NINE LEVEL INVERTER WITH BUCK BOOST CONVERTER FOR SOLAR ENERGY SOURCE

M.Sandhya[1], D.Danniel[2]

[1] Student, Power Electronics and Drives, CSI College of Engineering, Tamil Nadu, (India)

[1]Assistant Professor, Electrical and Electronics and Drives, CSI College of Engineering, Tamil Nadu, (India)

ABSRACT

Renewable energy systems, such as photovoltaic (PV) and wind power generation (WPG), are playing a more and more important role in energy production. In this the PV system is used. A single phase nine level multilevel inverter is proposed. The input to the nine level multilevel inverter is obtained from solar panel . The solar energy obtained from the solar panel varies with times. In order to maintain the constant voltage obtained from the solar panel the boost converter is used to maintain the constant output voltage using MPPT (Perturb and observe algorithm) algorithm. Then the buck boost converter output voltage is stored in the battery bank. The buck boost converter is operated according to the battery size. Finally the battery energy is connected to the nine level inverter circuits. The harmonics in the inverter is eliminated by using the fuzzy logic controller. The gate pulse for the multilevel inverter given by the fuzzy logic controller reduces the harmonics in the inverter which gives a pure sine wave. Then the inverter output is connected to the grid are some application.

Keywords: Fuzzy Logic Controller, Multilevel Inverter, MPPT (Perturb And Observe Algorithm), Total Harmonic Distortion (THD)

I. INTRODUCTION

1.1 Overview

The demand for renewable energy has increased significantly over the years because of shortage of fossil fuels and greenhouse effect. The definition of renewable energy includes any type of energy generated from natural resources that is infinite or constantly renewed. Examples of renewable energy include solar, wind, and hydro power. Renewable energy, due to its free availability and its clean and renewable character, ranks as the most promising renewable energy resources like Solar energy, Wind energy that could play a key role in solving the worldwide energy crisis. Among various types of renewable energy sources, solar energy and wind energy have become very popular and demanding due to advancement in power electronics techniques. Photovoltaic (PV) sources are used today in many applications as they have the advantages of effective maintenance and pollution free. Solar electric energy demand has grown consistently by 20% to 25% per annum over the past 20 years, which is mainly due to its costs and prices. This decline has been driven by the following factors: 1)An increasing efficiency of solar cells, 2)Manufacturing technology improvements, 3)Economies of scale. The focus of the Engineers is to make use of abundantly available PV energy and so to design and control an inverter suitable for photo voltaic applications. Power electronic circuits with pulse width modulation (PWM) are mostly used in energy conversion systems to achieve closed loop control. But even updated pulse width modulation (PWM) techniques; do not produce perfect waveforms, which strongly depend on the semiconductors switching frequency. Also, it is well known that distorted voltages and currents waveforms produce harmonic contamination, additional power losses, and high frequency noise that can affect not only the load power but also the associated controller. In recent years, multilevel inverters have become more attractive for researchers and manufacturers due to their advantages over conventional three level PWM Inverters. They offer improved output waveforms, smaller filter size and lower EMI, lower Total Harmonic Distortion (THD). The three common topologies for multilevel inverters are as follows: 1) Diode clamped (neutral clamped), 2) Capacitor clamped (flying capacitors), 3) Cascaded H-bridge inverter. The cascaded multilevel control method is very easy when compared to other multilevel inverter because it doesn't require any clamping diode and flying capacitor. The diode clamped inverter (neutral-point clamped), capacitor-clamped (flying capacitor) requiring only one dc source and the cascaded hbridge inverter requiring separate dc sources. The latter characteristic, which is a drawback when a single dc source is available, becomes a very attractive feature in the case of PV systems, because solar cells can be assembled in a number of separate generators. In this way, they satisfy the requirements of the CHB-MLI, obtaining additional advantages such as a possible elimination of the dc/dc buck booster (needed in order to adapt voltage levels), a significant reduction of the power drops caused by sun darkening (usually, it influences only a fraction of the overall PV field), and therefore a potential increase of efficiency and reliability. Performance of the multilevel inverter (such as THD) is mainly decided by the modulation strategies. For the cascaded multilevel inverter there are several well known pulse width modulation strategies such as space vector pwm, sinusoidal pwm, selective harmonics elimination and multicarrier pwm. Compared to the conventional method, the proposed method is subjected to a new modulation scheme adopting the sinusoidal pulse width modulation technique which reduces the total harmonic distortion.

II. OPERATING PRINCIPLE

The proposed concept consists of the single phase PV cell are connected to a H-Bridge Multilevel Inverter using a boost converter. Maximum Power Point Tracking (MPPT) is implemented in solar array power system with direct control method. The Perturb and Observe algorithm is used to track the Maximum Power Point tracking, as it performs better control under rapidly changing atmospheric condition. Boost converter can step up the voltage without using a transformer. In multilevel inverter use of single dc sources with the 16 switches for conventional H bridge inverter to get required nine level output voltage and to reduce the harmonics. The main disadvantage of conventional H bridge inverter is input voltage is fixed to over this problem, in the proposed prototype boost converter is used to regulate and to obtain the desired input voltage and further the DC source is replaced by a renewable resource such as solar panels to get desired DC voltage to grid connected system. In this paper there will be inputs one is from PV array. 223V is taken from PV cell and PV array and then they are boosted to a voltage from 350V respectively by using boost converter. Finally a nine -level output is observed by giving the single supply voltages to the multilevel inverter.

2.1 Modelling of Solar Cell

A solar cell is the building block of a solar panel. A photovoltaic module is formed by connecting many solar cells in series and parallel. Considering only a single solar cell; it can be modelled by utilizing a current source, a diode and two resistors. This model is known as a single diode model of solar cell shown in the figure 2.1. Two diode models are also available but only single diode model is considered here.

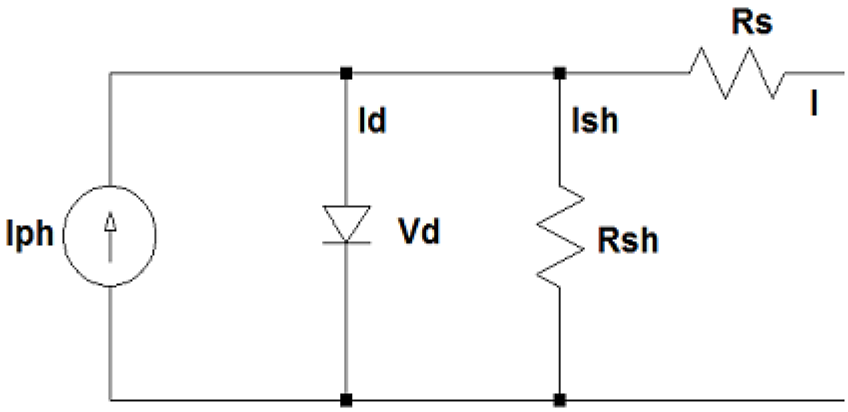

Fig.2.1 Circuit Model of PV Solar Cell

Fig.2.1 Circuit model of PV solar cell The equation (2)that describe I-V characteristics of the solar cell based on simple equivalent circuit shown in Fig.2.1, equations given below.

$$I_D = I_O \left[e^{\frac{q(V+IRs)}{KT}} - 1\right] \quad (1)$$

$$I = I_L - I_O \left[e^{\frac{q(V+IRs)}{KT}} - 1\right] - \frac{V+IRs}{Rsh} \quad (2)$$

Where:

I- is the cell current (A).

q-is the charge of electron = 1.6x10-19coulmbs

K -is the Boltzman constant (j/K).

T -is the cell temperature (K).

IL- is the light generated current (A).

IO- is the diode saturation current.

Rs ,Rsh-are cell series and shunt resistance (ohms).

V-is the cell output voltage (V)

B.PV Characteristics

Current Vs Voltage Characteristics: Equation (1) was used in computer simulation to obtain the output characteristics of a solar cell, as shown in the Fig.2

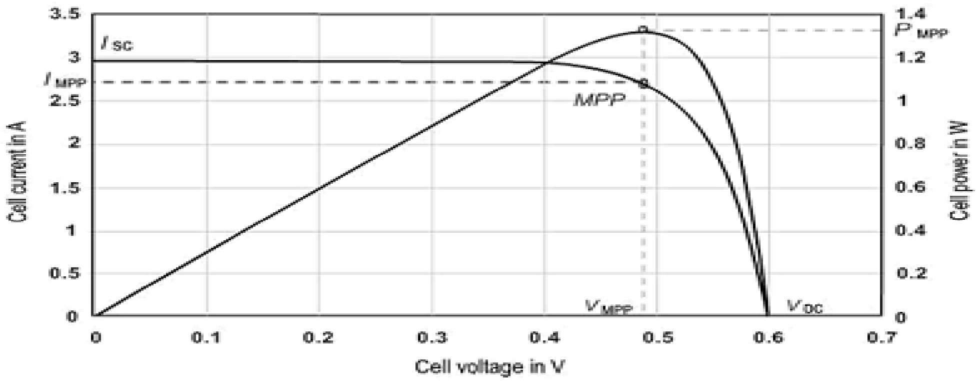

Fig.2.2 P-V, I-V Curve of a Solar Cell

III. MAXIMUM POWER POINT TRACKING TECHNIQUE

Tracking the maximum power point of a photovoltaic array is usually an essential part of PV cell. As such many MPP tracking methods have been developed and implemented. The problem considered by MPPT techniques is to automatically find the maximum power output PMpp under a given temperature and irradiance.

3.1 Perturb and Observe (P&O) Method

This method is the most common. In this method very less number of sensors are utilized .The operating voltage is sampled and the algorithm changes the operating voltage in the required direction and samples dP/dV. If dP/dV is positive, then the algorithm increases the voltage value towards the MPP until dP/dV is negative. This iteration is continued until the algorithm finally reaches the MPP. This algorithm is not suitable when the variation in the solar irradiation is high. The voltage never actually reaches an exact value but perturbs around the maximum power point (MPP).

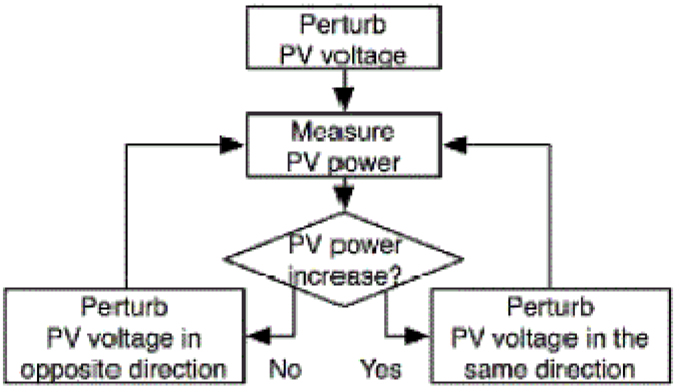

Fig.3.1 Flow Chart of Perturb & Observe

IV. BUCK BOOST CONVERTER

DC-DC converters are essential in variety of applications including power supplies such as personal/ laptop computers, cellular phones, office equipments, spacecraft power systems, and telecommunication equipments, as well as solar systems where input/output voltage ranges overlap. DC-DC converters with step-up/step-down characteristic are required to produce a regulated output voltage from the solar panel, by storing the input energy temporarily and then releasing that energy to the output at a different voltage.

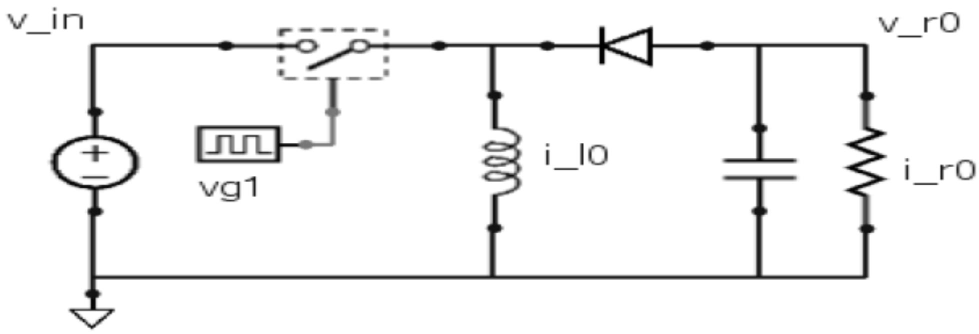

Fig.4.1.Circuit Diagram for Buck Boost Converter

Another important consideration in DCDC converters is the use of synchronous switching which replaces the flywheel diode with a power MOSFET with low "On" resistance, thereby reducing switching losses. This is achieved using PWM switched mode control design or pulse width modulation, PWM allows control and regulation of the total output voltage. In this work the concept of DC/DC buck-boost converter is studied to build the PWM+MPPT charge controller to achieve the better efficiency and battery protection compare to existing linear charge controller and MPPT charge controller.

V. MULTILEVEL INVERTER

The concept of multilevel converters has been introduced since 1975. The period multilevel originated with the three-level converter and subsequently, some multilevel converter topologies have been developed. The concept of a multilevel converter is to achieve higher power in which a series of power semiconductor switches with several lower voltage dc sources are arranged to perform the power conversion Capacitors, batteries and renewable energy sources can be used as the multiple DC voltage sources. A multilevel converter has several advantages over conventional two-level converter that uses high switching frequency Pulse Width Modulation (PWM).The input source PV and wind generator is used to obtain maximum power point tracking from the solar panel and wind generator generate the maximum power give the charging battery fed at cascade multilevel inverter. The output voltage waveform of a multilevel inverter is composed of the number of levels typically obtained from eleven levels. As the number of levels reach infinity, the output Total Harmonic Distortion (THD) approaches zero. Three different major multilevel converter structures have been applied in industrial applications: cascaded H-bridges converter with separate dc sources, diode clamped, and flying capacitors. The term multilevel converter is utilized to refer to a power electronic circuit that could operate in an inverter or rectifier mode. Multilevel converters not only can generate the output voltages with very low distortion, but also can decrease the dv/dt stresses. Thus Electro Magnetic Compatibility (EMC) problems can be reduced. Multilevel inverters are synthesizing a large number of levels have lot of merits such as improved output waveform, a smaller filter size, lower Electro Magnetic Interference (EMI), and reduced harmonics. There are many control techniques to reduce harmonics in output voltage waveforms. Normally Pulse Width Modulation (PWM) is widely employed to control output of static power inverters. The reason for using PWM is that they provide voltage and/or current wave shaping customized to the specific needs of the application under consideration. In this work, maximum energy is obtained from the solar cell and wind generator which is then given to a multilevel inverter using PWM technique.

5.1 Cascade H-Bridge Multilevel Inverter

A single-phase structure of an m-level cascaded inverter is illustrated in Fig.10. Each separate dc source (SDCS) is connected to a single-phase full-bridge, or H-bridge, inverter. Each inverter level can generate three different voltage outputs, +Vdc , 0, and –Vdc by connecting the dc source to the ac output by different combinations of the fours switchesS1,S2,S3,andSsSS4.To obtain $+V_{dc}$, switches S_1 and S_4 are turned on, whereas $–V_{dc}$ can be obtained by turning on switches S_2 and S_1. By turning on S_1, S_2, S_3, and S_4, the output voltage is 0. The ac outputs of each of the different full-bridge inverter levels are connected in series such that the synthesized voltage waveform is the sum of the MLI outputs. The number of output phase voltage levels m in a cascade inverter is defined by m = 2s+1, where s is the number of single dc sources .In the 9-level cascaded multilevel inverter with single DC sources are obtained. The DC sources feeding the multilevel inverter are considered to be varying in time.

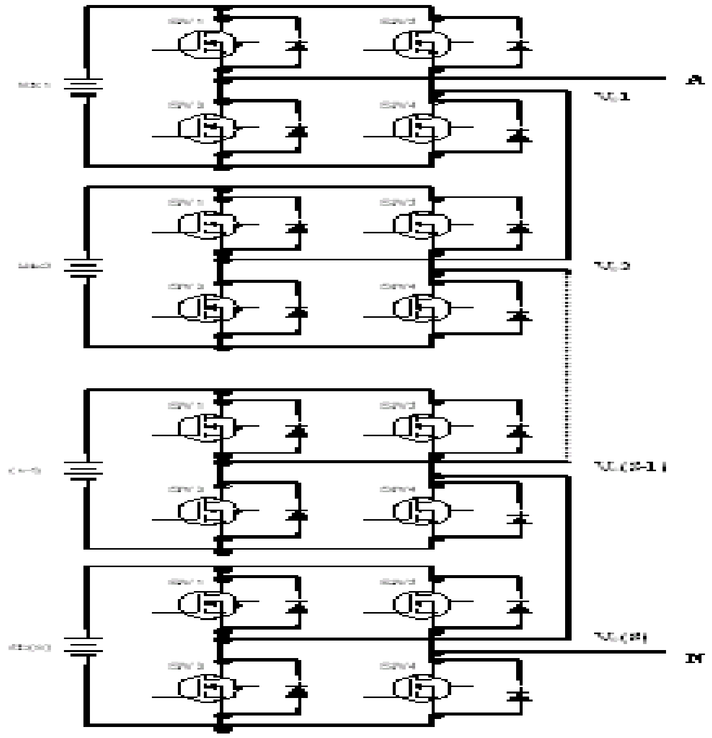

Fig.5.1 Nine Level Cascaded Multilevel Inverter

VI. SIMULATION MODEL

6.1 Simulation Model of 9-Level Cascaded H-Bridge Multilevel Inverter

The nine - level multilevel inverter has been developed by using MAT LAB is shown in Fig.17 To operate cascaded multilevel inverter using a solar source. Considering a cascaded multilevel inverter with four H-bridges and the nine level stepped output voltage is obtained. Simulation model of nine level cascade multilevel inverter modulation scheme are pulse width modulation technique is obtained. It consists of fuzzy logic used to determine the shape of the output is obtained. The Single Phase n -Cascaded H-Bridge Inverter for PV applications, *k* dc generators and *k* cascaded H-bridges arranged in a single phase multilevel inverter topology. Each dc generator consists of PV cell arrays connected in series and in parallel, thus obtaining the desired output voltage and current. H bridges basically consist of four metal oxide semiconductor field effect transistors embedding an anti parallel diode and a driver circuit. The number *k* of H-bridges depends on the number n = 2*k*+1 of desired levels, which has to be chosen by taking into account both the available PV fields and design considerations. Higher the number of levels the better the sinusoidal output waveforms. However, the number of level increases the complexity and the cost of the system while reducing its switching frequency in comparison with two level converters. Since low voltage transistors (typically MOSFETs) present significantly higher switching frequency than high power transistors (typically IGBT), MLIs can operate at significantly higher switching frequencies than two level converters.

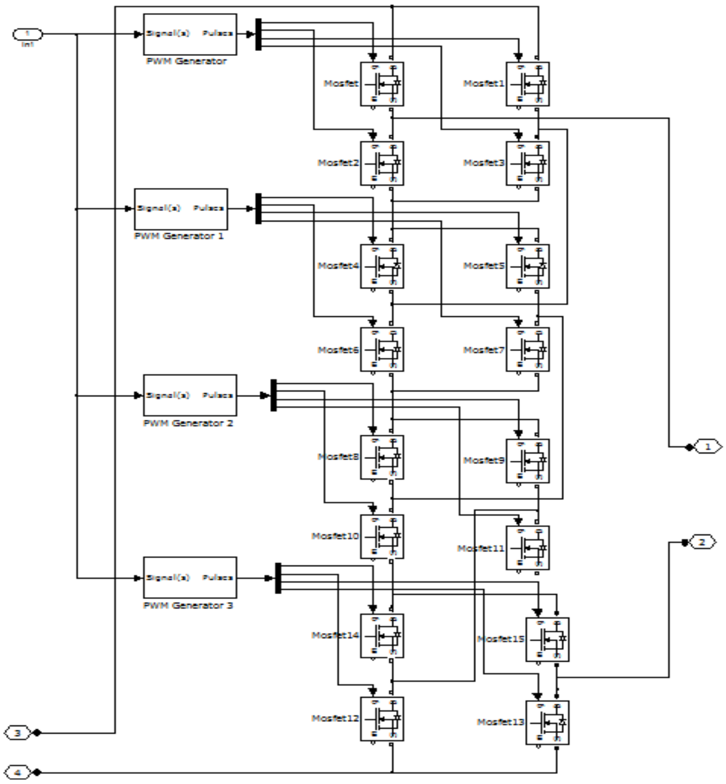

Fig.6.1 Simulation Model of 9-Level Cascaded H-Bridge Multilevel Inverter

This allows the use of smaller low pass filters. Each H-bridge can be driven by a square waveform with a suitable duty cycle or a PWM pattern, thus resulting in a staircase without or with PWM. In the considered single phase 230V system, the cells are arranged into five distinct arrays, thus resulting in an eleven level inverter, which can be considered a reasonable trade-off among complexity, performance, and cost.

VII. CASCADED H-BRIDGE MULTILEVEL CONTROLLER

This paper shows the potential of a Single Phase Cascaded H-bridge nine level inverter governed by the fuzzy logic controller using photovoltaic power source.

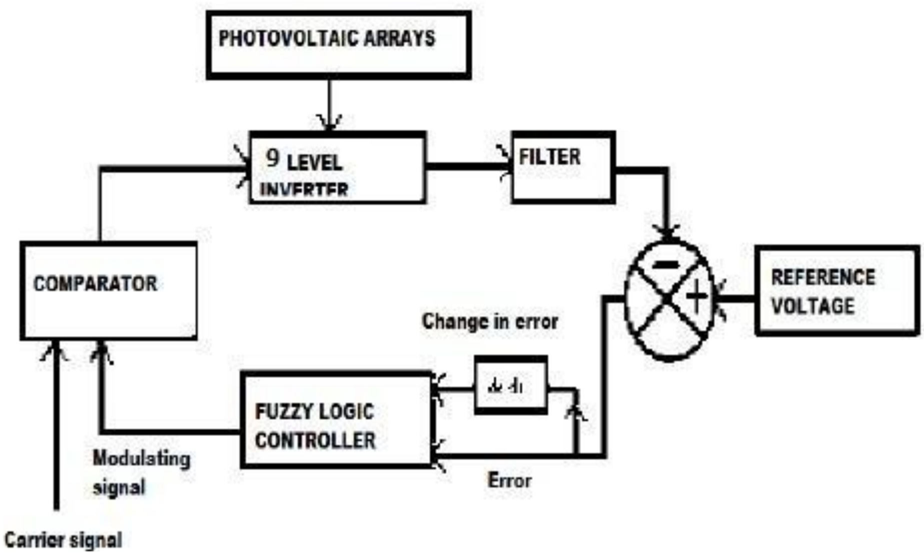

Fig.7.1 Block Diagram of Fuzzy Logic Controller

The labels "NB," "NS," "ZE," "PS," and "PB" used for AV diff stand as follows:

"NB"=negative−big,"NS"=negative−small, "ZE" = zero, and so forth. The fuzzy sets for both the input and output variables were nine, as the number of levels ,ZE,I+,II+,III+,IV+,V+. A Mamdani-based system architecture was realized; Max − Min, composition technique, and the centre-of-gravity method were used in the inference engine and in the defuzzification process, respectively. In this paper, the number and type of the control rules were decided according to a sensitivity analysis made by varying the number and type of rules.

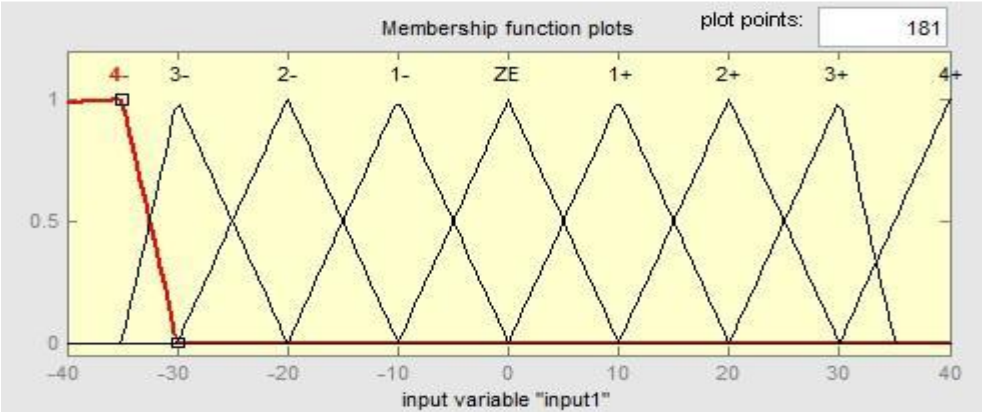

Fig.7.2 Membership Functions of Parameter *AV* diff

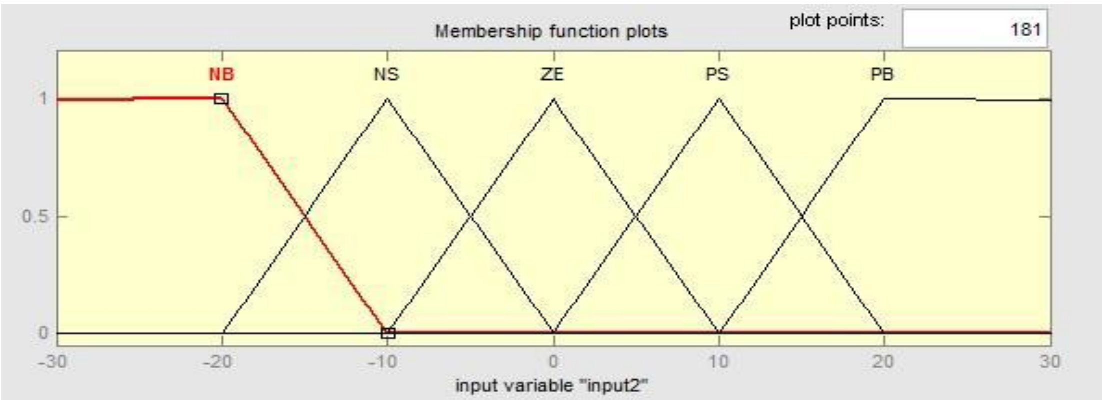

Fig.7.3 Membership Functions of Parameter *Vn*

INFERENCE RULES

V_n	AV_{diff}				
	NB	NS	ZE	PS	PB
IV^+	IV^+	IV^+	IV^+	III^+	III^+
III^+	IV^+	IV^+	III^+	II^+	II^+
II^+	III^+	III^+	II^+	I^+	I^+
I^+	II^+	II^+	I^+	ZE	ZE
ZE	I^+	I^+	ZE	I^-	I^-
I^-	ZE	ZE	I^-	II^-	II^-
II^-	I^-	I^-	II^-	III^-	III^-
III^-	II^-	II^-	III^-	IV^-	IV^-
IV^-	III^-	III^-	IV^-	IV^-	IV^-

TABLE: 7.1

The following logic was adopted for designing the inference rules:

1) If AV diff is equal to ZE, the current state is correct, and the inverter conserves its current state. 2) Consider a generic state ,if AV diff is positive Vout > Vref, then the inverter state should be reduced; if AV diff is negative Vout < Vref, the inverter state should be increased.

VIII. SIMULATION CIRCUIT

In this paper, the simulation model is developed in MATLAB/Simulink, shows the closed loop configuration of nine -level inverter. Filtered output voltage obtained from the eleven-level inverter through RC low pass filter. Output voltage feedback is given to the summer to compare the output voltage with reference voltage and the error voltage level obtained from the output of the summer for further operation. There are two inputs to the fuzzy logic controller one is error and derivative of the error , derivative of the error obtained from the previous sample value of the error voltage signal. The role of fuzzy logic controller is to convert the given crisp inputs to fuzzy sets using fuzzification, and defuzzification.

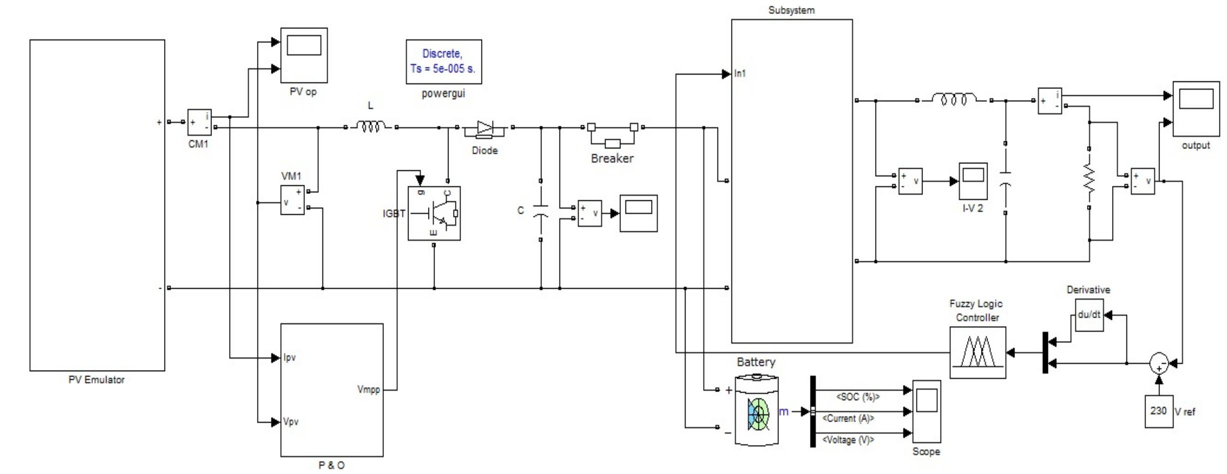

Fig.8.1 Over all Simulation

IX. SIMULATION RESULT

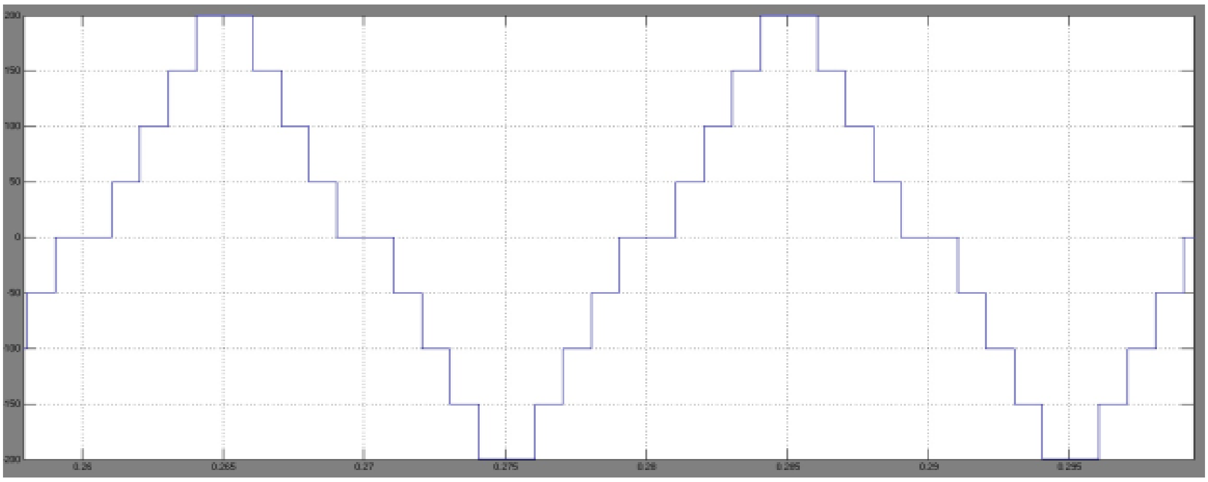

Fig.9.1 Output Waveform of Nine Level Inverter Without Filter

X. CONCLUSION

In the paper ,a new single phase cascaded H-Bridge Nine –level inverter with boost converter and fuzzy logic controller using solar power source was simulated using MATLAB/SIMULINK and sinusoidal pulse width modulation control technique was used to control this inverter. By tuning the fuzzy logic controller required

RMS voltage with less harmonic distortion obtained in closed loop configuration hence we could achieve the improved efficiency of the system and better performance over cascaded H-bridge seven level inverter.

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