

# A Review of Inverter Design for PV System

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**ABSTRACT:** photovoltaic panels which are connected to the utility grid energised the grid connected photovoltaic power systems. Grid connected power systems consist of photo voltaic panels, Power conditioning units, controllers, MPPT, Solar inverters, filter, and Grid connection equipments. Solar PV generation depend upon weather condition and require storage system during night. However, with the use of MPPT technology, the PV system can generate maximum power at different weather condition and feed to utility grid without using any storage system. The multilevel inverter has gained much attention in recent years due to its advantages in lower switching loss, better electromagnetic compatibility, higher voltage capability, and lower harmonics. Solar Energy is one of the favourable renewable energy resources and the multilevel inverter has been proven to be one of the important enabling technologies in photovoltaic (PV) utilization. Solar energy is free source of energy but it is seasonal in nature. Photovoltaic (PV) power systems are getting more and more widespread with the increase in the energy demand and the concern for the environmental pollution around the world.

**KEYWORDS:** Solar Inverters, Controllers, Filter.

## I. INTRODUCTION

The direct current to alternating current inverter concepts is used for photovoltaic applications. The PV module is capable of generating electric DC power, when exposed to sunlight. Inverter where the load is the low-voltage AC utility network and the source is a single PV module. The photovoltaic effect is the basic physical process through which a PV cell converts solar energy directly into electricity. PV technology works when sun is shining, but more electricity is produced when the light is more intense and when it is striking the PV modules directly. When the rays of sunlight are perpendicular to the PV modules, PV cell produces more electricity. Sunlight is composed of photons, or bundles of radiant energy. When photons strike a PV cell, they may be partly reflected, absorbed, or transmitted through the cell. PV cells are available in many shapes and size. The most common shapes are circles, rectangles, and squares. The size and the shape of a PV cell, and the number of PV cells required for one PV module, depend on the material of which the PV cell is made. Due to low voltage of the individual solar cell several cells are connected in series for manufacture of a laminate. Then the laminate is assembled into a protective weather proof enclosure thus making a PV module. Modules are then strung together into a photovoltaic array. A photovoltaic array is a linked assembly of PV modules. Most of the PV array uses an inverter to convert the dc power produced by the modules into alternating current. The modules in a PV array are connected in series to obtain the required voltage, the individual string are then connected in parallel to produce more current. A solar or PV inverter converts direct current (DC) output of the photovoltaic solar panel into a utility frequency alternating current. It is a critical component in the photovoltaic system allowing the use of ordinary commercial appliances.

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## II. DESCRIPTION OF PHOTOVOLTAIC SYSTEM

The solar cell is the main unit of a photovoltaic module. It is the element which is used for converting the sun rays or photons directly into electric power. The solar cell used is the P-N junction, whose electrical characteristics are slight different from a diode.

Applications of photovoltaic are-

Domestic buildings lighting and general power, Industrial Buildings Lighting, general power and process equipment, General Alarms for remote buildings, Area lighting CCTV Advertising, Leisure Boats, Electric boat, Battery charging (lighting & TV) Camping & Remote Homes, Commercial Buildings Lighting and general power.

Fig. 1 shows the block diagram of a photovoltaic system, which consist of solar photovoltaic panel with DC to DC converter, single phase inverter and load. The solar photovoltaic panel produces electricity when the sun light incident on the photovoltaic cell array. The output of the photovoltaic panel is directly connected to the DC to DC boost converter to step up the DC output of photovoltaic panel. Then it is goes to an inverter which converts DC into AC power at the desired voltage and frequency. A current controller is normally preferred due to its advantages like flexibility in design and modify easily through of software. The mechanism behind the photon to electron conversion inside the PV module is also described.

The power electronic interface for PV-grid systems has following main tasks:

It amplify and invert the generated DC power into a suitable AC current for the grid. A standard PV module generates approximately 100 W to 150 W at a voltage around 23 V to 38 V, whereas the grid mostly requires 110V at 60 Hz or 230 V at 50 Hz. To control the PV module so as to track the Maximum Power Point (MPP) for maximizing the energy capture. Both tasks must be made at the highest possible efficiency, over a wide power range, due to the morning-noon-evening and winter-summer variations. The maximum power point is tracked by means of a maximum power point Tracker (MPPT) device. The inverter has been optimized in respect to cost, reliability, efficiency, and a prototype has been build and tested. The MPPT Control, which the main property is to extract the maximum power from the PV generator.

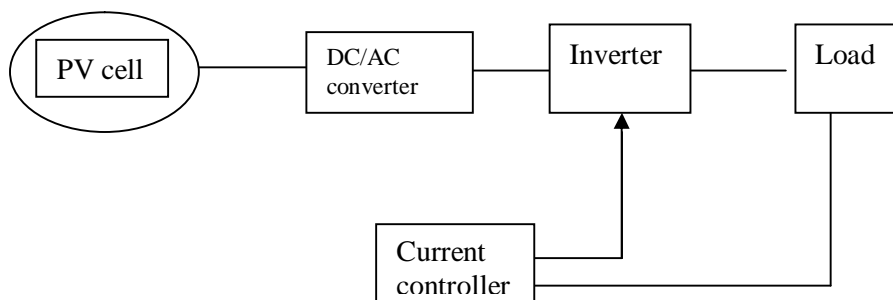


Fig.1. Block diagram of photovoltaic system

## III. MULTILEVEL INVERTER

Multilevel inverters can increases power than that of two-level inverter through the series connection of power semiconductor devices without additional circuit to have uniform voltage sharing. The general structure of the multilevel converters is to synthesize a near sinusoidal voltage from several levels of dc voltages, typically obtained from capacitor voltage sources. As the number of levels increases, the synthesized output waveform has more steps,

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which produce a staircase wave that approaches a desired waveform. Also, as more steps are added to the waveform, the harmonic distortion of the output wave decreases, approaching zero as the number of levels increases.

The multilevel inverters can be classified into three categories:

**1) Diode-Clamped Multilevel Inverter-**The diode-clamped multilevel inverter employs clamping diodes and cascaded DC capacitors to produce AC voltage waveforms with multiple levels. The diode clamped inverter uses half bridge version in each level. However, it is difficult to control voltage of each capacitor constituted DC-link beyond four levels. It is hard to be expanded to high level systems structurally due to large number of clamping diodes. The diode clamped inverter is most suitable for the back-to-back inertia system operating as a unified power controller.

**2) Flying Capacitor Multilevel Inverter-**A multilevel inverter is an electrical device that converts a DC power supply into an AC power supply. Multilevel inverter converts number of DC supplies into AC supply. The DC source can come from anywhere like solar energy or wind energy.

A quite well-known topology of multilevel inverter is Flying Capacitor Multilevel Inverter. It is quite similar to diode clamped multilevel inverter. This type of multilevel inverter requires capacitor to be pre-charged.

**3) Cascaded Multilevel Inverter-**Cascaded multilevel inverters synthesize a medium-voltage output based on a series connection of power cells which use standard low-voltage component configurations. This characteristic allows one to achieve high-quality output voltages and input currents and also outstanding availability due to their intrinsic component redundancy. Due to these features, the cascaded multilevel inverter has been recognized as an important alternative in the medium-voltage inverter market.

## Advantages of Multilevel Inverter:

1. Common Mode Voltage:

The multilevel inverters produce common mode voltage, reducing the stress of the motor and don't damage the motor.

2. Input Current:

Multilevel inverters can draw input current with low distortion

3. Switching Frequency:

The multilevel inverter can operate at both fundamental switching frequencies that are higher switching frequency and lower switching frequency. It should be noted that the lower switching frequency means lower switching loss and higher efficiency is achieved.

4. Reduced harmonic distortion:

Selective harmonic elimination technique along with the multilevel topology results the total harmonic distortion becomes low in the output waveform without using any filter circuit.

## IV. SPECIFICATIONS, STANDARDS, & TEST OF PV INVERTER

Power electronics inverters are necessary to transform DC into AC current then inject to the grid the energy delivered by the PV systems. Therefore, there are special standards and requirements concerning the connection of the PV to the grid. The rules and regulations set by the utility companies must be obeyed. These standards are to maintain the power quality produced by the photovoltaic distribution system. The grid-connected standards covered the topics about voltage, DC current injection, flicker, frequency, harmonics current, maximum current, total harmonics distortion (THD) and power factor.

**Voltage flicker:** The voltage flicker should not exceed the maximum limits.

**Power factor:** The standard power factor of a PV system should be 0.85 (lagging or leading). The grid connected PV inverter is designed in order to control current with a power factor unity. Sometimes the inverter may be used for reactive power compensation. Therefore, the inverter should be capable to control the output power factor.

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**DC component injection:** The DC current injected should be less than 0.5% of rated inverter output current into the utility AC interface. The DC current could produce affluence of the delivery converters within the grid. The topology has to be chosen along with the modulation scheme of the inverters should give an AC current with low level of harmonic distortion. High current harmonics can cause adverse effects on the equipment connected to the grid.

**Reconnect after disturbance:** The PV system should not be reconnected until continuous normal voltage and frequency are maintained by the utility for a minimum of 5-6 minutes, at which time the inverter can automatically reconnect.

**Frequency:** The PV systems should stay synchronized with the grid. The PV systems should have a fixed frequency between 59.3 – 60 Hz. For small PV systems, the frequency trip should be 59.2 Hz and 60.6 Hz.

Some tests are performed in order to evaluate the following characteristics of inverter.

- 1) **Power factor:** The purpose of this test is to determine the power factor of the system and see if it is consistent with the international standards.
- 2) **AC voltage limits:** The purpose of this test is to determine the AC voltage limits (over/under voltage) at which the inverter stops operating.
- 3) **Standby losses:** The standby loss is defined as the consumption of utility power when the inverter is not operating but under standby conditions.
- 4) **Disconnections of AC power line:** The purpose of this test is to observe the inverter response under loss of grid connection.
- 5) **Disconnections of DC power line:** The purpose of this test is to observe the reaction of the inverter when the DC power line is suddenly disconnected.
- 6) **Current harmonics:** In general the operation of the inverter should not cause excessive distortion of the grid voltage or result in excessive injection of harmonic currents into the grid.
- 7) **Field test:** The purpose of this test is to evaluate the performance of the inverter when connected to normally illuminated modules of different technologies. In this test many parameters such as energy efficiency, start up voltage, start up power, stop voltage and standby losses can be measured.

## V. CONCLUSIONS

PV modules are made by connecting PV cells which in series and parallel array. Hence PV module is important component which convert sunlight into DC power. PV module produces DC voltage upto 45 Volt and a typical maximum power of 160 Watt, depending solar irradiation. But mostly electrical appliances are based on AC voltage, with a few exceptions therefore PV modules directly connected to an inverter. The main task of the inverter isto inject a sinusoidal current into the grid.

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