Impact Factor (SJIF): 3.632

International Journal of Advance Research in Engineering, Science & Technology

e-ISSN: 2393-9877, p-ISSN: 2394-2444

Volume 3, Issue 4, April-2016

DESIGN OF BOOST CONVERTER FOR ELECTRIC VEHICLE APPLICATIONS USING PI & FUZZY LOGIC CONTROLLER

Bhaumik D Patel[1], Jignesh Patel[2], Chirag Patel[3], Divya Makwana[4]

[1]Electrical Engineering Ahmedabad Institute of Technology, Ahmedabad, Gujarat, India

[2]Prof. Electrical Engineering Department, Ahmedabad Institute of Technology

[3]Prof. Electrical Engineering Department, Ahmedabad Institute of Technology

[4]Prof. Electrical Engineering Department, L D College of Engineering

Abstract: In recent years the availability of petroleum resources has decreased, which has paved the way for Electric Vehicles (EVs) and Hybrid Electric Vehicles (HEVs). In order to achieve a better drive range and improved performance of the motor, control techniques are necessary for the DC to DC power converters which are used in these vehicles. Designing of linear controllers for these converters like Proportional Integral (PI) non-linear controllers like Fuzzy Logic Controller that gives constant output which improves the performance of Drive. The above concept is tested for DC to DC boost converters in simulation in this paper.

I-INTRODUCTION

With the dependency of the transportation sector on the petroleum resources, there is a fast decline in their availability. This has aroused the need to design vehicle on alternate propulsion technologies which has led to the progress of Electric Vehicle (EV) and Hybrid Electric Vehicle (HEV) Various topologies of the power converters which are used in operation of HEV or EV have been designed. But the main problems faced during the driving operation are the fluctuations in the input battery voltage, load variations, which decreases the performance of the drive. Hence proper control strategy should be implemented so that a better drive range and improved performance can be achieved [1].

In this paper a DC to DC boost converter is used to drive a PMDC motor. PMDC is used because of its simple operation, low cost and does not require complex controllers unlike induction and brushless DC motors. In order to have a constant output voltage from the DC to DC converter despite input fluctuations and load variations, linear control method (Proportional Integral control) is used to control the constant output.

This paper is divided into the following section as follows; the complete system description and the design of the converter are given in Section II. Section III Boost Converter & PMDC motor, Design of Boost Converter & PMDC motor with PI & Fuzzy controller. In this paper, the values of the voltage and current are taken from the running electric vehicles. The simulation waveforms are discussed for open loop and closed loop Boost Converter. The effect of fluctuation on the output voltage is also shown with the simulation results and at last, conclusion is considered.

II- SYSTEM DESCRIPTION

The system taken up for this study consists of a three basic blocks i.e. DC input voltage, DC to DC boost converter and PMDC motor as load as shown in Fig. 1 with its control strategy.

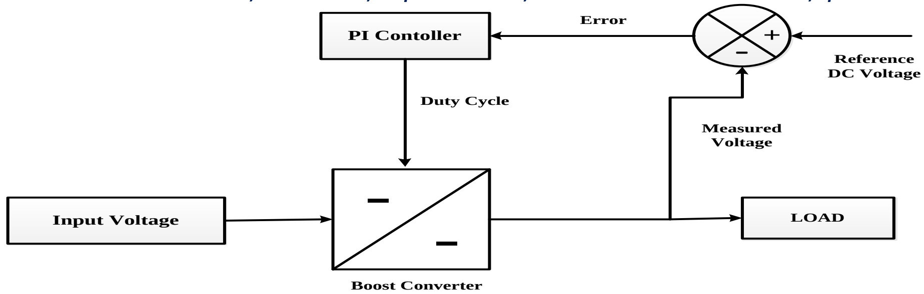

Fig. 1. Block diagram of DC/DC Boost converter with control strategies

The main idea is to control the output voltage of the converter during variations in the input voltage or at the time of change in the load. This is vital to ensure a constant input voltage in driving the PMDC motor during the motoring operation. The design parameters used in this study are given in Table I.

1. Design of Boost Converter:

The circuit diagram of DC to DC boost converter which is used is shown in Fig. 2. The converter can run both in continuous as well as in discontinuous mode. In this paper continuous conduction mode is considered which is determined by the value of the inductor, L.

TABLE-1 DESIGN PARAMETERS

Input Voltage to Converter	24 V
Output Voltage of Boost Converter	48 V
Frequency	32 KHz
Duty Cycle	50%

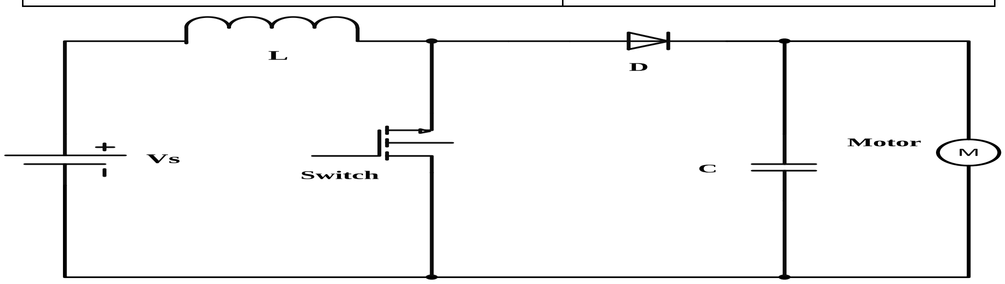

Fig. 2. Circuit diagram for Boost Converter

1) ***Inductor and capacitor design***: For continuous mode of conduction in boost converter, the relation among the input and output voltage is given by equation (1)

$$\frac{Va}{Vs} = \frac{1}{1-D} \tag{1}$$

Here D is the duty cycle, Vs is the input voltage (V) and Va is the output voltage (V) of the converter. The inductor and capacitor values are calculated from equations (2) and (3). For the converter to operate in continuous mode it should satisfy the condition which is given in equation (4).

$$L = \frac{Vs \times D}{f \times \Delta I} \tag{2}$$

$$L = \frac{Ia \times D}{f \times \Delta V} \tag{3}$$

$$L > D(1-D)R/2f \tag{4}$$

Where L is the inductor (H) and C is the capacitor (F) being used in the circuit, ΔI is the peak to peak ripple current of the inductor, R is the load resistance (Ω) and ΔV is the ripple voltage across the capacitor and f is the switching frequency (Hz).

2) Design of PMDC motor: PMDC motors are often used in electric vehicles because of their simple operation and low cost as compared to BLDC motors [4]. AC motors require an extra AC to DC converter for their operation, which is not required in the case of a PMDC machine. Hence the cost and complexity is reduced while using PMDC motors. PMDC motor can be modelled using the equations (5) - (8).

$$V = Eb + Ia \times Ra + La \times \frac{dIa}{dt} \quad (5)$$

Where V is the terminal voltage of the machine, Ia is the armature current and Ra is the armature resistance, La is the armature inductance and Eb is the back emf of the machine. The mechanical equation of the motor is given by equation (6).

$$J\frac{dw}{dt} = Te - Tl - Bm \times w - Tf \quad (6)$$

Where J is the inertia, B is the viscous friction coefficient, ω is the speed of the machine (rad/s), Te is the electromechanical torque, Tl is the load torque and Tf is the Coulomb friction torque. Back emf (electromotive force, Eb) and torque (Te) can be calculated using equations (7) and (8).

$$Eb = Kb \times w \quad (7)$$

$$Te = Kt \times Ia \quad (8)$$

Kt and Kb are the voltage and torque constants respectively.

III- CONTROL STRATEGY

1) With PI Controller

The demand for DC-DC converters is increasing at a very fast rate with the increase of battery operated devices. Electric vehicles also use such converters and their control is very important for the efficient working of the system. The boost converter has been operated in the closed loop mode with the help of PI Controller.

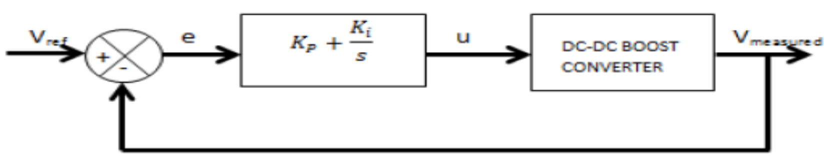

Fig. 3. Block diagram for PI control for boost converter

A PI controller is aimed for the DC to DC boost converter with PMDC motor as the load which is shown in Fig. 3. PI controller is considered for proper working of the converter during the transient period and to decrease the steady state error. The derivative term is not included because it results in oscillation of the duty cycle. The converter is designed using Ziegler–Nichols (ZN) controller tuning method. It is designed by setting the integral, Ki, and the derivative gain, Kd, to zero. The Simulink model for the DC/DC boost converter with PI controller is shown in Fig. 4.

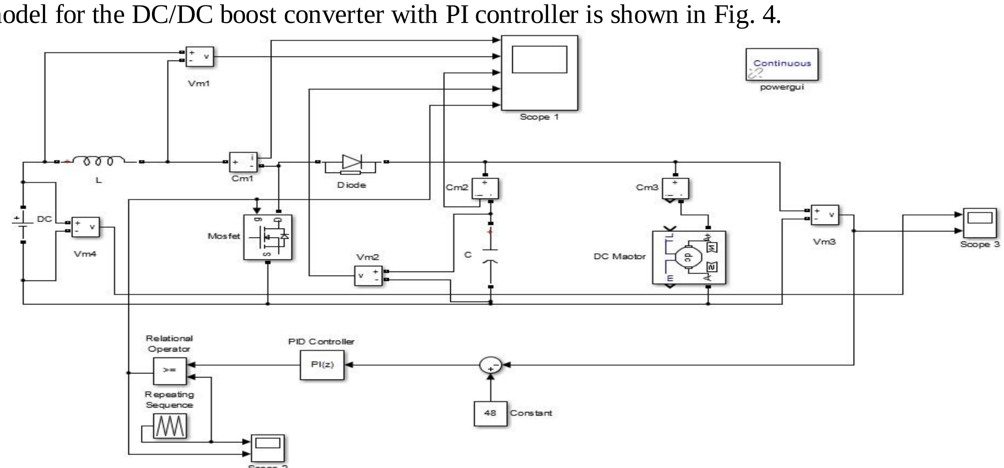

Fig. 4. Simulink model for PI controlled Boost converter.

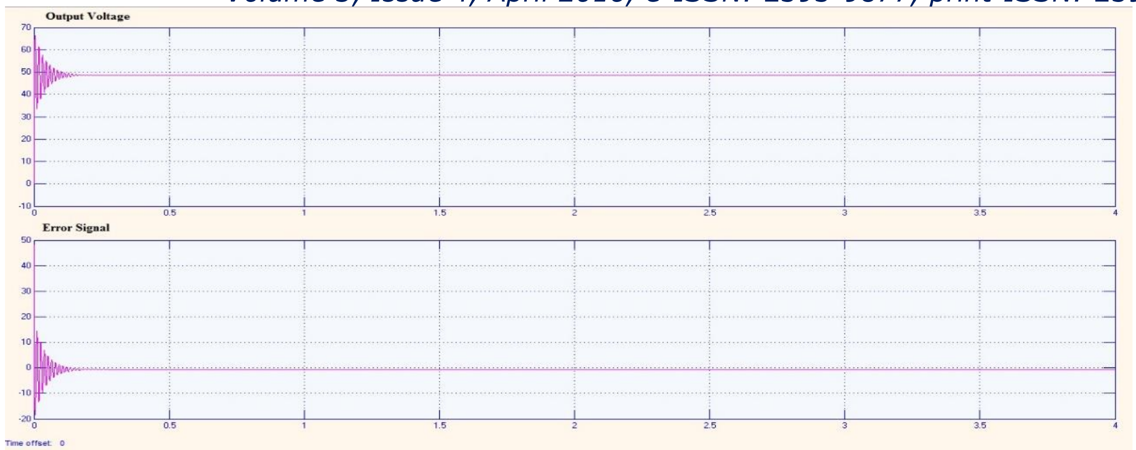

Fig. 5. Waveform Output Voltage & Error Signal

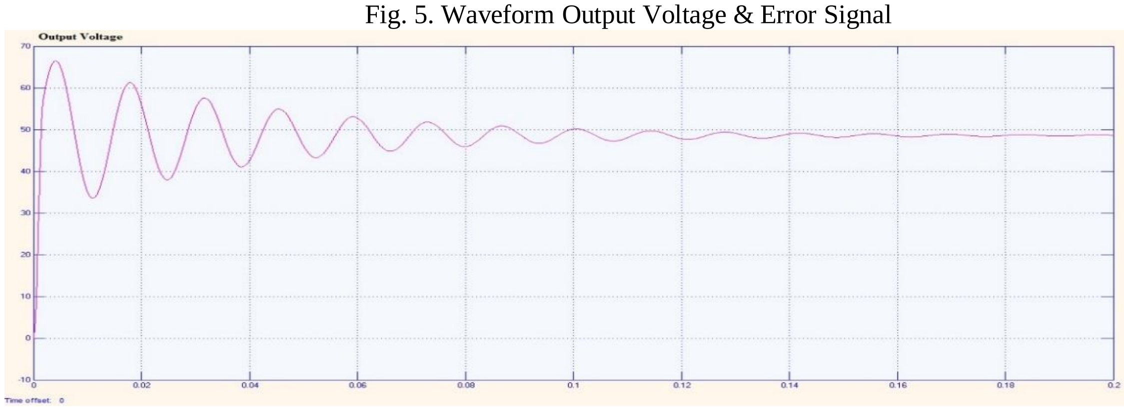

Fig. 6. Waveform of Output Voltage

2)With Fuzzy Contoller: The structure of this implemented FLC consists of two inputs and a single output. The input consists of the voltage error, e (k), and the change in voltage error, ce (k). The output of the fuzzy logic controller will be the duty cycle. Error and change in error is given by equations.

$e(k) = V_{ref} - V_{measured}$

$ce(k) = e(k) - e(k\text{-}1)$

Where V_{ref} is the reference DC bus voltage and V measured is the measured output voltage and k is the sampling instant. Here the FLC consists of three subsystems which are Fuzzification, Rule base or Decision making and Defuzzification. Fuzzification converts the numerical value of the e(k) and ce(k) into linguistic variable (fuzzy variable) like positive small, negative big etc. Defuzzification takes the fuzzy output and converts it into crisp numeric value. Decision making is assuming the control action of the FLC and the linguistic variables. The output of the FLC is the duty cycle, D (k). The generated duty cycle is used to generate the switching pattern of the gate pulse which fed to the gate of the switch of the DC to DC converter.

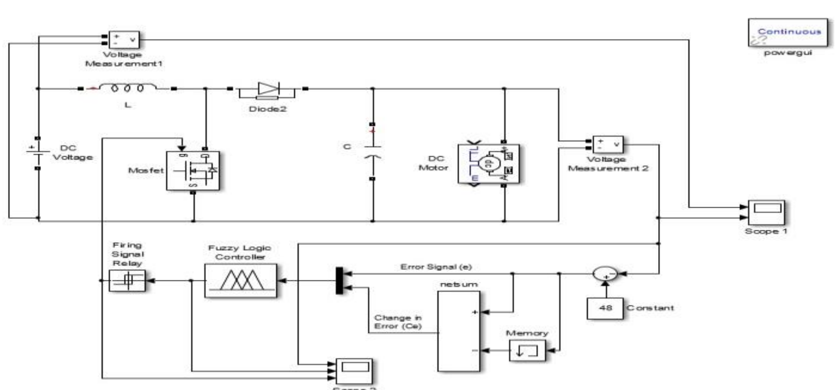

Figure 7 Circuit of Boost converter with Fuzzy Logic Controller

Fig. 8. Waveform Input & Output Voltage

IV- RESULTS AND DISCUSSIONS

Figure 4 & 7 is the closed loop of boost converter with PI & Fuzzy Logic controller and fig.5 and fig.6 are the waveforms of boost converter. When the input voltage is 24, we get 48 output voltage as shown in fig.5 and from fig 8, the output is 48 volts when input is 24.As seen the both controllers, both gives the controlled output.

REFERENCES

[1] Siddharth Mehta, Harsh Mittal and Nithya Venkatesan, “Design and Implementation of Intelligent Controller Based Boost Converter for Electric Vehicle Applications.”

[2] Liping Guo, John Y. Hung and R. M. Nelms, “Comparative Evaluation of Linear PID and Fuzzy Control for a Boost Converter.”

[3] Pellano, Kimji and Lin, Jia-Chuan’s, “Design and Implementation of Microcontroller Based Interleaved DC-DC Boost Converter for Fuel Cell Electric Vehicles.”

[4] K. B. Adam, “Design of Bidirectional Converter Using Fuzzy Logic Controller to Optimize Battery Performance in Electric Vehicle.” published in IEEE-2015.

[5] S.A. Elankurisil, Dr. S.S. Dash2, “Comparison of isolated and non-isolated bi-directional dc - dc converter for DC motor.”

[6] Sonima Antony and S. Paul Sathiyan “Design and Simulation of Boost Converter with Input Ripple Cancellation Network.”

[7] Pellano, Kimji and Lin, Jia-Chuan “ Design and Implementation of Microcontroller Based Interleaved DC-DC Boost Converter for Fuel Cell Electric Vehicles.”

[8] Muhammad H. Rashid “Power Electronics Circuits, Devices, and Applications”, Published in Prentice-Hall of India Private Liited-2006.

[9] S.Rajasekaran and G.A.Vijayalakshmi Pai “Neural Networks, Fuzzy Logic and Genetic Algorithms Synthesis and Applications” Published in PHI Learning Private Limited-2008.

[10] B.L.Theraja and A.K. Theraja’s “A Textbook of Electrical Technology Volume –II AC & DC Machines.” Published in S.Chand &Company Limited.

[11] http://www.ebikeschool.com/much-power-electric-bicycle-need/

[12] https://www.electricbike.com/12-kit-power-levels-360w-to-8000w/

[13] http://www.electrical4u.com/permanent-magnet-dc-motor-or-pmdc-motor/