Comparison Between Conventional H-Bridge MLI And Switched-Capacitors Based Multilevel Boost Inverter

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Abstract- *Multilevel inverters offers various applications in voltage ranging from medium to high such as in renewable sources, industrial drives, blowers, conveyors and fans. Multilevel inverters are key technology in various industries operations and becoming more and more popular day by day because of its many advantages over 2-level inverter such as less THD in output waveform, voltage stress on switches and less electromagnetic interference. This paper presents a comparison between 5-level H-Bridge Multilevel Inverter and Switched-Capacitors based Boost Multilevel Inverter with Single Input Source. This paper comprises of comparison of circuit diagram between the two MLI, also it shows comparison of different modulation schemes, comparison of their THD with each other. MATLAB/Simulation is used to simulate the results of 7-level MLI inverter topology.*

Keywords- Multilevel inverter (MLI), five level inverter, total harmonic distortion (THD), multicarrier pulse width modulation.

I. INTRODUCTION

A multilevel inverter is a power electronic device which is capable of providing desired alternating voltage level at the output using multiple lower level DC voltages as an input. Mostly a two-level inverter is used in order to generate the AC voltage from DC voltage. Multilevel Inverters have come upon with broad applications, especially high power and medium voltage drives, distributed generation, HVDC transmission, static VAR compensation, electric vehicular technology and many more [1-2]. The main advantage of multilevel inverter over two level inverters configurations are decrease total harmonic distortion (THD), decrease dv/dt stress across devices, less electromagnetic interference (EMI), less common mode voltage and improve use of rail voltage etc [12].

Several multilevel topologies have been classified as the diode clamped multilevel inverter (DCMLI) [2], the flying capacitor multilevel inverter (FCMLI) [3], the cascaded H-bridge multilevel inverter (CHBMLI) [4]. The diode clamped and flying capacitor converter configurations function with the single DC source but the number of device increase parabolically with the number of output levels raises production cost and complicated control. In cascaded H-bridge multilevel inverter uses full H-Bridge connected in series to produce inverter AC from separated DC sources but major disadvantage is requirement of multiple DC – sources, which is not feasible in many applications. In Multilevel inverters the basic principle is to use low voltage switches for getting high output voltage by dividing the supply voltage among the power electronics switches.

In Multilevel inverters the basic principle is to use low voltage switches for getting high output voltage by dividing the supply voltage among the power electronics switches. Here comparison of topologies of MLI is shown in paper. First one is H-Bridge which uses full H-bridge, connected in series to produce inverter AC from separated DC sources, but major disadvantage is requirement of multiple DC-sources, which is not feasible in many applications.

Second toplogy is Switched-Capacitors based Boost MLI with single input source, it comprises of cascaded H-bridge and switched capacitor converter with auxillary switch. The auxillary switch helps to increase the number of voltage levels. This topology also possesses inherent output voltage boosting capability, it can be extended to any number of levels in the output.

From here we can easily see which topology is better and give less THD, which have less conduction and switching losses. The proposed is stimulated in MATLAB for 5-level inverter. It can also be used for three phase system.

II. PROPOSED TOPOLOGY AND ITS OPERATION

A H-bridge topology for 5-level multilevel inverter is shown in Fig.1. It consists of six power electronic switches written as S1, S2, S3, S4, S5, S6, S7 and S8 and two dc

voltage sources of different rating named as V1 and V2. The Switched capacitor based MLI is shown in Fig.2., switches S1, S2, S3, S4 are switches for switched capacitor part whereas S5, S6, S7, S8 are switches of H-bridge cell. Sab is the auxillary switch.

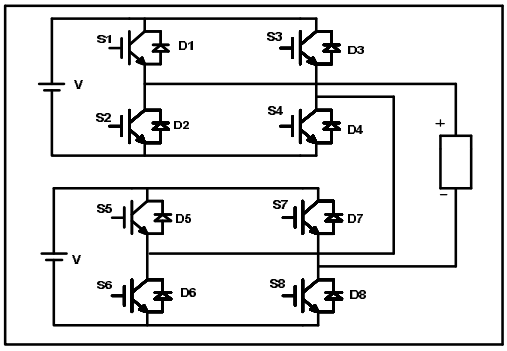

Fig.1 5-level H-Bridge

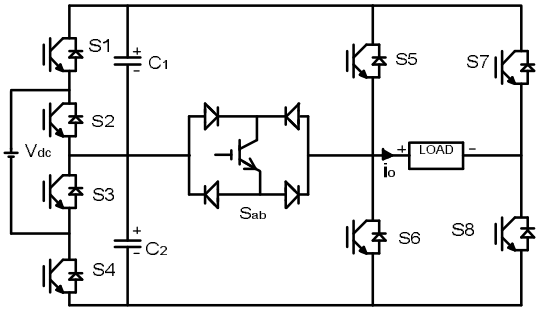

Fig.2 Switched Capacitor based boost MLI

Fig.1shows different modes of H-bridge while Fig.2 shows the different modes of Switched Capacitors based MLI.

Table I. Look up table for various operating modes of H-bridge

V_o	S1	S2	S3	S4	S5	S6	S7	S8
2V	1	1	0	0	1	1	0	0
V	1	1	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
-V	0	0	1	1	0	0	0	0
-2V	0	0	1	1	0	0	1	1

Table 2: Look up table for Switched capacitor based boost MLI

Level of output voltage	Switch States								
	S1	S2	S3	S4	S5	S6	S7	S8	Sab
0					✓	✓			
V_{dc}		✓		✓				✓	✓
$-V_{dc}$	✓		✓			✓			✓
$2V_{dc}$					✓			✓	
$-2V_{dc}$						✓	✓		

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III. MULTICARRIER PWM TECHNIQUES [6-8]

Carrier Disposition techniques-

1. Phase Disposition (PD) Technique
2. Alternate Phase Opposition Disposition (APOD) Technique
3. Inverted Sine Carrier PWM (ISCPWM) Technique

APOD, PD techniques are multicarrier PWM schemes having triangular carrier whereas reference is also sine wave .In ISCPWM carrier is sine of constant frequency and reference is also sine wave .

PHASE DISPOSITION TECHNIQUE

In PD technique all carrier waveform are superimposed over one another like layer with same phase, amplitude and frequency as shown in Fig 3.1

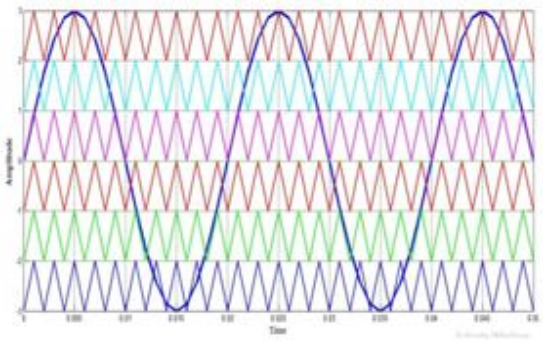

Fig.3.1 Alternate phase opposition disposition technique

ALTERNATE PHASE OPPOSITION DISPOSITION TECHNIQUE

In APOD technique all the adjacent carriers are 180 degree out of phase from each other on either side of zero reference level as shown in Fig 3.3

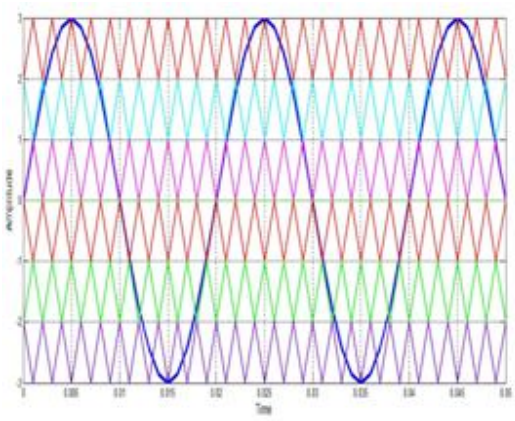

Fig.3.2 Alternate phase opposition disposition technique

INVERTED SINE CARRIER PWM TECHNIQUE

In ISCPWM technique inverted sine wave of certain constant frequency acts as a carrier signal as shown in Fig 3.4

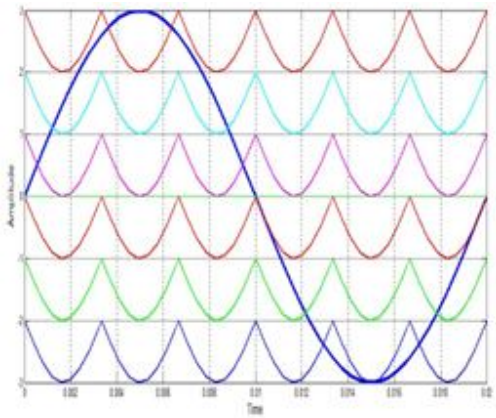

Fig.3.3 ISCPWM Schemes

IV. SIMULATION RESULT

Output voltage waveform of five level H-Bridge Multilevel inverter and Output waveform of five level Switched Capacitor based Boost MLI is shown in shown in Fig.4.1 and Fig.4.2 respectively. FFT analysis for various modulation schemes is shown from Fig.4.3 to Fig.4.8 and it can be seen that THD is lowest by PD technique which is 29.29% and 6.99% at modulation index(m_a=1). In APOD and POD technique THD is higher i.e. 26.62%, 32.37% and 17.87%. 7.80% respectively.THD is low in PD technique hence switching loss and power loss is less consequently efficiency is high and cost is reduced considerably.

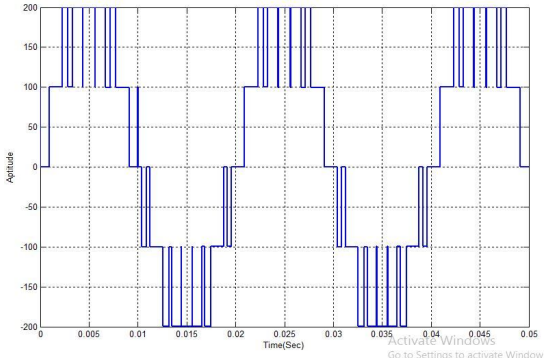

Fig.4.1Output voltage waveform of H-bridge MLI

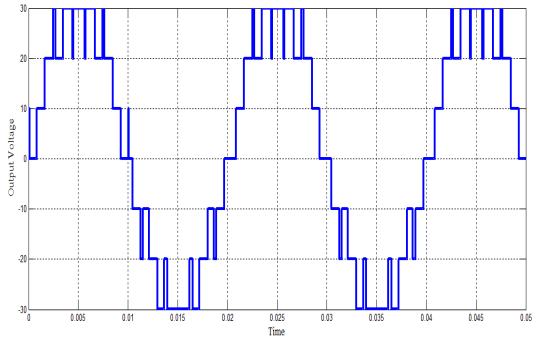

Fig.4.2 Output voltage waveform of Switched Capacitor based Boost MLI

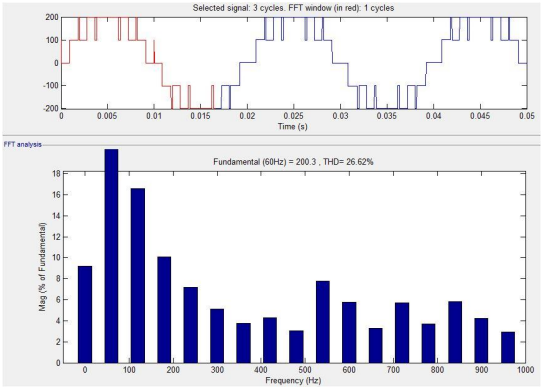

Fig.4.3 FFT Analysis of H-bridge MLI APOD

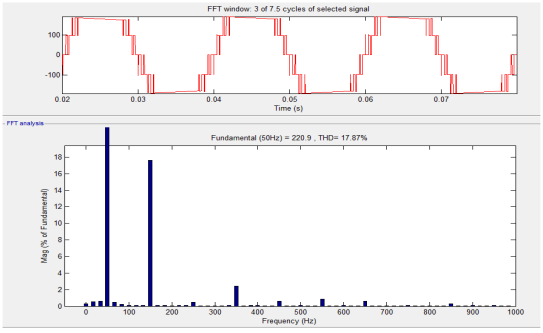

Fig.4.4 FFT Analysis of Switched Capacitor based Boost MLI APOD

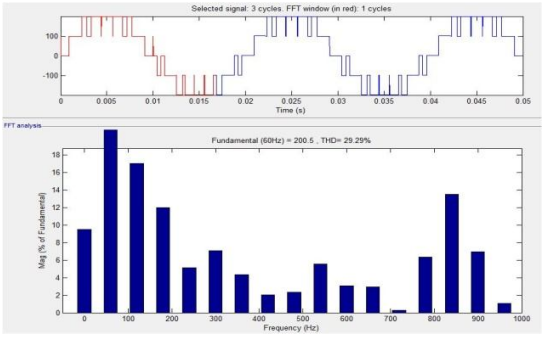

Fig.4.5 FFT Analysis of H-bridge MLI PD

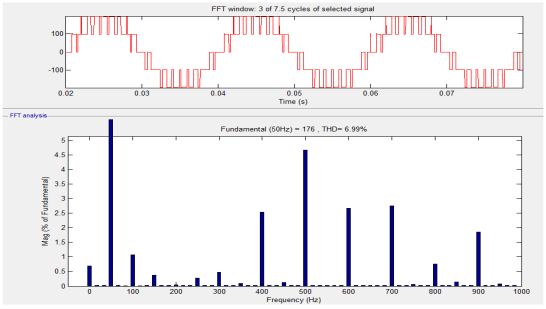

Fig.4.6 FFT Analysis of Switched Capacitor based Boost MLI PD(m_a=1)

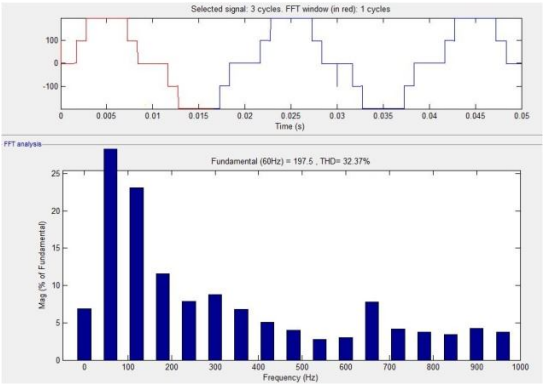

Fig.4.7 FFT Analysis of H-bridge MLI ISCPWM

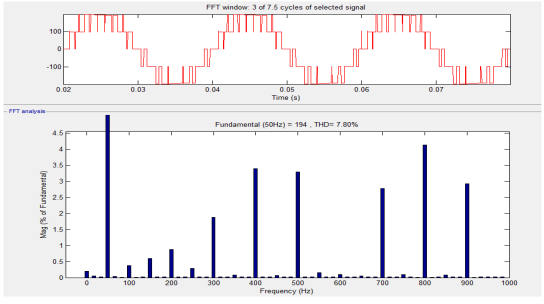

Fig.4.8 FFT Analysis of Switched Capacitor based Boost MLI ISCPWM (m_a=1)

Table. II Indicating THD(%) for various modulation schemes at different modulation indices of H-bridge MLI

SCHEMES	MODULATION INDICES			
	1	0.95	0.9	0.85
PD	29.29	30.03	30.10	31.84
APOD	26.62	27.12	27.75	28.17
ISCPWM	32.37	33.87	33.99	34.56

Table. III Indicating THD(%) for various modulation schemes at different modulation indices of Switched Capacitor based boost MLI

SCHEMES	MODULATION INDICES			
	1	0.95	0.9	0.85
PD	6.99	7.83	8.13	8.56
APOD	17.87	18.09	18.95	19.13
ISCPWM	7.80	8.34	8.78	9.35

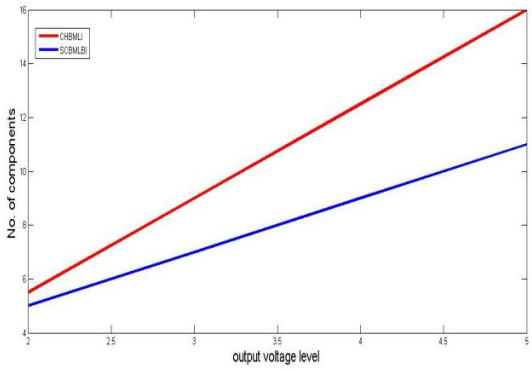

Fig.4.9 Comparison between CHBMLI and SCBMLBI

V. CONCLUSION

It can be concluded that switched capacitor based boost MLI offer reduced count of switches in comparison to conventional H-bridge topologies. Filter requirement is reduces as lower order harmonics are reduced and switching losses reduced which renders high efficiency and low cost. Switched capacitor based boost MLI offers greater advantage as it is less bulky that other topologies. Hence it can be

concluded that Switched capacitor based boost MLI is superior than conventional H-bridge MLI.

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