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Design a Simulation of Multilevel Inverter for Reduction of Harmonics for Grid Connected PV System

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Abstract: ***The existing topologies, Multilevelinverters acts as a promising solution for medium voltage, high power applications due to their modularity and reduced voltage stress across the power switches. They are becoming popular due to reduced voltage stress of the power switches and low THD. Among thedifferent multilevel configurations, H bridge multi-level inverter (HB-MLI) is found to beattractive for grid connected PV applications. H Bridge Multilevel Inverters (HB-MLI) are being considered as the best choice for grid connected Photovoltaic (PV) systems since they require several sources on the DC side. By means of high-quality output with less harmonic distortion is obtained compared to a two-level inverter. Different levels of output viz. three level is examined and conclusions are drawn mainly based on the number of switches andTotal Harmonic Distortion (THD). The main advantages of the multilevel inverter are that the regulation of the DC buses is simple. More number of levels results in reduced THD and nearly sinusoidal output. Simulation is performed using Matlab/Simulink.***
Keywords: H Bridge Multilevel Inverter (HBMLI), Photovoltaic (PV), THD.

I. INTRODUCTION

Fossil fuels are the source of most energy forms such as coal, diesel, petrol, and gas that present 80% of energy production. The demand for energy is expected to rise by almost a half over the next two decades. Lack of electricity is one of the main difficulties in the development of rural areas in many countries. Global energy scenario is witnessing a fast surge in the energy. Reduction in the availability of fossil fuels and pollution envisage the wide spread utilization of renewable energy resources. Among them, solar electric- energy demand has grown consistently by 20%- 25% per annum over the past 20 years. The grid integration of PV systems is gaining prominence in many countries. The power scalability of photovoltaic system enables its large-scalepenetration. It ranges from few kilowatts of residential applications to several megawatts of grid connected applications.

Among the existing topologies, multilevel inverters are gaining prominence for grid-connected PV systems. They are becoming popular due to reduced voltage stress of the power switches and low THD. Among the different multilevel configurations, H-bridge multilevel inverter (HB- MLI) is found to be attractive for grid connected PV applications. More number of levels results in reduced THD and nearly sinusoidal output. Simulation is performed using Matlab/Simulink. The main advantages of the multilevel inverter are that the regulation of the DC buses is simple. One disadvantage of multilevel inverter is the large requirement of power semiconductor switches. Each switch requires associated gate drive circuits thereby increasing the circuit complexity. This paper presents a performance comparison of H bridge multilevel inverters. Different levels of output viz. two level, three level is examined and conclusions are drawn mainly based on the number of switches and Total Harmonic Distortion (THD).

II. TWO LEVEL HB-MLI

MATLAB-SIMULINK is used to perform the simulation. Simulation model of conventional H- bridge two level is shown in the Fig.2 . The Multilevel Inverter Topology is based on the series connection of single-phase inverters with separate dcsources such as PV panels. Fig. shows the power circuit for one phase leg of a two- l e v e l HB-MLI.

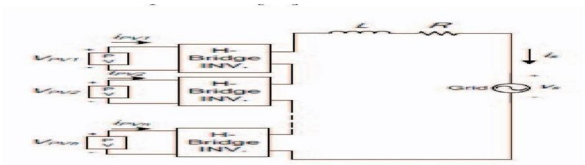

Fig. 1. Structure of a Cascaded H Bridge MLI for agrid connected PV system

Modular cascaded H-bridge multilevel inverters for single and three-phase grid-connected PV systems are shown in Fig.1. Each phase consists of n H- bridge converters connected in series, and the dc link of each H-bridge can be fed by a PV panel or a short string of PV panels. The cascaded multilevel inverter is connected to the grid through L filters, which are used to reduce the switching harmonics in the current. By different combinations of the four switches in each H-bridge module, three output voltage levels can be generated: −vdc, 0, or
+vdc. A cascaded multilevel inverter with n input sources will provide 2n + 1 levels to synthesize the ac output waveform. This (2n + 1)-level vltage waveform enables the reduction of harmonics in the synthesized current, reducing the size of the needed output filters. Multilevel inverters also have other advantages such as reduced voltage stresses on the semiconductor switches and having higher efficiency when compared to other converter topologies.

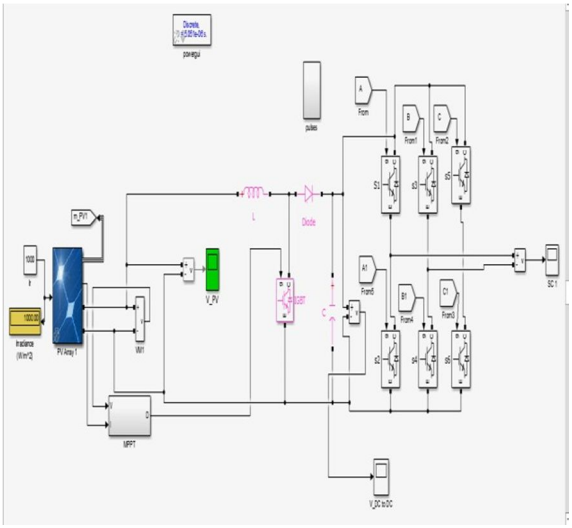

Fig.2 Simulation model of two-level H-bridge inverter

For this, the capacitors are connected sequentially to the ac side via the power switches. The output voltage is synthesized by the addition of the voltages generated by the different source. Even without much filtering, output exhibits a nearly sinusoidal.
Simulation parameters:
Vin=46 V,
Fundamental frequency = 60 Hz Max. frequency = 5 KHz, Modulation index, m = 0.77
No. of cycle = 3
WAVE FORM OF TWO-LEVEL H- BRIDGE INVERTER
MATLAB-SIMULINK is used to perform the simulation. Simulation output waveform of conventional cascade H-bridge two level inverter shown in fig. Output voltage waveform and THD analysis of two-level HB-MLI is shown in Fig.3 and Fig.4

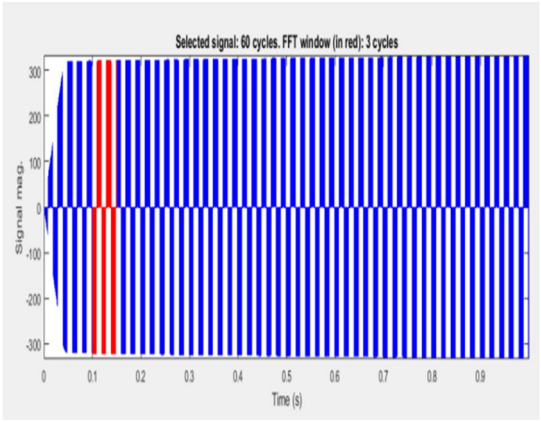

Fig.3 Output waveform of two- l e v e l HB-MLI

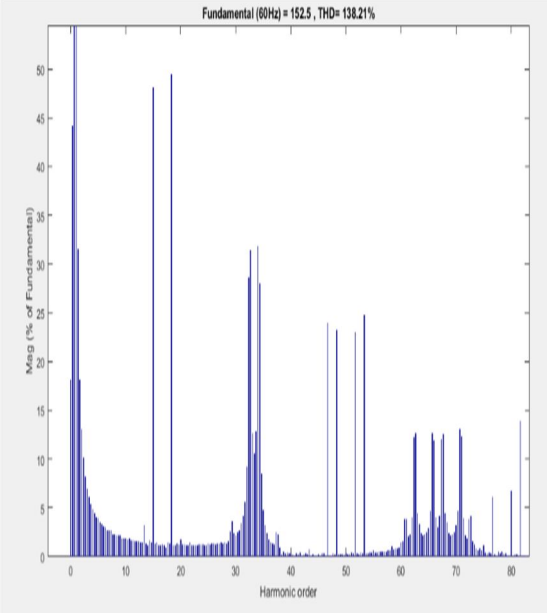

Fig.4 THD analysis of two- l e v e l HB-MLI

The different voltage levels are +320,0 and -320 with a THD of without filter in two level MLI value of 138.21 % and after including filter, THD will be also reduced.

III. THREE LEVEL HB-MLI

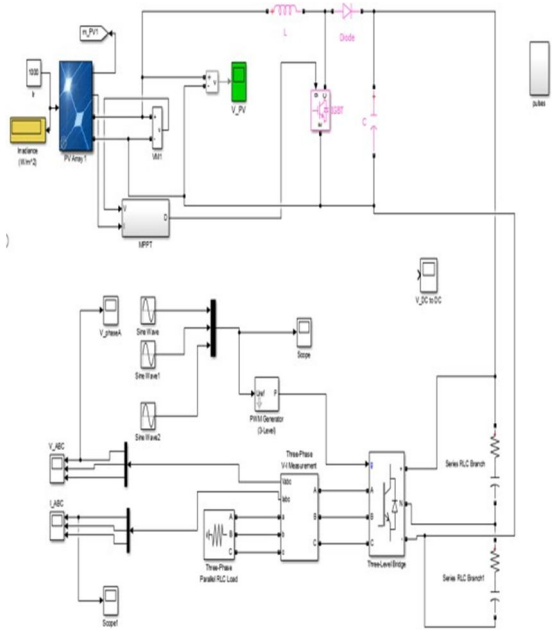

Fig.5 shows a three level H-bridge multilevel inverter.

Fig.5 Simulation model of three level H-bridgeinverter.

Simulation parameters:

Vin=46 V,

Fundamental frequency=50 HzMax. frequency =5 KHz, Modulation index, m=0.77

No. of cycle = 3

Waveforms of three level CHB-MLI

Output voltage waveform and THD analysis ofseven level CHB-MLI is shown in Fig.6 and Fig.7.

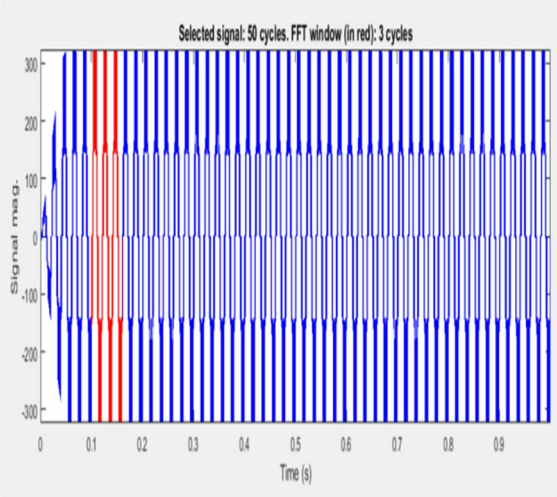

Fig.6 Output waveform of three level HB-MLI

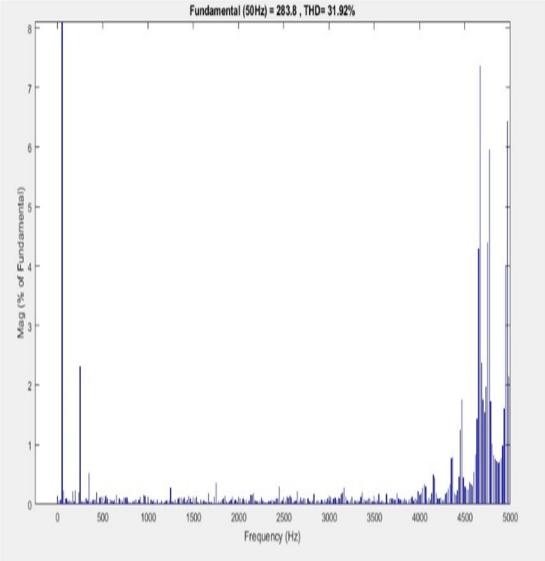

Fig.7 THD analysis of three level HB-MLI

In three level inverter, voltage levels obtained are
+320, 0, -320, with a THD value of without filterare 31.92 %.

IV. RESULTS

The simulation result obtained for different levels ofH bridge multilevel inverters used for grid connected PV applications gives in the following table.

No. of levels at the output	No. of switches	THD
Two level	four	138.21 %
Three level	six	31.92%

Following summary are occurs from the results:

1) The inverter output is approaching a puresinusoidal pattern as the number of levels is increased.
2) As the number of levels is increased, the total harmonic distortion (THD) is considerably reduced.
3) THD of a particular inverter is independent of the solar output voltage.
4) Hence it lacks the modularity required for H bridge multilevel inverter for PV application.
5) When the number of levels at the output increases, number of power electronic switches also increases.
6) Each switch requires a related gate drive circuit. Hence the overall system becomes more expensive and complex.

V. CONCLUSION

In H-bridge multilevel inverters are the most suitable inverter topologies for grid connected system. The comparison of two level and three level is performed.

It can conclude that from the result, if an increase the number of levels then the output improves its quality by a reduction in THD. The value of harmonic distortion varies from 138.21 % for a two-level HB-MLI to 31.92 % for a Seventeen level CHB-MLI. But the number of switches is increased thereby increasing the circuit complexity.

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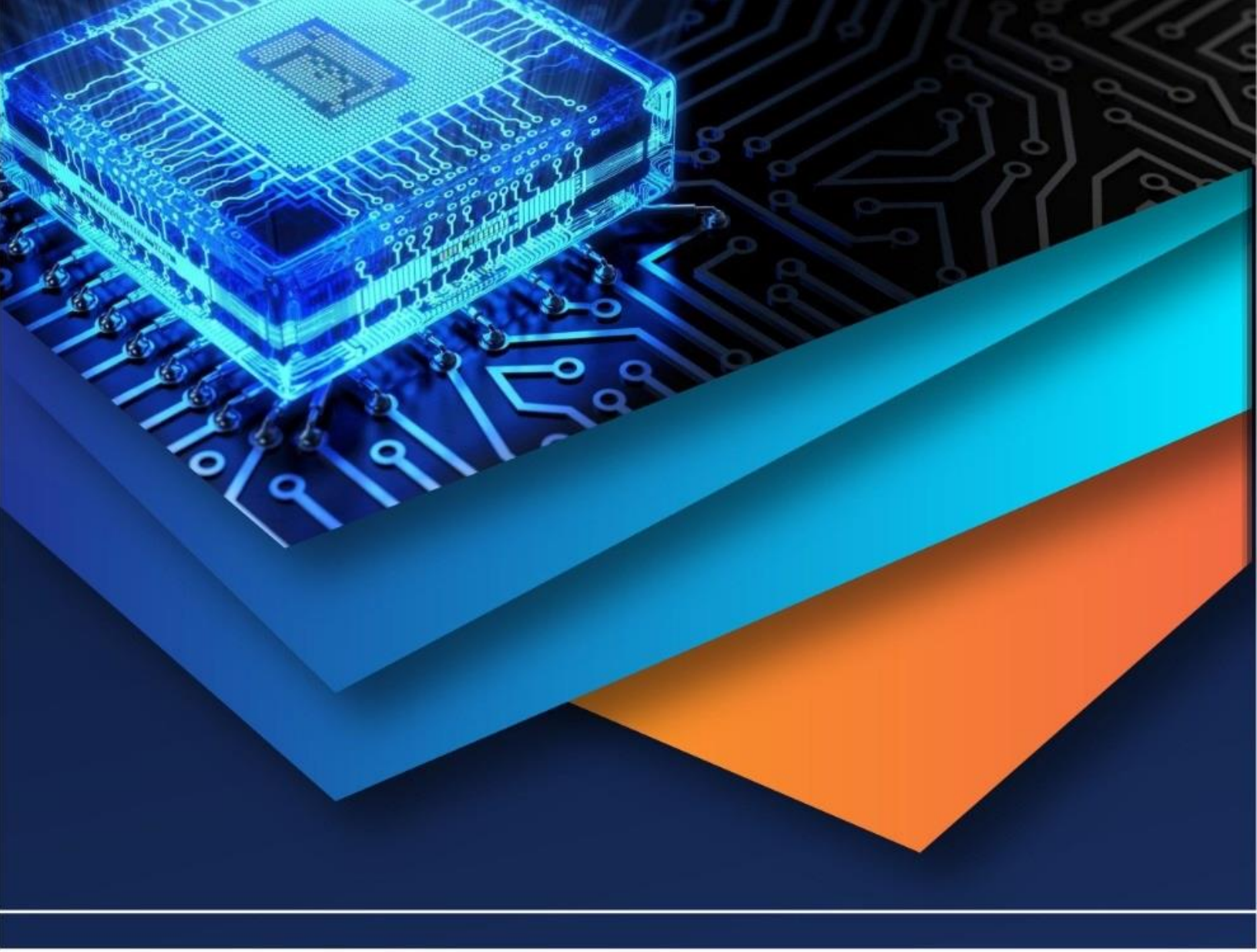

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