# ONLINE GRID INTEGRATED PHOTOVOLTAIC SYSTEM WITH NEW LEVEL INVERTER SYSTEM

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**Abstract -** This paper presents a single-phase five-level photovoltaic (PV) inverter topology for grid-connected PV systems. Two reference signals identical to each other with an offset equivalent to the amplitude of the triangular carrier signal were used to generate PWM signals for the switches. Operational principles with switching functions are analyzed. To keep the output voltage being sinusoidal and to have the high dynamic performances even in the cases of load variations. The validity the results proposed inverter is verified through MATLAB simulation

**Keywords - Grid -connected, photovoltaic (PV), Inverter, sine PWM**

## 1. INTRODUCTION

As the World's energy demand increases and resources become scarce, the search for alternative energy resources has become an important issue for our time. With advancements in power electronic technology, the solar Photovoltaic (PV) energy has been recognized as an important natural energy resource because it is clean, abundant and pollution free. . The photovoltaic (PV) system technologies are rapidly expanding and have increasing roles in electric power technology and regarded as the green energy of the new century. PV is world's fastest-growing energy technology. Photovoltaic(PV) is best known as a method for generating electric power by using solar cells to convert energy from the sun into electricity. The total solar energy absorbed by Earth's atmosphere, oceans and land masses is approximately 3,850,000exa ($10^{18}$) joules (EJ) per year. To operate PV array at maximum power point different algorithm are used in the buck boost converter and output DC is obtained which can be converted in to AC by using the inverter Multilevel inverters are considered today the most suitable power converters for high voltage capability and high power quality demanding applications [2]. PWM inverter can control their output voltage and frequency simultaneously. And also they can reduce the harmonic components in load currents.[1] The power-electronic technology plays an important role in the power-supply reliability and quality.[3]

## 1. PV SYSTEM

The photovoltaic system technologies are rapidly expanding and have increasing roles in electric power technology and regarded as the green energy of the new century. PV is world's fastest-growing energy technology. A solar cell or photovoltaic cell is a device that converts light directly into electricity by the photovoltaic effect. The working point of the solar cell depends on temperature and solar insulation. The I-V characteristics at short circuit and open circuit voltage conditions are as shown in Fig.1 In I-V characteristics is Maximal Power Point (MPP) is very important. At higher solar insulation even the cell temperature increases, and consequently decreasing the output power. As a measure for solar cell quality fill factor (F.F) is used. It can be calculated with the following equation

$$F.F = \frac{Impp \times Vmpp}{Isc \times Voc} \quad (1.1)$$

Where Impp - MPP current (A), Vmpp - MPP voltage (V), Isc- short circuit current (A), Voc- open circuit voltage (V).

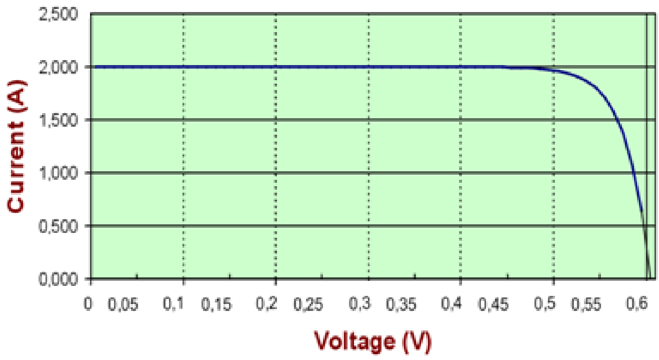


Fig.1 Solar cell I-V Characteristics

## 2. BOOST CONVERTER

A boost converter (step-up converter) is a power converter with an output DC voltage greater than its input DC voltage. Boost converter circuit as shown in fig.2,

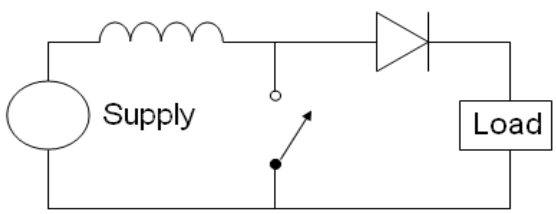


Fig.2 Boost converter circuit

It is a class of switching-mode power supply (SMPS) containing at least two semiconductor switches (a diode and a transistor) and at least one energy storage element. Filters made of capacitors (sometimes in combination with inductors) are normally added to the output of the converter to reduce output voltage ripple. The DC-DC Switching Boost Converter will take a 5 Volt DC voltage supply with ±10 % tolerance and deliver 12 Volts across the load. The maximum output ripple will be 2% of the output voltage, while the maximum current delivered to the load will be 100mA. The circuit will operate with a minimum efficiency of 70%.

## 3. MAXIMUM POWER POINT TRACKING

Tracking the maximum power point (MPP) of a photovoltaic (PV) array is usually an essential part of a PV system. As such, many MPP tracking (MPPT) methods have been developed and implemented. The methods vary in complexity, sensors required, convergence speed, cost, range of effectiveness, implementation hardware, popularity, and in other respects [9]. They range from the almost obvious (but not necessarily ineffective) to the most creative (not necessarily most effective). In fact, so many methods have been developed that it has become difficult to adequately determine which method, newly proposed or existing, is most appropriate for a given PV system. The MPP tracking process is shown in Fig.3 The starting points vary, depending on the atmospheric conditions, while the duty cycle is changed continuously, according to different algorithm, resulting in the system steady state operation around the maximum power point. The battery voltage is monitored continuously and, when it reaches a predetermined level, the battery charging operation is stopped in order to prevent overcharging P&O method is widely used in PV systems because of its simplicity and easy of implementation. However, it presents drawbacks such as slow response speed, oscillation around the MPP in steady state, and even tracking in wrong way under rapidly changing atmospheric conditions [10]

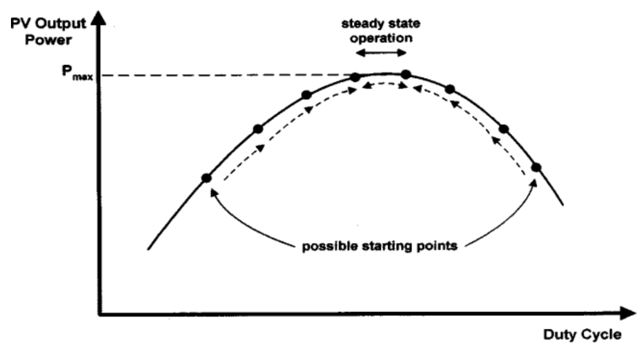


Fig.3 MPP Tracking Process

## 4. MULTILEVEL INVERTER

Multilevel inverter systems are generally classified as diode-clamping inverters, cascade inverters, and flying-capacitor inverters. Among multilevel inverters, the three-level diode-clamped inverter, which is called the neutral point clamped (NPC) inverter, has been commonly used [5]. However, it is difficult to control real power flow for balancing the neutral-point potential. Moreover, its extension to multilevel is limited by the additional clamping diodes. On the other hand, the flying-capacitor inverter has a demerit in that it needs additional flying capacitors, and requires the balancing control of flying-capacitor voltages [6]-[7].However, these capacitors may have a smaller than dc-link capacitor in capacity and there are two switch states to control the charging and discharging voltage of the flying capacitors. Hence, the flying-capacitor inverter may be another choice to extend to multilevel, together with the cascade inverter.

Single-phase inverters adopt the full-bridge type using approximate sinusoidal modulation technique as the power circuits. The output voltage of them has three values: zero, positive and negative supply dc voltage levels. Therefore, the harmonic components of their output voltage are determined by the carrier frequency and switching functions. Moreover, the harmonic reduction of them is limited to a certain degree. Under these technical backgrounds, this paper presents a single-phase five-level PWM inverter whose output voltage has five values: zero, halfand full supply dc voltage levels (positive and negative, respectively), so called a five-level single-phase PWM inverter. The proposed inverter can reduce the harmonic components compared with that of traditional full-bridge three-level PWM inverter under the condition of identical supply dc voltage and switching frequency [1]

## 6. THE OPERATIONAL PRINCIPLE OF PROPOSED INVERTER

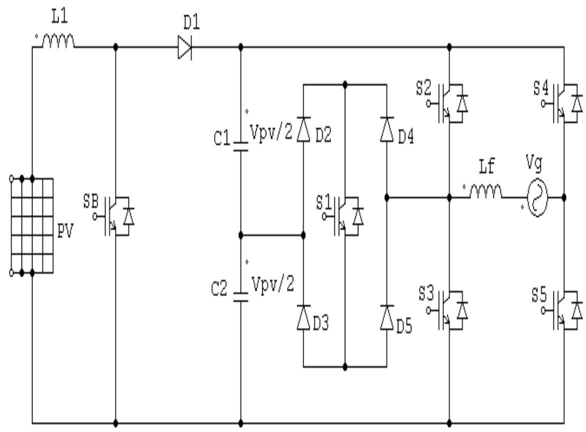


Fig.4 Single phase five-level inverter

Fig. 4 shows a configuration of the proposed single-phase five-level PWM inverter. One switching element and four diodes added in the conventional full-bridge inverter are connected to the center-tap of dc power supply. Proper switching control of the auxiliary switch can generate half level of dc supply voltage. The additional switch must be properly switched considering the direction of load current. The switching patterns adopted in the proposed inverterare illustrated in Fig. 5, and the output voltage levels according to the switch on off conditions are shown in Table I. Basic principle of the proposed switching strategy is to generate gate signals by comparing the reference signal with the two carrier waves having same frequency and in phase, but different offset voltages. Largely, there are two switching methods according to the output voltage levels. If the required output voltage for a certain load can be produced using only the half of dc bus voltage, only the lower carrier wave is compared with the reference signal the lower dc bus voltage is used to generate the output voltage. Namely, the modulation index is equal or less than 0.5, the behavior of proposed inverter is similar to the conventional full-bridge three-level PWM inverter [1]

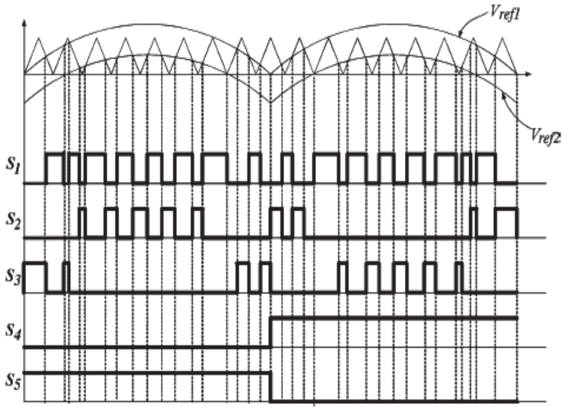


Fig.5 switching pattern for the Single phase five –level inverter

Two reference signals *V*ref1 and *V*ref2 will take turns to be compared with the carrier signal at a time. If *V*ref1 exceeds the peak amplitude of the carrier signal *V*carrier, *V*ref2 will be compared with the carrier signal until it reaches zero. At this point onward, *V*ref1 takes over the comparison process until it exceeds *V*carrier. This will lead to a switching pattern, as shown in Fig. 8. Switches S1–S3 will be switching at the rate of the carrier signal frequency, whereas S4 and S5 will operate ata frequency equivalent to the fundamental frequency.

Table I illustrates the level of *V*inv during S1–S5 switch on and off.

| S1 | S2 | S3 | S4 | S5 | Vinv |
|---|---|---|---|---|---|
| ON | OFF | OFF | OFF | ON | +Vpv/2 |
| OFF | ON | OFF | OFF | ON | +Vpv |
| OFF | OFF or (ON) | OFF or (ON) | ON or (OFF) | ON or (OFF) | 0 |
| ON | OFF | OFF | ON | OFF | -Vpv/2 |
| OFF | OFF | ON | ON | OFF | -Vpv |

**Inverter Output Voltage during S1-S5 Switch ON and OFF**

## 7. SIMULATION RESULTS

Fig.6 shows a simulation model of the proposed single-phase five-level inverter .The PV array converts the solar radiation into electrical power. This is fed to the dc-dc boost converter, through dc link inductance. This inductance is used to obtain steady direct current from the PV panels. From boost converter it is connected to full bridge inverter. The inverter transfers the power from the PV panels to the utility grid via the auxiliary circuit. Here full bridge inverter consists four switches i.e S2, S3, S4, S5. In positive half cycle, S2 and S5 conducting. In negative half cycle, S3 and S4

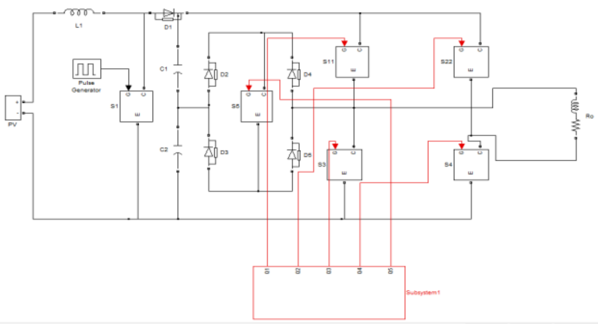

**Fig.6 Overall simulation model of single phase five level inverter**

Conducting. By giving proper firing angles to the power electronic switches of inverter, setting the simulation parameters, simulation time and then simulating the inverter, the switching pulse pattern as shown fig.7 pulses are generate for current of inverter as shown fig.8

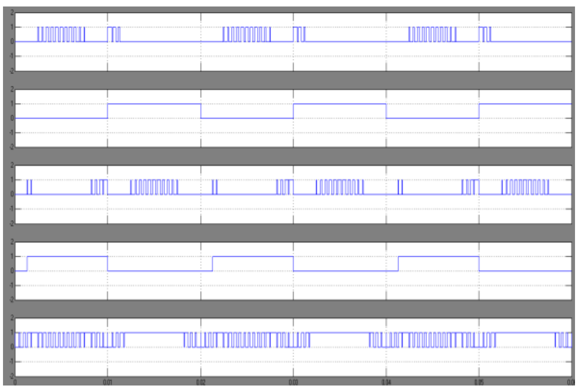

**Fig.7 Switching Pulse pattern**

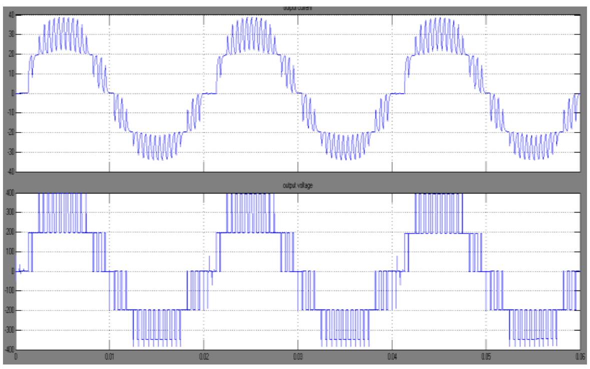

**Fig. 8 output voltage and current of inverter**

## 8. CONCLUSION

This paper presents a single-phase five-level inverter to reduce the harmonic components of output voltage and load current. The operational principles and the switching functions are analyzed in detail. It utilizes two reference signals and a carrier signal to generate PWM switching signals. As the number of levels increased THD will be less.

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## BIOGRAPHIES

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