THD Analysis in Cascaded H-Bridge Multilevel Inverter

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Abstract

This paper proposes a new fuzzy logic controller for seven-level hybrid cascaded H-bridge inverter. The inverter is used for on-grid application of PV a system. Here a Sinusoidal pulse width-modulation (SPWM) technique is applied for obtaining carrier signals. Multi-Level Inverter technology have been developed in the area of high-power medium-voltage energy scheme. It is because of their advantages such as devices of high dv/dt rating, higher switching frequency, unlimited power processing, shape of output waveform and desired level of output voltage, current and frequency adjustment. This topology can be used there by enabling the scheme to reduce the Total Harmonic Distortion (THD) for high voltage applications. The Maximum Power Point tracking algorithm is also used for extracting maximum power from the PV array connected to each DC link voltage level. The Maximum Power Point tracking algorithm is solved by Perturb and Observer method. It has high performance with low Total Harmonic Distortion and reduced by this control strategy.

Keyword- Total Harmonic Distortion (THD), Sinusoidal Pulse Width Modulation (SPWM), Multilevel Inverter, Fuzzy Logic Controller

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I. INTRODUCTION

Multilevel voltage source inverter has many advantages compared to their conventional methods. Cascaded H-bridge inverter provides stepped AC voltage wave form with lesser harmonics at higher levels by combining different ranges of DC voltage sources. The components of inverter filter circuit are reduced by increasing step level of the inverter to the shaped voltage wave form, reduced switching volume, very low THD and reduced cost. The several voltage sources on the DC side of the converter makes multilevel technology a gorgeous for photovoltaic applications. Because the multilevel inverters are classified into two types namely distinct source and multisource multilevel inverter. In the conventional nine and seven level H-bridge multilevel inverters, the THD considerably high and the output performance is low when compared to the proposed hybrid H-bridge multilevel inverter. It is found that the THD will be reduced with increases in output levels. As solar energy is one of the most promising nonconventional energy, the PV systems are becoming more and more popular. In recent years applying multilevel inverters to PV energy systems is getting more and more attraction due to the large power demands. Photovoltaic (PV) Converters are usually consisting of two stages [3], a dc/dc booster and a Pulse Width Modulated (PWM) inverter. The cascading technique of converters has some disadvantages such as efficiency issues, interactions between its stages and problems with the Maximum Power Point Tracking (MPPT). Therefore the part of the electrical energy produced is utilized for maintain the utilities. In this paper we proposed a single-phase H-bridge multilevel converter for PV systems governed by a fuzzy logic controller (FLC)/modulator with SPWM.

II. CASCADED H-BRIDGE MULTI-LEVEL INVERTER

A CHBMLI consists of a series of H-bridge (single-phase full-bridge) inverter units. The general function of this CHBMLI is to synthesize a desired voltage from several separate dc sources, which may obtain from batteries, fuel cells, or solar cells. Figure.1 shows a Single-Phase Structure of a CHBMLI with separate dc sources. Each separate dc source is connected to a single-phase full-bridge inverter. Each inverter level can generate three different voltage outputs, +Vdc, 0, and –Vdc. The output phase voltage level is defined by m = 2s+1, s = no. of dc s CHBMLI has been receiving wide attention due to its numerous advantages as a dc/ac interface. CHBMLI is the focus of this paper due to its components required is the least to achieve the same number of voltage levels. The circuit 1 Journal of Electrical Engineering www.jee.ro layout is in modular structure, which means a faulty module can be replaced with another module without affecting the rest of the circuit. The ac outputs of the inverters are connected in series such that the synthesized voltage waveform is the sum of the inverter outputs. It requires the least number of components compared to other MLI. It can generate almost sinusoidal waveform voltage while only switching one time per fundamental cycle improved .High efficiency is obtained due to its minimum switching frequency.

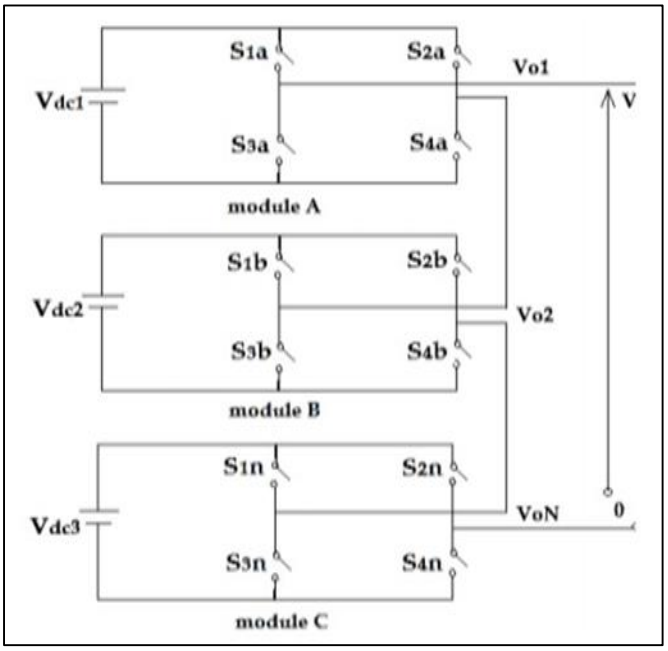
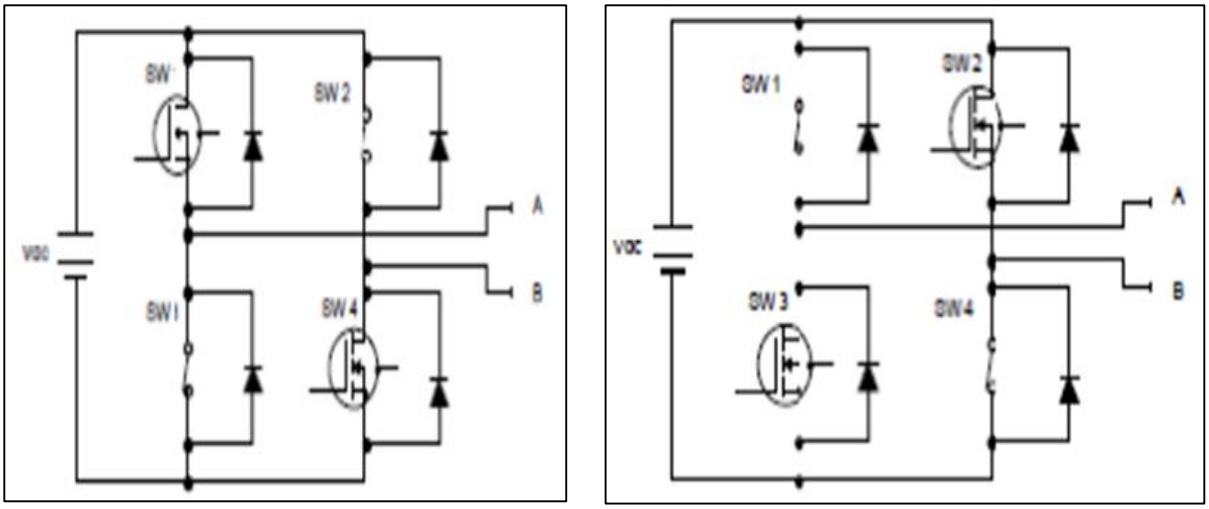


Fig. 1: Single-phase structure of a cascaded h-bridge multi-level inverter

III. PRINCIPLE AND OPERATION OF CHBMLI

A CHBMLI consists of basic H-bridge modules connected in series. This section will explain the working principle of the H-bridge module and how the CHBMLI modules are able to generate a single-phase ac output voltage. The structure of the single H-bridge module as shown in Figure.1, it consists of a separate dc source (SDCS), four semiconductor switching devices and four diodes. Switches, SW1, SW2, SW3 and SW4 are switched in 3 different sequences to generate output voltages across AB of the H-bridge module. The output voltage consists of three voltage levels, which are +Vdc, -Vdc and zero volts. To obtain +Vdc, switches SW1 and SW4 are turn 'ON'. To obtain –Vdc, switches SW2 and SW3 are turn 'ON'. To obtain zero volts, switches SW1 and SW2 or SW3 and SW4 are turn 'ON'



(a) (b)

Fig. 2: Modes of operation

The first mode of operation of single H-bridge CHBMLI as shown in Figure.2(a) and its sequence of operation for the first mode as revealed in following points, SW1 & SW4 are turn 'ON' SW2 & SW3 are turn 'OFF' Resulted a +Vdc at terminal AB. The second mode of operation of single H-bridge CHBMLI as shown in Figure.3 and its sequences operation of the second mode as revealed in following points, SW2 & SW3 are turn 'ON' SW1 & SW4 are turn 'OFF' Resulted a -Vdc at terminal AB.

The third mode of operation of single H-bridge CHBMLI is sequence of operation for the second mode as revealed in following points,SW1 & SW2 are turn 'ON' and SW3 & SW4 are turn 'OFF'. Alternately, SW3 & SW4 are turn 'ON' and SW1 & SW2 are turn 'OFF'. Resulted a zero volt at terminal AB.

IV. PROPOSED TOPOLOGY OF SEVEN LEVEL CHBMLI

The medium power applications for industrial and domestic equipments suffered by many serious power quality problems. The harmonic content of the output power from many inverters are not meet the IEEE standard. To obtain high quality sinusoidal output voltage with reduced harmonics an H-bridge cascaded asymmetric multilevel inverter with six switches is proposed here. If the number of power semiconductor device is increased, the inverter circuit size is also increased. The proposed model consists of one H-bridge with two switches connected with two flywheel diodes.

Since the number of switches is reduced for a seven level output of the proposed PV inverter, the gate driver circuit required is also reduced. The proposed technique has many advantages such as the system configuration seems to be compact and thereby reducing the switching losses, less installation area, less system cost, reduced control complexity and voltage stress on each switch is also minimized. Thus the output efficiency of the inverter can be increased by the above factors which are highly influenced. So, for obtaining a larger number of output levels in inverter, the number bridge circuits required should be reduced. By considering these factors a new topology is to be developed. In order to reduce the harmonic distortion further, one more switch is reduced and thus 6-swicth topology is developed.

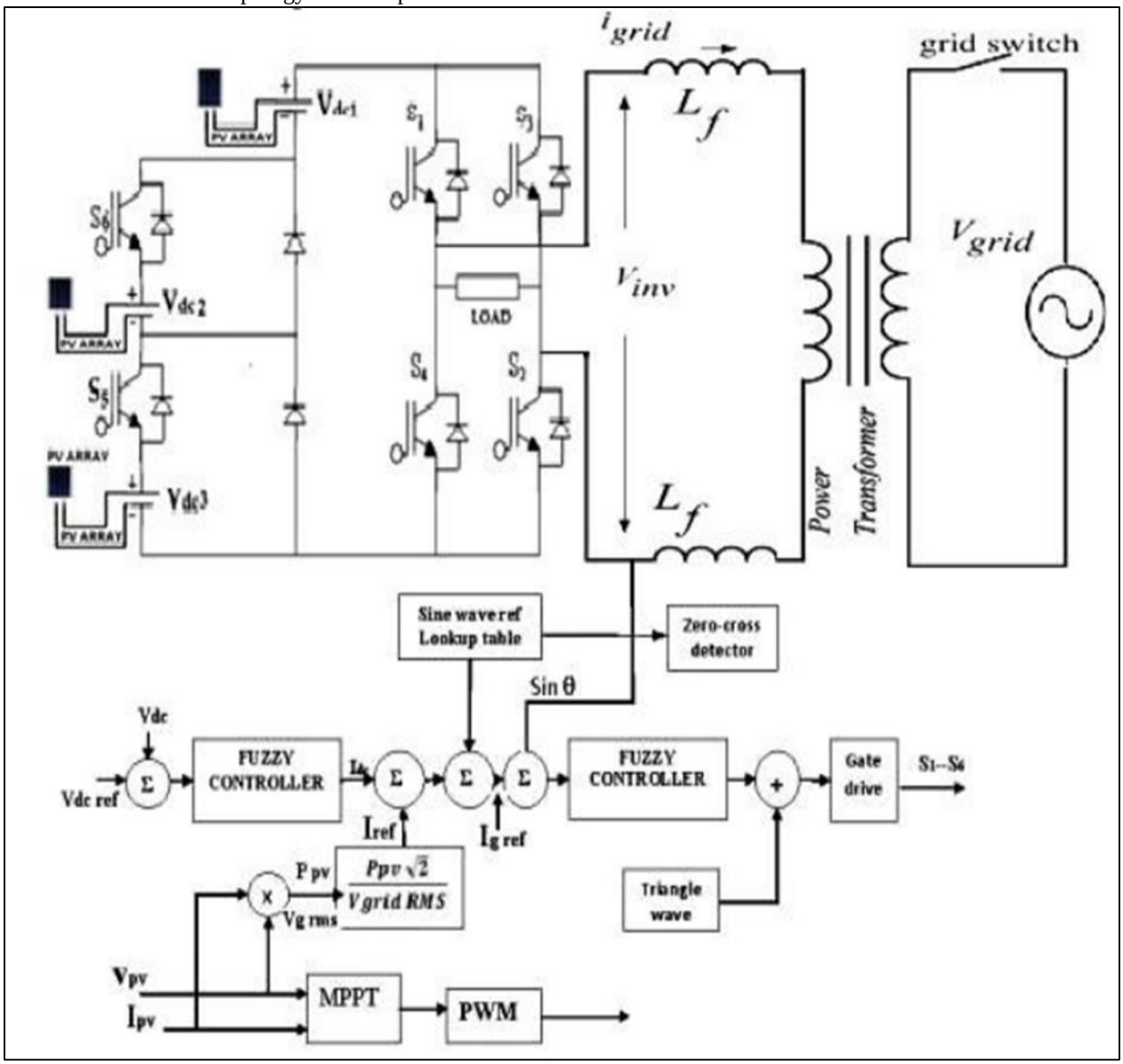


Fig. 3: Proposed circuit model of seven level cascaded PV inverter

PI control is developed using the control system toolbox. The gate signals are generated using SPWM strategy. The seven level output of the cascaded inverter is fed to the load through LC filter to produce sinusoidal output (Vo) which is compared with the reference voltage (Vref) to generate the error signal (e). The input to the PI controller is e. The output of the PI controller i.e the compensating signal (Cs) is added with the reference signal to yield the required modulating signal (ms) and is used to generate the gating pulses. Thus a voltage feedback loop is established to realize the required sinusoidal output voltage.

V. CONCLUSION

This paper presented a fuzzy logic controller based seven level cascaded H-bridge inverter for photovoltaic systems with minimum number of switches. A sinusoidal pulse width modulation (SPWM) technique with a fuzzy logic controller has been proposed here. From the obtained result it is found that fuzzy logic controller gives a reduced THD compared to conventional single carrier modulation and it gives a better quality output. From the simulation result it is observed that the current distortion is greatly reduced after harmonic reduction and it is within the limit to meet the IEEE 519-1992 standard. Therefore, the use of Photovoltaic (PV) model is recommended for the proposed inverter with reduced and minimum number of switches. Hence, seven-level inverter with reduced component along with fuzzy logic controlled SPWM technique will enhance the quality of the output voltage and provides a better efficiency suited for PV applications.

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