COMPRATIVE ANALYSIS OF FUZZY LOGIC CONTROLLER AND ADAPTIVE NUERO FUZZY INFERENCE SYSTEM (ANFIS) CONTROLLER FOR THE DC-DC BOOST CONVERTER

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Abstract— this research offerings the comparison between the two controllers i.e. FLC and ANFIS controllers respectively on DC-DC step--up Converter. In this paper the MATLAB/SIMULINK software has been used through which output response of the open loop converter and closed loop converter has been carried out. The transient performance of the controller has been compared such as peak time, overshoot, and rise time, settling time and output voltage deviations. DC/DC step-up converter operated as a step-up the output voltage and step down the output current.

Index Terms— DC/DC Boost Converter, FLC, ANFIS CONTROLLER;

1 INTRODUCTION

The need of DC-DC step-up Converter is increase for the regulated process of batteries because the Photovoltaic System grows day by day. In different field such as automotive, aerospace, home appliances and in other application DC-DC Converter is mainly used. These converters are categorized in to two types i.e. Isolated and Non-isolated converters[1][2]. For the converter the controller designing is really important. Through analog IC technology and linear technology they have been controlled for a long time. The different types of converters are available which are more appropriate for application. From those types' converters some converters decrease the output voltage and other converters increase the output voltage. And third category converters perform either both increase and decrease the output response[3].

To control the switching power supply has always been a discouraging task of non-linear load. DC/DC boost converters change state from one voltage level to another level. Especially Boost converter consist of the non-linear elements such as MOSFT; IGBT; which produce unwanted fluctuations in the output voltage form. The desired result does not get from these converters for that purpose the need of controllers is mandatory. There are several types of controllers PI, PID, FLC, ANFIS, SMC (Sliding Mode controller)[4][5]. The PI, PID controllers are linear controllers which do not show robust performance of the Boost converter. For that reason in this research the non-linear controller FLC and ANFIS controller are taken to produce better transient performance and get the desired output result. Fuzzy Logic controller is the non-linear controller works with the logic. This offers the best performance of the controller with rules and fuzzification. The FLC controllers consist of the following Components[6].

1. Fuzzification
2. Fuzzy Rule Base
3. Inference mechanism
4. Defuzzification

ANFIS Controller is also non-linear controller. ANFIS controller is the combination of two controllers. FLC and neural network respectively. The fuzzy controller has many inputs and many outputs but neural network has many inputs and one output that's why the combination of both controllers makes ANFIS an intelligent controller. The main purpose of this controller the data were trained through neural network algorithm (BPA or HA) in this paper the data was trained by hybrid algorithm (HA). For that reason the ANFIS controller is the best controller for the Non-linear Load[7][8].

2 DC-DC CONVERTERS

The most commonly used converter is the Boost converter which is also known as step-up converter. In the step-up converter the output voltage is greater than the input voltage. The Boost converter consists of the passive elements such as Inductor (L), Capacitor (C), and Resistor (R). These elements are the non-linear elements which distort the output waveform. For that reason converter require controller. Boost converter require high voltage from the constant DC voltage[9][10].

The state average model for the step-up Converter was used to model the system. In state space average model the switching circuit divides into two states ON and OFF. The derivative of capacitor voltage and inductor current are based on the theory and can be expressed from the matrix form.

The ordinary parameter values are applied on the DC-DC Boost Converter which are tabulated in Table: 1

Parameter	Values
Input Voltage	5V
Duty Cycle	0.75
Inductance	870µH
Capacitance	2.034mF
Resistance	37.5Ω
Switching Frequency	25KHZ

TABLE:1 Open Loop DC/DC Boost Converter Parameter

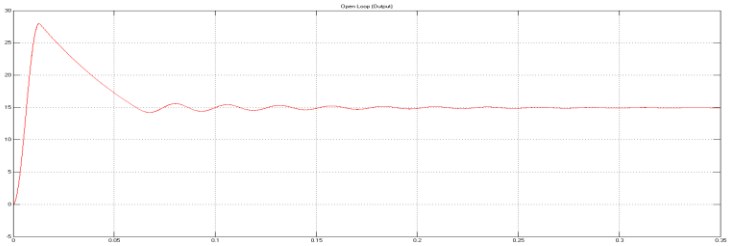

Figure 1 Output Voltage of Open Loop DC-DC Boost Converter

3 DC/DC CONVERTER CONTROLLERS

Many controllers such as linear i.e. PI, PID and non-linear controllers such as FLC, ANFIS, were used to regulate the output and improve the transient response of the DC/DC Boost Converter. The controller is mandatory with converter because without controller converter don't show robust performance and did not get desired output. For that purpose converter required controller[11][12].

3.1 FUZZY LOGIC CONTROLLER

In 1965 lotfi zadeh defined was defined fuzzy set theory from where this Fuzzy Logic Controller (FLC) derived. To control the logic of partial truth the Boolean logic has been extended. . In fuzzy logic control the truth value or the membership value are defined by a range of and that range is between [0.0, 1.0]. Where [0.0] represents absolute false value and 1.0 represents absolute true value. Fuzzy system actually deals with real world problem. FLC has proved to be most efficient control when crisp mathematical model become unrealizable and boost converter[13][14]. Fuzzy logic thoughts are like the individual's inclination and inference process. In contrast to ordinary control system which is highlight point control system which is highlight point control. Fuzzy logic controller is reach-to-point or reach-to-run control. FLC has proved to be most efficient control when crisp mathematical model become unrealizable. FLC's have exhibited their ability in various application especially in difficult nonlinear structures, for that logical showing remain tough. In FLC the variable are not crisp values, variables used are semantic in the form of language, which makes FLC more popular. The error signal derived from comparison can be defined by:

Negative Big, Negative Small, Zero, Positive Small, Positive Big.

The main aim of this research is that the output Voltage must be match with reference Voltage. There are two inputs of the FLC one is "error" and another is "change of error" which are derived from following equation.

$$E=Vref - V0$$

$$\Delta e= E- E (K-1)$$

The fuzzy Logic controller has two inputs with five membership functions NB, NS, ZE which are mentioned above. So they have 25 Rules which are shown in the TABLE: 2

(e) / (de)	NB	NS	ZO	PS	PB
NB	NB	NB	NB	NS	ZO
NS	NB	NB	NS	ZO	PS
ZO	NB	NS	ZO	PS	PB
PS	NS	ZO	PS	PB	PB
PB	ZO	PS	PB	PB	PB

TABLE: 2 Fuzzy Rule Base

The membership functions for input and output of Boost Converter using FLC from Fig ure 2 to 4 respectively.

Figure 2 membership function of input variable "Error"

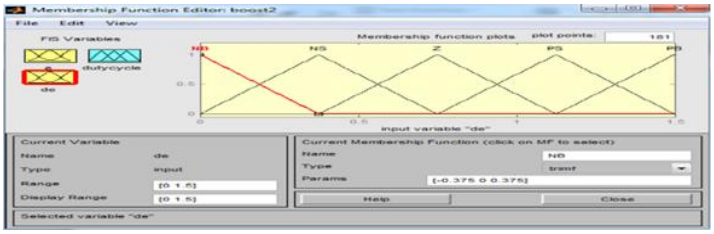

Figure 3 Membership function of input variable "change of error"

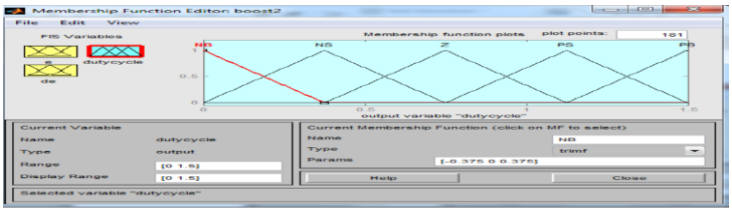

Figure 4 Membership function of Output variable "duty cycle"

3.2 ANFIS CONTROLLER

Jang developed the (ANFIS) in 1993 as a mixture of (FL)and (NN). IT inherits the benefits of (FL) and (NN), namely

planned information symbol and learning capabilities. Expert knowledge is used to create MFs, their sharing, and fuzzy rules in FL. from the FLC rules and Membership functions achieved are additional tuned in ANFIS through neural networks to produce enhanced triangular functions and their rules[15][16]. ANFIS controller employs neural network to tune fuzzy rules and adjust the parameters of MFs. The ANN component of the ANFIS contributes to error reduction, thereby optimizing the parameters. The ANFIS's FI component, on the other hand, deals with ambiguity effectively. The goal of Intelligent controller is to use a hybrid learning algorithm to classify the optimum additional parameters and triangular functions of the corresponding FIS by using input-output data sets and then achieving success with a wanted input-output plotting[17][18].

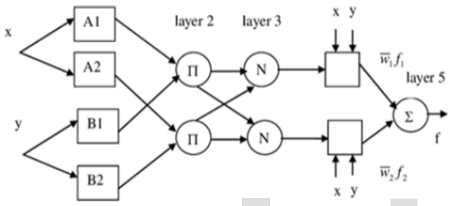

Figure 5 ANFIS architecture for Takaagi Sugeno System

With two inputs "x," i.e., e and "y," i.e., De, the first order Sugeno type as well as the instructions for a Sugeno-based ANFIS. To save space, the construction of two rules is presented here.

f1 = p1x + q1y + r1 if X is A1 and Y is B1.

If X is A2 and Y is B2, then f2 = p2x + q2y + r2

The "p1, q1, r1 and p2, q2, r2" are the boundaries use to produce specific measurements of F1 and F2. Outputs of every node are named as terminating quality of a standard. In the third layer, terminating qualities are standardized. The yield of the fourth layer is the main demand Sugeno work where all the nodes are versatile. These nodes locate the resulting boundaries. The last layer is the defuzzification layer which figures the hard yield of the ANFIS[19][20].

4 RESULTS AND DISCUSSION

In this Paper the researcher compares both controllers for DC-DC Boost converter. FLC and ANFIS were compared to improve the performance of the converter as well as enhance the output of the converter through load side. In this simulation the fuzzy logic controller used mamdani type and ANFIS controller was sugeno type used. In this simulation the Hybrid algorithm (BPA, LSM) was used for train the ANFIS data. Shows the Following Results of step-up converter with and without controllers.

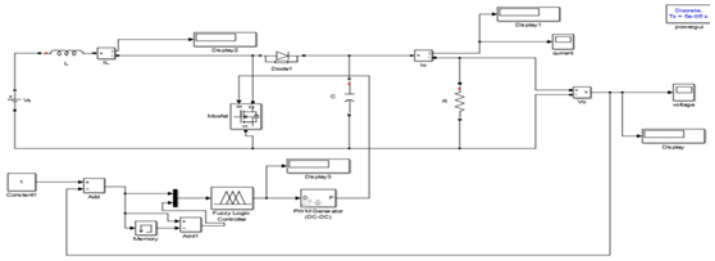

Figure 6 Simulink Model of closed loop Boost Converter

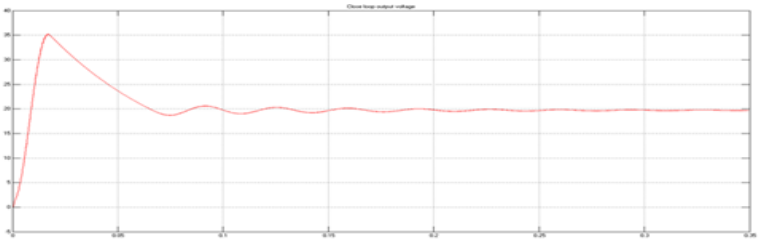

Figure 7 Output Voltage of Closed loop Boost Converter with FLC

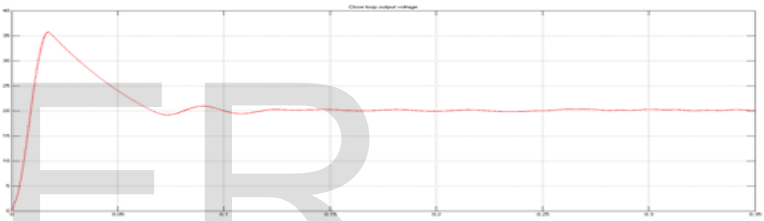

Figure 8 Output Voltage of Closed loop Boost Converter with ANFIS controller

The transient performance and output characteristic of the step up converter (open loop & closed loop) systems are presented. The simulation Results and reduction in the control characteristics are shown in the following TABLE 3.

TABLE: 3 Control Characteristics of DC-DC Boost Converter.

System consideration	Input Voltage	Output Voltage	Peak (os)%	Rise time (ms)	Peak time (ms)	Settling time (ms)	Steady state error
Open loop	5	14.93	62.3%	0.242	0.64	5.35	0.74
Fuzzy	5	19.73	30.79%	0.19	0.31	3.12	0.41
ANFIS	5	20.13	20%	0.2	0.10	1.7	0.07

5 CONCLUSION

This research accessible a comparison studies between FLC and ANFIS controller. The comparison of proposed controller is on the base of control characteristic of the model. I.e. settling time, Peak time, overshoot, rise time. Compared with FLC, ANFIS gives satisfactory results and less time consuming than Fuzzy logic controller. However ANFIS controller is an appropriate methodology in all over performance.

6 References

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