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Performance Evaluation of PI controller for Negative Output Triple Lift Luo Converter

N.Dhanasekar, Dr.R.Kayalvizhi

Abstract— The object of this paper is to design and analyze a Proportional – Integral (PI) control for negative output triple lift Luo converter (NOTLLC),which is the start- of –art-the DC-DC converter. The negative output triple lift Luo converter performs the voltage conversion from positive source voltage to Negative load voltage. In order to improve the dynamic performances of NOTLLC for both static and dynamic specifications, we propose a PI controller. The simulation model of the negative output triple lift Luo converter with its control circuit is implemented in Matlab/Simulink. The PI control for negative output triple lift Luo converter is tested for transient region, line changes, and load changes.

Index Terms— DC-DC converter, Matlab, Negative output triple lift luo converter, Proportional Integral control simulink.

I. INTRODUCTION

The 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 negative output Triple Lift Luo converter recently developed sub-set of DC-DC converters [3]. A PI controller is developed in this work to regulate the output voltage of this converter under line and load disturbances. The voltage lift (VL) technique is a popular method widely used in electronic circuit design. This DC-DC converter can convert the source voltage into a higher output voltage with higher efficiency, high power density and simple structure [4]. Proportional Integral (PI) controller has been implemented for the proposed DC-DC converter. PI control techniques offer stability, large line and load variation robustness, good dynamic response. PI control is chosen to ensure fast dynamic response for line side and load side disturbances with output voltage regulation [5]-[7]. 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 negative output triple lift Luo converter is studied in Matlab/Simulink. For the purpose of optimize the stability of negative 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].

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II. CIRCUIT DISCRPTION AND OPERATION

Negative output triple lift luo converter circuit is shown in Fig.1and it consist of one static switch S, four inductors L, L1, L2 and L_0 and five capacitors C,C_1,C_2,C_3 and C_0 and diodes .

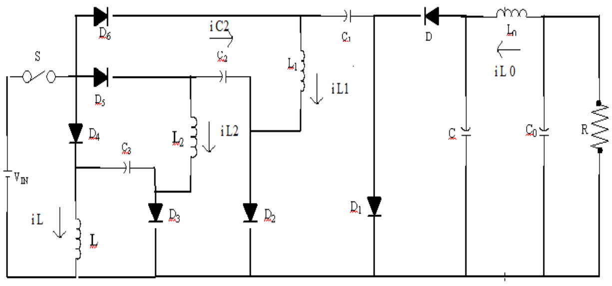

Figure 1. Negative output triple lift luo converter.

Circuit C_1–D_1-L_1-C_2-D_2-D_6-L_2-C_3-D_3-D_5 is the lift circuit. Capacitors C_1,C_2 and C_3 perform characteristics to lift the capacitor voltage V_c by three times that of the source voltage. L1 and L_2 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.

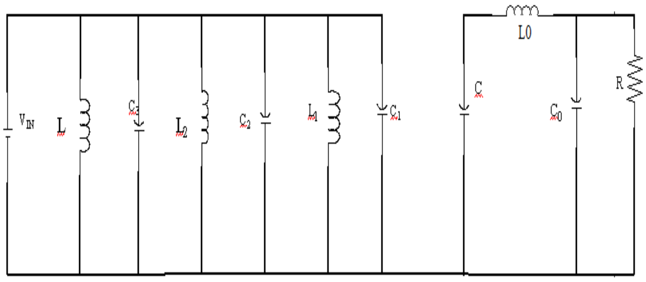

Figure 2 switch S is ON.

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

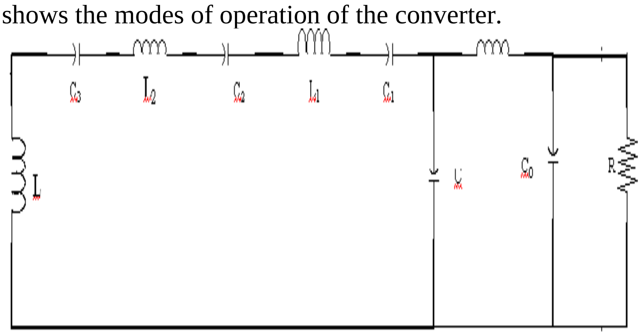

Figure 3 switch S is OFF.

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The switch is ON for period kT and OFF for (1-kT) period. The output voltage and current are

$$V_o = \frac{3}{1-k} V_I \quad (1)$$

and

$$I_o = \frac{1-k}{3} I_I \quad (2)$$

The voltage transfer gain in continuous mode is

$$M_T = \frac{V_o}{V_I} = \frac{3}{1-k} \quad (3)$$

Average currents

$$I_{Lo} = I_o$$
$$I_L = I_{L1} = I_{L2} = \frac{1}{1-k} I_o \quad (4)$$

The variation ratio of output voltage V_c is

$$\varepsilon = \frac{k}{128} \frac{1}{f^3 C C_o L_o R} \quad (5)$$

III. DSIGN OF PI CONTROLLER

The PI control is designed to ensure the specifying desired nominal operating point for NOTLLC, then regulating NOTLLC, 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 NOTLLC From the S-shaped curve of step response of NOTLLC may be characterized by two constants, delay time and time constant. 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. SIMULATION OF TRIPLE LIFT LUO CONVERTER

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

TABLE - 1

Parameter name	Symbol	value
Input voltage	V_I	10 volts
Output voltage	V_o	- 60 volts
Inductors	L, L_1, L_2 & L_o	10µH
Capacitors	C, C_1, C_2, C_3 & C_o	30 µf
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).

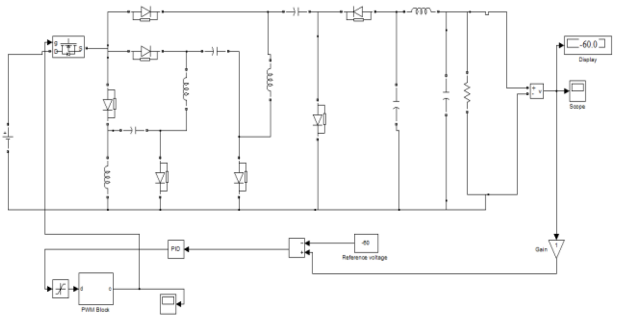

Figure 4.simulink negative output triple lift luo converter

The negative output triple left luo converter performance is done for three regions. They are transient region, line variations and load variations.

A. *Transient Region*

Fig 5 shows the output voltage of NOTLLC 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.

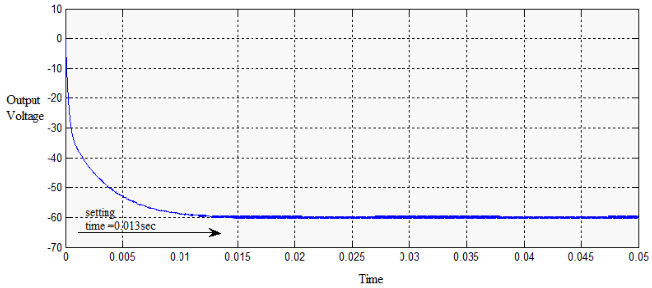

Figure 5 output voltage of NOTLLC

B. *Supply disturbance*

The output voltage of converter for input voltage step change from 10 V to 12 V (+20% supply disturbance) .the converter output voltages has maximum overshoot of 9.66% and 12msec settling time with designed PI control is sown in Fig 6. The Fig.7 shows the output voltage variations for the input voltage step change from 10 V to 8 V (- 20% supply disturbance).the converter output voltage has maximum overshoot of 5.6% and 11msec settling time with designed PI control.

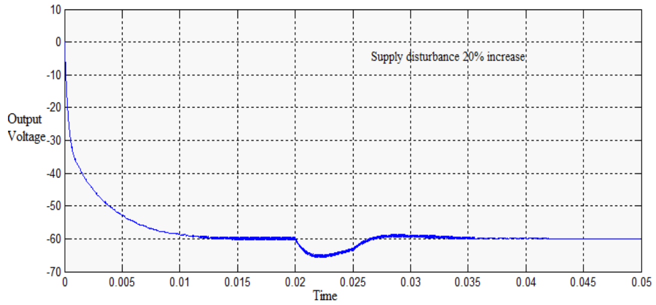

Figure 6 Output voltage - supply change from 10 V to 12 V

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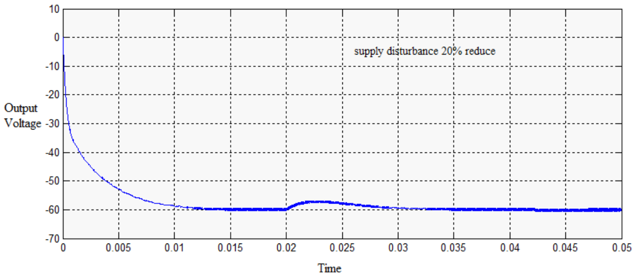

Figure 7 Output voltage - supply change from 10 V to 8 V

C. Load disturbance

Fig.8 shows the output voltage with change the load from 100 Ω to 120 Ω (+20% load disturbance).the maximum overshoot is 2.5% and settled at the 7msec .Fig.9 shows the variation of load from 100 Ω to 80 Ω(-20% disturbance) the maximum overshoot of 15% and settled at 17msec.

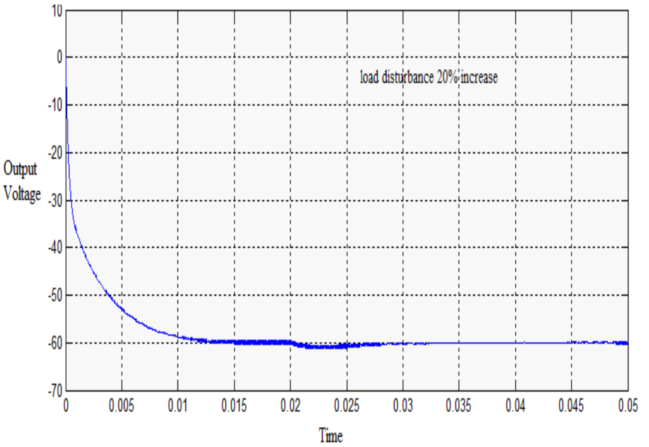

Figure 8 Output voltage –load change from 100Ω to 120Ω

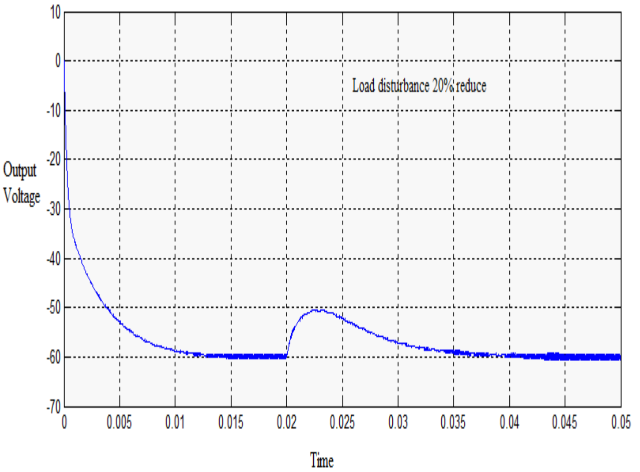

Figure 9 Output voltage –load change from 100Ω to 80

TABLE 2. Performance Evaluation of Pi Controller for Negative Output Triple Lift Luo Converter with Resistive Load Using Matlab

Conversion path	Start-up Transient			Line Disturbance				Load disturbance			
	Delay time (msecs)	Rise time (msecs)	Settling time (msecs)	Supply increase 2V		Supply decrease 2V		Load increase 20%		Load decrease 20%	
				Peak over shoot (%)	Settling time (msecs)	Peak over shoot (%)	Settling time (msecs)	Peak over shoot (%)	Settling time (msecs)	Peak over shoot (%)	Settling time (msecs)
Negative	1.2	7	13	9.66	12	5.6	11	2.5	7	15	17

V. CONCLSION

The negative output triple lift Luo converter (NOTLLC) performs the voltage conversion from positive source voltage to negative load voltage. From the table 2, PI control scheme has proved to be robust and it has been validated with transient region, line and load variations. The negative 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

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