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Development of Pi Controller for Multiple-Lift Push-Pull Switched Capacitor Luo Converter

KEYWORDS: Switched-Capacitor, Multiple-Lift, Push-Pull State.

R.Subbulakshmy
Assistant Professor, Department of Electrical and Electronics Engineering, Panimalar Institute of Technology,Chennai-600123,Tamilnadu, India.

D.Shobana
Assistant Professor, Department of Electrical and Electronics Engineering, Panimalar Institute of Technology, Chennai-600123,Tamilnadu, India.

N.Anipriya
Assistant Professor, Department of Electrical and Electronics Engineering, Panimalar Institute of Technology, Chennai-600123,Tamilnadu, India

K.P.Nithya
Assistant Professor, Department of Electrical and Electronics Engineering, Panimalar Institute of Technology, Chennai-600123,Tamilnadu, India

ABSTRACT *A DC-DC converter topology the controllable switches are operated switch mode where they turn entire load current ON-OFF during each switching cycle. Under these conditions the switches are subjected to high switching stress and power losses. Reasonly there is an increased interested in use of switched capacitor type DC-DC converter. Due to the advantage of high frequency of operation, high efficiency, small size, lightweight, Reduced electromagnetic interference (EMI) and low component stress. DC-DC multiple-lift PUSH-PULL switched capacitor luo converter. Find the application especially in telecommunication power supply, battery charging, aircrafts converter systems and fuel cell power system. The above converter are also employed in a personal computer ,laptop computer and plasma power supplies. A voltage lift techniques is a popular method to apply in electronic circuit design. The present work is on the performance evaluation of negative output multiple lift PUSH PULL SC luo converter. MATLAB software are used to study the dynamics characteristics and analysis the closed loop performance of these converter with Resistive load, supply and load disturbance. The simulation closed match with each other and high light the feasibility and validity of the developed control scheme.*

I.INTRODUCTION

The DC-DC converter widely used in number of applications such as adjustable speed drives (ASDs) electrochemical process such as electroplating, telecommunication, power system, battery charging, Uninterrupted power supply (UPS), high capacity magnet, power supply, aircraft converter system, plasma power supplies and converter for enable energy conversion system. Micro-power-consumption technique has been widely applied in microelectronics production and computer manufacturing. It requires high power density DC/DC converters and power supply sources. Since switched capacitor (SC) can be integrated into a power IC chip, its size is small. SC converters usually perform In push-pull state with conduction duty cycle k = 0.5.Voltage Lift (VL) Technique is a popular method widely used in electronic circuit design including DC/DC converters [l -11]. Combining both SC and VL techniques can construct the DC/DC converters with advantages such as small size, high power density, high voltage transfer gain, high power efficiency and low EMI. As positive output multiple-lift push-pull SC Luo-Converters [12], this paper introduces new series converters - negative output (N/O) multiple-lift push pull SC Luo-Converters. These converters are split into two sub-series: main and additional series. The first six stages of these converters are shown in Fig. 1 - 6. For convenience to explain, we call them N/O Elementary circuit (-1 -Lift circuit), -3- Lift circuit, -7-Lift circuit in main series and -2-Lift circuit, -5-Lift circuit, -1 1-Lift circuit in additional series respectively. The main switch is S in all circuits, and other switches are slaves. The main switch S is on and slaves off during switching-on period, and S is off and slaves on during switching-off period. The load is resistive load R. Input voltage and current are Vi, and Iin, output voltage and current are Vo and Io [13-261. For convenience, all calculation values are absolute values.

II.MAIN- SERIES AND ADDITIONAL- SERIES

Figure 1. shows the family tree of N/O Multiple-Lift Push-PullSwitched-Capacitor Luo-Converters.

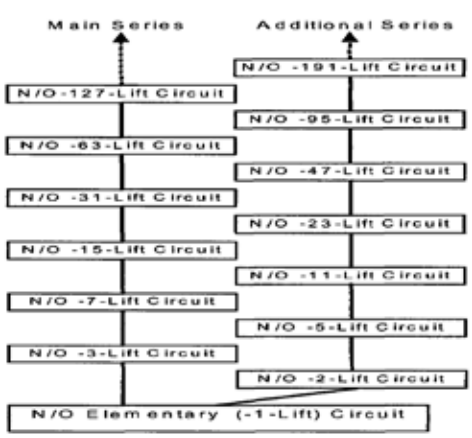

Figure 1.The family tree of N/O Multiple-Lift Push-Pull Switched-CapacitorLuo-Converters.

Using this technique, we can easily design Higher Order Lift circuit to obtain high output voltage. All these converters can be sorted into two categories: the main series (as -l-, -3-, -7-, -15, -31-, -63- and -127-lift circuit) and additional series (as -2-, -5, -1 1-, -23-, - 47-, -95- and -191-lift circuit). If the slave switches' number is m. the -nth-Lift cir-

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$$n=\begin{cases}2^m-1 & Main\_series\\ 1.5\times 2^m-1 & Additional\_series\end{cases} \quad \text{----------(1)}$$

For -nth-lifi circuit, the final output voltage is

$$V_O=\begin{cases}(2^m-1)V_{in}-\sum_{i=0}^{m-1}2^i\Delta V_{m-i} & Main\_series\\ 1.5\times(2^m-1)V_{in}-1.5\times\sum_{i=1}^{m-1}2^i\Delta V_{m-i}-\Delta V_m-\Delta V_O & Additional\_series\end{cases}$$

--------(2)

From above formulae, we can see that output voltage is nearly doubled by adding one stage. With comparison to the main series and additional series, output voltage of converters in additional series is enlarged by 50 % by adding the output parts. The family tree of Multiple-Lift Push-Pull Switched-Capacitor Luo-Converters is shown in Fig.1

III. N/O ELEMENTARY CIRCUIT

N/O Elementary circuit is shown in Fig. 1. Two switches S and S1 operate in push-pull state. The voltage across capacitor C1 is charged to Vi, during switching-on. The voltage across capacitor C2 is ideally charged to Vo = -Vin, during switching-off. Therefore, the output voltage is:

$$V_O=(2\text{-}1)\,V_{in} = V_{in} \quad \text{----------(3)}$$

Considering the voltage drops across the diodes and switches, we combine all values in a figure of ΔV_1. The real output voltage is:

$V_O=V_{in}-\Delta V_1$ ----------(4)

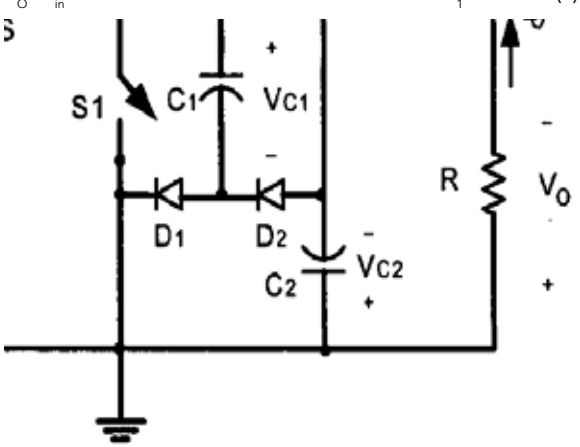

Figure 2. Elementary circuit

IV.DESIGN OF PI CONTROLLER

Many Many industrial processes are non-linear and are thus complicated to be described mathematically. However, it is known that a good many non-linear processes can satisfactorily be controlled using PID controllers provided the controller parameters are tuned well. Practical experience shows that this type of control has a lot of sense since it is simple and based on three basic behavior types or modes: proportional (P), integrative (I) and derivative (D).

Instead of using a small number of complex controllers, a larger number of simple PID controllers are used to control complex processes in an industrial assembly in order to automate the certain more complex process. Controllers of different types such as P, PI and PD are today basic building blocks in control of various processes. In spite of simplicity, they can be used to solve even a very complex control problem, especially when combined with different functional blocks, filters (compensators or correction blocks), selectors etc.

A continuous development of new control algorithms insure that the PID controller has not become obsolete and that this basic control algorithm will have its part to play in process control in foreseeable future. It can be expected that it will be a backbone of many complex control systems. While proportional and integrative modes are also used as single control modes, a derivative mode is rarely used in control systems. PI controller forms the control signal in the following way.

$$\mathbf{U(t) = K_p[\,e(t) + \frac{1}{T}\int_0^t e(\tau)\,d\tau]}$$

Using the transfer function, the tuning of the controller is done by the reaction curve method. Controller tuning involves the selection of the best values of K_p and T_i.

V.SIMULATION RESULTS

Figure 3 and 4 shows the Simulated start-up of the output voltage and current of Negative Output multiple-Lift push-pull Luo-Converters. Figure 5 and 6. shows Simulated output voltage and current of Negative output multiple-Lift push-pull Luo-Converters with sudden line disturbances. Figure 7 and 8 shows. Simulated output voltage of Negative Outputmultiple-Lift push-pull Luo-Converter with sudden load disturbances under nominal load.

Table 1 . Performance Evaluation of PI controller for negative outpu multiple-lift push-pull Luo converter with Resistive load using Matlab

Delay time (msecs)	Rise time (msecs)	Peak over shoot (%)	Peak time (msecs)	Settling time (msecs)	Supply increase 10%		Supply decrease 10%		Load increase 10%		Load decrease 10%	
					Peak over shoot (%)	Settling time (msecs)	Peak over shoot (%)	Settling time (msecs)	Peak over shoot (%)	Settling time (msecs)	Peak over shoot (%)	Settling time (msecs)
.118	0.278	2.2	4.78	23	5.68	38.2	2.38	52.7	4	80.9	5	60.9

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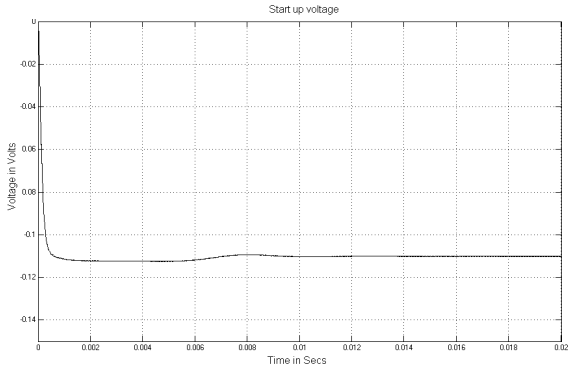

Figure 3. Simulated start-up of the output voltage of Negative Output multiple-Lift push-pull Luo-Converters .

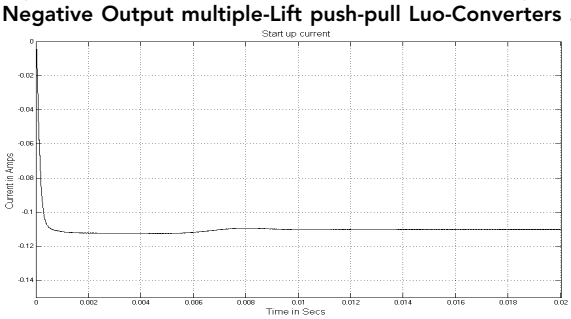

Figure 4 Simulated start-up of the output current of Negative Output multiple-Lift push-pull Luo-Converters.

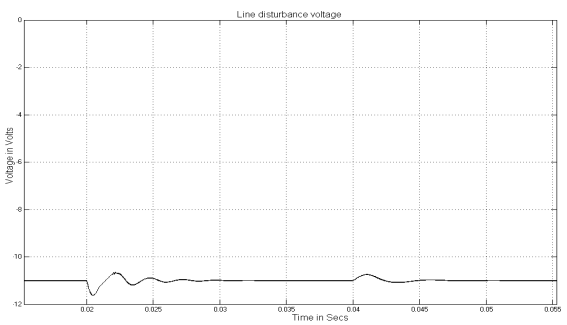

Figure 5. Simulated output voltageof Negativeoutput-multiple-Lift push-pull Luo-Converters with sudden line disturbances 12V-15V-12V

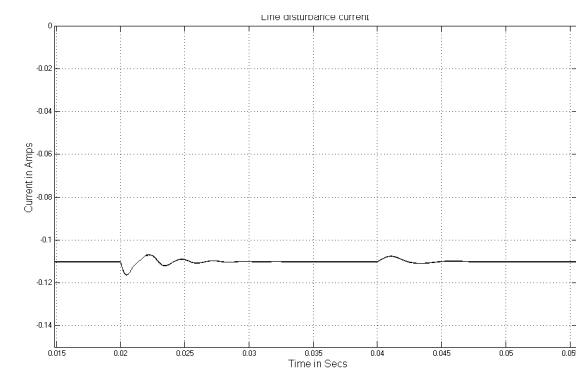

Figure 6. Simulated output current of Negative Output multiple-Lift push-pull Luo-Converters with sudden line disturbances 12V-15V-12V

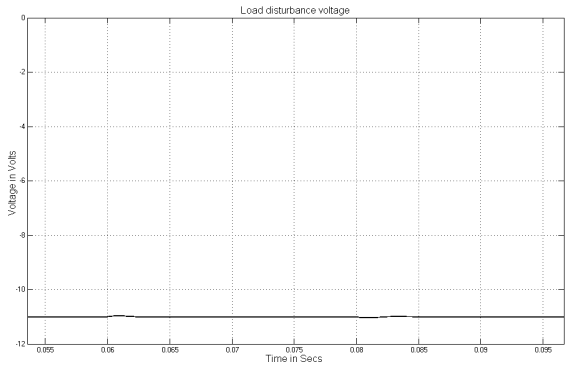

Figure 7. Simulated output voltage of Negative Outputmultiple-Lift push-pull Luo-Converter sudden with load disturbances under nominal load (100Ω –90Ω 100Ω)

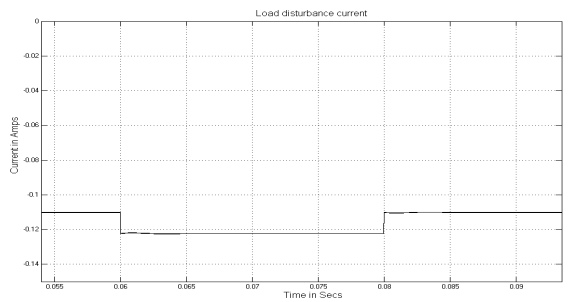

Figure 8. Simulated output current of Negative Output Output multiple-Lift push-pull Luo-Converter with sudden load disturbances under nominal load (100Ω –90Ω 100Ω

V.Conclusion

A new series of DC/DC converters multiple lift push-pull switched-capacitor Luo-Converters has been successfully created. Since these converters are constructed by switched capacitor, their size is very small and power density is very high. Using this method largely increases the voltage transfer gain, and high output voltage is easily obtained The Simulation results show that the proposed PI controller regulates satisfactorily the output voltage of multiple lift push-pull switched-capacitor Luo converters irrespective of line and load disturbances This series of DC/DC converters is suitable and conveniently to be applied in industrial applications with high output voltage.

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