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# Reduction of Harmonics in Solar fed Multilevel Inverter

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**Abstract**

The presence of harmonics in solar Photo Voltaic (PV) energy conversion system results in deterioration of power quality. To address such issue, this paper aims to investigate the elimination of harmonics in a solar fed cascaded fifteen level inverter with aid of Proportional Integral (PI), Artificial Neural Network (ANN) and Fuzzy Logic (FL) based controllers. Unlike other techniques, the proposed FLC based approach helps in obtaining reduced harmonic distortions that intend to an enhancementin power quality. In addition to the power quality improvement, this paper also proposed to provide output voltage regulation in terms of maintaining voltage and frequency at the inverter output end in compatible with the grid connection requirements. The simulations are performed in the MATLAB / Simulink environment for solar fed cascaded 15 level inverter incorporating PI, ANNand FL based controllers. To exhibit the proposed technique, a 3 kWp photovoltaic plant coupled to multilevel inverter is designed and hardware is demonstrated. All the three techniques are experimentally investigated with the measurement of power quality metrics along with establishing output voltage regulation.

***Keywords*** *- Harmonics, intelligent control, multilevel inverter, photo voltaic, power quality, voltage regulation.*

## I. INTRODUCTION

Sunlight based vitality age is one of quickest developing and most encouraging sustainable power wellsprings of intensity age around the world. These days, the electrical vitality ends up one of the fundamental needs in our day by day life, which makes expanding interest for it's a noteworthy wellspring of electrical power age petroleum derivatives are draining step by step and furthermore its use raises genuine natural concerns. These reasons force the development of new energy sources which are renewable and ecologically safe. The renewable energy sources include wind, solar, water, biomass and geothermal energy sources.Out of which, solar energy has the greatest potential in the long term and is predicted to play a major role in coming years. It is theleast expensive technique for creating power contrasted and other vitality sources. Sun based power is the transformation of sun radiation into power using sun oriented photovoltaic cells. This conversion takes place in the solar cell by photovoltaic effect. As said by numerous specialists that the measure of sunlight-based vitality arriving at the earth is in excess of multiple times the presentvitality utilization by man .Also, the power created by solar is sufficient for one year for the entire planet, if we could convert the 100 percent of the solar energy into electricity in one hour. There are a few applications that utilization sun-based power, here is the data on the age of power through PV cells. The sun-

oriented power age is the most effective course for power age since it makesa base number of strides (for delivering power) than that of other age techniques. There are two different ways of changing over daylight into power. In one strategy, sun-oriented vitality is utilized just as a wellspring of warmth. This warmth is additionally used to create the steam, which drives the steam turbine. This strategy for power age is called sunlight based warm control age. In the subsequent technique, sun-based vitality is legitimately changed over into power utilizing PV (or sunlight based) cells as referenced previously. The PV cell is comprised of silicon semiconductor material. A portion of the components for picking the sun-based power age are recorded underneath. Solar energy is available freely and conveniently in nature and it needs no mains supply.

1. Solar generation plant can be installed in a few months while the conventional power plants take several years to build an electricity generation plant.

2. Solar power is clean energy as it produces no air or water pollution. Also, there are no moving parts to create noise pollution. Unlike fossil fuels, no toxic emissions are released into the atmosphere during solar energy power generation.

3. Solar power has less running cost that means once the capital investment is made, there is no need for continues purchase of fossilfuels as the solar energy is effectively free in nature.

Looking at advantages of solar power generation, respective topic is selected for proposed work. The electricity generated from the solar panels is a Direct Current (DC), whereas the most electrical appliances work on Alternating Current (AC) and hencea converter is needed to convert DC to AC, nothing but an inverter. Also, if the solar system is connected to the grid, the generatedDC voltage must be converted into AC. So, the inverter equipment converts the DC voltage to the AC and to the same voltage as that of grid or appliance rating.

## II.TYPES OF SOLAR SYSTEM

### A. OFF- GRID SYSTEM

The solar panel was used to convert the available sun light into electrical energy. This was used to charge the battery via a charge controller. Then the stored energy in the battery in the battery is utilized to drive the DC loads. On the other hand, an inverter was connected with the battery for AC loads. After installation successfully, the system can produce the power and can possible to supplyit easily.

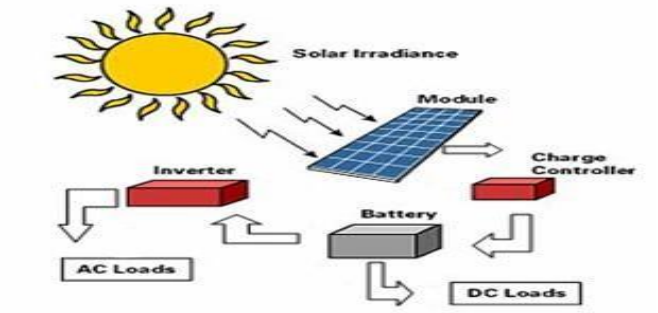


Figure 1.1 off- grid solar power system

### B. ON-GRID SYSTEM

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On-grid solar system is that of the system is connected to the grid (your present electricity provider) and you can run any load (ex. AC, lift or any other machinery) using this system. On-grid solar system does not contain battery. This kind of system does not run when there is power cut due to security issues. The main purpose of this system is the savings on electricity bill. Out of many kinds of solar systems, on-grid is the most preferred and economical solar system for industrial and commercial consumers. Electricity generated from the solar system is used to run the load. If the electricity generated by the solar system is greater than the consumption, the excess electricity is exported to the grid and monetary value of the exported electricity is deductedfrom the electricity bill. If the consumption is higher than that generated by the solar system, the remaining amount is taken from the grid. This is called imported electricity. This all happens automatically. No manual intervention needs. A new meter, called as the Net Meter, which is provided by the DISCOM to measure the imported and exported electricity. The amount of electricity generated from the solar system and that can be can be measured from the inverter of the system or using a separate meter. Here inproposed work Seven level inverter is proposed. A multi-level inverter is a power electronic device, which is built to synthesize a desired AC voltage from several levels of DC voltages. Multilevel inverters have been an important development in recent years, owing to their capability to increase the voltage and power delivered to the motor with semi-conductors which are available today.Multilevel inverters have gained more attention in high power applications because of it has got many advantages than conventional MLI. It can produce high voltage and high-power output by using semiconductor switches without the use of transformer and dynamic voltage balance circuits. When the number of output levels increases, harmonics of the output voltage and current as wellas electromagnetic interference (EMI) decrease proposed system is focusing on solar power generation using seven level inverters.

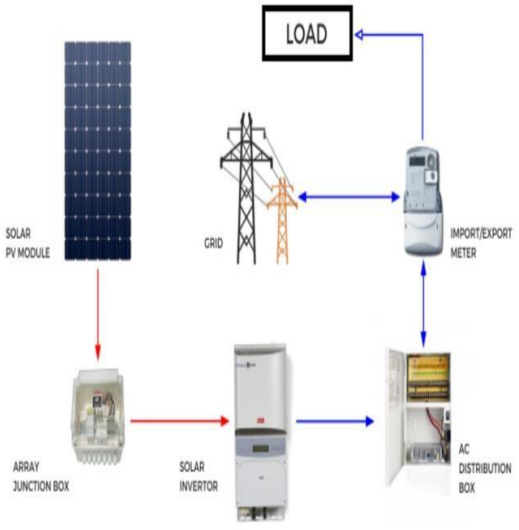


Figure 1.2 on- grid solar power

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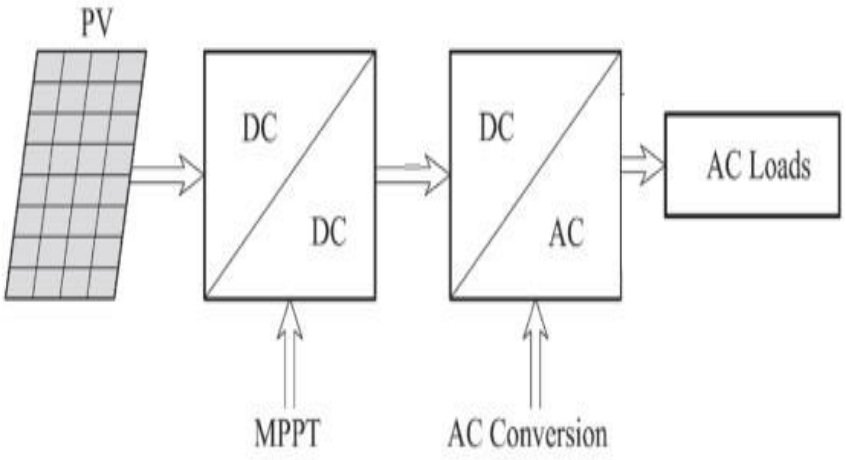
## III.OBJECTIVES

1) To interface Dc-Dc converter with solar PV array system and MPPT controller.
2) To Implement Maximum peak power tracking (MPPT) algorithm for tracing maximum solar power.
3) To Develop and Interface Seven level inverter with solar system in Mat lab.
4) To measure Total harmonic distortion at the output of proposed system.

## IV.METHODOLOGY

### A. MODULES OF THE SYSTEM




In Fig DC/DC converter is desired to track the MPP of the system. So, a special algorithm to determine the MPP of the System and vary the operating point of the system to the MPP all the time. This algorithm provides the MPPT. Different MPPT algorithms and methods are proposed which can be classified into two groups, called passive methods and active methods. Detachedstrategies utilize a few parameters, for example, the illumination level, board temperature, cut off, open-circuit voltage and some other module parameters straightforwardly or by using scientific conditions. Firstly, the parameters for the selected module are calculated and then the obtained data is used for MPPT. Although these methods are simple, low cost and removes the complex calculations, they cannot provide real MPPT, because the module parameters change with pollution or aging of the module.

The characteristics of the modules do not be taken into consideration while applying the active methods, so module independentMPPT is obtained. Such parameters like output current, voltage or power of the module and / or the converter circuit is to be monitored continuously to determine the operation point and if it is MPP or not. Since the active methods provide more actual results compared or passive methods, they are widely used. In which, different type of MPPT methods has been used. Perturb & Observe (P&O) method, Incremental conductance

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(IC) method, fuzzy logic control method, neural networks and parasit.

### B. BLOCK DIAGRAM OF PROPOSED SOLAR POWER GENERATION SYSTEM

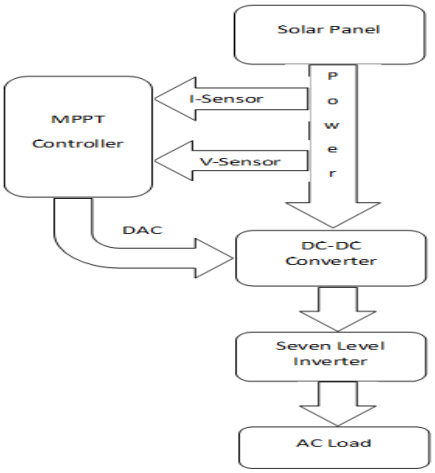


**Figure: Block Diagram of Proposed Solar Power Generation System**

The proposed system has following components:

1. Solar Panel
2. MPPT Controller
3. DC-DC Converter
4. Seven level Inverter
5. AC load

As shown in proposed system block diagram Solar panel is used as input source. The Dc power from input source is given to DC-DC converter. This converter boost input to specific level as well as MPPT controller maintains output power of DC-DC converterat maximum power point tracking using Incremental conductance algorithm. MPPT controller has feedback from voltage and current sensor. These feedbacks are utilized by incremental conductance algorithm as an input.

#### 1. Solar panel

A sunlight-based board is a bundled associated gathering of photovoltaic cells. The sunlight-based board can be

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utilized as a part of a bigger photovoltaic framework to create and supply power in business and private applications. Sun powered boards utilize light vitality photon from the sun to create power through the photovoltaic impact. The majority of modules use wafer-based cells or thin film cells based on non-magnetic conductive transition metals, telluride or silicon. Electrical associations are made in arrangement to accomplish an ideal yield voltage or potentially in parallel to give an ideal flow capacity. The directing wires that take the current off the boards may contain silver, copper or other nonmagnetic conductive change metals. The phones must be associated electrically to each other and to the remainder of the framework. Each board is evaluated by its DC yield control under standard test conditions, and ordinarily goes from 100 to 320 watts.

Contingent upon development, photovoltaic boards can deliver power from a scope of light frequencies, however for the most part can't cover the whole sun powered range (explicitly, bright and low or diffused light). Subsequently, a significant part ofthe episode daylight vitality is squandered by sun-oriented boards, and they can give far higher efficiencies whenever enlightened with monochromatic light.

The advantages of solar panels are,

1) They are the most readily available solar technology.
2) They can last a lifetime.
3) They are required little maintenance.
4) They operate best on bright days with little or no obstruction to incident sunlight.

## 2. MPPT Controller

MPPT stands for Maximum Power Point Tracking, which stands for the method these use to regulate charge. MPPT chargecontrollers utilize this strategy for charging, which basically discovers at some random condition, what is the most extreme

Working point for the boards current and voltage. With this strategy, MPPT controllers are really 94-99% effective. MPPT controllers have two unique highlights about them that will be referenced in the MPPT Charge Controller Sizing area. One is that they can acknowledge a high info voltage and step this voltage down to coordinate your battery bank voltage for a right charge. Two is that despite the fact that they bring down the voltage, they can recoup any potential lost power by means of a liftcurrent, which increment the amperage to make up for the lost voltage. MPPT Controllers will have an Amp perusing for it, forinstance a 40 Amp MPPT Controller. They will likewise have a voltage rating, yet not at all like PWM the info voltage rating is a lot higher than the battery banks it will charge. This is because of the uncommon property of the MPPT controller having option to bring down the voltage to the battery bank voltage and after that expansion the current to make up for lost power. Youdon't need to use the high info voltage in the event that you need to stay away from arrangement associations in little frameworks, yet it is helpful in bigger frameworks.

## 3. Dc-Dc Converter

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Lift converter ventures up the information voltage size to a required yield voltage greatness without the utilization of a transformer. The principle parts of a lift converter are an inductor, a diode and a high recurrence switch. These in an organizedway supply capacity to the heap at a voltage more prominent than the information voltage size. The control methodology lies in the control of the obligation cycle of the switch which causes the voltage change.

### 4. Seven Level Inverter

Staggered voltage source inverter is perceived as a significant option in contrast to the ordinary two-level Voltage SourceInverter particularly in high voltage application. Utilizing staggered system, the abundancy of the voltage is expanded, worry in theexchanging gadgets is decreased and the general sounds profile is improved. Among the recognizable topologies, the most prominent one is fell staggered inverter. It displays a few appealing highlights, for example, straightforward circuit format, less parts tallies, secluded in structure and stay away from unbalance capacitor voltage issue. Anyway, as the quantity of yield level expands, the circuit winds up cumbersome because of the expansion in the quantity of intensity gadgets. In this undertaking, it is proposed to utilize another procedure to get a staggered yield utilizing less number of intensity semiconductor changes when contrasted with customary fell staggered Cascaded Multilevel Inverter comprise of arrangement of H-connect (Full Bridge) Inverterunits. Each extension will be nourished from a different DC source which might be gotten from batteries, energy components, or sun-based cells. The capacity of this staggered inverter is to deliver an ideal voltage from a few Separate Dc Sources (SDCSs). Theair conditioning terminal voltages of various level inverters are associated in arrangement. This inverter does not require voltage- cinching diodes or voltage-adjusting capacitors not at all like in the diode-clip or flying-capacitors inverter thus inverter has a biggernumber of points of interest than other two sorts.

### 5.Control Technique

Inverter can likewise be balanced by practicing a control inside the inverter itself. The most the principle point of the regulation system of staggered inverters is to incorporate the yield voltage as close as conceivable to the sinusoidal waveform. Numerous balance methods have been created for symphonious decrease and exchanging misfortune minimization.

The regulation techniques utilized in staggered inverters can be grouped by exchanging recurrence. Methods that work with high switching frequencies have many commutations for the power semiconductors in one period of the fundamental output voltage. Yield voltage from an proficient technique for doing this is by heartbeat width regulation control utilized inside an inverter. In thistechnique, a fixed dc input voltage is given to the inverter and a controlled air conditioning yield voltage is acquired by altering theON and OFF times of the inverter parts. This is the most well-known technique for controlling the yield voltage and this strategy isnamed as Pulse-Width Modulation (PWM) Control.

The focal points controlled by PWM strategies are as under:

1) The yield voltage control can be acquired with no extra segments.

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2) The lower order harmonics can be eliminated or minimized along with its output voltage control.

3) The filtering requirements can be minimized as higher order harmonics can be filtered easily.The different PWM techniques are as under:

1) Single Pulse Width Modulation.

2) Multiple Pulse Width Modulation.

3) Sinusoidal Pulse Width Modulation

## V SIMULINK MODEL

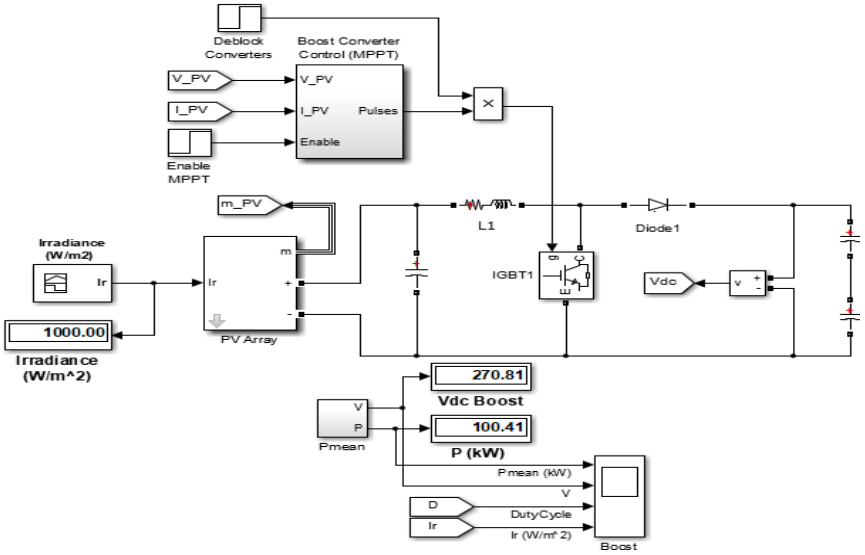


**Figure: MATLAB Simulink model of solar cell with MPPT and boost converter**

Figure: shows MATLAB Simulink model of solar cell with MPPT and boost converter. In which solar power generation system is equipped with MPPT Controller to track maximumpower for solar panel system. MPPT ensures maximum power at changing environment. In MPPT Controller Incremental conductance algorithm is implemented to ensure maximum peak power tracking. Solar panel is used as input source. The Dc power from input source is given to DC-DC converter. This converter boost input to specific level as well as MPPT controller maintains output power of DC-DC converter at maximum power point tracking using Incremental conductance algorithm. MPPTcontroller has feedback from voltage and current sensor. These feedbacks are utilized by incremental conductance algorithm asan input. According to output of incremental conductance algorithm, The MPPT controller sends feedback to update DC-DC converter for maximum.

## VI Simulation Result

MPPT with boost converter

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Figure shows the performance of boost converter. Figure shows the power, voltage, duty cycle and irradiance. In this system, the duty cycle of the boost converter is varied as the irradiance changes to track the MPPT. If the irradiance is vary then power is vary. But in this system require maximum power so the duty cycle is adjusted to itself and control the voltage and then give the maximum power. That means the irradiance changes then MPPT controller is vary and adjust the duty cycle and try to tracking the maximum power.

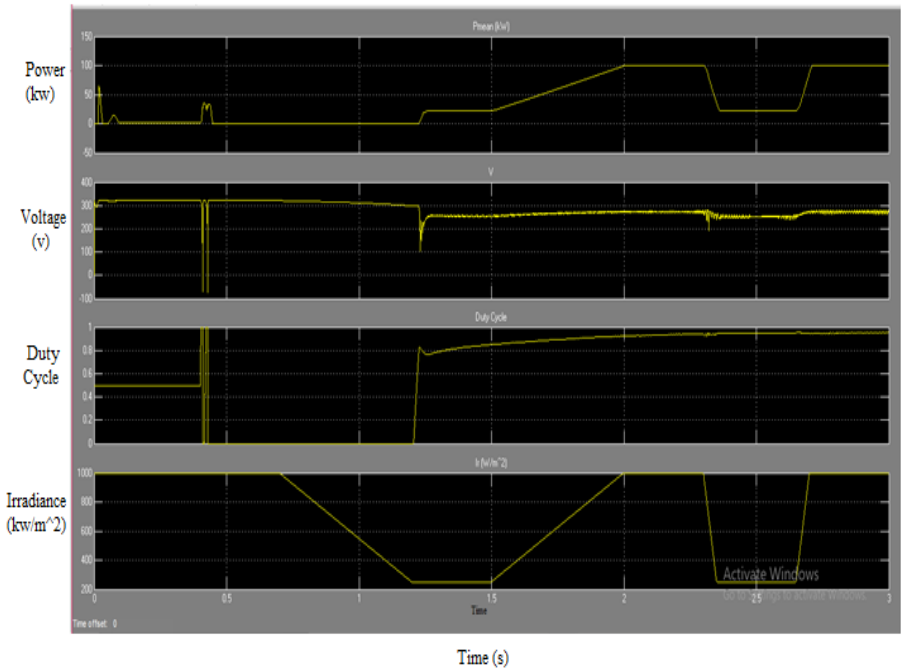


**Figure Simulation result of boost converter.**

## VII FUTURE SCOPE

1. To minimize the THD of inverter.
2. To minimize the no. of switches and component.
3. To improve the MPPT efficiency.
4. To increases the voltage level
5. To improve the system in real environmental condition.
6. Implementation and simulation in three phase system.

## VIII CONCLUSION

The voltage regulation topology along with power quality improvement is considered and implemented both in simulation and experimental setup for a solar fed 15 level inverter. While considering the results, it is found that FLC presents better results for while considering the variations at the input solar PV. Despite this, FLC is considered for the nine-level by [23], but the implementation is carried out with the DC power supplies without

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utilizing the solar panels. All the other methods are implementedfor low power and lesser levels of MLI topology. Commercial utilization of MLI by providing the constant output voltage is investigated, and the experimental results prove the effectiveness of the proposed system. The method is applicable for the users require grid interaction along with the power quality improvement.

## IX ACKNOWLEDGEMENT

I feel great pleasure to present the Project Stage-II entitled as "Reduction of Harmonics in Solar fed Multilevel Inverter" but it would be unfair on our part if we do not acknowledge efforts of some of the people, without the support of whom this work would not have been a success.

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