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Performance Analysis of Active & Reactive Power Flow in PV System Connected To Distribution Grid Using MATLAB

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ABSTRACT:In this paper, the implementation of photovoltaic system using simple circuit model with detailed modeling of photovoltaic modules circuit is presented with simulation results. The voltage source inverter is coupled between the dc output of photovoltaic system and ac grid along with MPPT control technique. The control technique applied is based on theory of instantaneous reactive power (p-q theory). According to this, proposed PV system used to deliver active power to the grid at the same time, the reactive power of load and harmonics will eliminate at change in both irradiation and load condition. During no sunlight, system is available only with reactive power and harmonic compensation.

KEYWORDS:Grid Connected PV, Reactive Power Compensation, MPPT, VSI, Power Quality, THD.

I. INTRODUCTION

Photovoltaic generation is the technique that uses photovoltaic cells to convert solar energy into electrical energy. Photovoltaic is assuming increasingly important as a source of renewable energy in place due to its clear advantages, such as simple architecture, easy allocation, pollution-free, low maintenance cost, and etc. In this paper, the design of photovoltaic system using simple circuit model with detailed modelling of photovoltaic modules circuit is presented. The physical equations supervising the (also applicable to PV cells) PV module presents. The operation of the circuit model developed with DC to DC boost converter was verified with simulations. This paper is proposed to the use of the theory of the instantaneous reactive power (PQ theory), which controls the active and reactive power at the inverter output. Here presents the experimental verification of simulation results. This paper also proposes to develop a photovoltaic simulation system with maximum power point tracking function using MATLAB/Simulink software in order to simulate, evaluate and predict the characteristics of the real photovoltaic system. The performance aspects of the established solar PV module model were simulated and compared with those of the original field test data under different temperature and solar irradiance conditions. After that, a model of a photovoltaic system with maximum power point tracker (MPPT), which was developed using DC-DC buck-boost converter with the P&O method, was then established and simulated to compare the THD.

II. SYSTEM MODEL

The preferred system overview is shown in Fig.1 for analysis of the system's knowledge of the mathematical models and equations that reflect the electrical quantities at the output of the solar PV panel and solar cell is required.

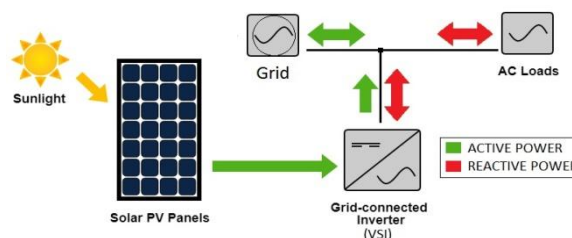


Figure 1:Grid Connected PV System

2.1. Equivalent Circuit of model PV:

A PV array consists of several PV cells connected in series and in parallel. Serial connections are responsible for the higher voltage of the module, while the parallel connection is responsible to increase the flow in the matrix. As shown in Fig. 2, typically, a solar cell can be modelled by a current source and a diode connected in reverse parallel. It has its own series and parallel resistance. Series resistance is due to the barrier to the flow path of electrons output 'P' and 'N' parallel resistance is due to the leakage current. The P-V and I-V Characteristics are shown in Fig.3.

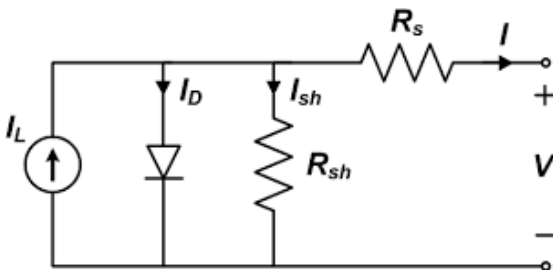


Figure 2: Mathematical Model of PV

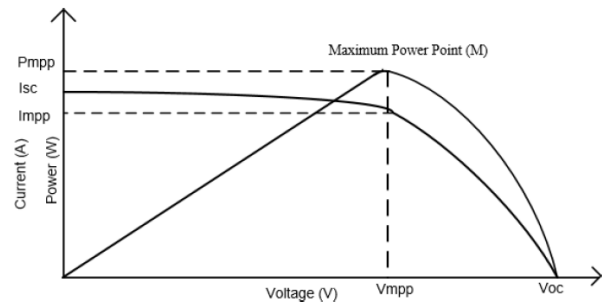


Figure 3: P-V and I-V Characteristics of PV array

2.2. MPPT Algorithm:

MPPT algorithms are necessary in PV applications because the maximum power point of a solar panel varies with the irradiation and temperature, so the use of MPPT algorithms is required in order to obtain the maximum power from a solar PV array. In this simulation, Perturbation and Observation (P&O) technique is used. It is most commonly used algorithm. In this method, the maximum power point is tracked by perturbing the duty ratio of boost converter at a regular interval based on the slop of power-voltage (P-V) curve. If the perturbation in duty cycle ratio increased the power than the next perturbation sign is equal otherwise perturbation sign is changed. This process is repeated until maximum power point is reached. The flowchart of the P&O algorithm is given in Fig. 4.

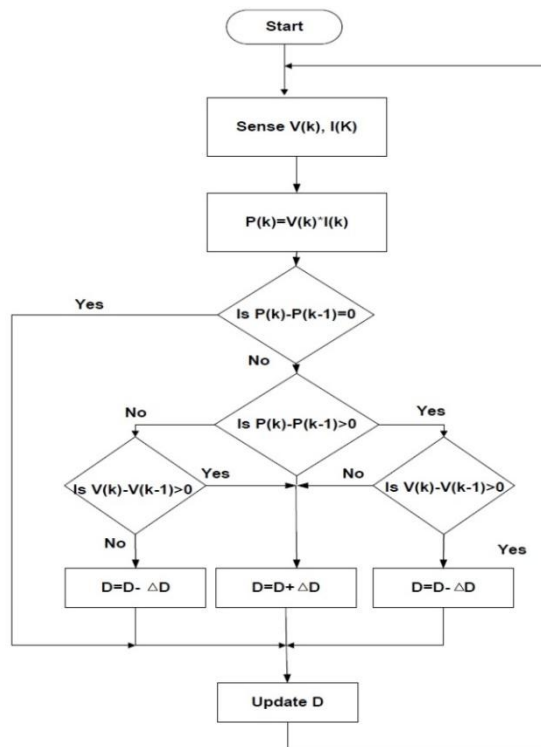


Figure 4:MPPT – P&O Algorithm Flow Chart

III. CONTROL STRATEGY OF GRID CONNECTED PV SYSTEM

For the control strategy of the grid-connected solar PV system “instantaneous reactive power theory” (P-Q theory) is applied and for control inverter output current the hysteresis band control technique is used. Block diagram of control technique for the grid connected PV system shown in the Fig.5.

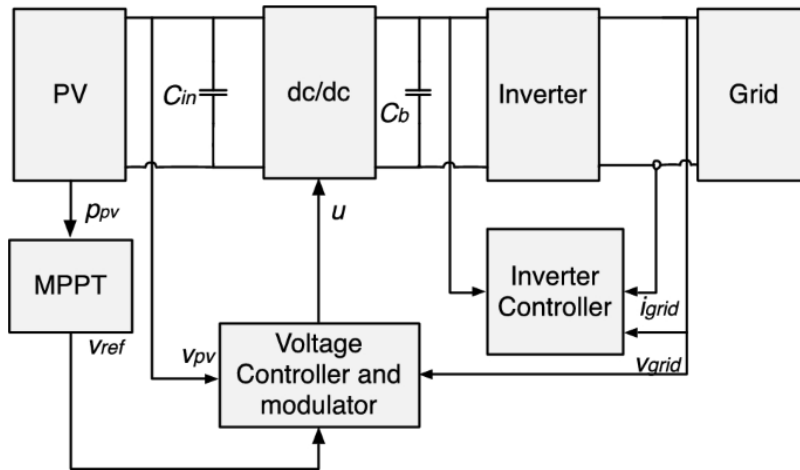


Figure 5:Block Diagram of Control Technique of PV System

The solar PV inverter injects the active power and reactive power in controlled manner, hence the system is compensated. The PV inverter is also used utilized as an active power filter to compensate the load harmonics and reactive power. The types of control methods are active power control, reactive power control, reference current generation, and current control. These are mentioned in the review topic.

IV. SIMULATION MODEL AND RESULTS

The preferred PV cells are not only capable of supplying extracted solar power to the power system units, but it also can significantly compensate the reactive power and mitigate harmonic order currents which are drawn by non-linear loads. In order to demonstrate the validity of the concepts discussed previously. The Simulink model of PV cell array is shown in Fig.6.

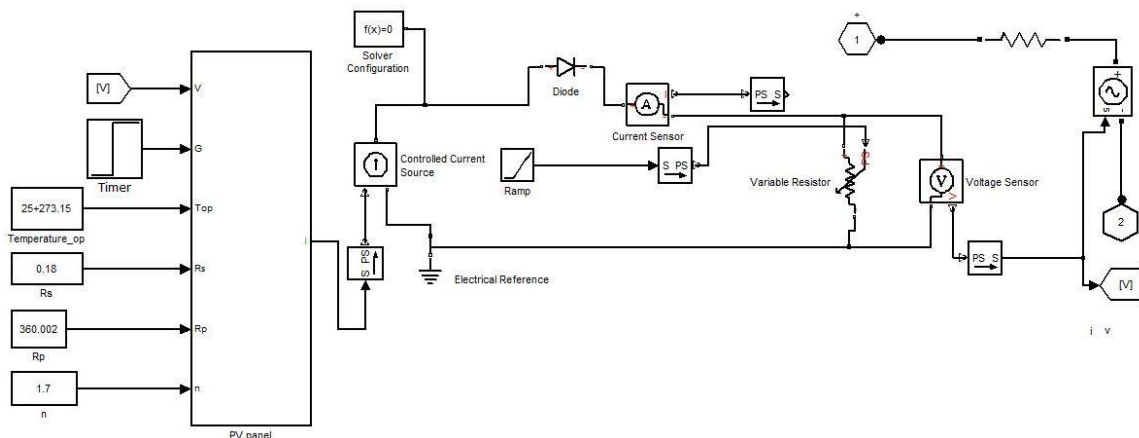


Figure 6: PV Cell Array Simulink Model

The Simulink model of PV cell array connected to grid via VSI inverter and MPPT charge controller is shown in the Fig.7.

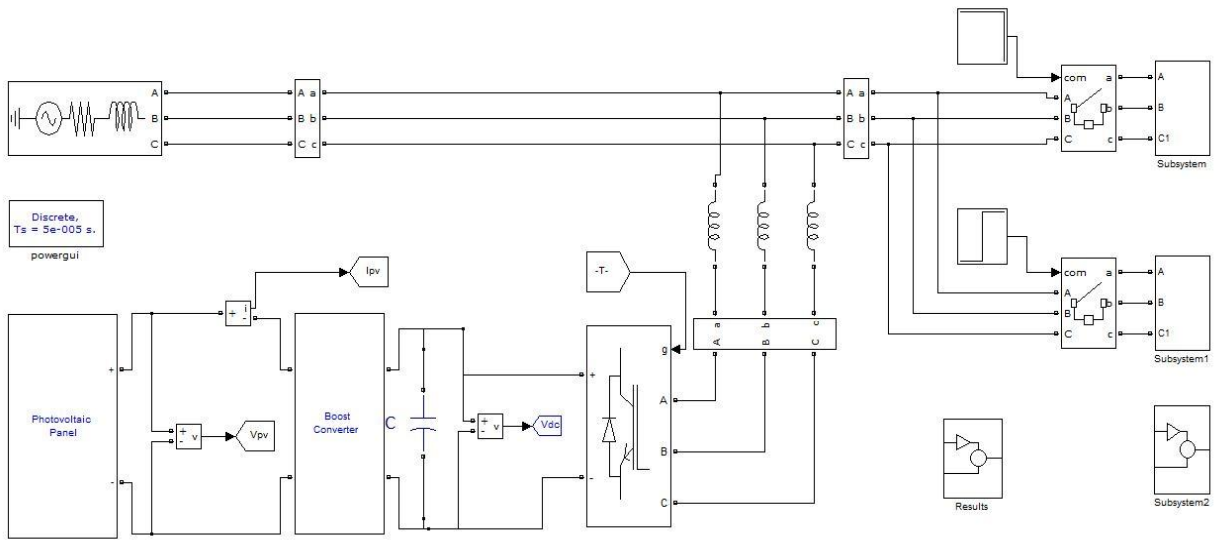


Figure 7: Main Simulink Model of System

The output current, voltage and power waveforms for the irradiance of 1000 W/m^2 are shown in graphical results along with the effect of varying irradiation with varying load condition in active power and reactive power (Fig.8.1 & Fig.8.2). For the time $0.0 \text{ sec} < t < 0.4 \text{ sec}$ load is 22.5 Kw and same time irradiation 500 W/m^2 . At that time, PV system supplies all generated active power to the load and remaining active power is supplied from the grid to the load. After 0.4 sec , load is decrease to 11.25 Kw and same time irradiation increase 1000 W/m^2 . At that time, active power generated by PV system is greater than load demanded active power. So, PV system supplied total load required active power and remaining active power supplied to the grid. The graph (Fig.8.3, Fig.8.4 & Fig.8.5) shows the result for reactive power of the load, PV system, and grid. In any insolation condition the inverter of PV system compensates near about 100% of total load reactive power demand thus, reactive power drawn from grid is ideally zero. $Q_{\text{LOAD}} = Q_{\text{PVINV}}$, $Q_{\text{GRID}} = 0$. The graph shows the phase current waveforms of the grid, PV system and nonlinear load. The load current is the sum of PV system current and grid current. It can be observed that at any time $I_{\text{LOAD}} = I_{\text{INV}} + I_{\text{GRID}}$. Also, shows in the graphs, harmonic content list relative to fundamental is analysed of the source current with and without PV system.

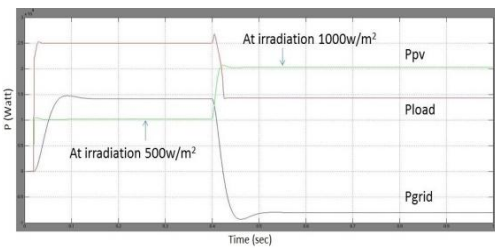


Figure 8.1: Active Power of Load (PV system & Grid)

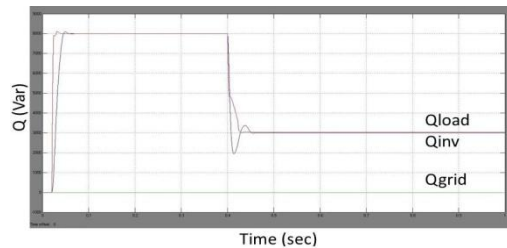


Figure 8.2: Reactive Power of Load (PV system & Grid)

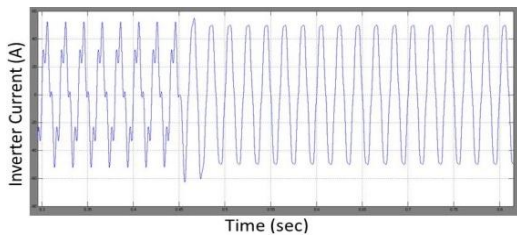


Figure 8.3: Current of Inverter

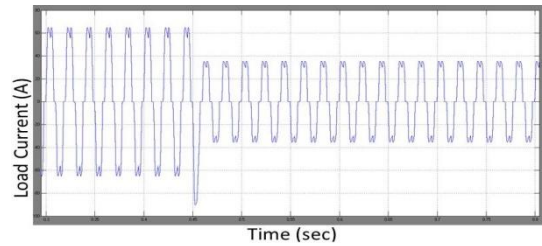


Figure 8.4: Current of Load

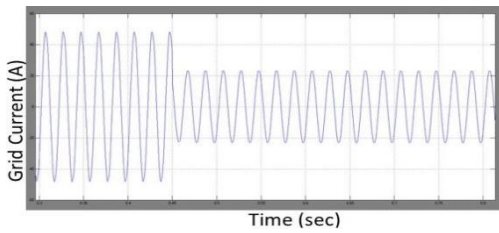


Figure 8.5: Current of Grid

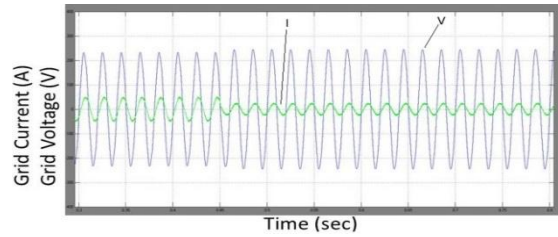


Figure 8.6: Waveform of Grid Voltage & Current

Figure 8: All graphical results of Simulink model

The graph (Fig.8.6) shows that the grid phase-A voltage and current waveform. We observed that the current is in phase with voltage because of total reactive power is compensated by solar PV inverter. The source current total harmonic distortion (THD) before PV system which is 6.15 % and it reduced to 1.56% as shown in Fig.9.1 and Fig.9.2.

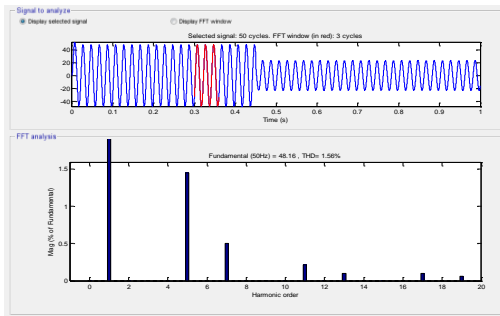


Figure 9.1: Harmonic analysis with PV system (THD=1.56%)

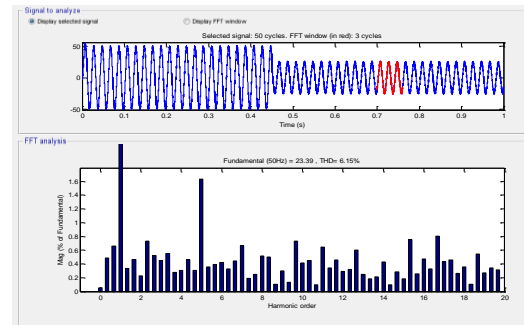


Figure 9.2: Harmonic analysis without PV system (THD=6.15%)

Table 1. System Parameters

1	AC Line Voltage	415 V
2	Line Frequency	50 Hz
3	Universal Bridge Rectifier Load- R-C	10 Ω, 1 mF
4	MPPT Controller Voltage Step Size	2 V
5	MPPT Sampling time	0.03 sec
6	DC link PI Controller gains	$K_p=1.5, K_i=0.1$
7	Capacitance of DC bus side	4000 μf
8	Load – Non-linear	22.5 kW
9	Inductance of grid	1.8 mh
10	PV- Open Circuit Voltage	64.212 V
11	PV- Short Circuit Current	5.956 A
12	PV- Max. Output Voltage	54.683 V
13	PV- Max. Output Current	5.576 A
14	Modules in Series per String (Ns)	5
15	Modules in Parallel per String (Np)	3

V. CONCLUSION

Finally, it is clear that the solar PV system injects sufficient amount of current to mitigate the harmonics of various orders generated by the non-linear loads. Also the reactive power compensated at the same time, PV inverter delivers the excess active power to the grid. Photovoltaic power seems to be the favourable clean energy source of the future. In order to optimize PV power usage, we have preferred a direct coupling of solar PV system to the grid. From the results obtained, it is proven that by using the preferred system, Photovoltaic power can be efficiently extracted by solar cells and injected into the grid and compensating reactive power of the load all 24 hours of the day. The preferred system also compensates the harmonics content of nonlinear load. Finally, and according to the obtained results we can consider the preferred system to be efficient solution to the growing demand of power at the present and in the future.

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BIOGRAPHY



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