ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 2, Issue 9, September 2013

HARMONIC REDUCTION TECHNIQUE USING MULTILEVEL INVERTER IN PHOTO VOLTAIC SYSTEM WITH MPPT

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Abstract:- This paper investigates the performance of a PV system with Boost Converter where switching is controlled by MPPT technique connected Multi Level Inverter topology. Multilevel inverters are suitable in high voltage & high power application due to their ability to synthesize waveforms with better harmonic spectrum. This paper presents first the design and study of P-V and I-V characteristics of PV system and then output is connected to Boost converter. Switching is done by P and O type MPPT algorithm. Lastly Multicarrier based cascaded Multilevel Inverter is connected to this previous mentioned system. .Cascaded Multilevel inverter strategy enhances the fundamental output voltage and reduced Total harmonic distortion. A Single phase five level cascaded inverter is used to explain the study. The study can be easily extended to an m-level inverter. In order to justify the advantages of the system, harmonic analysis and measured THD and output voltages are compared and discussed with DC-AC Bridge Inverter.

Keywords:- MPPT, Multilevel Inverter, Photovoltaic, P and 0,THD

I.INTRODUCTION

Energy is the prime mover of economic growth and is vital to the sustenance of a modern economy. Future economic growth crucially depends on the long-term availability of energy from sources that are affordable, accessible and environmentally friendly. Government, industry and independent analyses have shown that cost-effective energy efficiency improvements could reduce electricity use by 27% to 75% of total national use within 10-20 years without impacting quality of life or manufacturing output. Besides India is world's 6th largest electrical energy consumer, accounting 3.4% of global energy consumption. The present installed power generation capacity of India stands at1, 85,496.62MW as on 31.11.2011. About 66% of the electricity consumed in India is generated by thermal power plants and 20.88% by hydroelectric power plants and 2.57% by nuclear power plants and 11.2% from renewable energy sources. According to a 2011 projection by the International Energy Agency, solar power generators may produce most of the world's electricity within next 50 years, dramatically reducing the emissions of greenhouse gases that harm the environment.

Both research and technological development in the area of renewable energy sources are necessary to account for the increase in energy demand and environment problems in the world. Stand-alone photovoltaic systems are the best solutions such as communication system, water pumping and low power appliances in rural area. Such systems are consisting of a PV generator, energy storage devices, AC or DC consumers and elements for power conditions. PV module represents the fundamental power conversion unit of a PV generator system. The output characteristic of PV module depending on the irradiance intensity and the cell's temperature is nonlinear, so it is necessary to model it for the simulation of maximum power point tracking for stand-alone PV systems.

Solar photovoltaic (PV) energy is nowadays one of the most important available resources because is free, abundant, and pollution-free and distributed all over the world. Unfortunately, PV generation systems have two major problems: the conversion efficiency of electric power generation is low (in general less than 17%, especially under low irradiation conditions), and the amount of electric power generated by solar arrays changes continuously with weather conditions. Moreover, the solar cell V-I characteristic is nonlinear and varies with irradiation and temperature. In general, there is a unique point on the V-I or V-P curve, called the Maximum Power Point (MPP), at which the entire PV system (array, converter, etc.,) operates with maximum efficiency and produces its maximum output power. The location of the MPP is not known, but can be located, either through calculation models or by search algorithms. Therefore Maximum

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International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 2, Issue 9, September 2013

Power Point Tracking (MPPT) techniques are needed to maintain the PV array's operating point at its MPP. The P&O, incremental conductance (INC) method are the most known methods to track the MPP by updating repeatedly the operating voltage of the PV array varying the duty cycle of the power converter with a fixed step size.
However, by incorporating maximum power point tracking (MPPT) algorithms, the photovoltaic system's power transfer efficiency can be improved significantly as it can continuously maintain the operating point of the solar panel at the MPP pertaining to that irradiation and temperature and so on as shown in Fig.1.

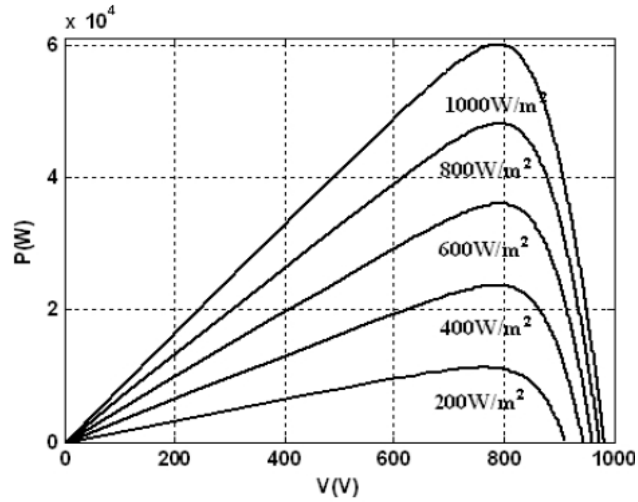

Fig.1 Power-voltage characteristics of photovoltaic module at different irradiance levels

This paper presents a PV system array connected to Cascaded H-Bridge type multi-level inverter to achieve sinusoidal voltage waveform and output sinusoidal current to the load with a simple power electronic solution. The topologies of multilevel inverters are classified in to three types the Flying capacitor inverter, the Diode clamped inverter and the Cascaded bridge inverter. The cascaded multicarrier multilevel inverter strategy reduced total harmonic. Now requirement of filter size also becomes less. Voltage and harmonics are plotted and compared with normal PWM inverter to capitalise the required result.

II.PV MODULE MODEL

A solar cell is basically a p-n junction fabricated in a thin wafer of semiconductor. The electromagnetic radiation of solar energy can be directly converted to electricity through photovoltaic effect. Being exposed to the sunlight, photons with energy greater than the band-gap energy of the semiconductor creates some electron-hole pairs proportional to the incident
irradiation. The equivalent circuit of a PV cell is as shown in Figure.

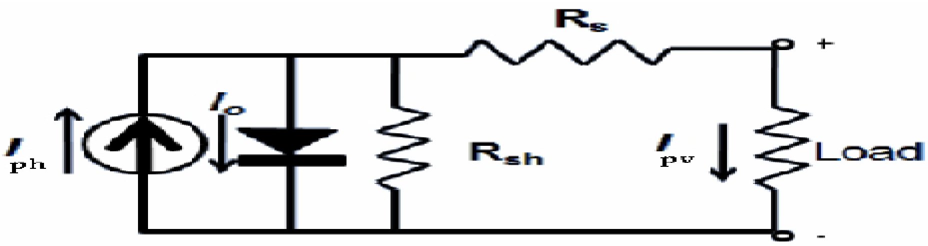

Figure shows PV cell modeled as single diode circuit.

The current source Iph represents the cell photocurrent. Rsh and Rs are the intrinsic shunt and series resistances of the cell, respectively. Usually the value of Rsh is very large and that of Rs is very small, hence they may be neglected to simplify the analysis.
PV cells are grouped in larger units called PV modules which are further interconnected in a parallel-series

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configuration to form PV arrays.

The photovoltaic panel can be modeled mathematically as given in equations (1)- (4).

Module photo current

$Iph=[Iscr+Ki(T-298)]*\lambda/1000$ ....(1)

Module Reverse Saturation current

$Irs=Iscr/[exp(q.Voc/Ns.k.A.T)]$ ....(2)

The Module saturation current I0 varies with the cell temperature which is given by

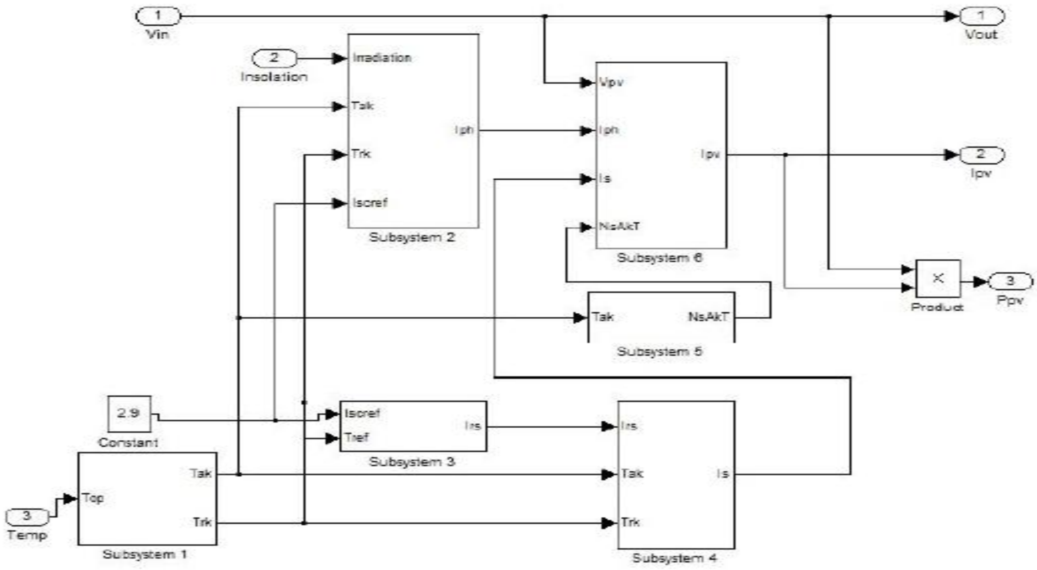
$I0=Irs*[T/Tr]3exp[q*Ego\{(1/Tr)-(1/T)\}]$....................(3)

The Current of the PV module is

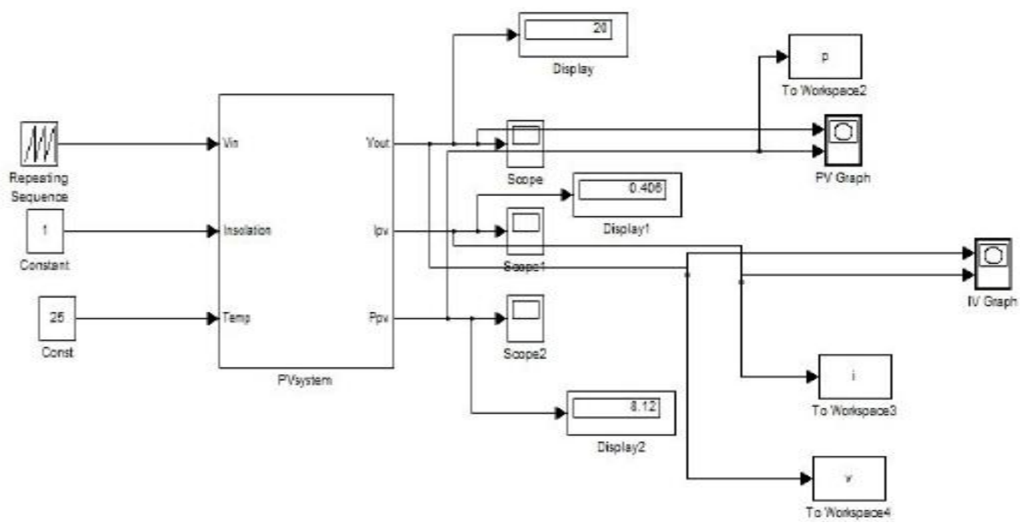
$Ipv=Np*Iph-Np*I0[exp\{(q*Vpv+Ipv*Rs)/NsAkT\}]$.(4)

where, $Vpv=Voc, Np=1, Ns=36$.

Based on these above equations Photovoltaic module is designed.



Now this is the model used in this paper, which gives Voltage, Current & power as a output of Subsystem PV module.



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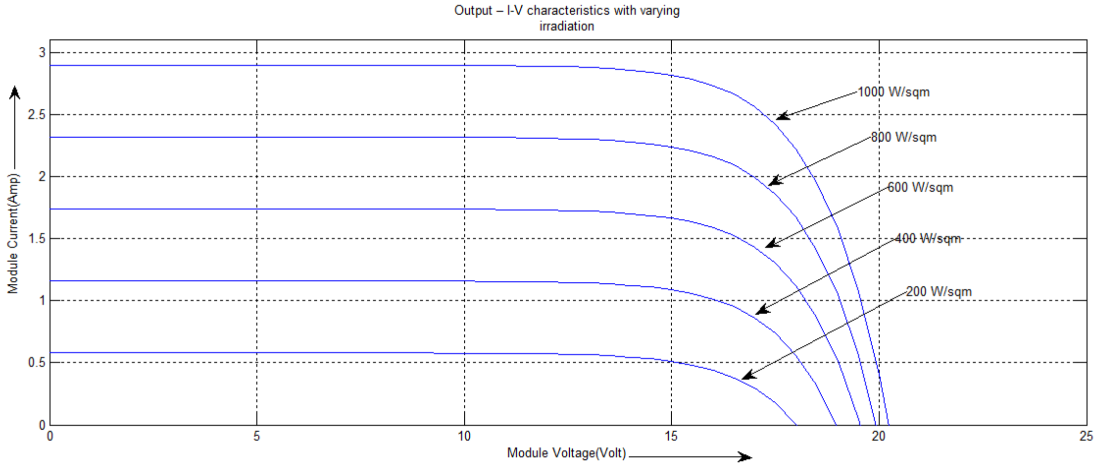
III.PV MODULE PV AND IV CHARACTERISTICS



This figure shows I-V curve with varying irradiation.

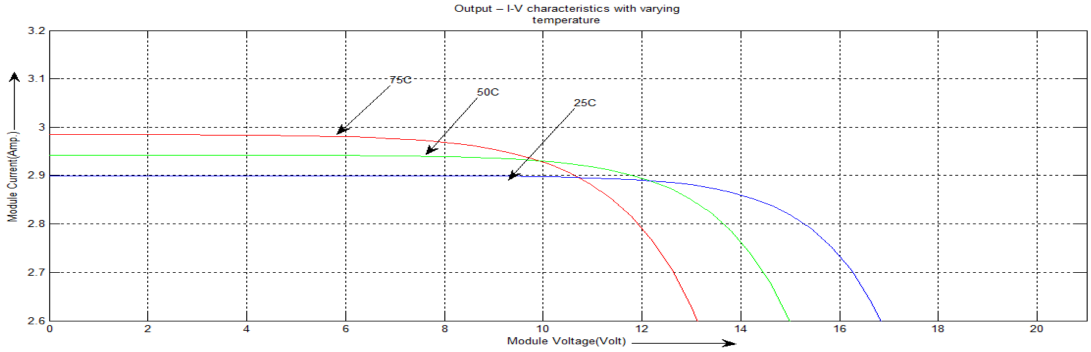


Figure shows the I-V curve with varying temperature.

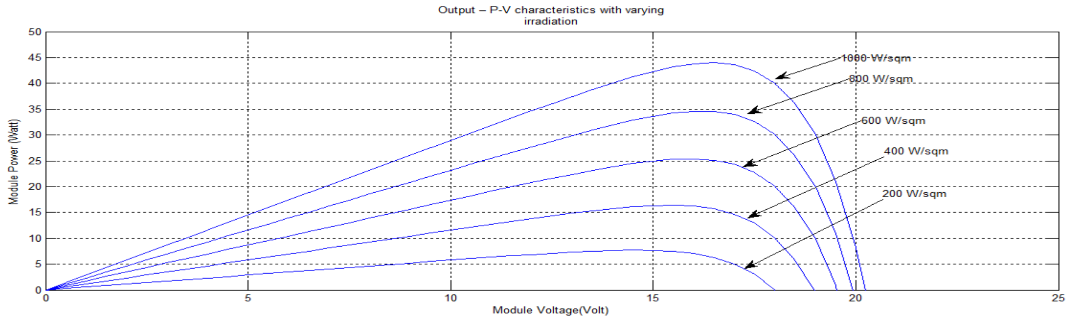


Figure shows P-V curve with varying irradiation.

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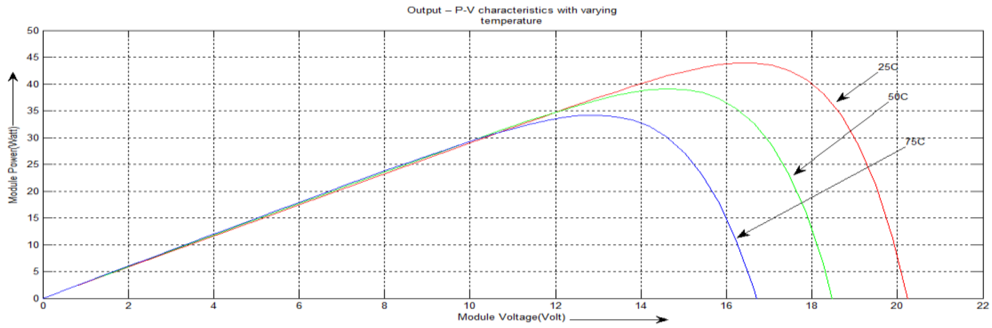
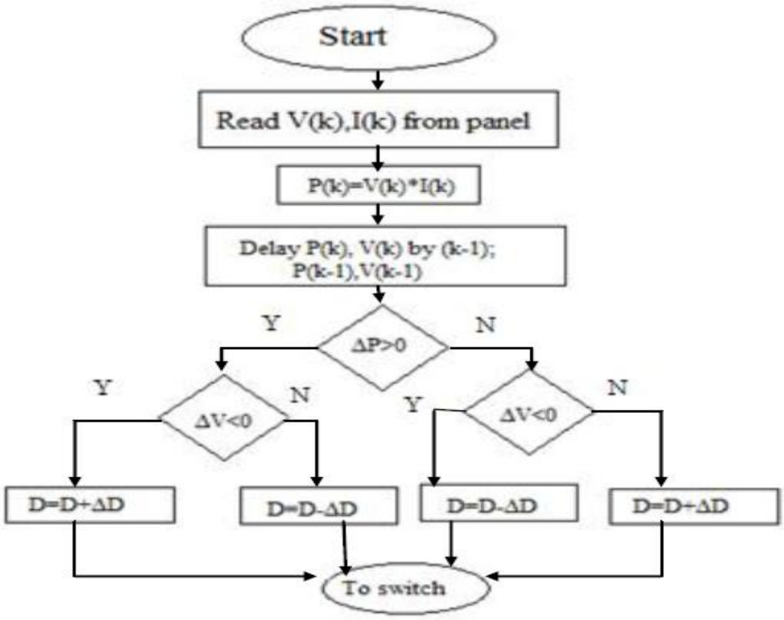


This graph shows P-V curve with varying Temperature.

IV.P AND O MPPT ALGORITHM

The most commonly used MPPT algorithm is the P&O due to its simplicity of implementation. However, it has some drawbacks, like oscillations around the MPP in steady state operation and also slow response speed at the event of changes in solar irradiance. Figure shows the algorithm of P&O.



P&O algorithm is based on the calculation of the PV array output power and the power change by sensing both the PV current and voltage. The controller operates periodically by comparing the present value of the power output with the previous value to determine the change on the solar array voltage or current. The algorithm reads the value of current and voltage at the output solar PV module. Power is calculated from the measured voltage and current. The magnitude of voltage and power at kth instant are stored. Then the magnitude of power and voltage at (k+1)th instant are measured again and power is calculated from the measured values.

V.MULTILEVEL INVERTER

A single-phase structure of an m-level cascaded inverter is illustrated in Figure 5. 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 four switches, S1, S2, S3, and S4. To obtain +Vdc, switches S1 and S4 are turned on, whereas –Vdc can be obtained by turning on switches S2 and S3. By turning on S1 and S2 or S3 and S4, the output voltage is 0. The AC outputs of each of the

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different full-bridge inverter levels are connected in series such that the synthesized voltage waveform is the sum of the inverter 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 separate dc sources. An example phase voltage waveform for an 11-level cascaded H-bridge inverter with 5 SDCSs and 5 full bridges is shown in Figure. The phase voltage VAM = VA1+ VA2+ VA3+ VA4+ VA5 For a stepped waveform such as the one depicted in Figure with s steps, the Fourier Transform for this waveform follows:

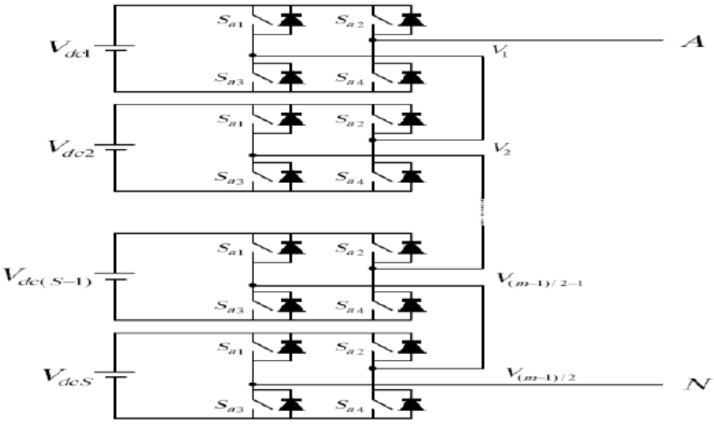
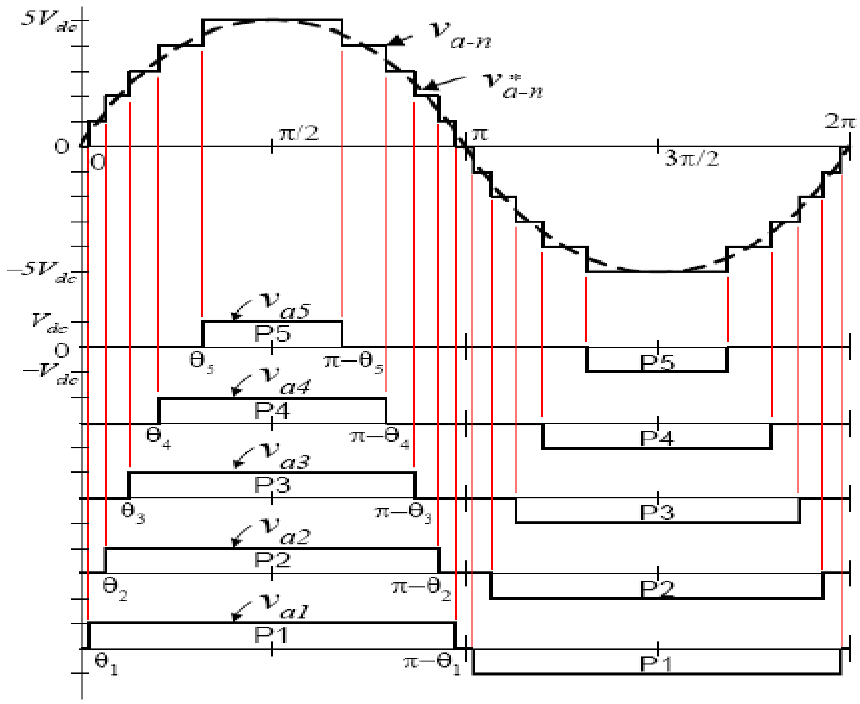


Figure shows Single-phase structure of a m level multilevel cascaded H bridge inverter.



This figure shows the Output phase voltage waveform of an 11-level cascade inverter with 5 separate dc sources.

VI. SIMULATION RESULTS

Figure shows complete PV generation system based on the proposed multilevel converter has been implemented in a prototype and the proposed block diagram as shown in the figure . If the power generated by all strings is equal, the output voltage of all cells will be equal. Simulations have been carried out in MATLAB–Simulink to study the

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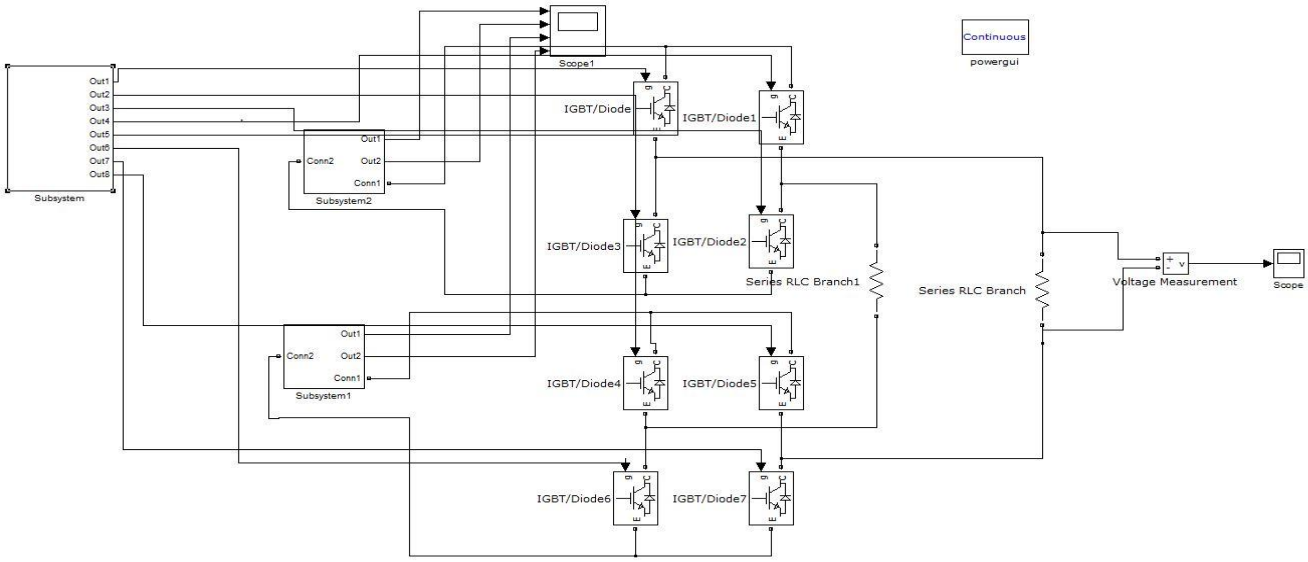
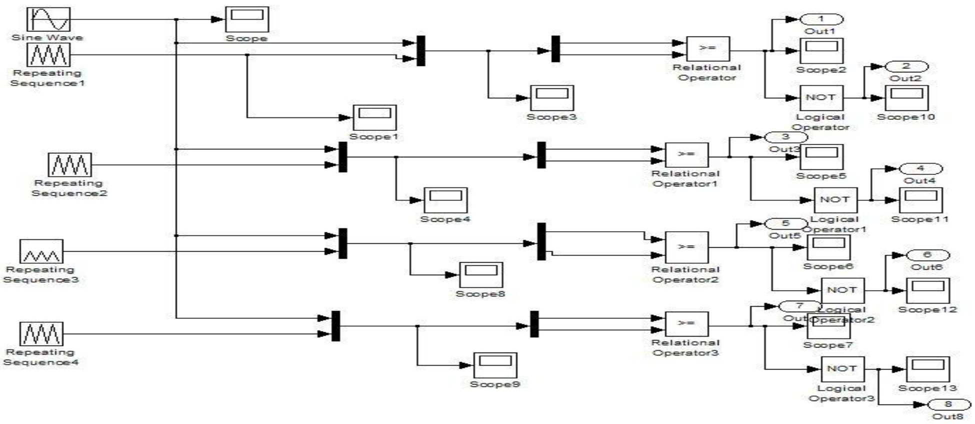
performance of the proposed control and modulation scheme. The particular system shown in Figure is modelled . Two PV Arrays are connected to a passive load through a Five-level cascaded H bridge inverter.



This figure shows the total circuit arrangement.



This figure shows the Modulation technique used to switch the multilevel inverter.

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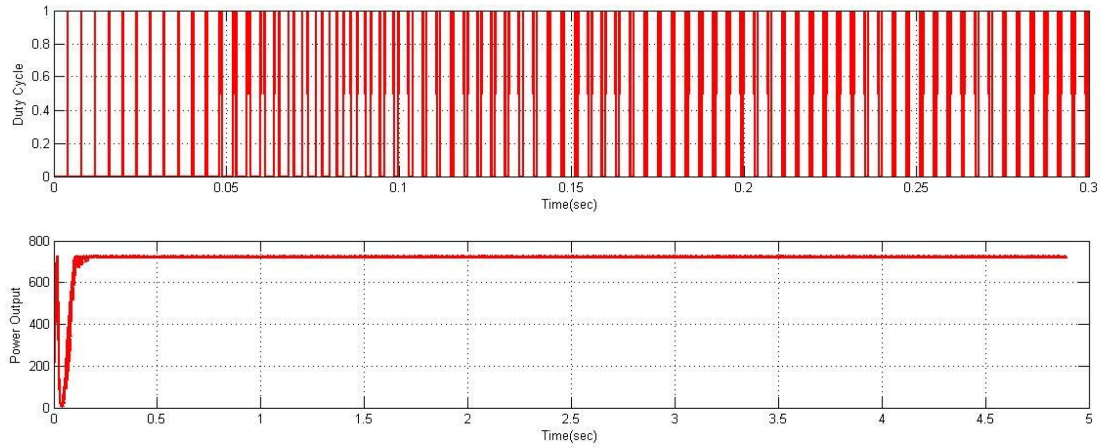
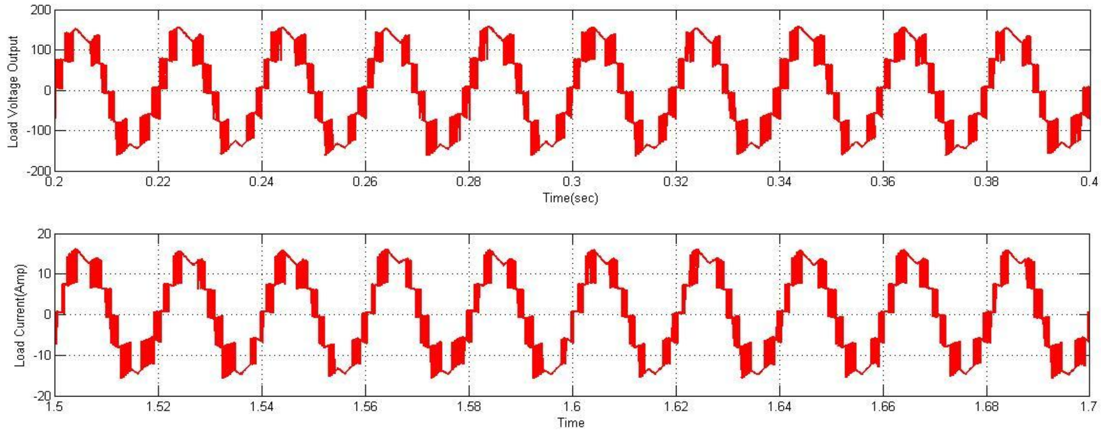


This figure shows Power output of PV module and the switching duty cycle which is controlled by MPPT.



This figure shows the Load Voltage and Load current output of total system attached with Multilevel Inverter.

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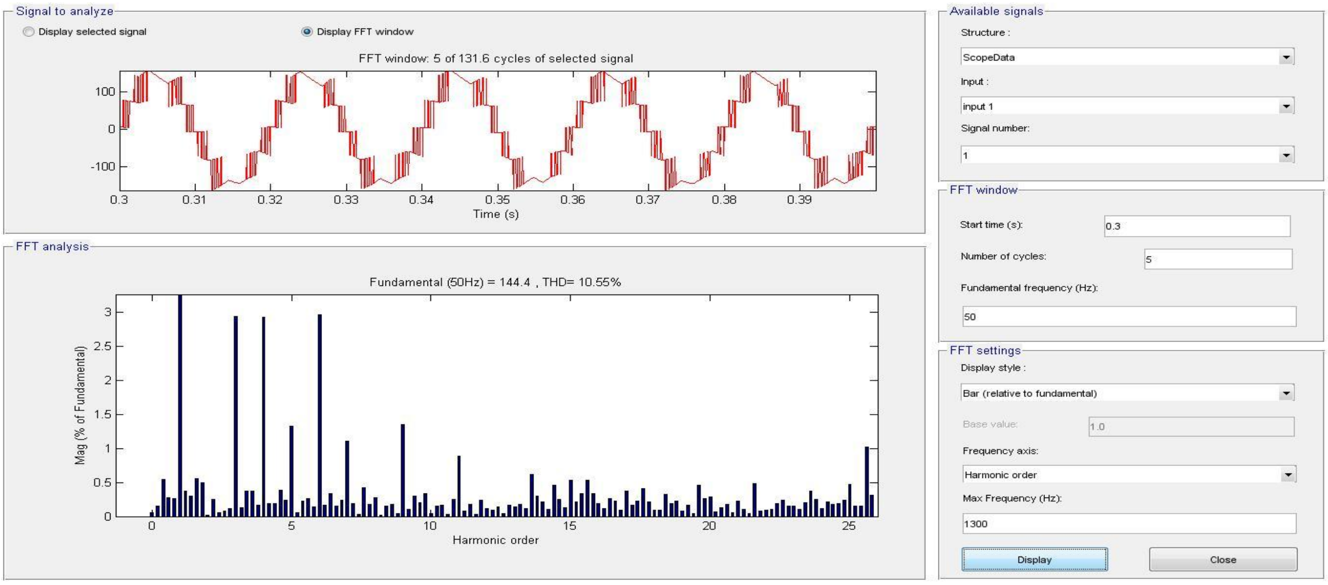
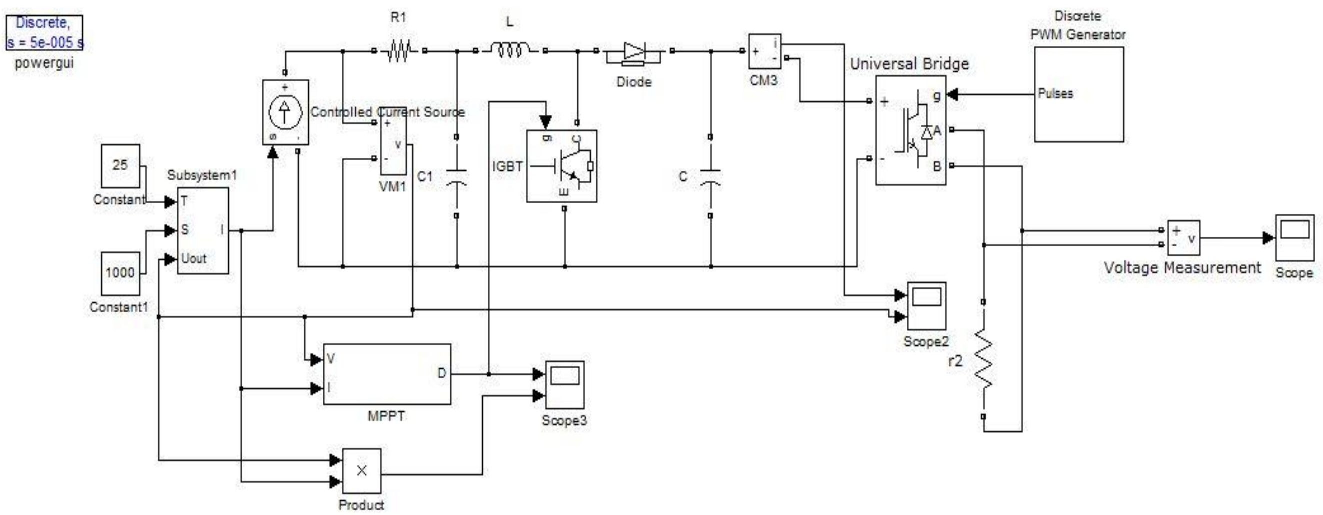


This figure shows the THD and harmonic spectrum of load voltage.

To compare the results obtained from this system simple DC-AC inverter is used with PV module.



This figure shows the THD and harmonic spectrum of load voltage.

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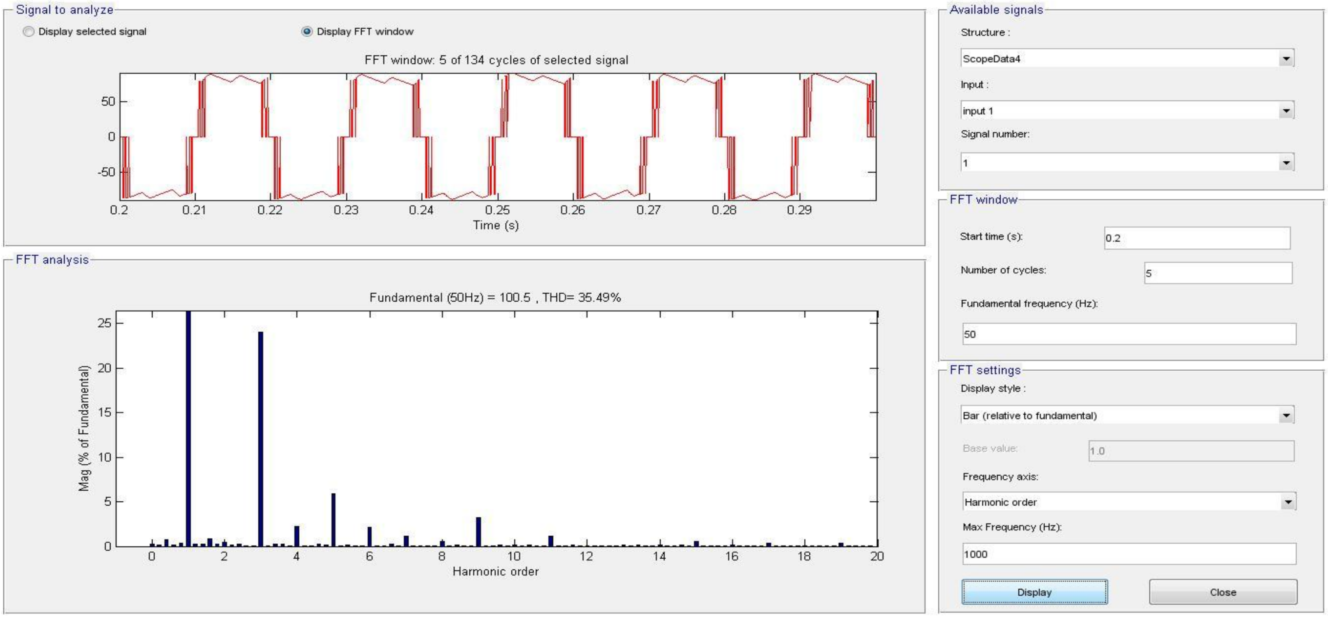
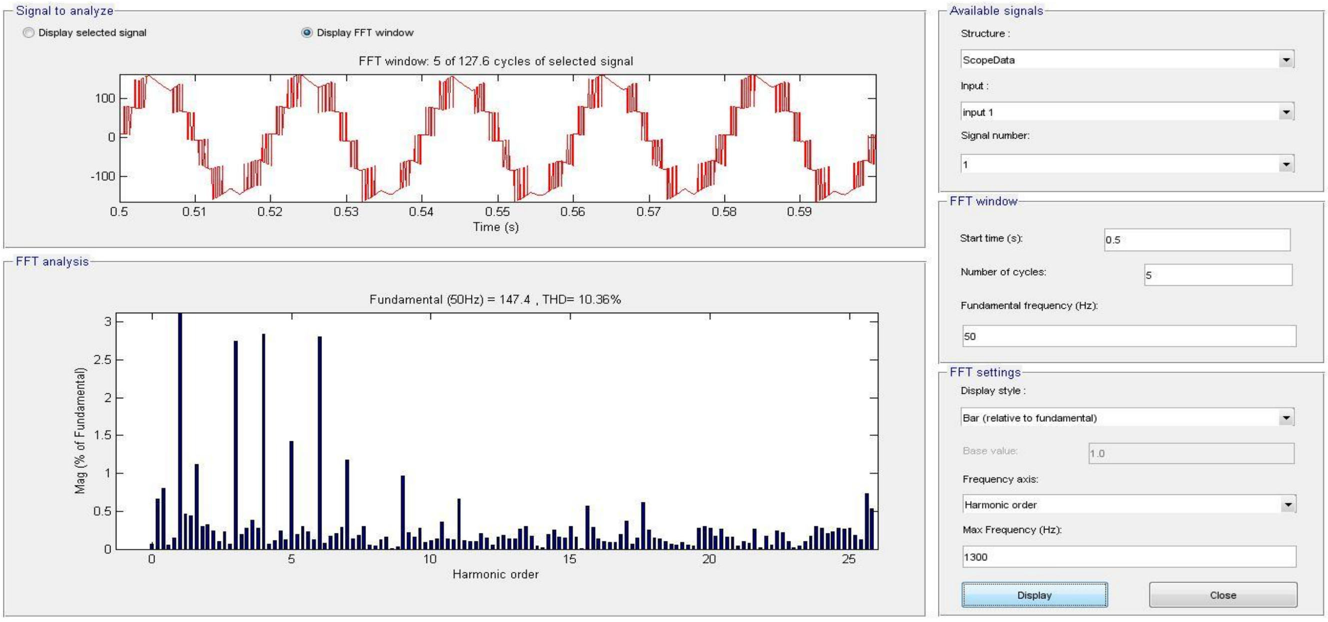


So, from the comparison it is clearly noted that total harmonic distortion gets reduced drastically.
Now if the system is investigated with R-L load then the THD changes but it depends on the value of inductance. Fundamental component also gets increased.



If the value of Inductance will increase then THD will be decreased and Fundamental component also gets increased. To show this phenomena the value of inductance will be increased and the result is plotted in the next plot.

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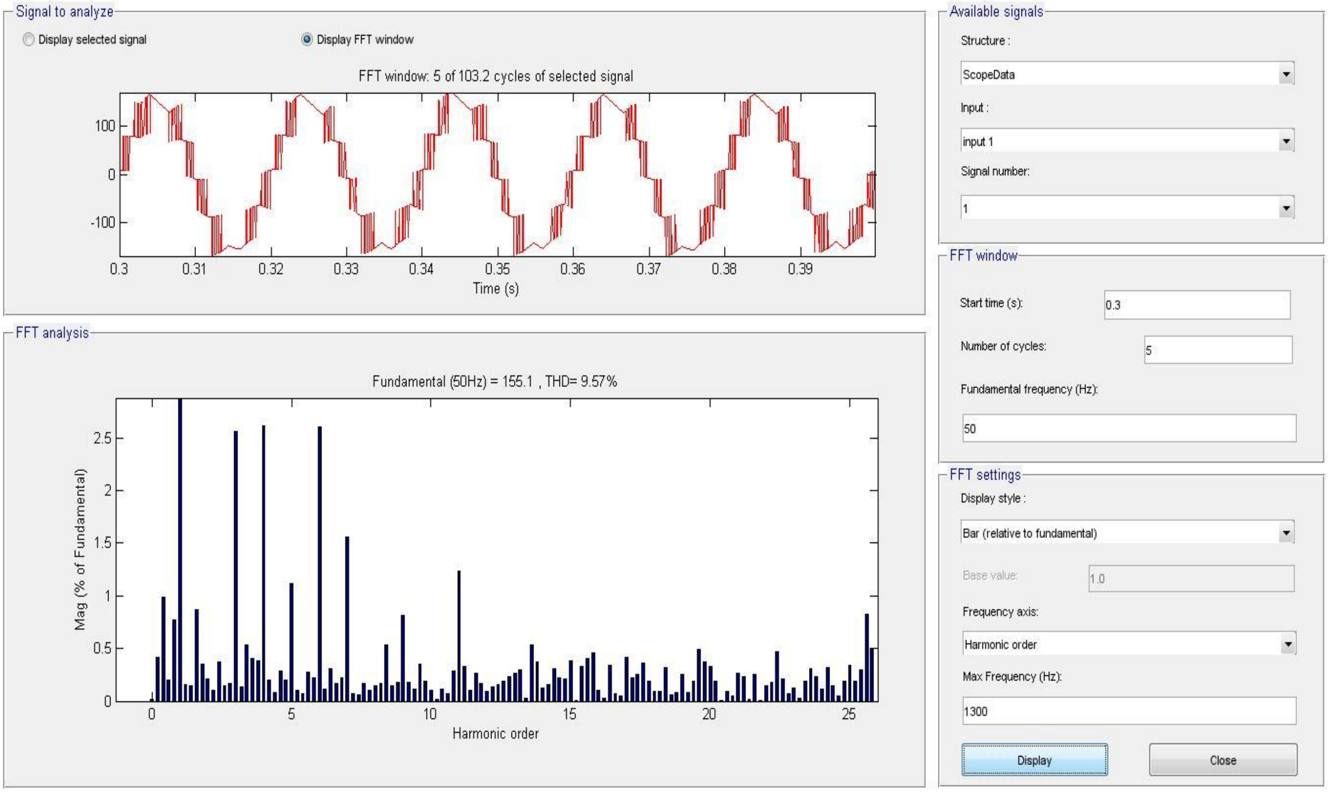

The switching patterns adopted are applied at the cascaded multilevel inverter switches to generate five output voltage levels at 0.9 modulation index. The THD of inverter output voltage and Harmonic spectrum of the simulation system is as shown in the figure.

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