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PV Based Single Phase Reverse Voltage Multilevel Inverter

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ABSTRACT: Multilevel inverters are used in high power and high voltage applications. There performance is finer to that of conventional two level inverter due to reduced harmonic distortion. This paper present a topology of multilevel inverter called reverse voltage multilevel inverter which is used with the solar panel. Selective harmonic elimination (SHE) technique is used for its modulation. Reverse voltage multilevel inverter needed less number of power electronics component, and less gate drive circuit. Due to all these factors its overall cost is low and it is less complex. A seven level reverse voltage MLI is simulated in Matlab and there simulation results are shown in the paper.

KEYWORDS: Multilevel inverter, inverter, power.

I.INTRODUCTION

Multilevel power conversion was first introduced more than two decades ago. The general concept involves utilizing a higher number of active semiconductor switches to perform the power conversion in small voltage steps. There are several advantages of MLI when compared with the conventional inverter. The smaller voltage steps lead to the production of higher power quality waveforms and also reduce voltage (dv/dt) stress on the load and the electromagnetic compatibility concerns[1]. Another important feature of multilevel converters is that the semiconductors are wired in a series-type connection, which allows operation at higher voltages. However, the series connection is typically made with clamping diodes, which eliminates overvoltage concerns [2]. The multilevel voltage source inverters' unique structure allows them to reach high voltages with low harmonics without the use of transformers or series-connected synchronized switching devices. The general function of the multilevel inverter is to synthesize a desired voltage from several levels of dc voltages. For this reason, multilevel inverters can easily provide the high power required of a large electric drive.

As the number of levels increases, the synthesized output waveform has more steps, which produces a staircase wave that approaches a desired waveform [3]. The voltage balancing can be addressed by using redundant switching states, which exist due to the high number of semiconductor devices. However, for a complete solution to the voltage-balancing problem, another multilevel converter may be required [4]. Some applications for these new converters include industrial drives [5], flexible ac transmission systems (FACTS) [6]–[8], and vehicle propulsion [9], [10]. One area where multilevel converters are particularly suitable is that of renewable photovoltaic energy that efficiency and power quality are of great concerns [11] In [12] and [13], the multilevel output is generated with a multi winding transformer. However, the design and manufacturing of a multi winding transformer are difficult and costly for high-power applications.

II.MULTILEVEL INVERTER USING REVERSE VOLTAGE TOPOLOGY

This topology is a hybrid multilevel topology which separates the output voltage into two parts. Fig.1 shows the block diagram of reverse voltage multilevel inverter. The topology combines the two parts (high frequency and low frequency) to generate the multilevel voltage output. In order to generate a complete multilevel output, the positive levels are generated by the high-frequency part (level generation), and then, this part is fed to a full-bridge inverter (polarity generation), which will generate the required polarity for the output. This will eliminate many of the semiconductor switches which were responsible to generate the output voltage levels in positive and negative polarities.

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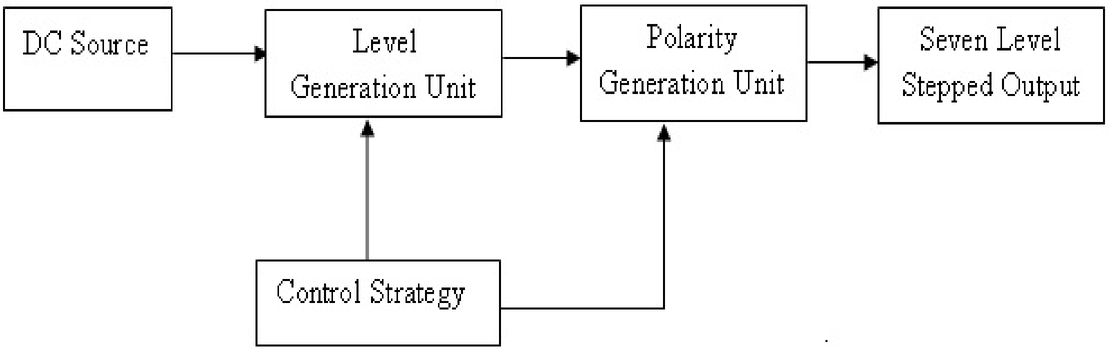

Fig. 1 Block diagram of Reverse Voltage Multilevel Inverter

The Reverse Voltage topology in seven levels is shown in Fig. 2. As it can be seen, it requires ten switches and three isolated sources.

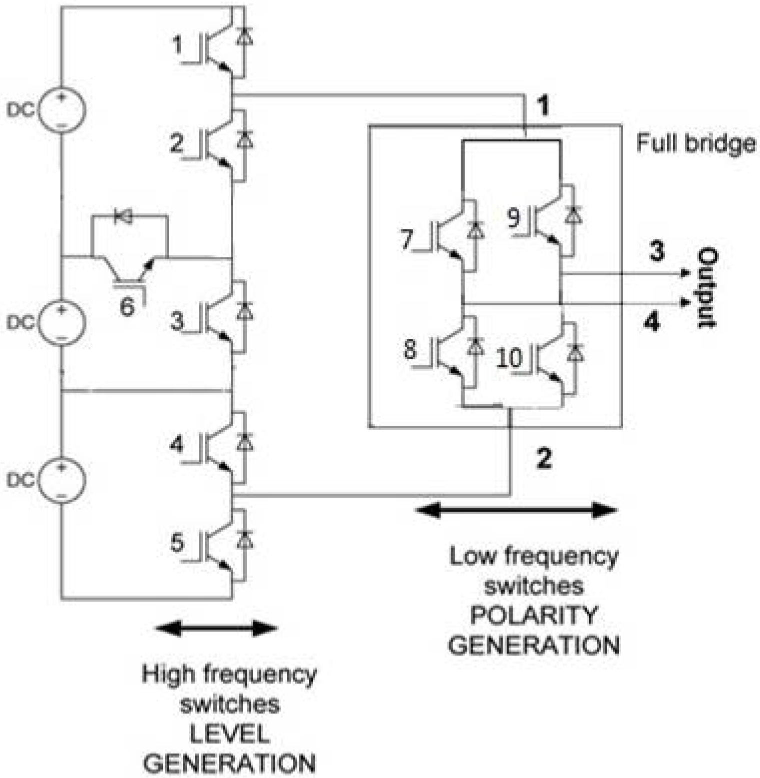

Fig. 2 Single phase Seven-level Reverse voltage Multilevel Inverter

III.SELECTIVE HARMONIC ELEMINATION

Selective harmonic elimination (SHE) is a low switching frequency PWM method developed for converters in which a few switching angles per quarter fundamental cycle are predefined and pre calculated via Fourier analysis to ensure the elimination of undesired low-order harmonics [15]. Basically, in SHE, the Fourier coefficients or harmonic components of the predefined switched waveform with the unknown switching angles are made equal to zero for those undesired harmonics, while the fundamental component is made equal to the desired reference amplitude. By applying Fourier

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series analysis, the amplitude of any odd nth harmonic of the stepped waveform can be expressed as (1), whereas the amplitudes of all even harmonics are zero.

$$h_n = \frac{4}{n\pi}\sum_{k=1}^{m} V_k \cos(n\alpha k) \qquad (1)$$

Where v_k is the k_{th}level of dc voltage, n is an odd harmonic order, m is the number of switching angles,$\alpha_k$is the k_{th}switching angle. According to Fig.3 $\alpha_1$1 to α_m must satisfy the condition $\alpha_1 < \alpha_2 \ldots\ldots \alpha_m < \pi/2$. According to (1), to keep the number of eliminated harmonics at a constant level, all switching angles must be less than $\pi/2$.

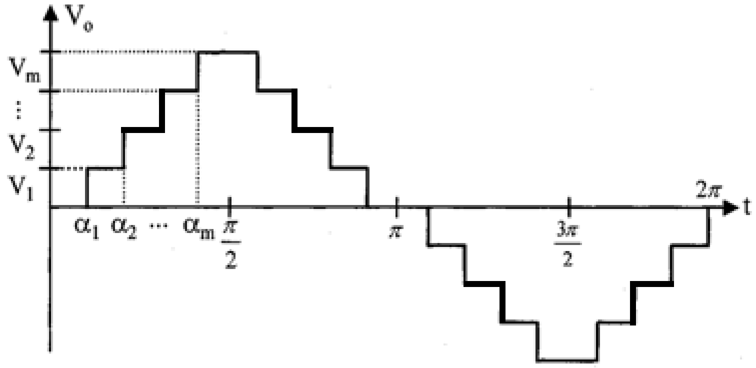

Fig. 3 Stepped voltage waveform

The third harmonics and its multiple are usually not eliminated by using SHE. Since they are naturally eliminated by three phase load[14].

IV.BOOST CONVERTER

Boost converter is an important element in pv system. Boost converter give output voltage greater than the input voltage. Fig.4 shows the circuit diagram of boost converter. It is a class of switch mode power supply containing at least two semiconductor switches and at least one storage element such as capacitor, inductor.

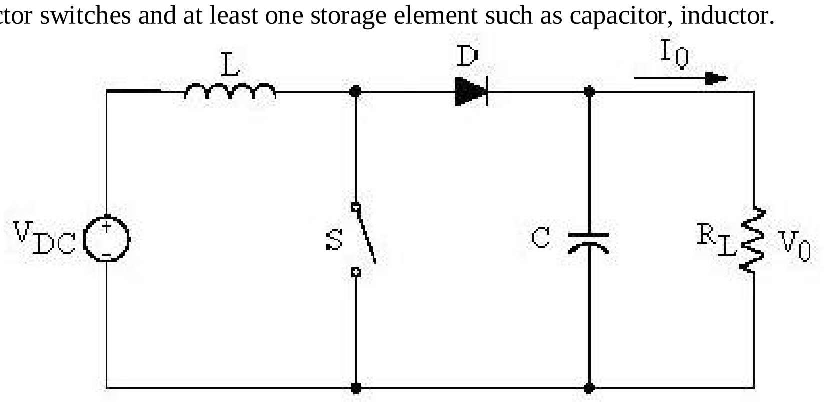

Fig. 4 Boost converter

Mode of operation: When switch is closed inductor gets charged through the battery and store the energy. In this mode inductor current rises exponentially. The diode blocks the current flowing and so the load current remain constant which is being supplied due to discharging of capacitor. When the switch is open diode become short circuited. The energy stored in inductor gets discharged through the opposite polarity which charge the capacitor and load current remain constant through the operation.

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V.SOLAR PHOTOVOLTIC CELL

Solar photovoltaic (PV) electrification is an important renewable energy source. The electric which is converted directly from solar irradiation via PV panel is not steady due to different solar intensity. To maximize the PV panel output power, perturb and observe (P&O) maximum power point tracking (MPPT) has been implemented into the PV system. Through a buck-boost DC-DC converter, MPPT is able to vary the PV operating voltage and search for the maximum power that the PV panel can produce [14].

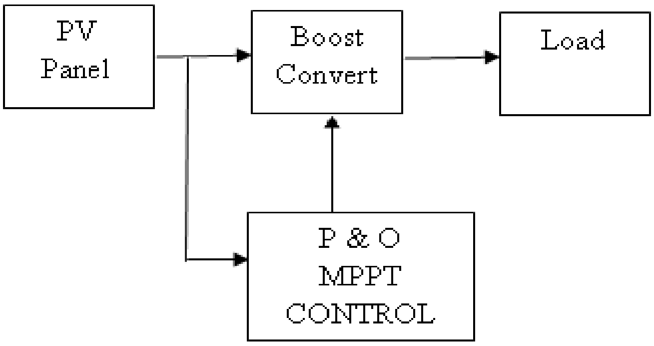

Fig. 4 P & O based MPPT Solar PV System

PERTURB AND OBSERVE (P & O) MPPT: Perturb and Observe (P&O) MPPT has been used to track the MPP by continuously changing the operating voltage point of solar panel. This method applies a little increase or decrease in operating voltage to the panel and compare the PV output power at the present and the previous perturbation cycle [16]-[18]. Fig. 5 shows the operation of P&O MPPT.

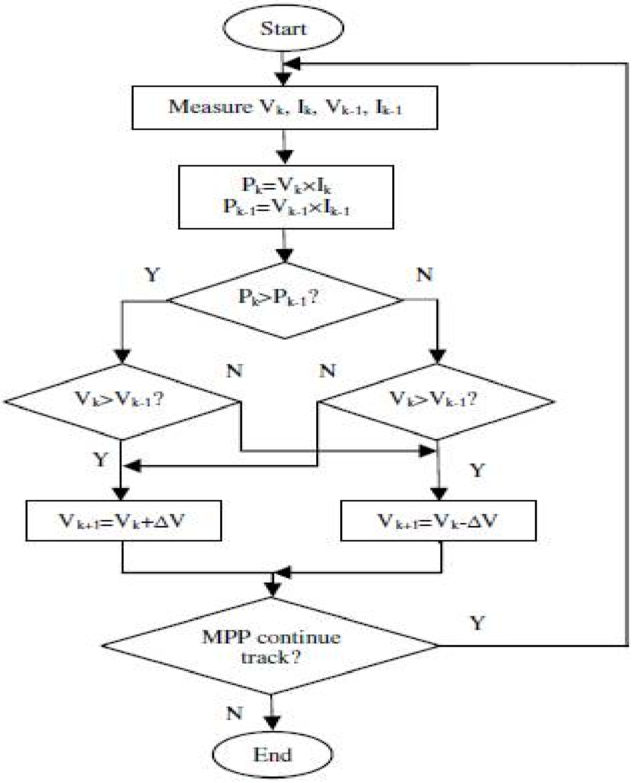

Fig. 5 Flow chart of P& O MPPT[14]

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VI.RESULT AND DISCUSSION

The Fig. 6 shows the simulink model of seven level reverse voltage multilevel inverter. Three separate dc voltage source are used and IGBT are used as a switch. For seven level reverse voltage multilevel inverter ten switches are used. Six switches are used for the level generation and h-bride for polarity generation.

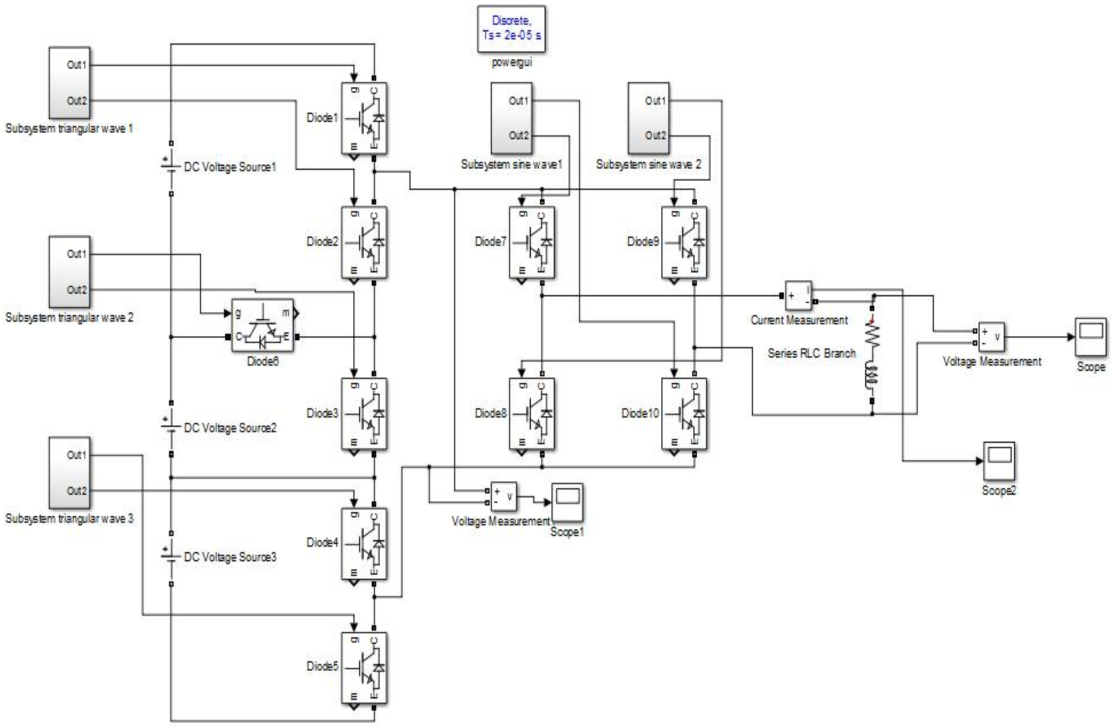

Fig. 6 Single Phase Reverse Voltage MLI

Boost converter is used to step up the output voltage. Some time we does not get the desired output voltage from the pv system so to boost the output voltage of pv system we used the boost converter.Fig.7(a) shows the boost converter and fig.7(b) shows the output voltage of boost converter.

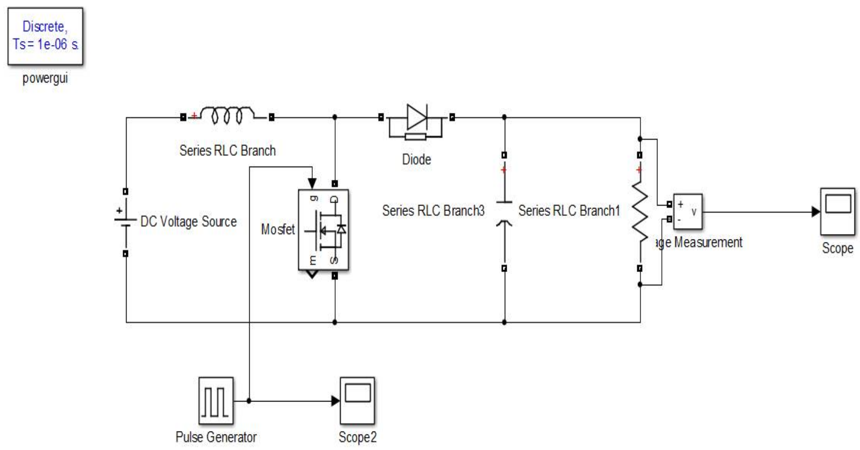

Fig. 7(a) Boost Converter

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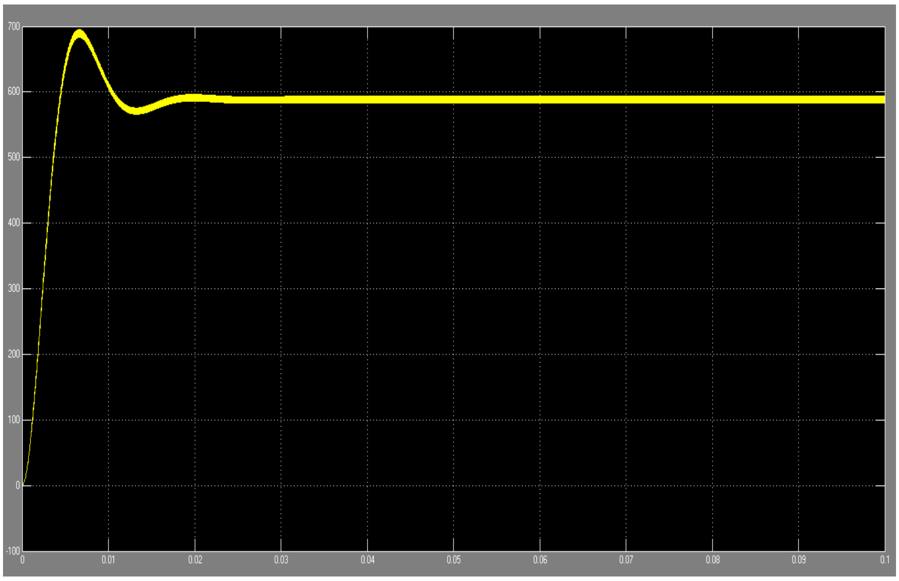

Fig. 7(b) Output voltage of Boost Converter

The fig. 8(a) shows that the pv system is connected with the boost converter. The output of solar pv module is given to the boost converter. This output is used as an input source of boost converter. Fig.8(b) shows the power voltage characteristics and fig. 8(c) shows the voltage current characteristics.

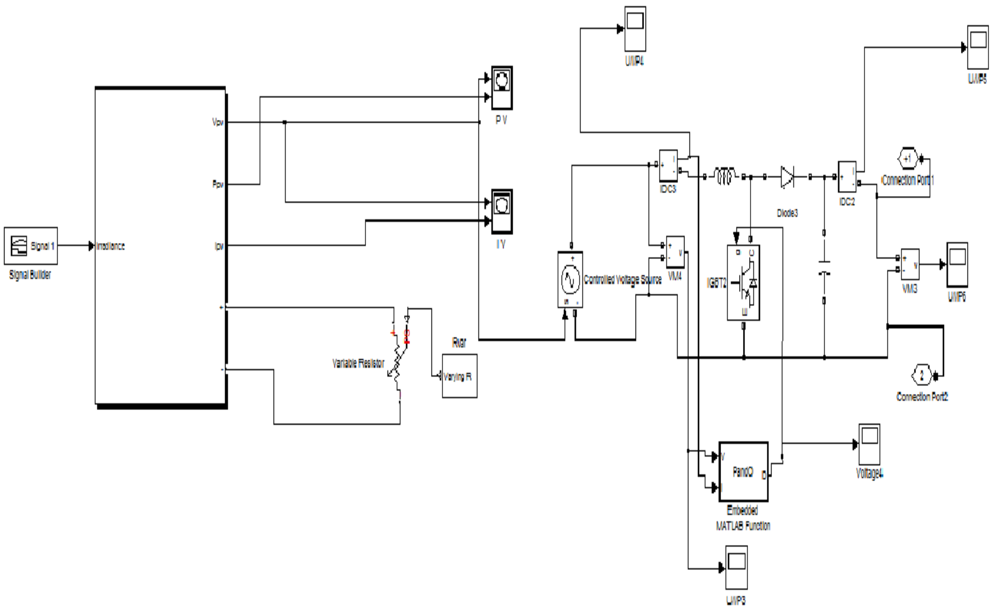

Fig. 8(a) Boost Converter when connected with PV System

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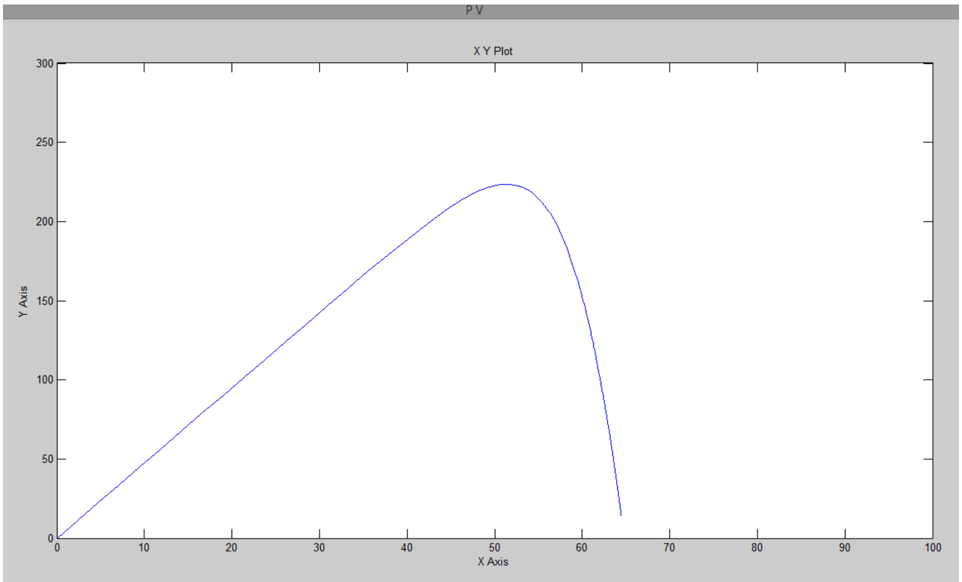

Fig. 8(b) Power voltage curve

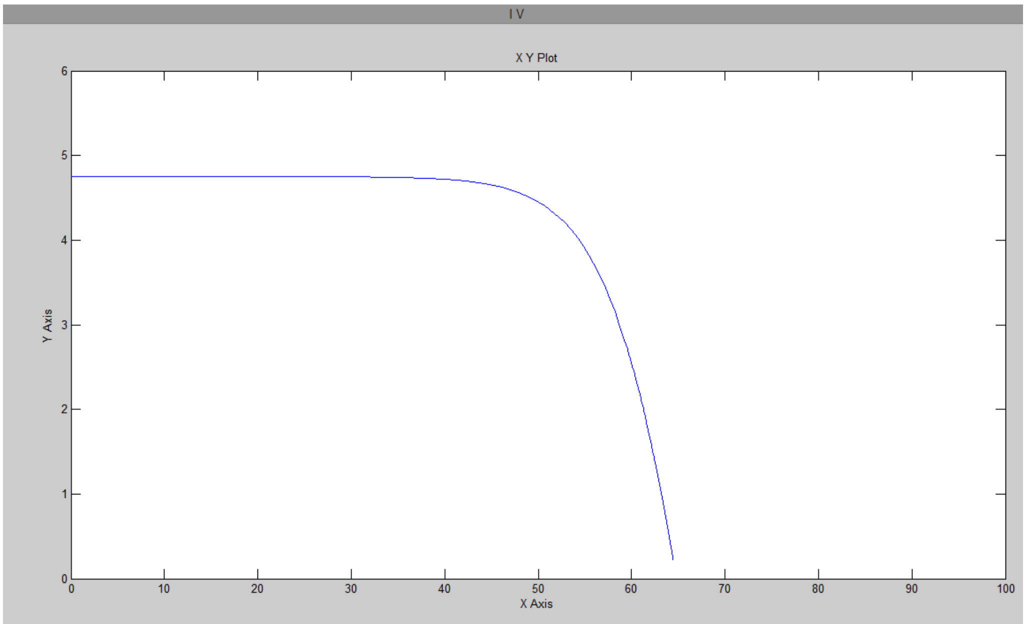

Fig. 8(c) Current Voltage curve

The fig. 9 shows the simulink model of pv based single phase reverse voltage multilevel inverter. In this figure a constant signal is given to the pv model and a maximum power point is tracked. Then this output is given to boost converter. Boost converter step up the input voltage this output is given to the reverse voltage multilevel inverter. Due to this reverse voltage multilevel inverter we get seven level at the output.

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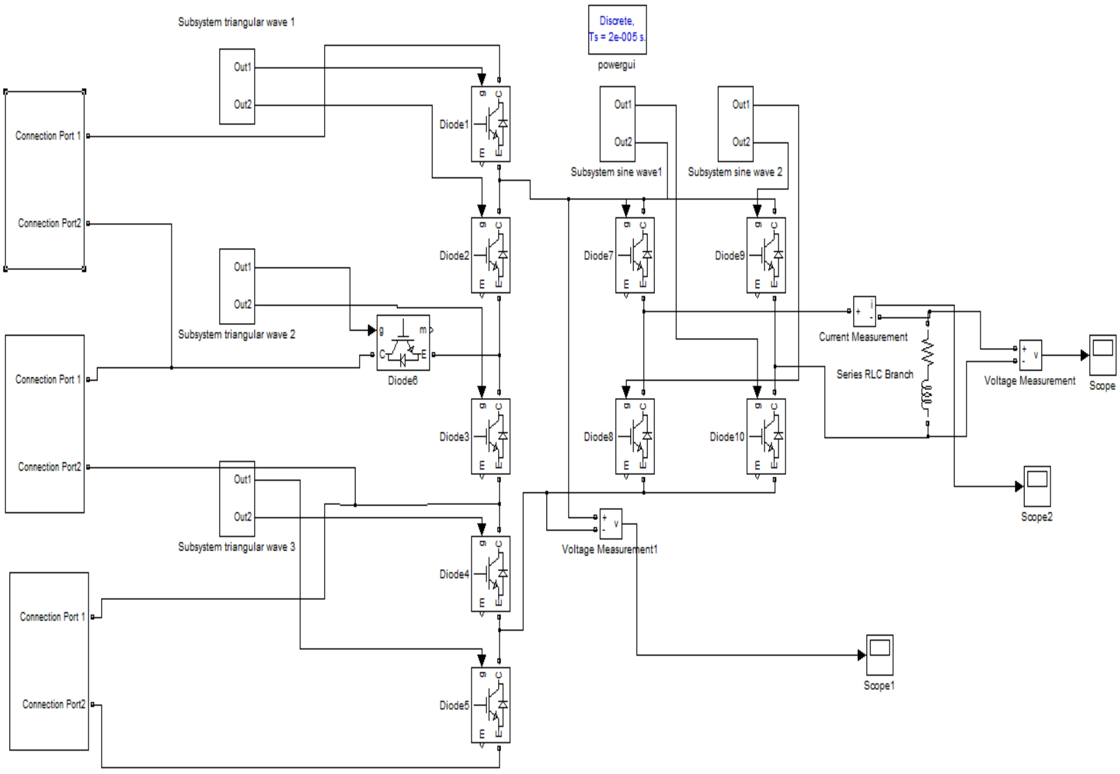

Fig.9(a) Matlab/Simulink Model with PV array, boost converter & Reverse Voltage Multilevel Inverter.

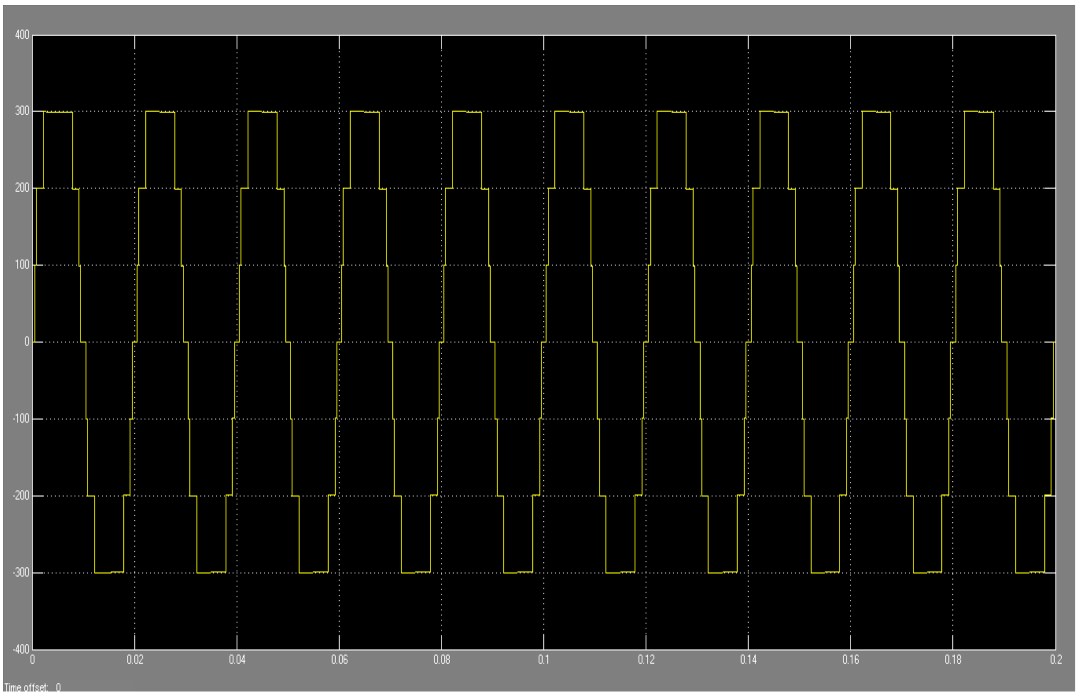

Fig. 9(b) Seven level Reverse Voltage Output Waveform.

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VII.CONCLUSION

The main purpose of this thesis was to analyse the PV based reverse voltage multilevel inverter. A Matlab/Simulink Model with PV array, boost converter & Reverse Voltage 7-level Inverter is simulated. Output waveform is analysed & Maximum power point is tracked using Perturb and observation (P & O) method.

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