An Improved Perturb and Observe MPPT Method and Power Stabilization of Grid Connected PV System

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Abstract- Photovoltaic present the capacity to produce electricity in a immaculate, calm and authoritative manner. Photovoltaic systems are encompassed of photovoltaic cells and devices that transform light energy straightway into electricity . Maximum power point techniques (MPPT) are harnessed in photovoltaic systems for perfect profiteering of PV array output power. MPPT techniques are used to elicit the maximum output power from PV modules and various DC/DC converters are utilized to convey maximum power from PV modules to loads. a lot of methods have been suggested for tracking the maximum power point (MPP).The perturb and observe (P&O) algorithm is the most exceedingly applied and workhorse MPPT algorithm as its equipoise between execution and straightforwardness. However, it suffers from oscillation and power loss at steady state. The modified P&O algorithm is proposed to tackle such problems . In this paper presents a modified Perturb and Observe (P&O) algorithm for the grid connected PV and standalone system . Grid-connected photovoltaic and standalone system simulate in MATLAB/Simulink .Grid connected of photovoltaic (PV) systems with modified algorithm has the merit of efficient employment of produced power because there are no storage losses .

Keywords- *Photovoltaic , Maximum Power Point Tracking System, Boost converter, Perturb and Observe Algorithm, grid-connected.*

I. INTRODUCTION

Energy is the most requisite and fundamental of all resources. So, the grade of evolution and urbanization of a country is gauged by the quantity of exploitation of energy . The want for renewable energy sources is on the embarkation because of the intense energy squeeze in the world today [1]. The diminution of non-renewable energy sources and mounting issue of environmental defilement, has compelled us to search for preferable energy sources Renewable energy is the energy which derives from natural resources such as sunlight, wind, tides ,rain, and geothermal heat. Renewable energy sources (RES) has got immense awareness as an alternative source of electrical energy. photovoltaic (PV) energy is one of the most noteworthy and vastly used renewable resource because of its round the clock availability during the day, eco friendly , low maintenance [2-8] only, the weak energy efficacy due to the transmutation of solar energy into electric energy is one of the prime hurdles . Therefore, the elicitation of the maximum possible power of each panel is the major technological defy these days [29].In addition to, the solar cell V-I characteristic is nonlinear. In general, there is a singular point on the V-I or V-P curve, termed to the Maximum Power Point (MPP), at which the entire PV system (array, converter, etc…) works with maximum effectiveness [20].

According to Ref. [9], maximum power point tracking (MPPT) can rise the output of electricity by 25%.

There are various manners that have been widely performed to track the MPP such as Perturb and Observe (P&O) methods[10-13], the Incremental Conductance(IC) methods[10-14] , the Artificial Neural Network method [15] , the Fuzzy Logic method [16] , Particle Swarm Optimization (PSO) , Constant voltage (CV) etc. These techniques difference in intricacy, cost, speed of convergence, sensors used, hardware enforcement, and efficacy [17-19].

Most control projects use the P&O technique because it is easy to perform, control schema is straightforward, the cost is low compared to others and does not demand previous awareness of the PV generator features or the gauge of solar intensity and cell temperature.

However it flops to track MPP when the atmospheric condition is quickly varied and the operating point fluctuate around the MPP voltage at steady state.

This paper suggests a close study zone based modified P&O algorithm . The proposed algorithm splits the power curve into three district: Area 1 , Area 3 are on either side of the MPP and Area 2 is the middle district of the power curve including 10% area of the power curve and MPP

locates in this area 2. This decrease in the study zone minimize the step response time and the steady-state oscillations at the maximum power point

II. Modeling of photovoltaic cell

Solar photovoltaic (PV) is used to mutate the solar energy into electrical energy [21].

PV cells are collaged in greater units named PV modules which are moreover linked in series -parallel arrangement to combine PV arrays. A mathematical model is proceeded to simulate the PV array. Figure(1) explains the tantamount circuit of a single solar cell, where I and V are the PV array's current and voltage, Iph is the cell's photocurrent [22].

The primary equation that depicts the (I-V) characteristics of the PV model is accorded by the following equation:

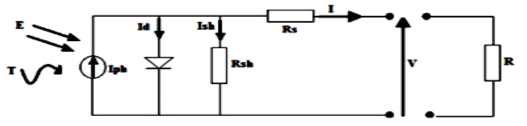
$$I = Iph - Io\left[e^{\frac{q(v+IRs)}{kT}} - 1\right] - \frac{v+IRs}{Rsh} \qquad (1)$$

I is the cell current (A), Iph is the light generated current (A), Io is the diode saturation current, q is the charge of an electron = 1.6x10-19 (coulombs), K is the Boltzmann constant (j/K), T is the cell temperature (K), Rs, Rsh aress cell series and shunt resistance (ohms), V is the cell output voltage (V).The Io is the dark saturation.

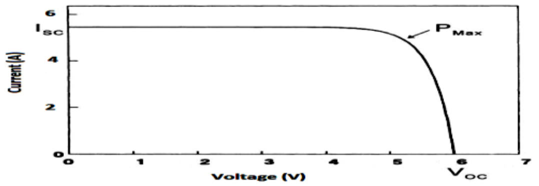
Figure(2) and Figure(3) are showing the characteristic PV array curves, voltage versus the output power and the current versus voltage.

The simulation results of i-v curve and p-v curve of SPR-315E-WHT-D model for different solar irradiation and constant temperature (T=25^{o}c) are shown in Figure(4). it can be notice that current & power of the PV module rises with increasing the solar irradiation.

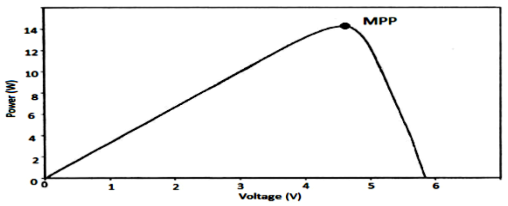
The simulation results of i-v curve and p-v curve of SPR-315E-WHT-D model for constant solar irradiation (β= 1000 W/m2) and different temperature are shown in Figure(5). it can be notice that voltage and power of the PV module diminishes with increasing the cell temperature



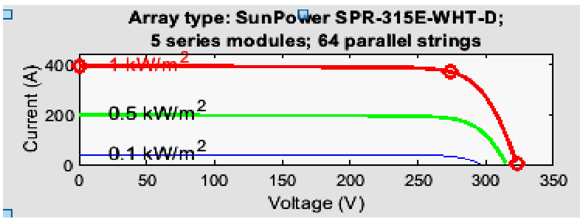
Figure(1): Single diode model of solar PV cell

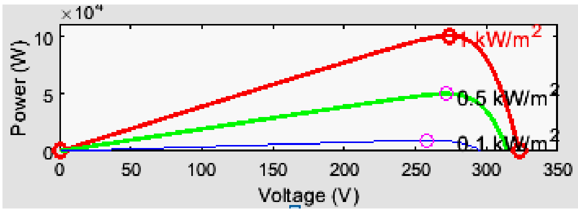


Figure(2): I-V characteristics of solar PV cell

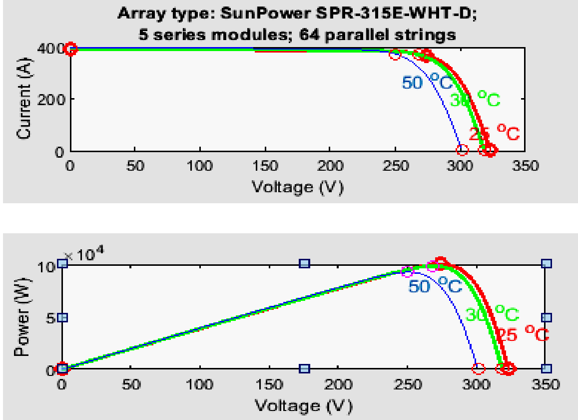


Figure(3): P-V characteristics of solar PV cell





Figure(4): SPR-315E-WHT-D Characteristics with Different Irradiance Values and a Constant Temperature (25°C)



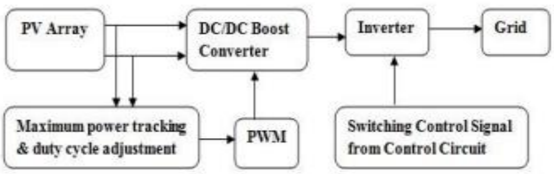
Figure(5): SPR-315E-WHT-D Characteristics with Variable Temperatures and Constant Irradiance (1KW/m2).

Specifications of solar module SPR-315E-WHT-D are presented in Table (1). The solar module provides 315.072 W with VMPP 54.7 V and IMPP 5.76 A at standard conditions (25^{o}C and 1 kW/m2).

Table (1):Specification of solar module SPR-315E-WHT-D

Characteristic	Value
Rated Power (Pmax)	315.072 W
Temperature coefficient of Voc	-0.27269 %/deg.C
Voltage Maximum Power (Vmax)	54.7 V
current at Maximum power (Imax)	5.76 A
voltage at Open circuit (VOC)	64.6 V
Photo Current (ISC)	6.14 A
Temperature coefficient of Isc	0.061694 %/deg.C
Number of series-connected PV cells, Ns	64
Number of parallel-connected PV cells, Np	5

III. SYSTEM CONFIGURATION



Figure(5): Block diagram of grid-connected PV System

The configuration of the grid connected PV is shown in Figure(5) in which the PV is linked to the DC-DC converter which carries the maximum power from the solar PV cell to the load. The DC-DC boost converter is dominated using PWM .the load impedance is modified and matched at the point of the peak power with the source [23]. P & O MPPT algorithm produces the duty cycle. A three-phase inverter is used to mutate photovoltaic DC voltage into AC voltage The Three-phase inverter is also synchronized with grid by using phase locked loop The BOOST converter was designed according to the specification shown in Table(2).

Table(2): Specification of Boost converter

Parameter	Value
Inductor L	0.01 H
Capacitor C1	4700 µF
Capacitor C2	4700 µF
Resistor R	1.3Ω
Switching frequency	5 kHz

IV. Conventional P&O algorithm

The flow chart of the conventional P&O method is shown in Figure(7). When using this algorithm first disorganizes the PV voltage by modifying the duty cycle in a particular tendency. Then, it supervises the alteration in power dP due to this perturbation. If $dP > 0$ then duty cycle is more modified in the same tendency till the maximum power point is realized. But If $dP < 0$, the modification in the duty cycle will be in adverse tendency. Subsequently, by pursuing this execution the MPP is tracked. Table (3) shows the outline of the P&O
algorithm .Taking into account that a minimum rise is necessary to realize an accepted steady state error, the algorithm speed can be increased by a greater sampling rate. So there is always a equalization between the rise and the sampling rate in the P&O method.
The prevalent issue in P&O algorithms is that the output power oscillates around the maximum, resulting in power loss in the PV system.
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V. Modified P&O algorithm

The issues confronted with the conventional algorithm as specified above can be revoked by the proposed modifications. The proposed algorithm reduces the study zone to only 10% area of the power curve that not only minimizes the response time but also minifies the steady state oscillations. Ref[28] displays that the VMPP is about 76% of the open circuit voltage (VMPP= 76% of VOC). So, the P-V curve has been separated into three regions named Area1, Area 2, and Area 3 as shown in Figure(6).
Specifications of each of these areas are given in Table (4).
Area 2 is the MPP restraining region enclosing to only 10% of the PV curve that reduces the step response time and the steady state oscillations about the MPP because the improved algorithm requires to discover the maximum power point only in area 2.

Flowchart of the modified Perturb and Observe algorithm is shown in Figure(8).
It first gauges the voltages V1 and V2 to find the MPP including region(area 2) and then begins perturbation and observation. In slight perturbations, MPP is accomplished

Table (3):Scheme of the P&o algorithm

Perturbation	Delta P	Resulting Perturbation
+ve	+ve	+ve
+ve	-ve	-ve
-ve	+ve	-ve
-ve	-ve	+ve

Table (4):Area distribution of power curve

	Starting(% of Voc)	Ending(% of Voc)	Total area
Area 1	0	70	70
Area 2	70	80	10
Area 3	80	100	20

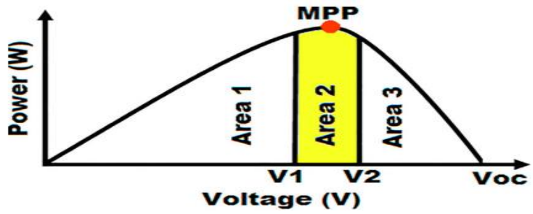
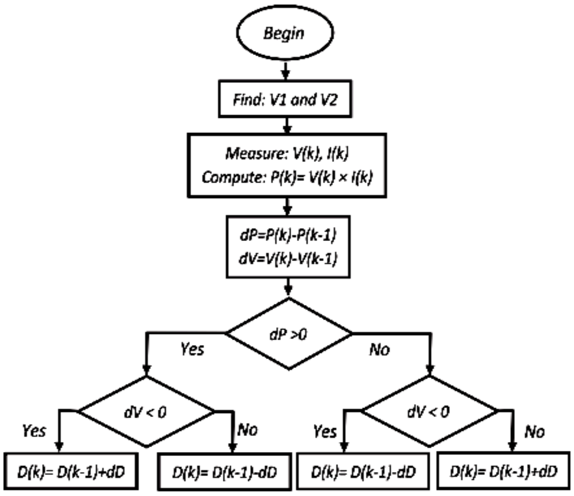


Figure (6):Study zone limitation of the power curve

VI. Results and discussion

To notarize the legislation of the recommended algorithm ,a MATLAB/Simulink model was improved as depicted in Figure(9).The tracking bureaucracy of the conventional and the proposed perturb and observe MPPT algorithm in constant solar irradiance can be analyzed by Figures(10) and (11) respectively. The conventional P&O produced many oscillations at the maximum power point. In the proposed P&O algorithm give a smooth PV output as shown in Figure (11). The results demonstrated the truth that the conventional algorithm holded the problem of steady-state oscillations .The proposed algorithm minutely tracked the MPP under both uniform and varying atmospheric condition without any steady state oscillation at the maximum power point. Figure(12) shows the outputs under varying solar irradiance and temperature for standalone system . Solar irradiance was varied from 1 kW/m to 0.25 kW/m in various



Figure(7): Flow chart diagram of conventional P&O method

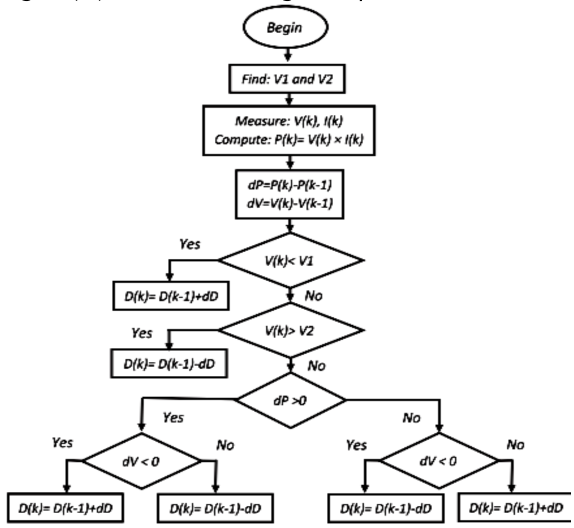


Figure (8): Flowchart of modified P&O algorithm.

stages and the temperature was varied from 25^{0}C to 50^{0}C. Power .

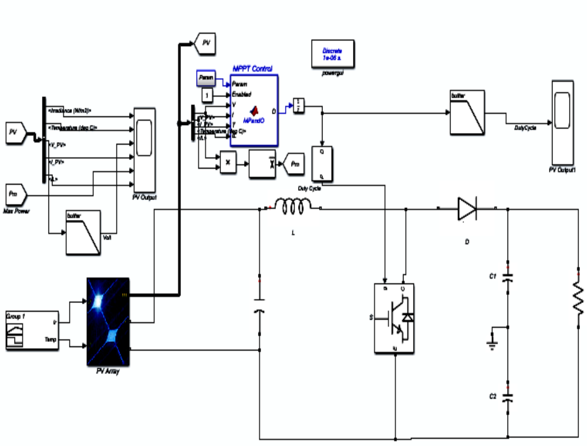
Figure(14) shows the outputs of grid connected system by conventional method.

Figure(15) shows the outputs of grid connected system by modified method.

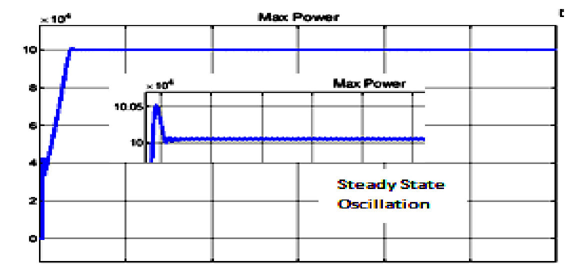
VII. Conclusions

The proposed approach is simulated and analyzed in MATLAB/SIMULINK, and the performance of the both conventional and modified algorithms is compared during steady and varying weather conditions. The simulation results of the proposed technique demonstrate that it tracks the maximum power point accurately and improves the efficiency of the PV system by removing of the steady state oscillations and reduction in step response .

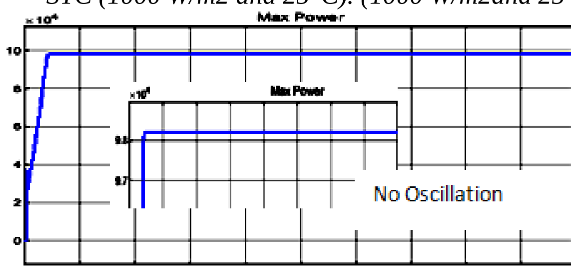
A grid connected PV System was implemented and its effectiveness was emphasized by the simulation results in MATLAB/SIMULINK as shown in Figure(13) .The system was also operated by applying the P&O based MPPT algorithm .The DC/AC Inverter is used to adjust the output voltage of DC/DC converter and fastens the PV cell with DC/DC converter to the grid. The Three-phase inverter is also synchronized with grid by using phase locked loop. Grid connected photovoltaic (PV) systems with modified algorithm has the merit of efficacious exploitation of generated power because there are no storage losses.



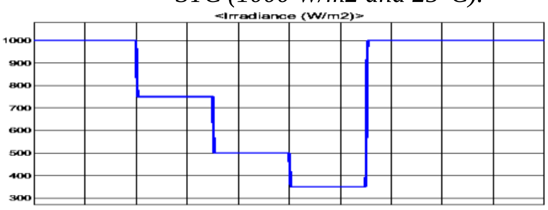
Figure(9):Simulation model of Standalone system

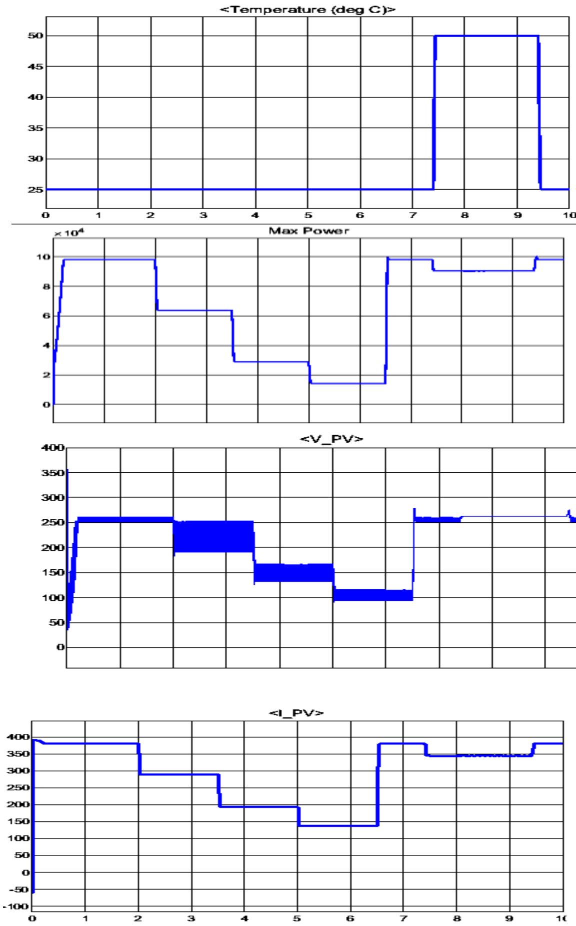


Figure(10): PV power for conventional P&O algorithm under STC (1000 W/m2 and 25 ℃). (1000 W/m2and 25 ℃).



Figure(11):PV power for proposed P&O algorithm under STC (1000 W/m2 and 25 ℃).





Figure(12)PV Power, voltage and current under varying atmospheric weather conditions for proposed P&O algorithm.

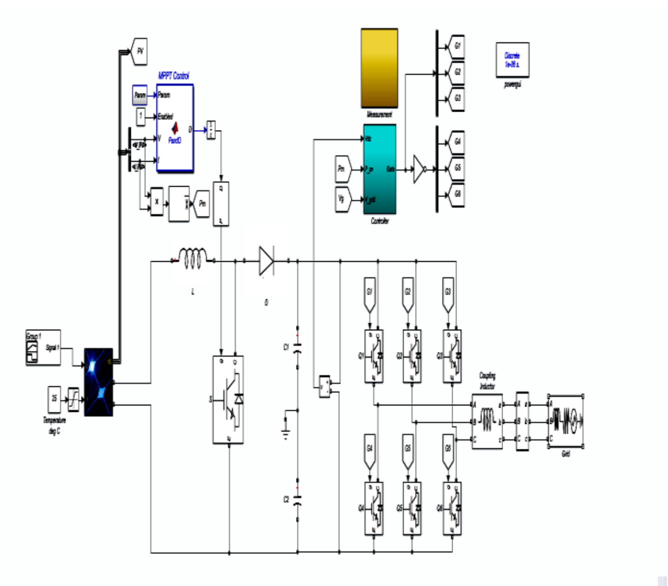


Figure (13):Simulation model of grid connected system

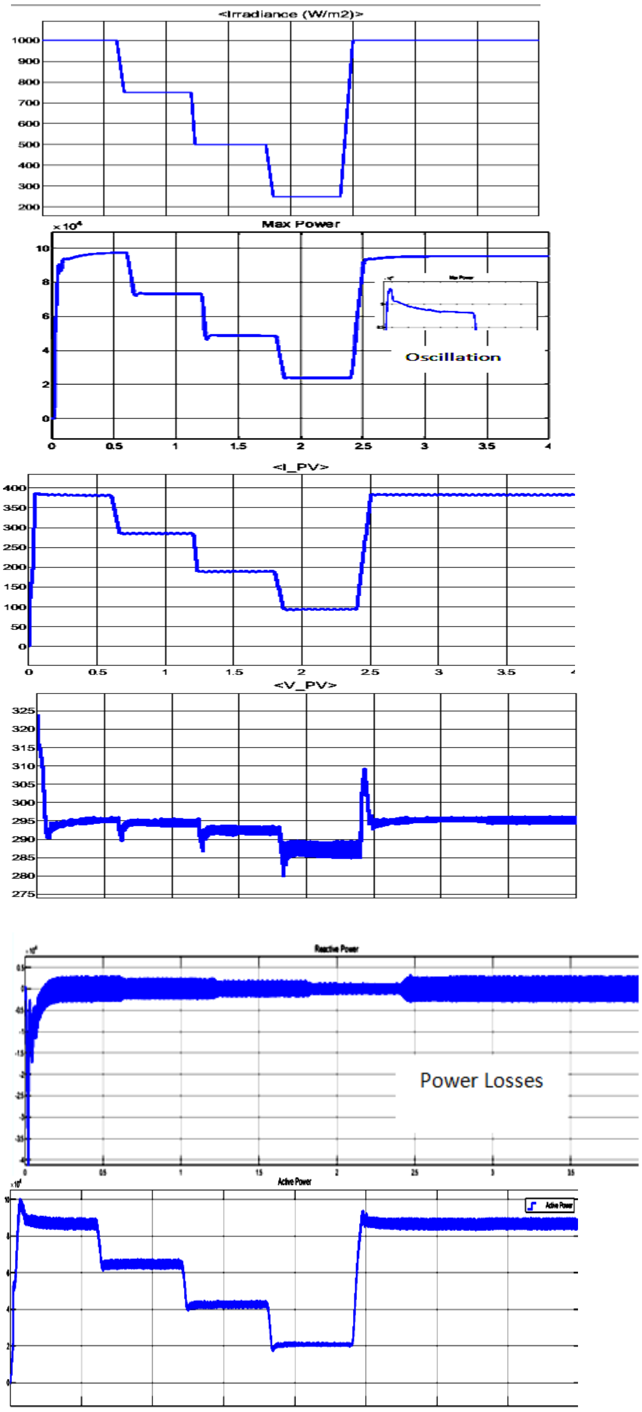
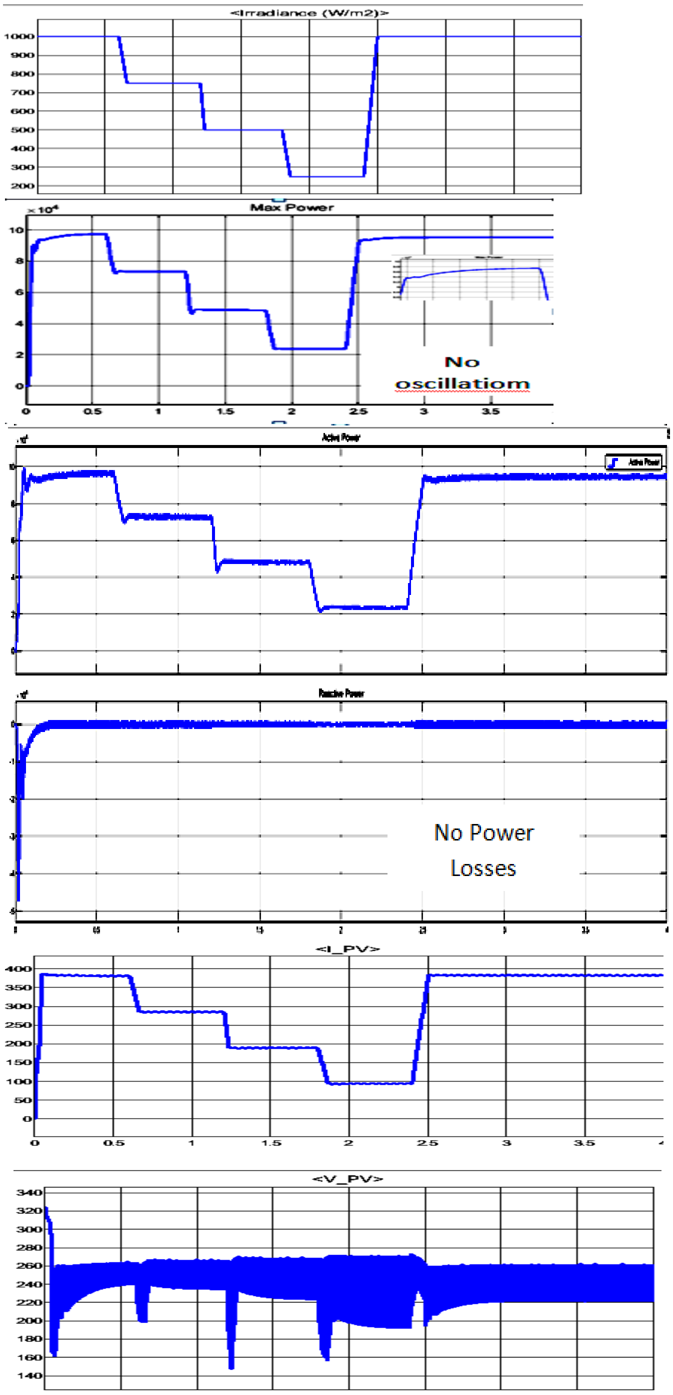


Figure (14):PV Power, voltage , Current , active and reactive power for grid connected system by conditional method under varying atmospheric weather conditions



Figure(15):.PV Power, voltage , Current , active and reactive power for grid connected system by proposed method under varying atmospheric weather conditions

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