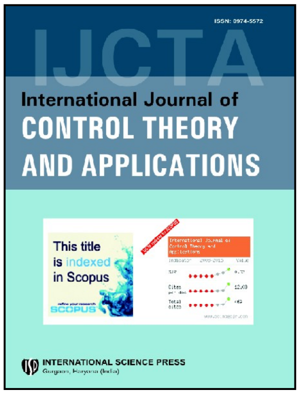

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An Analysis of Cascaded H-Bridge Multilevel Inverter for Photovoltaic System

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Abstract: Contemporary development in the expanse of modern power electronic applications to the photovoltaic (PV) system. Solar systems are becoming extensive with the increase in the energy demand. Multilevel inverter can be used to abstract power from solar panel. A sum of topologies in multilevel inverters are there; out of that cascaded H-bridge multilevel inverter(CMLI) is new suitable converter for PV applications, because each PV panel acts as a single source for every cascaded h-bridge module. To diminish the power demand and deficiency we have to improve the power extracting methods. The dispassionate of this paper is to analysis the 5-level and 7-level cascaded multilevel inverter. In this paper the voltage, current and THD values for 5-level and 7-level CMLI are observed. These techniques are simulated and the outcomes are verified and compared through MATLAB/ Simulink.

Keywords: Model of Photovoltaic, H-Bridge Multilevel inverter, PWM controls Technique, LCL Filter.

1. INTRODUCTION

It is necessary to appearance in the direction of natural energy sources as a upcoming solution for energy. Photovoltaic systems (PV) are currently predictable for their impact to unsoiled power generation. Solar irradiance, temperature are several parameters that affect the power quality [1]-[2]. Research is in advancement to increase the efficiency of PV cells and optimizing the production of energy through minimization of power losses. Inverters are integrated with photovoltaic systems to change the PV output voltage to alternating voltage. Multilevel inverters are recycled as a solution for higher voltage levels. A number of inverters have been designed to interface the photovoltaic system. In conventional voltage source inverter, the pressure across the switches is high. So, multilevel inverter can produce output voltage with distortion. By using H-bridge multi-level inverter reduces switching losses and improves the efficiency of the inverter. Section II discuss equivalent model of photovoltaic cell. In section III discuss the entire system configuration. In section IV talk over the results and discursion of the CMLI.

2. MATHEMATICAL MODEL OF PV CELL

The PV array converts solar energy into electricity by using photovoltaic effect. The corresponding circuit of a Photovoltaic cell is as shown in Fig.1. To shorten the analysis series resistance may be ignored as the value of shunt resistance (Rsh) is very large. Solar cells are connected in larger units called as a Photovoltaic module; these are further interconnected in a parallel-series configuration to form PV arrays.

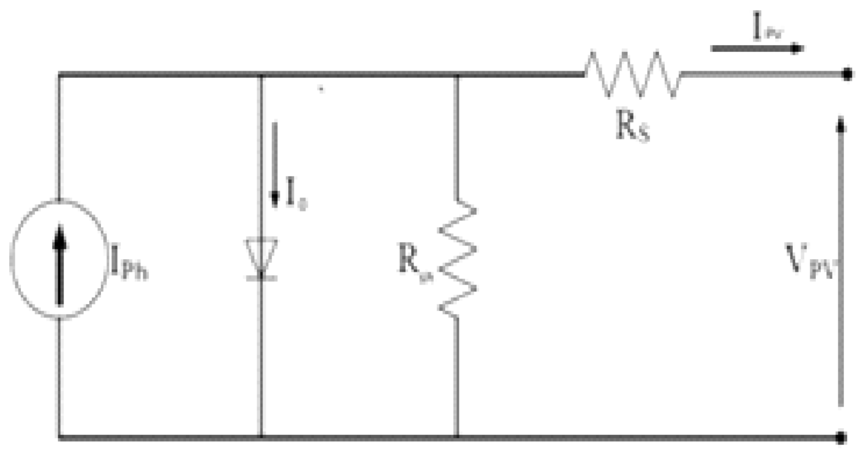

Figure 1: Equivalent circuit for PV cell

The calculated model of the photovoltaic cell [2-5]. Photon-current of module is in (1),

$$I_{ph} = (I_{scr} + k_i (t - 298)) \times S/1000 \tag{1}$$

Inverse saturation current of module;

$$I_{rs} = I_{scr} / [\exp(qV_{oc} / n_s k D_f T)\text{-}1] \tag{2}$$

PV module output current is:

$$I_o = I_{rs} \left[\frac{T}{T_r} \right]^3 \exp\left[\frac{q * E_{go}}{Ca} \left(\frac{1}{T_r} - \frac{1}{T} \right) \right] \tag{3}$$

$$I_{PV} = N_P * I_{ph} - N_p * I_o \left[\exp\left(\frac{q * (V_{pv} + I_{pv} R_s)}{b} \right) - 1 \right] \tag{4}$$

Where,

$$b = n_s d_f kT$$

3. SYSTEM CONFIGURATION

(A) Block Diagram of System Configuration

The suggested system configuration has presented in fig.2. It consists of PV array, CMLI, filter and load. In this proposed work 7-level cascaded MLI and filter are designed. DC power generated on or after the PV array given to the cascaded inverter. Multilevel inverter turns DC voltage into a sinusoidal voltage. Harmonics attainable in the output are reducing by using the filter. Particularly LCL filters design IEEE standards [4].

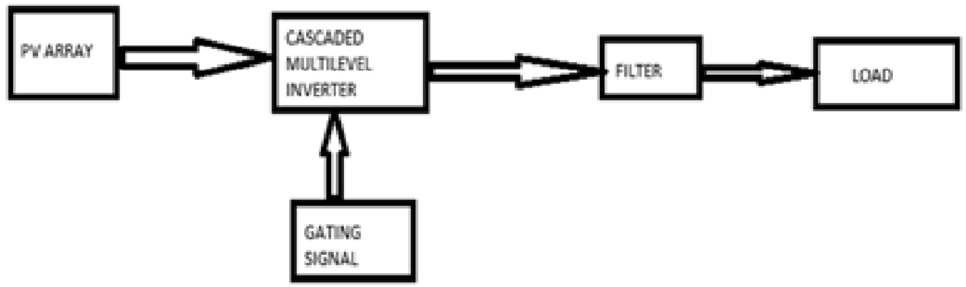

Figure 2: Block diagram of System Configuration

(B) Cascaded H-bridge Multi-level Inverter

Multilevel converters can incorporate switches waveforms with lower levels of harmonic distortion compared to two- level converter. Multilevel inverter takes a potentiality to handle high-power and high-voltage with less harmonic distortion. Multilevel inverter is a few limitations that their complexity requires greater count of power devices. CMLI requires ‘a’ DC voltage sources for 2a+1 level. Three h-bridge inverters are required for getting seven-levels. The CMLI having more number of benefits such as integrated structure compare to other techniques and a reduced amount of components. Several topologies proposed for PV systems [3]. It contains a series combination of multiple h-bridge inverters. Multilevel inverter has a separate PV array for every H-bridge to produce a output voltage. By arranging the output voltage of every H-bridge inverter a stepped voltage waveform is produced. A single source CMLI having single PV array for entire circuit. Whereas compound source CMLI having altered values of PV module for all h-bridges.

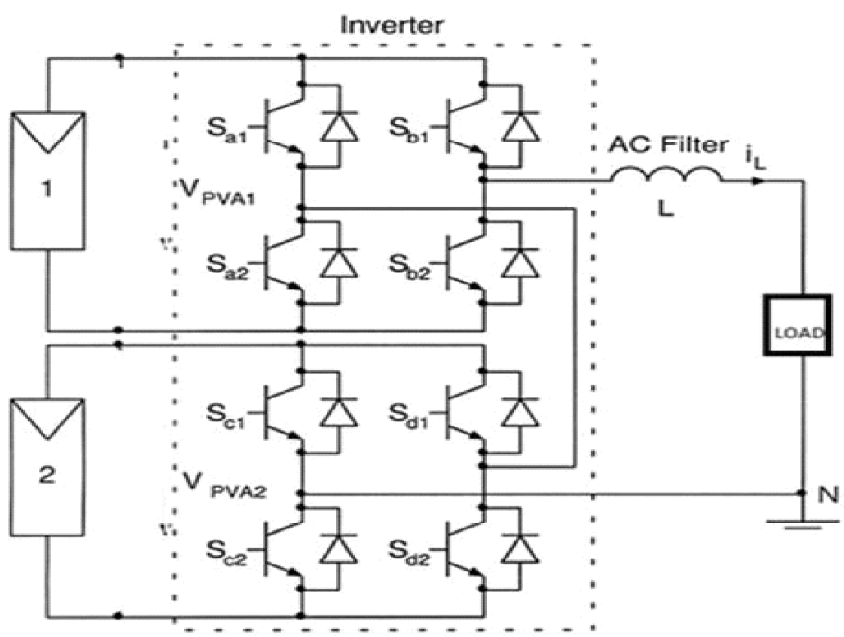

Figure 3: General Block Diagram of cascaded H-Bridge Multi-level Inverter

The advantage of a multiple source CMLI over single PV array cascaded MLI that allows more levels to be created in the output voltage using same number of h-bridge as a single PV array cascaded MLI and thus decreases the THD with less bridges.

(C) LCL-filter

For reduction of harmonics effectively the designing circuit consists of filter. The inductance is used for reduction of harmonics existing in the circuit. High-order filters are becoming more challenging for increasing the capacity of the system due to low dynamic response. The harmonic distortion produced by the inverter is attenuate by using L filter or LCL. This filter has better depletion capacity of high-order harmonics and improved dynamic characteristic compared to L-filter. The basic procedure for the selection of the LCL filters [5]. The inductor near to the inverter is designed by considering current ripple. The capacitor rating is bounded by the fundamental reactive power and the load-side inductor is calculating based on the high-frequency current attenuation from the inverter to load side.

$$L_i = V_{pv} / (16fs*\Delta I_L\text{-max}) \tag{5}$$

Where,

$$\Delta I_L\text{-max}=10\%\text{ current ripple } (Pn\ \sqrt{2})\ D\ V_n \tag{6}$$

The capacitance of the filter is

$$C = k\ C_b \tag{7}$$

Where,

$$k = 0.05$$

The output side inductor L can be calculated as

$$L = r\ _*\ L_i \tag{8}$$

The design of filter components, first calculating the inverter side inductor which can limit the current ripple by up to 10% of the normal amplitude.

IV. RESULTS AND DISCUSSION

The replication circuit model of cascade MLI of developed in MATLAB. The gating signal for inverter is produced by using PWM technique. The different constraints, like voltage, current and THD values are observed.

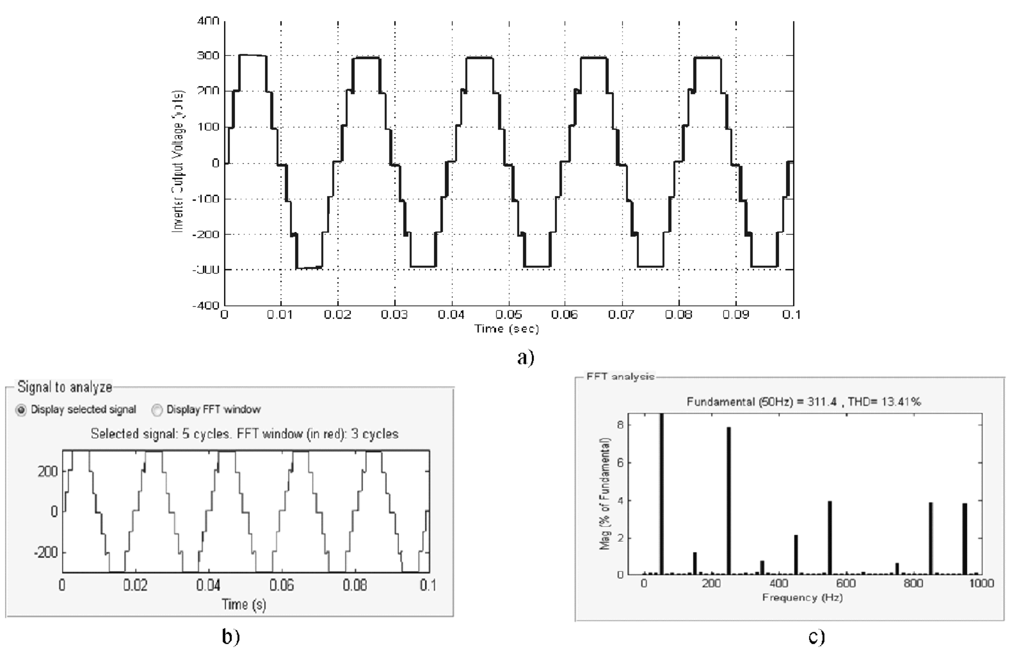

Figure 4: Simulation results of 7-level cascaded H-bridge multilevel inverter without filter a) Output Voltage b) & c) THD Value

Fig.4. shows the model results of seven-level cascade multi-level inverter. From the obtained results, it is detected that the inverter output voltage is 298.85 V. The gained voltage is without using filter. The THD is 13.41. The obtained load voltage is like a stepped waveform.

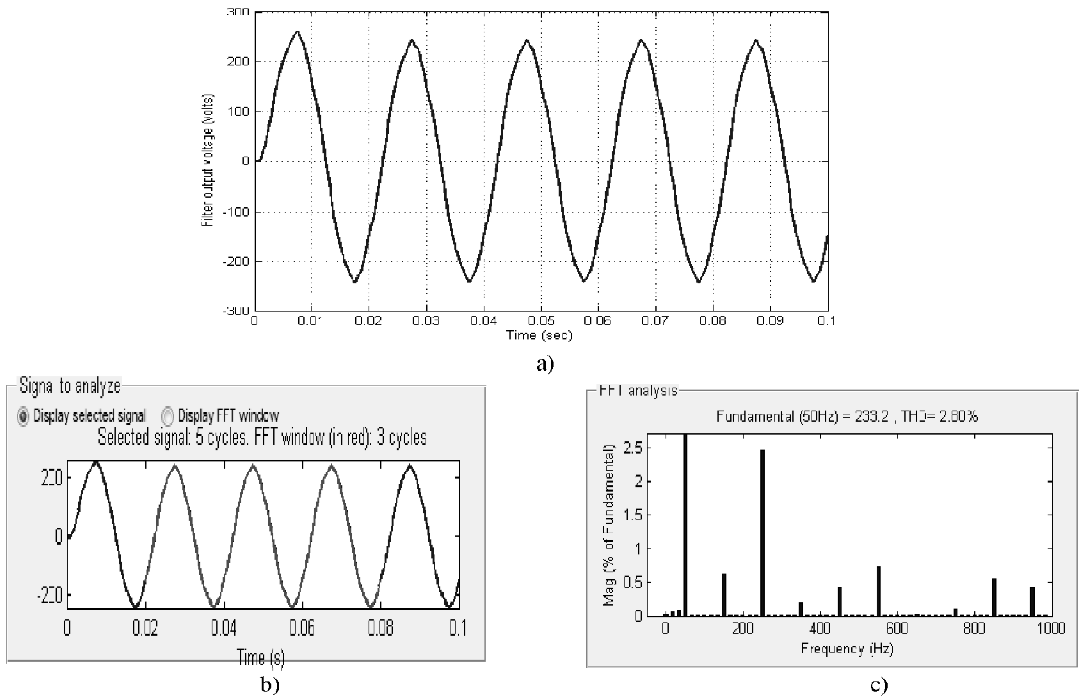

Figure 5: Simulation results of 7-level cascaded multi-level inverter by using filter a) Output Voltage b) & c) THD Value

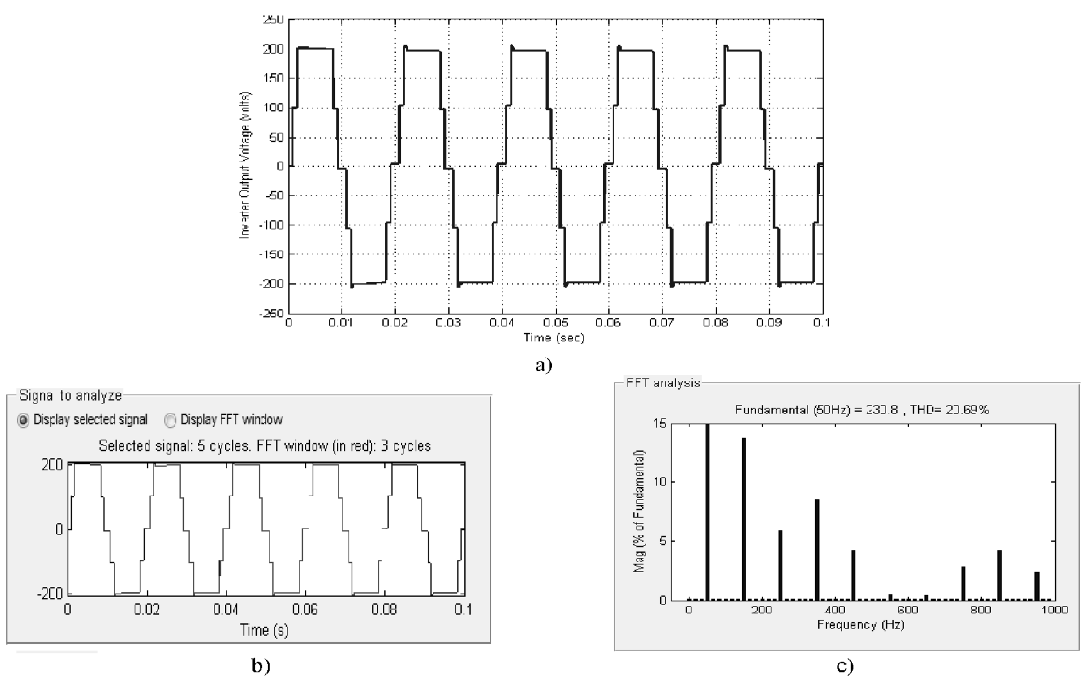

Figure 6: Simulation results of 5-level cascaded multi-level inverter a) Inverter output voltage without filter b) & c) THD Value

Fig. 5. illustrations model results of 7-level CMLI by using the filter circuit. The getting inverter output voltage is 231.1V. The harmonics are reduced by using the filter. The obtained THD value is 2.80%. By seeing the above results the total harmonic content existing in the waveform reduced by placing the filter circuit.

Fig. 6. illustrations the inverter output voltage and THD values of the 5-level CMLI. The obtained inverter output voltage is 200.0V. The harmonic distortion value is 20.69%.

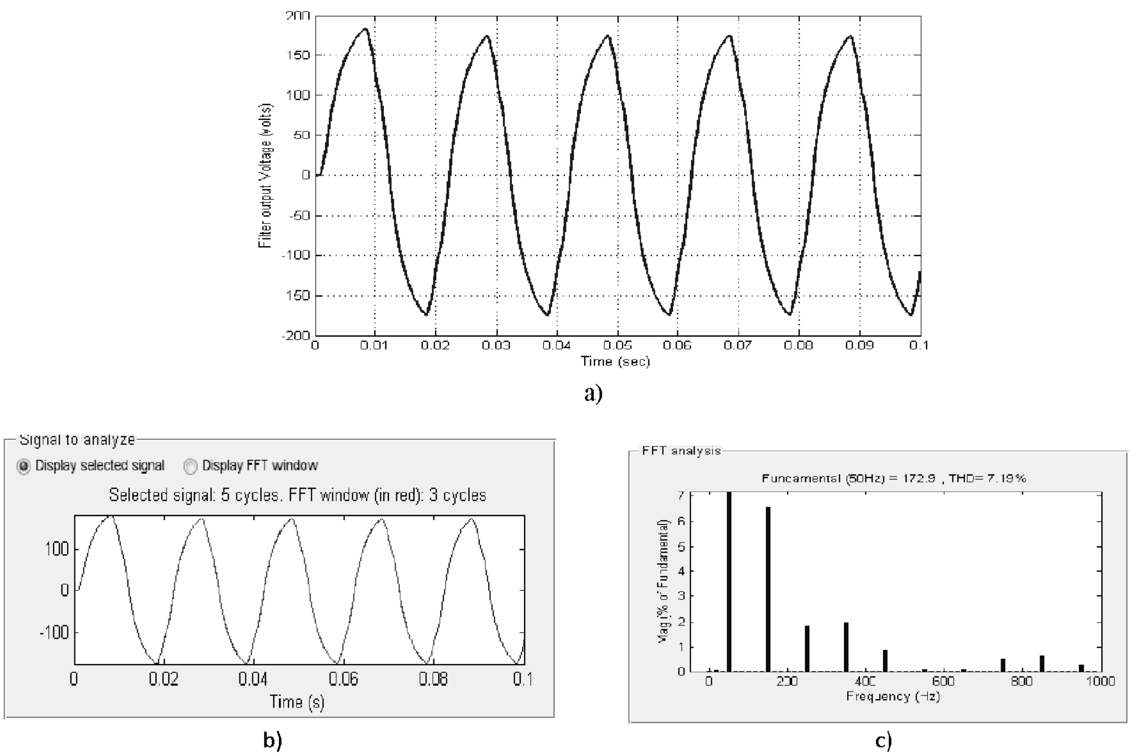

Figure 7: Simulation results of 5-level Cascaded multilevel inverter by using filter a) Output voltage b) & c) THD Value

Fig.7. (a) and (b) illustration of the output voltage and total harmonic distortion by using the filter. The THD value of the inverter is 7.19%.

Table 1
Evaluation of THD values for different cascaded inverters

	5-level Cascaded H-bridge Inverter		*7level Cascaded H-bridge inverter*	
	Irradiance = 1000	*Irradiance = 800*	*Irradiance = 1000*	*Irradiance = 800*
Without filter	20.63%	20.66%	13.41%	13.52%
With filter	7.19%	7.20%	2.80%	2.81%

The table 1 shows the evaluation of the THD values for different cascaded multilevel inverter with and without filter. By seeing the above table, it is observed that increasing the number of levels the harmonic distortion of the output waveform is reduced. 7-level CMLI inverter is more improvement than the 5-level CMLI.

V. CONCLUSION

In this discussion a cascaded H-bridge MLI for PV applications has been presented. The multi-level inverter topology will help to improve the utilization of connected PV modules. Multi-level inverter containing more harmonics in output waveform. In this discussion a single-phase PV nurtured CMLI is simulated in MATLAB/ Simulink. It is clear that by increasing the number of levels there is a major decrease in the harmonic content of the cascaded multilevel inverter output. From the simulation results it is determined that the 7-level CMLI is more advantage than the 5-level CMLI for harmonic reduction.

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