International Journal for Innovative Engineering and Management Research

PEER REVIEWED OPEN ACCESS INTERNATIONAL JOURNAL

www.ijiemr.org

IJIEMR Transactions, online available on 27 jul 2023. Link

:http://www.ijiemr.org/downloads.php?vol=Volume-12&issue=Issue 07

10.48047/IJIEMR/V12/ISSUE 07/12

Title **A NOVEL H-BRIDGE MULTILEVEL INVERTER WITH A REDUCED NUMBER OF SWITCHES FOR PV SYSTEMS**

Volume 12, ISSUE 07, Pages: 107-114

Paper Authors **PEGUDA RAGHU, K. SOWJANYA**

International Journal for Innovative Engineering and Management Research
PEER REVIEWED OPEN ACCESS INTERNATIONAL JOURNAL
www.ijiemr.org

A NOVEL H-BRIDGE MULTILEVEL INVERTER WITH A REDUCED NUMBER OF SWITCHES FOR PV SYSTEMS

PEGUDA RAGHU[1] K. SOWJANYA[2]

[1]PG Scholar, Department of Electrical and Electronics Engineering (Power Electronics and Electrical Drives), Siddhartha Institute of Technology & Science, Narapally, Korremula Road, Ghatkesar, Hyderabad, TS, India.

[2]Assistant Professor, Department of Electrical and Electronics Engineering, Siddhartha Institute of Technology & Science, Narapally, Korremula Road, Ghatkesar, Hyderabad, TS, India.

Abstract: The main aim of this project is an H-bridge multilevel inverter with a reduced number of switches for solar systems. In this paper the (Photovoltaic) PV based multilevel inverter with reduced number of switches is presented. Compared to conventional inverter this inverter produces higher number of output levels with a smaller number of switches and thus harmonics are reduced and the power quality is improved. This modified H-bridge inverter uses the same level of an inverter with a 25% reduction in the number of switches. This results in reduced switching losses, installation cost, and converter cost. Special care is taken to obtain an optimal number of switches. The proposed PV based inverter is simulated for a five-level using MATLAB/SIMLUNIK with Phase Shift Pulse Width Modulation (PSPWM) control. A comparison between conventional (PDPWM) and proposed (PSPWM) control systems for Modified H-bridge multilevel inverter are shown.

Keywords: Photovoltaic (PV), Phase Shift Pulse Width Modulation (PSPWM), H-bridge Multilevel Inverter

I.INTRODUCTION

The most essential study topics in society are energy efficiency, electrical supply, and sustainability. The energy that is sustainable, renewable, cost-effective, reliable and secure is the fundamental requirement for economic growth, human and industrial development of a country. Ecological concerns, exhausting petroleum reserves and expanding reliance on fossil fuels from unstable locales have expanded the significance for more efficient use of energy. Sources like thermal, nuclear that has been used for some time now for the generation of electricity has its own merits and demerits. Renewable energy can be termed as liveliness from unlimited natural resources. There are many sources of natural renewable energy resource like sunlight, water, air, biomass, and geothermal heat. Over a specified geographical area, the scope and opportunities for renewable energy resources are vast in contrast to other forms of energy like fossil fuels that are limited and concentrated to specific localities. With the rapid deployment of renewable energy, efficiency, economic benefits are immense and would result in significant energy security, while reducing the environmental effects.

This includes positive developments in improved healthcare and reduction in infant mortality rates due to reduced pollution effect and countries would save millions on healthcare [6]-[8]. Renewable energy often displaces convention energy requirements in generation of electricity, water heating, transportation, energy services at rural areas (off grid). Along these lines, it can securely be expected that renewable energy assets go about as an impetus to increment and improve energy access in rural areas [9]. Solar energy is harnessed from the sun using PV technologies, solar heating, concentrated solar power, concentrated photovoltaics and are generally characterised based on the way the energy is captured, converted and distributed. They are either classified as active or passive. A PV system converts light into electrical energy taking advantage of the photoelectric effect. The PV system involves an array of silicon semiconductors that collect the photons and changes over to electrons. The generated DC is then converted to AC using converters. Therefore, it is essential to utilize specific MPPT system to maximise the energy captured from the sun. This is generally achieved by using sun-tracking PV's. The sun-tracking PV's achieve this goal by adjusting itself

International Journal for Innovative Engineering and Management Research
PEER REVIEWED OPEN ACCESS INTERNATIONAL JOURNAL
www.ijiemr.org

to the global solar insolation shifts and amplifies the captured sunlight radiation to generate maximum power at a steady voltage. Efficiency in the solar array is estimated by the capacity to change over daylight into energy and is an exceptionally unique factor in picking the right panel for the PV system.

A two-level inverter has two different output voltages and is the simplest one. But the ac output is rectangular with high total harmonic distortion (THD) whereas the load needs sinusoidal voltage. Multilevel inverter (MLI), a step ahead of the two-level inverter tends to reduce this effect. It does so by using many low rated dc voltage sources as input for the desired ac voltage output. So, in a multilevel inverter, the output voltage is stepped more than twice. As the level increases in the multilevel inverter, the waveform is smoother than the two-level inverter. MLI has two classes; current source inverter and voltage source inverter. In the former, a short circuit in the circuit can cause a very high fault current which will damage any other types of equipment connected to the circuit. Hence, multilevel voltage source inverters are preferred [2]. There are four types of MLI topologies; neutral point clamped (NPC), diode clamped (DC), flying capacitor (FC), and cascaded Hbridge (CHB) multilevel inverter. Cascaded H-bridge multilevel inverters have preferably low THD [1]. The difference between several topologies of MLI lies in the source of input voltage and the mechanism of switching. MLI is used in power intense and high voltage applications. The industry demands additional solutions of high dv/dt resulting in voltage doubling in motor output, compliance of % THD, high electromagnetic interference (EMI) and high common-mode voltages which trigger research of inverters [3] [4]. Baker and Banister [5] pioneered the series H-bridge inverter. The demerits of DC and FC topologies, for instance, additional clamping diodes and capacitors are overcome by a proposed CHB inverter [6]. It can give high output power from a medium-voltage source. Higher voltage can be generated using the lower rating devices. The control of switches in this converter is simple and easy to construct. A survey on multilevel inverter configuration, control, and application, and an MLI with reduced number switches is described [6]. Because of its isolated dc sources, cascaded inverters are appropriate to interface photovoltaic generation to an ac grid for power quality management [7]. They are suitable for regenerativetype motor drive applications, fuel cell-based electric vehicles. Potential applications include electric and hybrid power trains. A review of MLI configuration was brought by Pharne [8]. An MLI with a reduction in the number of switches was described by Ebrahimi et al [9]. The topology has multiple bridge inverters with a sub-multilevel concept. Further development in MLI configuration's design and implementation was proposed by Najafi [10], Nedumgatt [11]. A CHB configuration with a reduction of switches count is described by Ebrahimi et al. [12]. A survey of multilevel inverter configurations, control, applications was made by Rodriguez et al. [13]. A CHB with regeneration capability and a smaller number of switches was dealt with by Lezana et al. [14]. In a similar context, Babaei [15] proposed CHB MLI for high-voltage applications. Looking into the main advantages, owing to its modular arrangement and absence of energy-storing elements like capacitor a CHB MLI is used in this study. A new method PSPWM is proposed as a modified H-bridge inverter having similar stepped output voltage using a smaller number of switches and it is PV applications. This reduction in switches count will result in reducing switching losses, converter cost, and installation cost.

II. PROPOSED SYSTEM

The below figure 1 shows the proposed system block diagram which consists PV system, boost converter, modified H-bridge multilevel inverter and load the arrangement is shown in figure 1. PSPWM control technique used for controlling the multilevel inverter. Fig 2 shows the modified 5 level inverter. The higher the voltage level, the no of switches required is higher. So, switching losses, costs, and complexity also increase. By using the modified multilevel inverter with less no. of switches the efficiency of the system increases. The modified 5-level cascaded multilevel inverter which has 6 no. of IGBTs and 2 voltage sources. Here the output voltage step at 2Vdc, Vdc, -2Vdc, -Vdc. Table II shows the on and off period of the switches of the modified 5-level inverter.

International Journal for Innovative Engineering and Management Research
PEER REVIEWED OPEN ACCESS INTERNATIONAL JOURNAL
www.ijiemr.org

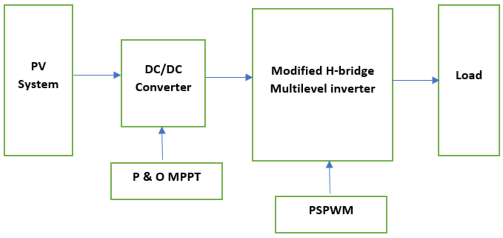

Fig. 1 Block diagram of the Proposed system

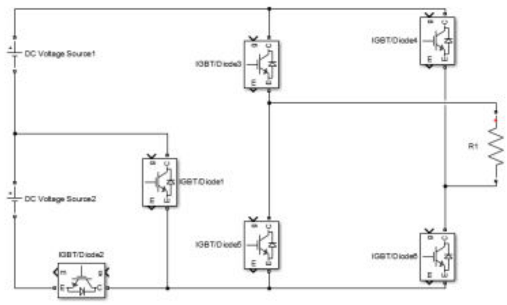

Fig.2 Structure of modified 5-level inverter

A) PV CELL

DESIGNING OF PV MODULE

Equivalent Circuit

In comparison to other PV module designs, the single diode variant shown in Figure 3 is the most utilised. Shunt resistance current flows through Rsh between the n and p layers, Io is diode saturation current, Iph is light-generated current, which depends on solar radiation and cell temperature, Ish is shunt resistance current, which flows between the n and p layers, Rse is series resistance which represents losses due to flowing current across highly resistive emitter and contacts, Voc is the terminal voltage of a solar cell, respectively.

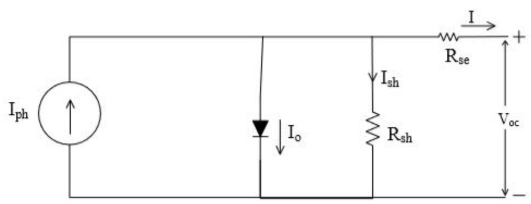

Fig 3 Solar cell equivalent circuit

In this circuit the mathematical expression for cell current in single diode model is obtained by applying KCL,

I= Iph-Io-Ish(1) 1

Where, Iph= [Isc+Ki (Tk-T)] *G/1000 2

Standard test conditions (STC) are defined as 1000 W / m2 solar radiation, 1.5A solar spectrum, and 25°C reference temperature of the solar cell Tk. Iph is photocurrent under these conditions. T is the current temperature of the solar cell, Ki is the current temperature coefficient, and G is the current solar radiation.

B) DC/DC CONVERTER

To obtain the maximum performance of the maximum power point, PV modules are always used with DC-to-DC converters. Buck, boost, and buck-boost are types of converters used for this purpose. For grid-connected applications boost converter is used where as buck-boost configuration is used for battery charging applications. Figure.4 represents the configuration of boost converter and it is composed of load resistance R, filter capacitor C, diode D, control switch S, boost inductor L, and DC input voltage source Vs. The voltage gain of boost converter when switch operated with a duty ratio D is expressed as,

$M_v= V_o/V_s= 1/1 – D$ 3

Where Vo is output voltage, Vs is input voltage, and D is duty cycle of PWM (pulse width modulation) signal and used to control ON and OFF states of MOSFET.

C) Design of MPPT

The solar cell has very low efficiency. Therefore, to boost the efficiency some methods are implemented to balance the source and load properly. Maximum Power Point Tracking (MPPT) method is one of the methods which are used to obtain the maximum possible power from a variable source. It is difficult to use photovoltaic systems to power certain load because the I-V curve in photovoltaic systems is non-linear. So boost converter is used and its duty cycle is varied by using a MPPT algorithm. By the help of

International Journal for Innovative Engineering and Management Research
PEER REVIEWED OPEN ACCESS INTERNATIONAL JOURNAL
www.ijiemr.org

simulation with developed circuit mode lthe data is collected for the design of MPPT.

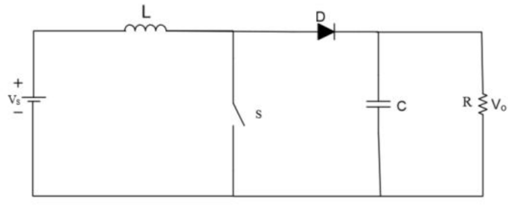

Figure 4 DC to DC boost converter configuration

Perturb and Observe method

It is widely used method. Minimum sensors are used in this method. In this method, sampling of operating voltage is done and operating voltage is changed in a specific direction by using algorithm and therefore it samples dp / dv. The algorithm increases the voltage value towards MPP until dp / dv is negative if dp / dv is positive. This iteration continues until the algorithm arrives at MPP. When there is a large variation in solar irradiation then this algorithm is not suitable. The voltage perturbs around the maximum power point (MPP) and never actually reaches an exact value.

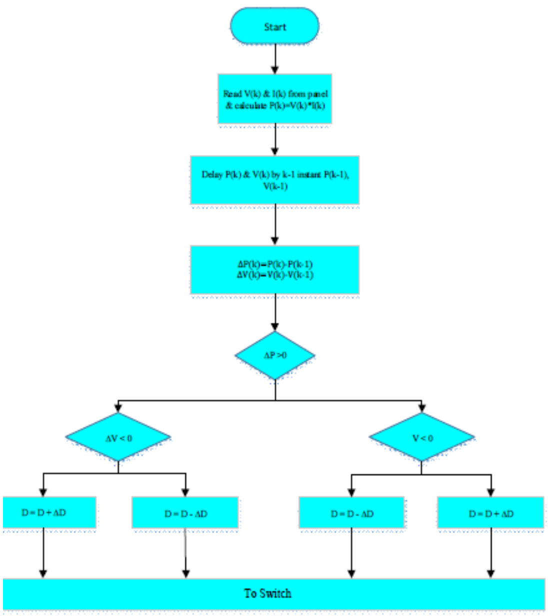

Fig 5 MPPT flowchart P&O algorithm

III. PSPWM

The principle of Phase-shifted carrier PWM lays on setting two 180° phase shifted sinusoidal reference signals for the control respective of the two legs of each cell. The modulation is obtained by comparing the reference signals with regularly phase shifted carrier signals; a carrier signal for each cell. For m-level inverter, the phase angle between two consecutive carriers is 360 / (1) θcr = – m . Fig6 shows a block diagram for PS-PWM generation.

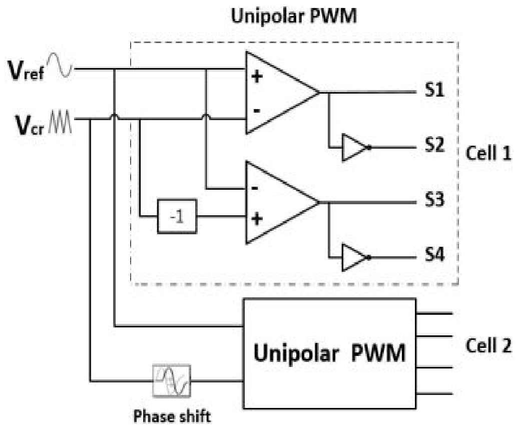

Fig.6 PS-PWM generator diagram for two cells CHB-MLI

IV.SIMULATION RESULTS

A) EXISTING RESULTS

CASE-1 (CASCADED H BRIDGE)

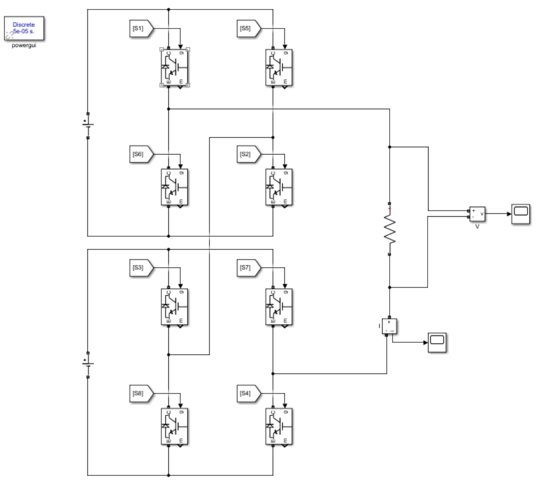

Fig 7 MATLAB/SIMULINK circuit diagram of the conventional cascaded H-bridge MLI

International Journal for Innovative Engineering and Management Research
PEER REVIEWED OPEN ACCESS INTERNATIONAL JOURNAL
www.ijiemr.org

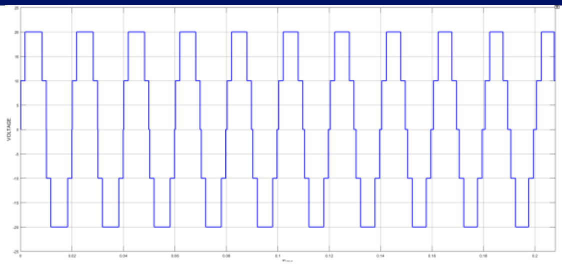

Fig.8 Output voltage

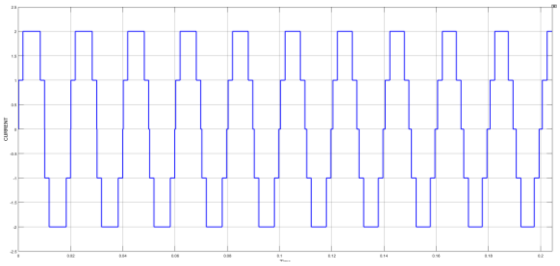

Fig.9 Output current

CASE-2

I. MODIFED CONFIGURATION WITH R LOAD

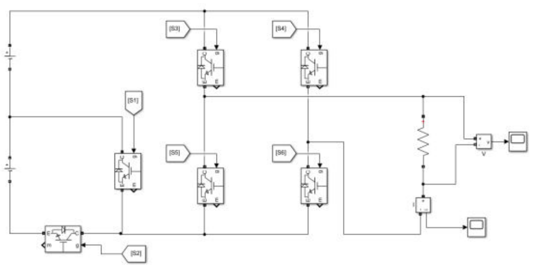

Fig.10 MATLAB/SIMULINK circuit diagram of the Modified MLI with R load

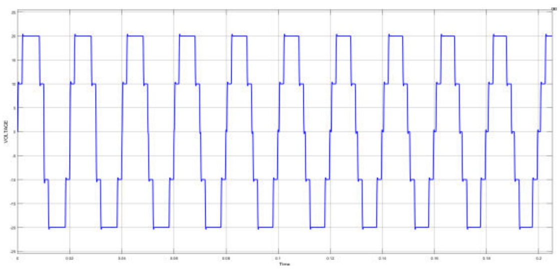

Fig.11 Output voltage

Fig.12 THD% of voltage

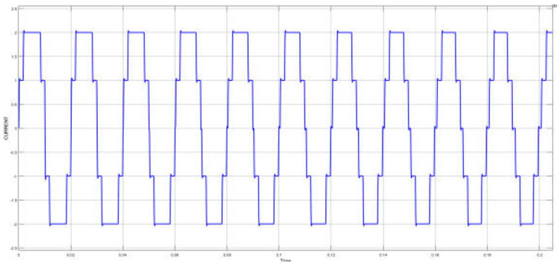

Fig.13 Output current

Fig.14 THD% of current

MODIFED CONFIGURATION WITH RL LOAD

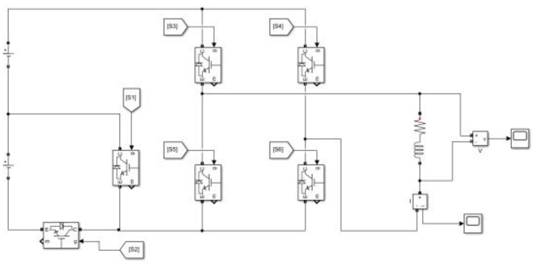

Fig.15 MATLAB/SIMULINK circuit diagram of the Modified MLI with RL load

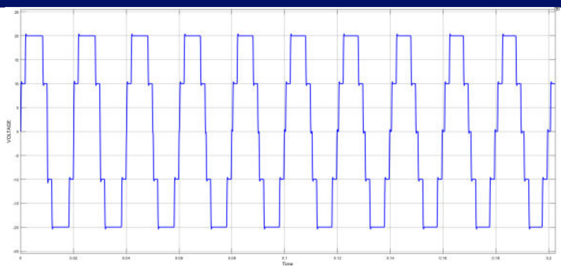

Fig.16 Output voltage

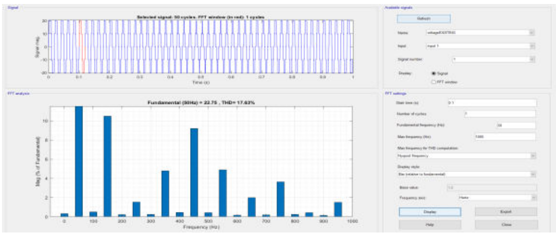

Fig.17 THD% of voltage

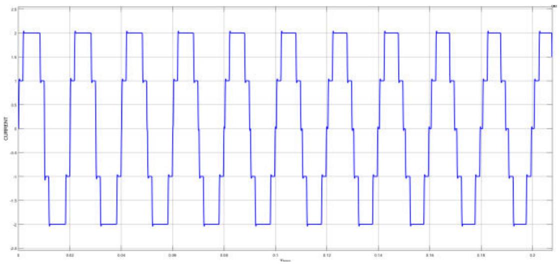

Fig.18 Output current

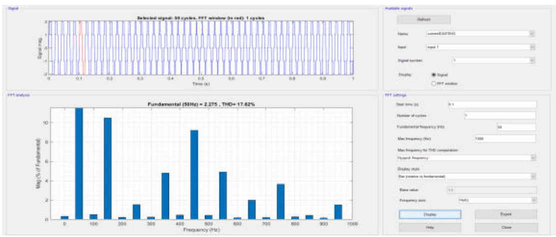

Fig.19 THD% of current

B) EXTENSION RESULTS

CASE-1 WITH R LOAD

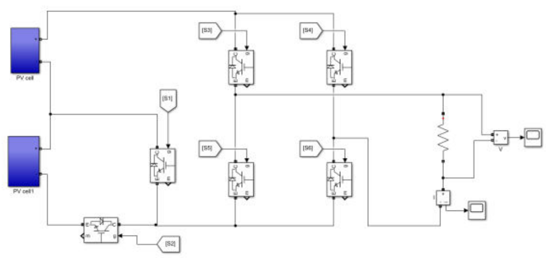

Fig.20 MATLAB/SIMULINK circuit diagram of the Proposed MLI with R load

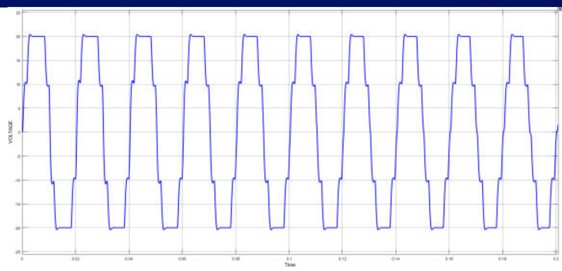

Fig.21 Output voltage

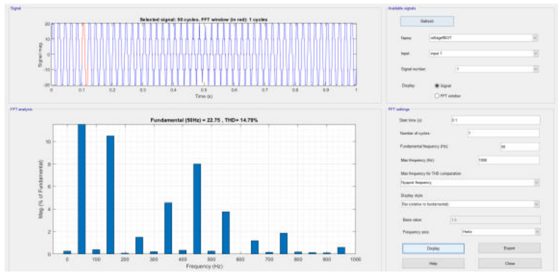

Fig.22 THD% of voltage

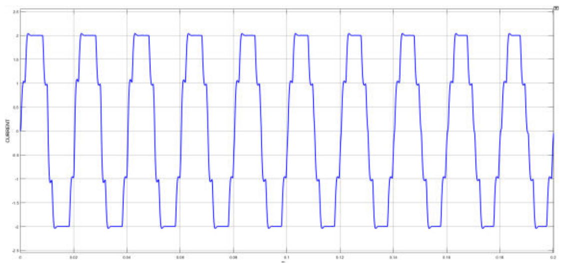

Fig.23 Output current

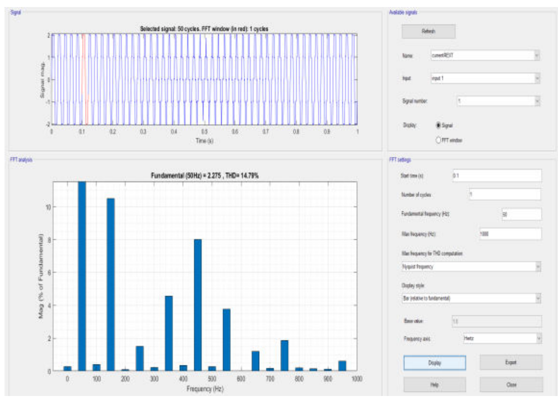

Fig.24 THD% of current

International Journal for Innovative Engineering and Management Research
PEER REVIEWED OPEN ACCESS INTERNATIONAL JOURNAL
www.ijiemr.org

CASE-2 WITH RL LOAD

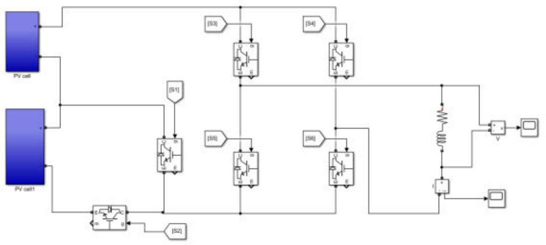

Fig.25 MATLAB/SIMULINK circuit diagram of the Proposed MLI with RL load

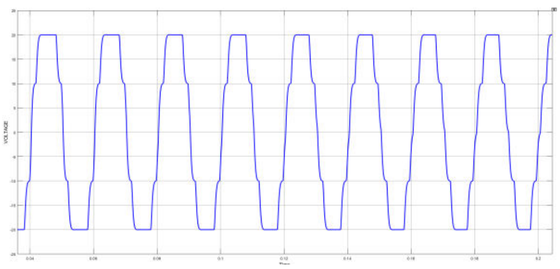

Fig.26 Output voltage

Fig.27 THD% of voltage

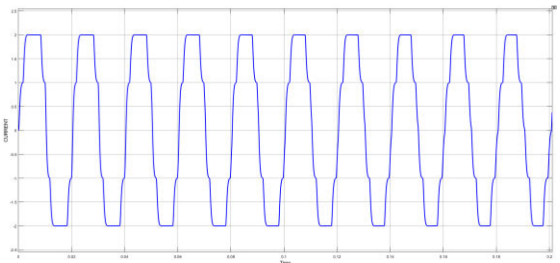

Fig.28 Output current

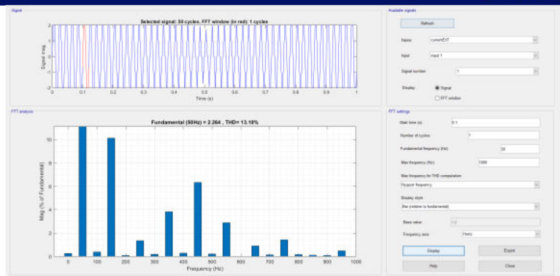

Fig.29 THD% of current

COMPARISION TABLE

THD%	EXISTING		EXTENSION	
	R Load	RL Load	R Load	RL Load
Voltage	17.66	17.63	14.79	13.25
current	17.66	17.62	14.79	13.10

CONCLUSION

In this paper the (Photovoltaic) PV based multilevel inverter with reduced number of switches is based on PSPWM presented. This proposed H-bridge inverter uses the same level of an inverter with a 25% smaller count of switches. This subsides the cost, switching losses, and electromagnetic interference. However, the higher level of modified topology can significantly reduce the harmonics with a considerable saving of component cost and improvement of reliability in comparison to conventional MLI. The proposed topology of the CHB MLI can be a good option in standalone single-phase PV power applications.

REFERENCES

[1] P. A. Arbune and A. Gaikwad, "Comparative Study of Three level and five level Inverter," International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering. 2016 Feb;5(2), pp. 681-686.

[2] E. Babaei, S. Laali, and Z. Bayat, "A single-phase cascaded multilevel inverter based on a new basic unit with reduced number of power switches," IEEE Transactions on industrial electronics. 2014 Jul 8;62(2), pp. 922-929.

[3] J. Rodriguez, J. S. Lai, and F. Z. Peng, "Multilevel inverters: a survey of topologies, controls, and applications," IEEE Transactions on

industrial electronics. 2002 Nov 7;49(4), pp. 724-738.

[4] M. D. Manjrekar and T. A. Lipo, "A hybrid multilevel inverter topology for drive applications," In IEEE APEC'98 Thirteenth Annual Applied Power Electronics Conference and Exposition, Vol. 2, 1998 Feb 15, pp. 523-529.

[5] R. H. Baker and L. H. Bannister, "Electric power converter," U.S. Patent 3 867 643, 1975.

[6] M. Derakhshanfar, "Analysis of different topologies of multilevel inverters," Master of Science Thesis submitted to Department of Energy and Environment, CHALMERS UNIVERSITY OF TECHNOLOGY, Sweden. 2010.

[7] Y. Wang, Y. Li, Y. Cao, Y. Tan, L. He, and J. Han, "Hybrid AC/DC microgrid architecture with comprehensive control strategy for energy management of smart building," International Journal of Electrical Power & Energy Systems. 2018 Oct 1;101, pp. 151-161.

[8] I. D. Pharne and Y. N. Bhosale, "A review on multilevel inverter topology," In IEEE International Conference on Power, Energy and Control (ICPEC) 2013 Feb 6, pp. 700-703.

[9] J. Ebrahimi, E. Babaei, and G.B. Gharehpetian, "A new topology of cascaded multilevel converters with reduced number of components for high-voltage applications," IEEE Transactions on Power Electronics. 2011 Apr 29;26(11), pp. 3109-3118.

[10] E. Najafi and A. H. Yatim, "Design and implementation of a new multilevel inverter topology," IEEE Transactions on Industrial Electronics. 2011 Nov 18;59(11):4148-4154.

[11] J. J. Nedumgatt, D. V. Kumar, A. Kirubakaran, and S. A. Umashankar, "multilevel inverter with reduced number of switches," In 2012 IEEE Students' Conference on Electrical, Electronics and Computer Science 2012 Mar 1, pp. 1-4.

[12] J. Ebrahimi, E. Babaei, and G. B. Gharehpetian, "A new multilevel converter topology with reduced number of power electronic components," IEEE Transactions on Industrial Electronics. 2011 May 5;59(2), pp. 655-667.

[13] J. Rodriguez, J. S. Lai, and F. Z. Peng, "Multilevel inverters: a survey of topologies, controls, and applications," IEEE Transactions on industrial electronics. 2002 Nov 7;49(4), pp. 724-38.

[14] P. Lezana, J. Rodríguez, and D. A. Oyarzún, "Cascaded multilevel inverter with regeneration capability and reduced number of switches," IEEE Transactions on Industrial Electronics. 2008 Mar 3;55(3), pp. 1059-1066.

[15] E. Babaei and S. H. Hosseini, "New cascaded multilevel inverter topology with minimum number of switches Energy Conversion and Management", 2009 Nov 1;50(11), pp. 2761-2767.

[16] B. Sirisha and P. S. Kumar, "A simplified space vector PWM for cascaded H-Bridge inverter including over modulation operation," In2016 IEEE Annual India Conference (INDICON) 2016 Dec 16 (pp. 1-6). IEEE.