PERFORMANCE ENHANCEMENT OF SOLAR PHOTO VOLTAIC SYSTEM USING ISOLATED SEPIC CONVERTER AND MULTILEVEL INVERTER

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Abstract:

Non conventional power is booming, as innovation brings down costs and starts to deliver on the promise of a clean energy future. This paper focuses on to increase efficiency and reduce the cost of photovoltaic grid connected systems. Normally in the existing model, hybrid power converters with integrate different power sources are used. This paper is designed with SEPIC converters which provides non inverted output, low number of switching devices as they are connected in cascaded H-bridge structure, multilevel inverter which combine different power sources leading to low harmonic distortion even at high switching frequencies which are well suited for power generation in rural areas or isolated areas as well as grid connected system.In this paper, the performance has been enhanced for a solar photovoltaic through an isolated SEPIC converter and Multilevel Inverter. Simulation and hardware results also shown reduction in harmonic distortionto enhance the performance of Solar PV.

Keywords: Solar Energy, Photovoltaic, SEPIC converter, Multi Inverter, Total harmonic distortion.

I. INTRODUCTION

Renewable energy resources are resources which can be renewed or replenished by the nature itself. The renewable energy resources are classified into three types: Direct solar energy resources, Indirect solar energy resources, Non solar energy resources. Direct solar energy resources involves direct use of solar energy which includes solar photovoltaic and solar thermal. Indirect solar energy involves indirect use of solar energy which includes wind energy, bio energy etc.,[1-3]. Non solar energy resources does not involve the solar energy in it. Ex: Geothermal energy, Tidal energy. By the endof.September 2019, India has introduced in excess of.82,580 M W.of.sustainable power source limit with around.31,150 MW.of.limit under different phases of.installation. India's expanding endeavors for extending the portion of sustainable power source has prompted a generous increment in solar power generation in the past few years [6-9]. The solar industry in India has colossal

possibilities to develop as the creation of solar energy in the nation is at a high rate because of various components and topographical area in the tropics being one of them. Ongoing reports uncovered that India gets yearly radiation of in excess of 5000 trillion kWh, which if potentially grasped by the solar energy organizations in India, will create a liberal measure of energy. Solar

Photovoltaics is the eminent technology which is widely being use. Various circuit topologies can implement the switching mode DC / DC converters. Among them are the buck, boost , buck-boost, Cuk, and SEPIC (Single-Ended Primary Inductor Converter) converters which are mostly used depending on power conversion system requirements. In recent years step up or down DC-DC converters have become common in applications where the voltage of the battery may be above or below the voltage of the regulator output. Nowadays, DC/DC converters are widely used in industrial applications and renewable energy systems. A SEPIC (single-ended primary inductance converter) DC-DC converter is capable of operating in either step-up or step-down mode and commonly used in a battery charger system. SEPIC converter is capable of producing output voltage greater than, less than or equal to the input voltage. Due to its various advantages such as non-inverting output, easy-to-drive switch, low input current pulsation, it is desirable and necessary to accurately monitor the maximum power point application for photovoltaic systems and minimize EMI.

This paper presents the modeling of the SEPIC converter in MATLAB/Simulink environment. The obtained SEPIC model was simulated for different input parameters, and hardware results have been compared.The FFT analysis done to calculate the harmonic distortion shows a reduced THD of 13.22 % with minimum number of switches for the proposed system

II. PROPOSED SYSTEM

It is designed with SEPIC converters which provides non inverted output, low number of switching devices. It consists of cascaded H-bridge multilevel inverter has various advantages such as reduced number of switches, low harmonic distortion of output voltage for higher switching frequencies. It also reduce the circuit complexity and cost is economical [18]. Addition of isolation transformeralso reduce power surges, provide direct current power isolation and prevent the risk of electric shock. It is well suited for power generation rural areas or isolated area as well as grid connectedsystem.

A. COMPONENTS USED FOR PERFORMANCE ENHANCEMENT:

- ✓ Solarpanel
- ✓ Isolated SEPICConverter
- ✓ MOSFETswitches
- ✓ Multilevelinverter
- ✓ CRO
- ✓ Total harmonic distortionanalyzer
- ✓ Simulink forsoftware

B. Solarmodule:

The term solar panel is a photovoltaic module. It is an assembly of photovoltaic cells endorsed in frame work for establishment. PV cells convert lightenergy from sun to electrical energy. PV modules-->PV panel-->PV array-->Electrical device. Commonly solar energy is used in agricultural for water heating. The conversion of light energy into electrical power is done by modules using photovoltaic effect. There is usage of another structural modules- Thin film, which can be used as either top layer or back layer supported by a shield for protecting it from physical harm and moisture. Some modules are inflexible, partially adaptable.

Fig. 1. Solar modules arrangement

The cells are arranged in series to get an fixed voltage and in parallel to increase the capacity. The scientific result of the voltage and current gives total power of the system. PV intersection box is attached to the solar panel functioning as its output interface. To make the External connection simple MC4 connectors or sometimes USB power interface can be implemented. A USB power interface can likewise be utilized. Modules are arranged in such a way to give an ideal output voltage and to have ideal current capability of the solar panel. The conducting wires made of silver, copper, or non attractive conductive metals are used to carry the current from module. Diodes can be utilized,in case of partial shading, to expand the output of module areas despite everything lit up. Some exceptional solar based PV modules incorporate concentrators in which light is engaged by focal points or mirrors onto smaller cells. This empowers the utilization of cells with a significant expense for every unit area in a cost effective way. Racking parts, sections, reflectors, troughs are used to increase the efficiency of solarpanel.

C. Converter:

A buck boost converter is a DC to DC power converter in which the magnitude of output voltage is either greater than or less than the magnitude of input voltage .Similar to fly back converter which

uses single inductor instead of atransformer.

There are two modes in this converter:
1.Continuous conduction mode 2.Discontinous conduction mode

1. Continuous conductionmode:
Here the current from end to end of inductor never goes zero. So inductor partially discharges before the switching cycle.

2. Discontinuous conductionmode:
Here the current through inductor becomes zero. So inductor totally discharges at the end of switching cycles.

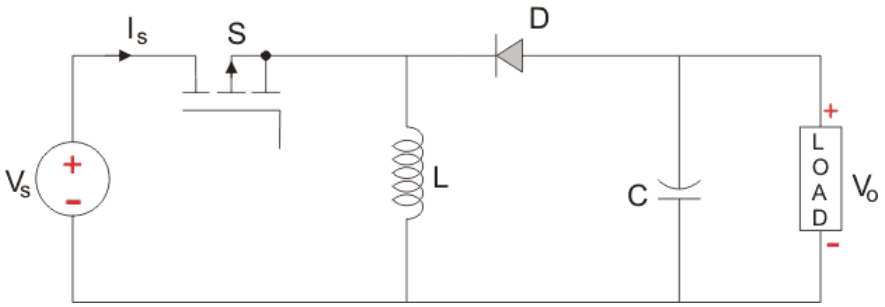

Fig.2 Buck Boost converter

D. Isolated SEPICConverter:

The single inductor primary inductor converter(SEPIC) is likely DC to DC converter which converts lower input potential into higher potential [15,17]. Based on duty cycle of the switch the output of the converter is constrained. In addition to boost converter principle it follows inverted buck boost converter method in order to provide non inverted output.

Duty cycle of SEPIC converter is related to output voltage which is given by

Vout= Vin*D/(1-D)
Where; Vout=SEPIC converter output voltage Vin=PV panel input voltage; D=duty ratio of the switch

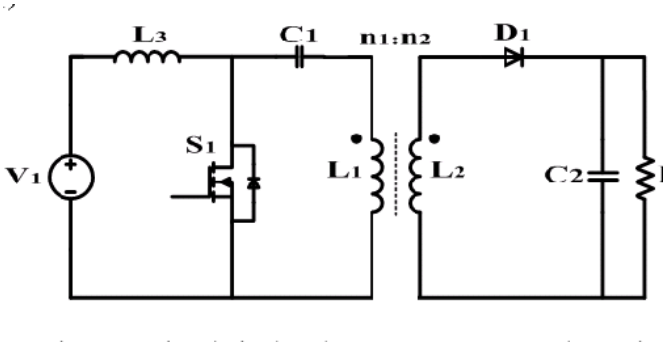

Fig.3. Isolated SEPIC Converter

The circuit diagram of Isolated SEPIC converter based multilevel inverter standalone photovoltaic system is represented below.

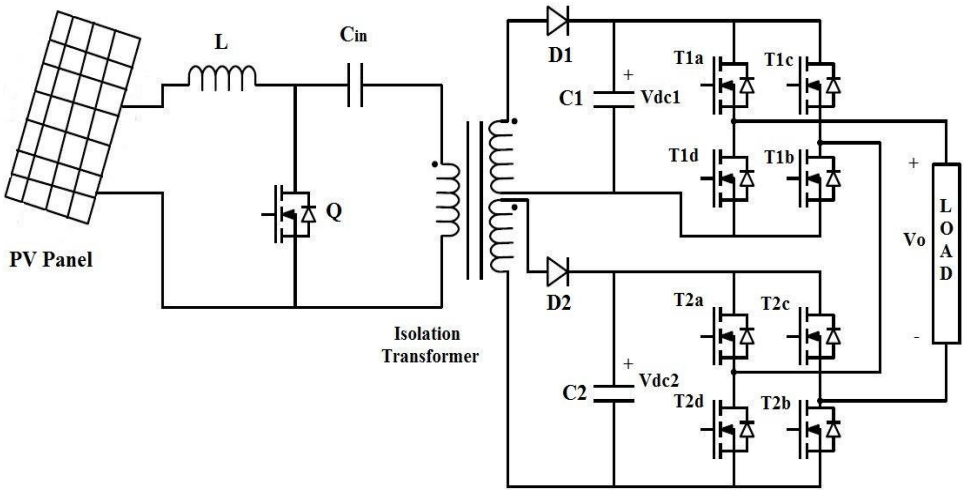

Fig.4. Proposed model for performance enhancement

The input source is provided the solar panel which provides a DC input source.This low input voltage source is not suitable to run the resistive load in thissystem.Therefore the low input voltage is boosted into high DC voltage by isolated SEPIC converter.The reason to choose SEPIC converter is it provides non inverted output. Additionally with addition of isolated SEPIC converter also reduces the risk of power surges and provides direct current powerisolation.Harmonic value is recorded across the converter with the help of THDmeter.The boosted DC voltage is converted into AC voltage with the help of inverter. Here cascaded H-bridge multilevel inverter is selected because it has various advantages such as reduced number of switched, low harmonic distortion of output voltage even at high switchingfrequency.The output from the multilevel inverter is used as input to the resistive load torun.Now the harmonic value is recorded across the load and it is found that the harmonic value is reduced. This is due to use of multileveled inverter which provides low harmonic distortion output even at high switchingfrequency.Thus the harmonic reduction within the system is achieved and expected results are obtained in waveforms with the help of CRO.

III. RESULTS AND DISCUSSIONS

From results obtained from both software and hardware it is clear that the output is multileveled with minimum number switching devices. There is reduction in harmonic distortion due to the usage of SEPIC converter and multileveled inverter. The FFT analysis is done to calculate the harmonic distortion and THD of 13.22 % is obtained. Fig 5 indicates the Simulink model for the proposed system.

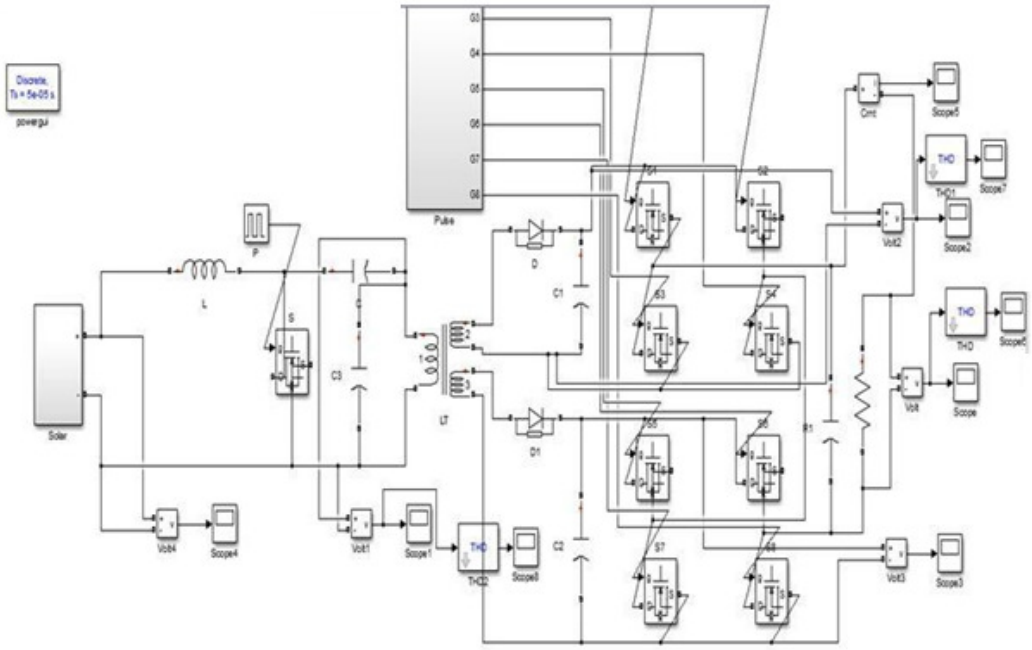

Fig.5. Simulink model of proposed system

A. Solar inputvoltage:

Initially the input voltage for solar is 20V DC and the Fig.6 shows the same in varations.

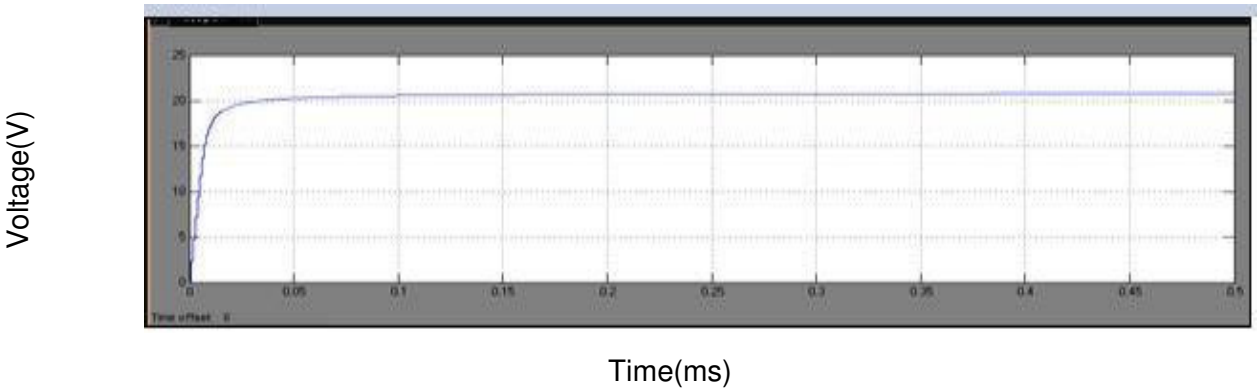

Fig.6. Solar input voltage waveform

B. I-V Plot:

The drooping characteristics of Current Vs Voltage is shown in the fig.7 which speaks when the voltage increases due to power rating of the panel, the current produces in the panel will starts to decline.

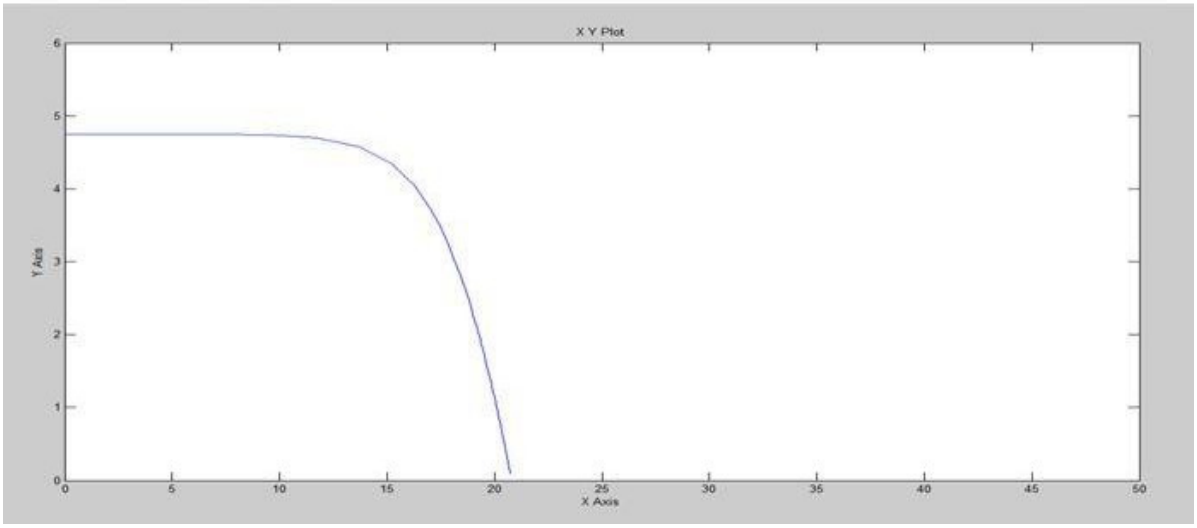

Fig.7. I-V plot of solar panel

C. P-V Plot:

Fig. 8 shows the Power Vs Voltage plot of the panel varied at differentlevels.

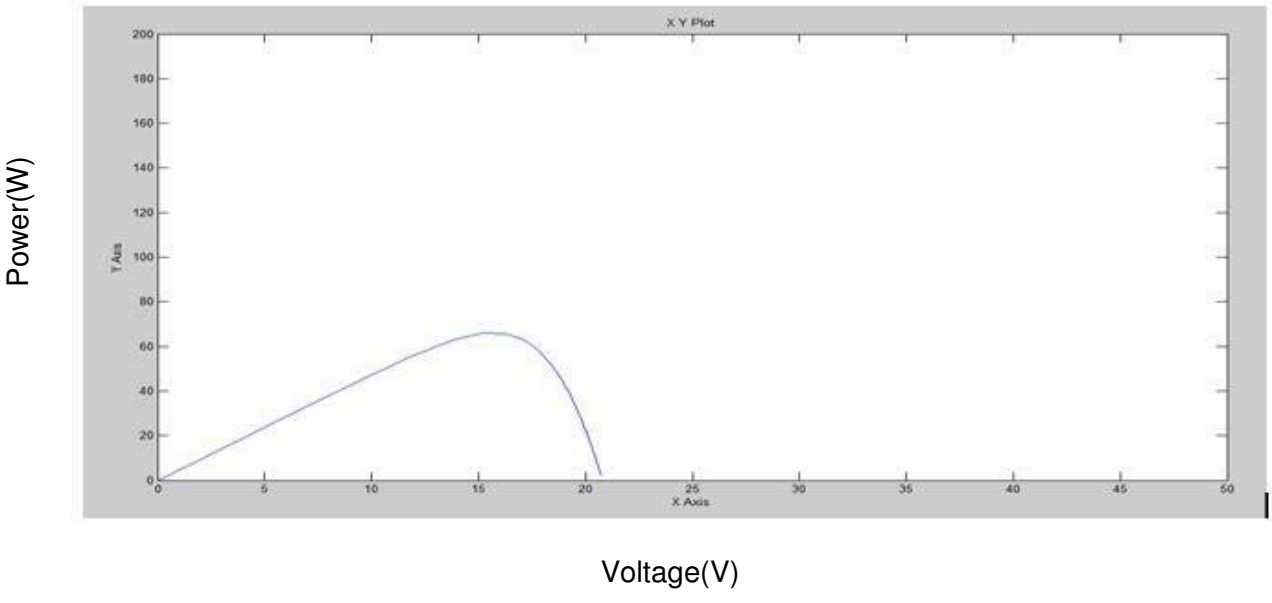

Fig 8. P-V Plot of solar panel

D. Outputvoltage:

Fig.9 represents the multi level inverter output voltage for enhancing the performance of solar PV panel.

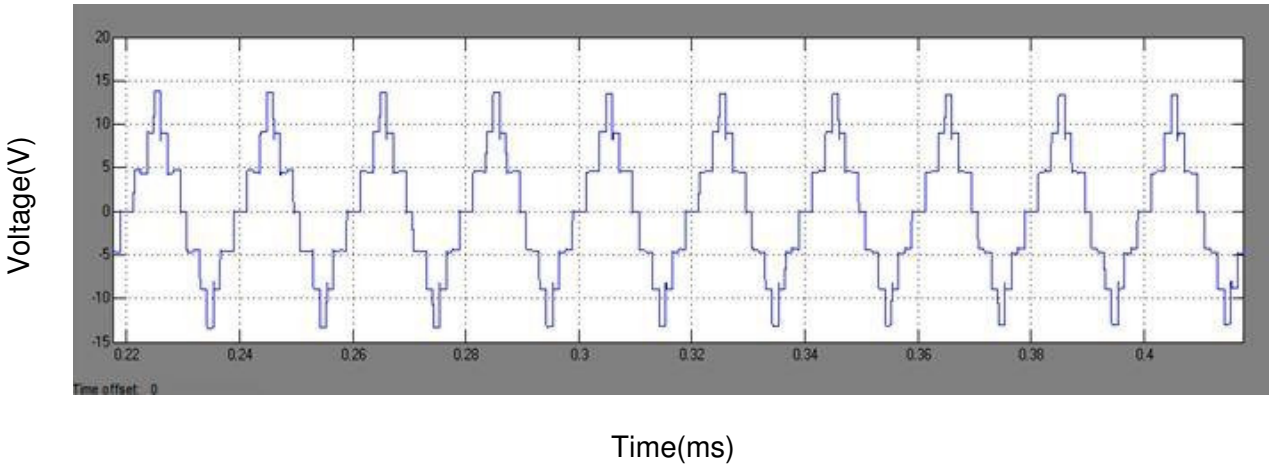

Fig. 9 Inverted Output voltage of 14.28V

E. Graph from THD before inverter connection:

Fig.10 shows the peak and fluctuated THD level of an inverter before it is connected with the panel.

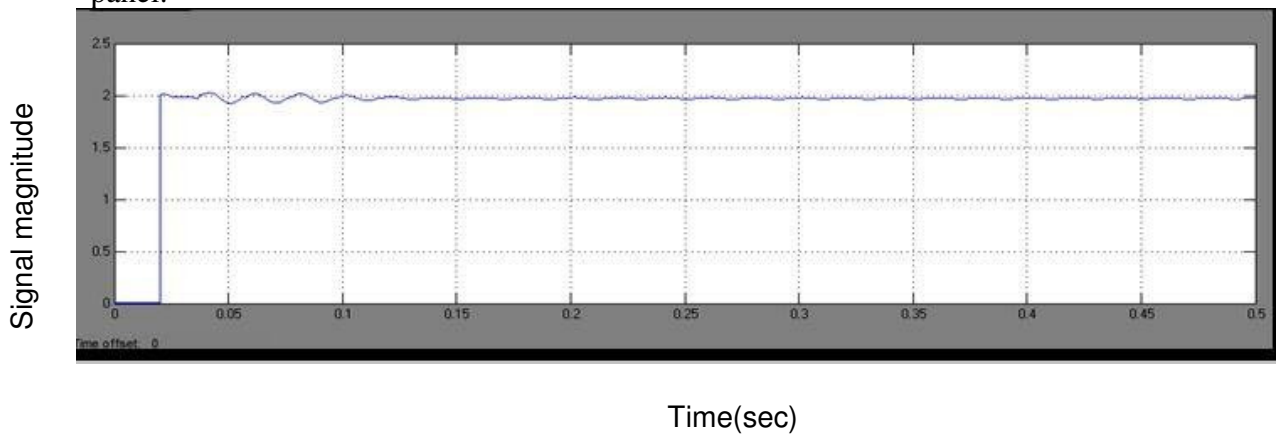

Fig 10. Graph from THD before inverter connection

F. Graph from THD after inverter connection:

Fig.11 shows the reduced THD levels of an inverter when it is connected to the solar panel.

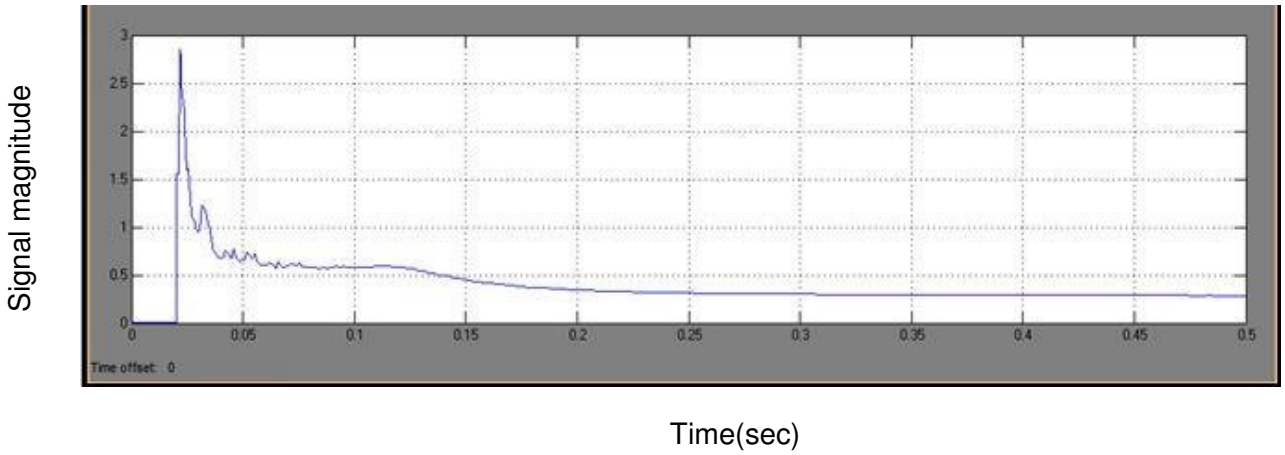

Fig 11. Graph from THD after inverter connection

G. Frequency spectrum of output voltage:

As when the resistive load introduces to the circuit, the enormous peak overshoot value of the spectral part appears which is normally produces increases in harmonics and it is shown in the fig.12

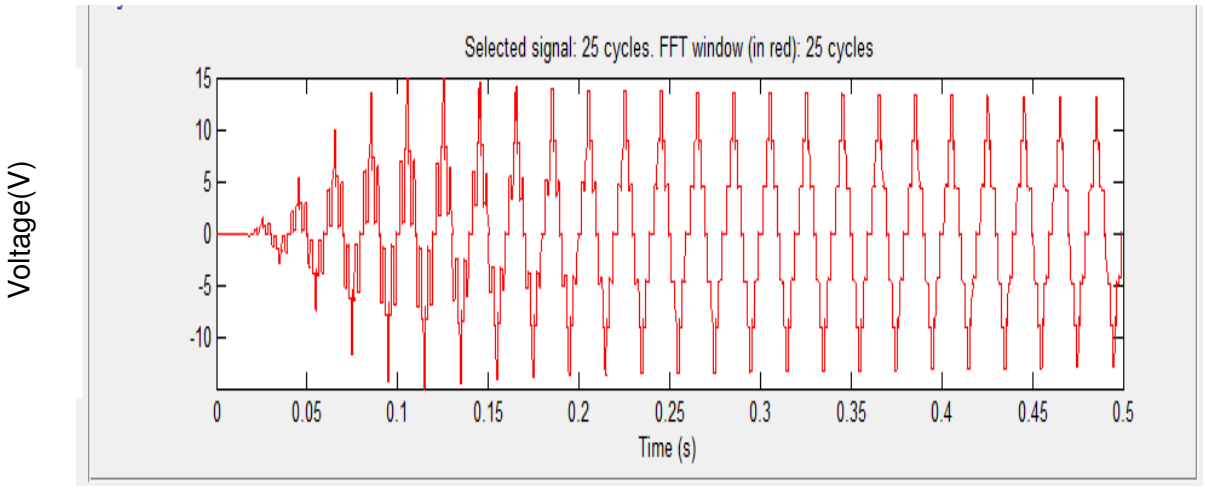

Fig 12. Inverted output of the resistive load

A reduce THD value is obtained at a nominal frequency and it is represented in the Fig.13

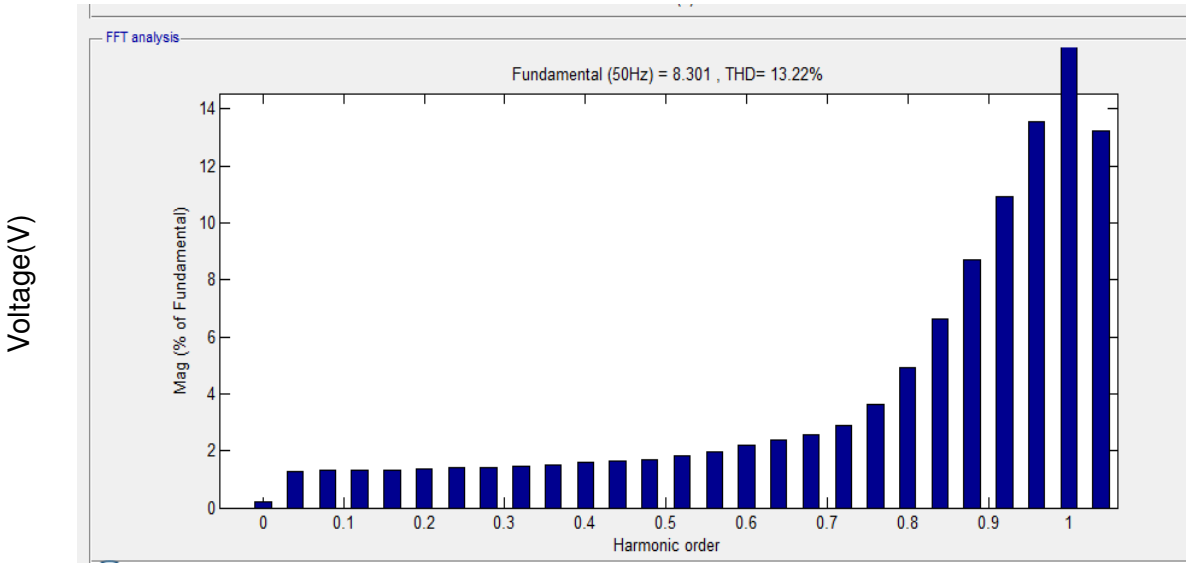

Fig. 13.THD value of 13.22% at fundamental frequency of 50Hz is obtained

H. Hardware model of proposed system

The below Fig.14 and Fig.15 represents the hardware snapshot and the output voltage of the solar panel.

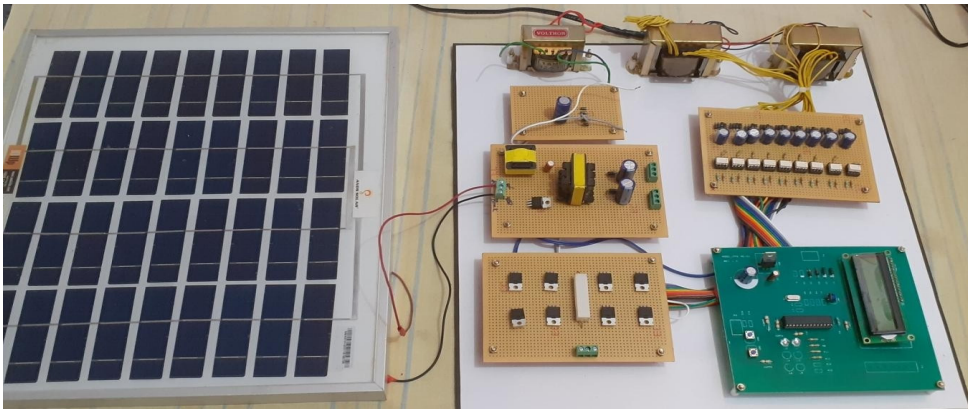

Fig.14. Hardware model of proposed system

I. Inverted outputvoltage:

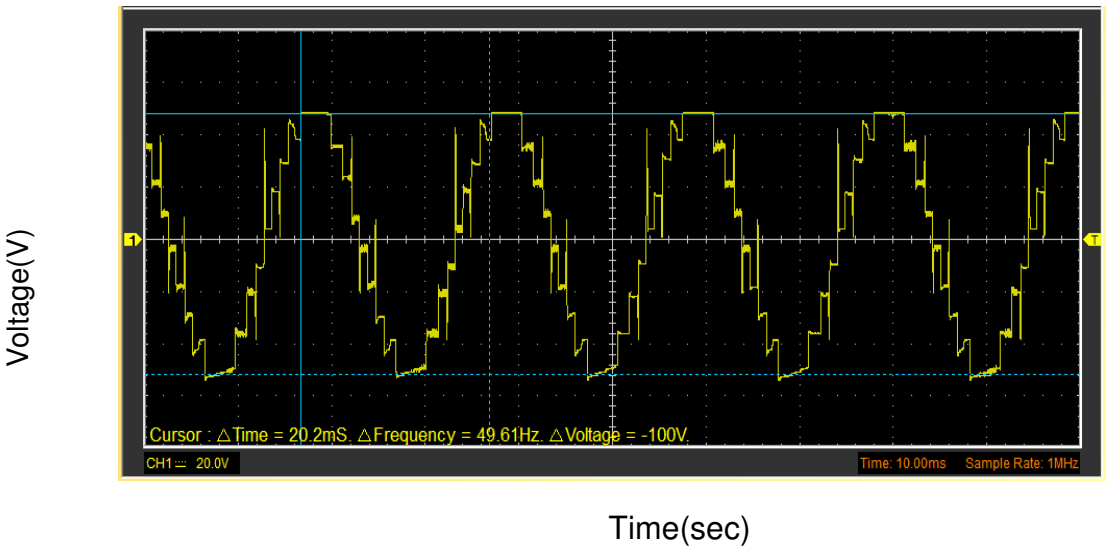

Fig 15. Inverted output voltage obtained from hardware

CONCLUSION

Solar energy usage is being increased due to the pollution free and abundant nature of it and the model designed based on PV system applications has some shortcomings like less efficiency, high harmonic distortion, high losses etc.,.Isolated SEPIC converter and multilevel inverter has been implemented in both software and hardware. By analyzing the results it is clear that the output obtained is multileveled with minimum number of switching devices leading to reduction in switching losses and cost .There is a reduction in harmonic distortion which is obtained from FFT analyzer. Thus with minimum switching devices simple construction and better efficiency is achieved.

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