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RESEARCH ARTICLE OPEN ACCESS

Performance Analysis of Solar PV based Flying Capacitor Multilevel Inverter using MATLAB/Simulink

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ABSTRACT
Sun oriented photovoltaic system is drawing much consideration all over the world. Sun oriented photovoltaic power generation is a successful method to produce the sustainable power. The multilevel inverters are utilized in high voltage PV plants, because of the high voltage ability, low power losses, and low switching frequency. The flying capacitors are under exceptional consideration among the multilevel inverter topologies associated sustainable power source and electric grid. The flying capacitor multilevel inverters is appropriate to PV application, industrial applications and research as it satisfies the prerequisite of unadulterated sinusoidal waveforms, with less harmonics substance. In this work, a novel multilevel inverter is presented and dissected for the high voltage PV applications with new modulation systems and the excess switching states to lessen the electromagnetic impedance and common mode voltage. The simulation analysis of proposed framework has been carried out with the Matlab/Simulink.
***Keywords* -** Flying Capacitor, Multilevel Inverter, Solar PV, Simulink

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I. INTRODUCTION

Sustainable power sources are best options to replace the customary energy sources, like petroleum derivatives, oil, coal, gas. The traditional vitality sources are limited and can be depleted. Numerous sustainable power sources are gaining popularity among researchers, like sun powered, wind energy, biomass, hydro-power, geothermal energy and sea power. Solar PV has the upside among these sustainable power therefore PV frameworks are leading the renewable energy sector across the planet. The essential component of a PV framework is the sun powered cell .A sun oriented cell straightforwardly changes over the vitality of sun light into power as dc. The SPV Framework interconnection with consumer framework requires a proficient converter to converter the low voltage dc into usable AC. This transformation and controlling of AC is finished by Inverter. The traditional H connect inverter delivers output as square wave, comprises additionally high dv/dt stress and odd harmonics in large quantity. The THD can be decreases by typical PWM inverter, however high switching losses are also present here. Therefore this PWM inverter is utilized for lower power applications. The above mentioned issues are removed by the multilevel Inverters, The multilevel inverters has been significantly expanded in recent previous decades. These inverters are appropriate for high power and voltage application because of their flexible ability to intermingling. The multilevel topologies incorporate the diode braced, flying capacitor, and cascaded H-connect converters. This paper proposes another sort of multilevel inverter, flying capacitor multilevel inverter. This inverter necessitates less DC power and switches contrasted with H-bridge Cascaded MI. THD of the output voltage is likewise less when contrasted with the ordinary MIs.

II. SPV- FCMLI TOPOLOGY

The basic schematic diagram of a Solar PV system with flying capacitor multilevel inverter is shown in figure1. The entire scheme is composite of four separate section excluding the load or consumer. First block is solar PV module where solar panel of desired rating and specification is used. Second block is represented by controller which perform the controlling process. Later on, for improving the low DC power, boost converter is used. The output of DC-DC converter is given to the multilevel inverter in next block. The inverter is the essential part of whole scheme is that includes semiconductor switches. The driver section of inverter gives the switching pulses. A controller zone is used to control the inverter [7]. The rectifier changes over AC to dc, given by the step down transformer. After that, it is then given to flying capacitor inverter over the dc associate capacitors. The flying capacitors will charge and discharge suitably for keeping up the different levels. This capacitor is furthermore called as a bypassing capacitor. The voltage controller accepts a huge activity in any power supply unit. The principle job of a controller is to support the rectifier and divert circuit in giving the consistent DC yield voltage.

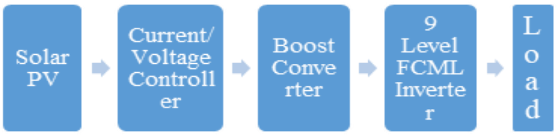

Figure 1: Basic diagram of the proposed system

III. SPV- FCMLI FRAMEWORK

The scheme given in figure1 shows the whole framework. It comprises a solar PV system, boost converter and a 9-level flying capacitor staggered inverter, which is associated with load. From Fig. 1, the PV cell straightforwardly converters the sunlight based vitality into power as dc. The voltage from the PV is given into DC\DC converter which boosted the DC and fed into a 9-level flying capacitor inverter.

3.1. Solar PV Scheme

A sunlight based cell (Solar PV) cell changes the vitality of solar radiations into electrical energy by the semiconductor impact [9].

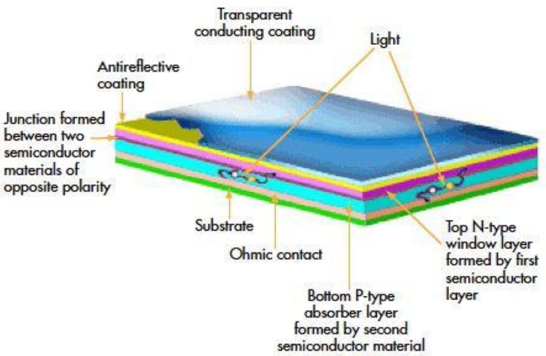

Figure 2: Structure of Solar cell

Solar cells are forming the panel structure called as photovoltaic modules. The layered structure is shown in figure 2. The electrons of PV cell make free by the photons of light having higher vitality in comparison to the band-gap vitality of the PV cell molecules that hold them [10]. These electrons rise as an electric flow. In this manner the IV and PV characteristics are obtained as follows.

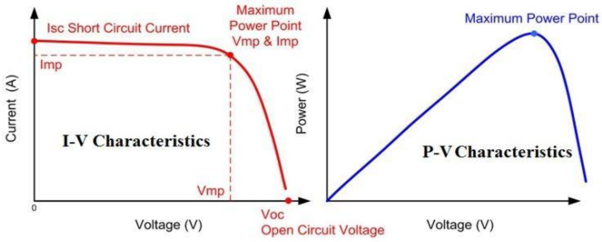

Figure 3. I-V and P-V Characteristics of solar cell

3.2. Boost Converter

In numerous presentations, fixed-voltage DC is required to change into a variable voltage dc source. A boost converter changes the dc into variable dc at a different higher power level [2]. A boost converter can be considered as dc transformer with a persistently factor. It may be utilized to step up a dc voltage like a transformer. A boost converter is appeared in Figure 4.

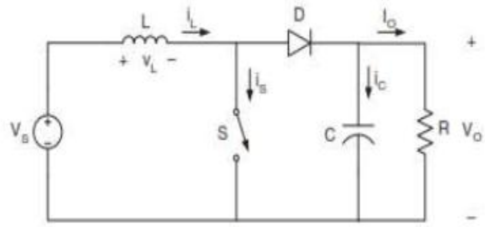

Figure 4. Schematic Arrangement of Boost Converter

3.3. Multilevel Inverter

The principle capabilities of the inverter is the transformation of DC power into AC power, smoothing and shaping of the output AC wave form, with captivating estimation of the output [6]. The significant highlights of a multilevel inverter for PV association are efficient characteristics and reliability attributes. It is intended to work a PV framework consistently close to peak point. The frequency switching inverters are conceivable by SMPS in SPV applications. This disposes of the massive, costly, and vitality expending power channels. The SPV Inverter interfacing system includes two significant tasks. First is the PV is working at the maximum extent point (MPP). Another condition is the infusion of sinusoidal supply into the system. These inverters have numerous focal points, for example, ability to deal with higher voltages, lower switching distortions, and little electromagnetically apprehensions. Contrasted with two-level inverter Topologies at a similar force appraisals, Multi-level Inverters (MIs) likewise have the favorable circumstances that the harmonics parts of line-to-line voltage given to the load are decreased attributable to exchanging frequencies. It additionally gives an option in contrast to medium voltage frameworks, while simultaneously empowering the interface of sustainable power source to higher power application. For the most part MIs are ordered into three sorts: they are Diode Clamped, Flying capacitor, and cascaded type [8].

3.4. Flying Capacitor Multilevel Converter

Most basic issue related with the FCMI is the capacitor adjusting [2]. The correct adjusting is basic need for the FCMI. Since, the capacitors voltage would set the voltage step for output waveforms. In this event the capacitor acquire excessively uneven condition, with the higher THD in output and the losses will be high which cause diminished existence of the system [4]. There are various procedures to adjust the capacitors, for example, the utilization of switching states and the utilization of a RLC filters in corresponding with the load and the least difficult system which is oneself adjusting of the capacitors. Here MOSFETs are chosen as switches in FCMI [5]. The estimations of the flying capacitors are structured dependent on the permitted voltage swell. A higher voltage ripples empowers the flying capacitor to move more vitality in an exchanging cycle, and in this manner lessens the necessary capacitor esteems, however the huge wave additionally builds the voltage weight on the switches. [7].

IV. MODELLING OF SYSTEM

This Model was created utilizing the MATLAB/ Simulink platform. The whole model is developed as separate entity after that all bocks are synchronized into a combined system. These individual blocks are described as follows.

4.1. Modeling of PV Array

The SPV array is developed by joining various solar cells in series and parallel arrangements. These are typically shown by an improved proportional circuit model, as given in Figure 3.

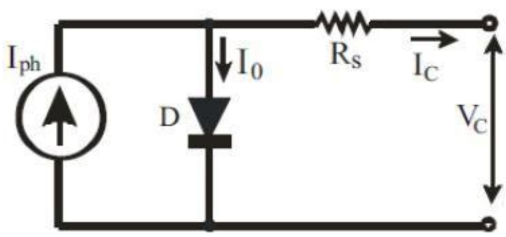

Figure 5. Solar cell equivalent circuit

The output voltage of PV cell is described as function of the photocurrent that is determined by load current and solar Irradiation level as given in the expression. The symbols used in the expression has their standard significance.

$$V_c = \frac{AkT_c}{e} ln\left(\frac{I_{ph}+I_0-I_c}{I_0}\right) - R_s I_c \qquad (1)$$

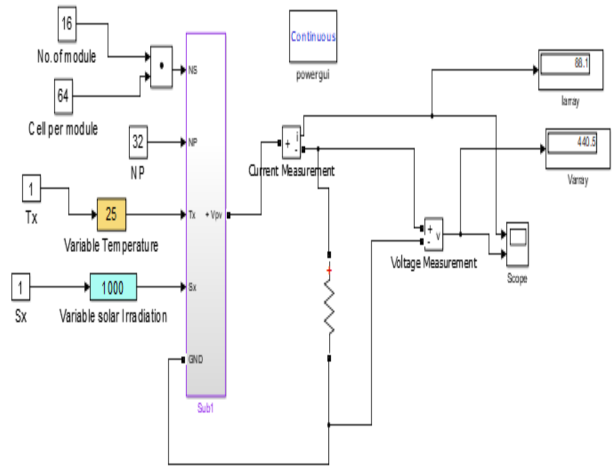

Figure 6: Solar PV Simulink Model

A simple arrangement of SPV modules is considered for analysis purpose. Here, 32 solar panel consisting 64 cell design is used .It is expected to obtain 35kW output power from solar PV. The Simulink result shows the output voltage of 440V and output current of 81A DC.

4.2. Modelling of FCMLI

The power electronic switches are used for turning the system OFF and ON according to the required output level. The flying capacitors become charged and release the signal for keeping up the various levels. The nine level output is obtained for PV system and delivered it to the load, the entire simulation scheme of 9-level FCMLI is shown in figure 7.

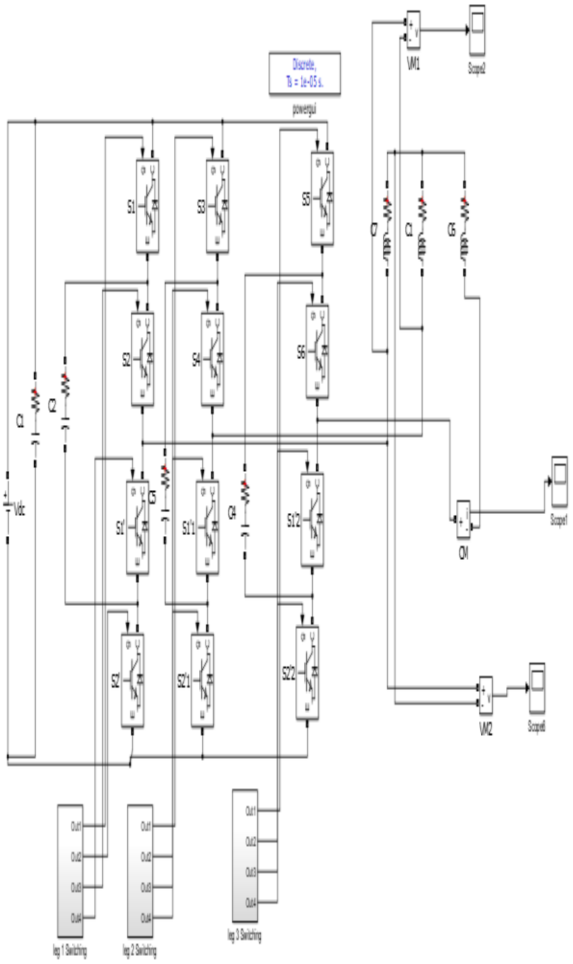

Figure 7. Simulink model of flying capacitor of multilevel inverter

V. SIMULATION RESULTS

The entire simulation is performed by using the parameters shown in the table1.The output wave forms of Simulink model is shown in figure

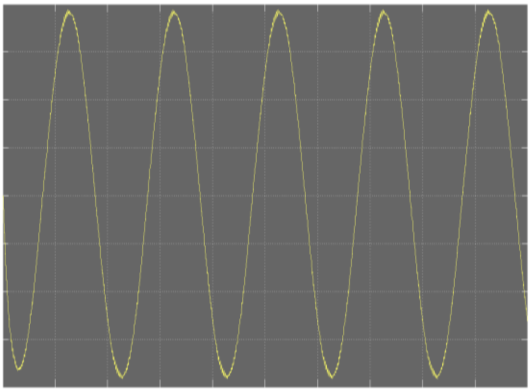

Figure8: Output of PV Current Waveform

Table 1: Simulation Parameters

S.No.	Particulars	Values
1.	PV Parameters	Pm-35kW,Vpv=440V,Ipv= 88 A 16 No. of modules 64 cell per module 32 No. of parallel modules
2.	RL-Load	P=1000W,Q=500 VAr
3.	Switching frequency	5kHz
4.	Output Frequency	50kHz

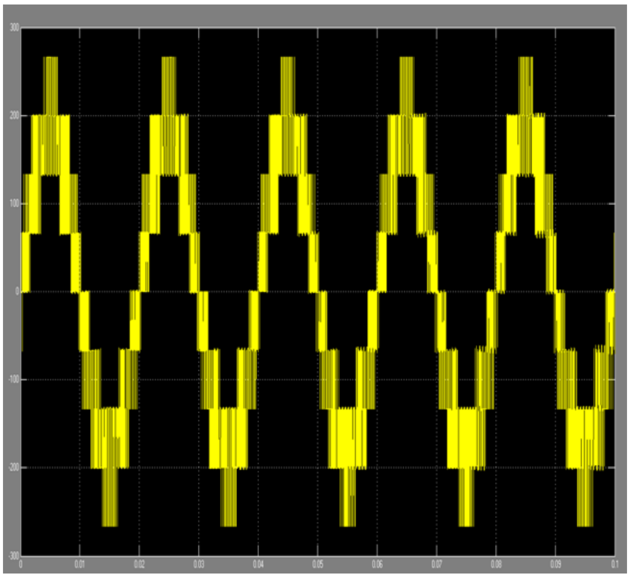

Figure 9: Inverter output Voltage (266 V) for 400V DC

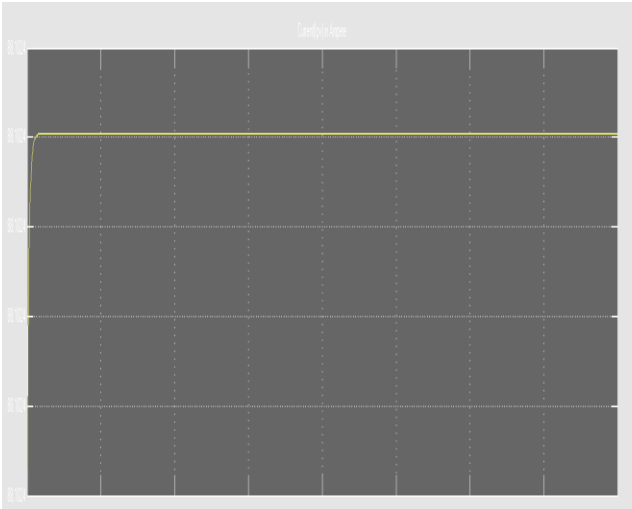

Figure10: PV Voltage output

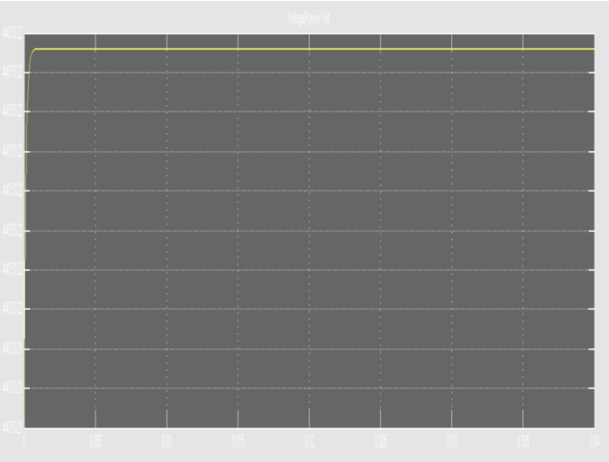

Figure 11: PV Current output

VI. CONCLUSION

The proposed system of FCMLI used for solar PV system is analyzed in this work. It is observed that less number of gate drivers and switches are used in the present scheme as compared to conventional multilevel inverter. It has better balancing of DC voltage and frequency output. In present structure of FCMLI produces twice RMS and increased output levels, this structure also reduces the numbers of flying capacitors. The simulated output provides an efficient, distortion less and lossless output level. The proposed structure has better understanding with the higher rating applications.

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