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Photovoltaic Cell as Power Quality conditioner forGrid connected system by using PI Controller

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***Abstract**- The paper deals with the simulation study of PV cells as well as power quality conditioner for voltage sags. A computer simulation derived study of photovoltaic cells or modules utilizing MATLAB is demonstrated. The MATLAB is an analog simulator or digital simulator which estimates voltage and current in a circuit under a variety of distinctive situations. This MATLAB is used to simulate a circuit based model for PV cells or modules and then to conduct a behavioral analysis under altering conditions of solar insolation, including blending effect, temperature, diode model variables, series and shunt resistance. In future the supporting services provided by PV system could speed up their penetration in to power systems. Furthermore low power PV systems can be used effectively to enhance the power quality using MPPT algorithm. This paper presents a single -phase voltaic system that furnishes grid voltage support and compensation of harmonic distortion at the point of common coupling (PCC). Simulation results validate the proposed solution.*

***Key words**- Circuit simulator, Insolation, PV cells or modules, shunt controller, Diode model parameters, MPPT algorithm.*

1. INTRODUCTION

A PV system not only consists of PV modules but also requires a good amount of power electronics as an interface between PV modules and load for effective and efficient utilization of naturally attainable sun power. The simulator used should be capable of modeling of not only PV cells or modules but as well as posses the ability to simulate connected power electronics so that a simulation of a whole PV system can be carried out.

The present paper deals with the simulation study of PV cells as well as power quality conditioner for voltage sags this paper proposes to solve power quality issue using a voltage controlled converter that behaves as a shunt controller improving the voltage quality in case of small voltage dips and in the presence of nonlinear loads. Shunt controllers can be used as static VAR generator for stabilizing and improving voltage profile in power system and to compensate current harmonics and unbalanced load current.

The PV inverter supplies the power generated by the PV panels but also enhances the voltage profile. The presented topology takes on a repetitive controller capable of compensating the selected harmonics. An MPPT algorithm chosen is based on incremental conductance method. It has been adjusted to seize the power oscillations on the PV side and it controls the phase of the PV inverter voltage.

2. PV CELL MODEL

PV cell is a method of generating electrical power by converting solar radiation into direct current electricity using semiconductors that exhibit the photovoltaic effect the basic PV cell model is presented.

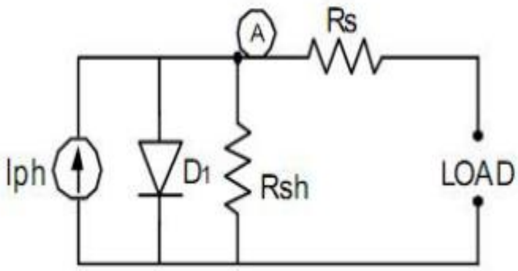

Fig.1: PV Cell circuit model

The behavior of PV cells can be described by five parameters (I_{ph}, N, I_s, R_s, R_{sh}) represents a physical PV cell or module. These five variables of PV cell or module are in fact related to two environmental criterions of solar insolation and temperature and owing to non-linear nature of equation**.**

3. V-I CHARACTERISTICS OF PV CELL

SHORT CIRCUIT CURRENT OF SOLAR CELL

The maximum current that a solar cell can deliver without harming its own constriction. It is measured by short circuiting the terminals of the cell at most optimized condition of the cell for producing maximum output. The term optimized condition I used because for fixed exposed cell at most optimized condition of the cell for producing maximum output. The term optimized condition I used because for fixed exposed cell surface the rate of production of current in a solar cell also depends upon the intensity of light and the angle at which the light falls on the cell. As the current production also depends upon the surface area of the cell exposed to light it is better to express maximum current density instead maximum current. Maximum current density instead maximum current. Maximum current density or short circuit current density rating is nothing but ration of

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maximum or short circuit current to exposed surface area of the cell.

$$J_{sc} = \frac{I_{sc}}{A}$$

Where I_{sc} is the short circuit current, J_{sc} is maximum current density and A is the area of the PV cell.

OPEN CIRCUIT VOLTAGE OF SOLAR CELL

It is measured by measuring voltage across the terminals of the cell when no load is connected to the cell. This voltage depends upon the techniques of manufacturing and temperature but not fairly on the intensity of light and area of exposed surface. Normally open circuit voltage of solar cell nearly equal to 0.5 to 0.6 volt. It is normally denoted by V_{oc}.

MAXIMUM POWER POINT OF SOLAR CELL

The maximum electrical power one solar cell can deliver at its standard test condition. If we draw the V-I characteristics of a solar cell maximum power will occur at the bend point of the characteristics curve. It is shown in the V-I characteristics of solar cell by P_m.

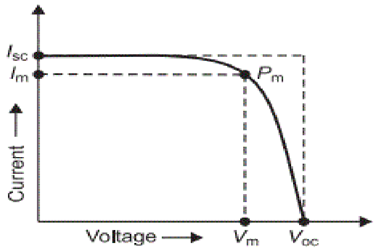

Fig 2 : PV cell characteristics

CURRENT AT MAXIMUM POWER POINT

The current at which maximum power occurs Current at maximum power point is in the V-I characteristics of solar cell by I_m.

VOLTAGE AT MAXIMUM POWER POINT

The voltage at which maximum power occurs Voltage at maximum power point is shown in the V-I characteristics of solar cell by V_m.

4. SHUNT CONTROLLERS FOR VOLTAGE DIP MITIGATION

Shunt devices are normally used to neutralize minute voltage deviations which can be regulated by reactive power insertion. The capability to control the fundamental voltage at a particular point relies on the grid ohmic resistance and the power factor of the load. The compensation of a voltage dip by current injection is hard to attain since the grid impedance is usually low and the introduced current has to be very high to increase the load voltage. The shunt controller can be current or voltage controlled. When the converter is a current controlled it can be represented as a grid feeling component that supports the grid voltage by modifying its reactive output power matching to the grid voltage diversities. When the converter is a voltage can be represented as agrid supporting part that controls its output voltage. However also in this second case the control action results in injecting the reactive power in order to regularize the voltage. The vector diagrams of a shunt controller formed to provide only reactive power are stated in Fig3. when the grid voltage is 1p.u., the converter supplies the reactive power absorbed by the load and the vector diagram of the current or voltage controlled converter is the same then in the first case it is controlled by the compensating current I and in the one it is controlled by the load voltage as underlined in Fig3(a) and Fig3(b).

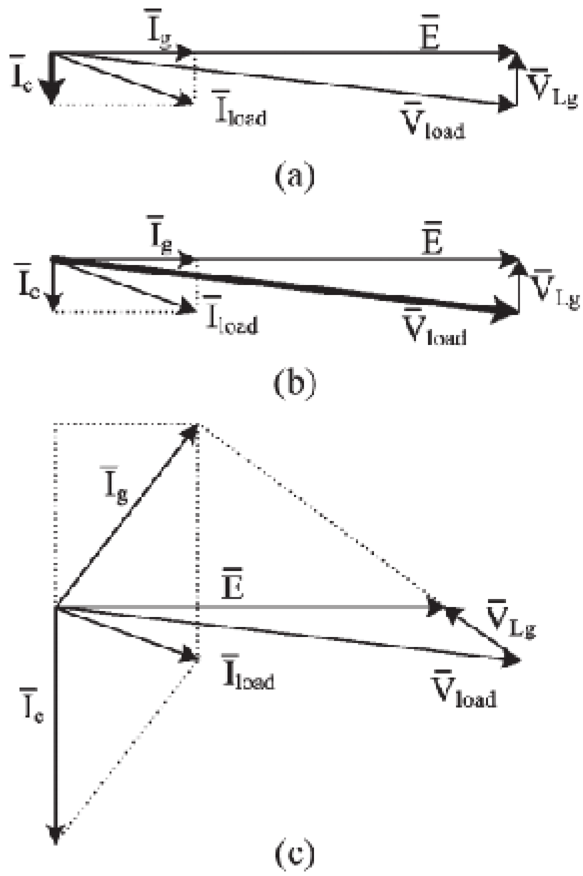

Fig3:Vector diagram of the shunt controller providing only reactive power. (a) Current controlled converter in normal conditions.(b)voltage controlled converter in normal condition.(c)vector diagram for compensation of a voltage dip of 0.15 pu.

When a voltage sag occurs the converter provides reactive power in order to support the load voltage and the grid current I_g has a dominant reactive component i.e.,

$I_g + I_c = I_{Load}$

Where V_{Lg} is the inductive voltage drop shown in Fig 3(c). If the shunt controller suppliesthe load with all the required active and reactive powers as in normal conditions it provides a compensating current $I_c = I_{Load}$; hence, the system operates as in island mode and $I_g = 0$.

In case of a voltage dip, the converter has to provide the active power required by the load and it has to inject the reactive power needed to stabilize the load voltage as shown in Fig4(b). the grid current in this case is reactive. It can be seen that

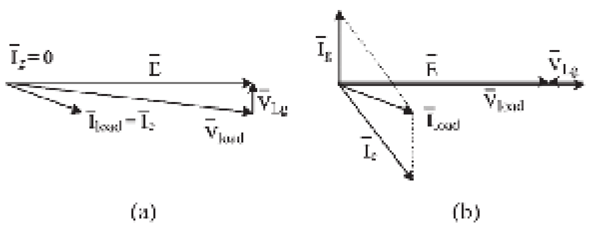

Fig4:Phasor diagram of the shunt controller providing both active and reactive powers. (a)normal conditions.

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(b)phasor diagram for compensation of a voltage dip of 0.15pu.

Hence during voltage sag the amount of reactive current needed to maintain the load voltage at the desired value is inversely proportional to ωL_g. This means that a large inductance will help in mitigating voltage sags although it is not desirable during normal operation.

5. PV SYSTEM WITH SHUNT CONNECTED MULTIFUNTION CONVERTER

In case of low power applications it can be beneficial to use the converter that is parallel linked to the grid for the amends of minute voltage sags. This feature can be viewed as an ancillary service that the system can be furnished to its sectional burdens. The suggested PV converter functions by providing active and reactive powers while the sun is present. At low beam of light the PV converter only acts as a harmonic and reactive power compensate. Only act as a harmonic and reactive power compensator.It is difficult to improve the voltage and current. In addition a large rated converter is necessary in order to compensate voltage sags. The PV shunt converter must be rated for the peak power produced by the panels. In the proposed system the PV converter operates as a shunt controller it is connected to the load through an LC filter and to the grid through an extra inductance$L_g$of 0.1pu as shown in Fig5.

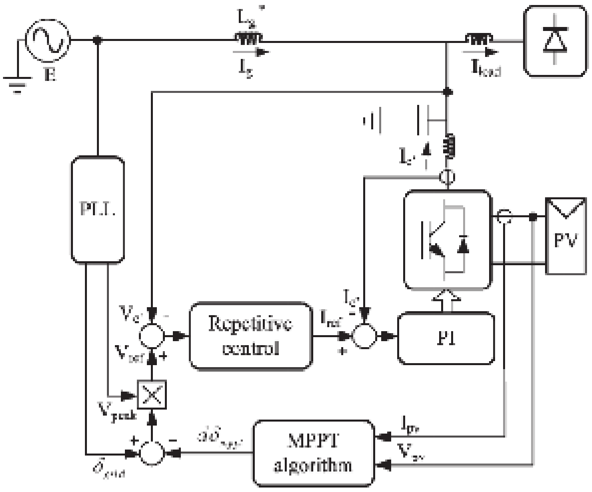

Fig 5: grid connected PV system with shunt controller functionality

Usually in case of low power applications the systems are connected to low voltage distribution lines whose impedance is resistive. Yet in the suggested topology the grid can be considered mainly inductive as a consequence of L_g total on the grid side. Though the voltage regulation is clearly affected by the voltage drop on the inductance L_g it is not comfortable picking an inductance L_g of high value in order to bound the voltage drop in grid normal conditions. It denotes the main disadvantage of the proposed topology.

6. SIMULATION RESULTS

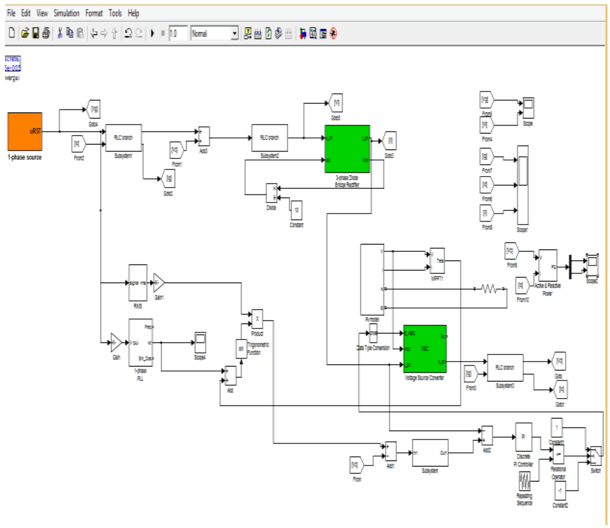

Fig 6: Simulation circuit

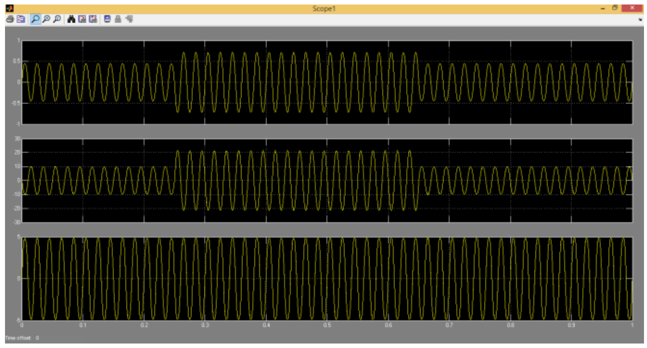

Fig 7: The performance of the voltage controlled shunt converter with MPPT algorithm: grid current, converter current and load current.

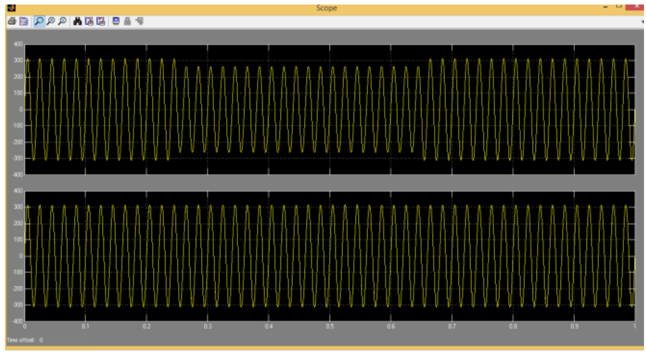

Fig 8: The performance of the voltage controlled shunt converter with MPPT algorithm: grid voltage and load voltage.

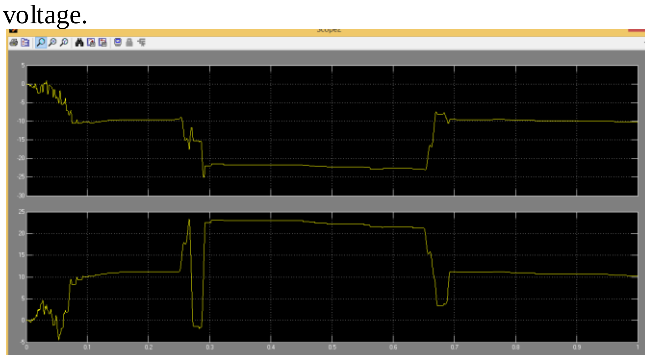

Fig 9: The performance of the Active and Reactive power provided by the shunt connected multifunctional converter.

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7. CONCLUTION

In this paper PV system with shunt controller has been presented. The PV converter is voltage controlled with a repetitive algorithm. An MPPT algorithm has been specially designed for the proposed for the proposed voltage controlled converter. It is based on the incremental conductance method and it has been modified to change the phase displacement between the grid voltage and the converter voltage thus maximizing the power extraction from the PV panels. The designed PV system provides grid voltage support at fundamental frequency and compensation of harmonic distortion at the point of common coupling. An inductance is added on the grid side in order to make the grid mainly inductive .experimental results conform the validity of the proposed solution in case of voltage dips and nonlinear loads.

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