed Technique