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Analysis of Cascaded Multilevel Inverters with Series Connection of H-Bridge in PV Grid

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Abstract: Multilevel inverter is recognized as an important alternative to two levels inverter for PV Grid. In multilevel inverter technique, the Voltage amplitude is increased and the stress on switching devices is reduced and the overall harmonics profile is improved. The general purpose of the multilevel inverter is to synthesize a nearly sinusoidal voltage from different levels of PV voltages. In Multilevel inverter harmonic distortion will decreases in Output voltage for PV grid. In this paper, we are designing cascaded multilevel inverter with series connection of H-bridge for dc to ac conversion in PV grid and it is done in MATLAB/SIMULINK.

Keywords: Multilevel Inverters, PWM (Pulse Width Modulation), Hormonics, Cascaded H-Bridge, Topolgy, Simulation.

I. INTRODUCTION

Multilevel inverters have been gaining considerable popularity in recent years. Multilevel inverters have very important development for medium voltage and high power applications due to their ability to synthesize waveforms with better harmonic spectrum .i.e it produces a staircase output voltage from PV Grid. It is refers to the multilevel inverters with output which have more than two voltage levels possible with respect to pole [1-3]. For higher applications, more switches can be connected in series in order to provide the desired voltage rating.

One of the most important problems in controlling a multilevel voltage source inverter is to obtain a variable amplitude and frequency sinusoidal output by employing different control techniques. Harmonic reduction can improve the performance of an inverter with any switching strategy. In this multilevel inverters, Pulse Width Modulation control schemes have been developed. Multilevel inverter has the advantages that the lower harmonic components on the output voltages can be eliminated.

The cascaded H-bridge can operate as symmetric or asymmetric Inverter. In asymmetric multilevel Inverter the DC voltage sources are proposed to be chosen as different value according to different methods. As compared to other inverter topologies, series cascaded multilevel inverter has the higher output Power level, voltage levels, and the higher reliability due to its modular topology and the simplicity and also it reduces the cost [5-7].

To develop the model of a cascaded multilevel inverter with series connection of H-bridge, a simulation is done based on PWM and MATLAB/SIMULINK platforms. Their integration makes the design and analysis of a H-bridge multilevel inverter more complete.

II. Cascaded Multilevel Inverters

Inverter is nothing but an electronic device or circuitry that changes dc into ac. The input, output voltage and frequency and overall power handling depend on the specific device. The Multilevel inverters will converter the Dc to Ac from PV grid [8].

There is a growing interest in multilevel topologies since they can extend the application of power electronics systems to higher voltages and power ratios. The general function of this multilevel inverter is to synthesize a desired voltage from different DC sources, like solar cells and fuel cells, or. In this paper we are using PV Grid [1-3]. The cascaded inverter has been largely studied and used in the various fields such as drives, transmission system and power conditioning.

The Conventional two-level inverters, are given in Figure 1, are mostly used today to generate an AC voltage from an DC voltage which is obtained from PV. The two-level inverter can only create two different output voltages for the load, $V_{dc}/2$ or $-V_{dc}/2$ (when the inverter is fed with V_{dc}). To build up an AC output voltage these two voltages are usually switched with PWM, see Figure 2. Though this method is effective it creates harmonic distortions in the output voltage [9].

The concept of Multilevel Inverters (MLI) will create several levels an AC signal as shown in Figure 3, with lower harmonic distortions. By increasing more voltage levels in the inverter the output waveform will be smoother, but the design of many levels becomes more complicated, with more components and a more complicated controller for the inverter is needed. To better understand multilevel inverters the more conventional three-level inverter, shown in Figure 4, can be investigated. It is called a three-level inverter since every phase-leg can create the three voltages $V_{dc}/2$,0, -$V_{dc}/2$, as can be seen in the first part of Figure 3. A three-level inverter design is similar to that of an conventional two-level inverter but there are twice as many valves in each phase-leg[10].

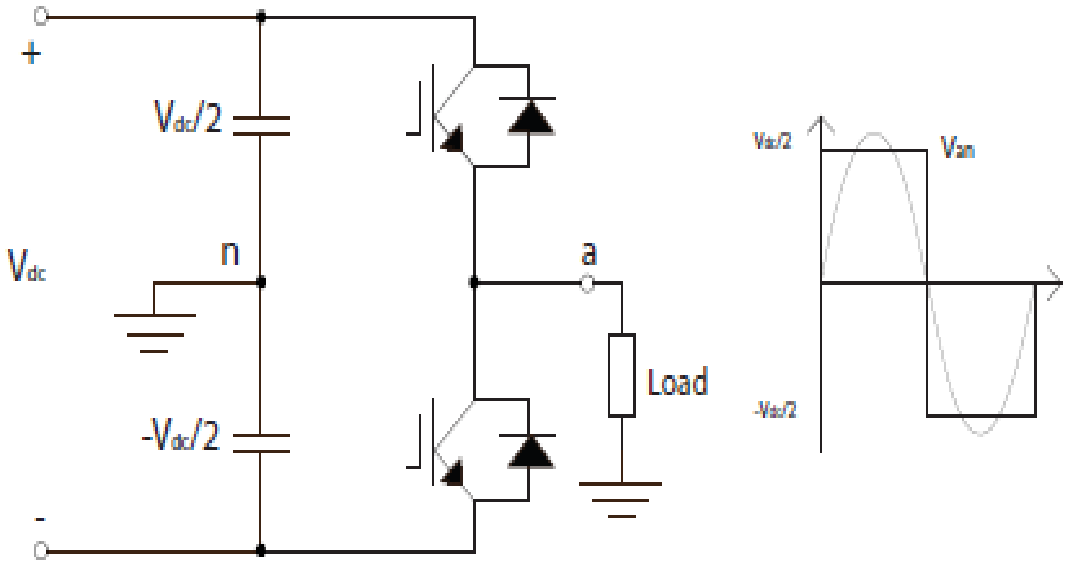

Figure 1: One phase leg of a two-level inverter and a two-level waveform without PWM

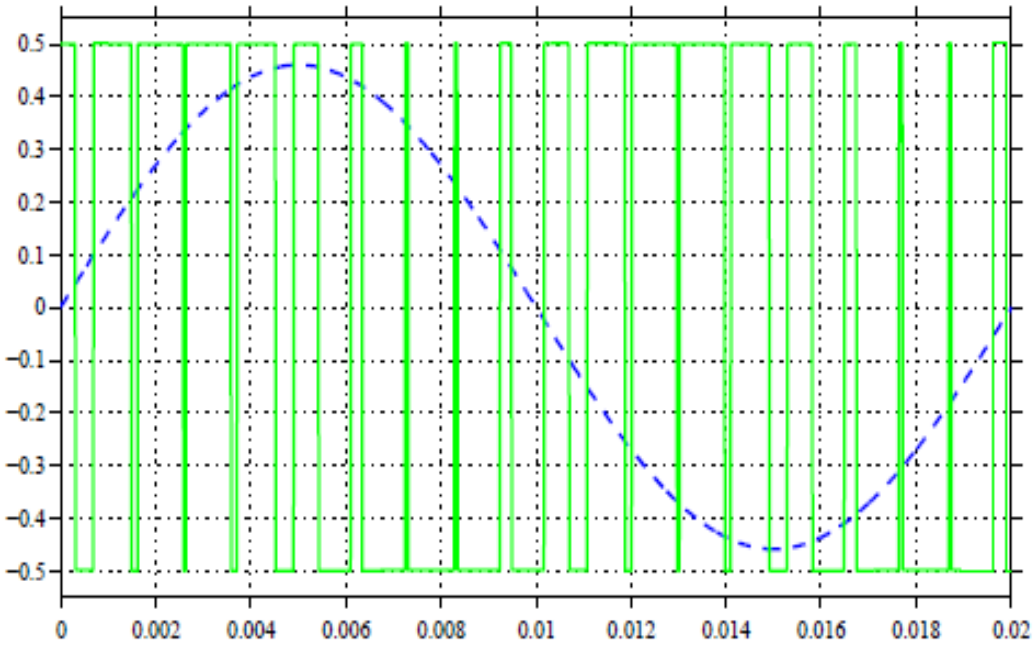

Figure 2: PWM voltage output, reference wave in dashed blue

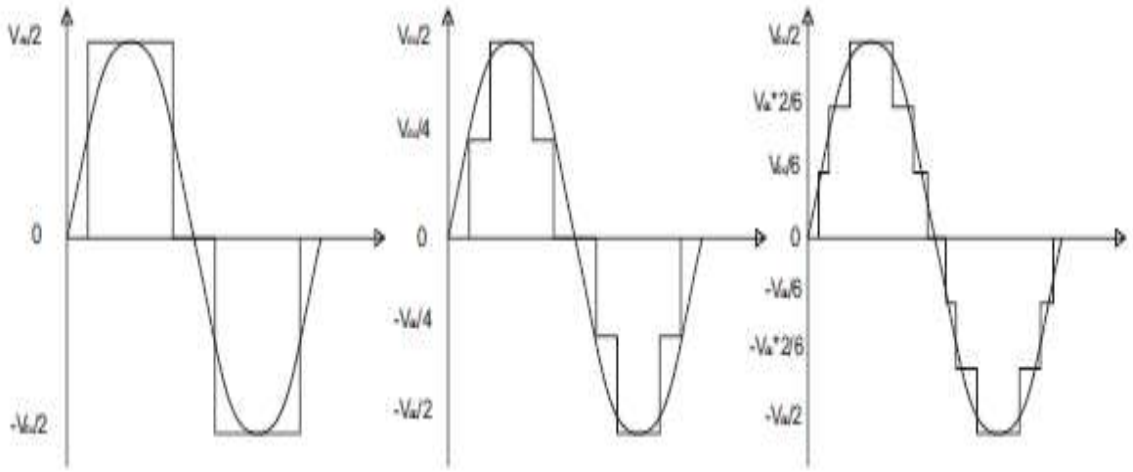

Figure 3: A three-level waveform, a five-level waveform and a seven-level multilevel waveform, switched at fundamental frequency

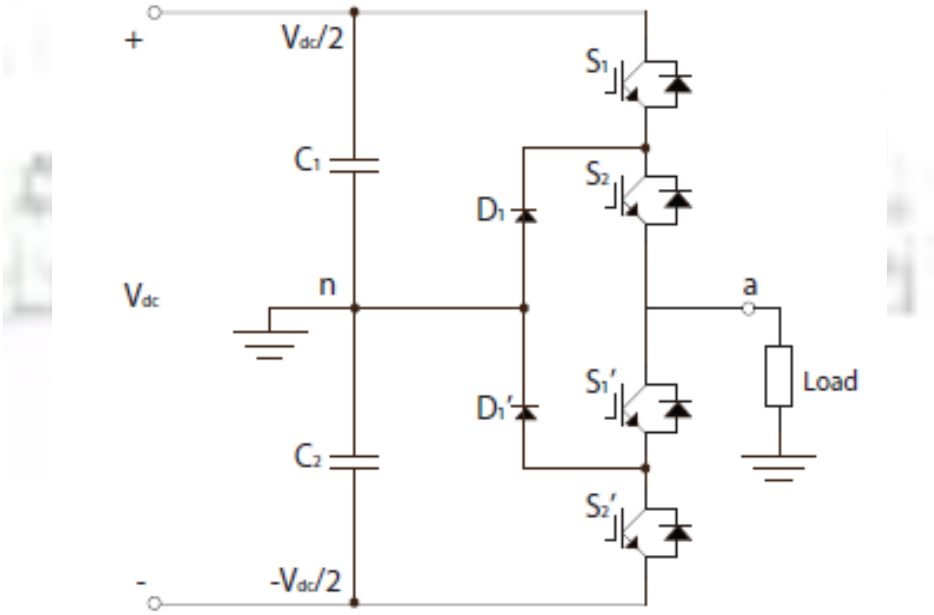

Figure 4: One phase leg of a three-level inverter

Midpoint in between two capacitors, marked n in the figure. These capacitor build up the DC-bus, each capacitor is charged with the voltage $V_{dc}/2$. Together with another phase-leg an output line-to-line voltage with even more levels can be obtained. To create the zero voltage the two switches closest to the midpoint are switched on and the clamping diode should the voltage to zero with the neutral point. Now, if more valve pairs, clamping diodes and capacitors are added the inverter can generate even more voltage levels, see Figure 3, the result is a multilevel inverter with clamping diode topology. Some of the most attractive features in general for multilevel inverters are that they can generate output voltages with very low distortion and dv/dt, generate smaller common-mode voltage and operate with lower switching frequency [9] compared to the more conventional two-level inverters.

With a lower switching frequency the switching losses can be reduced and the lower dv/dt comes from that the voltage steps are smaller, as can be seen in Figure 3 as the number of levels increase. There are also different kinds of topologies of multilevel inverters that can generate a stepped voltage waveform and that are suitable for different applications. By designing multilevel circuits in different ways, topologies with different properties have been developed, some of which will be looked upon in this report. The Multilevel inverter topologies that are investigated in

this work are: Neutral-Point Clamped Multilevel Inverter (NPCMLI), Capacitor Clamped Multilevel Inverter(CCMLI), Cascaded Multicell Inverter (CMCI), Generalized Multilevel Inverter (GMLI),Reversing Voltage Multilevel Inverter (RVMLI), Modular Multilevel Inverter (M2I) and Generalized Multilevel Current Source Inverter (GMCSI).The most dominant multilevel inverters use one or more voltage sources [11], as the three-level inverter, and most topologies presented in this report will have voltage sources, so called Voltage Source Inverters (VSI). There are however also multilevel inverters with current sources, Current Source Inverters (CSI), for example the GMCSI in the list above [12,13,14].

III. Single Phase CMLI (Cascaded Multilevel Inverter)

In order to obtain the cascaded multilevel inverter, the H-bridges are connected in series as shown in Figure 5 in the MATLAB/SIMULINK environment. The output of the first H-bridge is connected in series with the second bridge and so on. The switching pulses for the power switches in the H-bridge is provided by the pulse generation units. The individual pulse generation units will have its own subsystems interlinked with other pulse generation units to avoid the short circuit problems among the switches present in the same leg. The input pulse patterns applied to the respective power switches and the generated stepped output AC voltage are captured using the scopes at the appropriate points on the circuit. The implimentated simulation for cascaded multilevel inverter is shown in the figure-5.

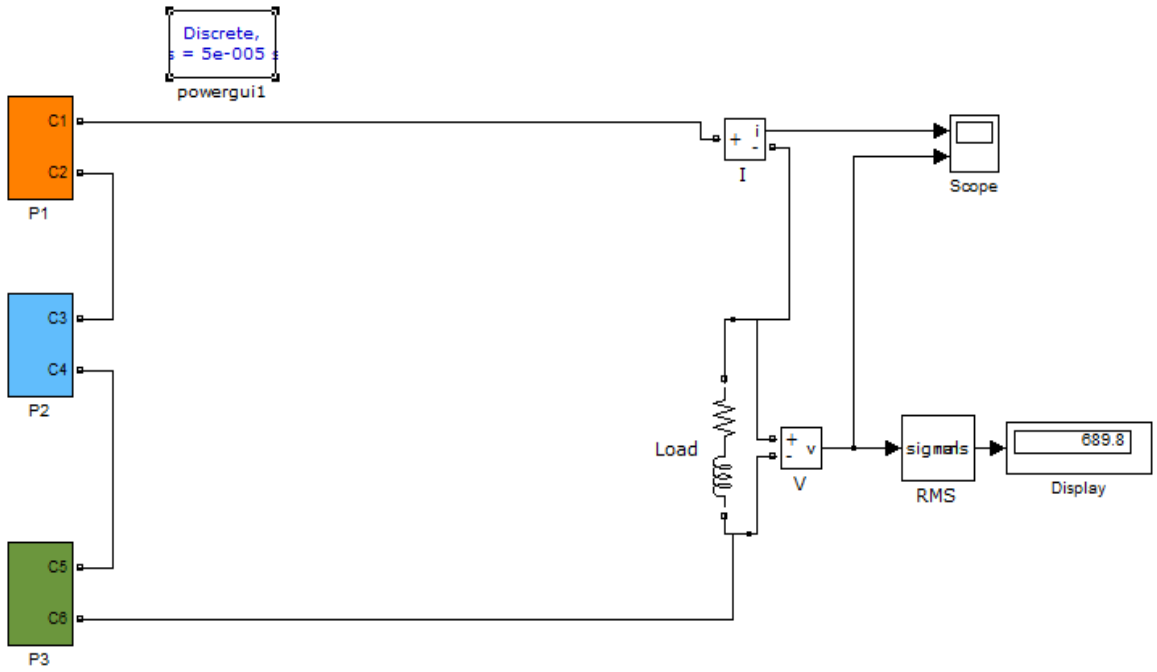

Figure 5: Cascaded multilevel inverter

Output waveform for current, voltage and FFT analysis is shown in the figure 6,7, 8 and Figure-9.

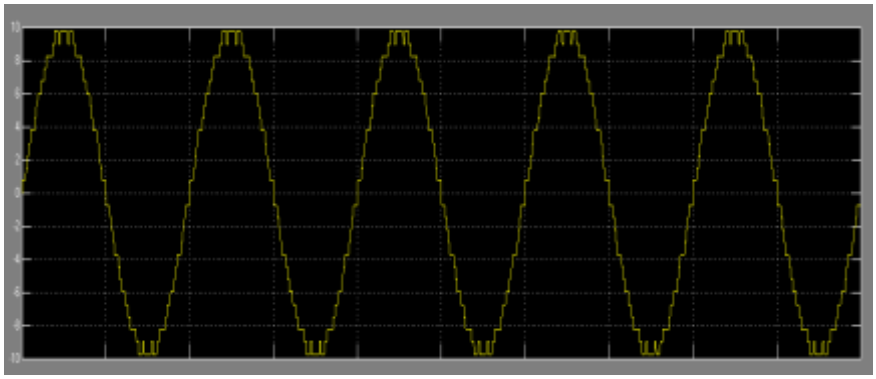

Figure 6: simulated output current waveform for CMLI

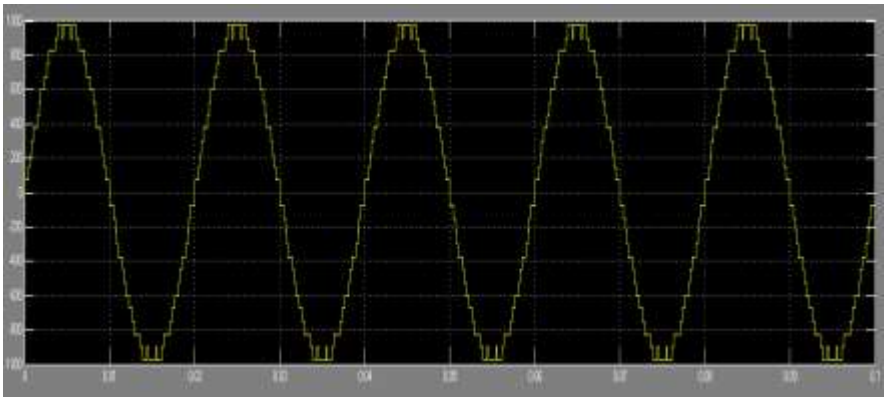

Figure 7: simulated output voltage waveform for CMLI

Comparing two level THD with multilevel THD:

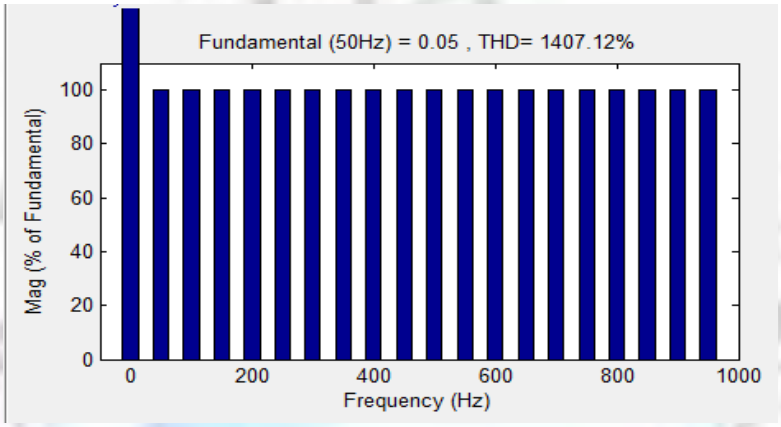

Figure 8: Two level THD FFT analysis spectrum for Output voltage

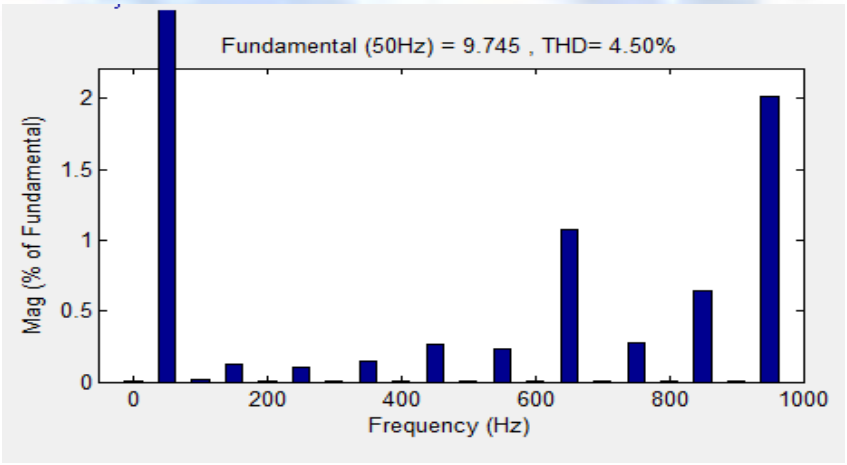

Figure 9: Multilevel THD FFT analysis spectrum for output

Conclusion

The cascaded multi level inverters are modeled and simulated using MATLAB/SIMULINK model for PV Grid. From Simulation analysis when the level of inverter is increasing the output voltage of inverter is improving. In this paper we compare the THD value of two levels inverter with multilevel inverter. From the values of percentage total harmonic distortion it can be concluded that as the number of levels of the inverter increases the percentage of the output THD value decreases.

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