International Journal of Research in Advent Technology, Vol.3, No.2, February 2015
E-ISSN: 2321-9637

Photovoltaic System by Using Single Z-source Based Multi level inverter

Dr.L.V.NarasimhaRao[1]
Professor EEE Department KL University Guntur, Andhra Pradesh, India
Email: lvnrao1964@gmail.com1

Abstract-This paper a novel single Z-source based seven level multilevel inverter. In this topology single Z-source impedance network is used to boost up the output voltage using shoot through state control. A new PWM technique is implemented by using three reference signals and a triangular carrier signal which are used to generate the PWM signals for inverter switches, and the shoot through state for Z-network is achieved by inserting DC reference signal. The advantage of proposed topology makes reduction in number of switches, and this new configuration is suitable for applications working at lower and medium power levels.

Index Terms- PWMTechnique, Z-network, VSI, Mulitilevel Inverter

1. INTRODUCTION

Authors are encouraged To overcome the above problems of the traditional V-source and I-source converters, this paper presents an impedance-source (or impedance-fed) power converter (abbreviated as Z-source converter) and its control method for implementing dc-to-ac, ac-to-dc, ac-to-ac, and dc-to-dc power conversion. Fig.1.shows the general Z-source converter structure proposed. It employs a unique impedance network (or circuit) to couple the converter main circuit to the power source, load, or another converter, for providing unique features that cannot be observed in the traditional V- and I-source converters where a capacitor and inductor are used, respectively. The Z-source converter overcomes the above-mentioned conceptual

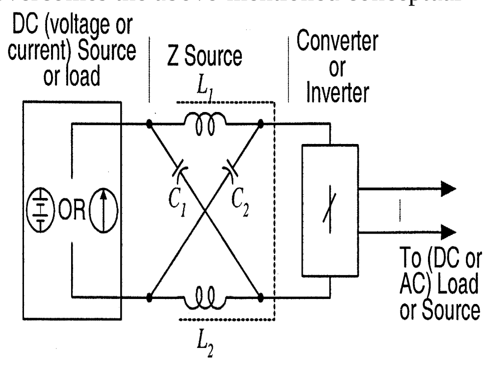

Fig. 1. General structure of the Z-source converter.

Theoretical barriers and limitations of the traditional V-source converter and I-source converter and provides a novel power conversion concept. In Fig. 1., a two-port network that consists of a split-inductor L1and L2and capacitors C1 and C2 connected in X shape is employed to provide an Impedance source (Z-source) coupling the converter (or inverter) to the dc source, load, or another converter. The dc source/or load can be either a voltage or a current source/or load. Therefore, the dc source can be a battery, diode rectifier, thyristor converter, fuel cell, an inductor, a capacitor, or a combination of those. Switches used in the converter can be a combination of switching devices and diodes such as the ant parallel combination as shown in Fig.1, the series combination as shown in Fig.2,. The inductance and can be provided through a split inductor or two separate inductors. The Z-source concept can be applied to all dc-to-ac, ac-to-dc, ac-to-ac, and dc-to-dc power conversion. To describe the operating principle and control, this paper focuses on an application example of the Z-source converter: a Z-source inverter for dc-ac power conversion needed for fuel-cell applications.

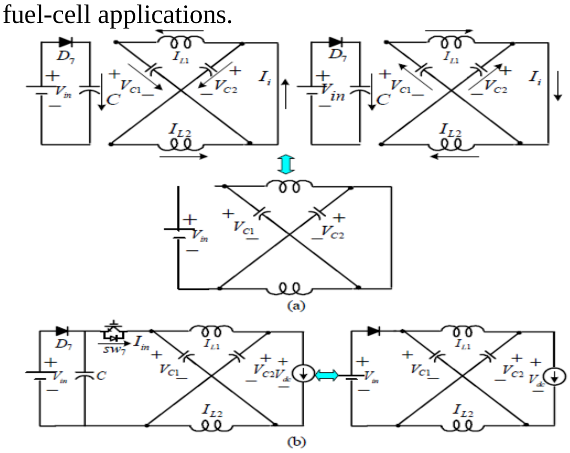

Fig. 2. The basic two equivalent operation modes. (a) shoot-through State

2. **L** LITERATURE SURVEY

Recent advances in the power-handling capabilities of static switch devices such as IGBTs with voltage rating up to 4.5 kV commercially available, has made the use of the voltage source inverters (VSI) feasible for high-power applications. High power and high-voltage conversion systems have become very important issues for the power electronic industry handling the large ac drive and electrical power applications at both the transmission and distribution levels. For these reasons, a new family of multilevel inverters has emerged as the solution for working with higher voltage levels. Multilevel inverters include an array of power semiconductors and capacitor voltage sources, the output of which generate voltages with stepped waveforms. Capacitors, batteries, and renewable energy voltage sources can be used as the multiple dc voltage sources. The commutation of the power switches aggregate these multiple dc sources in order to achieve high voltage at the output; however, the rated voltage of the power semiconductor switches depends only upon the rating of the dc voltage sources to which they are connected. Switch-mode dc-to-ac inverters used in ac power supplies and ac motor drives where the objective is to produce a sinusoidal ac output whose magnitude and frequency can both be controlled. Practically, we use an inverter in both single-phase and three phase ac systems. A half-bridge is the simplest topology, which is used to produce a two level square-wave output waveform. A center-tapped voltage source supply is needed in such a topology. It may be possible to use a simple supply with two well-matched capacitors in series to provide the center tap. Today, multilevel inverters are extensively used in high-power applications with medium voltage levels. The field applications include use in laminators, mills, conveyors, pumps, fans, blowers, compressors, and so on

3. PROPOSED CONCEPT

In Recent years, due to energy crisis, renewable energy resource, such as wind turbine, photovoltaic (PV) cell, and fuel cell are becoming more and more popular in industrial and residential applications [1]. Photo-Voltaic (PV) sources are used today in many applications as they have the advantages of being maintenance and pollution free. Solar-electric-energy demand has grown consistently by 20%–25% per annum over the past 20 years, which is mainly due to the decreasing costs and prices. This decline has been driven by the following factors: 1) an increasing efficiency of solar cells 2) manufacturing technology improvements and 3) economics of scale

TABLE I
COMPARITION OF MULTILEVEL INVERTER

Multilevel Inverter type	H bridge Auxiliary switch	Diode Clamped	Capacitor Clamped	Asymmetric Cascade
Main switch	4	36	36	36
Required blocking voltage	Vs/2	Vs/7	Vs/7	Vs/7
Antiparallel diodes	8	36	36	36
Auxiliary switches	2	36	-	-
Required blocking voltage	Vs/3	-	-	-
Auxiliary diodes	4	-	-	-
Switches total	6	36	36	36
Diodes total	12	72	36	36
Capacitors	3	7	17	9

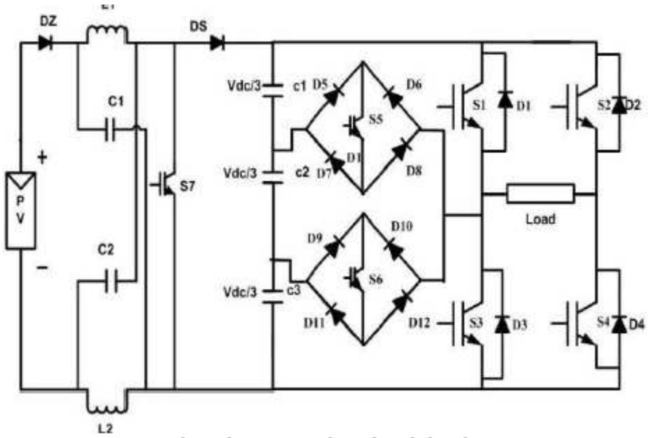

Fig.3. Proposed single Z-source based multilevel inverter

They offer improved output waveforms, smaller filter size, lower EMI and lower total harmonic distortion (THD). This paper recounts the development of a novel modified H-bridge single-phase multilevel inverter that has two diode embedded bidirectional switches and a novel pulse width modulated (PWM) technique.

3.1. PROPOSED TOPOLOGY

3.1.1Z-source network

Fig. 3. Shows the suggested basic unit for a proposed Z-source topology. This consists of a DC voltage source, Z impedance with one switch S7 and Diode DS. It can operate in two modes: non shoot-through and shoot-through state. In the shoot-through state, switch S7 is on and diode DS off output voltage of z-network is zero. The shoot-through pulse is generated by comparing a dc reference line with the triangular carrier wave.

i) Shoot-through state:

The equivalent circuit of shoot-trough state is shown in Fig. 4(a). With the analysis of circuit's fig4 (b) it can be expressed as:

$$V_L = V_C$$

$$V_{in} = 0$$

ii. Non Shoot-through state:

The equivalent circuit in non shoot-through state is shown in Fig. 4(c). Inductors voltage and output of LC network can be calculated as:

$$V_L = V_{dc} - V_c$$

$$V_{in} = V_c - V_L$$

$$V_{in} = 2V_c - V_{dc}$$

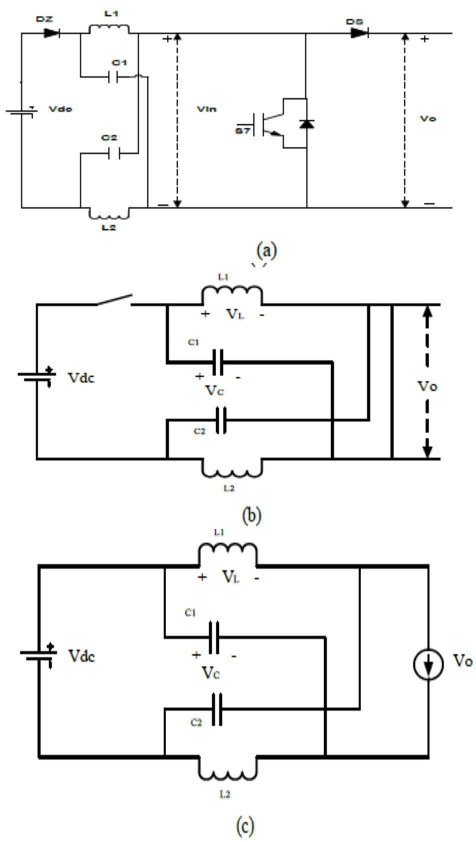

Fig.4.Circuit diagram of (a) single phase proposed basic unit, (b) basic unit in shoot through state, (c) basic unit in non shoot through state.

It is assumed that average voltage of inductor is zero so relation between capacitor and output voltage is found as:

$$\frac{V_c}{V_{in}} = \frac{T_{ns}}{T_{ns} - T_{sh}}$$

Where Tsh is the total shoot-through state period and Tns is the total non shoot-through state period during all period of switching. Substituting (8) in to (7) during non shoot through state Vin is obtained as

$$V_{in} = \frac{V_{dc}}{1-2\frac{T_{sh}}{T}}$$

$$B = \frac{1}{1-2\left(\frac{T_{sh}}{T}\right)}$$

Where T is period of switching and B is boost factor and it is clear that B ≥ 1.

TABLE II
SWITCHES STATES AND Vo VALUE

State	Output Voltage(V_0)	Switches
1	V_{in}(Non Shoot-through)	S_7 OFF, D_S ON
2	0(Shoot-through)	S_7 ON, D_S OFF

3.1.2Multilevel inverter topology

The proposed single-phase seven-level inverter was developed from the five-level inverter in It consist of a single-phase conventional H-bridge inverter, two bidirectional switches, and a capacitor voltage divider formed by *C*1, *C*2, and *C*3, as shown in (Fig. 3.1). The modified H-bridge topology is significantly advantageous over other topologies, i.e., less power switch, power diodes, and less capacitors or inverters of the same number of levels. Photovoltaic (PV) arrays were connected to the inverter via a single z-source converter. Proper switching of the inverter can produce seven output-voltage levels (*V*dc, 2*V*dc/3, *V*dc/3, 0, −*V*dc, −2*V*dc/3, −*V*dc/3) from the dc supply voltage.

TABLEIII
SWITCHING STATES OF PROPOSED INVERTER

V_o	S1	S2	S3	S4	S5	S6
V_{dc}	On	Off	Off	On	Off	Off
$2V_{dc}/3$	Off	Off	Off	On	On	Off
$V_{dc}/3$	Off	Off	Off	On	Off	On
0	Off	Off	On	On	Off	Off
0*	On	On	Off	Off	Off	Off
$-V_{dc}/3$	Off	On	Off	Off	On	Off
$-2V_{dc}/3$	Off	On	Off	Off	Off	On
$-V_{dc}$	Off	On	On	Off	Off	Off

4. NOVEL PWM MODULATION

PWM switching signals are generated by a novel PWM modulation technique. Three reference signals (Vref1, Vref2, and Vref3) were compared with a carrier signal ($V_{carrier}$).The reference signals had the same frequency and amplitude and were in phase with an offset value that was equivalent to the amplitude of the carrier signal. The reference signals were each compared with the carrier signal. If Vref1 had exceeded the peak amplitude of$V_{carrier}$, Vref2 was compared with $V_{carrier}$ until it had exceeded the peak amplitude of $V_{carrier}$. Then, onward, Vref3 would take charge and would be compared with $V_{carrier}$ until it reached zero. Once Vref3 had reached zero, Vref2 would be compared until it reached zero. Then, onward, Vref1 would be compared with $V_{carrier}$. The shoot-through pulse for Z-source network is generated by comparing dc reference line with the carrier signal. Shoot-through time varies depending on the magnitude level of dc reference line as compared with Vcarrier.

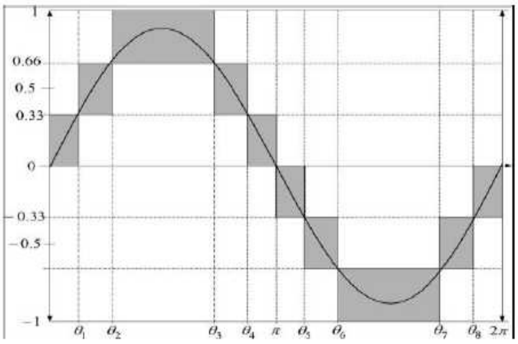

Fig.5. PWM Modulation

5. SIMULATION RESULTS

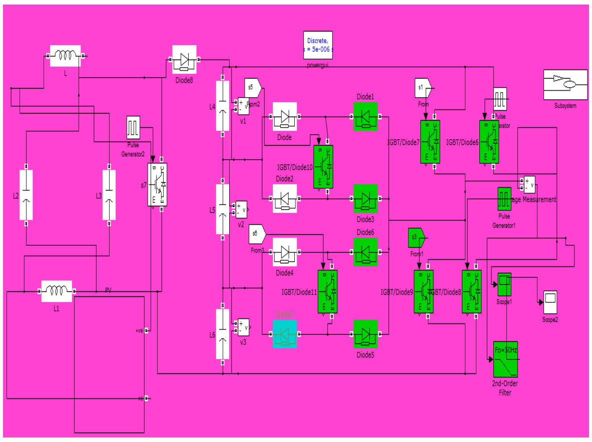

Fig6.Z-source inverter for using PWM

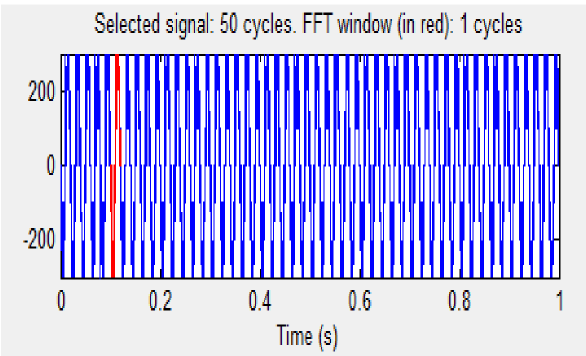

Fig7.Z-source inverter for using PWM-voltage wave form

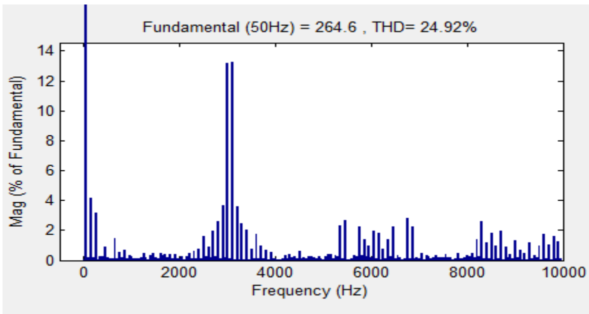

Fig8. Z-source inverter for using PWM-voltage wave form without filter

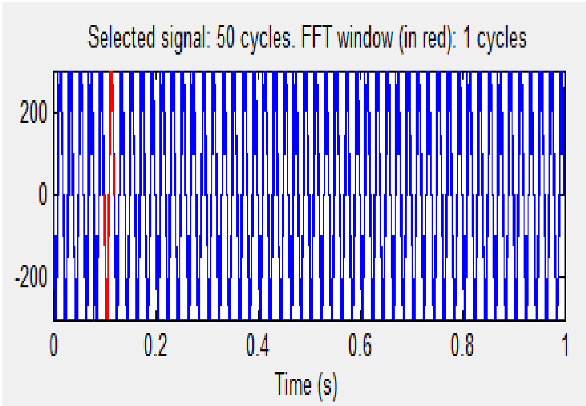

Fig9..Z-source inverter for using PWM-Second order system voltage wave form

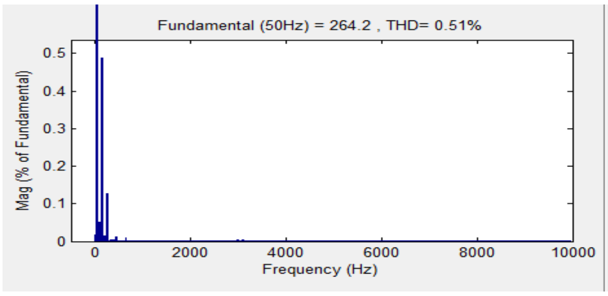

Fig10.Z-source inverter for using PWM-Second order system voltage wave form with filter

6. CONCLUSION

In this paper the modeling and simulation of novel single Z-source based multilevel inverter have been shown. The PWM switching signals are generated by comparing three reference signals against a triangular carrier signal. The voltage level of the PV panel is improved using Z-source network & multilevel inverter. The proposed multilevel inverter is to reduce both voltage & current THD of the inverter .The proposed topology has minimum number of switches compare than other configuration.

REFERENCES

[1] B. K. Bose, “Energy, environment, and advances in power electronics,” *IEEE Trans. Power Electron.*, vol. 15, no. 4, pp. 688–701, Jul. 2000

[2] Miaosen Shen, Stefan Hodek, Fang Z.Peng, "Control of the Z-Source Inverter for FCHEV with the battery Connected to the Motor Neutral Point", Power Electronics Specialists Conference, pp. 1485-1490,2007

[3] Amitava Das, Debasish Lahiri, A.K.Dhakar , “Residential Solar Power Systems Using Z-Source Inverter", TENCON, IEEE Regional 10 Conference, 2008

[4] Jin Wang, Fang Z. Peng, Leon M. Tolbert, Donald J. Adams, "Maximum Constant Boost Control of the Z- Source Inverter " , Industry Application Conference, 39 th Annual meeting Conference Record, Vol.1,2004

[5] J. Rodríguez, J. S. Lai, and F. Z. Peng, “Multilevel inverters: A survey of topologies, controls, and applications,” *IEEE Trans. Ind. Electron.*, vol. 49, no. 4, pp. 724–738, Aug. 2002

[6] J. Rodriguez, S. Bernet, B. Wu, J. O. Pontt, and S. Kouro, “Multilevel voltage-source-converter topologies for industrial medium-voltage drives,” *IEEE Trans. Ind. Electron.*, vol. 54, no. 6, pp. 2930–2945,Dec. 2007.

[7] M. M. Renge and H. M. Suryawanshi, “Five-level diode clamped inverter to eliminate common mode voltage and reduce dv/dt in medium voltage rating induction motor drives,” *IEEE Trans. Power Electron.*, vol. 23, no. 4, pp. 1598–1160, Jul. 2008

[8] E. Ozdemir, S. Ozdemir, and L. M. Tolbert, “Fundamental-frequency modulated six-level diode-clamped multilevel inverter for three-phase stand-alone photovoltaic system,” *IEEE Trans. Ind. Electron.*, vol. 56, no. 11, pp. 4407–4415, Nov. 2009.

[9] E. Villanueva, P. Correa, J. Rodríguez, andM. Pacas, “Control of a single phase cascaded H-bridge multilevel inverter for grid-connected photovoltaic systems,” *IEEE Trans. Ind. Electron.*, vol. 56, no. 11, pp. 4399–4406, Nov. 2009

(A.1)