



Review on Power Quality Improvement in Solar Fed Multilevel Inverter

Rahul D. Aher¹, Prof.A.M.Solanki², Dr.Pawan.C.Tapre³

¹Students of master of engineering, ²Assitant Professor, ³Head of Department

¹SND COE &RC, YEOLA

¹SND COE &RC YEOLA, NASHIK, INDIA

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 enhancement in 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, ANN and 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.

Index Terms - 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 the least 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 present vitality 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 makes a 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 continuous purchase of fossil fuels 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 hence a converter is needed to convert DC to AC, nothing but an inverter. Also, if the solar system is connected to the grid, the generated DC 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 supply it easily.

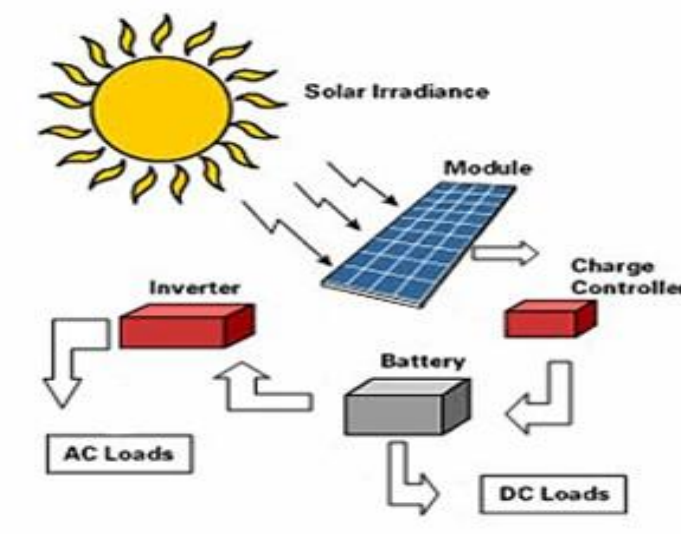


Figure 1.1 off- grid solar power system

B. ON-GRID SYSTEM

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 deducted from 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 in proposed 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 well as electromagnetic interference (EMI) decrease.

Proposed system is focusing on solar power generation using seven level inverters.

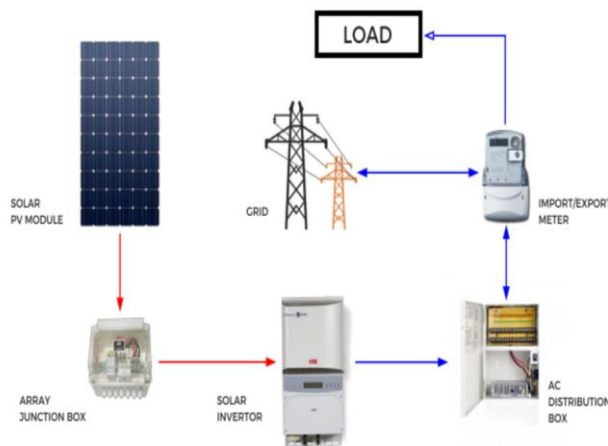


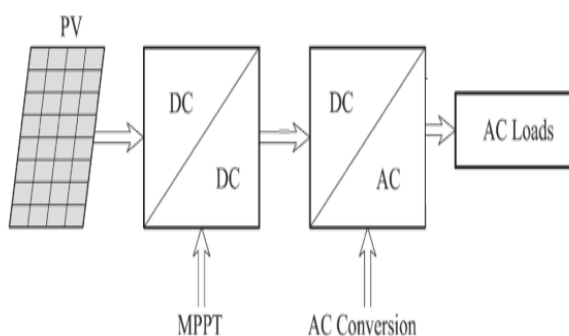
Figure 1.2 On- grid solar power system.

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 Matlab.
- 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. Detached strategies 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 independent MPPT 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 (IC) method, fuzzy logic control method, neural networks and parasitic

capacitance method and ripple correlation control method can be given as example to these methods. Because of the advantage of being easy to implement and the low costs, the use of P&O and IC are more common among these methods.

B. BLOCK DIAGRAM OF PROPOSED SOLAR POWER GENERATION SYSTEM

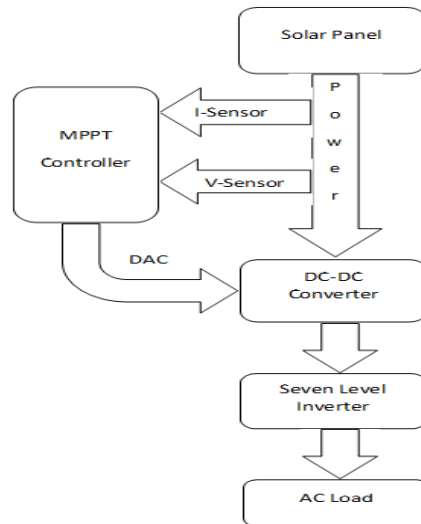


Figure: Block Diagram of Proposed Solar Power Generation System

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 converter at 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 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 of the 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 charge controllers 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 lift current, which increment the amperage to make up for the lost voltage. MPPT Controllers will have an Amp perusing for it, for instance 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. You don'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

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 organized way 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 Source Inverter particularly in high voltage application. Utilizing staggered system, the abundancy of the voltage is expanded, worry in the exchanging 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) Inverter units. 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). The air 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 bigger number of points of interest than other two sorts.

6. 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 this technique, a fixed dc input voltage is given to the inverter and a controlled air conditioning yield voltage is acquired by altering the ON and OFF times of the inverter parts. This is the most well-known technique for controlling the yield voltage and this strategy is named 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.
- 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

The literature survey is carried out by different E-medias, IEEE journals, national and international conference paper-paper, research journals etc.

1] Albert Alexander Stonier, Srinivasan Murugesan, Ravi Samikannu, Sampath Kumar Venkatachary, Senthil Kumar S, Prakash Arumugam, 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 enhancement in 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, ANN and 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.

2] Oswaldo Lopez-Santos, Carlos A, Jacanamejoy-Jamioy, Diego F. Salazar-D'antonio, Germain Garcia, Luis Martinez-Salamero, This paper introduces a method to enforce balanced power distribution between the stages of a single-phase transformer-based cascaded multilevel inverter using the new asymmetric ratio 6:7:8:9 between stages. Since the inverter is fed by a single DC source, asymmetry is enforced by means of the transformer turns ratio providing multiple redundant switching patterns to synthesize an output signal of until 35 levels. As it is developed in the paper, optimum switching patterns for the proposed ratio allow reducing typical power unbalance produced by commonly used ratios in four stage multilevel inverters (1:2:4:8 and 1:3:9:27). The proposed method consists on determining off-line the best switching patterns for minimizing deviation error, and then, storing them as lock-up tables in the digital device controlling the inverter. By permanently reproducing the selected switching patterns, balanced power distribution is achieved. A closed-loop control approach to regulate the RMS value of the output voltage compatible with the proposed method is also developed. The experimental results using a laboratory prototype are presented validating the entire approach.

3] Jainil K. Shah, Manish S. Patel, Total harmonic distortion (THD) is a term used to describe the net deviation of a nonlinear waveform from ideal sine waveform characteristics. Total harmonic distortion is the ratio between the RMS value of the harmonics and the RMS value of the fundamental. In multilevel Inverter As we try to increase the number of levels THD reduces. his paper contains different single phase multilevel inverter configuration. Different cascaded H bridge type of inverters are pointed out in this paper. Cascaded H bridge type multilevel inverters are built in MATLAB simulation and results are illustrated.

4] Vikalp Kulshrestha, Raj Kiran Pandey, C. S. Sharma, Multilevel output voltage source converters are emerging as a new methodology of power converter options for high-power and medium power. The multilevel voltage source converters typically synthesize the staircase voltage wave from several levels of dc Source .this paper present a new method multilevel inverters ,which has the less number of switching devices used and no any capacitor and inductor dependency to smooth output current wave. it comprises input dc source alternatively connected in opposite polarity with an another switching devices' and the design has been fully investigated with the help of theoretical analysis, simulations with the MATLAB / SIIMULINK and reduced THD result are shown through the FFT window, comparison with the proposed topology is made against the typical commercial available inverter topology.

5] G Kanakaratra Prasanna Vijaya Kumari, Dr.k.Chithambaraiah Setty, 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 enhancement in 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, ANN and 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

6] A. Al-Mamun, K. Sundaraj, N. Ahmed, N. U. Ahamed, S.A.M. M. Rahman, R.B. Ahmad & Md. H. Kabir, Currently, the solar energy has turned into a popular alternative energy source to meet certain demands around the world due to the instability of oil as well as coal prices with global warming issues. The aim of this paper is to develop of a simple as well as cost-effective solar system for the rural areas where grid electricity is not available. To fulfil this objective, first a 5-Watt PV (photovoltaic) stand-alone solar module was used as solar power source and a common type lead acid battery (12V, 7AH) is used for backup system. The solar panel was connected to the battery via a charge controller which was responsible to pass the correct voltage for charging the battery and also, ensure that the battery was not overcharged. In addition, the system was designed for 22W AC and 12W DC loads. An inverter was designed for the AC loads which could convert the fixed DC voltage from battery to an AC output voltage. Finally, the entire system was tested successfully as well as cost evaluation also presented in the paper. This developed system will be effective for the poor people in the rural area those are deprived from the electricity and the conventional fuels being saved.

7] Abhinay Shrivastav, Aamir Sohail, Ravi Pandey, Shivam Sachan and Naimuddin, The proposed new fell H-connect staggered inverter sustained acceptance engine utilizing equivalent DC sources was approved and created with the equipment. The essential exchanging plan is utilized utilizing the Sinusoidal Pulse Modulation Technique. The terminating points are determined and nourished to the inverter for its task by utilizing the Selective music end. At last utilizing the power quality analyzer the sounds are estimated and appeared. In the ordinary H-connect staggered inverter for seven level yield 12 switches are required though in altered topology just 7 switches are required to accomplish seven level yield. The 41.667% of decreased number of switches is utilized in the framework.

8] Anjali Krishna R, Dr. Padma Suresh L, The framework exhibits a short talk on fundamental staggered inverter topologies. Key staggered converter structures including the preferences and inconveniences of every method have been examined. The primary preferred position of MLI family is that it finds an answer for the issues of all out sounds twisting, EMI, and dv/dt weight on switch. In mechanical and business advertise regions, increasingly more item are accessible that relies upon the staggered inverter topologies. Research works are in advancement thinking about the structure intricacy and control circuits. This decreases the power hardware parts and improve absolute music profile and complete expense of the framework.

VI.SIMULINK MODEL

1. MPPT with boost converter

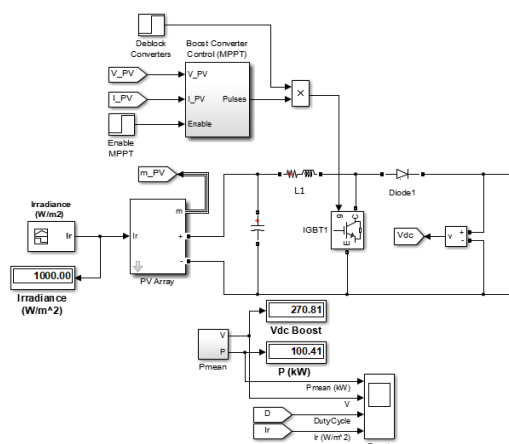


Figure: MATLAB Simulink model of solar cell with MPPT and boost converter.

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 maximum power 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. MPPT controller has feedback from voltage and current sensor. These feedbacks are utilized by incremental conductance algorithm as an input. According to output of incremental conductance algorithm, The MPPT controller sends feedback to update DC-DC converter for maximum

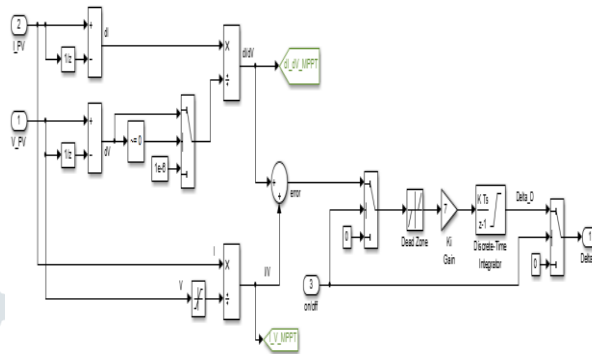


Fig: MATLAB Simulink model of MPPT using IC method

2. Seven Level Inverter

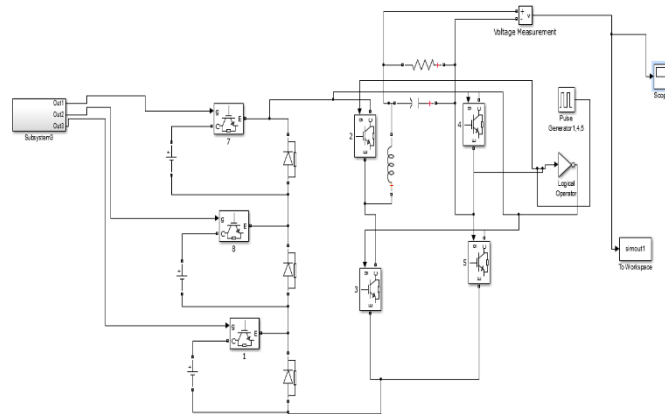


Figure MATLAB Simulink model of seven level inverter

The load used is 1 ohms. Using from label the control signal i.e., SPWM pulse width modulation signal, this pulse signal triggers the gate of IGBT and we the seven-step output voltage waveform. In this type of modulation the width of each pulse is varied in proportion to the amplitude of sine wave evaluated at the center of the same pulse. The gating signal is provided by comparing a sinusoidal reference signal with a triangular carrier signal. Output of seven level inverter is given to filter for harmonic reduction

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 vol5. To improve the system in real environmental condition.
6. Implementation and simulation in three phase system.

Implementation in fuzzy logic

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 VR 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 utilizing the solar panels. All the other methods are implemented for 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 “Review on Power Quality Improvement in Solar feed 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.

Very first I am greatly thankful to my respected project guide Prof. Amit M. Solanki Assistant Professor & P.G Coordinator of Electrical Engineering Department for permitting me to use the all available facilities for successful work of Project Stage-I. & for guidance and encouragement in carrying out this project work. He helped me in every possible way. The knowledge acquired during the preparation of the report would definitely help me in my future ventures

I would like to express my sincere gratitude to respected Dr. Tapre P. C. , HOD of Electrical Engineering Department and Dr. D. M. Yadav, Principal of SND COE & RC YEOLA for finding out time and helping me in this project work.

I am also thankful to all Teaching and Non-Teaching staff member of Electrical Engineering department who has helped me directly or indirectly during this work. Last but not least I wish to express my gratitude to my loving parents and my friends and all well-wishers for their moral support during completion of this project work.

X. REFERENCES

- [1] Power Quality Improvement In Solar Fed Cascaded Multilevel Inverter With Output Voltage Regulation Techniques Albert Alexander Stonier , Srinivasan Murugesan , Ravi Samikannu 2 Sampath Kumar Venkatachary3 , Senthil Kumar S.4 , And Prakash
- [2] A Single-Phase Transformer-Based Cascaded Asymmetric Multilevel Inverter With Balanced Power Distribution Oswaldo Lopez-Santos 1, Carlos A. Jacanamejoy-Jamioy2 , Diego F. Salazar-D’antonio1 , Julian R. Corredor-Ramírez1 , Germain Garcia 3 , And Luis Martinez-Salamero 4
- [3]Comparative Analysis Of Single Phase Cascaded H-Bridge Multilevel Inverter, Jainil K. Shah1 , Manish S. Patel.
- [4] Design Of Multilevel Inverter To Improve The Power Quality By Reducing The Harmonics , Vikalp Kulshrestha1, Raj Kiran Pandey, C. S. Sharma.
- [5] Solar Fed Cascaded Multilevel Inverter with Output Voltage Regulation for power quality improvement, G Kanakaratna Prasanna Vijaya Kumari, Dr.k.Chithambaraiah Setty.
- [6] Design and development of a low cost solar energy system for the rural area, A. Al-Mamun, K. Sundaraj, N. Ahmed, N. U. Ahamed, S.A.M. M. Rahman, R.B. Ahmad & Md. H. Kabir
- [7] Komparasi Multilevel Inverter Satu Fasa, Irma Husnaini, Asnil, Habibullah, Krismadinata
- [8] Staircase Modulation using GWO Technique for CHB-MLI with Symmetrical and Asymmetrical Mode, Asala. S. AL-Dmour, Hussein. D. AL-Majali, Ziyad. S. AL-M

tage level.