Reactive Power Compensation in Distribution Network with slide mode MPPT Control for PV System

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ABSTRACT

The Grid connected PV system requires a proper voltage control controller. In this paper an efficient voltage control by using slide mode controller with Maximum Power Point Tracking (MPPT) is presented. The voltage command is determined by the PV panel. Here the sliding mode controller is designed so as to balance the power flow from PV panel to the grid and load such that the PV power is utilized effectively. The design and simulation using MATLAB is presented in this work.

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I. INTRODUCTION

One of the most popular non-conventional energy sources is the solar energy. The Grid connected PV system is the very popular way of utilizing solar energy. Photovoltaic panels are used to convert the solar energy into electrical energy. PV has nonlinear characteristics. The voltage-power characteristics of the PV panel is varied which depends upon insolation and temperature. Considering the high initial installation cost of the PV system, it is always necessary to operate PV at its Maximum Power Point (MPPT).In this system, sunlight is captured by the PV array. Therefore, daily and seasonal solar position changes are followed in order to face the sun directly and capture the most available sunlight. The output of the PV panel is connected to an inverter to operate at the desired voltage to match the maximum available power from the PV module. A sliding mode controller is used to estimate the maximum power point as a reference for it to track that point and force the PV system to operate in this point. The load is composed of a battery bank. It is obtained by controlling the duty cycle of an inverter using sliding Mode control. This MPPT inverter for grid connection or to supply power to the AC loads. It can also store energy when the PV module generates more power than that demanded. In distribution system, these generated powers are transmitted through grid to load. If the load increased, the source side power demand occurs. In order to maintain the power be constant in both grid and load side, inject the additional power to grid by using PV module. The PV plants, the voltage are controlled by using a voltage control devices like on load tap changers, autonomous voltage regulators and capacitors. These voltage control mechanisms are increased the tap operation and also reduces the life time of the feeder circuit. So in advanced, by using the power electronic switching devices, the reactive power be compensated and that improves the operation and functionality of the power distribution system. Electricity generated by a grid- connected photovoltaic power system will reduce power bill and easily installed and do not need a Battery system. Once installed, these systems are essentially maintenance free, generate no pollution and are as silent as the sun. Increasing evidence suggests installing a PV system adds value to your property.

II. Principle of Operation

This project is about to carried out the optimization and implementation of a slide mode maximum power point controller for PV system, are presented. This controller is used to estimate the maximum power point as a reference for it to track that point and force the PV system to operate in this point. Maximum power point tracking are used to integrate with photovoltaic power systems so that the photovoltaic arrays are able to deliver the maximum power available. In general, PV generates megawatt power. In distribution system, these generated powers are transmitted through grid to load. If the load increased, the source side power demand occurs. In order to maintain the power be constant in both grid and load side, inject the additional power to grid by using PV module. The PV plants, the voltage are controlled by using voltage control devices like on load tap changers, autonomous voltage regulators and capacitors. These voltage control mechanisms are increased the tap operation and also reduces the life time of the feeder circuit. The main objective of this project is using the power electronic switching devices instead of voltage control mechanisms, the reactive power be compensated and that improves the operation and functionality of the power distribution system.

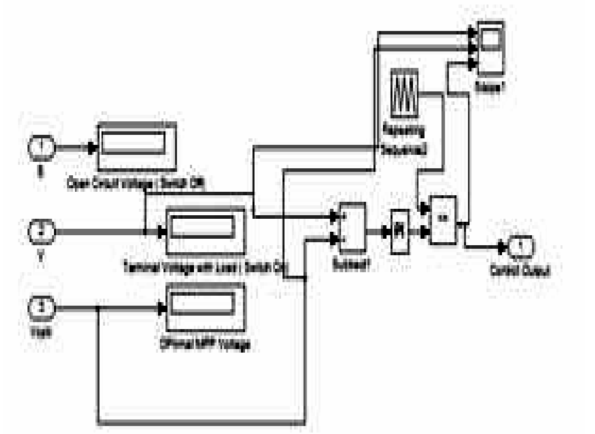

Fig1 Simulation of slide mode controller

III. Experimental Result

A. *Simulation of MPPT Algorithm*

Constant Voltage and Current Methods

The constant voltage algorithm is based on the observation from I–V curves that the ratio of the array's maximum power voltage, Vmp, to its open-circuit voltage, Voc, is approximately constant

Vmp / Voc = K < 1

Vmp is maximum power.

Voc is open circuit voltage.

The constant voltage algorithm can be implemented using the flowchart shown in Figure. The solar array is temporarily isolated from the MPPT, and a Voc measurement is taken. Next, the MPPT calculates the correct operating point using Equation and the preset value of K, and adjusts the Array's voltage until the calculated Vmp is reached. This operation is repeated periodically to track the position of the MPP. Although this method is extremely simple, it is difficult to choose the optimal value of the constant K. The literature Reports success with K values ranging from 73 to 80%. Constant voltage control can be easily implemented with the Analog hardware. However, its MPPT tracking efficiency is low relative to those of other algorithms. Reasons for this include the aforementioned error in the value of K, and the fact that measuring the open-circuit voltage requires a momentary interruption of PV power. It is also possible to use a constant current MPPT algorithm that approximates the MPP current as a constant percentage of the short-circuit current. To implement this algorithm, a switch is placed across the input terminals of the converter and switched on momentarily. The short-circuit current is measured and the MPP current is calculated, and the PV array output current is then adjusted by the MPPT until the calculated MPP current is reached. This operation is repeated periodically. However, constant voltage control is normally favored because of the relative ease of measuring voltages, and because open-circuiting the array is simple to accomplish, but it is not practically possible to short-circuit the array (i.e., to establish zero resistance across the array terminals) and still make a current measurement.

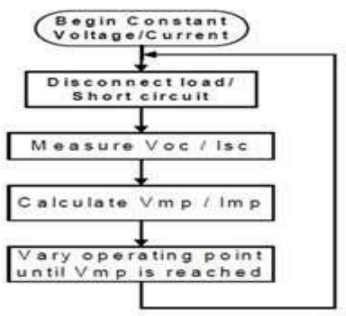

Fig 2 Flow chart for constant voltage algorithm

Table-1 PV module and converter output power for various Insolation.

S.No.	Insolation (W/m^2)	PV output power (W)	Converter output (W)
1	1000	37.08	36.02
2	700	22.26	20.03
3	500	11.8	10.37
4	300	4.46	3.71
5	100	0.6	0.47

B. *Proposed Block Diagram*

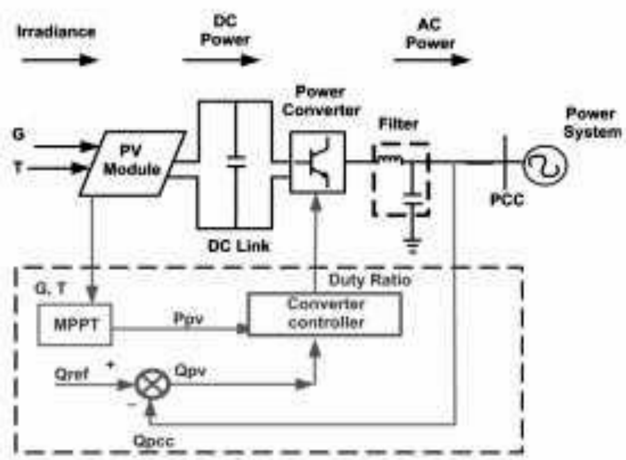

Fig 3 Proposed block diagram

PV generates megawatt power. In distribution system, these generated powers are transmitted through grid to load. If the load increased, the source side power demand occurs. In order to maintain the power be constant in both grid and load side, inject the additional power to grid by using PV module. The PV plants, the voltage are controlled by using voltage control devices like on load tap changers, autonomous voltage regulators and capacitors. These voltage control mechanisms are increased the tap operation and also reduces the life time of the feeder circuit.so in advanced, by using the power electronic switching devices, the reactive power be compensated and that improves the operation and functionality of the power distribution system. The distribution system contains the basic components PV module, Power Converter, Filter, MPPT, Grid, Load etc.

C. *Simulation Block Diagram*

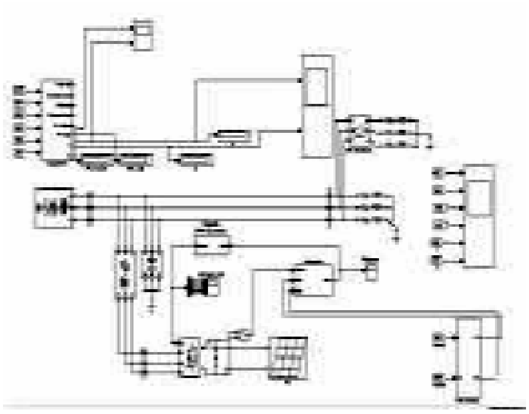

Fig 4 Simulation Diagram

D. *Simulation Output*

The grid side voltage and current is given below

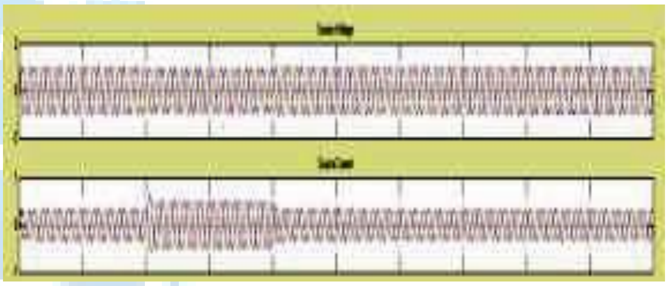

Fig 5 Source voltage & Source current.

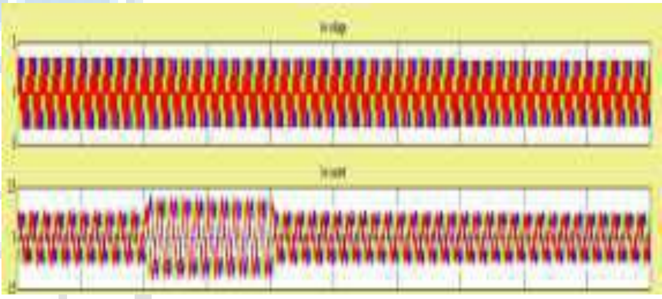

Fig 6 Inject the additional voltage to source to maintain the grid and load voltage is constant

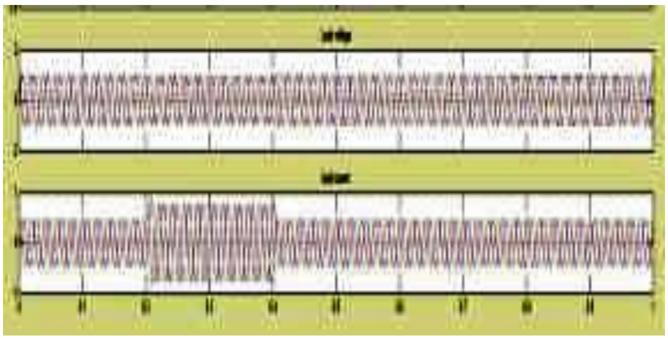

Fig 7 load voltage and current

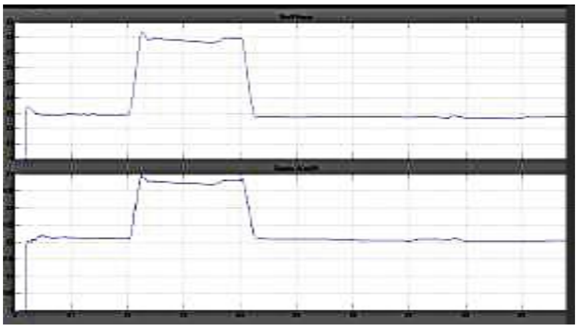

Fig 8 The real and reactive power utilization

Here the real power is maintained nearly 0.9 and reactive power be 0.4. Therefore the system maintains better power factor and stability.

E. Building of Generalized PV Model

The voltage generated by a single solar cell is very low, around 0.5v. So a number of solar cells are connected both in series and parallel connections to achieve the desired output. In case of partial shading, diodes may be needed to avoid reverse current in the array. Good ventilation behind the solar panels is provided to avoid the possibility of less efficiency at high temperatures.

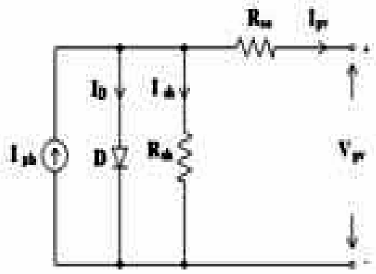

Fig 9 Equivalent circuit of pv model

$$I_{pv}=I_{ph}(G,T-I_d-V_d/R_{sh})$$
$$I_d=I_r\,(e_{vd/vt}-1)$$
$$V_T=nKT/q$$
$$V_d=V_{pv}+I_{pv}R_{sc}$$

It contains two PV panel, one for reference module and other for instant moment watch the power of the system. To compare the two output and finally the reference be set by using tracking system in the slide mode controller, the reference wave is given below.

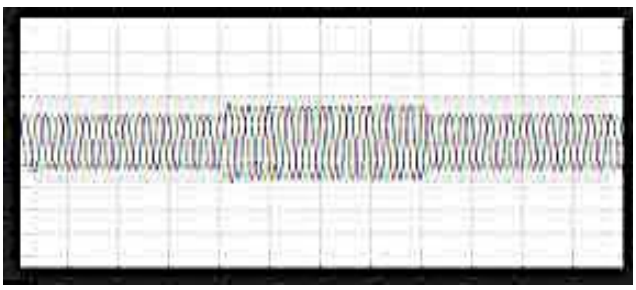

Fig 10 Reference PV model

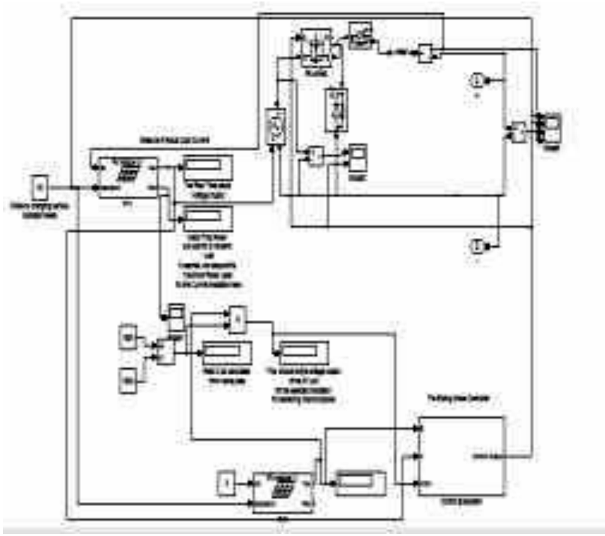

Fig 11 PV panel

F. Building of Filter

Three-phase harmonic filters are shunt elements that are used in power systems for decreasing voltage distortion and for power factor correction. Nonlinear elements such as power electronic converters generate harmonic currents or harmonic voltages, which are injected into power system.

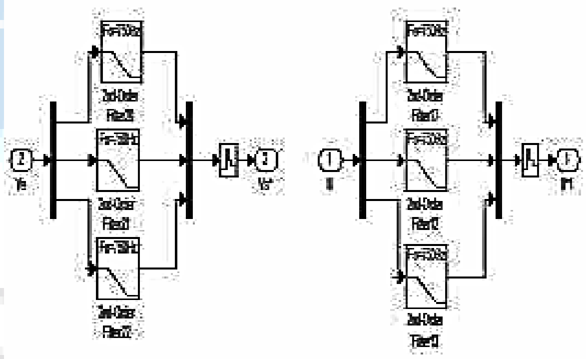

Fig 12 Filter

The resulting distorted currents flowing through system impedance produce harmonic voltage distortion. Harmonic filters reduce distortion by diverting harmonic currents in low impedance paths. Harmonic filters are designed to be capacitive at fundamental frequency, so that they are also used for producing reactive power required by converters and for power factor correction. In order to achieve an acceptable distortion, several banks of filters of different types are usually connected in parallel. The most commonly used filter types are Band-pass filters, which are used to filter lowest order harmonics such as 5th, 7th, 11th, 13th, etc. Band-pass filters can be tuned at a single frequency (single-tuned filter) or at two frequencies (double-tuned filter).High-pass filters, which are used to filter high-order harmonics and cover a wide range of frequencies. A special type of high-pass filter, The C-type high-pass filter is used to provide reactive power and avoid parallel resonances. It also allows filtering low order harmonics (such as 3rd), while keeping zero losses at fundamental frequency.

G. *Subsystem*

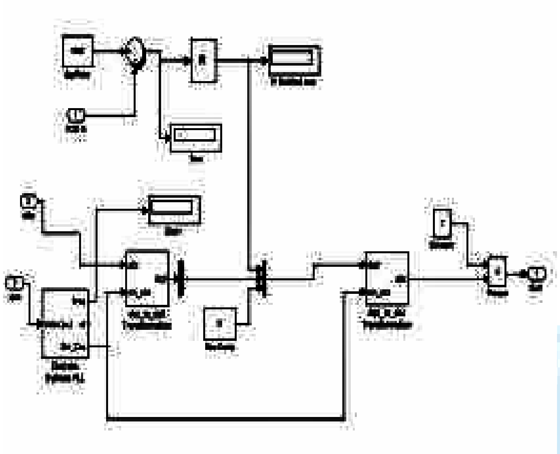

Fig 13 Subsystem

The subsystem contains the set point value as 1600. It contains the input of the inverter (Vabc, Iabc, Vdc). It used to rectify the error by using PI controller and finalized output be produced and it is given to the gate terminal of the inverter sections.

IV. Conclusion

Thus the simulation results are verified for the output voltage is maintained constant for both grid side and load side with the help of power electronics switches. The effectiveness of the scheme is tested through simulations on a realistic distribution network model. Proposed coordinated reactive power dispatch, are reduced without detrimental impact on the feeder voltage. By using the slide mode controller, the constant voltage is maintained. By reducing the voltage control mechanisms like on load tap changers and autonomous regulators and capacitors etc. and also avoid runaway condition and Life time of the system be improved.

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