International Journal of Modern Engineering Research (IJMER)
www.ijmer.com Vol.2, Issue.6, Nov-Dec. 2012 pp-4186-4188 ISSN: 2249-6645

Design and Simulation of PI Control for Positive Output Triple Lift Luo Converter

N.Dhanasekar[1], Dr.R.Kayalvizhi[2]
1(Department of Electrical & Electronics, A.V.C.College of Engineering,Mayiladuthurai, India)
2 (Department of Instrumentation, Annamalai University, Chidambaram, India)

ABSTRACT : *The positive output triple lift Luo converter is a newly devolved DC-DC converter. The object of this paper is to design and analyze a Proportional – Integral (PI) control for positive output triple lift Luo converter (POTLLC). The positive output triple lift Luo converter performs the voltage conversion from positive source voltage to positive load voltage. The simulation model of the positive output triple lift Luo converter with its control circuit is implemented in Matlab/Simulink. The PI control for positive output triple lift Luo converter is tested for transient region, line changes, load changes, steady state region.*

Keywords: *DC-DC converter, Matlab, Positive output triple lift Luo converter, Proportional – Integral control, simulink*

I. INTRODUCTION

DC-DC conversion technology has been developing rapidly, and DC-DC converters have been widely used in industrial applications such as dc motor drives, computer systems and medical equipments. The output voltage of pulse width modulation (PWM) based DC-DC converters can be changed by changing the duty cycle [1]-[2]. The voltage lift technique is a popular method that is widely applied in electronic circuit design. This technique effectively overcomes the effects of parasitic elements and greatly increases the output voltage. Therefore these converters perform DC-DC voltage increasing conversion with high power density, high efficiency and high output voltage with small ripples [3]. Compared with conventional dc-dc converters, triple-lift Luo converters can implement the output voltages by increasing stage by stage along a geometric progression and obtain higher voltage transfer gains. They are divided into various categories according to their power stage numbers, such as the elementary circuit (single power stage), re-lift circuit (two power stages), triple-lift circuit (three power stages) etc.[4]. Due to the time variations and switching nature of the power converters, their static and dynamic behavior becomes highly non-linear.[5]. A good control for DC-DC converters always ensures stability in arbitrary operating condition. Moreover, good response in terms of rejection of load variations, input voltage variations and even parameter uncertainties is also required for a typical control scheme. The PI control technique offers several advantages compared to PID control methods: stability, even for large line and load variations, reduce the steady error, robustness, good dynamic response and simple implementation [2].

In this paper PI control with zero steady state error and fast response is brought forward. The static and dynamic Performance of PI control for positive output triple lift Luo converter is studied in Matlab/Simulink. For the purpose of optimize the stability of positive output triple lift Luo converter dynamics, while ensuring correct operation in any working condition, a PI control is a more feasible approach. The PI control has been presented as a good alternative to the control of switching power converters [5]-[6]. The main advantage PI control schemes is its insusceptibility to plant/system parameter variations that leads to invariant dynamics and static response in the ideal case [2].

II. CIRCUIT DESCRIPTION AND OPERATION

Triple lift circuit is shown in Fig.1 and it consists of two switches S and S_1, four inductors L_1, L_2, L_3 and L_4, five capacitors C, C_1, C_2, C_3 and C_0 and five freewheeling diodes.

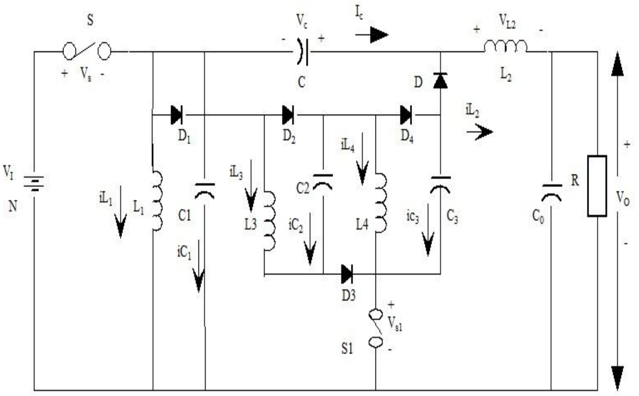

Figure 1 triple lift Luo circuit

Capacitors C_1, C_2 and C_3 perform characteristics to lift the capacitor voltage V_c by three times the source voltage V_I. L3 and L_4 perform the function as ladder joints to line the three capacitors C_1, C_2 and C_3 and lift the capacitor voltage V_c up.

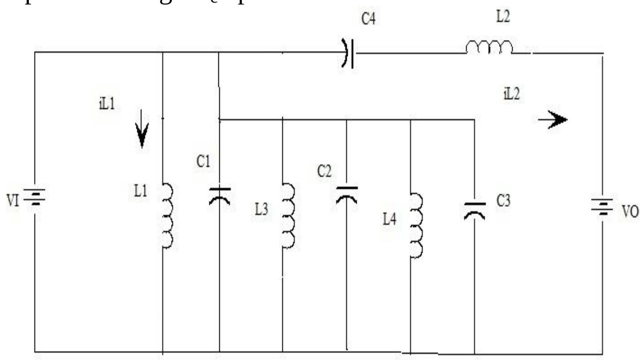

Figure 2 switches S and S_1 are ON

In the description of the converter operation, it is assumed that all the components are ideal and positive output triple lift converter operates in a continuous conduction mode. Fig. 2 and 3 shows the modes of operation of the converter.

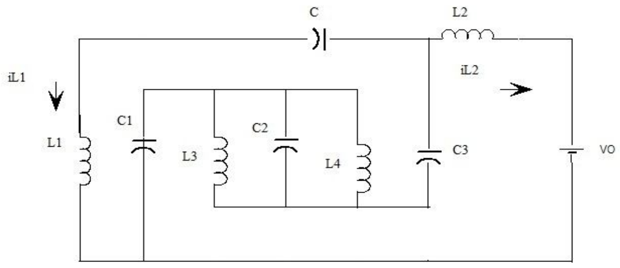

Figure 3 switches S and S_1 are open

The current iL_2 increases in switches are in ON period kT. And it decreases in switches are in OFF period (1-kT). The output voltage and current are

: $$V_0 = \frac{3V_I}{1-K} \quad (1)$$

: $$I_0 = \frac{(1-k)\, I_I}{3} \quad (2)$$

The voltage transfer gain in continuous mode is

: $$M_T = \frac{V_0}{V_I} = \frac{3V_I}{1-K} \quad (3)$$

Average current

: $$IL_1 = \frac{kI_0}{1-k} \quad (4)$$

: $$IL_2 = I_0 \quad (5)$$

: $$IL_3 = IL_4 = IL_1 + IL_2 = \frac{I_0}{1-k} \quad (6)$$

Current variations

$$\eta = \frac{k}{M_{T2}} \frac{3R}{2fL} \quad (7)$$

Therefore variation ratio of output voltage v_c is

: $$\varepsilon = \frac{k}{8M_T} \frac{1}{f^2 c_0 L_2} \quad (8)$$

III. DESIGN OF PI CONTROLLER

The PI control is designed to ensure the specifying desired nominal operating point for POTLLC, then regulating POTLLC, so that it stays very closer to the nominal operating point in the case of sudden load disturbances and set point variations. The PI control settings proportional gain (*Kp*) and integral time (*Ti*) are designed using Zeigler – Nichols tuning method [6] by applying the step test obtain S – shaped curve of step response of POTLLC From the S-shaped curve of step response of POTLLC may be characterized by two constants, delay time *L* and time constant *T*. The delay time and time constant are determined by drawing a tangent line at the inflection point of the S-shaped curve and determining the intersections of the tangent line with the time axis and line output response c(t).From this value calculate the proportional gain (*Kp*) and integral time (*Ti*) are designed using Zeigler – Nichols tuning method

IV. 4. SIMULATION OF TRIPLE LIFT CONVERTER

The simulations has been performed on the positive output triple lift Luo converter circuit with parameters listed in Table I. The static and dynamic performance of PI control for the positive output triple lift Luo converter is evaluated in Matlab/Simulink

TABLE - I

Parameter name	Symbol	value
Input voltage	V_I	10 volts
Output voltage	V_o	60 volts
Inductors	L_1, L_2, L_3 & L_4	100µH
Capacitors	C, C_1, C_2 & C_3	5 µf
Capacitor	C_0	300µf
Switching frequency	f_s	100kHz
Load resistance	R	100Ω
Duty cycle	k	0.5

The Matlab/Simulink simulation model is shown in Fig.4. The difference between feedback output voltage and reference voltage is given to PI control and output of PI control, change in duty cycle of the power switch (n - channel MOSFET).

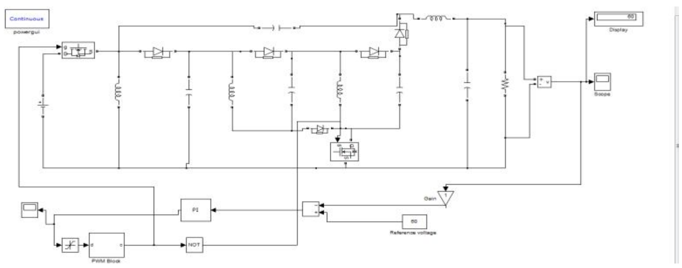

Figure 4 PI control positive output triple lift Luo converter.

The POTLLC performance is done for three regions .they are transient region, line variations and load variations.

4.1 Transient region

Fig 5 shows the output voltage of POTLLC with PI control in the transient region. It can be that the converter output has settled at time of 0.014 sec. with designed PI control.

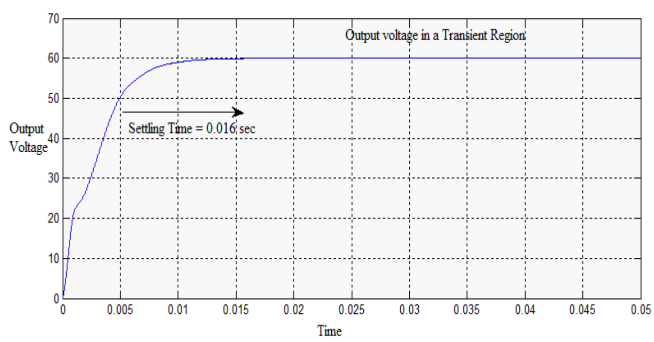

Figure 5 output voltage in transient region

4.2 Line variations

Fig.6 shows the output voltage of converter for input voltage step change from 10 V to 7 V (-30% supply disturbance).the converter output voltage has maximum overshoot of 2.5V and 0.007sec settling time with designed PI control. Fig.7 shows the output voltage variations for the input voltage step change from 10 V to 13 V (+ 30% supply disturbance).the converter output voltage has maximum overshoot of 5 V and 0.012 sec settling time with designed PI control.

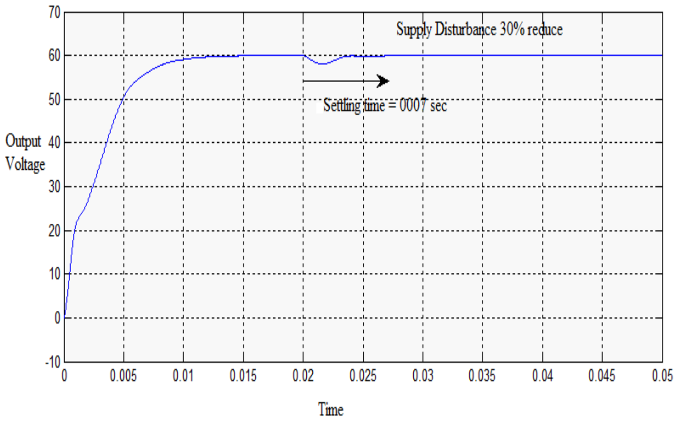

Figure 6 Output voltage - supply change from 10 V to 7 V

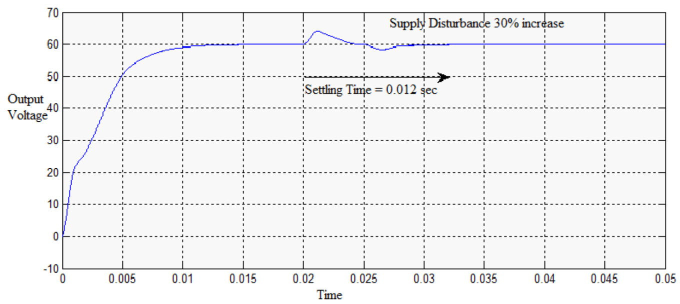

Figure 7 Output voltage - supply change from 10 V to 13V

4.3 Load variations

Fig.8 shows the output voltage with change the load from 100 Ω to 80 Ω (-20% load disturbance).the maximum overshoot is 0.6 V and settled at the 0.005 sec .Fig.9 shows the variation of load from 100 Ω to 120 Ω(+20% disturbance) the maximum overshoot of 0.003 V and settled at 0.00 sec.

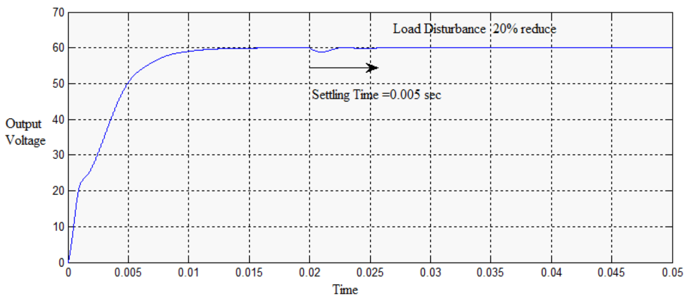

Figure 8 output voltage – load change from 100 Ω to 80 Ω

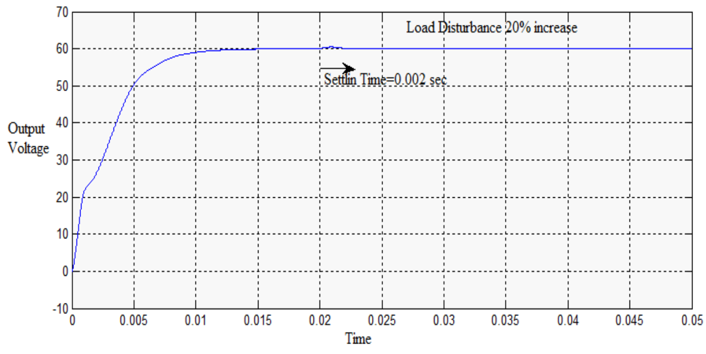

Figure 9 output voltage – load change from 100 Ω to 120Ω

V. CONCLSION

The positive output triple lift Luo converter (POTLLC) performs the voltage conversion from positive source voltage to positive load voltage. The PI control scheme has proved to be robust and it has been validated with transient region, line and load variations. The positive output triple lift Luo converter with PI control use in applications such as switch mode power supply, medical equipments and high voltage projects etc.

VI. ACKNOWLEDGEMENT

The author wish to thank the A.V.C.College of Engineering Management for their moral support.

REFERENCES

[1] F.L.Luo and H.Ye, "Positive output super lift converters," IEEE Transaction on power electronics, Vol.18, No. 1, pp. 105-113, January 2003.

[2] K. Ramesh kumar and S. Jeevanantham." PI Control for positive output elementary super lift luo converter,'' World Academy of Science, Engineering and Technology. pp. 732-737, March 2010.

[3] Fang Lin Luo and Hong Ye. Advanced DC/DC Converters. CRC Press, London, U.K.

[4] R. Kayalvizhi, S.P. Natarajan and AnnRosella. "Design and simulation of PI controller for positive output elementary Luo converter", Journal of Engineering and Technology, AUJET. pp. 90-93.

[5] T. S. Saravanan , R. Seyezhai and V. Venkatesh "modeling and control of split capacitor type elementary additional series positive output super lift converter", ARPN Journal of Engineering and Applied Sciences, vol. 7, no. 5, may 2012.

[6] P. Comines and N. Munro, "PID controllers: recent tuning methods and design to specification", in IEEE Proc. Control Theory Application, vol.149, no.1, pp.46-53, Jan 2002.