DESIGN AND SIMULATION OF GRID TIED SOLAR INVERTER WITH DIFFERENT TOPOLOGIES ALONG WITH MPPT ALGORITHM

Harsh Prajapati[1], Prof. Ankit Gajjar[2], Archan Parikh[3]
[1]PG Scholar, [2]Assistant Professor, Electrical Department, KITRC, Kalol, Gujarat, India
[3]Senior Engineer in Komal Electrotech, Ahmedabad, Gujarat, India

ABSTRACT: Increasing fossil fuel prices with continuous increasing demand has made use of renewable energy sources a necessity then a luxury. This project focuses on development of a photovoltaic inverter which can be used to supply the generated photovoltaic energy to grid. Interfacing a solar inverter module with the power grid involves three major tasks. One is to ensure that the solar inverter module is operated at the Maximum Power Point (MPP), the second is to inject a sinusoidal current into the grid and the third is the efficiency. Since the inverter is connected to the grid, the standards given by the utility companies must be obeyed. These standards deal with issues like power quality, detection of islanding operation, grounding, and so on. A rigorous design and simulation verification process of different photovoltaic inverter topologies through PSIM will be carried out and after having analyzed results which also comply with IEC norms of grid connection the proposed topology will be implemented.

I. INTRODUCTION

The Photo Voltaic inverter is the main element of Grid coupled PV Power Systems. The Function of PV panels is to convert the Generated DC power into Grid synchronize AC power.

Depending on the PV power plant Formation, the PV inverters can be classified as:

- Module Integrated Inverter: - Here the inverter's range is 50 to 400w for very small Photo voltaic Plants (i.e. one panel).
- String Inverters: -In this Inverter the range is 0.4 to 2kW for small Roof-Top plants. And connected in one string.
- Multi String Inverter: -This Inverter range is 1.5 – 6kW for medium large Roof top plants. Panels connected in one to two strings.
- Mini Central Inverters: -In this 6kW with 3-Phase topology and the design for big roof top plants or small power plants the range is 100 kW and the Unit size is 6, 8, 10 and 15 kW.
- Central Inverters: - In this central inverter the range is 100 – 1000 kW with 3- Phase topology and design for big power plants of a MW and the unit size is 100, 150, 250, 500 and 1000 kW.

Topology Selection

Classification of the Photovoltaic inverters is as follows:

Based on Power Processing Stage

1. Two Stage Power Processing
2. Single Stage Power Processing

Based on Galvanic isolation to Grid

1. with Galvanic Isolation
2. without Galvanic Isolation

II. SELECTED TOPOLOGY

Generally, the generated voltage of the Photovoltaic array is not sufficient to synchronize with grid. Furthermore, the voltage down property of the voltage source inverter, so this is the reason of low voltage of "PV array + Inverter" topology so the two stages topology is recommended so this topology add a voltage up link part, generally Designed as Fig. (3.5).The DC-DC part repeatedly assumes a Boost circuit or some other versions like Buck-Boost, isolated Boost, etc. In addition voltage-up function, so the Boost circuit gives more stable input voltage for the inverter. So the main Benefit of the two stages topology is of the two stages topology is the flexible of designing its control scheme since it has a high freedom degree, i.e. more manageable variables, it means Multiple control objectives(MPPT, Grid connecting VAR compensating, active filter etc.) can share by two stages individually simultaneously.

III. POWER SCHEMATIC

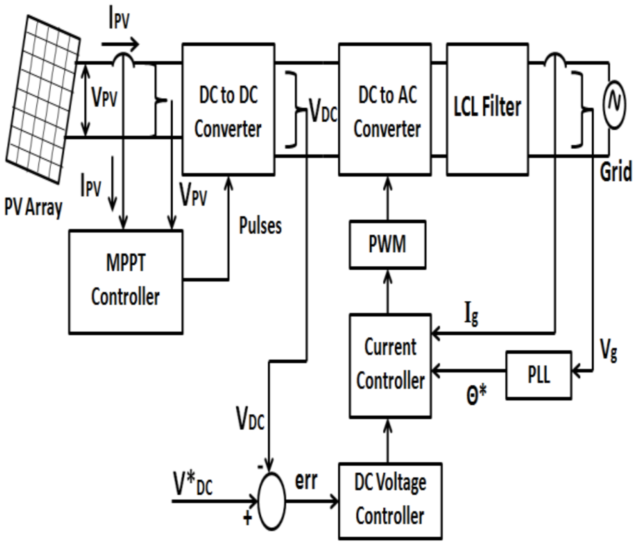

Fig-proposed system

So we can see the Fig-3.5 that power schematic of the established system. So the generated output voltage is not enough and it will costly to maintain large number of panels so we need to connect the DC to DC boost converter in system. So that low power system a single phase full bridge inverter is hired. In this the generated output voltage is not sinusoidal so can't connect directly with grid so that we need to add filter stage then connect to grid.

Simulation Verification of boost Inverter

For the compatibility testing of the selected components simulation analysis has been carried out and different operating conditions taken into consideration. Below Fig shows the circuit connection in the simulation. As shown in Fig input current has been sensed which is compared by the given input reference. As it is already mentioned that input voltage variation will be between 190 V to 290 V and irrespective of the change in the input voltage DC link voltage will remain constant to 380 V. While testing the system with constant voltage and current source (3- Phase variac), a current controlled system is developed, which controls the input dc current. DC link voltage while testing with resistive (R) load depends on IR drop in resistors and when it is integrated with inverter system it is maintained by the inverter system.

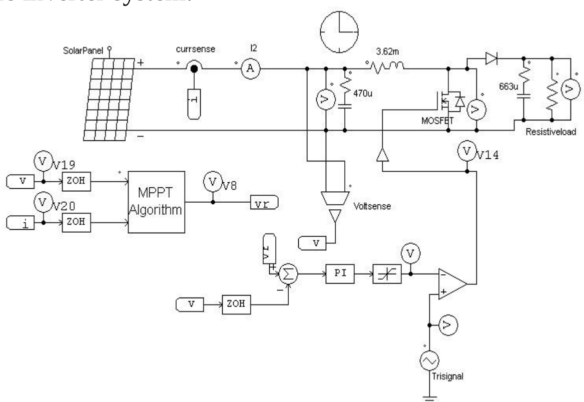

FIG – 4.1

4.4.1 Simulation Results

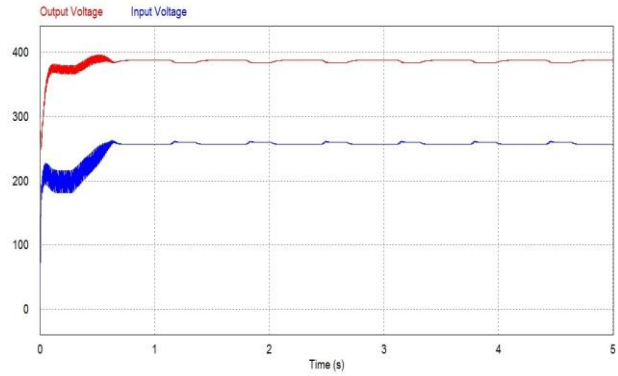

FIG – 4.2

As shown in Fig the applied input voltage is 190 V and given current reference is 100%. Resistive load across the resistor is 48 and the value of the DC link capacitance is 1.88 µF. Same way, the results at the time of input voltage is 290 V and current reference is 100% are shown in Fig. In both the cases above duty cycle is kept at 50% constant. It is clear that whenever value of resistor or current reference or both increase, drop across resistor increases and hence more boost voltage appears across the DC link. When the system will be integrated with the inverter system DC link voltage (VDC) will be maintained by the close loop control through inverter. Now seeing the output in terms of ripple content in output voltage and current, at the time of minimum input voltage 190 V the ripple content in output voltage and current are shown in Fig.4.5

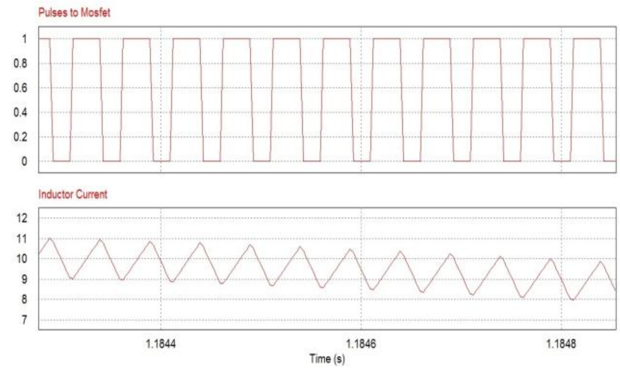

FIG – 4.3

From the above Fig it can be seen that ripple in DC link voltage V_{DC} is not more than 1% of the total DC link voltage and same way the ripple in the output Current is also not more than 10% of the output rated current.

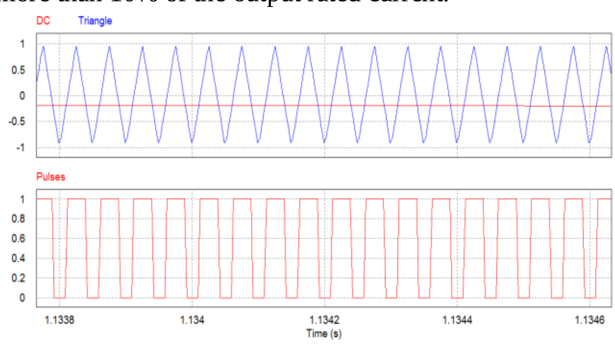

Fig- 4.4

From the above Fig we can saw that here compare the DC and Triangle wave and we get the pulses. In which the comparison of the dc and triangle wave when the magnitude of triangle is more then to dc the Pulse will be generate and when the magnitude of the triangle wave is less the pulse is zero.

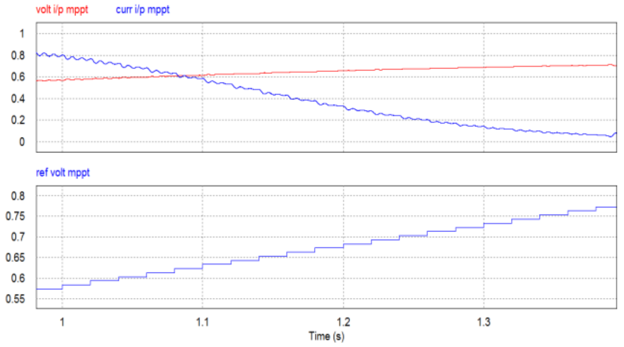

Fig- 4.5

From the above fig we can see that the input current and the input voltage is variable when we apply the load. Here we have use the mppt algorithm for the constant output. In which the input voltage and input current apply the mppt sense the maximum input value for the reference voltage and then mppt compare the input value and set the maximum value with the reference value and get the constant output at the inverter side.

IV. DC TO AC CONVERTER

Introduction

For the feeding of sinusoidal current and voltage into the grid and for the conversion of DC voltage at the DC link into AC, effective DC-AC conversion stage (Inverter) has been kept into the system. As the system is in low power category single phase full bridge inverter is employed. Output of the inverter cannot be directly feed in to the grid, so an output low pass filter stage has been designed to maintain sinusoidal voltage and current at the output. In the converter there is four IGBT's work in this inverter and at that time only two IGBT work simultaneously, in which we apply the sine and triangle wave the first 1and 4 no of IGBT work and then the second 2 and 3 no of IGBT work but in second cycle there are negative polarity so we get the pulse at that time

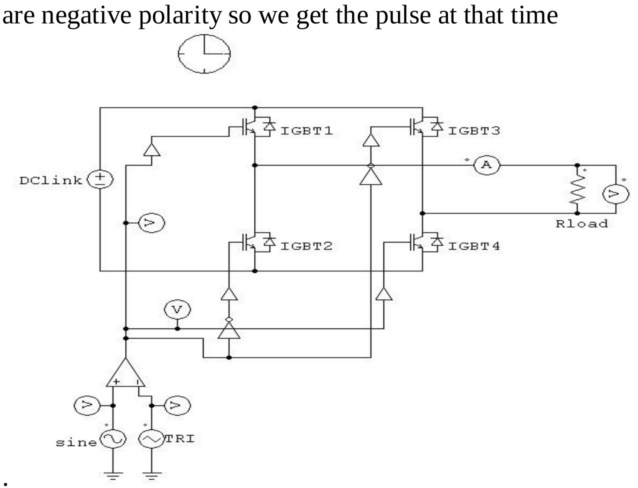

Fig-4.6

V. SIMULATION RESULTS

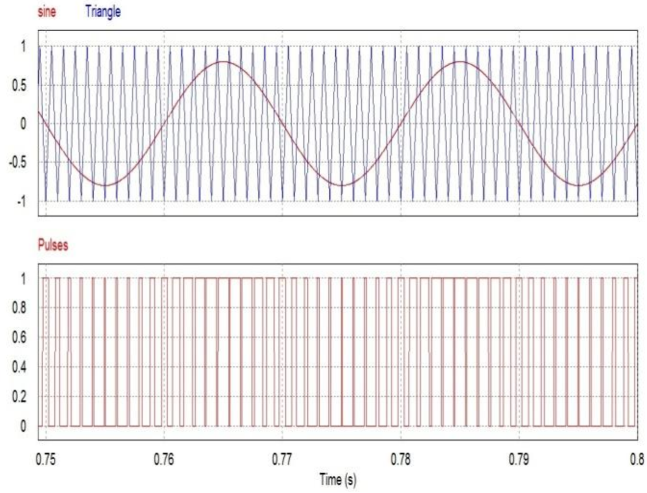

Fig – 4.7

From the above fig compare the sine and triangle wave form and in this also when the magnitude of triangle wave form high from the sine we get the pulse and when the magnitude is less than the sine wave the pulse is zero.

Filter Design

The inverter output voltage is non-sinusoidal and hence it is required to connect a low pass filter between the inverter and the grid. Here Passive low pass harmonic filter will be used to reduce voltage harmonics and current distortion. This filter may be of L type or LC type or LCL type filter. The L type filters provide an attenuation of -20 dB/decade for all the range of frequencies. The switching frequency of inverter needs to be high in case of L filter for effective attenuation of high order harmonics. So as the switching frequency increases, the switching losses will increase. The resonance frequency of the LC filters changes with the change in grid inductance so it is not recommended for a weak grid. Hence for the current system LCL type filter is taken into consideration.

VI. POWER FLOW OF COMPLETE SYSTEM

Simulation of Complete System

The configuration of a single phase grid connected photovoltaic system is shown in above Fig. It consists of photovoltaic array, a DC- DC boost converter, input and output capacitor, single phase VSI, filter inductor, and supply voltage. The single phase vector control can be used to control active and reactive power independently. The main aim of this decoupled control is to maintain a constant dc link voltage as well as feed active power to grid. In this system DC Voltage in the range of 190 V DC to 290 V DC is generated from the solar panel. This voltage obtained is boosted to 380 V DC which acts as a DC-link voltage for the single phase inverter. To obtain the maximum power from the solar panel MPPT algorithm is to being implemented for the maximum power transfer. To obtain the pure sine wave with 230 V AC and 50 hz frequency PLL loop is applied along with PWM technique for the proper transfer of power to the grid. In the single phase inverter d-qtechnique is applied to obtain the PWM. L-C-L Filter is design to mitigate the harmonics and get it within the permissible limits of 5 % as per the IEEE standards.

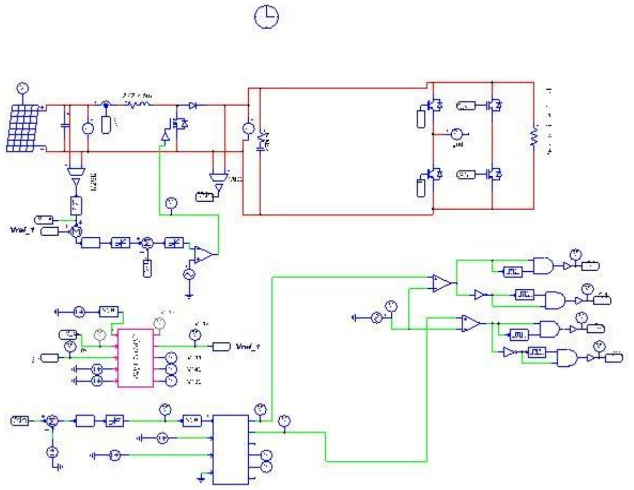

Fig-4.8

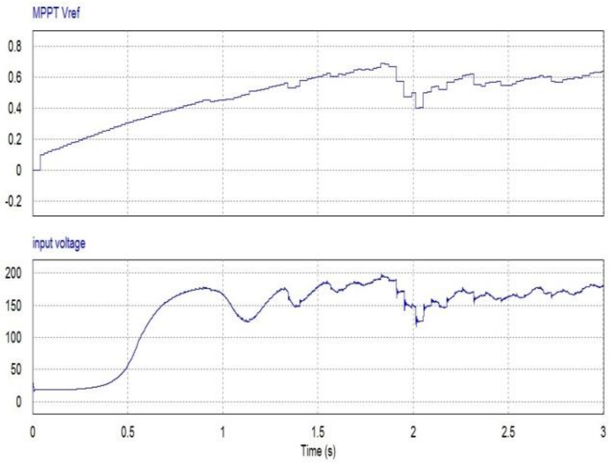

Fig-4.9

The above figure shows the Reference voltage generated by MPPT Algorithm. The below figure shows the input voltage following the path of reference voltage. As the actual input voltage is trying to follow the path of MPPT voltage we can say that maximum power is obtained from the panel.

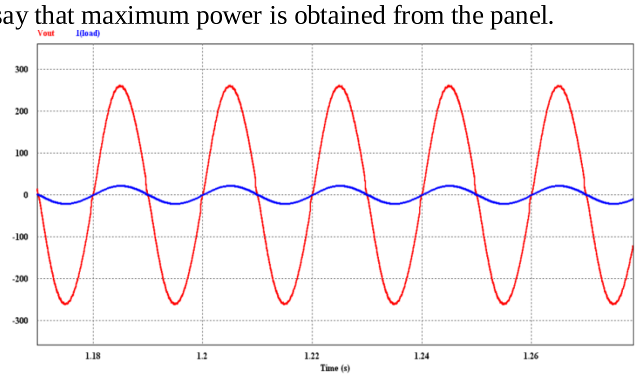

Fig-4.10

The above figure shows the Output Voltage and Output Current of an inverter when tested on the resistive load. As the load is resistive both voltage and current are in phase with each other. Hence the power factor is unity.

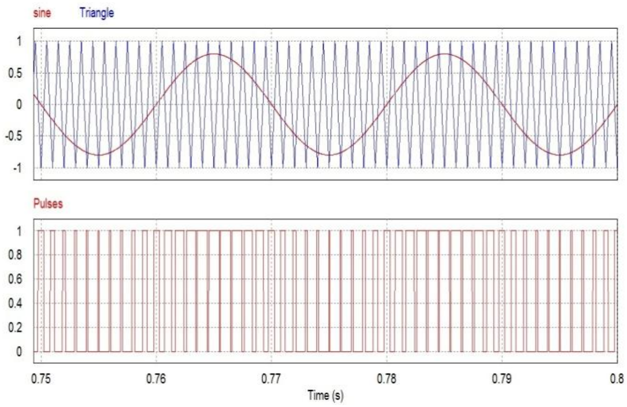

Fig-4.11

The Above figure shows the Sine –Triangle comparison and pulses generated from that comparison are shown.
When the amplitude of Sine is greater than Triangle pulses are given to IGBT 1 and IGBT 4.
When the amplitude of Triangle is greater than Sine pulses are given to IGBT 2 and IGBT 3.
Thus from the above waveforms it can be said that the system is working properly as per our requirement.
Hence our close loop system along with boost converter and MPPT algorithm and single phase inverter is working properly and is being tested on resistive load.

VII. CONCLUSION

- Close loop of Boost converter along with MPPT algorithm is been completed as per requirement and is been verified with simulation results.
- Simulation of Single phase inverter is carried out and is verified with simulation results
- Simulation of whole system is carried out and is working as per our requirement which can be verified with the help of simulation waveforms

REFERENCES

[1] Xuanyuan Wang, MehrdadKazerani "A Novel Maximum Power Point Tracking Method for Photovoltaic Grid-Connected Inverters" IEEE 2003

[2] Rong-Jong Wai, Wen-Hung Wang "Grid-Connected Photovoltaic Generation System" IEEE TRANSACTIONS ON CIRCUITS AND SYSTEM -1: REGULAR PAPERS, VOL. 55, NO. 3, APRIL 2008

[3] ShakilAhamed Khan, Mohammad JakirHossain " Design and Implementation of MPPT Controlled Grid Connected Photovoltaic System" 2011 IEEE Symposium on Computers &Informatics

[4] WenhaoCai, HuiRen, Yanjun Jiao, MingweiCai, Xiangpu Cheng "Analysis and Simulation for Grid-Connected Photovoltaic System Based on MATLAB" IEEE

[5] ChihchiangHua, chihmingshen " Study of Maximum Power Tracking Techniques and Control of DC/DC Converters for Photovoltaic Power System" IEEE 1998

[6] A. Zegaoui1, M. Aillerie, P. Petit, J.P. Sawicki, A. Jaafar, C. Salame and J.P.Charles,\Comparison of Two Common Maximum Power Point Trackers by Simulating of PV Generators", IEEE Proceedings, The International Conference on Advanced Power System Automation and Protection, 2011.
[7] Roberto Faranda, Sonia Leva, in this paper titled \Energy comparison of MPPT techniques for PV Systems" comparative analysis between different mppt algorithm and their response in sudden change in atmospheric condition variations are discussed.
[8] Hyosung Kim, Kyong- Hwan Kim, \Filter Design For Grid Connected PV Inverters", ICSET 2008, IEEE Proceeding, 978-1-4244-1888-6/08.
[9] S. Samerchur, S. Premrudeepreechacharm, Y. Kumsuwun, K. Higuchi, \Power control of single phase Voltage control Inverter for Grid Connected Photovoltaic Systems", IEEE Proceeding, 978-1-61284- 788-7/11, 2011.

