# Modelling and Simulation of MPPT Based Standalone PV System with Upgraded Multilevel Inverter

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***Abstract*—This paper present the multi level inverters and the minimization of total harmonic distortion by increasing levels. The Harmonic distortion technique is used as a switching scheme. The analysis of twenty five and thirty level cascaded H-bridge inverter and boost converter simulation work is done by using the MATLAB and Simulation results show the improvement of output voltage waveform and reduction of the Ttotal harmonic distortion (THD) by increasing the levels in inverter.simulation results of 30 level inverter THD is 10.09%and in 25 level inverter THD is 12.41%.THD can be reduced more and more by increasing level of inverter.In this paper MPPT extract maximum power from pv string at different radiance.This paper also a comparative study of modeling and simulation of 30 level inverter and 25 level inverter with boost converter PV system uses MPPT.**

***IndexTerms*—Boost converter, PV module,Multilevel Inverter,THD,MPPT etc.**

## I. INTRODUCTION

For high-power applications, multilevel inverter structure have the particular advantages of operation at high dc bus voltages, achieved using series connections of switching devices and a reduction in output voltage harmonics, achieved by switching between multiple voltage levels [1].Multilevel pulse width modulation (PWM) inversion is an effective solution for increasing power and reducing harmonics of ac waveforms. A multilevel inverter has four main advantages over the conventional bipolar inverter. They are the voltage stress on each switch is decreased due to series connection of the switches so the rated voltage and consequently the total power of the inverter are safely increased, the rate of change of voltage dv/dt is decreased due to the lower voltage swing of each switching cycle, Total harmonic distortion is reduced due to more output levels. Fourth, lower acoustic noise and electromagnetic interference (EMI) is obtained.Based on these advantages, various circuit topologies and modulation strategies have been reported for better utilization of multilevel voltage source inverters (VSIs)[2].

Multilevel topologies are classified into three categories: diode clamped inverters, flying capacitor inverters, and cascaded inverters. The topologies have an equal number of main switches. Diode clamped inverter requires additional clamping diodes. Flying capacitor inverter requires the most number of capacitors. Cascaded inverter has simple structure but it needs various separate dc sources. The main drawback of diode clamped inverter is the unbalanced dc link capacitor. It restricts the application of diode clamped inverter to five or less number of levels. The problem may be mitigated using combinational topologies. The cascaded inverter uses series strings of single-phase full bridge inverters to construct multilevel phase legs.The most popular control technique for traditional inverters is the sinusoidal or “sub harmonic” natural pulse width modulation (PWM) method. Its popularity is due to its simplicity and to the good results it guarantees in all the operating conditions. [3].

For systems where high switching efficiency is needed, it is desirable to keep the switching frequency much lower. In this state, another approach is to choose the switching angle in such a way that a desired fundamental output is generated and chosen harmonics of the fundamental voltage are suppressed, this is called as harmonic elimination or programmed harmonic elimination to eliminate specific harmonics[4].

### *Total harmonic distortion*

THDis a complex and often confusing concept to grasp. However,when broken down into the basic definitions of harmonics and distortion, it becomesomuch easier to understand.

THD, is the summation of all harmonic components of thevoltage or current waveform compared against the fundamental component of the voltageor current wave:

$$\mathrm{THD} = \frac{\sqrt{(V_1^2 + V_2^2 + V_3^2 + \cdots + V_n^2)}}{V_1} \times 100\%$$

The formula above shows the calculation for THD on a voltage signal. The end result is apercentage comparing the harmonic components to the fundamental component of asignal. The higher the percentage, the more distortion that is present on the mains signal. This paper explains that THD is reduced by increasing level of inverter,In 25 level inverter it is 12.41% that is reduced by 30 level level inverter to 10.09%.

## II. PV MODULE

A Photovoltaic cell is a device used to convert solar radiation directly into electricity. It consists of two or more thin layers of semiconducting material, most commonly silicon. When the silicon is exposed to light, electrical charge are generated. A PV cell is usually represented by an electricalcircuit equivalent one-diode model shown in fig.1

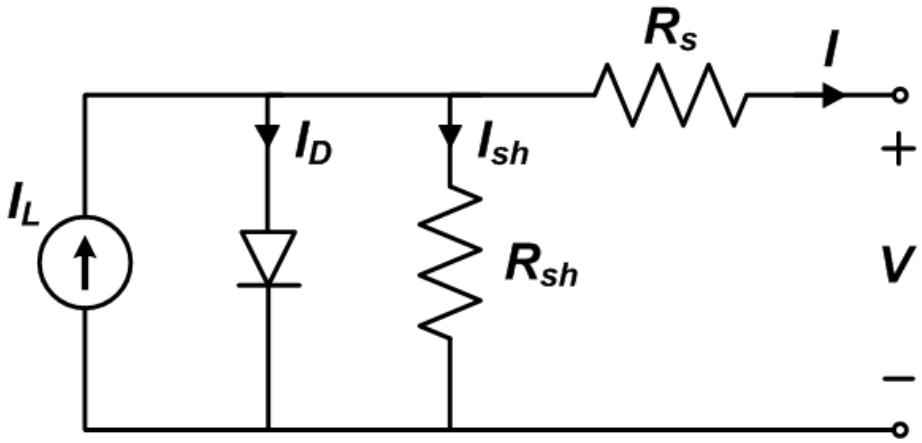


Fig.1 PV system diode circuit

here Rs=Series resistance, Rsh=Shunt resistance,Iph=Photogenrated current
Io=Diode saturation current

## III. PHOTOVOLTAIC ARRAY

Thepower that one module can produce is not sufficient to meet the requirements of home or business. So series parallel combination of Most PV arrays use an inverter to convert the DC power into alternating current that can power the motors, loads, lights etc. The modules in a PV array are usually first connected in series to obtain the desired voltages; the individual modules are then connected in parallel to allow the system to produce more current.

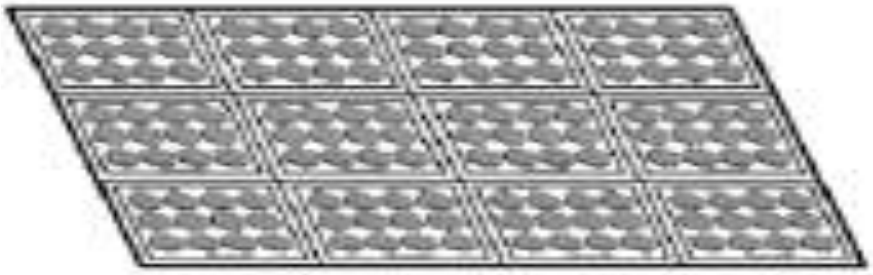

Fig. 2Photovoltaic Array

Pv array input are temperature is 25c and radiation is 1000 and 132 v is operating voltage and operating current is 25.44A for MPPT condition.Total PV array voltage is 132V having 200 cells in series each having 0.66vand Total current is 25.44A consist 10 cells in paralleleach having current of 2.5A. The output voltage of PV array is different at different irradiance.

## IV. MPPT

Maximum Power Point Tracking is used for extracting maximum available power from PV module under certain conditions. The voltage at which PV module can produce maximum power is called „maximum power point" (or peak power voltage). Maximum power varies with solar radiation, ambient temperature and solar cell temperature.

For any given set of operational conditions, cells have a single operating point where the values of the current (I) and Voltage (V) of the cell result in a maximum power output. These values correspond to a particular load resistance, which is equal to V / I as specified by Ohm's Law. The power P is given by P=V*I. A photovoltaic cell has an approximately exponential relationship between current and voltage. From basic circuit theory, the power delivered from or to a device is optimized where the derivative (graphically, the slope) dI/dV of the I-V curve is equal and opposite theI/V ratio (where dP/dV=0). This is known as the maximum power point (MPP) and corresponds to the "knee" of the curve.

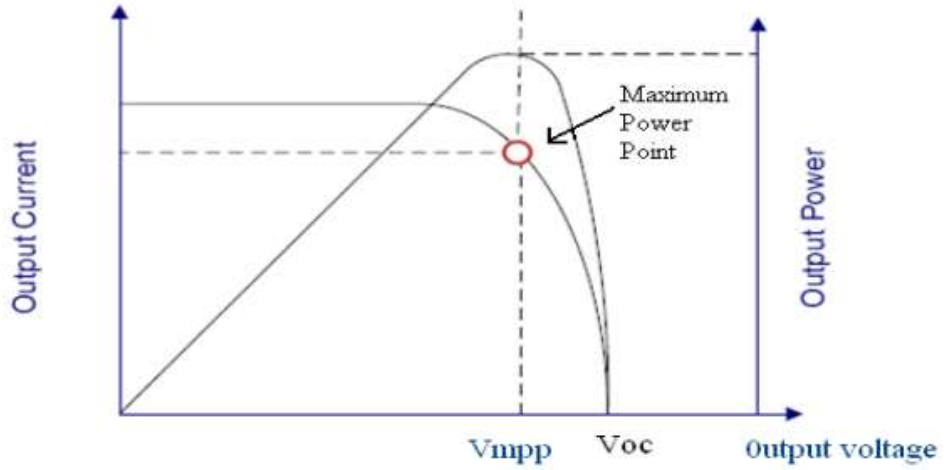


Fig.3 Maximum Power Point of a Solar Panel

MPPT Techniques The MPPT techniques are:

1. Perturbation and Observation (P&O) method.
2. Incremental Conductance (InC) method.
3. Constant Voltage method. In these we get maximum peak voltage 74.99 V and maximum current 9.691A.

## V. DC TO DC BOOST CONVERTER

A boost converter has been employed in this application to regulate the power output to the load. A step up, also known as a boost converter, is capable of providing a dc output voltage that is greater than thedc input voltage. The operation of a boost converter can be divided into two modes- the Continuous Current Mode and the Discontinuous Current Mode.

Basic Configuration of a Boost Converter where the switch is integrated in the used IC. Often lower power converters have the diode replaced by a second switch integrated into the converter. If this is the case, all equations in this document apply besides the power dissipation equation of the diode.

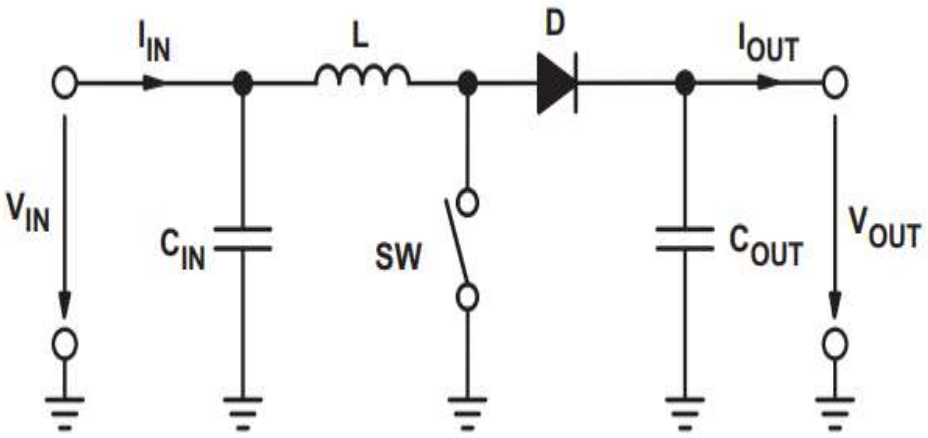


Fig.4 Basic Boost converter

The following four parameters are needed to calculate the power stage:

1. Input Voltage Range: VIN(min) and VIN(max)
2. Nominal Output Voltage: VOUT
3. Maximum Output Current: IOUT(max)
4. Integrated Circuit used to build the boost converter.

This is necessary, because some parameters for the calculations have to be taken out of the data sheet. If these parameters are known the calculation of the power stage can take place.Boost converter dc input voltage is 74.99 V and output DC Voltage is 487.1V.

## VI. SIMULATION

In this Paper**,**multi-level inverter isused to achieve high power from medium voltage source. The main feature is the lower harmonic distortion content due to the multiple voltagelevels at the output. Therefore it can eliminatethe use of filter circuits. The multilevel invertercan operate at both fundamental switching frequency and higher switching frequency.

***Twenty Five Level Inverter***

The twenty five level Simulink model used for the implementation of the required MPPT based solar cell and boost converter is as shown. The results of these is referred by Paper "Modeling and Simulation of Hybrid MPPT Based Standalone PV System with Upgraded Multilevel Inverter [10].

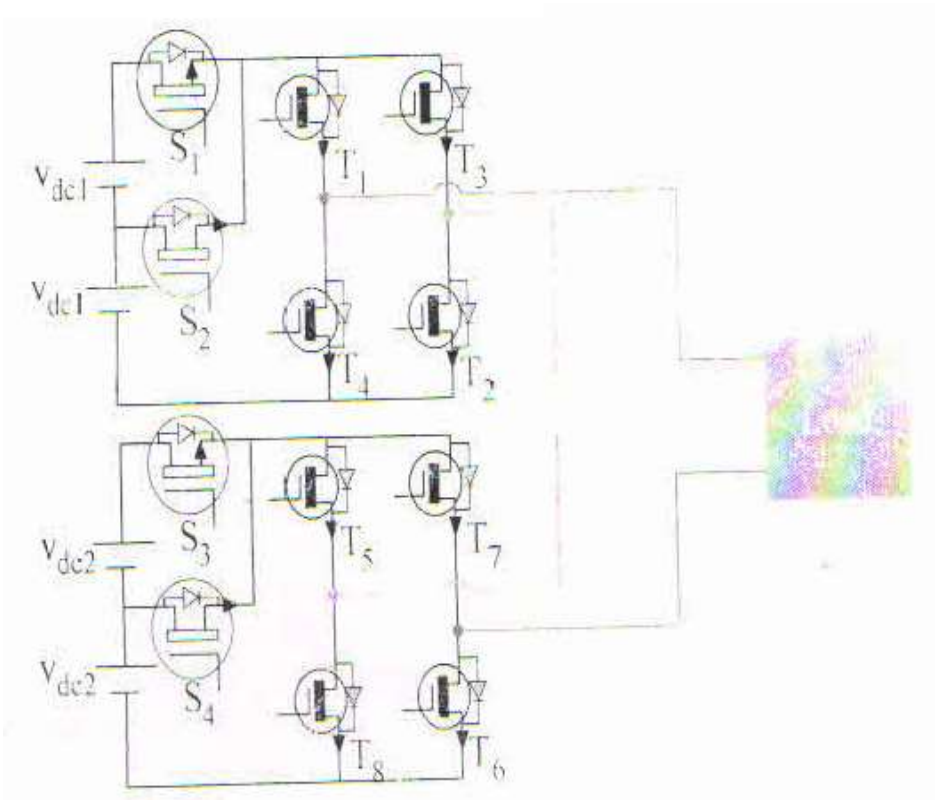


Fig.5 MPPT based PV system 25 level inverter with boost converter output waveform

In this paper the modeling and simulation of PV system is done using MATLAB/SIMULINK. Four PV strings are used for the modeling. Out of 4 strings, two strings are containing 34 PV cells each in a series parallel fashion to provide output voltage of 19.16V each, whereas other two strings contain 170 PV cells in series parallel fashion to provide output voltage of 95.83V each. The total rating of the PV array is 230V, 1kW. The 25-level proposed inverter uses only 12 switches compared to other type of conventional multilevel inverter which uses 48 switches and 12 separate dc sources. But in proposed inverter the requirement of separate dc source is only four. Separate dc supply to the MLI is provided using PVstrings. The harmonic content in the output voltage is found through FFT analysis. It is measured by THD and is found to be 12.14%.

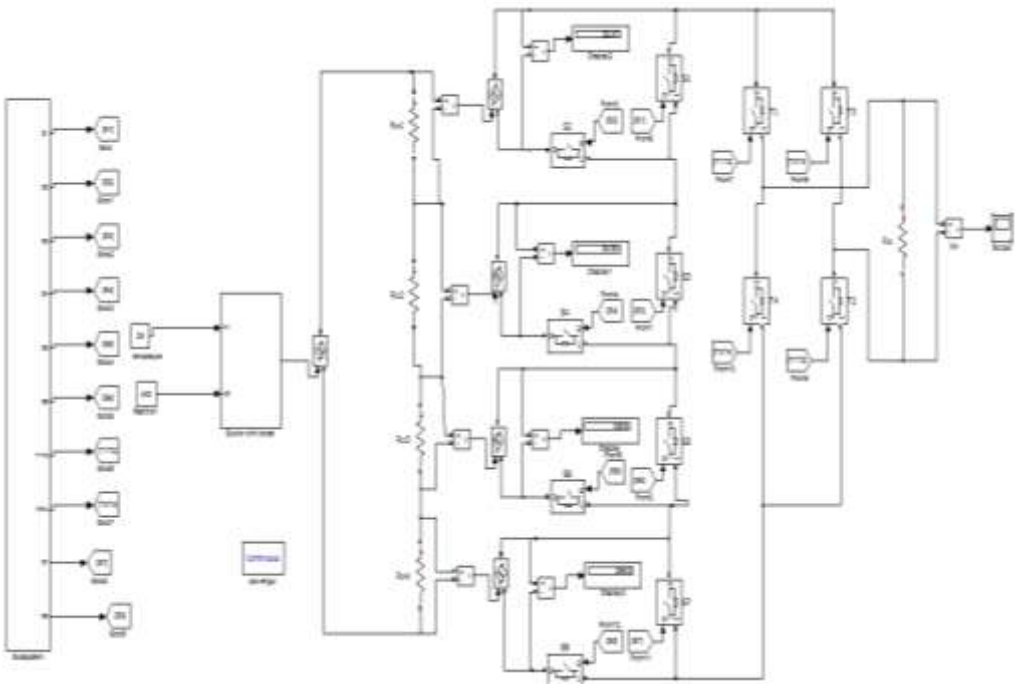

Fig.6 MPPT based solar pv system 30 level inverter with boost converter

The simulation circuit of multi-level inverter(thirty level inverter) is shown in Fig.**6**. THDvalue can be reduced without any additional control system. This type of inverter can eliminate the choice of large filter inductor and capacitance.To reduce the THDvalue, the Thirty level MLI is simulated.Thirty level inverteruses **total** 12**s**witches to produce the required levels at the output voltage.out of these 4 switches are used as a toggel switch which are configured as H-bridge configuration.four voltage is selected in sub multilevel cells as a pattern of 1R,2R,4R,8R which are 32.47V,64.94V,129.88V,259.76Vrespectively.the total voltage 487.1v is divided into 15 parts and the one part is 1R.These four volatge is taken as reference and by adding these we make

voltages at different 30 levels.thusmultilevel inverter generates AC output at different 30 leveland THD by FFT analysis found to be 10.09%.

## VII. RESULTS AND DISCUSSION

All simulation results of the proposed multi level inverter i.e. thirty leveland twenty five level inverter are done on MATLAB/Simulink. The simulation results are discussed for thirty level inverter and twenty five level inverter.The simulation is carried out in following as.

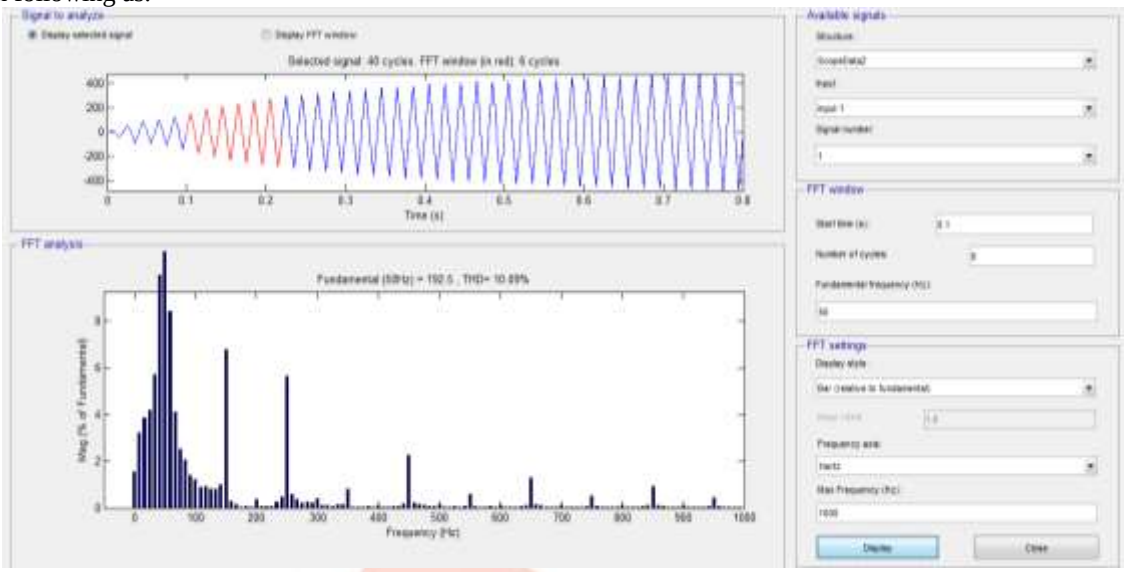

Fig.7 PV System with 30 level Multi level inverter output

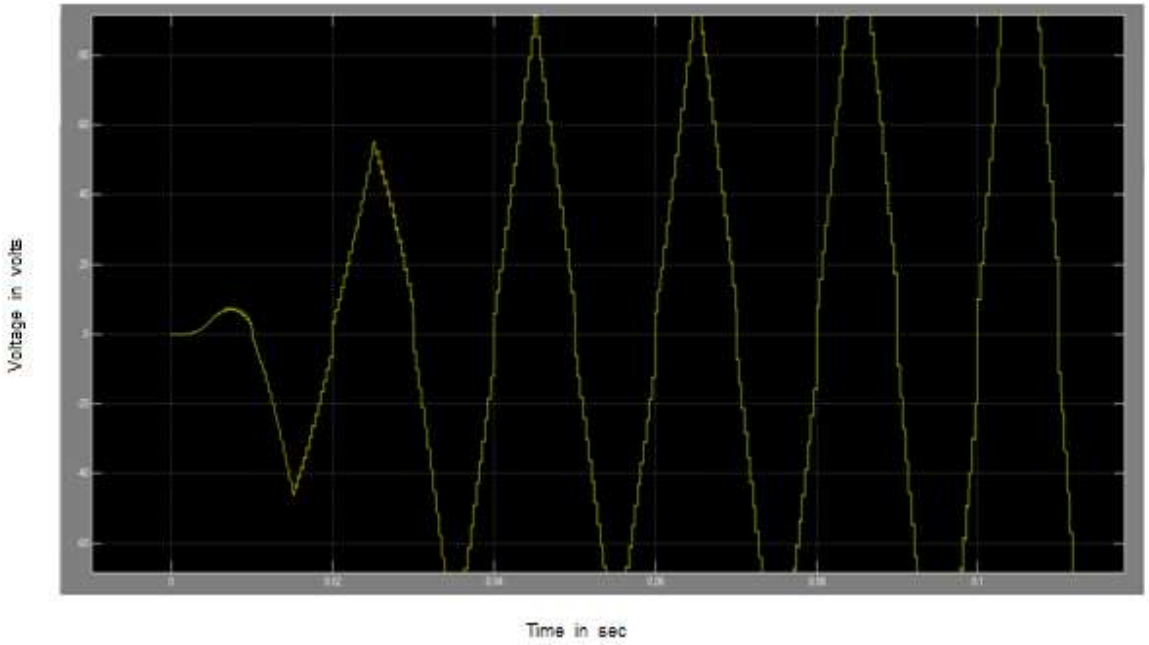


Fig.8 Performance of voltage Vs time of 30 level Multi level inverter output

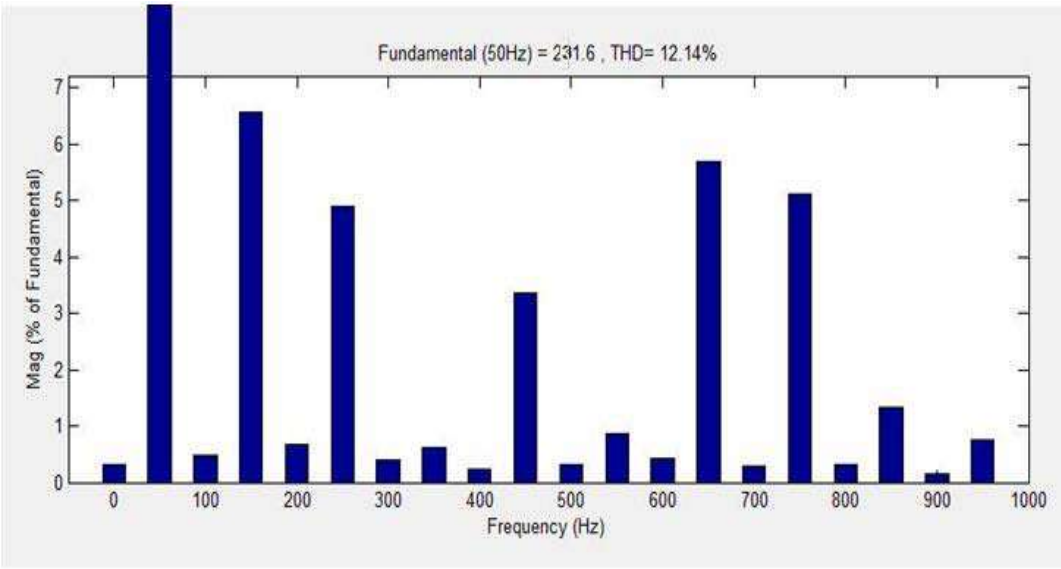


Fig.9 PV System with 25 level Multi level inverter output

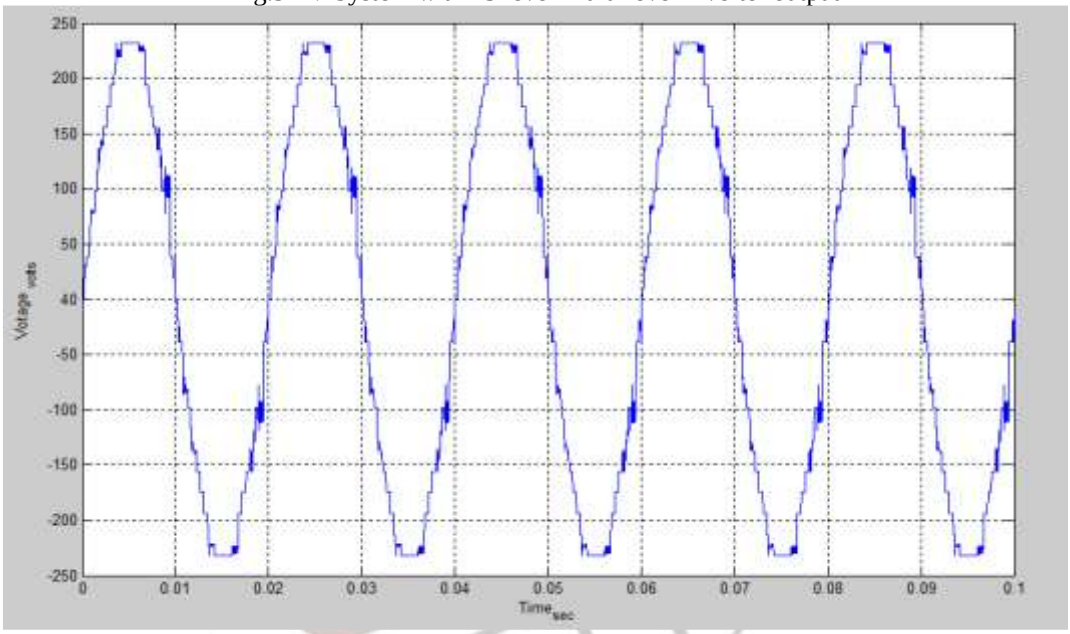


Fig.10 Performance of voltage Vs time

The output voltage of thirty level inverter is shown in the Fig.7 and fig.8 THD result is 10.09% which are relatively very low when compared with other levels of inverter.From the Fig.9 and fig.10,the result of 25 level inverter is observed that the percentage of total harmonic distortion (THD) is 12.14.

## VIII. CONCLUSION

This paper present modeling and simulation of standalone PV system with upgraded multilevel inverter using MATLAB/SIMULINKthe 30 level inverter THD is 10.09% and in 25 level inverter THD is 12.41%.THD can be reduced more and more by increasing level of inverter. Modeling include 30 level inverter which reduces THD 10.09%. In this paper MPPT extract maximum power from PV string at different radiance. This paper also a comparative study of modeling and simulation of 30 level inverter with boost converter PV system uses MPPT. This paper explains that THD is reduced by increasing level of inverter.

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