Performance Analysis of Extended Boost Switched Capacitor Impedance Type DC-AC Converter

Chinnapettai Ramalingam Balamurugan, R.Kalai Surya, N.Kayalvizhi, M.Raouf Khan, P.Santhosh

Abstract: The improvement in impedance type DC-AC converter with step up voltage is achieved by the inclusion of new type of On/OFF capacitor. Impedance source inverter is used to step up and step down the input voltage. Impedance source DC-AC converter is used to decrease the effect of wide change in electrostatic effects for the capacitor used. To have better step up voltage without change in switches initially impedance source inverter is proposed. The proposed circuit overcomes the disadvantages of traditional impedance source inverter.

Keywords: THD; boost; shoot through; non shoot through

I. INTRODUCTION

Impedance Source inverters has advantages over the conventional inverters like voltage source inverter and current source inverter. The conventional inverters cannot able to step up the input voltage. But due to the impedance source inverter the voltages can be stepped up and stepped down simultaneously. The range of voltage buck-boost ratio is obtained through formula. The author [1] discussed in detail about the concept of Z-source inverter. Step up control of maximum control of the impedance source inverter is suggested in [2]. The control circuit for impedance source inverter [3] was discussed. To minimize current ripple and voltage handling capability in terms of stress has been proposed with fixed step-up control for impedance source inverter [4]. For service main with photo voltaic [5] system was developed using impedance source inverter. Three phase Z-source inverter are proposed and implemented [6]. The analysis is made on the modulation schemes. Advanced impedance source inverter was developed [7] using special type of inductor. Further the family of impedance source inverter was developed with two inductors [8].

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Chinnapettai Ramalingam Balamurugan, Department of Electrical and Electronics Engineering, Karpagam College of Engineering, Myleripalayam Village, Othakkalmandapam, Coimbatore, 641032, India

R.Kalai Surya, Department of Electrical and Electronics Engineering, Karpagam College of Engineering, Myleripalayam Village, Othakkalmandapam, Coimbatore, 641032, India

N.Kayalvizhi, Department of Electrical and Electronics Engineering, Karpagam College of Engineering, Myleripalayam Village, Othakkalmandapam, Coimbatore, 641032, India

M.Raouf Khan, Department of Electrical and Electronics Engineering, Karpagam College of Engineering, Myleripalayam Village, Othakkalmandapam, Coimbatore, 641032, India

P.Santhosh, Department of Electrical and Electronics Engineering, Karpagam College of Engineering, Myleripalayam Village, Othakkalmandapam, Coimbatore, 641032, India

The circuit discusses about five level h type multilevel inverter using control freedom degree pulse generation technique. For renewable energy systems [10] the recent power conditioning system was developed using Quasi impedance source inverter with modeling and control. Development of reduced cost phase conversion converter using step up technology [11]. To develop photovoltaic applications embedded inverter are recent topologies that can perform both buck/boost functions are used [12]. To suggest [13] an impedance source inverter with different loads the simulation study was carried out and analysed its performance. For different loads the developed inverter has the additional step up capacity to increase the voltage [14]. With different configurations of voltage stress and low value of L, the inverter will have better performance [15]. A hardware is developed for ON/OFF configuration of inductor with Z network [16]. H-bridge inverter fed AC motor using SPWM technique is implemented [17]. A detailed study is made on various power circuits and control topologies of proposed inverters [18,19]. The single phase switched inductor switched capacitor type inverter is developed by [20]. The new type of cascaded Z source neutral point clamped inverter is developed [21]. For voltage step applications [22] new impedance source inverter was developed. Digital control is designed using MATLAB coding for new impedance source inverter.

II. PROPOSED METHOD

Switched Capacitor Z Source Inverter can be realized by replacing the inductor cell with a capacitor cell with small modifications in the positions of the passive Switched Capacitor Z Source Inverters with Extended Boost Capability components. This proposed topology has overcome the existing topologies constraints. The advantages of the proposed method are boost factor increases as the number of (n) cascaded cells increases, It provides high gain, It minimize the ripple current within the inverter, Efficiency of the system can be improved, Reduces the voltage stress across the capacitors during initial conditions and It reduces the THD value.

III. SIMPLE BOOST CONTROL

In this technique or methods the time durations are represented by two constant lines. The line magnitude will be higher or lower than the maximum of the reference wave.

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Fig. 3 displays the MATLAB tools to create gate pulses by comparing the reference and carrier signals.

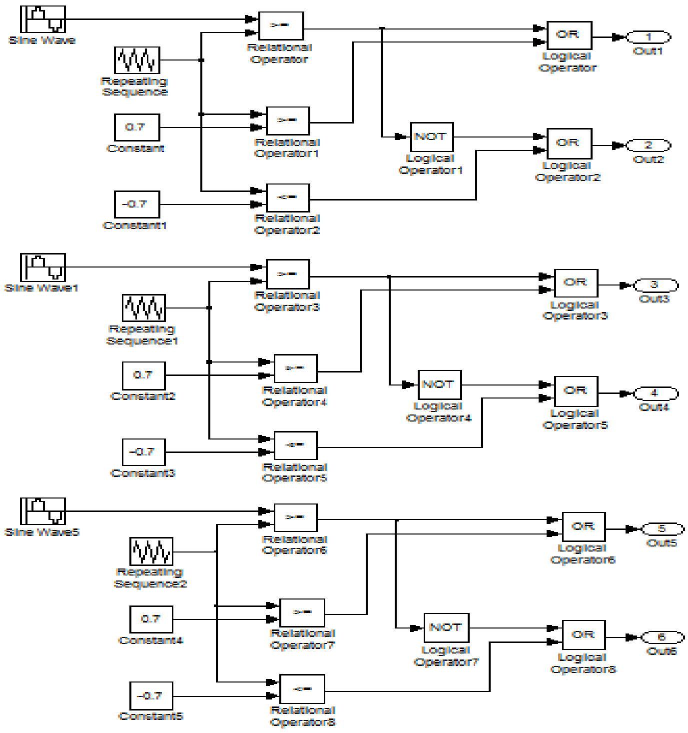

Fig. 1 Gate pulse generation

Reliability Calculation

Formulae to find reliability of a inverter is

$\lambda_P = \lambda_B \pi_T \pi_A \pi_B \pi_S \pi_Q \pi_E$ failure/106 hrs

IGBT used for calculation is = KGT 25N120NDA

(i) Calculate the reliability for switched capacitance with $\frac{600V}{120A}$ IGBT

$\lambda_B = 0.00074$ $\qquad$ $\pi_R = 62.7$

$\pi_T = 5.9$ $\qquad$ $\pi_S = 0.39$

$\pi_A = 0.7$ $\qquad$ $\pi_Q = 0.7$

$\pi_E = 6.0$

λ_P,IGBT = 0.3138 failure/10^6 hrs

Use 6 IGBT ,

λ_P,INV = 6*0.3138

= 1.8828 failure/10^6 hrs

[**note:** Failure rate = $\frac{1}{\lambda_P}$]

Mean time to failure ,

MTTF = $\frac{1}{\lambda_P}$,INV

= $\frac{1}{1.8828}$

= 0.53112

Mean time to failure,

MTTF = 531123 hrs

(ii) Calculate the reliability for switched capacitance with $\frac{600V}{25A}$ IGBT

$\lambda_P = \lambda_B \pi_T \pi_A \pi_B \pi_S \pi_Q \pi_E$ failure/10^6 hrs

$\lambda_B = 0.0007$ $\qquad$ $\pi_R = P^{0.37}$

$\pi_T = 5.9$ $\qquad$ $_S = 1$

$\pi_A = 0.7$ $\qquad$ $\pi_Q = 2.4$

$\pi_E = 6.0$

λ_P,IGBT = 0.0007*5.9*0.7*$(600*25)^{0.37}$ *2.4*6

= 0.007*5.9*0.7*35.08*1*2.4*6

λ_P,IGBT = 1.46 failure/10^6 hrs

Use 6 IGBT ,

λ_P, INV = 6*1.46

= 8.76 failure/10^6 hrs

[**note:** Failure rate = $\frac{1}{\lambda_P}$]

Failure rate = $\frac{1}{\lambda_P}$

= $\frac{1}{8.76}$ *10^6 hrs

= 0.114155251 hrs

Mean time to failure,

MTTF = 0.114155251*10^6 hrs

= 11455 hrs

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Reliability in years = $\frac{114155}{365*24}$

= 13yrs

Switching Power Device Calculation

Formula used:

Total average SDP=(SDP)av= $\sum_{M=1}^{N}$ Vmlm-average

Total peak SDP =(SDP)pk = $\sum_{M=1}^{N}$ Vmlm-peak

The average and peak SDPs of Z-source inverter are

Given data:

Po=152*13=1976 watts

M=1

cos θ =1

(SDP)av = (2Po(2-$\sqrt{3}$ M)/($\sqrt{3}$ M-1)+(4$\sqrt{3}$ P0/cos θ π))

= (2(1976)(2-$\sqrt{3}$ (1))/($\sqrt{3}$ (1)-1)+4*$\sqrt{3}$ *1976)/cos0o* π)

= (3952)(0.267)/(0.732)+13690/3.141

= 1055.184/13960.732/3.141

(SDP)av = $\frac{8V_{max}P_o}{cosV_i\pi m}$

= $\frac{8*105*1.9761}{1*100*\pi*1}$

(SDP)av = 5.283 KVA

Ip= $\frac{p_o}{3cos\Phi V_p}$

= $\frac{1.976*10^3}{3*1*V_p}$

then,

Vp = $\frac{V_i}{2\sqrt{2}}$ *M

Vp = $\frac{100}{2\sqrt{2}}$ *1

Vp = 35.35

Ip = $\frac{1.976*10^3}{3*1*35.35}$

= 18.632 Amps

IPK = $\sqrt{2}*18.632$

IPK = 26.35 Amps

(SDP)pk = 6*Vs*Ipk

= $\frac{8V_{max}*p_o}{\cos\Phi*V_i*M}$

= $\frac{8*105*1.976*10^3}{1*100*1}$

(SDP)pk = 16.60 KVA

LC Filter Design

GIVEN:

V_p =57.73 V_{dc} =98.10 P_n =120 W

I_L =7.6 A f_s =2*103 Hz

$resonant\ frequency =$

$\frac{1}{2} of\ switching\ frequency(Fsw)$

Solution

$$Z_b = \frac{(v_p)^2}{P_h}$$

$$= \frac{(57.73)^2}{120}$$

=27.772

$$C_b = \frac{1}{W_n Z_b} = \frac{1}{2\pi f * Z_b}$$

$$= \frac{1}{2\pi*50*27.77}$$

C_b =1.146*10^{-4} F

$$\Delta I_{L\ max} = \frac{0.1*P_n\sqrt{2}}{3V_{ph}}$$

$$= \frac{0.1*120*\sqrt{2}}{3*57.73}$$

=0.097 A

$$L_i = \frac{V_{dc}}{16*f_s*I_L}$$

$$= \frac{98.10}{16*20*10^3*0.097}$$

L_i = 3.16 mH

C_f = 0.05*C_b

=0.05*1.146*10^{-4}

C_f =5.73 μF

$$W_{ref} = \sqrt{\frac{L_i + L_g}{L_i * L_g * C_f}}$$

$$10*10^3 = \sqrt{\frac{3.16*10^{-3} + L_g}{3.16*10^{-3}*L_g*5.73*10^{-6}}}$$

$$10*10^{10} = \frac{3.16*10^{-3} + L_g}{1.8106*10^{-8}*L_g}$$

1810.68*L_g =3.16*10-3+ L_g

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$1810.68 * L_g - L_g = 3.16*10\text{-}3$

$L_g\,(1810.68\text{-}1) = 3.16*10\text{-}3$

$$L_g = \frac{3.16*10^{-3}}{1810.68-1}$$

$$W_{res} = \sqrt{\frac{3.16*10^{-3} + 1.746*10^{-6}}{3.16*10^{-3} * 1.746*10^{-6} * 5.73*10^{-6}}}$$

$$= \sqrt{1.00009*10^{11}}$$

$$= 316242.7$$

$W_{res} = 316.242\ kHz$

$$R_{sd} = \frac{1}{3*W_{res}*C_f}$$

$$= \frac{1}{3*316.242*10^{3}*5.73*10^{-6}}$$

$R_{sd} = 0.1839\,\Omega$

$$L_f = \frac{R_{sd}}{2\pi * f_s}$$

$$= \frac{0.1839}{2\pi*20*10^{3}}$$

$$\therefore L_f = 1.46*10^{-6}H$$

IV. SIMULATION RESULTS

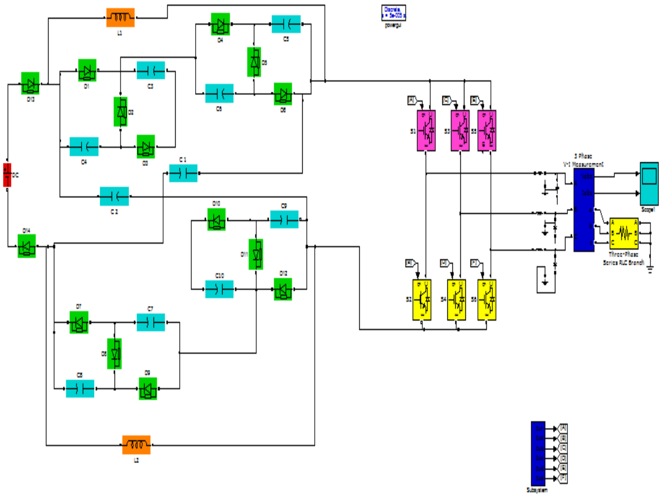

Fig. 2 Simulation circuit for proposed work

The Simulation parameters chosen are

Source voltage	=	100V
Z-source network		
Capacitors	=	50µf
Inductors	=	2mH
LC filter side		
Capacitors	=	2000µf
Inductors	=	10mH
Load	=	12ohm

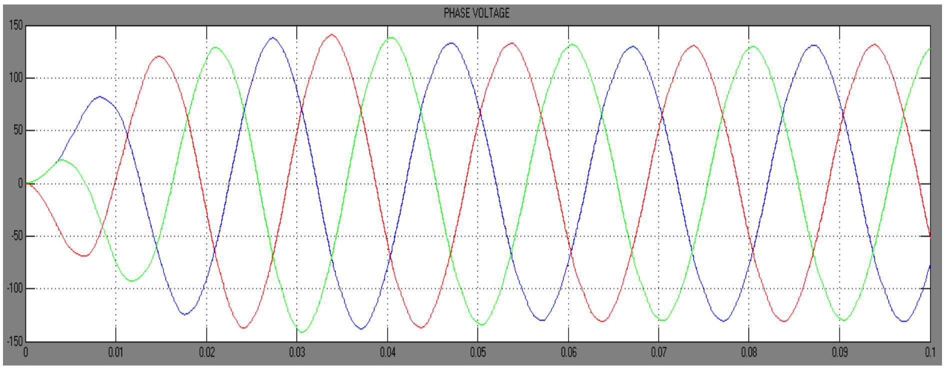

Fig. 3 Output voltage waveform

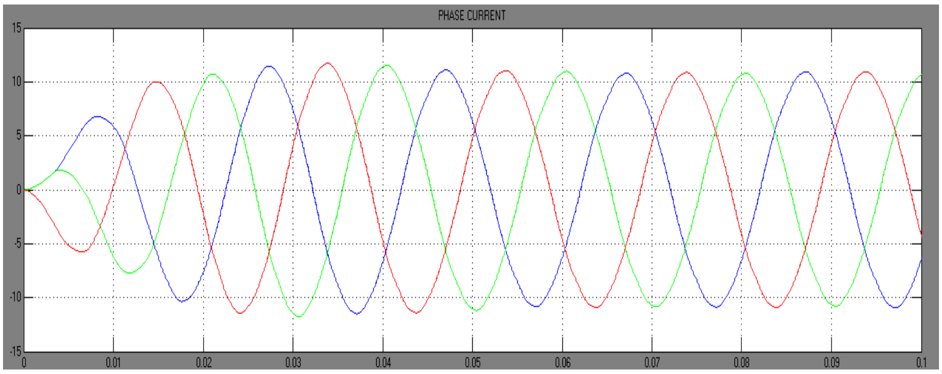

Fig. 4 Output current waveform

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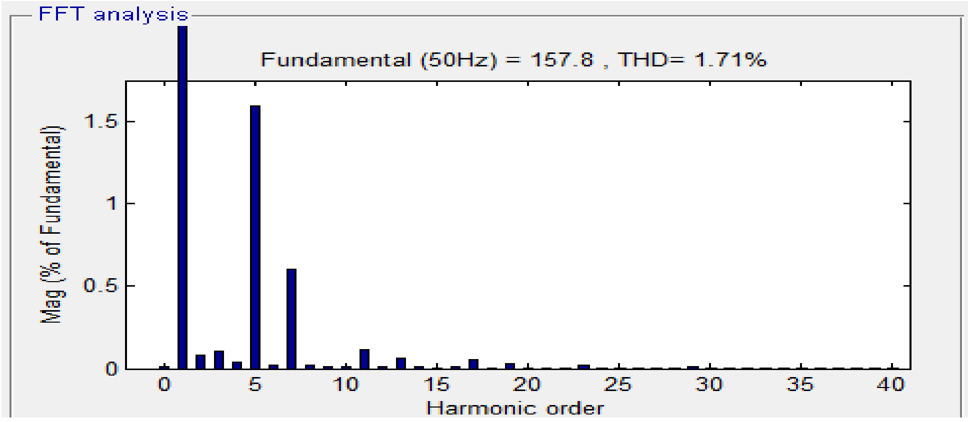

Fig. 5 Output voltage total harmonic distortion

Table. 1 Comparison of various performances with different topology

Topology Name	Input Voltage	Output Voltage	Output Current	V_{THD} %
VSI	100	63.1	5.3	0.46
ZSI	100	153.35	13	2.7
EZSI	100	155.9	13.3	2.35
EBSCZSI	100	157.7	14	1.71

V. CONCLUSIONS

The proposed extended boost switched capacitor Z Source inverter have better voltage gain characteristics and less THD values . It is to be appreciated that Z Source inverters are flexible for various modifications and can be applied to the entire spectrum of power conversion which finds applications in renewable energy and motor drives. It is also evident that much new class of Z Source inverters is possible with suitable modifications either in topological design and/or modulation schemes for the above applications, if required.

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Biographical notes: Chinnapettai Ramalingam Balamurugan was born in 1978 in Kumbakonam. He has obtained B.E (Electrical and Electronics), M.E (Power Electronics and Drives) and Ph.D (Instrumentation Engineering- Power Electronics) degrees in 2000, 2005 and 2015 respectively from Arunai Engineering College, Tiruvannamalai, Sathyabama University, Chennai and Annamalai University, Chidambaram. He has been working in the teaching field for about 14 years. His areas of interest include power electronics, electrical machines and solar energy systems. He has 110 publications in international journals. His research papers 80 have been presented in various/IEEE international/national conferences. Currently, he is working as Professor and Head in the Department of EEE, Karpagam College of Engineering, Coimbatore. He is guiding 7 Ph.D scholars under anna university, Chennai. He got best faculty awards for nearly five times. He wrote more than thirty books. He is the reviewer for many reputed journals. He is a life member of Instrument Society of India and Indian Society for Technical Education. He is a member in IEEE. He cleared NPTEL certification Course. Received "DIGITAL GURU AWARD AND CASH PRIZE" for valuable contributions towards the digital content developed for Power Electronics.. Contact number- +91-9894522351. E-mail: crbalain2010@gmail.com.

R.Kalai Surya, N.Kayalvizhi, M.Raouf Khan and P.Santhosh are U.G. students of department of electrical and electronics engineering, Karpagam College of Engineering, Coimbatore