ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 6, June 2015

Design of Boost Converter with Fuzzy Logic Controller for Renewable Energy Sources

Amit Kumar verma[1], Mukesh Kumar[2], Dr.S.R.Kapoor[3], Rajkumar Nagar[4]

Associate Professor, Dept. of EE, University College of Engineering, Kota, Rajasthan, India[3]

PG Student, Dept. of EE, University College of Engineering, Kota, Rajasthan, India[1,2,4]

ABSTRACT: Due to the lack of conventional energy sources, world is moving towards renewable energy sources as an alternative for the energy needs. As these are pollution free and cheap, these are very useful. Fuel Cell energy and solar energy are examples of renewable energy sources which give a small amount of DC voltage as output. To increase this voltage level, Boost converter is designed. This Boost Converter is best suited for applications where load is 100 Ω. Fuzzy Logic Controller is used to control the duty ratio of Boost Converter. Results of Fuzzy Logic Controlled Boost Converter is compared with conventional PI controlled Boost Converter.

KEYWORDS: Boost Converter, proportional Integral Controller (PI), Fuzzy Logic Controller.

I.INTRODUCTION

As the population of world is increasing the requirement of energy is also increasing resulting in "Energy Crisis" [1]. To overcome this energy crisis world is moving towards the renewable sources of energy like solar, wind, biomass and geothermal etc. All these sources are green sources as these are combustion free hence gives promise to clean source of energy. But the output of solar cell and fuel cell is DC voltage and its amount is so small that cannot be used for practical applications [5]. To overcome this problem, Boost Converter is used to increase the DC voltage. Boost converter increases the DC voltage to the acceptable level for use in different applications. Wherever AC signal is required, the output of Boost Converter is fed to the inverter and this AC signal is used for different applications.

II.BOOST CONVERTER

DC/DC boost converter is a power device which gives a constant high DC-voltage as output in spite of a varying DC-voltage on the input. Primarily, boost converter consists of two semiconductor devices a diode and a switching device (IGBT, MOSFET, Thyristor etc.) and energy storage elements, a capacitor and an inductor. Filter made of capacitor is normally added to the output of the converter to reduce output voltage ripple. The input-output voltage ratio is controlled by the switching duty cycle D of the switching device. The value of duty ratio D lies between 0 and 1. The boost converter has a non-linear relationship between duty cycle and input-output voltage ratio. The output of the boost converter is given as follows.

$$V = \frac{Vs}{1-D} \quad (1)$$

$$D = \frac{Ton}{T} \quad (2)$$

$$T = Ton + Toff \quad (3)$$

Functional diagram of typical boost converter is shown in fig. 1.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 6, June 2015

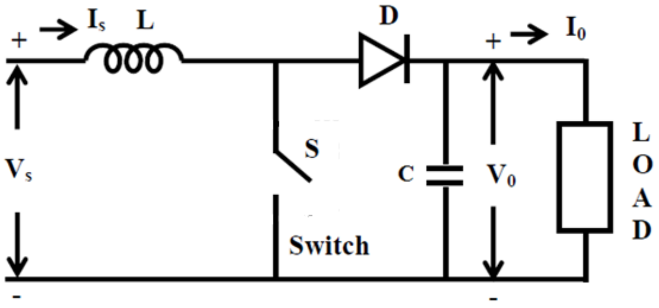

Fig. 1 Functional Diagram of Boost Converter

BASIC PRINCIPLE

The principle behind the boost converter is the ability of an inductor to resist changes in current by generating a magnetic field. Working of the boost converter can be explained from the following points.

(i) ON State: - In this state the switch is ON which results an increase in inductor current and current does not pass through diode D, Capacitor C and Load. On state is shown in the following Fig. 2.

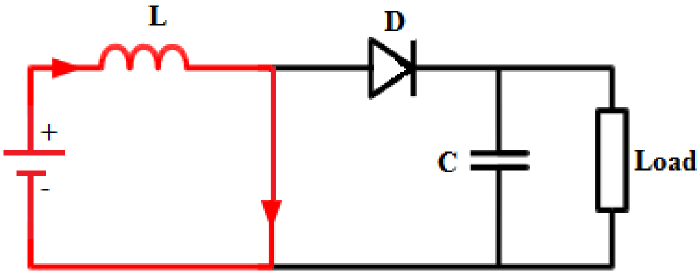

Fig. 2 Boost Converter in ON State

(ii) OFF State: - In this state, the switch is OFF and the path of inductor current is through the freewheeling diode D, the capacitor C and the load R. This results in transferring the stored energy during the ON state to the capacitor.

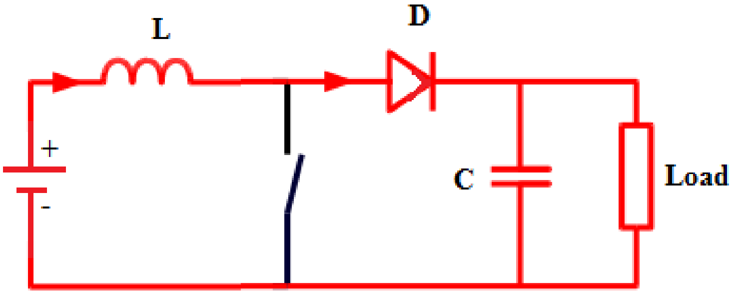

Fig. 3 Boost Converter in OFF State

The switching of switching device is maintained fast, so the inductor will not discharge fully in between charging stages, and when the switch is open the input source alone will provide a voltage greater than its value to load. Also the capacitor in parallel with the load will be charged to this additional voltage. Now when the switch is closed, the capacitor will be able to provide the voltage and energy to the load. During this time, the blocking diode will prevent

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 6, June 2015

the capacitor from discharging. The switch has to be opened again fast enough to prevent the capacitor from discharging too much.

The parameters of designed Boost converter are shown in the following table I.

Table I Parameter of Boost Converter

Parameter	V_{in} (V)	L (mH)	C (μF)	Load (Ω)
Value	17	100	100	100

Error signal generated from comparison of desired output and actual output is controlled by the controller. Output of this controller generates the switching pulses of the MOSFET (switch) of Boost Converter.

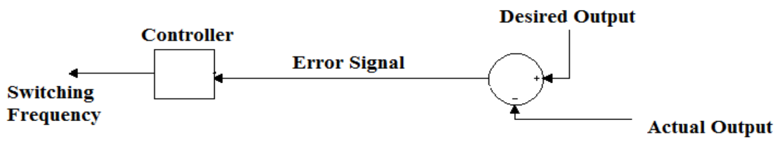

Fig. 4 Closed loop system of Boost Converter

Two controllers namely PI Controller and Fuzzy Logic controller are used for the purpose and results are compared.

III. PI CONTROLLER

PI controller is one of the most common types of controller used for the control purpose. It needs mathematical modeling of the system to compute the values of parameters k_p and k_i[2].
k_p is the parameter to adjust the value of proportional controller and ki to control the value of integral controller.

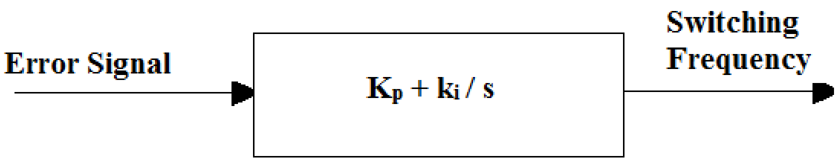

Fig. 5 PI controller

IV. FUZZY LOGIC CONTROLLER

Rules for fuzzy logic control are derived from the practical knowledge of behaviour of the system. It does not need mathematical calculation hence it is very easy to construct [3-4].

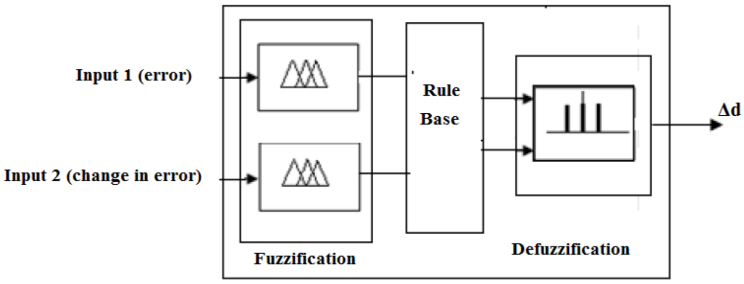

Fig. 6 Block Diagram of Fuzzy Logic Controller

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 6, June 2015

To implement the fuzzy based rule, error and change in error are taken as FIS variables [5-9].
Value of error and change in error are taken as follows.

$e(n) = V_{out}(desired) - V_{out}(actual)$ (4)

$Ce(n) = e(n) – e(n-1)$ (5)

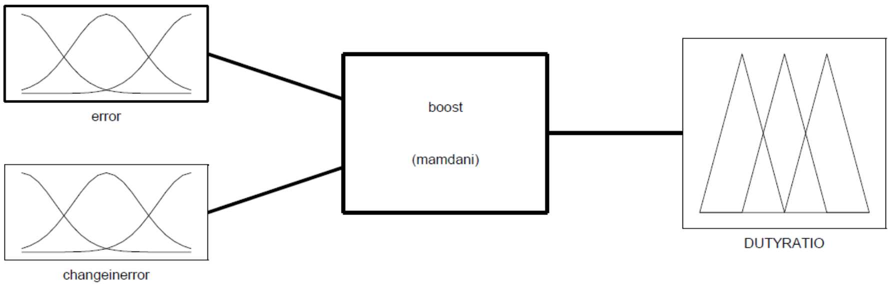

Fig. 7 FIS variables for Boost Converter

Mamdani triangular Membership function for the input variable “error” is defined as in following figure 8.

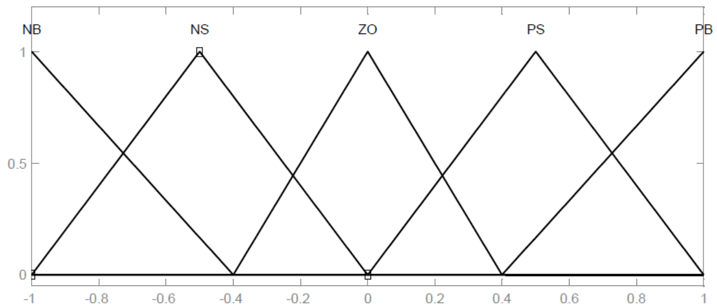

Fig. 8 Input Variable “Error”

Mamdani triangular Membership function for the input variable “change in error” is defined as in following figure 9.

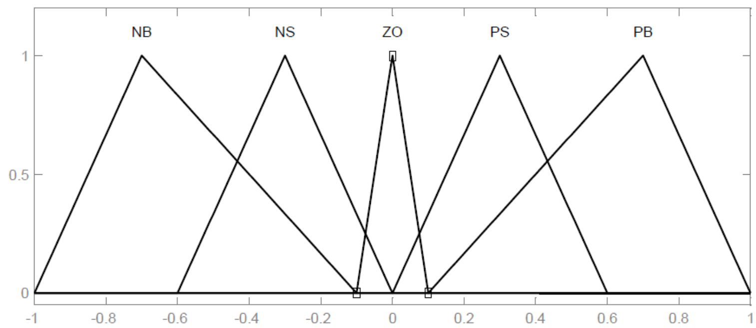

Fig. 9 Input Variable “change in error”

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 6, June 2015

Mamdani triangular Membership function for the output variable “duty ratio” is defined as in following figure 10.

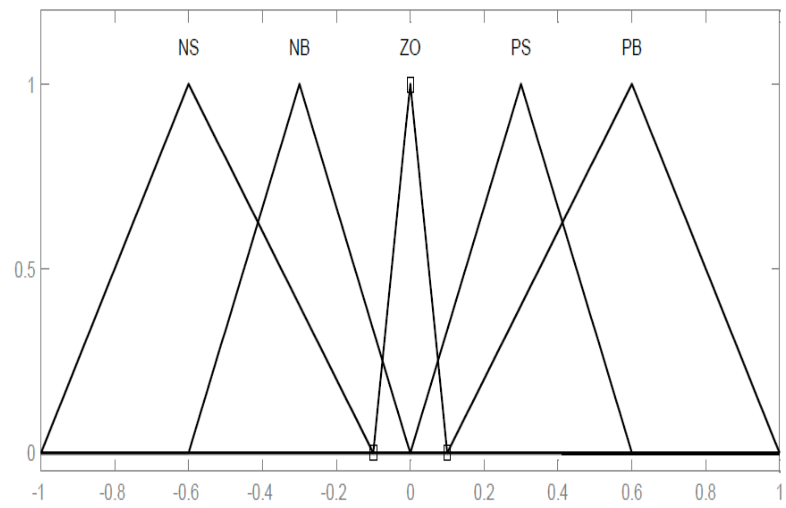

Fig. 10 Output Variable “Duty Ratio”

Rules for the Fuzzy Logic Controller are defined in the following table.

Table I

ce \ e	NB	NS	Z	PS	PB
NB	NB	NB	NB	NS	Z
NS	NB	NB	NS	Z	PS
Z	NB	NS	Z	PS	PB
PS	NS	Z	PS	PB	PB
PB	Z	PS	PB	PB	PB

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 6, June 2015

V. RESULT AND ANALYSIS

Result of Boost Converter with PI controller is shown in Fig. 11.

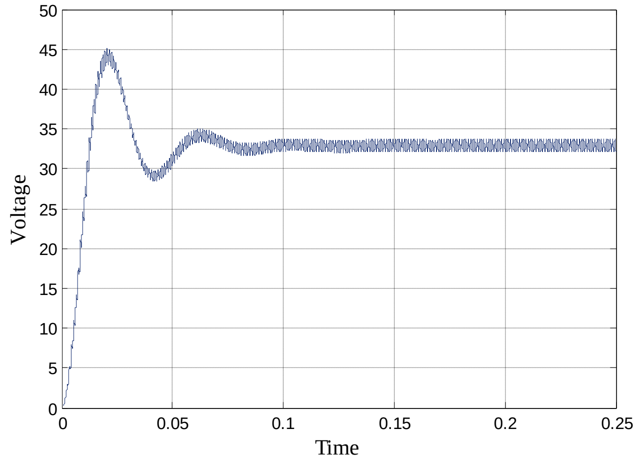

Fig. 11 output of Boost Converter (PI Controller)

Result of Boost Converter with Fuzzy Logic Controller is shown in Fig. 12.

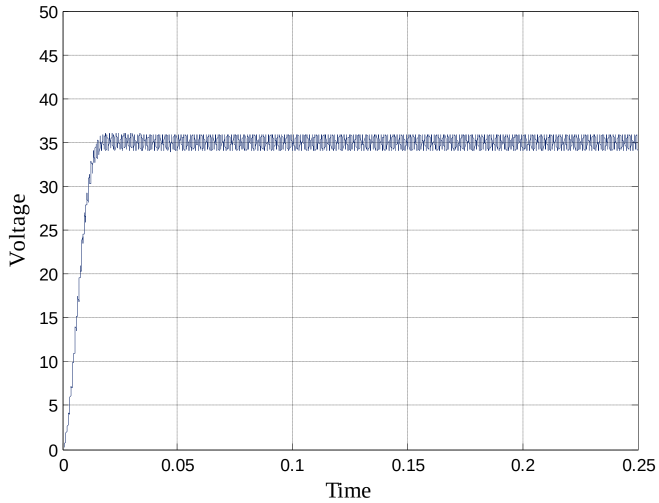

Fig. 12 Output of Boost Converter (Fuzzy Logic Controller)

Comparison of both the results is shown in the following table II.

Table II Comparison of Boost Converter output

	PI Controller	Fuzzy Controller
Peak Overshoot	45.0866 V	No Oscillations
Settling Time	120 ms	17 ms

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 6, June 2015

VI.CONCLUSION

In this paper the boost converter is designed for the renewable energy sources like fuel cell, solar cell etc. The output of this source is fed to the Boost Converter to get required output for use in different application. Two types of controllers PI Controller and Fuzzy controller are used to control the output. With reference to Table I it is seen that Peak Overshoot of PI controller is 45.0866 V while output of Fuzzy Controller has no oscillations and with reference to Table II it is seen that settling time of PI controller is 120 ms while of Fuzzy Controller is 17 ms. So it can be said that Fuzzy controller is better than conventional PI controller.

REFERENCES

[1]. SerdarOzturk, Ali sozdemir and OzlemUlger, "The Real Crisis Waiting for the World: Oil Problem and Energy Security" International Journal of Energy Economics and Policy, vol. 3, Special Issue, 2013, pp 74-79.
[2]. Dr. Osama Y. Mahmood Al-Rawi, Dr.Yousif I. Al Mashhadany and Dr.Jwan S. Ra'afatKhadim AL-Sujada," High Performance DC-DC Boost Converter Based on Tuning PI controller", The Second Engineering Conference of Control, Computers and Mechatronics Engineering (ECCCM2, 2014)
[3]. M. Hellmann," Fuzzy Logic Introduction", LaboratoireAntennes Radar Telecom, F.R.E CNRS 2272, Equipe Radar Polarimetrie, Universit´e de Rennes 1, UFR S.P.M, Campus de Beaulieu - Bat. 22, 263 Avenue General Leclerc, CS 74205, 35042 Rennes Cedex, France
[4]. N.F Nik Ismail, I. Musirin, R. Baharom and D.Johari, "Fuzzy Logic Controller on DC/DCBoost Converter", IEEE International Conference on Power and Energy 2010, Kuala Lumpur, Malaysia
[5]. D. Lenine, Ch.SaiBabu, G.Shankaraiah "Performance Evaluation of Fuzzy and PI Controller for Boost Converter with Active PFC" International Journal of Power Electronics and Drive System (IJPEDS) Vol.2, No.4, December 2012, pp. 445~45.
[6]. T.Balamurugan, S.Manoharan "Fuzzy Controller Design using Soft Switching Boost converter for MPPT in Hybrid System", International Journal of Soft Computing and engineering (IJSCE) ISSN: 2231-2307, Volume-2, Issue-5, November 2012.

BIOGRAPHY

Amit Kumar Verma was born in Bundi, Rajasthan in 1984. He received his B. E. in Electronic Instrumentation and Control Engineering from Poornima College of Engineering, Jaipur (Rajasthan), India in 2006. He is pursuing his M. Tech. in Power System from University College of Engineering, RTU, Kota. He is currently working towards his PG project in Fuel cell.

Mukesh Kumar was born in Gokulpura, Sikar Rajasthan in 1988. He received his B. Tech (Electrical Engineering) from Sobhasaria Engineering College, Sikar (Rajasthan), India in 2011. Two years experience as a teaching assistant in RTU Kota. He received his M. Tech. (Power System) degree from University College of Engineering, RTU, Kota (Rajasthan), India in 2015. He is assistant professor in Department of Electrical Engineering at Sobhasaria Engineering College, Sikar (Raj.). His fields of interest solar power electronics and power converters, solar MPPT techniques, Fuzzy logic, renewable energy and solar photovoltaic systems.

Shashi R. Kapoor was born in Kota, Rajasthan in 1971. He received B. E. (Electrical) from the University of Rajasthan in 1993 and stood second in the University. He received his M. Tech. (System Engineering and Operations Research) degree for IIT Roorkee in 2003 and received Dr. J.C. Mukhopadhyay medal, Dr. Jai Krishna medal, Late Smt. Uma Goyal W/O Sri Uday Shankar Goyal memorial prize, Laxmi Devi and Shri Banadri Das prize for academic performance in M.Tech. He received his Ph.D. degree from Rajiv Gandhi Prodyogiki Vishwavidyalaya (RGPV), Bhopal (M. P., India) in 2011.He joined Govt. Engineering College, Kota as Lecturer in 1999. Presently he is Associate Professor in Department of Electrical Engineering at University College of Engineering, Rajasthan Technical University, Kota (Raj.). His fields of interest are FPGA implementation of control algorithms of electrical motors, Microprocessors, Embedded systems, Artificial Intelligence and Optimization Techniques.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 6, June 2015

Rajkumar Nagarwas born in kota, Rajasthan in 1992. He received his B. Tech in Electrical Engineering from Modi Institute of Technology, Kota (Rajasthan), India in 2013. He is pursuing his M. Tech. in Power Electronics and Electric Drives from University College of Engineering, RTU, Kota (Rajasthan), India. He is currently working towards his PG project in multilevel inverter topologies for solar photovoltaic systems.