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Reactive Power Compensation using Three Phase Cascaded H Bridge Inverter

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***Abstract*--Grid Tied Solar Inverters Are Designed To Generate Power At Unity Power Factor Which Means They Have The Capability To Produce Active Power Only. The Reactive Power Requirement Of The Load Is Catered By Grid Only. With The Increase In The Use Of Renewable Based Distributed System, Reactive Power Drawn From The Grid As Compared To Active Power Has Increased Considerably. This Affects The Power Quality Of The Grid. If The Grid Tied Solar Inverter Is Made Smart In Terms Of Supplying Reactive Power In Addition To Active Power, The Reactive Power Requirement From The Grid Will Reduce As The Grid Has To Supply Lesser Reactive Power.**

***Keywords*--Solar Pv System, Cascaded H Bridge Inverter, Reactive Power Compensation, Var Management.**

I. INTRODUCTION

Grid tied solar inverter are traditionally designed to operate at unity power factor which means that they have capability to produce active power only. As electrical loads are predominantly inductive loads, they tend to consume more amount of inductive reactive power. Currently this reactive power requirement is catered by grid only. With the increase in penetration of large number of Distributed Energy Resources (DERS) which pump only active power into the grid, the site power factor becomes poor from utility point of view, affecting the performance of the grid previously, the reactive power injection absorption is done through the FACTS devices for mitigating power quality issues. There are different types of FACTS devices like series, shunt, series-series, series-shunt which are used based on the requirement but these devices suffer from the drawback of large sizing, high cost, large area of installation etc. On account of these reasons, there is a need to regulate the reactive power flow in the power system network as this may affect the voltage regulation also In this paper control strategies for grid tied solar inverter to supply reactive power in addition to the active power are discussed.

As the number of grid tied1inverters increases, their usage as VAR compensators will help in grid voltage regulation and reduce the need of expensive capacitor banks. In order to use the reactive power capability of the smart inverters, there are two main options: oversizing the inverter or the active power curtailment. Oversizing the inverter has an extra of cost that needs to be taken into account. Active power curtailment is the active power reduction and can be - to implement in different ways such as fixing the maximum for power point to say 70% of rated power or based on PCC voltage as the reference voltage.

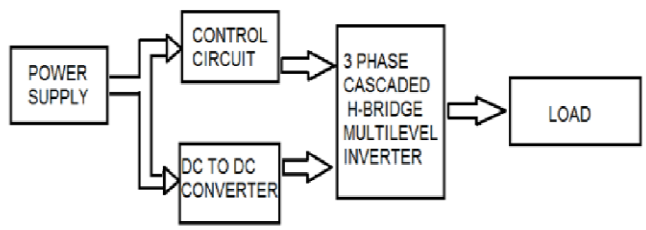

Fig 1: Block diagram

II. LITERATURE REVIEW

The active power inserted by grid tied solar inverter into the grid is a function of solar insolation. This means that the amount of active power pumped into the grid will be lower than the designed rated capacity of solar inverter if the solar irradiance is less (which actually happens as the solar irradiance is not uniformly maximum throughout the day). This leads to underutilization of the inverter resource. If the inverter is programmed to provide reactive power also in addition to active power (based on solar irradiance availability) then the inverter can be operated at its rated capacity even when the solar resource is not fully available. Reactive power compensation through solar inverter is an interesting method to manage network voltages through reactive power injection and absorption.

Reactive power support as provided by solar PV inverters are of two types: dynamic support and static support.

Dynamic reactive power compensation is used to provide stability to the grid when some events like short term voltage sags or peaks occur These type inverters use dynamic reactive power provision for their riding-through capabilities

Static reactive power support is used to maintain voltage levels within an acceptable range The idea of using reactive power for maintaining voltage limitations derives from a traditional power system operation, where reactive power is necessary to support the overall voltage stability in the grid Control system can be developed and solar PV inverters can be programmed for implementation of static reactive power compensation by means of four different control strategies:

1. fixed Q
2. fixed cos p
3. cos p (P)
4. Q (V)

For all the control strategies, the MPPT operation is given priority which means that if abundant solar irradiance is available (say from 1000 W/m² to 800 W/m) and the grid voltage is within limits, then the complete solar PV generation is fed to grid in the form of active power.

However, if the cloud blocks the sun and causes the PV array's maximum power to drop below a set value, say 80% then any of the above stated control mode can be switched ON. This will enable the system to utilize the unused capacity of the solar inverter which otherwise would not be used when the solar inverter is operated at unity power factor.

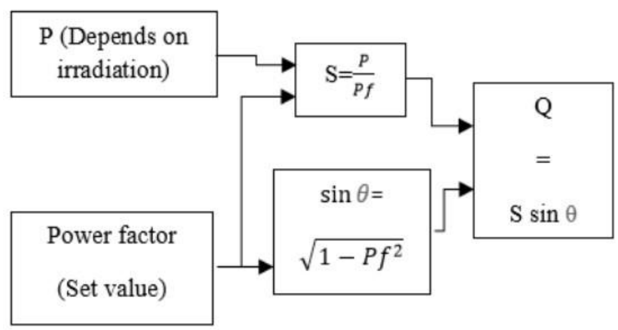

Fig 2: Reactive Power Calculation

III. Simulation Result

The simulation has been carried for this paper in matlab for better understanding and to explain process of it.

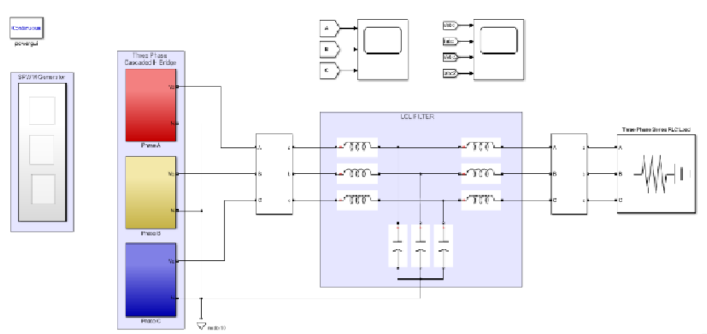

Fig 3: Three phase h bridge inverter

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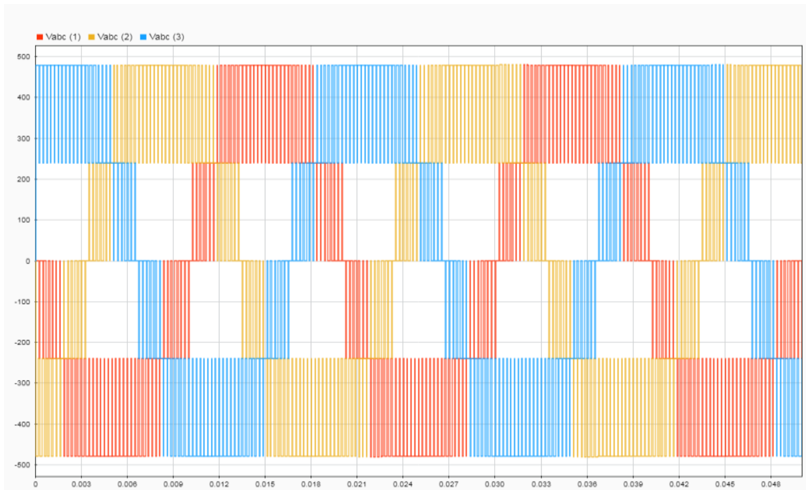
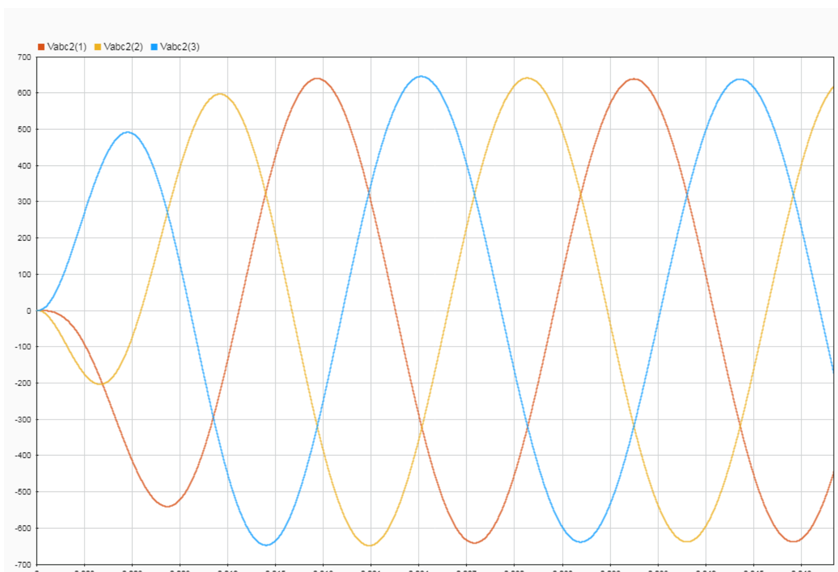


Fig 4: Voltage waveform



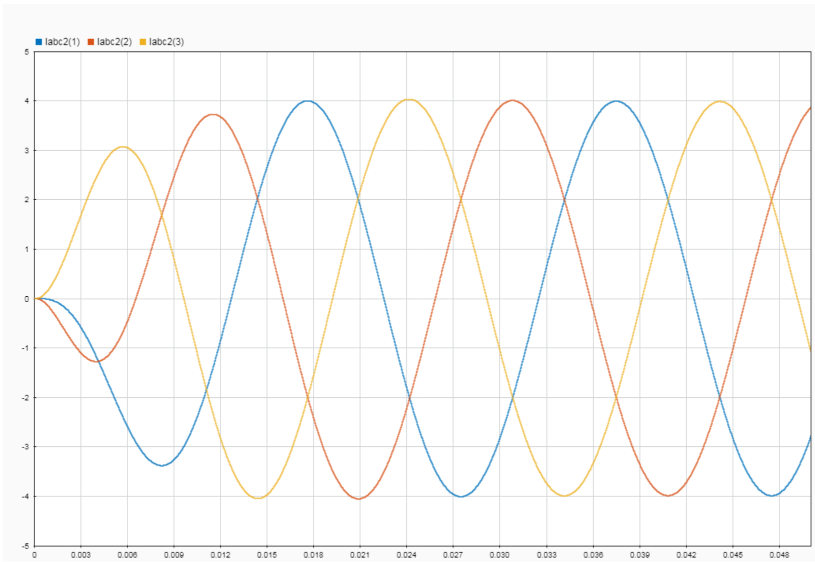


Fig 5: voltage & current

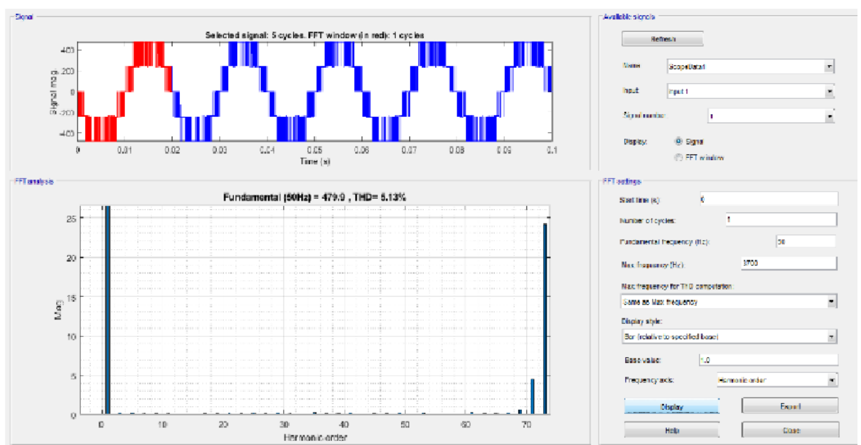


Fig 6: THD

Constant irradiance commanding constant active power pump to grid, various reactive power.

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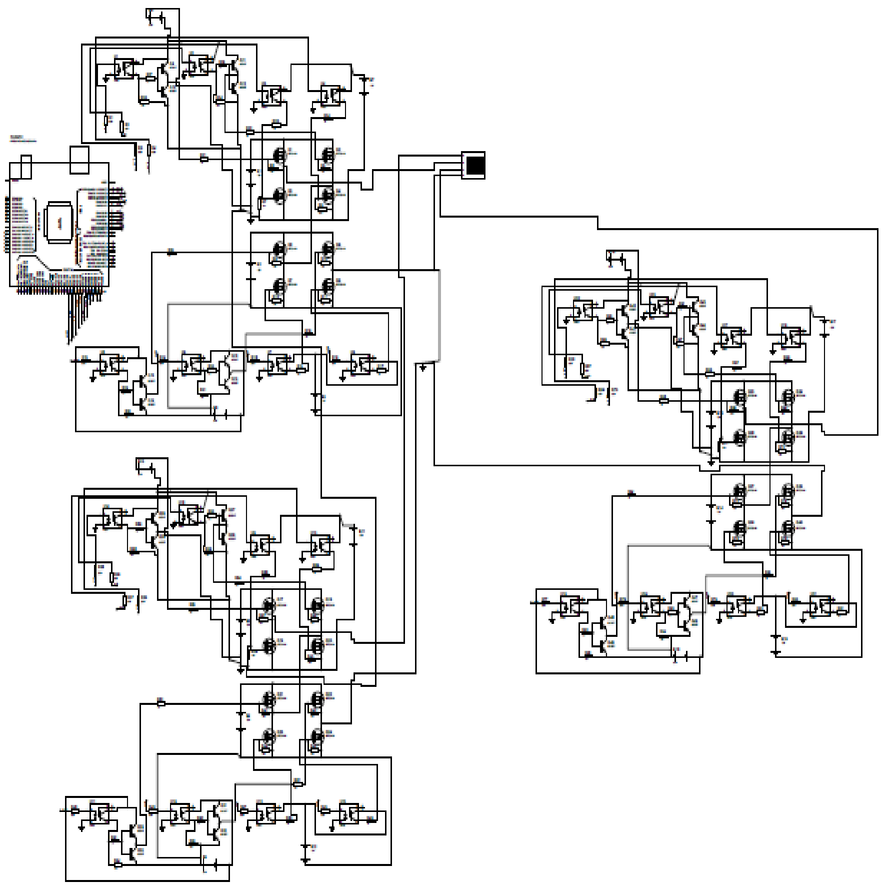

Fig 7: Circuit Diagram

The waveform of the reactive power command (Q*) and injected or absorbed reactive power (Q), u phase inverter voltage and current, active power and DC voltage Irradiance is set at 500 W/m2 during g the simulation time, which means that 50 kVA rating inverter will continue to feed active power of 25 kW owing to MPPT operation as can be seen from active power waveform of figure 7. In the beginning, the Q* is set to 0 VAR. At time t = 0.7, Q* is abruptly changed from 0 to 30 kVAR (reactive power absorbed). Thus the amplitude of the current fed by the inverter increases due to the increment of reactive power command. The phase angle of the inverter current also becomes leading and can be seen from the inverter phase voltage and current waveform. Likewise, at t=0.9, the Q* is changed from 0 to 30 KVAR (reactive power supplied). In this case, the phase angle of the inverter current becomes lagging.

During the time period, 0.8 <t<09, the inverter operates at unity power factor with 25 kW injected active power into the grid. It can be found that the VAR compensation scheme

Using fixed Q method can control the PV inverter reactive output power without causing noticeable drop in the active power generation.

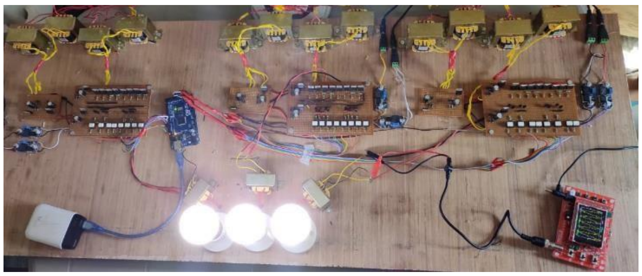

Fig 7: Hardware

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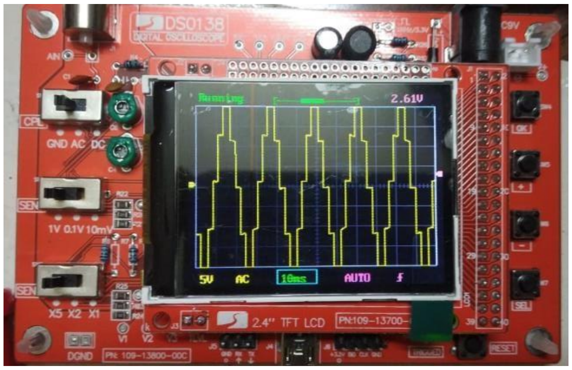

Fig 8: 5 Level Output Waveform

IV. CONCLUSION

This paper presents a grid connected photovoltaic inverter system having reactive power compensation feature. The need of reactive power generation in the PV inverter has been discussed. Simulink model of three phase dual stage grid connected solar PV inverter is developed in MATLAB, PV inverter operation in active and reactive power generation mode has been simulated. The various active and reactive power measurements were captured for analysis.

Simulation results presented for various control modes showed that the VAR compensation schemes can be implemented in solar inverter control system to control the PV inverter reactive output power without causing noticeable drop in the active power generation. The reactive power compensation should be made available in solar a solar plant to improve the effective utilization of the system when the solar irradiance is not abundant.

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