ZETA Converter with PI controller

Srishti Sharma[#1], Ritesh Diwan[*2]
M.E. (Power Electronics),RITEE,Raipur,C.G, INDIA[#1],
*Associate Professor ,RITEE,Raipur,C.G,INDIA[*2]*

Abstract

Dc-dc Zeta converter is a buck-boost type of converter, which yields dc output voltage with same polarity that of the input voltage. It is widely used in various domestic and industrial applications. For good voltage regulation, fast dynamic response, and stable operation of this converter, a feedback control design is necessary. Therefore, in this paper, the duty cycle to output voltage small-signal transfer function of dc-dc Zeta converter is obtained using state-space technique and Leverrier algorithm. Then this transfer function is used for designing a PI controller using stability equations to meet specific phase margin and desired cross-over frequency. The simulation results display that compensated Zeta converter exhibits good dynamic and steady-state behaviour in presence of line and load variations.

Keywords - *PI controller, zeta converters, Simulink model*

I. INTRODUCTION

A ZETA CONVERTER is an electronic circuit which converts a source of direct current (DC) from one voltage level to another. It is a Switched DC -DC converter which provides a regulated and stepped up output voltage. It is widely applied to maximize the energy harvest for photovoltaic systems and for wind turbines; hence they are called power optimizers. In this paper, ZETA converter is designed controlled using a PI controller and the corresponding output response is simulated using MATLAB software. Also the response of ZETA converter when it is subjected to line and load variations is simulated.

II. PROPORTIONAL-INTEGRAL (PI) CONTROLLER

In some systems, if the gain is too large the system may become unstable. In these circumstances the basic controller can be modified by adding the time integral of the error to control the operation (Fig 6.5.7). Thus the output can be given by an equation,

$$OP = K\left(\text{error} + \frac{1}{T_i}\int \text{error}\, dt\right)$$

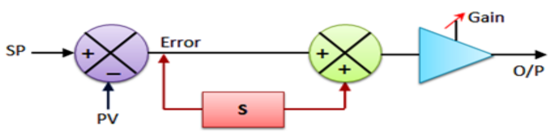


Fig. 1:- Block diagram of P-I controller

The $T\ i$ is a constant called integral time. As long as there is an error the output of the controller steps up or down as per the rate determined by T_i. If there is no error then the output of the controller remains constant. The integral term in the above equation removes any offset error.

The block diagram of a closed loop control system for a process using PI controller is shown in Figure 2.

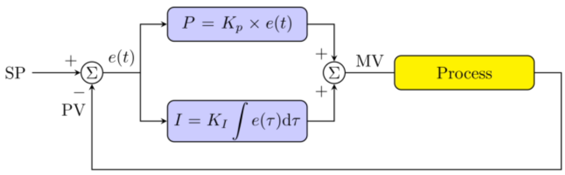


Figure 2:- Basic PI Controller

The controller output is given by the equation (2.1)

$$MV(t) = K_p \times e(t) + K_i \int e(t)\, dt$$

Equation (2.1)

Figure 2 shows the basic structure of a PI controller. The PI controller calculates an error value e (t) as the difference between a measured Process Variable (PrV) and a desired Set Point (SP). The controller attempts to minimize the error by controlling the process through the use of a Manipulated Variable (MV). In this work, derivative action is not used because it may provide disturbances to the SEPIC in steady state condition due to high frequency switching operation of SEPIC.

III. DESIGNING OF CONVERTERS AND SIMULINK MODEL

Simulation has been done in MATLAB® version R2013 software package. MATLAB has various applications such as it is used for mathematical computational task and can solve very complicated application equations within very less time. MATLAB SIMULINK is a model design, which provides an interactive graphical environmental and a set of block libraries that lets us design, implemented and test a variety of design. Block diagrams of converters are design using "SIMPOWER system" blocks.

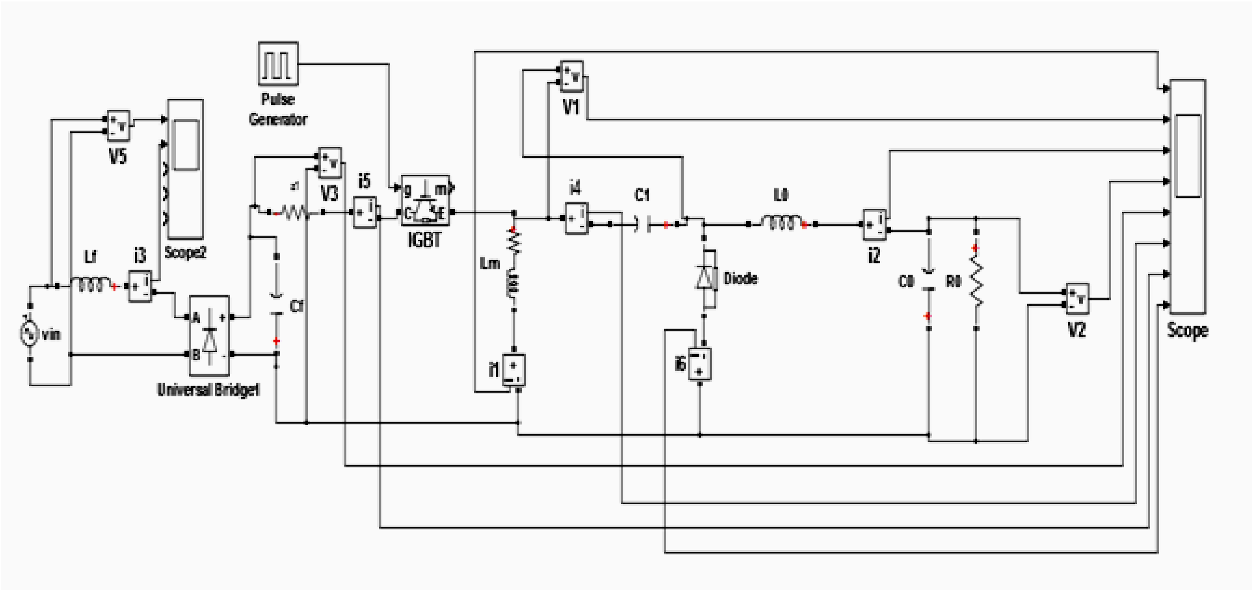


fig (a)

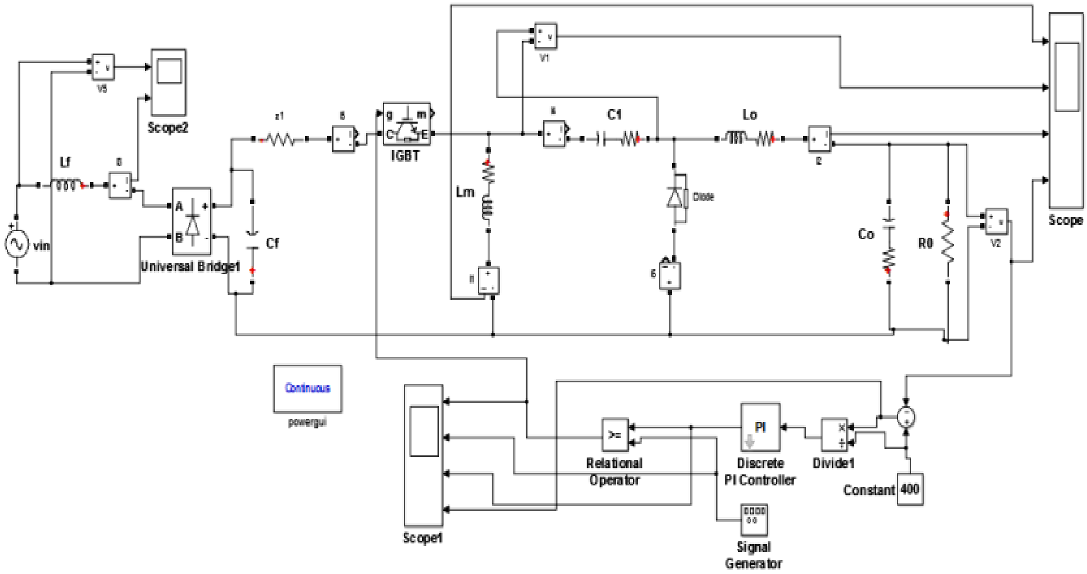


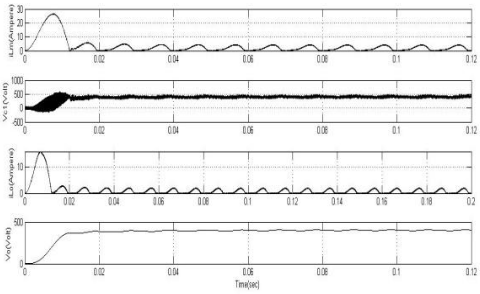
fig (b)

Fig 3 – SIMULINK model of power circuit and control scheme of ZETA (a) without PI controller (b) with PI controller

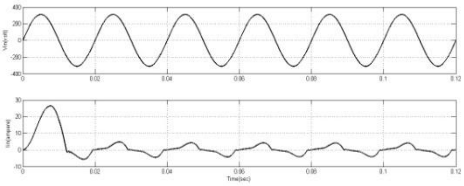
IV. SIMULATION RESULT OF ZETA CONVERTER

Steady state results of the ZETA converter waveforms {output (a) and input (b) waveform and FFT analysis(c)} are shown in fig.(6.1) to fig(6.6) for without PI controller and fig.(6.7) to fig(6.12) with PI controller in both mode CCM and DCM. As below figure show that steady state input and output waveform and FFT analysis of converter for following condition:

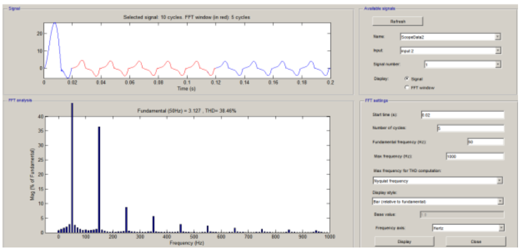
(1) The steady state response under normal condition.
(2) The variation on input voltage change 311 volts to 285 volt.
(3) The variation on provided load 640 ohm to 500 ohm.



(a)

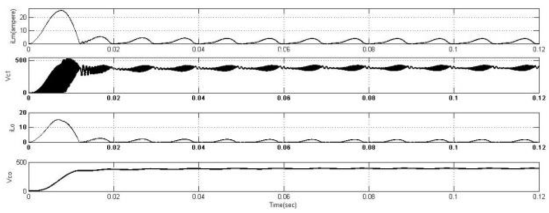


(b)

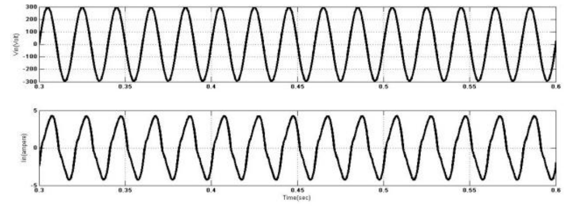


(c)

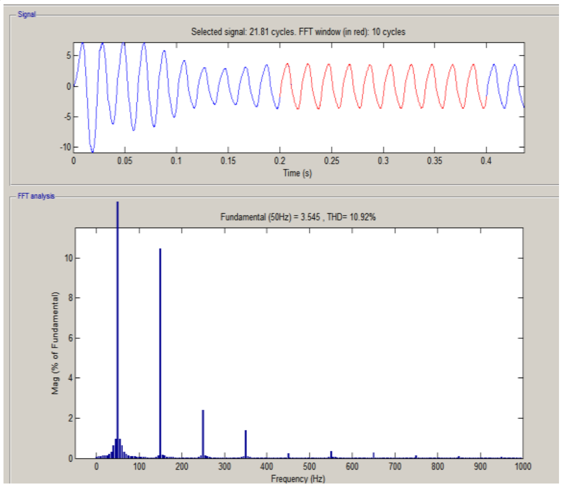
Fig. 4 for point (1) waveforms and FFT analysis of ZETA converter in CCM mode without using PI controller (a) output waveform (b) input waveform (c)THD of input current waveform(Iin)=38.26%



(a)



(b)



(c)

Fig. 5 for point (1) waveforms and FFT analysis of ZETA converter in CCM mode with using PI controller (a) output waveform (b) input waveform (c)THD of input current waveform (Iin)=10.92%

V. CONCLUSIONS

In this paper the design strategy of converters is described. The converter parameter designed successfully, and understands the fact of designing AC-DC converters, to and evaluates the performance of designed converters simulation has been done. For comparing the converter performance PI control techniques has implemented.

Advantages:

1. It is a buck-boost type converter. It means you can step up the voltage and step down as well.
2. It provides better efficiency and better voltage gain than the regular buck-boost converter.
3. The output voltage is positive in reference to the ground which makes the sensing circuit simple.

Disadvantages:

1. The input current is discontinuous, which is not desired for some applications.
2. The passive element requirement is more.
3. It is a fourth order converter, which makes the control difficult. Some control techniques gets eerily difficult to implement in this converter, like sliding mode control.

VI. FUTURE SCOPE

1) The Artificial Neural Network (ANN) can be implemented for isolated converters.
2) ZETA Converter may be used as charge controller for efficient use of solar energy in street lighting system.
3) Power factor corrected zeta converter also can be used as improved power quality switched mode power supply.

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