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Reactive Power Control in Grid Associated PV System

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Abstract:

Grid tied solar inverters are designed to generate power at unity power factor which means that they have capability to produce active power only. The reactive power requirement of the load is catered by grid only. With the suddenly increase in the deployment of renewable based Distributed Energy Resources, 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 and reactive power requirement from the grid will reduce as the grid has to supply lesser reactive power. A cuckoo algorithm is implemented to improve the performance of PV system. To maintain proper synchronization between PV and grid system to suitable controller is designed for the inverter. For this purpose, this work proposes a svm controller for PV inverter to mitigate the system voltage fluctuations. Also, the method considers the loss associated with the reactive power production. Simulations are presented to assess the voltage regulation characteristics under different load conditions.

.**Key Words:** Photovoltaic System, Cuckoo MPPT, Boost Converter, SVM controller and Grid Connection.

Introduction:

At present, most of energy demand in the world relies on fossil fuels such as petroleum, coal, and natural gas that are being exhausted very fast. One of the major severe problems of global warming is one of these fuels combustion products, carbon dioxide; these are resulting in great danger for life on our planet [1].

Among all the available Renewable energy sources, PV array systems are trusted to play a significant role in prospective energy production. PV systems transform photon energy into electrical energy. These energy systems generate low voltage output, thus, high step-up dc/dc converters are employed in many applications, including fuel cells, wind power, and photovoltaic systems, which converts low voltage into high voltage. Due to the increasing demand on electricity, and limited availability and high prices of non-renewable sources, the photovoltaic (PV) energy conversion system has becomes an alternative as it is freely available, pollution free, and has less operation al and low maintenance cost. Therefore, the utilization of PV energy systems has to be increased for standalone and as well as grid-connected modes of PV systems. Photovoltaic (PV) as a renewable energy resource

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naturally is not stable by location, time, season and weather and its installation cost is comparatively high. An important consideration in increasing the efficiency of PV systems is to operate the system near maximum power point (MPP) so to obtain the approximately maximum power of PV array. For getting maximum possible energy produced by a solar system.

This paper focuses on developing a simulation model to design and size the hybrid system for a variety of loading and meteorological conditions. This simulation model is performed using Matlab and SimPower Systems and results are presented to verify the effectiveness of the proposed system. The proposed grid connected hybrid energy generation system is shown in figure 1.

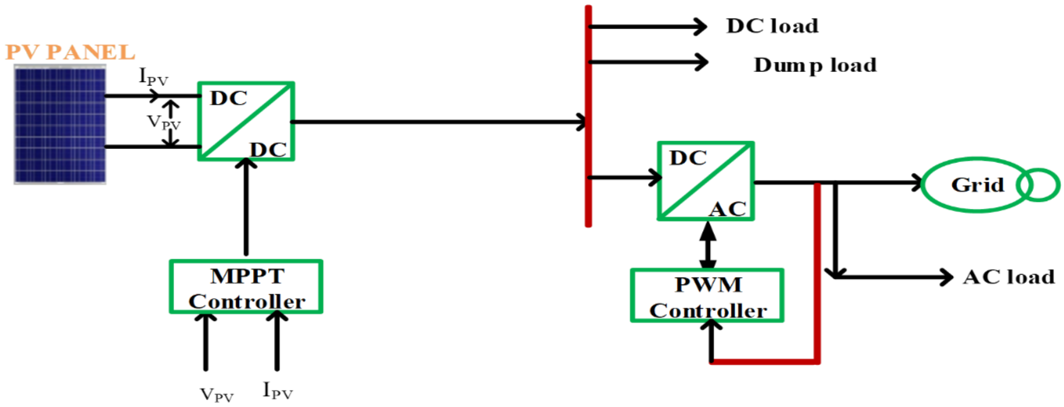

Figure 1: Configuration of proposed grid connected hybrid system

SOLAR SYSTEM:

In photovoltaic (PV) system, solar cell is the basic component. PV array is nothing but solar cells are connected in series or parallel for gaining required current, voltage and high power. Each Solar cell is similar to a diode with a p-n junction formed by semiconductor material [5]. It produces the currents when light absorbed at the junction, by the photovoltaic effect. Figure 3 shows at an insulation output power characteristic curves for the PV array. It can be seen that a maximum power point exists on each output power characteristic curve. The Figure 3 shows the (I-V) and (P-V) characteristics of the PV array at different solar intensities. The equivalent circuit of a solar cell is the current source in parallel with a diode of a forward bias. Load is connected at the output terminals. The current equation of the solar cell is given by:

$$I = I_{ph} - I_D - I_{sh}$$

$$I = I_{ph} - I_o [\exp(q V_D / nKT)] - (v_D / R_S)$$

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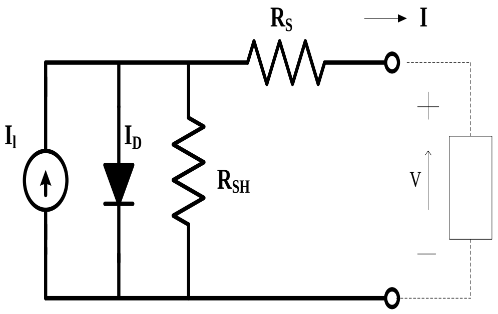

Figure 2: Equivalent circuit of PV Module

Power output of solar cell is P = V * I

MAXIMUM POWER POINT TRACKING METHOD:

The irradiance and temperature curves are the two most vital factors which influence the output power characteristics of the PV system. And these two are momentarily maintained by solar irradiation and temperature. As discussed, there will be blunt changes in the values of solar radiation during the day as shown in Figure 1. A typical solar panel converts only 30 to 40 percent of the incident solar irradiation into electrical energy. According to Maximum Power Transfer theorem, the power output of a circuit is maximum when the thevenin impedance of the circuit (source impedance) matches with the load impedance. In this way, Maximum power point tracking technique is necessarily used to improve the efficiency of the solar panel.

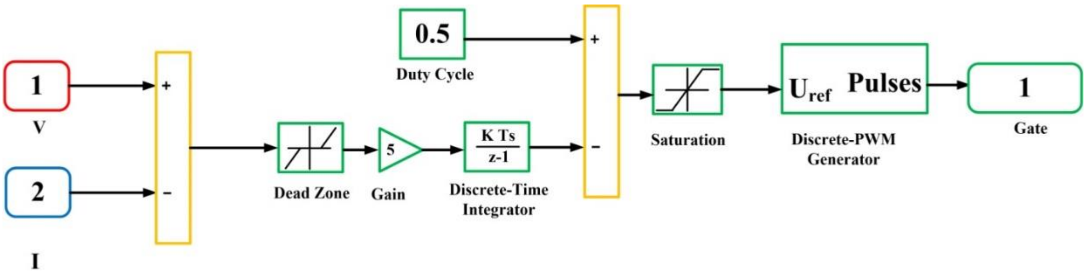

Figure 3: DC-DC converter MPPT Controller

PROPOSED SYSTEM:

The active power pumped 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.

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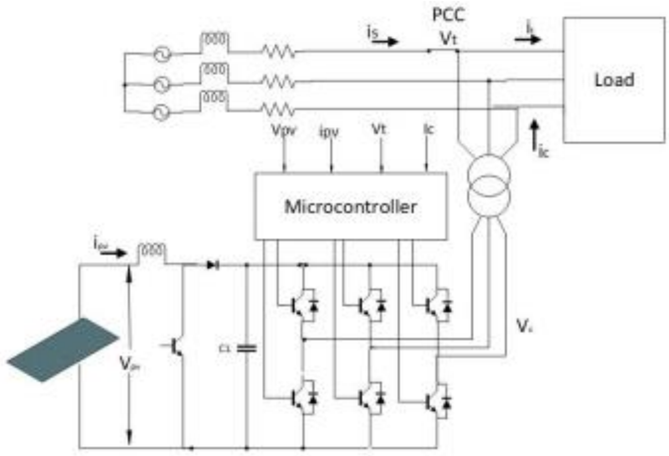

Figure 4: Structure of Grid Connected PV system for Reactive Power Control

Space Vector Modulation Technique:

A different approach for getting gate triggering signals instead of general pulse width modulation technique is based on the space vectors generated by the system two phase vector components d, q axis.

Fig: 5 shows the space vector representation of the adjacent vector V1 and V2 with 8 space vector switching pattern positions of inverter as shown in figure.

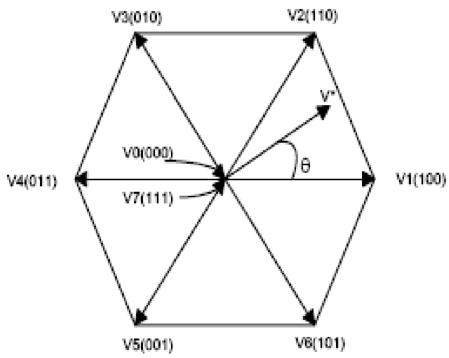

Fig 5: Space Vector Modulation Technique

Generally, the Space Vector Modulation Technique is one of the most popular and important technique in pulse width modulation methods of the three phase voltage source inverters for technique, we get the less harmonics in the both output voltage and output currents of the applied ac motors. The space vector modulation technique is used in this paper for creating the reference vectors generated by modulating the switching time sequence of space vectors in each of six sectors as shown in figure 6. From figure 6, six switching sectors are used for inversion purpose and two sectors are behave like a null vectors.

Space vector modulation can be implemented by the following procedures:

1. Transformation of three phase quantities into two phase quantities.
2. Determine time duration T1, T2 and T0.

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The reference signals for voltages and V0 to V7 and switching time sequences are generated by the following expression

V* Tz = V1 *T1 + V2 *T2 + V0 *(T0/2) + V7 *(T0/2)

RESULTS AND DISCUSSION:

The complete grid connected hybrid system is given in figure 1. The PV system consists of PV module in series mode and boost converter.

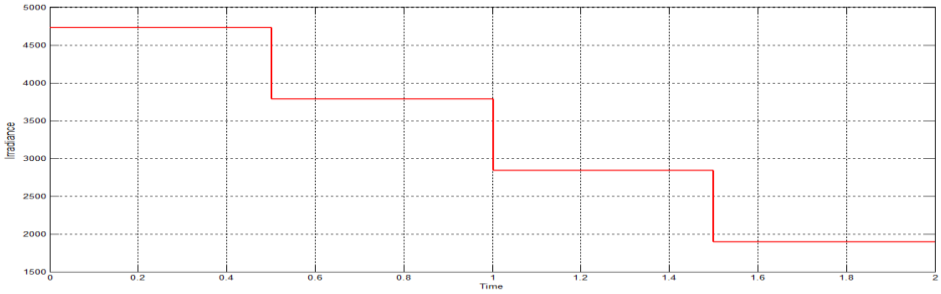

Figure 6: Simulation Waveform for Solar Irradiance (W/m2)

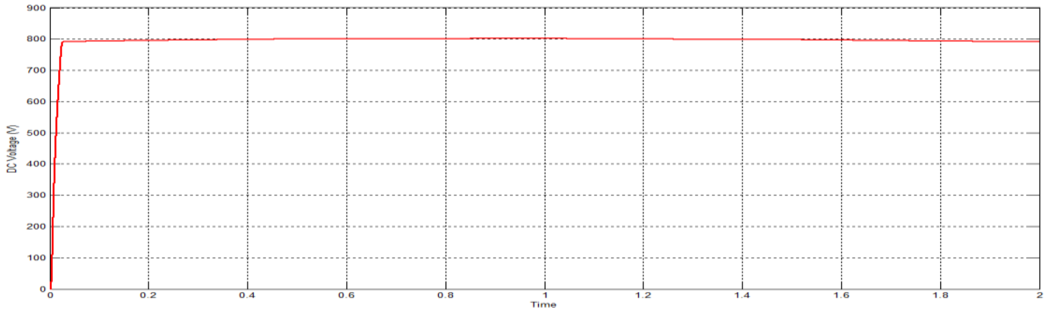

Figure 7: Simulation Waveform for Solar DC Voltage

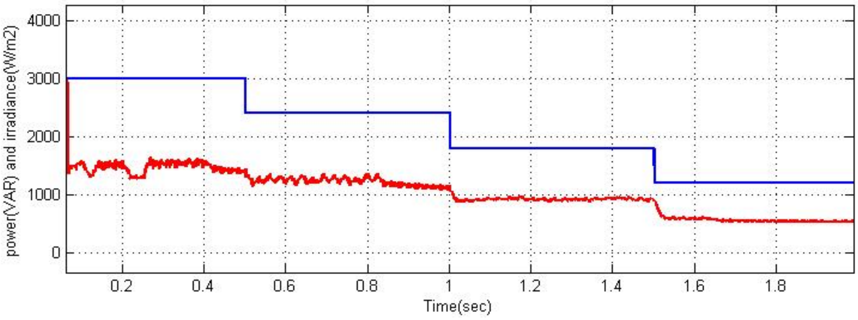

Figure 8: Simulation Waveform for Active and Reactive Powers of PV System

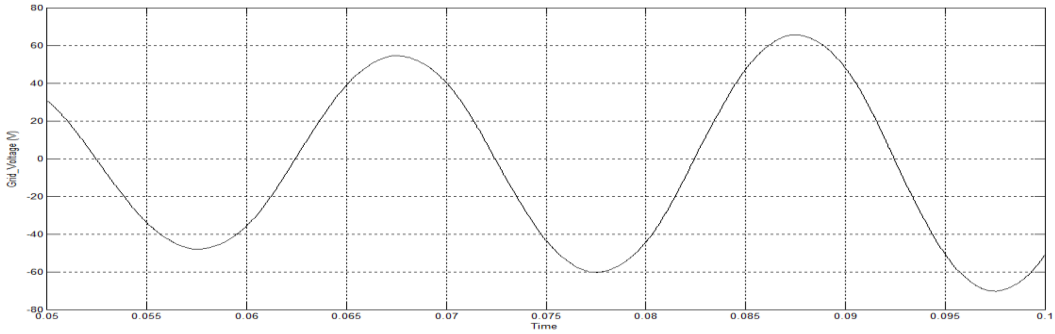

Figure 8: Simulation Waveform for Grid Voltage

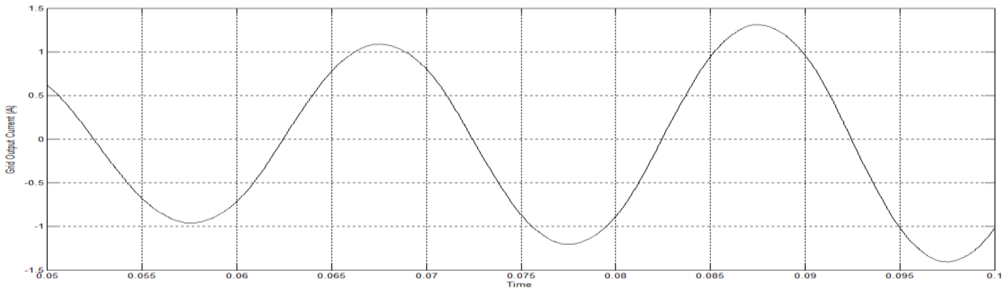

Figure 9: Simulation Waveform for Grid Current

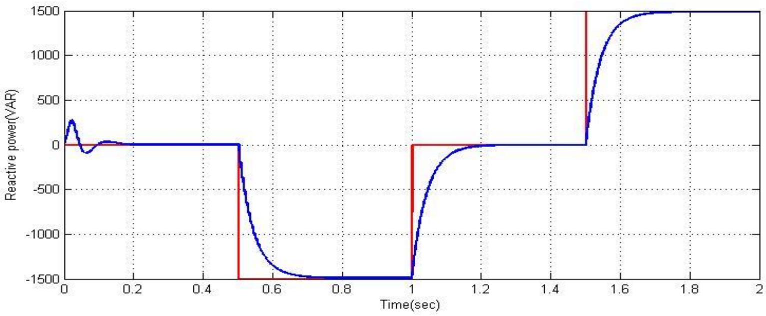

Figure 10: Simulation Waveform for Reference and Actual Reactive Power under fixed Q-Mode

CONCLUSION

This article provides a SVM controller based grid tied PV system for reactive power compensation. It also gives an idea about grid-tied or standalone mode of operations and types of preferable converters for each MPPT technique. This review has included many recent hybrid MPPT techniques along with their benefits. This review is expected to be a useful tool for not only the MPPT users but also the designers and commercial manufacturers of PV systems. From this study we observe that both P&O and IC were developed based on the extreme value theory. Ideally, they can track the maximum power point accurately based on the maximum value condition. However, both rely on the numerical approximation of differentiation, of which the stability and accuracy is difficult to be guaranteed in practical applications considering noise and quantization error etc. The continuous oscillation around the optimal operating point is an intrinsic problem of the algorithms.

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