SIMULATION OF MODIFIED MPPT CONTROL FOR OSCILLATION DAMPING IN GRID CONNECTED SOLAR

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Abstract: Rapid depletion of fossil fuel resources on a worldwide basis has necessitated an urgent search for alternative energy sources to cater to the present days' demand. In this paper a modified P&O algorithm is developed to increase the tracking efficiency. The approach is to simultaneously reduce the steady state oscillation while minimize the loss due to the losing direction. The key to the success of the algorithm is its ability to accurately detect the occurrence of oscillation and to introduce a boundary condition preventing it from being diverged away uncontrollably from the MPPT. The modified scheme retains the conventional P&O structure, but with a unique technique to dynamically alter the perturbation size. At the same time, a dynamic boundary condition is introduced to ensure that the algorithm will not diverge from its tracking locus.

I. INTRODUCTION

Rapid depletion of fossil fuel resources on a worldwide basis has necessitated an urgent search for alternative energy sources to cater to the present days' demand. Therefore, it is imperative to find alternative energy sources to cover the continuously increasing demand of energy while minimize the negative environmental impacts Recent research and development of alternative energy sources have shown excellent potential as a form of contribution to conventional power generation systems. There is a huge potential for utilizing renewable energy sources, for example solar energy, wind energy, or micro-hydropower to provide a quality power supply to remote areas. The abundant energy available in nature can be harnessed and converted to electricity in a sustainable way to supply the necessary power demand and thus to elevate the living standards of the people without access to the electricity grid.The advantages of using renewable energy sources for generating power in remote islands are obvious such as the cost of transported fuel are often prohibitive fossil fuel and that there is increasing concern on the issues of climate change and global warming. The disadvantage of standalone power systems using renewable energy is that the availability of renewable energy sources has daily and seasonal patterns which results in difficulties of regulating the output power to cope with the load demand. Also, a very high initial capital investment cost is required. Combining the renewable energy generation with conventional diesel power generation will enable the power generated from a renewable energy sources to be more reliable, affordable and used more efficiently.Solar and wind energy systems are being considered as promising power generating sources due to their availability and topological advantages for local power generations in remote areas. This Paper focuses on the combination of solar wind systems for sustainable power generation. The solar energy also varies with the hourly, daily and seasonal variation of solar irradiation. The wind turbine output power varies with the wind speed at different conditions. However, a drawback, common to solar irradiation and wind speed options, is their unpredictable nature and dependence on weather and climatic changes, and the variations of solar and wind energy may not match with the time distribution of load demand. This shortcoming not only affects the system's energy performance, but also results in batteries being discarded too early.

Basic Block Diagram of MPPT system with DC-DC boost converter

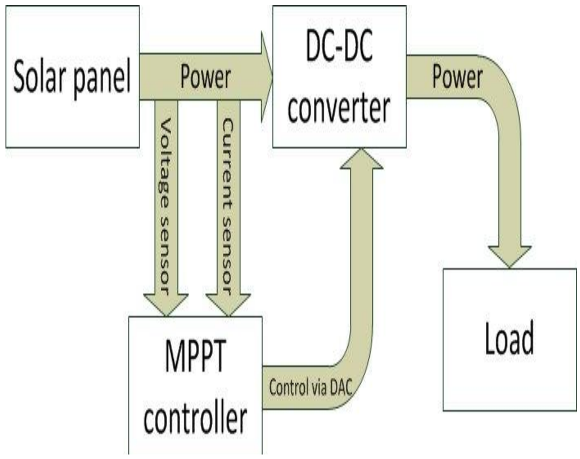

Fig.1. Basic Block Diagram

Maximum power point tracking (MPPT) is a technique that solar battery chargers and similar devices use to get the maximum possible power from one or more photovoltaic devices, typically solar panels, though optical power transmission systems can benefit from similar technology. Solar cells have a complex relationship between solar irradiation, temperature and total resistance that produces a non-linear output efficiency which can be analyzed based on the I-V curve. It is the purpose of the MPPT system to sample the output of the cells and apply the proper resistance (load) to obtain maximum power for any given environmental conditions.

Above Fig.1 shows a typical feed-forward configuration of DC-DC Converter through MPPT controller which in total aids in tracking Maximum Power Point and makes it evitable for PV Array to operate at Maximum Power Point. The basic components used in MPPT system are

- Solar panel

- DC-DC converter
- MPPT controller

This component at final connected to the load (as per our application).

II. SOLAR PV MODEL

Fig.2. Solar panel

A photovoltaic system uses one or more solar panels to convert solar energy into electricity. It consists of multiple components including the photovoltaic modules, mechanical & electrical connections and mountings means of regulating and/or modifying the electrical output. Here above shown figure.2 is of solar panel

Basic PV arrangement in step to made of PV cell, PV module, and PV array, shown in below figure.

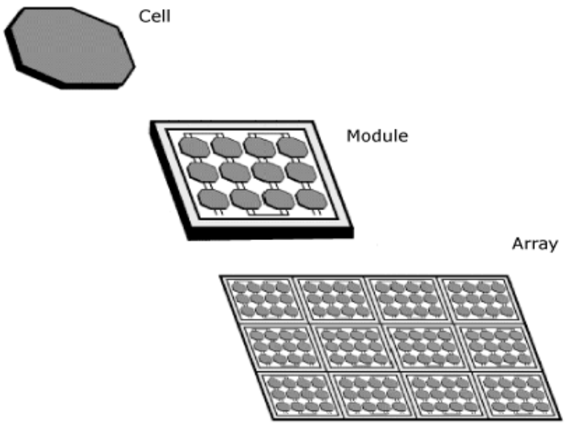

Fig.3. Solar PV Cell, PV Module, and PV Array

Two types of solar cells models are provided. One is the functional model that requires the minimum parameter inputs, and the other is the physical model that can take into account the light intensity and ambient temperature variations.

Functional model

In the Fig.4, the nodes with the "+" and "-" signs are the positive and negative terminals. The node on the top is for the theoretical maximum power giving the operating conditions. While the positive and negative terminal nodes are power circuit nodes, the maximum power output node is a control circuit node.

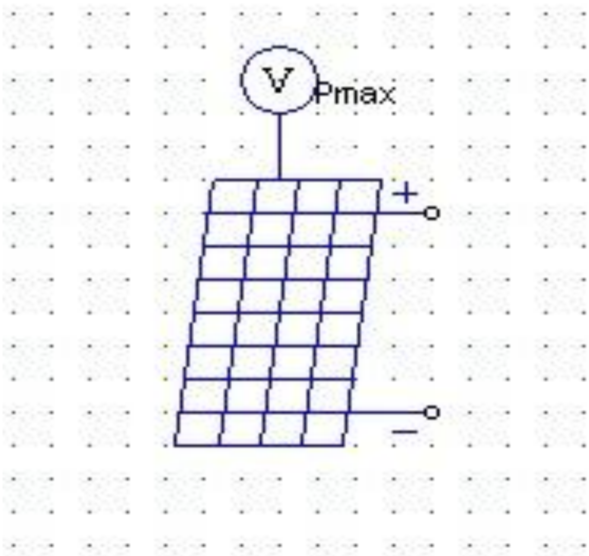

Fig.4. Functional model of PV cell

Table.1.Parameters of functional model

Open Circuit Voltage (Voc)	Voltage measured when the solar cell terminals are open circuit, in V.
Short Circuit Current (Isc)	Current measured when the solar cell terminals are short circuit, in A
Maximum Power Voltage (Vm)	Solar cell terminal voltage when the output power is at the maximum, in V
Maximum Power Current (Im)	Solar cell terminal current when the output power is at the maximum, in A
Open Circuit Voltage (Voc)	Voltage measured when the solar cell terminals are open circuit, in V.

III. PHYSICAL MODEL

The physical model of the solar module can take into account variations of the light intensity and ambient temperature. However, it requires many parameter inputs. Some of the parameters can be obtained from manufacturer datasheets, while other parameters need to be obtained by trial-and-error, In order to make it easier for users to define parameters for a particular solar module [1].In the Fig.5, the nodes with the "+" and "-" signs are the positive and negative terminals. The node with the letter "S" refers to the light intensity input (in W/m^2), and the node with the letter "T" refers to the ambient temperature input (in ^{o}C). The node on the top is for the theoretical maximum power giving the operating conditions. While the positive and negative terminal nodes are power circuit nodes, the other nodes are all control circuit nodes.

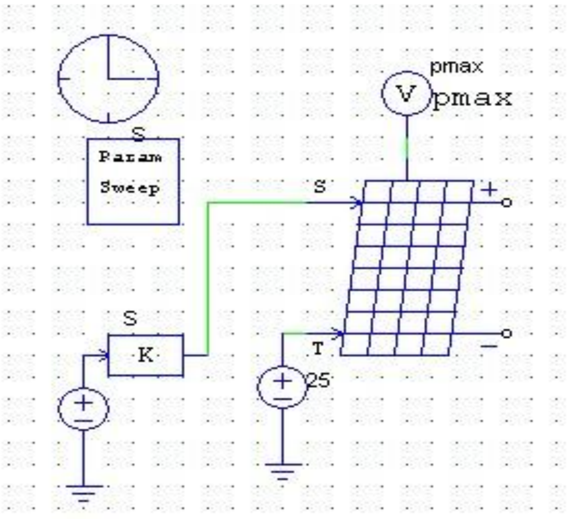

Fig.5. Physical model of PV array

Proposed Control Methods for Reduced Steady State Oscillation and Improved Tracking Efficiency

For a long term and sustainable supply of energy, it is essential to exploit and utilize the renewable sources at a much larger scale. Among the renewables, the solar photovoltaic (PV) is expected to be among the most prominent due to its abundance, ease of installation and almost maintenance free. In addition, it is considered as green energy and thus addresses the concerns over the environment. However, due to the low conversion efficiency of the PV modules, the cost of solar power is still higher relative to the fossil fuel. One effective way to increase the efficiency is to improve its maximum power point tracking (MPPT) algorithm. Since the MPPT comprises of software codes, this approach appears to be the most economical way to enhance the energy throughput.

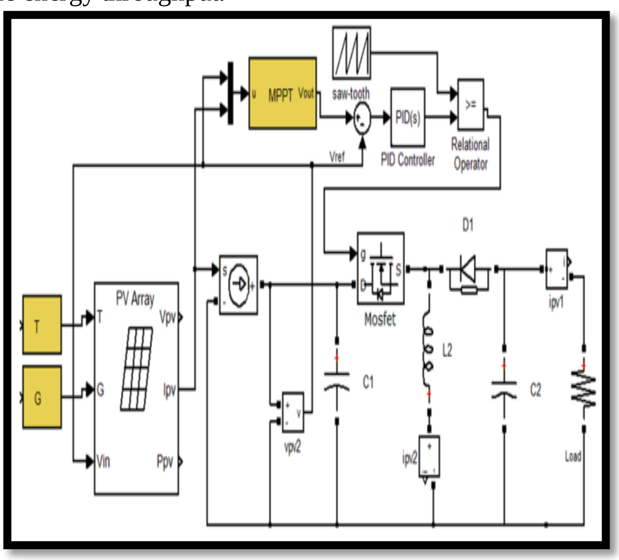

Fig.6 the Matlab simulation platform

The function of MPPT is to ensure that the operating voltage and current always stay at the maximum power point (MPP) on the *P-V* characteristic curve. To date, numerous MPPT techniques are reported in literature [1-3]; they are broadly classified into two categories, namely the conventional and soft computing approach. The most popular conventional MPPT are the perturb and observe (P&O) [4, 5], hill climbing [6] and incremental conductance [7]. These algorithms are widely used in commercial products—mainly due to their simplicity and robustness. On the other hand, soft computing based MPPT such as artificial neural network, fuzzy logic, differential evolution, particle swarm optimization and cuckoo search tend to be more versatile and flexible. Despite exhibiting better steady state performance, they are much slower and in practice, are not as acceptable. Among the conventional MPPT, P&O is the simplest and exhibits very good convergence. However, the algorithm suffers from two serious drawbacks. First is the continuous oscillation that occurs around the MPP. Second, the P&O is prone to lose its tracking direction when the irradiance (*G*) increases rapidly. Both problems contributes to the loss of power and hence reduced tracking efficiency. Although there exists several work that address the oscillation issue using the adaptive P&O schemes [4-8], none has comprehensively address the loss of tracking direction–despite it being highlighted by [1, 5]. Notwithstanding this, authors in [1-2], have introduced several solutions to address these two problems. However, the methods are limited for specific conditions as shall be discussed in Section II. With this hindsight, this work proposes a more comprehensive modification to the P&O, with the aim to solve both problems simultaneously. The modified algorithm maintains a similar structure to the conventional P&O, but it incorporates a unique dynamic perturbation to decrease the oscillation, while maintaining a reasonable convergence time. In addition, the method introduces boundary conditions on the *P-V* curve that prevents the operating point from being diverged (uncontrollably) from the MPP.

Solar PV System under MPPT Control with fixed Radiation using P&O Algorithm

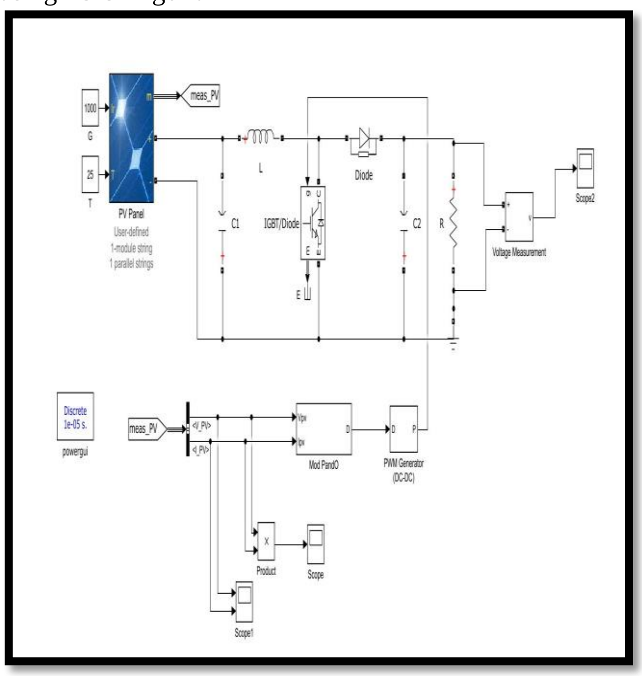

Fig 7- Matlab simulation of Solar PV Array with MPPT & Boost converter

Simulation Results

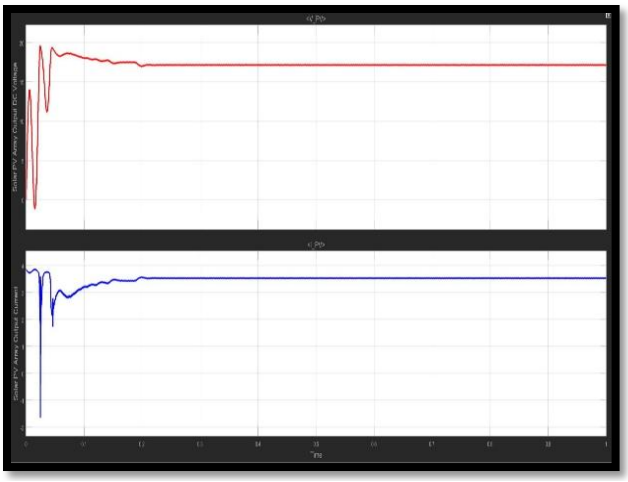

Fig.8- Solar PV Array Output Voltage and Current

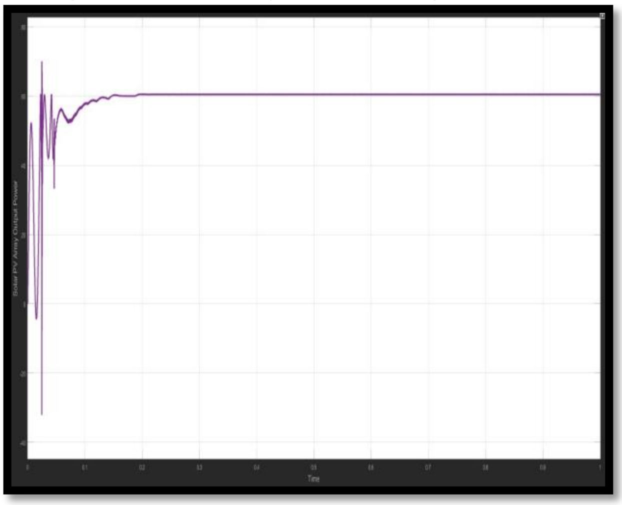

Fig.9- Solar PV Array Output Power

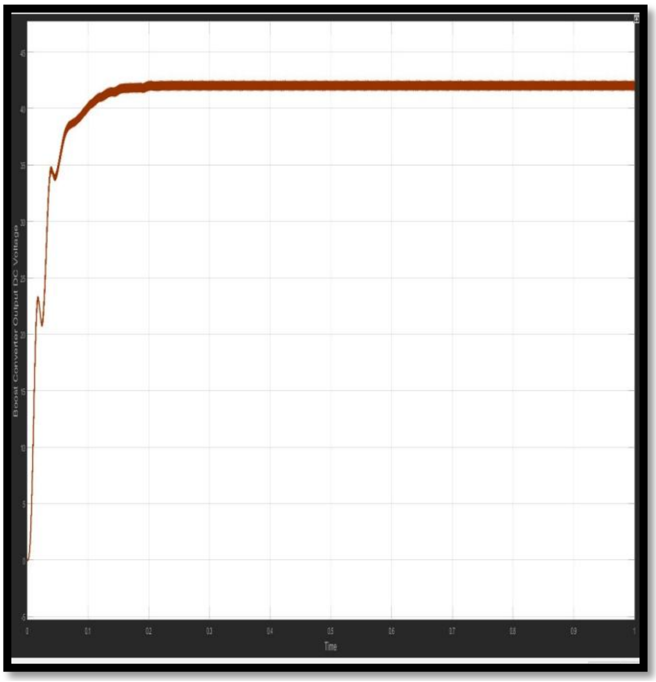

Fig.10 Solar PV Array Boost converter Output Voltage

Solar PV System under MPPT Control with Variable Radiation using P&O Algorithm

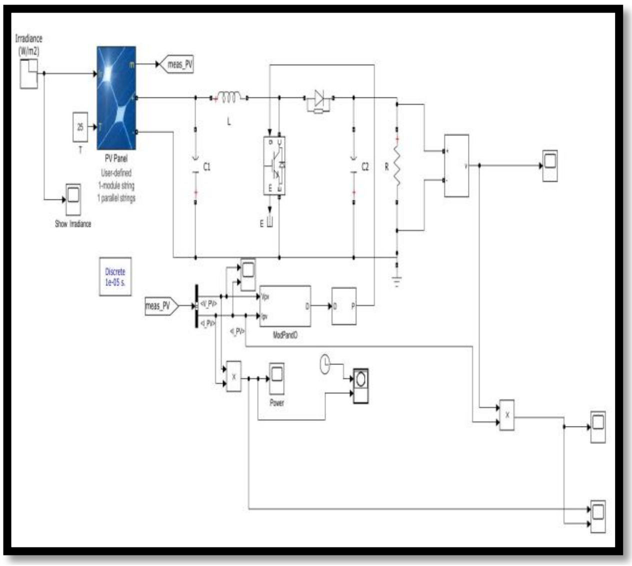

Fig.11- Solar PV System with variable Radiation with P&O Algorithm

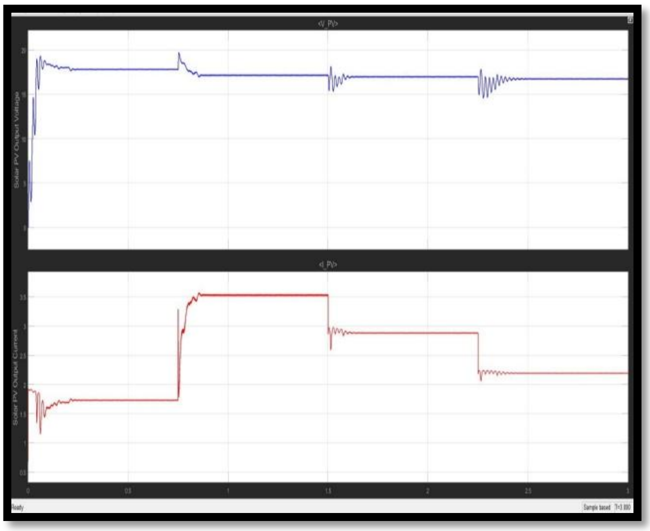

Fig.12- Solar PV array output Voltage and Current

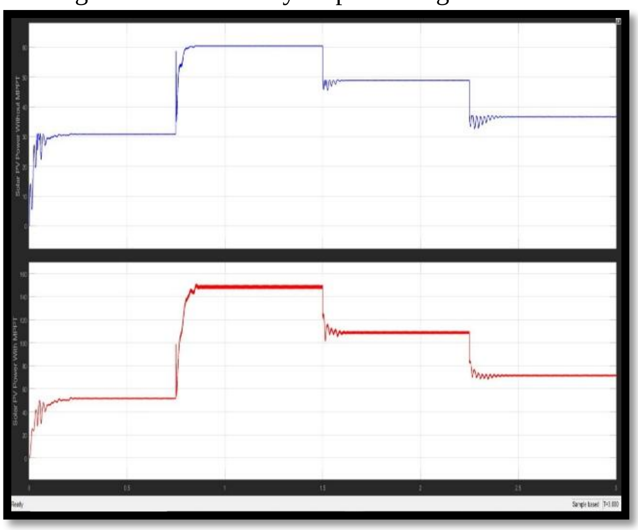

Fig.13- Solar output Power without and with MPPT

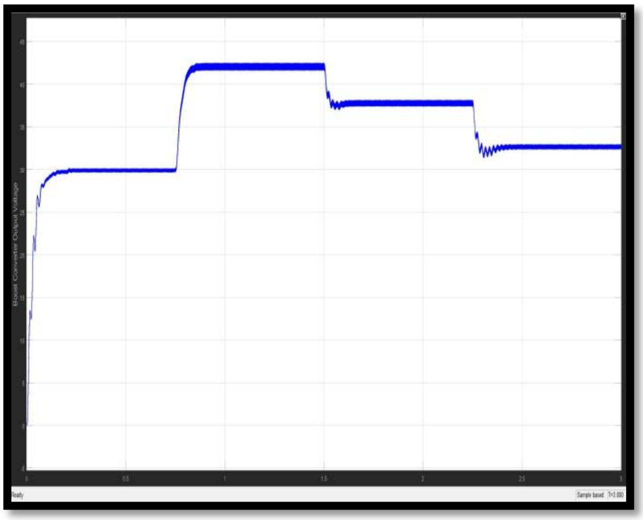

Fig.14- Solar PV output voltage using Boost converter

Solar PV System MPPT Comparison for P&O and INC Algorithm

MPPT Method	Output Voltage	Output Current	Power	Time Response	Accuracy
P & O	35 Volt	3 Amp	105 Watt	0.0175 Sec	Less
INC Method	40 Volt	4 Amp	160 watt	0.01 Sec	More

Matlab Simulation of Modified P&O MPPT algorithm for Oscillation Damping

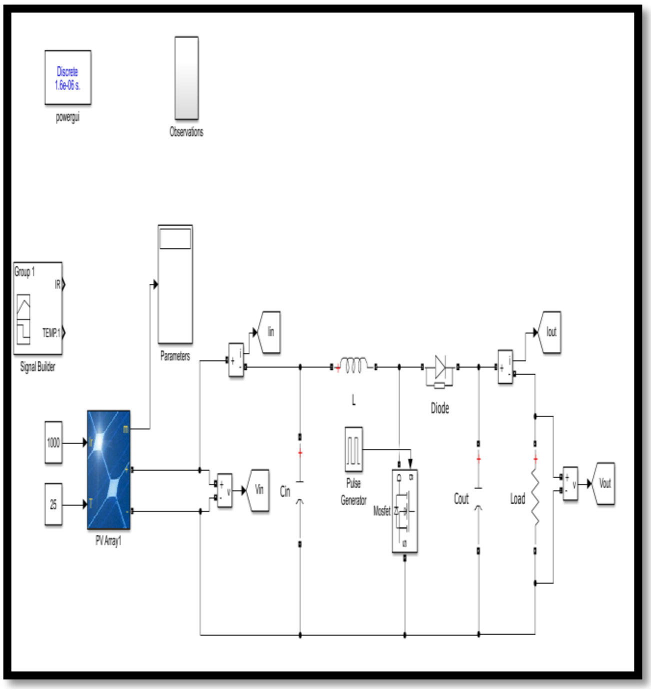

Fig.15- Solar PV System without MPPT control

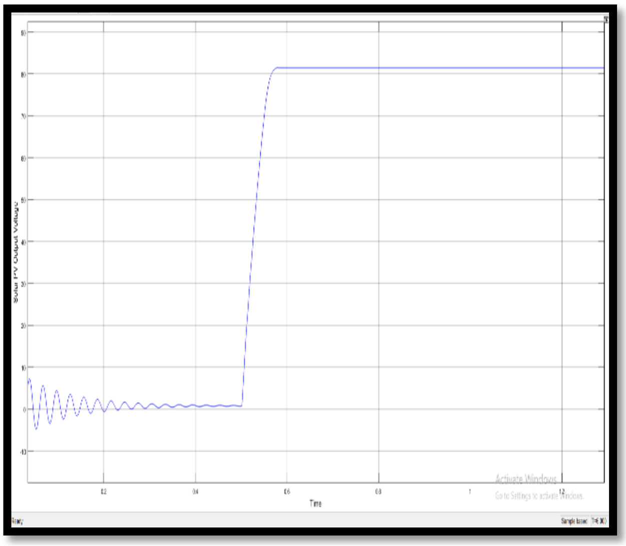

Fig.16- Oscillation in Solar PV output voltage with Zoom Scale

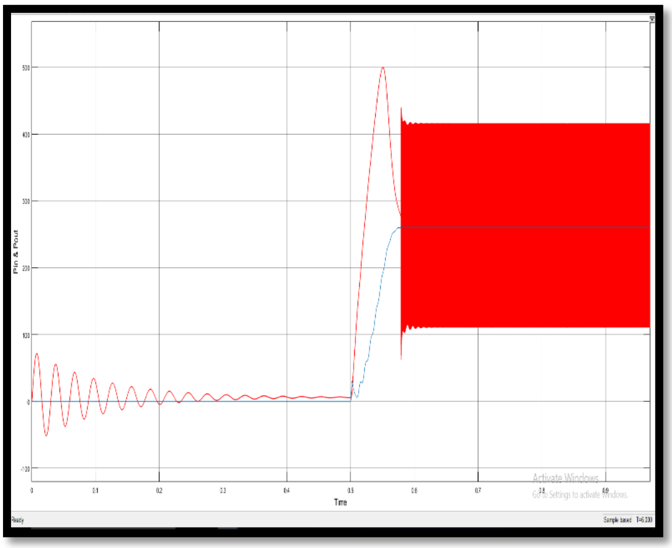

Fig.17- Oscillation in Solar PV Output Power

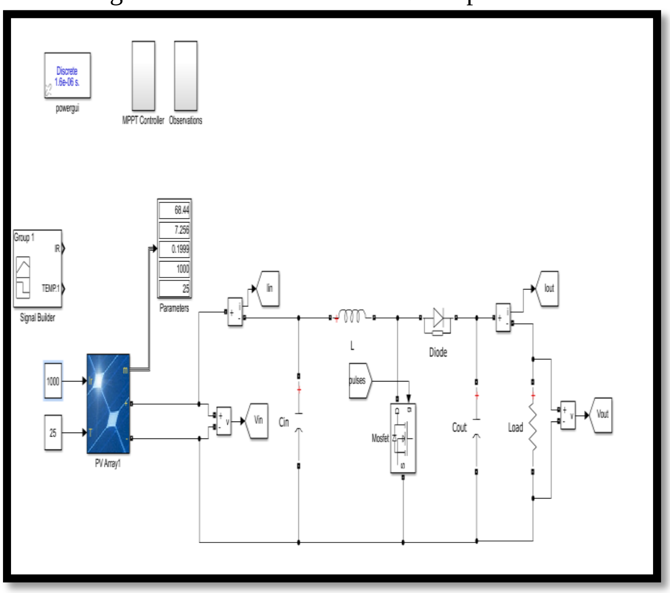

Fig.18- Solar PV System with Modified P&O MPPT control

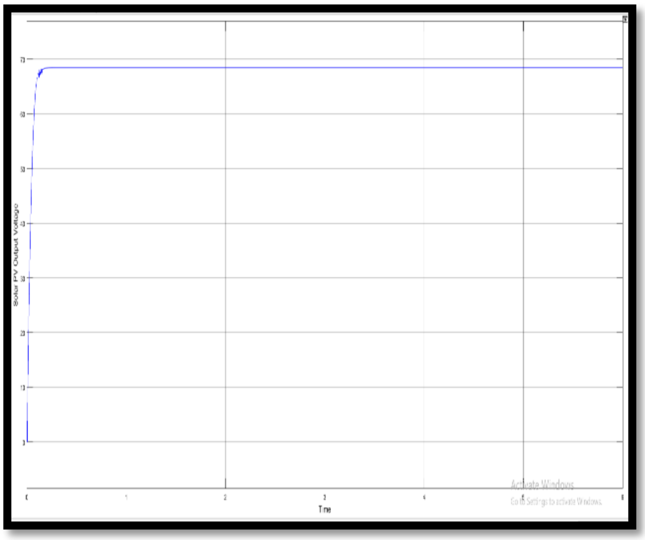

Fig.19- Oscillation damping in Solar PV output Voltage

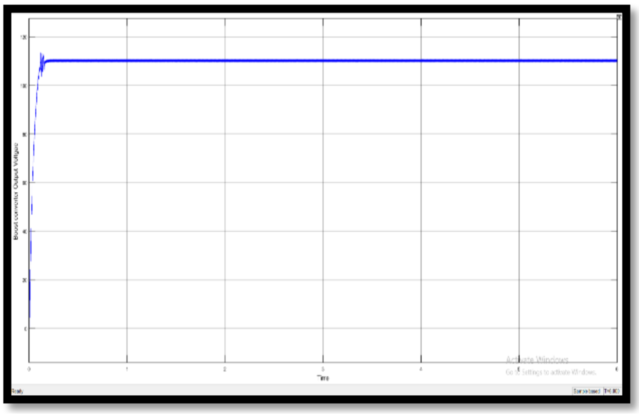

Fig.20- Oscillation damping in Boost converter output Voltage

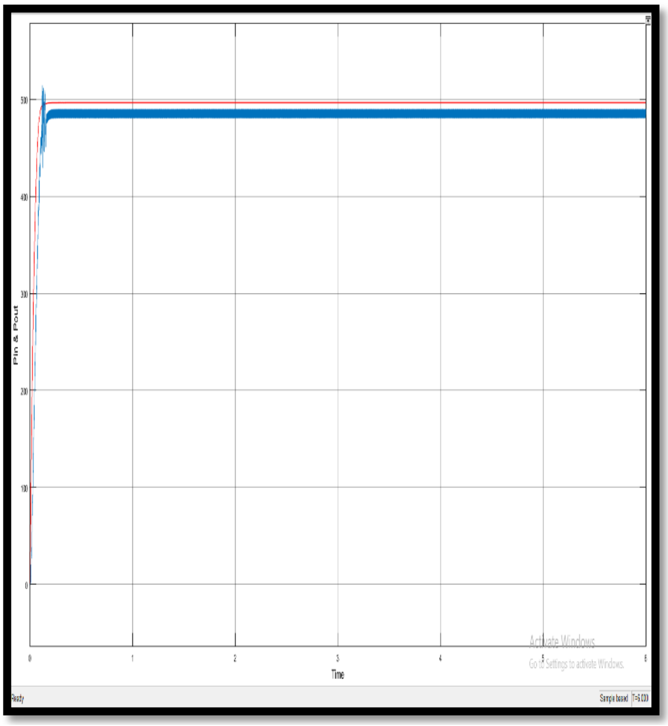

Fig.21- Oscillation damping in Solar PV output power

Oscillation Damping in Grid connected Solar Using VSC control method

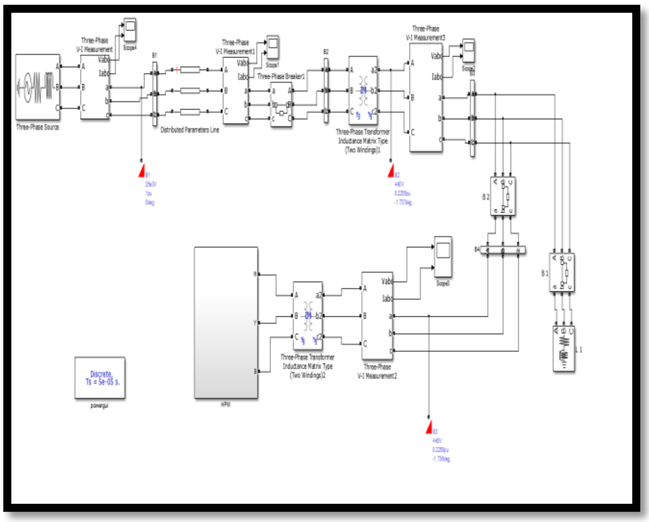

Figure.22Grid Connected Solar System

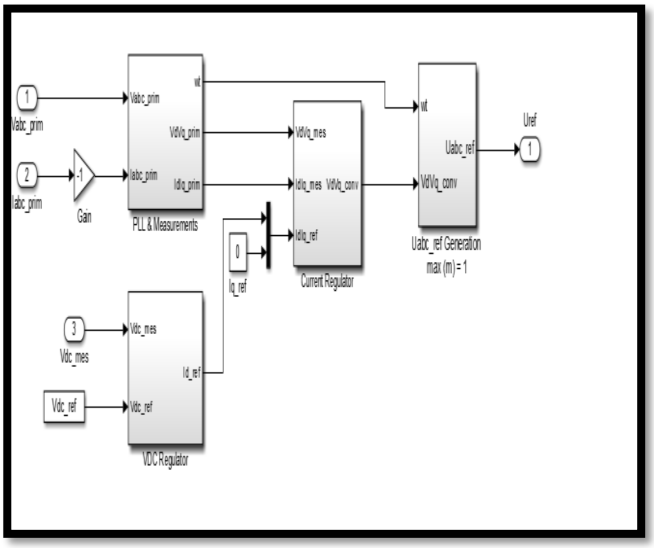

Figure.23 Oscillation Damping control system with VSC controlling

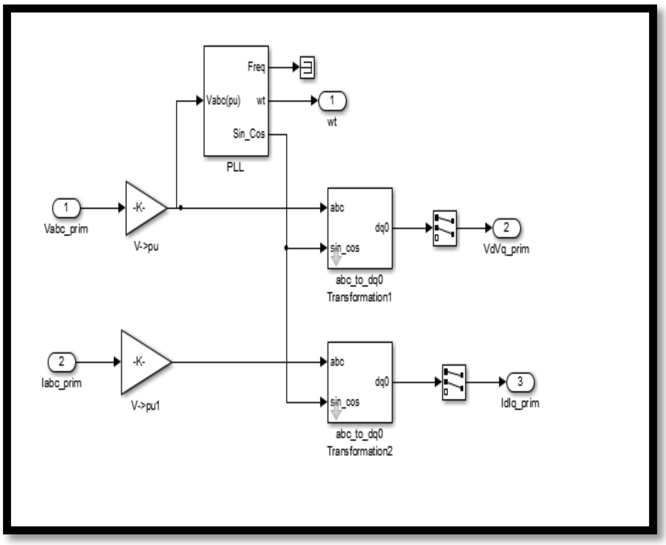

Figure.24 PLL Control Subsystem

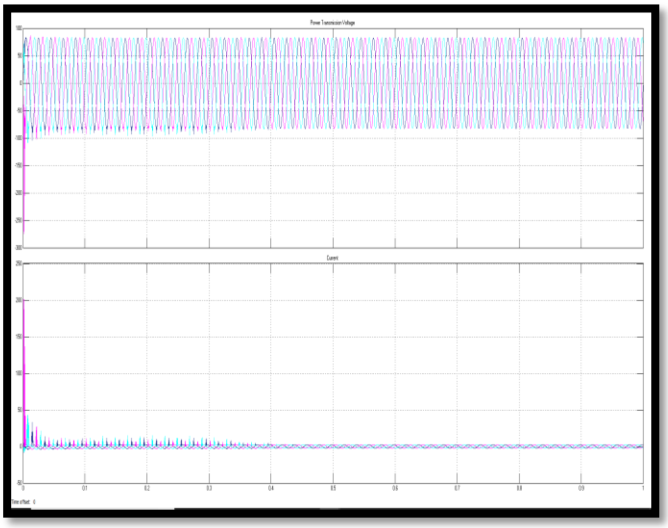

Figure.25 Without control output voltage & Current oscillation

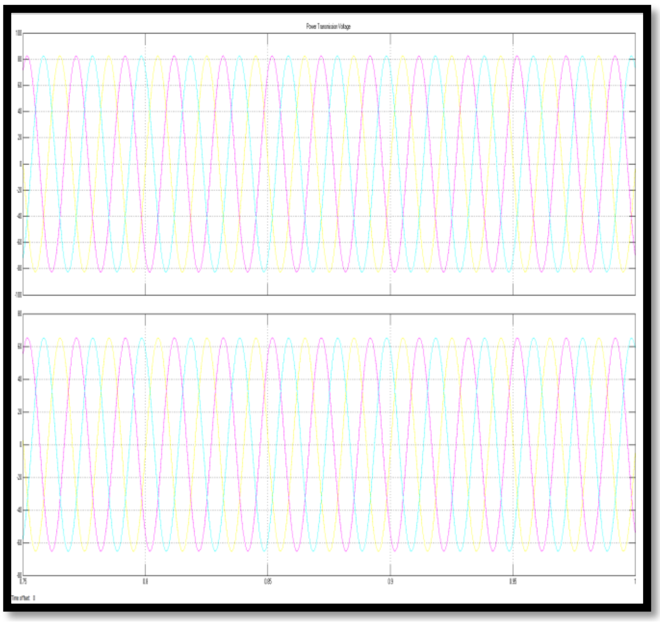

Figure.26 Grid Integration Output Voltage & Current with oscillation damping

IV. CONCLUSION

This paper presents a hybrid wind/PV energy system for standalone system. The standalone hybrid system is better than a single energy source. The Simulation results show the ideal I-V and P-V characteristics of the solar PV system and MPPT & Boost converter Simulation shows the boost up voltage level done successfully done. The MPPT Control methods P&O and INC is implemented for proposed Solar PV system in fixed radiation level and variable radiation level. The Comparison of these two methods are also done. In the simulation results shown the Modified P&O algorithm provides oscillation damping in Solar PV output as well as VSC control provides oscillation damping in grid integration of Solar PV system.

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