

Simulation of Three Phase Nine-level Inverter for Interfacing with Solar PV system

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ABSTRACT: The proposed model of photovoltaic (PV) system has a interconnected network of PV modules in which several series and parallel combinations of solar cells are present. The DC output of the PV system is need to converted into AC because of the whole power system network and the grid system is three phase AC supply, so this operation is performed with three phase nine-level diode clamped multilevel inverter(DC-MLI) which was the major equipment is known as heart of the system. As the total no. of levels of inverter system increased to nine, the stair case output of DC-MLI has less harmonic content with reduced THD up to 8.33% by placing a high pass filter at inverter output end the THD was reduced to 1.81%. Nine-level DC-MLI has an advantagein improving sinusoidal nature and power system stability of grid network.

I. INTRODUCTION

In present era the awareness about renewable energy sources (RES) raised a lot [3], because of their non-degradation, friendly nature about eco-system and independent characteristics [1][11]. The major concern about fossil fuels is their nature of degradation, exhaustible and causes for global warming and imbalance in eco-system, these impacting situations creates interest for developing and increasing the generation of electricity with the RES inputs. Res meats power demand for increasing load demand in future aspects [4]. RES have a capability to become a major potential scope in mobile technological applications where there is need of electricity and these RES are cost free, having cleanliness nature and sustainability [5].

At present days the various sources used for electricity generation in RES perspective are solar, wind, geo-thermal and tidal etc.,in those solar energy us one of the great choice for meeting future power demand because of its adverse nature of conversion of solar energy into electrical energy.

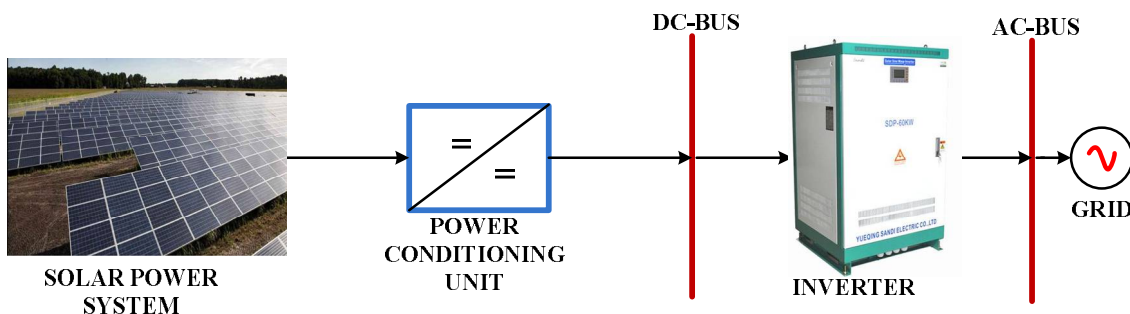


Fig.1: Solar system integrated grid.

The solar system has photo voltaic (PV) modules interconnected network in which series and parallel combinations of PV cells are present. The composite material used in PV cell manufacturing is silicon. In order to increase the power rating of the solar system there is a need of increasing the no PV cells in the system. We all know that the output of solar system is DC. For integrating PV system with grid system the PV output is need to be converted into AC, which is done by means of an interfacing medium, multi level inverter (MLI) which is a heart of the system. MLI is used in place of conventional two level VSI for getting greater stability and improved sinusoidal nature with

lower harmonic content in the output waveform. Multi level concept was come into practice due to advancement in power electronics. The proposed solar system integrated to grid is shown in fig.1.

II. PROPOSED SYSTEM IMPLEMENTATION

PV system:

The proposed system consists of array of seven PV modules which are connected in parallel. Each PV module has 32 solar cells connected in series [6]. The total output of PV system is given as input to the DC-MLI. The proposed model of PV module is implemented as shown in fig.2

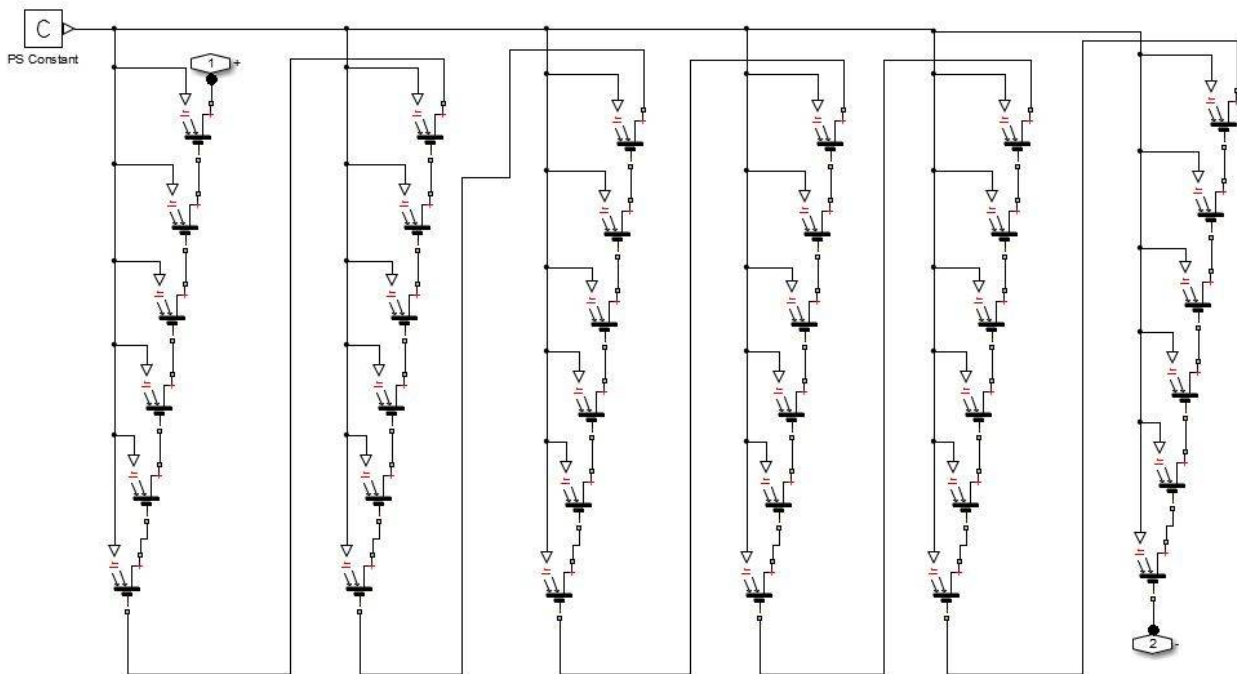


Fig.2: implemented diagram of PV module in SIMULINK.

The block diagram of solar system implemented in MATLAB is shown in fig.3

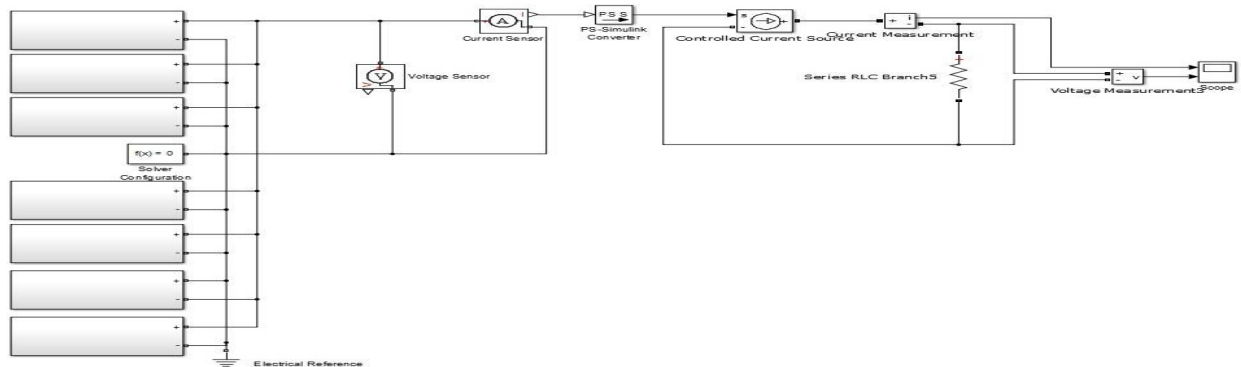


Fig.3: Block diagram of solar system implemented in MATLAB.

Nine-level DC-MLI:

At present there three main topologies used in MLI they are:

- Diode clamped MLI (DC-MLI)
- Cascaded H-bridge MLI (CH-MLI)
- Flying capacitor MLI (FC-MLI)

In the above topologies the proposed inverter system is implemented with DC-MLI structure. In nine –level DC-MLI there are n-1 (8) capacitors at input stage in order to provide constant [1], stable DC input, 56 clamping diodes for clamping the voltage across capacitors in accordance with each switching state, 2(n-1) main switches i.e. total 16 switches per leg are present[2]. The implemented diagram of nine-level DC-MLI is shown in fig.4.

Diode Clamped Nine-Level Inverter

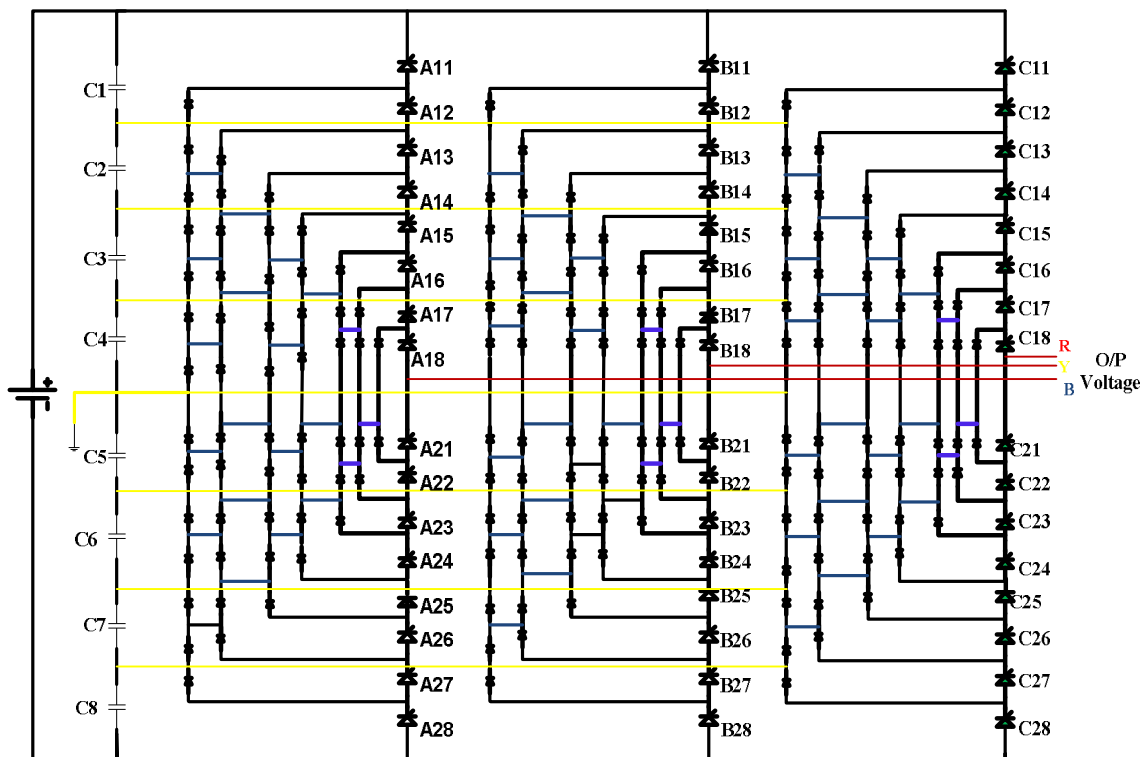


Fig.4: Three phase nine-level DC-MLI structural diagram.

III. CONTROL STRATEGY

AS the switches used in DC-MLI are forced commutated so these switches are controlled by sending PWM output pulses to each switch in regular intervals of time [2]. The PWM technique used in this proposed system is level shifted sinusoidal PWM in which sine wave is modulated wave and triangular wave is carrier wave and it is implemented as shown in fig.5

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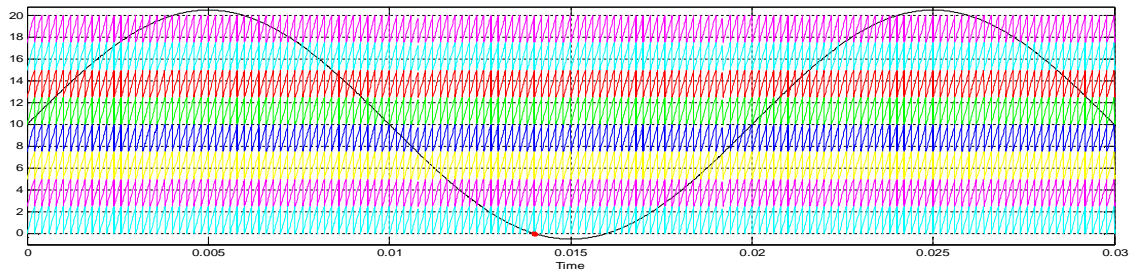


Fig.5: level shifted sinusoidal PWM technique for DC-MLI switching.

The operation of DC-MLI is performed for each switching state in accordance with switching table shown in fig.6.

switches Voltage	A_{11}	A_{12}	A_{13}	A_{14}	A_{15}	A_{16}	A_{17}	A_{18}	A_{21}	A_{22}	A_{23}	A_{24}	A_{25}	A_{26}	A_{27}	A_{28}
$V_9 = V_{dc}$	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0
$V_8 = \frac{7V_{dc}}{8}$	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0
$V_7 = \frac{3V_{dc}}{4}$	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0
$V_6 = \frac{5V_{dc}}{8}$	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0
$V_5 = \frac{V_{dc}}{2}$	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0
$V_4 = \frac{3V_{dc}}{8}$	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0
$V_3 = \frac{V_{dc}}{4}$	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0
$V_2 = \frac{V_{dc}}{8}$	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0
$V_1 = 0$	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1

Fig.6: Switching table of the nine-level DC-MLI.

Results:

The output voltage, current and power waveforms are shown in fig.7 and fig.8 respectively. It was observed that the output voltage, current and power of solar system are 735V, 37.67A, 27244.245W respectively.

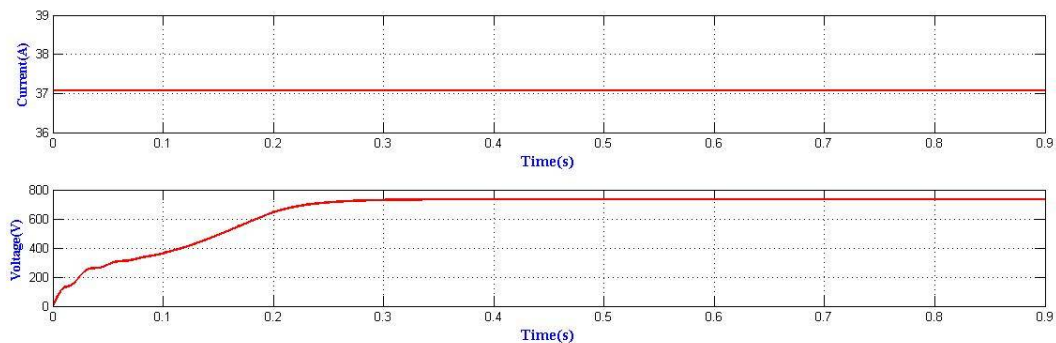


Fig.7: Output voltage and current waveforms of solar PV system.

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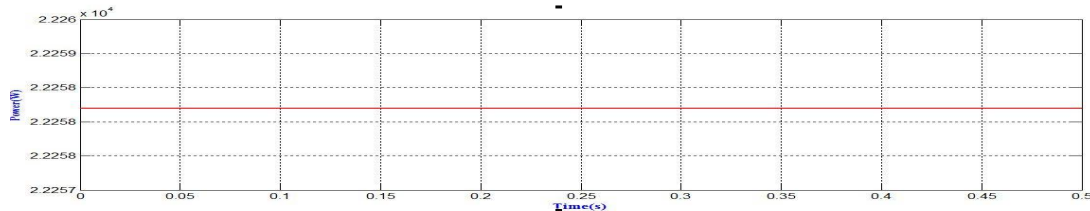


Fig.8: Output power of solar PV system.

The steady state line to line voltage output of the inverter in staircase form is shown in fig.9. The steady state line to line voltage output of the inverter at the end of the filter is shown in fig.10. The three phase output of inverter without and with filter is shown in Fig.11.

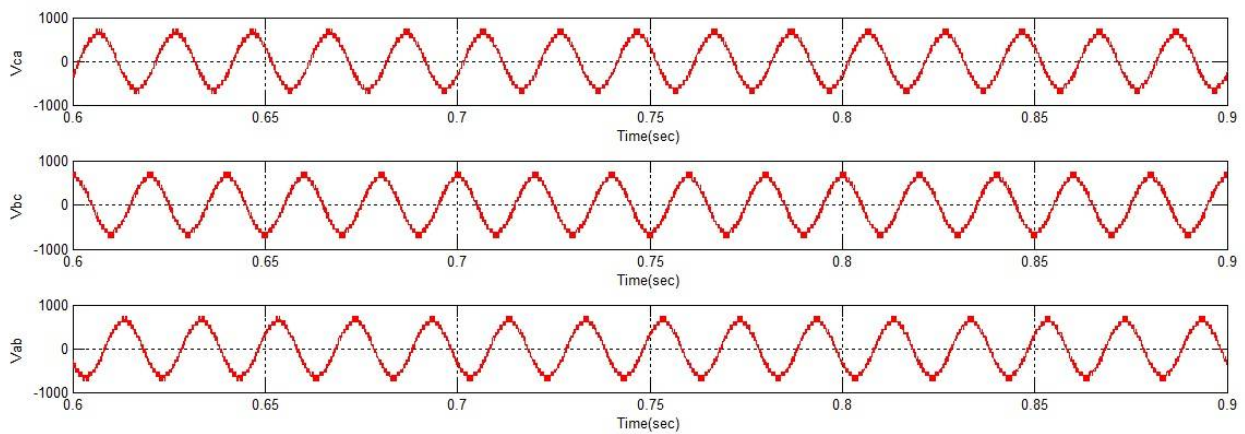


Fig.9: Steady state staircase output of inverter with nine levels.

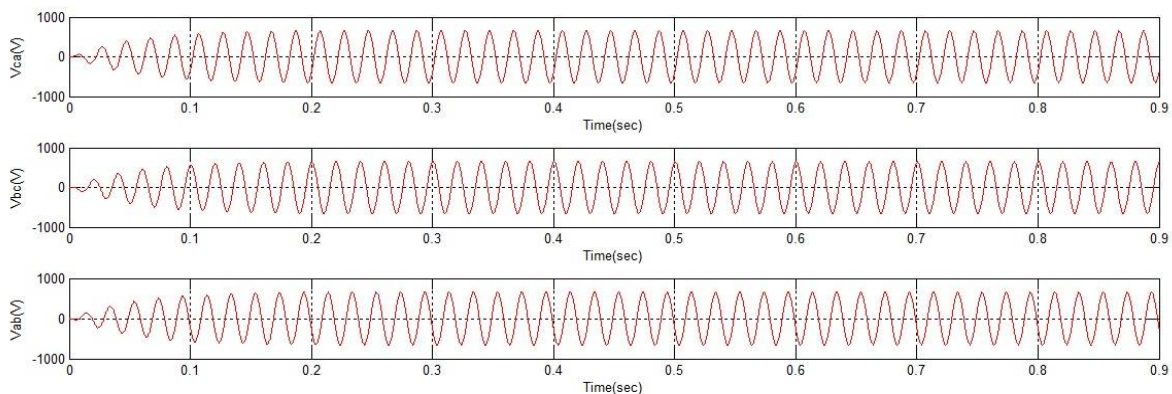


Fig.10: Line to line voltage output of inverter at the end of filter.

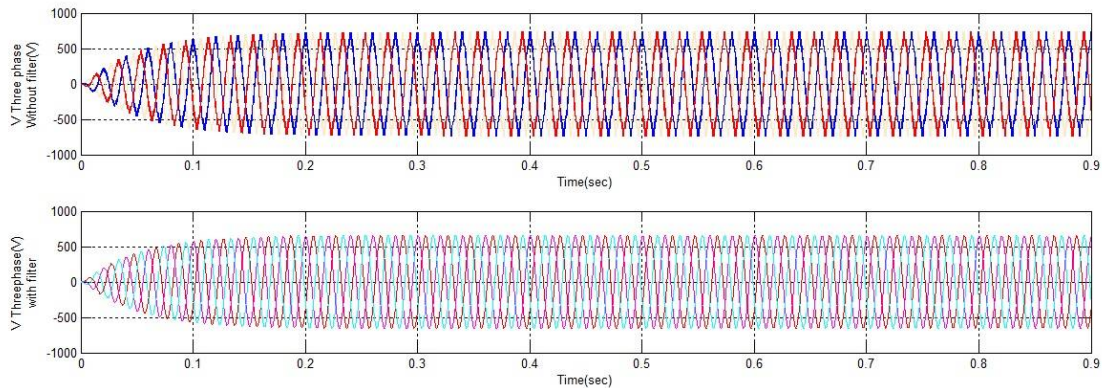


Fig.11: Three phase output of inverter without and with filter.

From the FFT analysis it is observed that as the inverter is implemented with nine-level DC-MLI topology the THD was reduced to 8.33% without filter and the THD was reduced to 1.81% with the help of filter placing at the end of inverter output ports which was shown in fig.3 and fig.14 respectively [1]. The inverter output at the end of filter after removing the harmonic content was shown in fig.12.

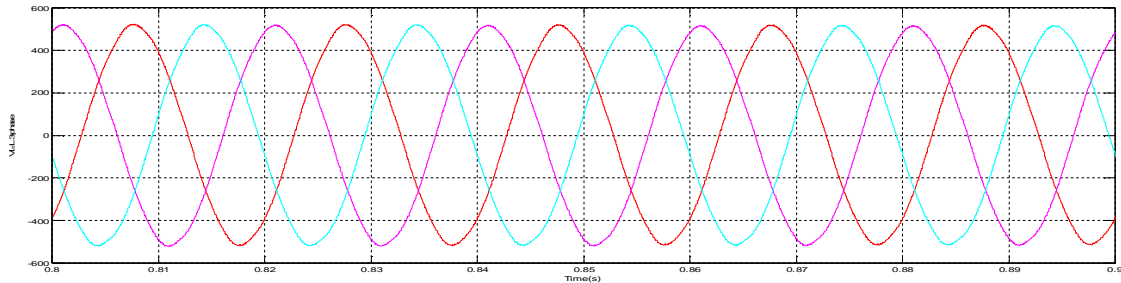


Fig.12: Inverter output connected to grid system.

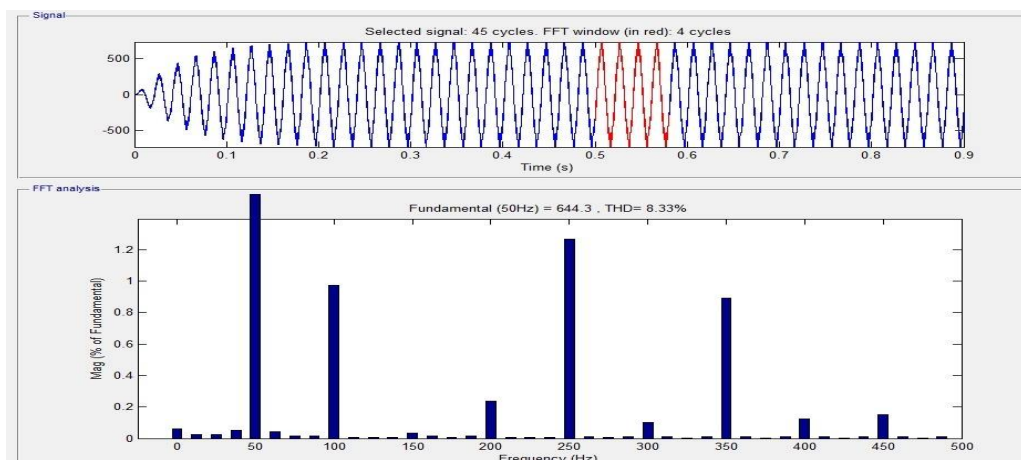


Fig.13: FFT analysis of inverter without filter.

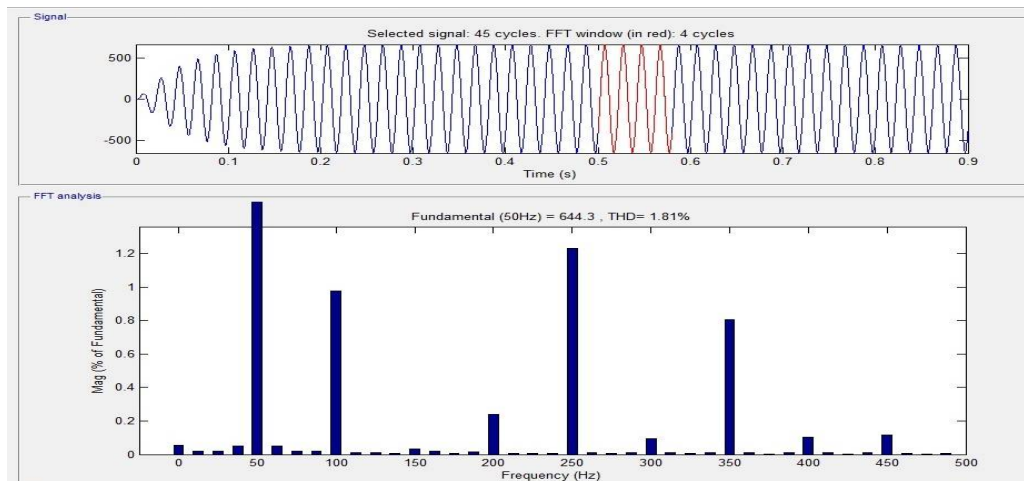


Fig.14:FFT analysis of inverter with filter.

IV. CONCLUSION

In this the proposed system has a solar PV system which was integrated to grid system with the use of interfacing medium i.e. nine-level DC-MLI which was the heart of the system. As the no. of levels in the inverter is increased to nine the harmonic content in the output waveform was reduced to 8.33% without placing filter and the THD was reduced to 1.81% by placing a filter at the end of inverter output terminals. As the no. of levels increased to nine the rating of devices are reduced with increased power and voltage and power rating.

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