



Transformerless PV Three Level NPC Central Inverter

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Abstract. Generally inverter is developed with centre on high reliability, low cost and mass-production for transformed electrical energy from the PV module to the grid. Basically the DC/AC inverters are used in grid connected photovoltaic energy production systems as the power processing interface between the electric grid and the photovoltaic energy source. The energy injected into the electric grid by the photovoltaic system depends on the amount of power extracted from the photovoltaic power source and the efficient processing of the DC/AC inverter power. Our future energy sources are renewable energy sources, one of the renewable energy is solar energy, so there is need to convert these energy forms into electrical energy efficiently. Generally solar to electrical energy conversion efficiency is very less. The conversion process has different stages at each stage there will be some energy loss. In solar system dc-ac conversion is one of the stages in these paper three level NPC converter is used. In this paper explain the basic idea about conversion DC voltage of PV in AC voltage by use The three level NPC inverter.

Keywords: Photovoltaic system (PV) · Three level NPC converter · SPWM · THD

1 Introduction

Recent year renewable energy sources, like wind, tides, solar, geothermal heat, biomass etc., are advantageous for electrical power generate due to the friendly environmental nature and infinite existence. Recent year energy policies and global warming have become a main topic on the international agenda. Today developed countries are trying to mitigate the greenhouse effect [1]. In this circumstance, generation of photovoltaic power has an important role to play due to the fact that it is a green source. Solar photovoltaic array generates DC power at its maximum by using boost converter with while power inverter converts this DC power to AC power and feeds to utility grid. Requirement of renewable energy sources is rapidly increasing because of the high cost and limited conventional energy sources as gas, oil, coal and multilevel inverters are more reliable to interface with renewable energy sources than a conventional two-level inverter for a high power application in aspects of better quality of power [2, 10], further more multilevel Inverters have become more popular over the years in application of

electric power with the secure of less disturbances outputs and the possibility to function at higher switching frequencies other than ordinary two-level inverter [2].

2 The Different Photovoltaic Sectors

2.1 Crystalline Silicon Solar Cell

Crystalline silicon photovoltaics is the most widely used photovoltaic technology. Crystalline silicon photovoltaics are modules built using crystalline silicon solar cells (c-Si), developed from the microelectronics technology industry. Crystalline silicon solar cells have high efficiency, making crystalline silicon photovoltaics an interesting technology where space is at a premium (Fig. 1).

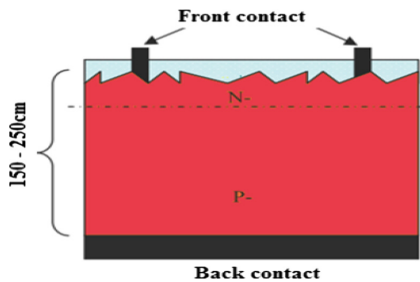


Fig. 1. Schematic diagram of a cell based on crystalline silicon.

2.2 High-Efficiency Multijunction Solar Cells

Today, most inorganic photovoltaic cells consist of a single PN junction. In this junction, only photons whose energy is equal to or greater than the forbidden band of the material (denoted E_g in eV) are capable of creating electron-hole pairs. In other words, the photovoltaic response of a single junction cell is limited. Only the proportion of the solar spectrum whose photon energy is greater than the absorption gap of the material is useful, the energy of the lower photons is therefore not usable.

On the other hand, even if the energy of the photons is sufficient, the probability of meeting an electron is low. Thus, most photons pass through the material without having to transfer their energy. A first response to limit losses has long been known from the technological point of view, it is sufficient to use multi-level systems, stacking junctions with decreasing gaps, (Fig. 2). Thus it is possible to exploit almost all the solar spectrum with very high conversion efficiencies [11].

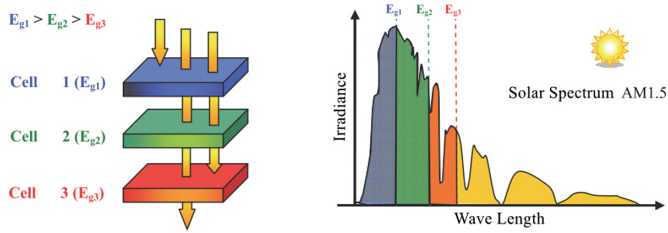


Fig. 2. Schematic diagram of a cell based on crystalline silicon. [11]

2.3 New Photovoltaic Technologies

Other research has focused on an organic and inorganic photovoltaic cell model (hybrid cells) that offers many advantages over traditional cells. Thus, a nanocrystal line cell has been developed that mimics photosynthesis of plants. Used for a long time in dye lasers or optical materials, the efficient use of organic dye molecules in photovoltaics was discovered in 1991 by Michael Graetzel. Pigmented organic molecules (dye) absorb light and release electrons. The electrons are transported to the anode by a porous layer of titanium dioxide (TiO_2), an inorganic semiconductor material. At the anode, the electrons are directed to an external circuit where their passage produces electrical energy [12, 13] (Fig. 3).

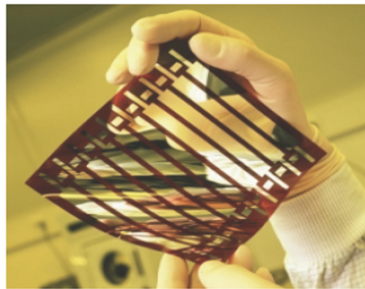


Fig. 3. All organic solar cell on flexible substrate [11]

3 The PV-Load Generator Connection via a DC-AC Adapter Stage

There are different management topologies for these installations. Nevertheless, all of these approaches rely on grid-connected GPVs through inverters that transfer and shape electrical solar energy. The progress made in recent years in the development of inverters dedicated to photovoltaics has made it possible to significantly change these management systems. there are mainly three UPS architectures giving good technical solutions: the central inverter, strings inverters and inverters integrated into the panels, (Fig. 4).

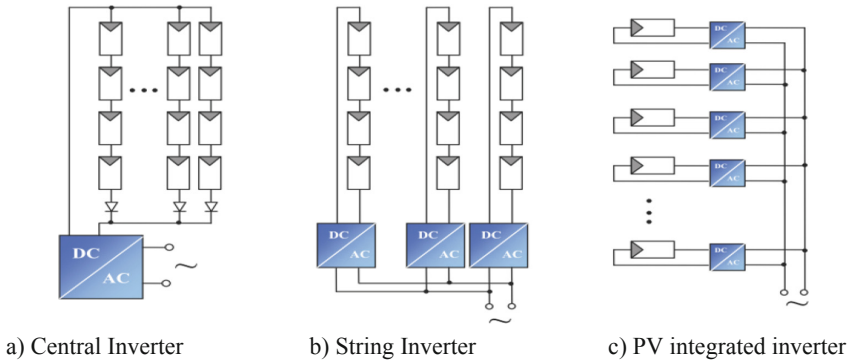


Fig. 4. Schematic diagrams of different topologies of PV installations connected to an electrical network [11].

In this case we used the central inverter, the various solar panels for a large installation are mounted in rows to form a string, which is itself coupled in parallel with non-return diodes to several others, Fig. 4a. The high power PV generator thus structured is connected on the DC side to a single inverter. This central inverter is highly energy efficient at reduced costs. The main function of this device is to create an AC voltage from a DC voltage most compatible with the network and to constantly examine the presence or absence of the network to allow the injection of current. The conventional structure of the inverter is often a bridge circuit for connecting each of the two input poles to each of the two output poles by means of power switches.

Solar array consists of solar module connected in series and parallel. A single solar module is constructed with a number of cells depending upon the capacity of module. The cells operate at a low voltage, ranging from less than 1 V (PV cell) to 3 or 4 V (Li-Ion cell). These low voltages do not interface well to existing high power systems, so the solar cells are series connected to create a battery or a PV module with a higher voltage terminal [8, 9].

3.1 Maximum Power Tracker Controller

The algorithm implemented in the first MPPT commands was relatively simple. Indeed, the capabilities of microcontrollers available at the time were low and applications, especially for the space had much less constraints in temperature and illumination variation than terrestrial applications. Applied initially to photovoltaics, its principle was first described by A. F. Boehringer. This command is based on an adaptive control algorithm, keeping the system at its maximum power point (PPM). The latter is described in Fig. 5 and can be implemented entirely in digital.

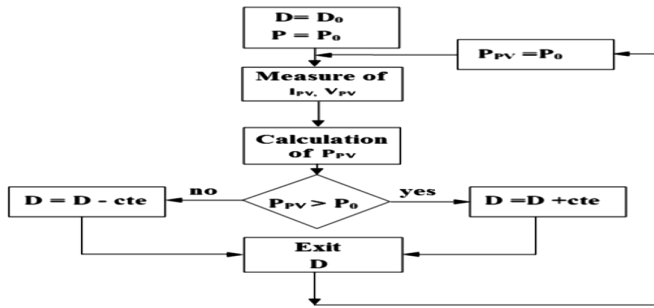


Fig. 5. Principle of MPPT control

4 Multilevel Inverter Topology

The basic three types of multilevel topologies are [3, 4]:

- Diode clamped multilevel inverters
- Flying capacitors multilevel inverter or capacitor clamped multilevel inverter
- Cascaded inverter with separate DC sources.

4.1 Three-Level Diode Clamped Inverter

Usually simple two-level inverters are generally used to generate an AC voltage from a DC voltage. Working of the two-level inverter can create only two different output voltages for the load is $+V_{dc}/2$ and $-V_{dc}/2$ (This is consider when the inverter is fed with V_{dc}). The basic circuit diagram of 3-level diode clamped inverters as illustrate in Fig. 6 does not depend on just two levels of voltage to generate an AC signal. When we get the smoother waveform, the more voltage levels generated in the inverter. However if many levels of voltage will make raise the complexity of the circuit, with more apparatus and a more complications the controllers for the inverter are required and being used [6].

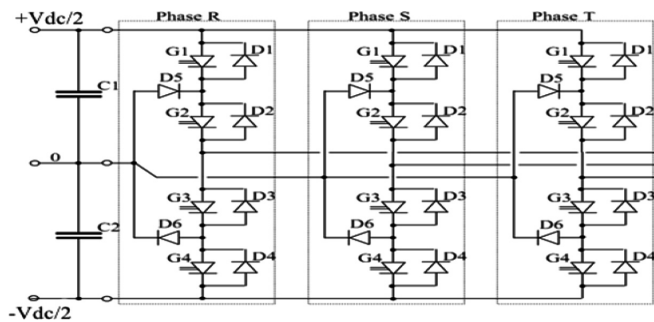


Fig. 6. Circuit arrangement for three-level diode clamped inverter for single phases.

In neutral point clamp topology or diode clamp topology, multilevel inverter diodes have been apply as a clamping device to generate required output voltage levels [5]. In 3-level diode clamp inverter, the duty cycle for switches ON/OFF is done shown in Table 1 [5].

Table 1. Switching modes of 3-level inverter for phase R.

| Magnitude of voltage (VDC) | No. of switches to be on/off | | | |
|----------------------------|------------------------------|-----|-----|-----|
| | S1 | S2 | S3 | S4 |
| +Vdc/2 | On | On | Off | Off |
| 0 | Off | Off | On | Off |
| -Vdc/2 | Off | Off | On | On |

4.2 Control Technique: Sinusoidal Pulse Width Modulation (SPWM)

For the switching techniques inverters that use pwm techniques have a dc input voltage that is always constant in magnitude. The inverter will acquire this as an input voltage and output ac where the frequency and magnitude can be controlled as per the requirement. There are various ways by which pwm can be implemented to make the output to be ac. A widespread technique known as spwm (sinusoidal pulse width modulation) has been used and discussed here. In order to get output as a sinusoidal waveform for 7-level inverter at a definite frequency a sinusoidal control signal (vsine) at the definite frequency is compared with a (m-1) triangular waveform (vtri). Here, m is number of inverter level (2, 3, 4, ..., etc.). Usually the inverter will use than the frequency of the triangle wave as the switching frequency which is essentially kept constant [5–7] (Figs. 7 and 8).

5 Simulation and Results

The studied system is presented in Fig. 9; The output power of solar array depends upon solar irradiance (in KW/sq.), cell temperature and area of array. Here total 300 modules have been used (connected in series) each having 54 solar. The rating of solar panel is tabulated in Table 2.

Table 2. Solar panel rating.

| | |
|---------|--------|
| Voltage | 32.9 V |
| Current | 8.21 A |
| Power | 270 W |

The PV arrays output is gives as input to the inverter and Fig. 9 shows the I-V Characteristics of the solar cell here Alternate phase opposition displacement Sinusoidal Pulse Width Modulation Scheme is used to generate the control signals for the inverter Fig. 11 shows the modulation scheme diagram (Fig. 10).

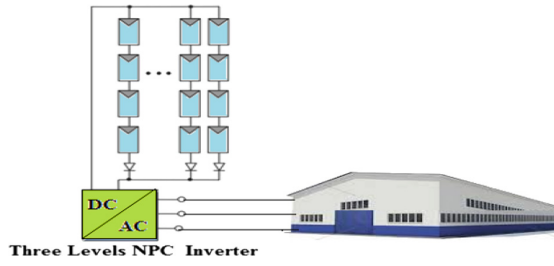


Fig. 7. Studied system.

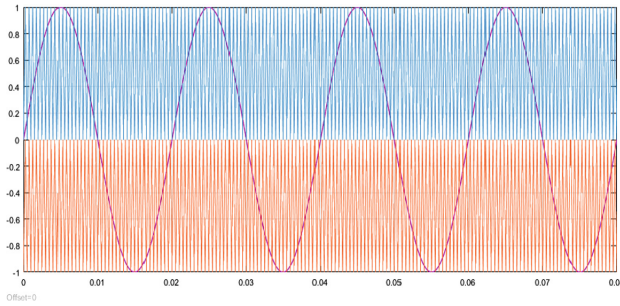


Fig. 8. Comparison of carrier signals and reference for SPWM generation.

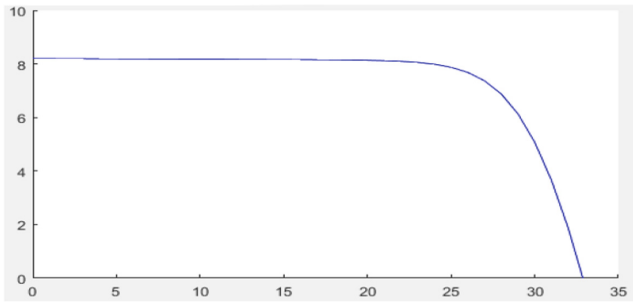


Fig. 9. Current and voltage (I-V) characteristic of the solar cell.

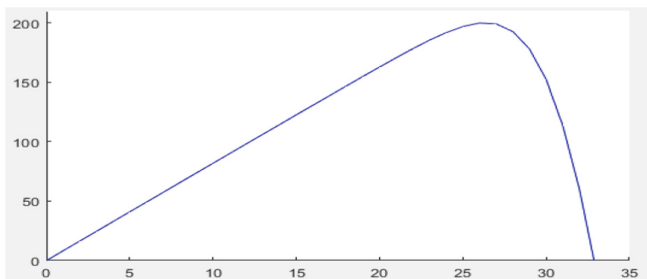


Fig. 10. Power and voltage (P-V) characteristic of the solar cell.

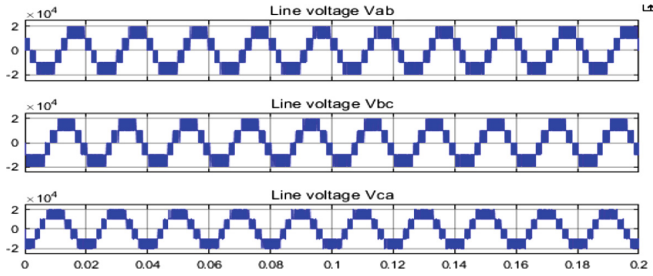


Fig. 11. Output line voltage waveform of three level NPC converter.

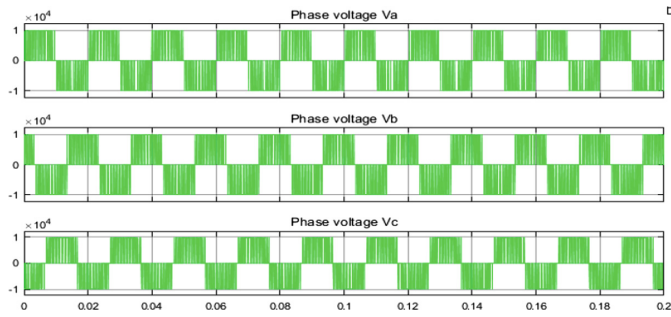


Fig. 12. Waveform of phase voltage across the switches.

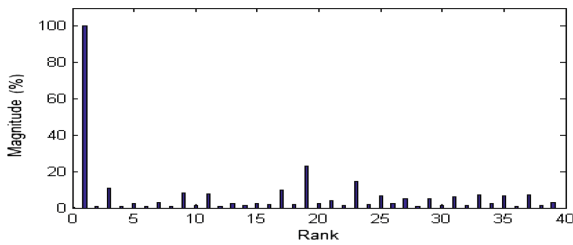


Fig. 13. Total harmonic distortion of the three level NPC converters for phase displacement sinusoidal pulse width modulation, for switching frequency $f_s = 2$ kHz, reference wave frequency $f_r = 50$ Hz.

According to the spectral analysis of each one of these results, that the increase of the levels of the converter makes it possible to have a better quality of the signal; and a more sinusoidal look; and following several scientific researches that this quality does not change in case of more than nine levels, the major disadvantage of these structures remains economic (Figs. 12, 13 and 14).

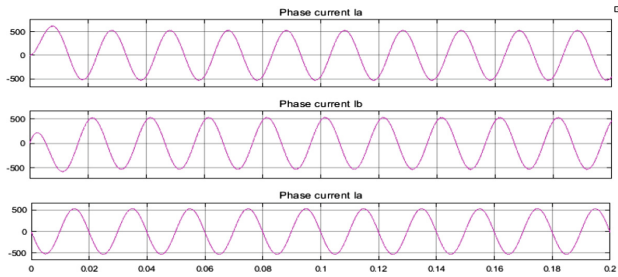


Fig. 14. Load current waveform of 3 phase for $R = 10$ ohms, $L = 50e-3$ H.

6 Conclusion

The paper has existing the model of the 3-level diode clamped inverter for solar application along by using SPWM modulation techniques and simulation is done by using MATLAB. By doing different analysis on basis of MATLAB results. Here a complete design of solar power system in open loop has been done to feed required power in grid system with appropriate number of solar module connected in series. Also different level of inverters have been used to reduce the harmonics and filter, to achieve sinusoidal waveform by NPC three level inverter.

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