HYBRID PI-FUZZY LOGIC CONTROLLER BASED DC-DC CONVERTER

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Abstract— *DC-DC converters are used to convert one DC voltage to other. One of the main limitations of these converters is unregulated supply of voltage and current. To overcome these problems there are various control techniques used in combination with these converters. The aims of developing the converters are high efficiency and high gain with fast response.*

A feedback controller for DC-DC boost converter is designed to obtain constant output voltage. Design equations are derived and it is modeled in MATLAB. Extensive simulation is carried out with linear controller parameters and the results are presented. Fuzzy logic controllers (FLC) and FLC tuned by PI controller have been investigated. The comparative study Results point out that FLC tuned by PI controller is superior to the other control strategies because of fast transient response, minimum steady state error and good disturbance rejection under various variations of the operating conditions. Hence, it achieves the most closely output voltage regulation.

KEYWORDS: Fuzzy logic Controller, PI Controller, DC-DC Boost Converter.

I. INTRODUCTION

In the previous few years the dc-dc converters are controlled using analog integrated circuit technology and linear system design techniques. Conventional control techniques used for dc-dc converters are PID controllers which tend to give linear characteristics [1]. However dc-dc converters exhibit nonlinear characteristics. The causes of nonlinearity in the power converters contain a variable structure within a single switching period, saturating inductances, voltage clamping, etc. So at whatever time there is any change in system, any parameter variations or even load disturbances PID controllers tend to be less [1-6]. To control non linear systems satisfactorily non linear controllers are repeatedly developed. It is continuously desirable for buck converters with constant output voltage that the output voltage remains unchanged in both steady and transient operations whenever the supply voltage and/or load current is disturbed. This condition is known as zero-voltage regulation, which means that the output voltage is independent of the supply voltage and the load current. To achieve zero voltage regulation, the choice of the control method acting a very critical role in the performance of converters. The normally used method in converters is the time ratio control. This method is too complicated to be practically executed. A different popular method is the current control mode control. Except this method cannot eliminate the load current disturbances. Using human linguistic conditions and common sense, a number of fuzzy logic based controllers have been developed. The main trouble with fuzzy logic is that there is no systematic method for the design of fuzzy controllers [4,5]. Fuzzy logic, which is the logic on which fuzzy control is based, is much closer in spirit to human thinking and natural language than the conventional logical systems. Fundamentally, it gives an effective means of capturing the approximate, in accurate nature of the real world [2]. The necessary part of the FLC is a set of linguistic control rules related by the dual concept of fuzzy implication and the compositional rule of inference. The FLC gives an algorithm which can convert the linguistic control strategy based on expert knowledge into an automatic control strategy. Experience proves that the FLC yields results better to those obtained by conventional control algorithms. The FLC appears very beneficial when the processes are too complicated for analysis by conventional quantitative techniques [3].

II. BOOST CONVERTER

The boost converter of Fig. 3 is given with a switching period of T and a duty cycle of D. Again, assuming continuous conduction mode of operation, the state space equations when the main switch is ON are shown by, [6].

$$\begin{cases} \dfrac{di_L}{dt} = \dfrac{1}{L}(V_{in}) \\ \dfrac{dv_o}{dt} = \dfrac{1}{C}(-\dfrac{v_o}{R}) \end{cases}, \quad 0 < t < dT, \quad Q: ON$$

and when the switch is OFF

$$\begin{cases} \dfrac{di_L}{dt} = \dfrac{1}{L}(V_{in} - v_o) \\ \dfrac{dv_o}{dt} = \dfrac{1}{C}(i_L - \dfrac{v_o}{R}) \end{cases}, \quad dT < t < T, \quad Q:OFF$$

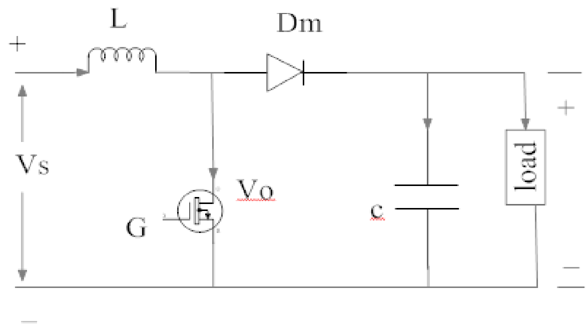


Fig.1 - DC-DC Boost Converter

III. FUZZY LOGIC CONTROLLER

Fuzzy system is useful in the formulation and quantification of human observations. A unique property of a fuzzy system is that the rules derived from the observational data provide knowledge of the system being simulated;this knowledge is in the form of linguistic rules that are understandable to a human in terms of the underlying physical system behavior.(book)Fuzzy gives a remarkably simple way to describe definite conclusions from vague ambiguous or imprecise information [7].

Structure of a fuzzy logic controller consists of: input, fuzzification, Rule base, Defuzzification, output. There are certain components characteristic of a fuzzy controller to support a design procedure. Figure 2 shows the controller between the input and output [8].

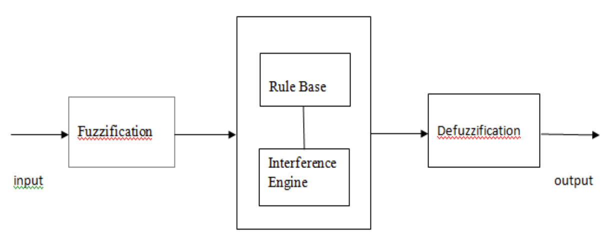


Fig. 2-Structure of fuzzy logic controller

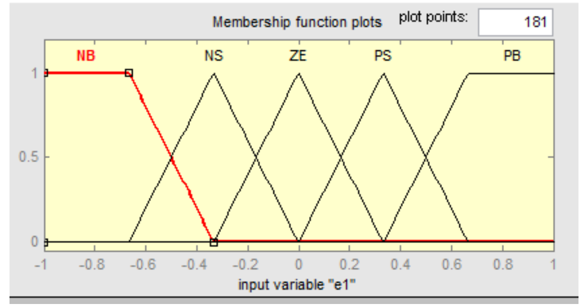


Fig. 3(a): Membership function of Error signal

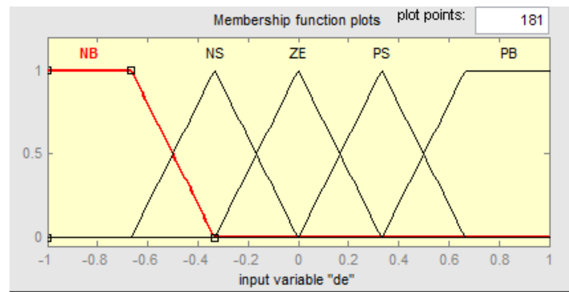


Fig. 3 (b) Member function of Derivative signal

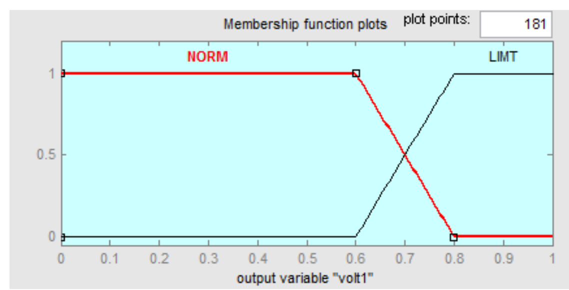


Fig. 3 (c) Membership function of Output

Table 1

Fuzzy Rule

		Error				
		NB	NS	ZE	PS	PB
Change in Error	NB	NB	NB	NB	NS	ZE
	NS	NB	NB	NS	ZE	PS
	ZE	NB	NS	ZE	PS	PB
	PS	NS	ZE	PS	PB	PB
	PB	ZE	PS	PB	PB	PB

IV. SIMULATION RESULTS

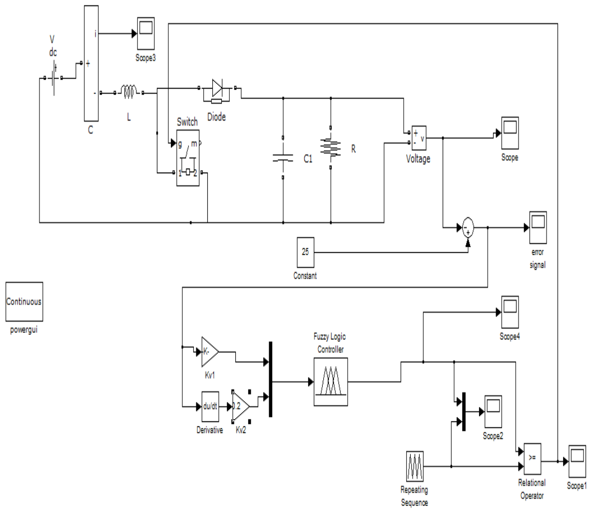


Fig.4 Simulink Model for Boost Converter with FLC Controller

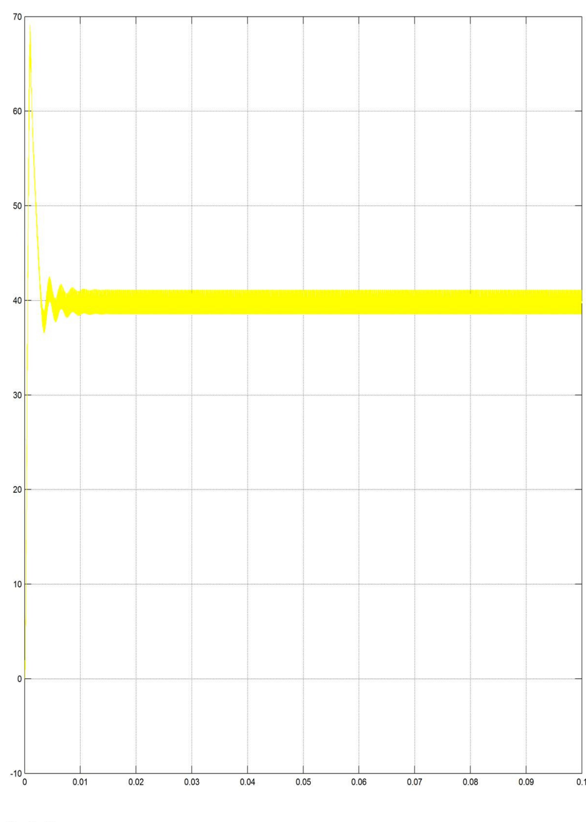


Fig. 5 Output of Boost Converter using Fuzzy Logic Controller

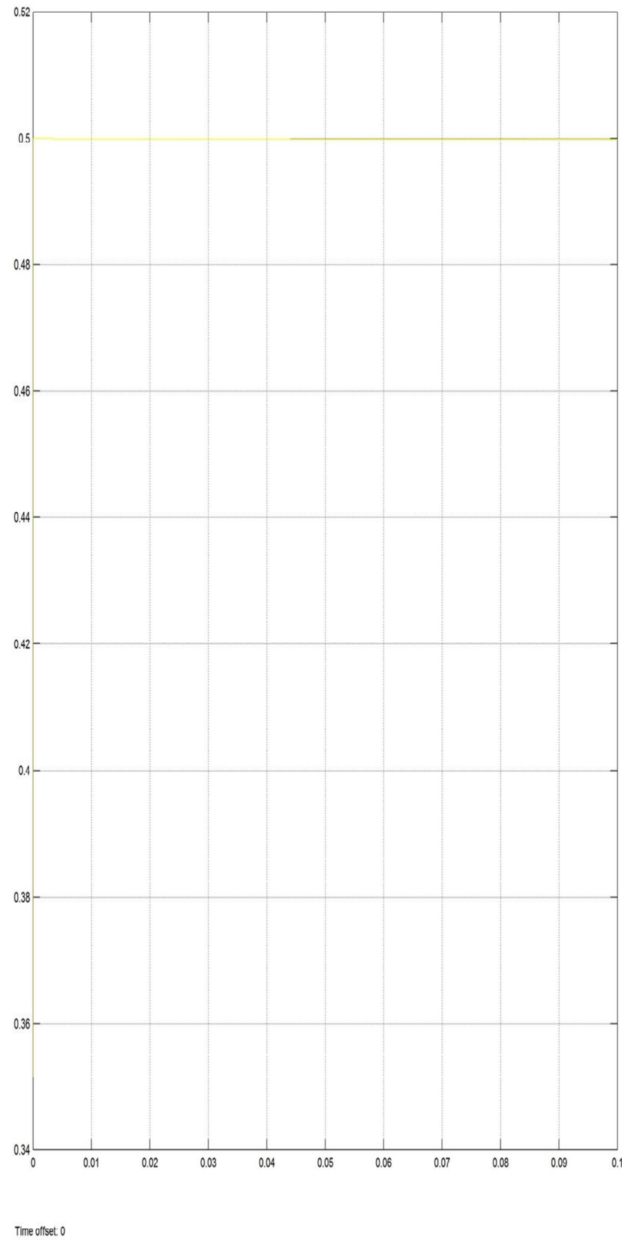


Fig. 6 Minimized Error Signal by Fuzzy Logic Controller

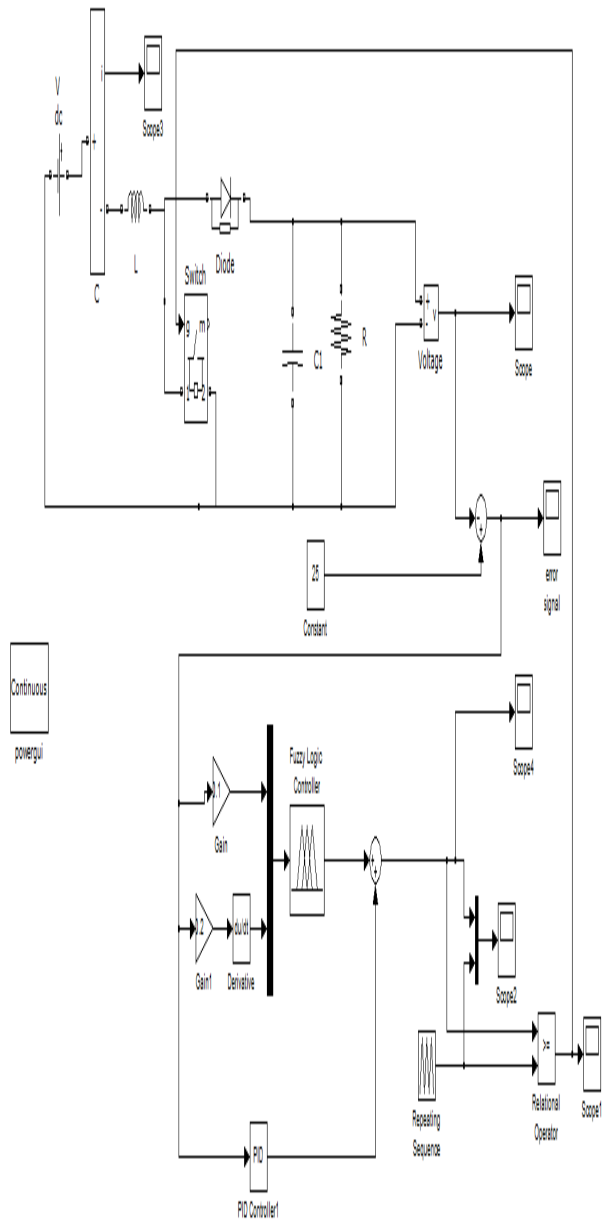
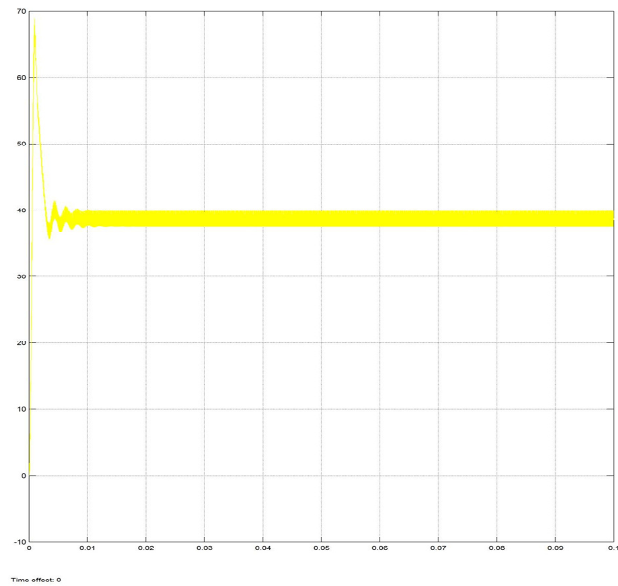


Fig. 7 Simulink Model for Boost Converter with Hybrid PI-FLC Controller



Output of Boost Converter using Hybrid PI- Fuzzy Logic Controller

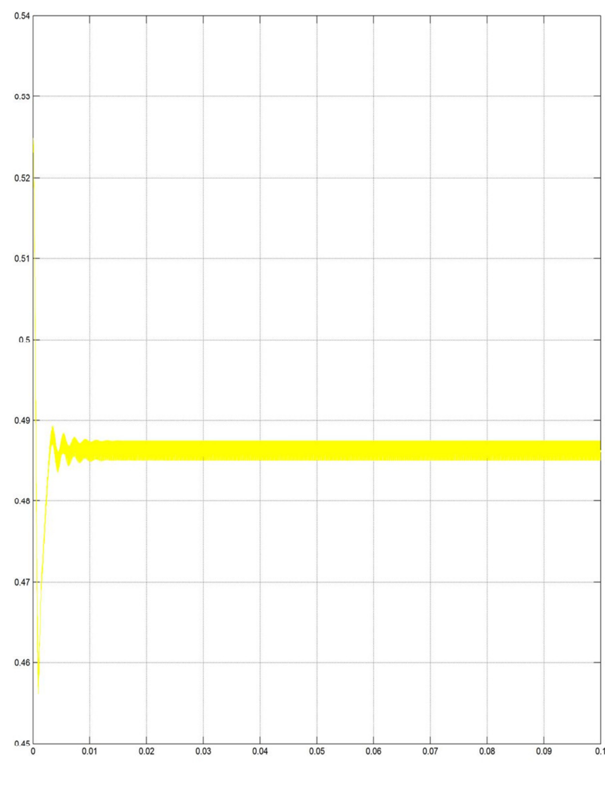


Fig.8 Minimized Error Signal by Hybrid PI-Fuzzy Logic Controller

V. CONCLUSION

A Feedback Controller for DC-DC Boost Converter is designed to obtain constant output voltage. Design equations are derived and it is modeled in MATLAB. Extensive simulation is carried out with linear controller parameters and the results are presented. Fuzzy Logic Controllers (FLC) and FLC tuned by PI controller have been investigated. The Comparative Study Results point out that FLC tuned by PI Controller is superior to the other control strategies because of fast transient response, minimum steady state error and good disturbance rejection under various variations of the operating conditions. Hence, It achieves the most closely output voltage regulation.

As per proposed controller in this paper the output of controller is 0.48 error, we want to optimize the output of controller in future apply sugeno based fuzzy logic controller.

In Future, apply Type-2 Fuzzy logic Controller on DC-DC Boost Converter to improve the response of DC-DC Converter and minimize the error signal to provide desired response.

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