"PERFORMANCE ANALYSIS OF DC TO DC BOOST CONVERTER USING THE ADAPTIVE FUZZY LOGIC IN MATLAB SIMULINK"

[1]MR. SAGAR J. TIKHE
G. H. Raisoni College of Engineering and Management, Amravati, India
sagartikhe1991@gmail.com

[2] PROF. C. M. BOBADE
Assistant Professor, G. H. Raisoni College of Engineering and Management, Amravati, India
chetan.bobade@raisoni.net

ABSTRACT: *Now a days the voltage regulation can be maintain using feedback loop system but dc-dc converter can be design in open loop system whose control dc output voltage can be depend upon open loop system. DC-DC converters are basically used for stabilizing a given dc voltage to a desired value. This is generally achieve by using chopping and filtering of input voltage through suitable switching action, generally implemented by using pulse width modulation. In this paper proposed the voltage output for DC to DC boost converter between open loop, PID controller and fuzzy logic controller through Matlab Simulink. Simulink input voltage was set at 24V and the voltage reference was set at 48 V.*

***Keywords*:** DC to DC boost converter, fuzzy logic controller, PID circuit, FLC, Matlab Simulink.

1. INTRODUCTION

In the last two decade, there has been significant development in control strategies to enhance the dynamic behavior of DC–DC converters by using fuzzy logic system controller in very efficient manner [7]. The aim of control system in dc-dc converter is to ensure desired voltage output can be produced efficiently as compared to open loop system [8]. The voltage regulation can maintain using feedback loop system but dc-dc converter can be design in open loop system whose control dc output voltage can be depend upon open loop system. For the reliable operation of the open loop system to maintain the voltage regulation to take more time. This time can be reduction of this time we have to design the close loop system whose control action is independent on close loop system. The close loop system can be design with proportional integral derivative (PID) controller. In close loop system linear and switching regulate or adjust the power transfer stage to maintain the constant dc output voltage. The close loop system design also reduced the PWM and regulates the constant dc output voltage in short duration of time. In this paper, we are proposed the design for closed loop system using the PID controller and fuzzy logic and also show the performance analysis with other methods.

2. PROBLEM STATEMENT

Developing the fuzzy controller is beneficial than developing a model based or other controllers for the same purpose. Foe the simple design Proportional-Integral- Differential (PID) controllers are used in the converters [1]. However, the main drawback of PID controller is unable to adapt and approach the best performance when applied to nonlinear system. It will suffer from dynamic response, produces overshoot, longer rise time and settling time which in turn will influence the output voltage regulation of the Boost converter [4].

For the voltage conversion suffered from following problem

[1] The sum method will suffered from dynamic response for converter output.
[2]Sum system to maintain the voltage regulation will take more time.
[3] Flickering or unstable voltage take more time.
[4] It also takes the more time for duty ratio.
[5] The main drawback of these techniques is that they need an exact mathematical modeling which contains a lot of complex computations.
[6] Lack of performance in terms of efficiency reduced transfer gain and increased the content of sensor units.

3. LITURATURE BACKGROUND

Muhammad Mujtaba Asad et al. proposed voltage output for DC to DC boost converter between open loop, PID controller and fuzzy logic controller through Matlab Simulink. Simulink input voltage was set at 12V and the voltage reference was set at 24V. The analysis on the deviation of voltage resulted that the difference between reference voltage setting and the output voltage is always lower. Comparison between open loop, PID and FLC shows that, the open loop circuit having a bit higher on the deviation of voltage. The PID circuit boosts for FLC has a lesser deviation of voltage and proved that it is such a better performance on control the deviation of voltage during the boost mode. [1]

Sanjeevikumar Padmanaban et. al. presents the control strategies by Proportional-Integral (PI) and Fuzzy Logic (FL) for a DC-DC boost power converter for high output voltage configuration. In this paper author investigate on extra high-voltage (EHV) DC-DC boost power converter with inbuilt voltage-lift technique and overcome the deficiencies. Further, author adapted the control strategy which is based on proportional-integral (P-I) and fuzzy logic, closed-loop controller to regulate the outputs and ensure the performances. Complete hardware prototype of EHV converter is realized and experimental tasks are set out with digital signal processor (DSP) TMS320F2812 under different perturbation conditions. Author observed set of results is provided and shown good conformity with developed hypothetical predictions. [2]

By Ms. Kashmira Rathi(Kasat) et al. uses a DC-DC power converters is continuously growing both in power electronics products and systems. In a DC- DC converter application, it is always desired to obtain a regulated output voltage despite changes in input voltage, load current and converter components. To obtain regulated output voltage researchers have used various simple conventional to complex automatic control methods. With the development of semiconductor manufacturing technology, simplicity of design, size of devices, cost and better conversion efficiency have become important design criteria. This paper author proposed the design of a simple PID controller that can be applied to any DC-DC converter topology. The designed PID controller is tested with buck and boost converter in MATLAB-Simulink environment. Simulation results show that the controller realizes a better output voltage tracking and improved converter efficiency along with the ease and simplicity in design [3].

3.1 Fuzzy Methodology

How to Build Mamdani Systems Using Fuzzy Logic Toolbox Graphical User Interface Tools This example shows how to build a Fuzzy Inference System (FIS) for the tipping example, described in The Basic Tipping Problem, using the Fuzzy Logic Toolbox graphical user interface (GUI) tools.

You use the following graphical tools to build, edit, and view fuzzy inference systems:

- Fuzzy Logic Designer to handle the high-level issues for the system: How many input and output variables? What are their names?
  Fuzzy Logic Toolbox software does not limit the number of inputs. However, the number of inputs may be limited by the available memory of your machine. If the number of inputs is too large, or the number of membership functions is too big, then it may also be difficult to analyze the FIS using the other tools.
- Membership Function Editor to define the shapes of all the membership functions associated with each variable
- Rule Editor to edit the list of rules that defines the behavior of the system.

3.2 Open Loop DC DC Boost Convertor

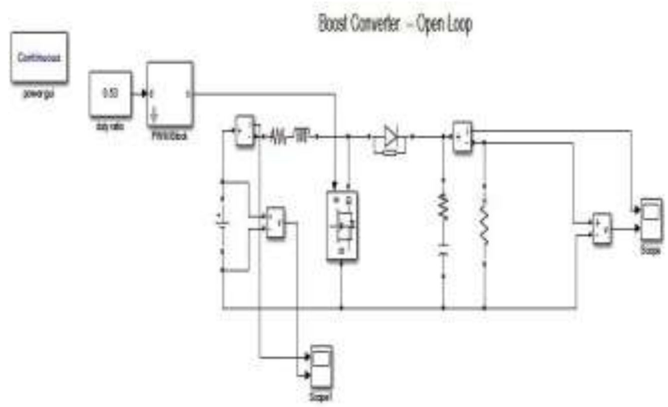

Figure 1: Open loop simulation model for DC DC loop convertor

The simulation diagram shows the variation of output load current and voltage during open loop system. It is observed the the open loop system the variation of graph rising time,falling time and settling time takes long duration regarding operation, hence we have to improve open loop system to close loop system for reduce time for getting output result.

3.3 Close loop system using PID controller

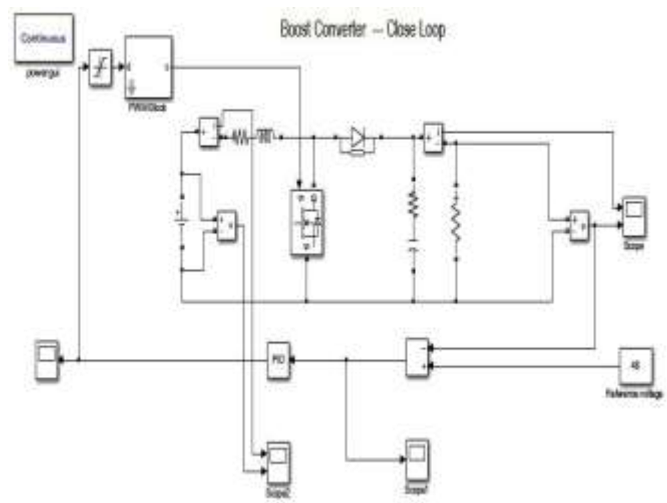

Figure 2: Close loop simulation model for DC DC boost convertor using PID controller

For improve our rising ,falling, and settling time using close loop system to get output load current and load voltage .In this simulation using PID as a feedback controller ,i.e proportional is zero and integer is five. After finding the error during simulation it will compare with reference voltage ,repeat the procedure until the zero error during operation, and this output goes to PWM it checks send to MOSFET it gives output to main scope that is our compensated or removed error output.

3.4 Fuzzy logic membership function

The boost dc-dc converter is a nonlinear function of the duty cycle because of the small signal model and its control method was applied to the control of boost converters. Fuzzy controllers do not require an exact mathematical model. Fuzzy controllers are designed to adapt to varying operating points. In our research work we have design the fuzzy Logic Controller to control the output of boost dc-dc converter using Mamdani style fuzzy inference system. Two input variables, error (e) and change of error (de) are used in this fuzzy logic system. The single output variable (u) is duty cycle of PWM output.

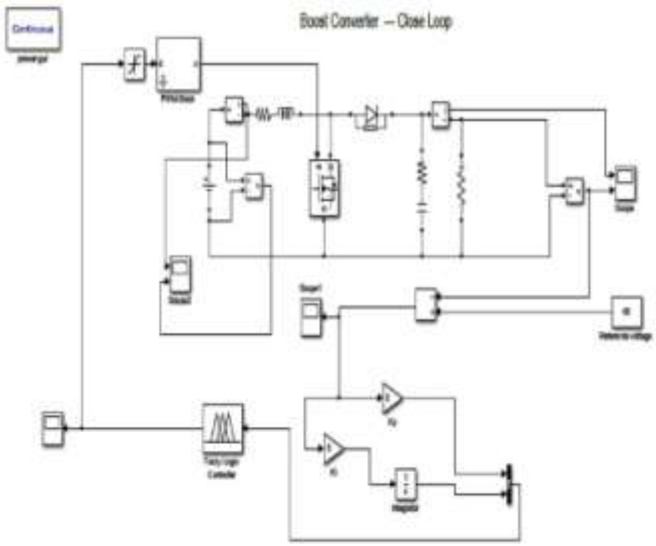

Figure 3: close loop simulation model of DC DC boost convertor using PI and fuzzy logic convertor

In this simulation using PID as a feedback controller, i.e proportional is zero and integer is five. After finding the error during simulation it will compare with reference voltage, repeat the procedure until the zero error during operation, and this output goes to fuzzy logic controller contain membership function and fuzzy logic rules to get exact value of logic controller after that output goes to PWM it checks send to MOSFET it gives output to main scope that is our compensated or removed error output. It will found that the output load voltage and load current rising, falling and settling time is improved.

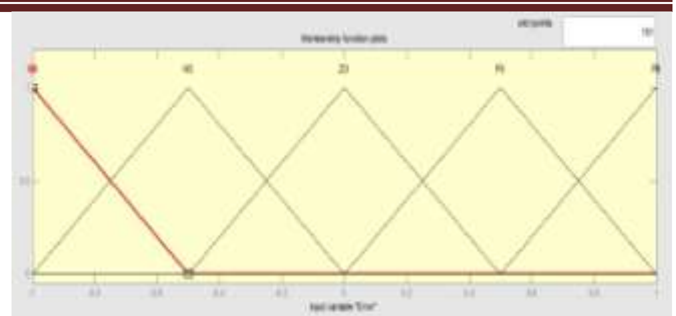

Figure 4: The Membership Function plots of error

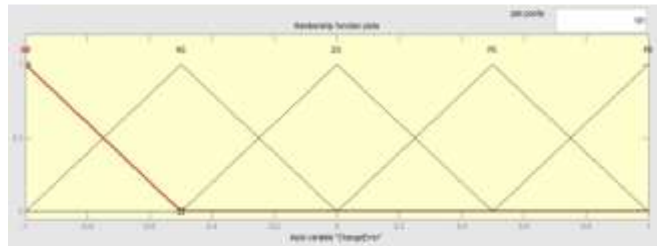

Figure 5: The Membership Function plots of change error

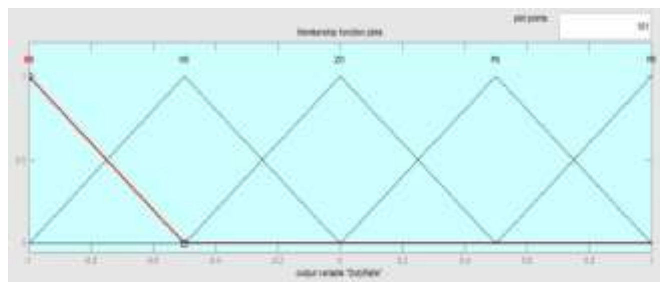

Figure 5: The Membership Function plots of duty ratio

3.5 System Parameters

	Parameters		**Value**
Source	Voltage input	V	24 volt
	Voltage output	V	48 volt
	Current input	I	10 Amp
	Current output	I	4.8 Amp
Parameters	Load Resistance	R	10 ohm
	inductor	L	161.94 uH
	Capacitor	C	220 uF
Duty ratio	Duty ratio	D	0.53
Output Power	Power	VA	230.4 VA
	Switching Frequency	Fs	100 KHz
PI Controller	Proportional constant	Kp	0
	Integral constant	Ki	5
MOSFET	FET resistance	Ron	0.1
	Internal resistance	Rd	0.01
	Snubber resistance	Rs	500
Diode	Snubber capacitance	Cs	250×10^{-09}

4. RESULT ANALYSIS

Voltage output for DC-DC Boost converter between open loop, PID controller and fuzzy logic controller through Matlab simulink package. Simulinks input voltage was set at 24V and the voltage reference was set at 48V

4.1 Simulation result of Open Loop DC DC Boost Convertor

Figure 6 and Figure 7 are shows the simulation ,the waveform of Input and output voltage and current , the value of output voltage is about 48 V then the mean value of input current is about 10A and it has high overshoot compare the output current that has more stable. The value of output current is about 4.8A

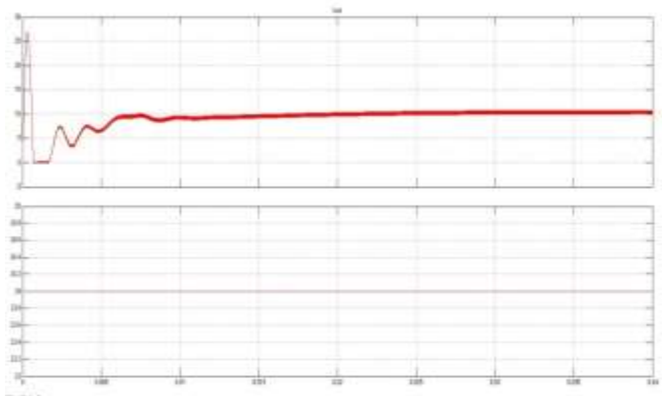

Figure 6: Result of Input current and voltage for open loop circuit DC DC boost convertor

From figure 5 the output voltage of open loop circuit shows that voltage boost up for a value of 70V and after sometime it settled down to 48V .This shows that open loop circuit produce overshoot voltage

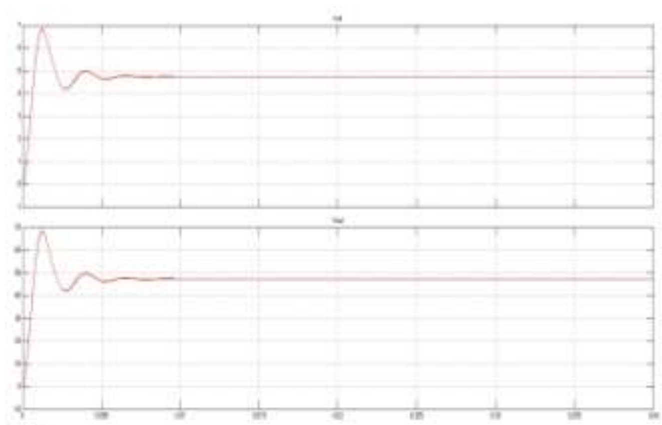

Figure 7: Result of output current and voltage for open loop circuit DC DC boost convertor

4.2 Simulation result of Close loop system using PID controller.

The simulation result of input voltage current with DC DC boost convertor with close loop PID controller as shown at figure 8 from the simulation result

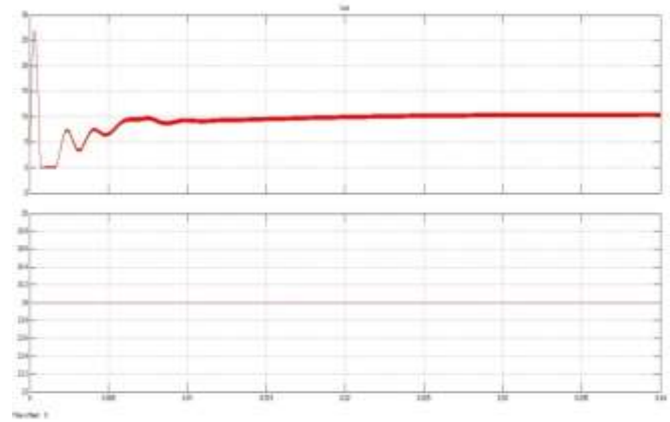

Figure 8: Simulation results of input voltage and current close loop system using PID controller

Figure 9 shows the improvement of output voltage simulation of the close loop circuit showed that voltage rising time is 42 volt compared to pen loop system is to low and after some time it settles down to 48 volt.

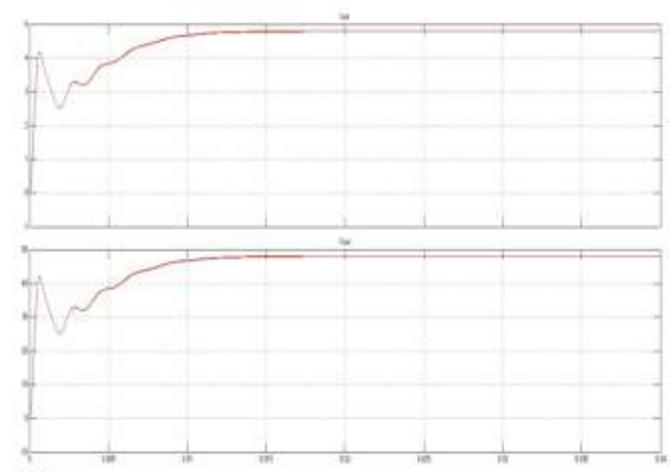

Figure 9: Simulation result of output voltage and current close loop system using PID controller.

Figure 10 shows that simulation of feedback PID controller of Error between reference voltage and output voltage of DC DC boost converter. Error simulation continue up to zero error between reference voltage and output voltage

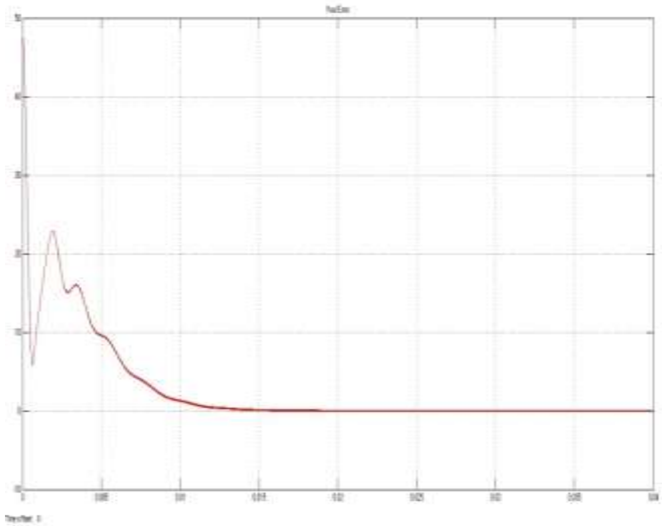

Figure 10: Simulation result of Error of PID controller

The simulation result of duty ratio increases continue up to get exact value of PWM block. The value is D=0.53

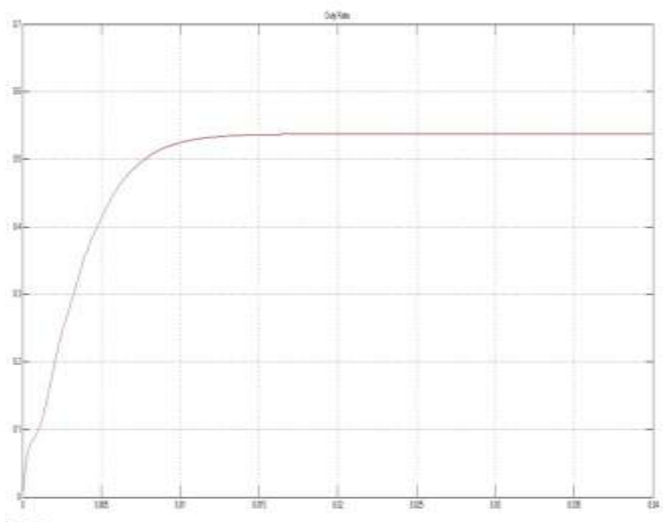

Figure 11: Duty ratio of PWM block

4.3 Simulation result of Close loop DC DC convertor using PI and Fuzzy logic controller.

Figure 12 shows the simulation results of input current and voltage for boost converter with fuzzy logic controller

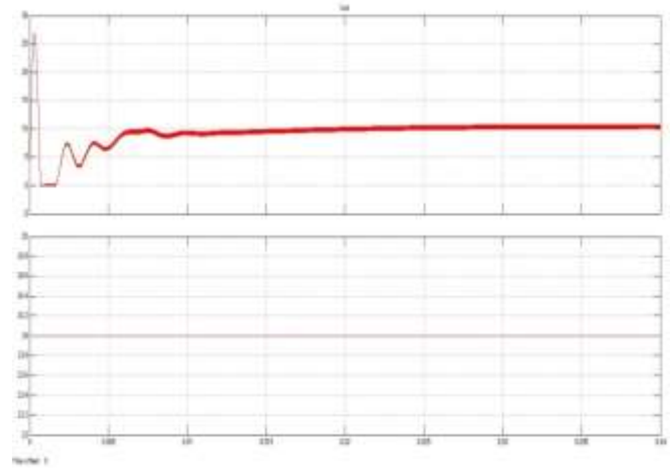

Figure 12: Simulation result of input voltage and current Close loop DC DC convertor using PI and Fuzzy logic controller.

Figure 13 shows the closed loop circuit the output voltage boosts up till 48 V. The fuzzy logic controller plays it roles to control the voltage output as the desired requirement. It proved that the fuzzy logic controller successfully control the overshoot value better than system without fuzzy logic controller with the same input voltage 24V and the settling time for the closed loop converter is much faster. The system with fuzzy logic controller had controlled the current of output by driving it to produce the desired current that needed by the system and eliminating the overshoot current. the duty cycle value was display at rules viewer is about 0.53.

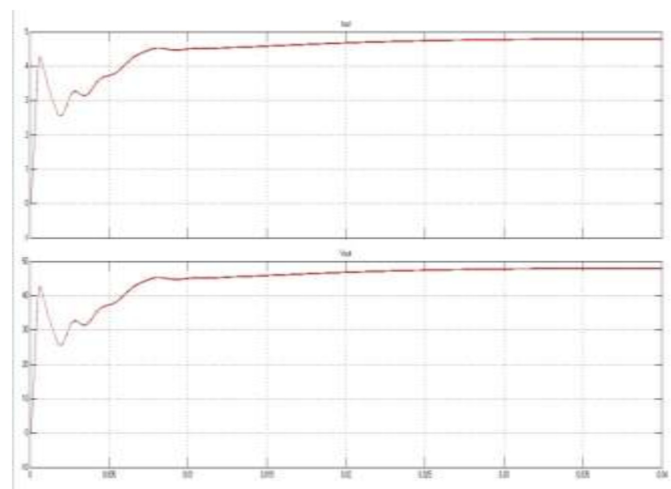

Figure 13: Simulation result of output voltage and current Close loop DC DC convertor using PI and Fuzzy logic controller

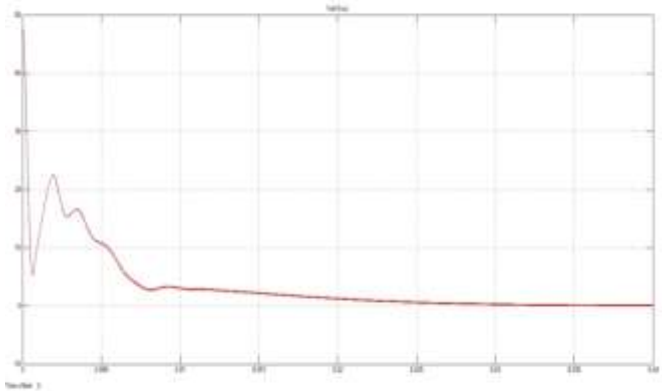

Figure 14: Simulation result of Error of PI controller and fuzzy logic controller

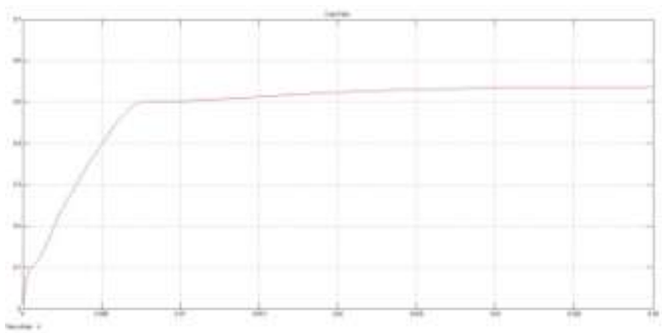

Figure 15: Duty ratio of PWM block

Table 2 shows the comparative result analysis of different method with proposed method i.e. closed loop using PID and FLC used in our research work.

Parameter	Open loop	Closed loop using PID	Closed loop using PID and FLC
Voltage Input(v)	24	24	24
Voltage reference (v)	48	48	48
Voltage output(v)	47.4376	48.0848	48.0397
Deviation (v)	0.5624	0.0878	0.0397
Deviation (%)	1.1717%	0.1829 %	0.0827 %
Rise Voltage (V)	70	43	43
Rise time Tr (ms)	0.75	0.3	0.3
Peak time Tp (ms)	1.3	0.65	0.6
Settling time Ts (s)	0.01	0.012	0.0078

In the above table 2 show the different parameter and methods. The proposed method result is better than open loop and closed loop using the PID.

5. CONCLUSION

In conclusion of this paper is the comparison between Voltage output for DC-DC Boost converter between open loop, PID controller and fuzzy logic controller through Matlab simulink package. Simulinks input voltage was set at 24V and the voltage reference was set at 48V. The analysis on the deviation of voltage resulted that the difference between reference voltage setting and the output voltage is always lower. Comparison between open loop, closed loop using PID and our proposed method closed loop using PID and FLC shows that the better result in table 2. The PID circuit boosts for FLC has a lesser deviation of voltage and proved that it is such a better performance on control the deviation of voltage during the boost mode.

These studies could solve many types of problems regardless on stability because as we know that fuzzy logic controller is an intelligent controller to their appliances.

6. REFERENCES

[1] Muhammad Mujtaba Asad, Razali Bin Hassan, Fahad Sherwani, "An Analytical Comparison between Open Loop, PID and Fuzzy Logic Based DC-DC Boost Convertor", World Academy of Science, Engineering and Technology International Journal of Electrical, Computer, Energetic, Electronic and Communication Engineering Vol:8, No:11, 2014.

[2] Sanjeevikumar Padmanaban, Frede Blaabjerg , Pierluigi Siano , Luigi Martirano , Zbigniew Leonowicz , Kiran Pandav Maroti "PI and Fuzzy Control Strategies for High Voltage Output DC-DC Boost Power Converter – Hardware Implementation and Analysis" 2016 IEEE.

[3] Ms. Kashmira Rathi(Kasat)a and Dr.M.S.Ali, "Design and Simulation of PID Controller for Power Electronics Converter Circuits", International Journal of Innovative and Emerging Research in Engineering Volume 3, Issue 2, 2016.

[4] Ozdemir, E.; Ural, A.; Abut, N.; Karakas, E.; Olcer, E.; Karagoz, B.;(1997): Design of fuzzy logic controller for DC-DC converter fed traction motor Drives Intelligent Control, Proceedings of the 1997 IEEE International Symposium.

[5] Jantzen, J. (2007). Foundations of Fuzzy Control. West Sussex PO19 8SQ, England: John Wiley & Sons Ltd.

[6] Adel E. El-kholy and A. M. Dabroom, (2006): Adaptive Fuzzy Logic Controllers for DC Drives: A Survey of the State of the art, Journal of Electrical Systems, pp. 116-145.

[7] Cetin Elmas, Omer Deperlioglu, Hasan Huseyin Sayan, "Adaptive fuzzy logic controller for DC–DC converters", Expert Systems with Applications 36 (2009) 1540–1548.

[8] Sk.Gouse Basha and P.D.V.S.K. Kishore, "Implementation and Performance of Fuzzy Logic Controller on DC-DC Boost Converter"

7. AUTHOR PROFILE

	**Mr. Sagar Tikhe** Completed Bachelor of Engineering in Electrical Engineering from Rajiv Gandhi College of Engineering Research and Technology from Chandrapur, india And currently pursuing Master of Engineering in Electrical Engineering from G. h. Raisoni College of Engineering and Management Amravati, India. His research area is electrical circuit and network, switch gear and protection and electrical transformer.
	**Prof. Chetan M. Bobade** received the Bachelor of Engineering in Electrical (Electronics and power) Engineering and Master Degree in Electrical Power System from SSGMCE Shegaon. He is working as an assistant professor and Head of Electrical Engineering Department at G.H. Raisoni college of Engineering and Management Amravati, Maharashtra, India. his research areas is Power System control, Optimization techniques, FACTS and power system stability improvement, Electrical machine.