# Hybrid Power Control Concept for Grid Connected PV Inverter with Reduced Thermal Loading

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**Abstract – In this paper introduced a hybrid power control concept for grid-connected photovoltaic inverters (PV). The hybrid power control is combination of two controls. This control strategy is based on either a maximum power point tracking control or a constant power generation (CPG) control. This is depending on the instantaneous available power from the PV panels. A constant power generation (CPG) control mode is activated by using a direct power control when the dc power from PV panels reaches to above the specific limit. The MPPT mode is active when the dc power is below the specific power level. The proposed control concept allow a reduction of required power ratings of PV inverters and also a reduction of junction temperature peaks and variations on the power devices. And To improve maximum power extraction from PV panel, used various techniques such as Perturb & observe and incremental conductance methods.**

**Keywords - MPPT, CPG, PV.**

## 1. INTRODUCTION

In the past few decades, price and efficiency were two disincentive factors for the growth of PV panels in power generation applications. Since the price of PV panels is the major contributor in the cost of the whole system, the decrease in price of PV panels has lead power generation companies to focus on this cheap, pollution-free, maintenance-free, and innovative solution. Solar cell efficiencies (measured by using the ratio of electrical output power to the total light energy covers a cell) vary from 6% to around 40%. Using high efficiency cells is not always economically justifiable because of the production cost. Energy conversion efficiencies for commercially available solar cells are around 14 to 19%.With the increasingly urgent energy issues, the world attach great importance to begin the development of new energy and related technology. At present, large scale photo-voltaic power generation and scale of renewable energy has become parts of development strategy, meanwhile it is the way to guide the development of photo-voltaic industry. However, because of PV characteristics different from conventional power generation grid connected PV power station and its security, stability, reliable operation become new challenges which power grid and PV power plant need to face. In recent years, solar energy demand has grown consistently due to the following factors:

- Increasing efficiency of solar cells
- Manufacturing technology improvement
- Economies of scale

PV panels can be used either offline or online. In offline applications, supply loads of PV panels can be residential or commercial. In online applications, these modules not only supply local loads, but also are connected to the utility grid. In this case, the system would be called “grid-connected PV system.” Recently, grid-connected PV system installation is increasing tremendously in many countries.

The hybrid power control is combination of two controls. This control strategy is based on either a maximum power point tracking control or a constant power generation (CPG) control. This is depending on the instantaneous available power from the PV panels. A constant power generation (CPG) control mode is activated by using a direct power control when the dc power from PV panels reaches to above the specific limit. [1]

## 2. RELATED WORK

A constant power generation (CPG) control mode is activated by using a direct power control when the dc power from PV panels reaches to above the specific limit, the value of which depends on the trade-offs of thermal loading. The MPPT mode is active when the dc power is below the specific power level. The proposed MPPT-CPG control concept allows a reduction of required power ratings of PV inverters and also a reduction of junction temperature peaks and variations on the power devices [1].

A detailed analysis of the two most well-known hill-climbing maximum power point tracking (MPPT) algorithms: the perturb-and-observe (P&O) and incremental conductance (INC). The purpose of the analysis is to clarify some common misconceptions in the literature regarding these two trackers, therefore helping the selection process for a suitable MPPT for both researchers and industry. The two methods are thoroughly analyzed both from a mathematical and practical implementation point of view. Their mathematical analysis reveals that there is no difference between the two.[2]

## 3. PROPOSED MODELLING

### 3.1. Maximum Power Point Tracking Methods:

The control system mainly controls the maximum power point tracking of photo-voltaic, current waveform and power of the output of grid connected inverter, which makes the output of the grid corresponding with the export by PV array. MPPT is not a mechanical tracking system that "physically moves" the modules to make them point more directly at the sun. MPPT is a fully electronic system which varies the electrical operating point of module so that it will able to deliver maximum available power. Moving towards general discussions of various MPPT methods, we come across four methods (algorithms).

- Perturb & observe
- Incremental conductance method.

#### 3.1.1. Perturb & observe algorithm

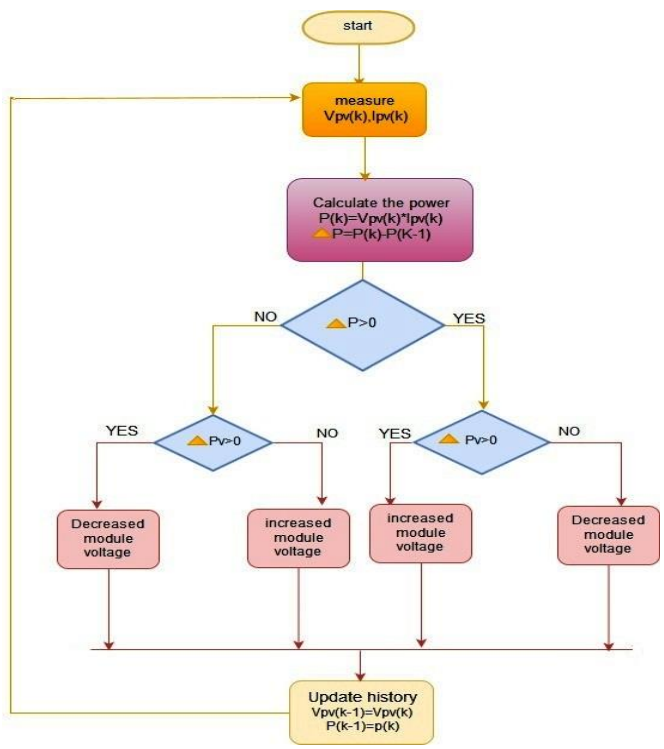



Figure 3.1: Perturb & Observe algorithm

In this algorithm we use only one sensor, that is the voltage sensor, to sense the PV array voltage and so the cost of implementation is less and hence easy to implement. The computation time of this algorithm is very less but on reaching very close to the MPP it doesn't stop at the MPP and keeps on perturbing in both the directions. after completion of this, the algorithm has reached very close to the MPP and we can set an appropriate error limit or can use a wait function which ends up increasing the time complexity of the algorithm. The photovoltaic system has a non-linear current-voltage and power-voltage characteristics that continuously varies with irradiation and temperature. In order to track the continuously varying maximum power point of the solar array the MPPT (maximum power point tracking) control technique plays an important role in the PV systems. The task of a maximum power point tracking (MPPT) network in a photovoltaic (PV) system is to continuously tune the system so that it draws maximum power from the solar array regardless of weather or load conditions. figure 3.1 represents perturb & observe algorithm.

#### 3.1.2. Incremental conductance

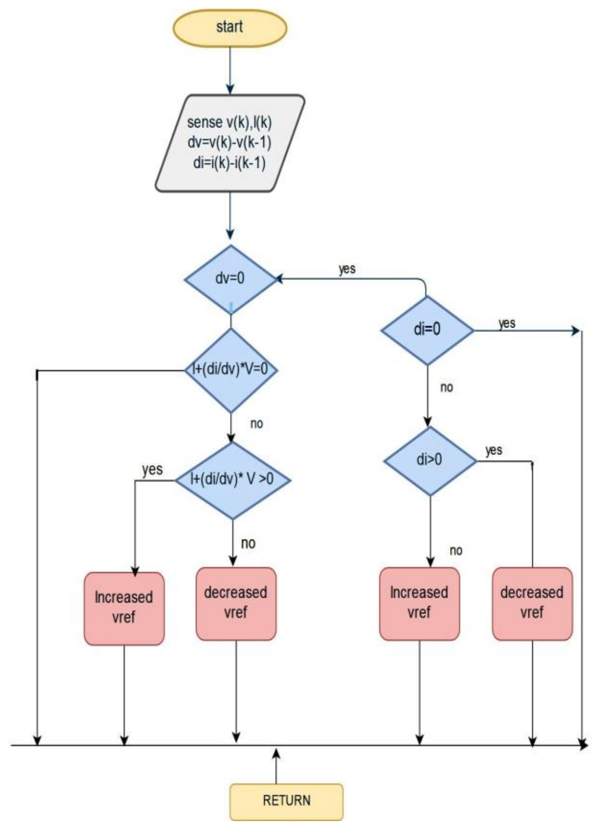



Figure.3.2. : Incremental conductance algorithm

Incremental conductance method predicts the MPP by judging whether PV system proceeding right or left MPP. Based on this incremental conductance algorithm give the idea towards MPP. The step can be done by incrementing the conductance value (dI/dV). The system will move from initial to final value if there is increment conductance value otherwise it is at same position. now here is two conditions. If $dp/dv < 0$ then system is moving to right of MPP. In second case, if it is greater than 0, then it is left to the MPP. Figure 3.2. represents incremental conductance algorithm. The advantage of this algorithm is robustness to weather changes and less efficient in partial shading.

## 4. RESULTS AND DISCUSSIONS

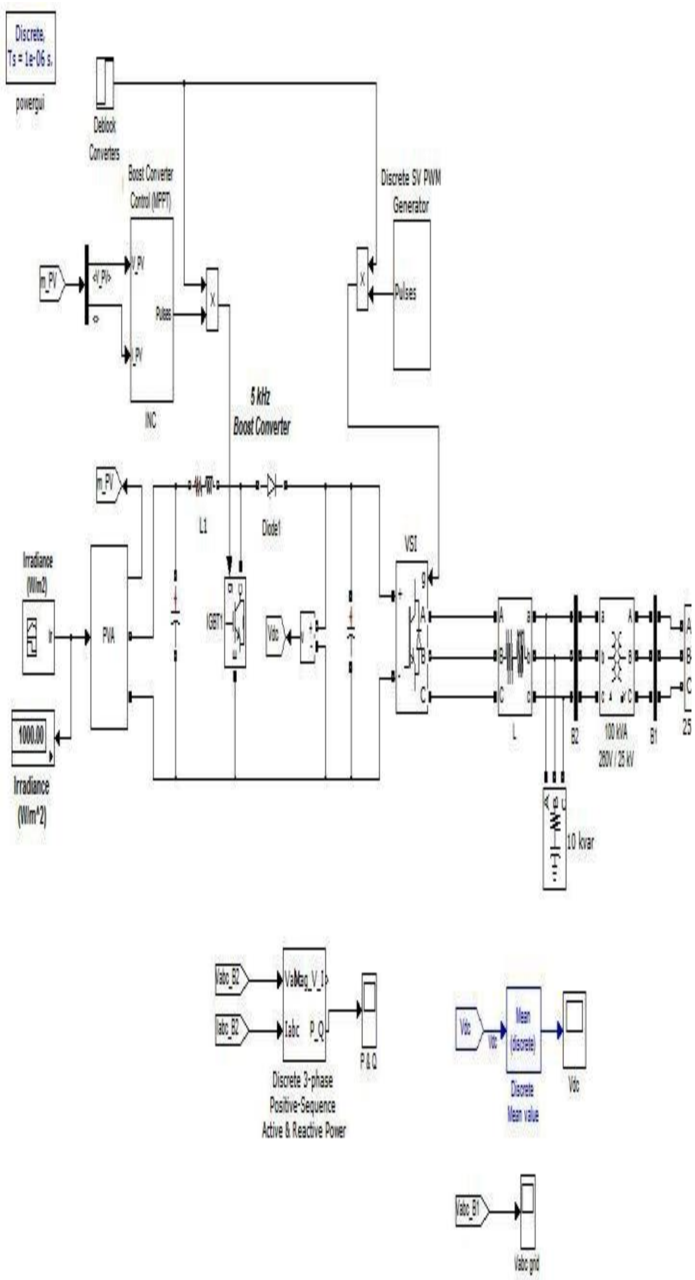



Figure.4.1: model for Incremental algorithm for grid connected PV inverter.

| Sr. no. | Parameter | Value |
|---|---|---|
| 1 | PV panel rated power | $P_n$=38.32kW |
| 2 | Inductor of boost convertor | L=5mH |
| 3 | DC Link capacitor | $C_{dc}$=100uf |
| 5 | Switching frequency of boost stage | $f_{boost=}$5 KHz |
| 6 | Switching frequency of invertor | $f_{in}$=1000KHz |
| 7 | Grid nominal voltage | Vg=230 |
| 8 | Grid nominal frequency | W=2πf |

Table 1 parameter of 38.32 kW two-stage single phase grid connected PV system

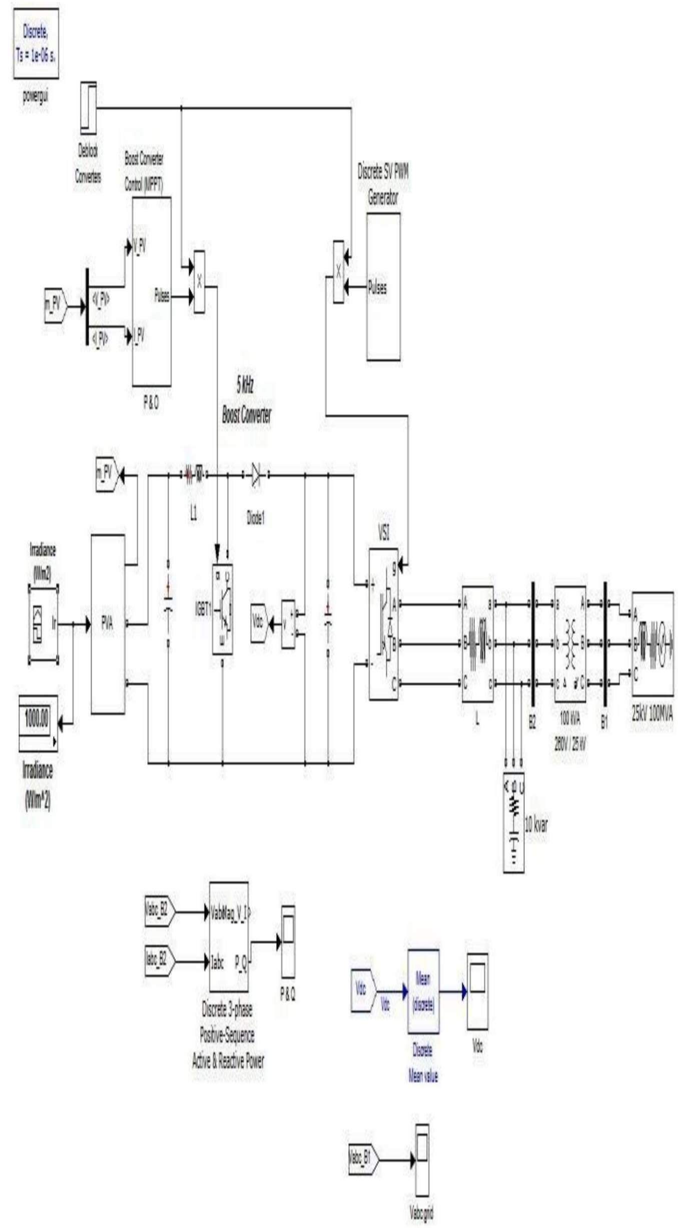
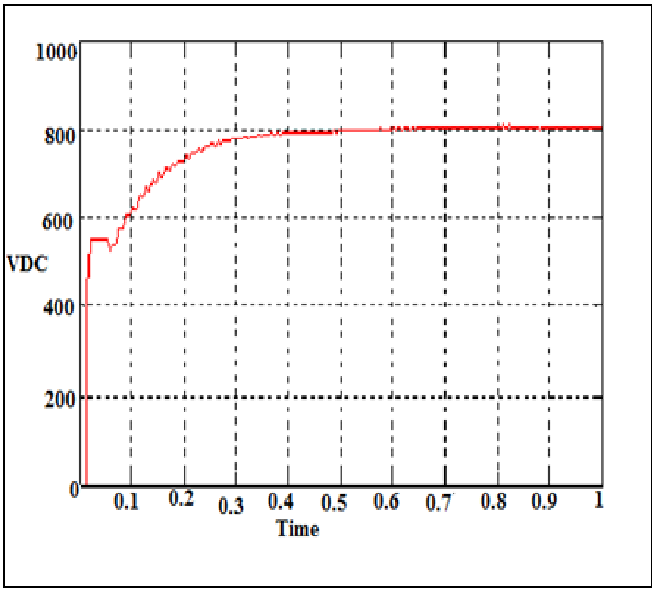



Figure.4.2. : model for P & O algorithm for grid connected PV inverter.

## 5. SIMULATION RESULT

### 5.1 Incremental conductance method

#### 5.1.1. For Constant Irradiance level




**F**igure 5.3: Time Vs DC voltage for constant Irradiance

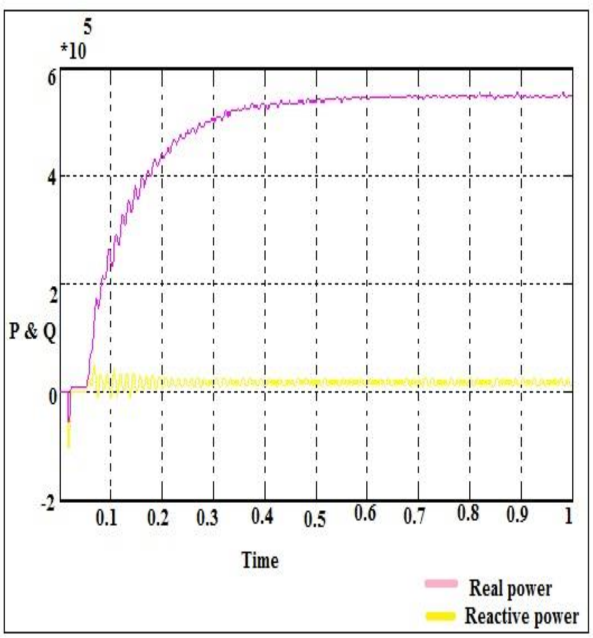



Figure 5.4: Time vs Real and reactive power for constant Irradiance.

#### 5.1.2 Step Irradiance level

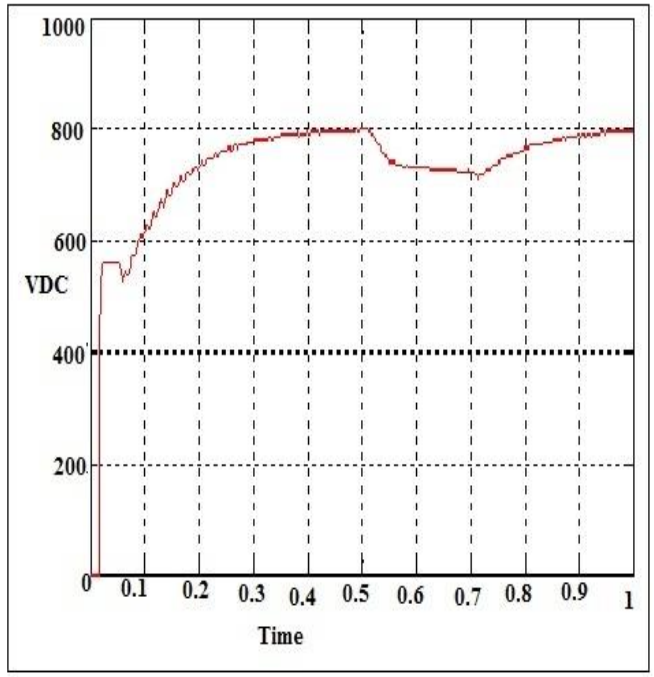



Figure 5.5: Time Vs DC voltage for step Irradiance

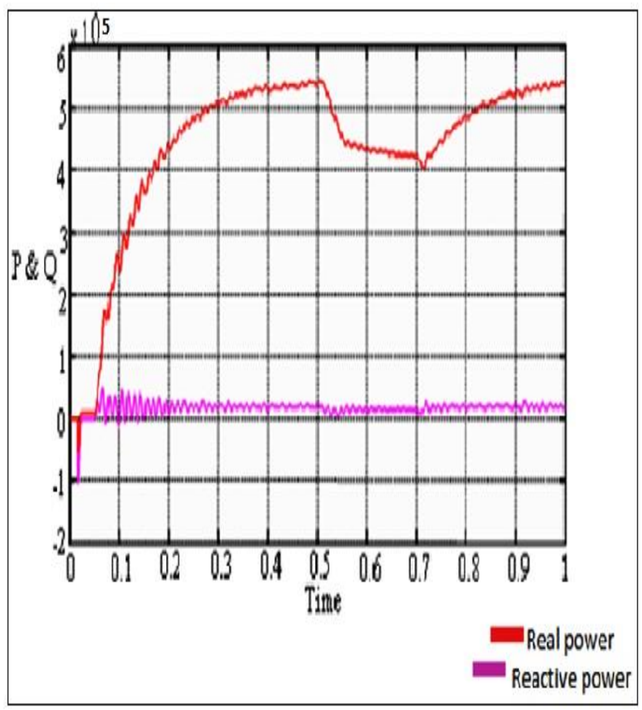



Figure 5.6: Time Vs Real and reactive power for step Irradiance [ICM]

5.1.3 Ramp up down irradiance level

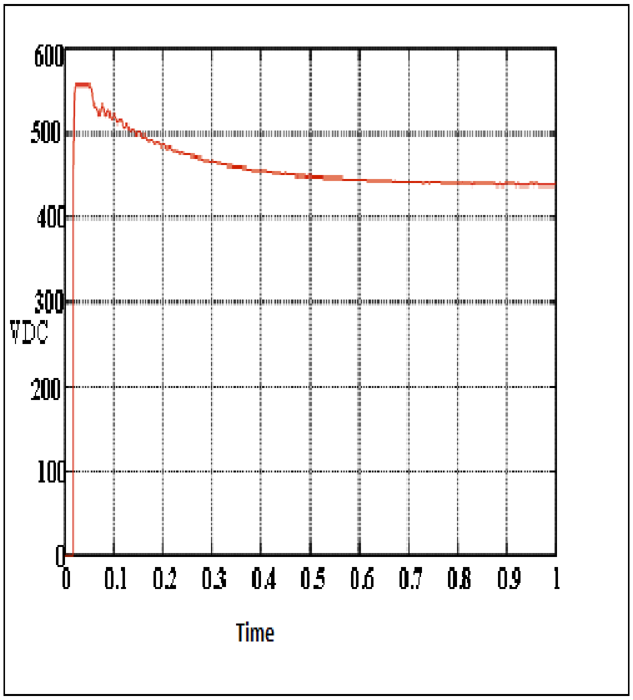



Figure 5.7: Time Vs DC voltage for ramp updown Irradiance

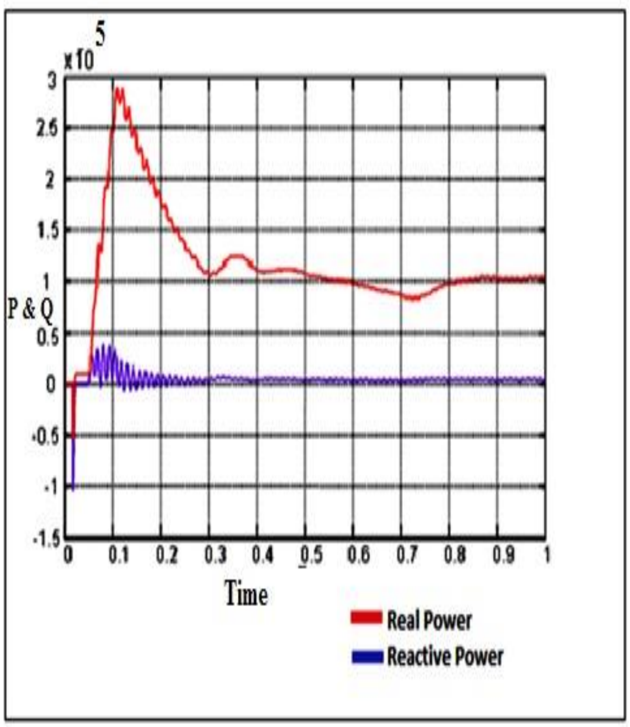



Figure 5.8: Time Vs Real and reactive power for Ramp updown Irradiance [ICM]

## 5.2 Perturb & observe

### 5.2.1 For Constant irradiance level

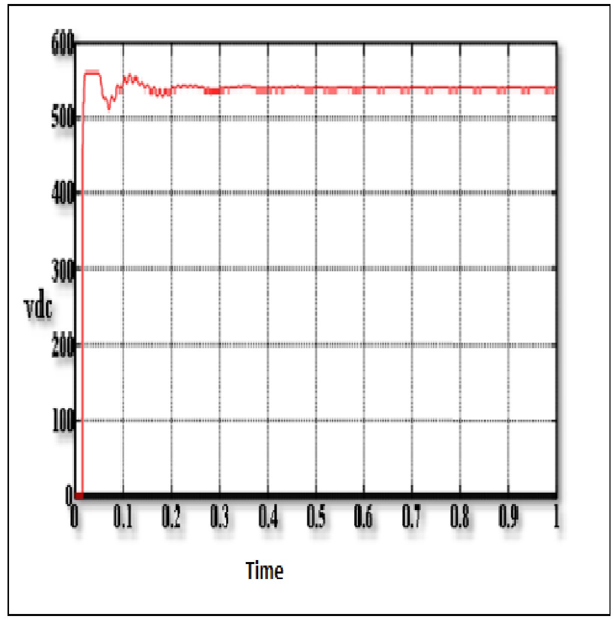



Figure 5.9: Time Vs DC voltage for constant Irradiance [P&O].

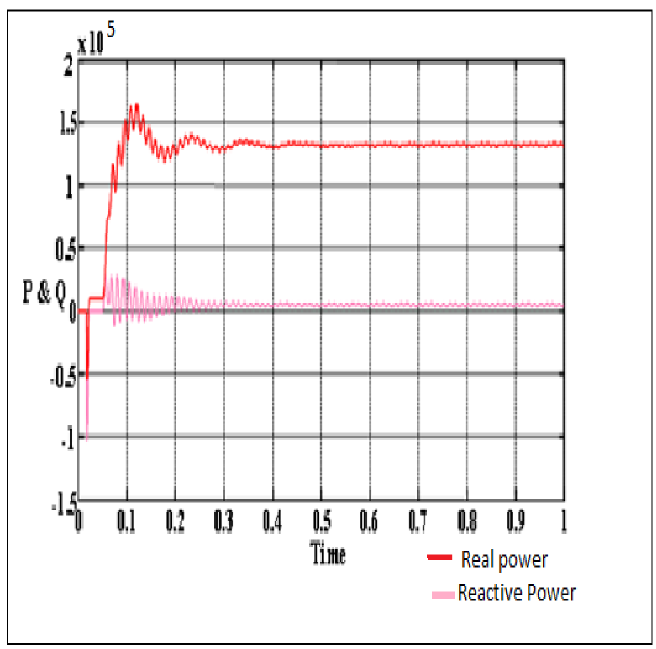



Figure 5.10: Time Vs Real and reactive power for constant Irradiance [P&O]

5.2.2 step irradiance level

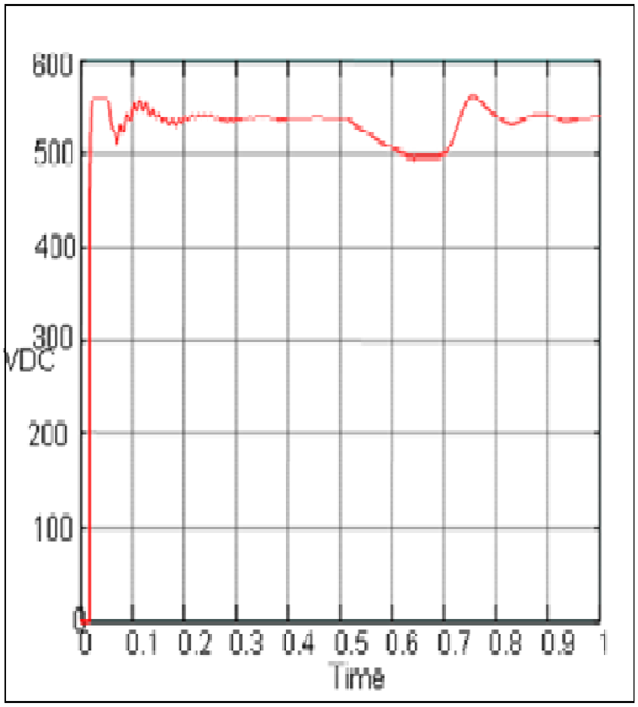



Figure 5.11: Time Vs DC voltage for Step Irradiance

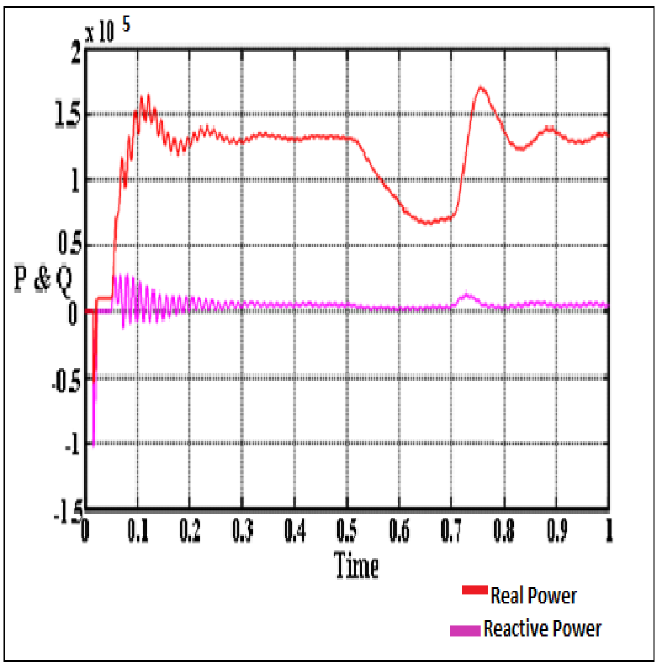



Figure 5.12: Time Vs Real and reactive power for step Irradiance [P&O]

5.2.3 For Ramp updown irradiance level

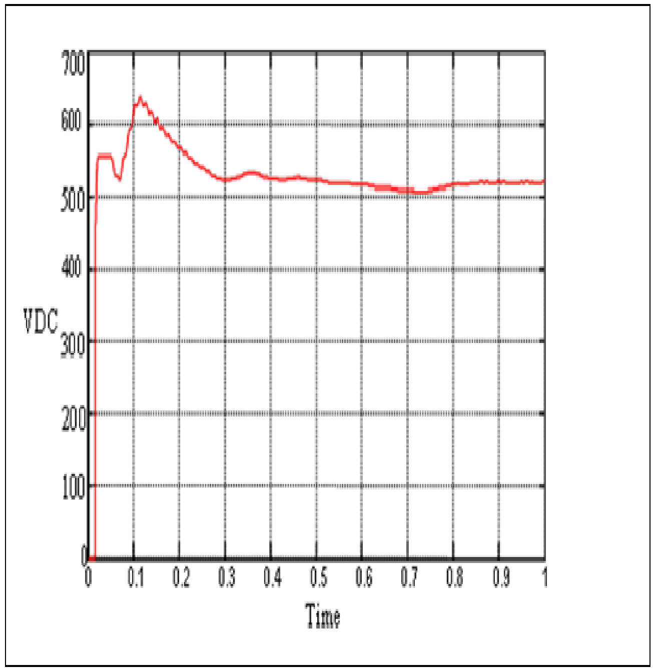



Figure 5.13: Time Vs DC voltage for Ramp updown Irradiance [P&O]

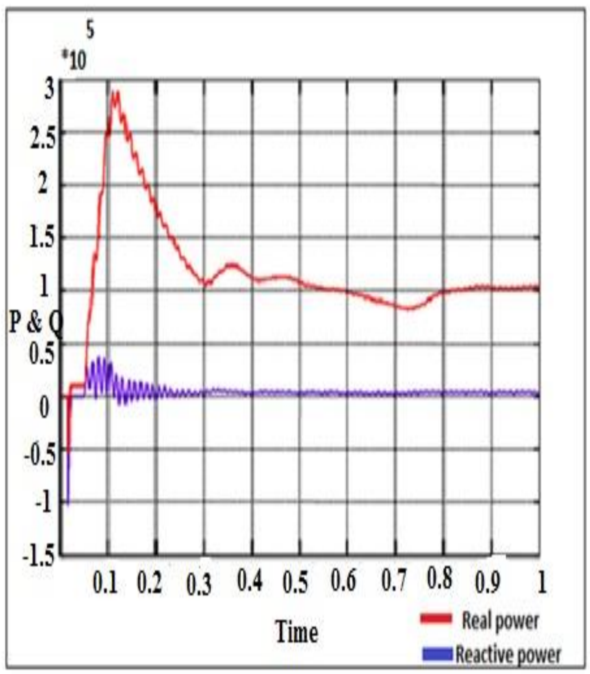



Figure 5.14: Time Vs Real and reactive power for ramp updown Irradiance [P&O].

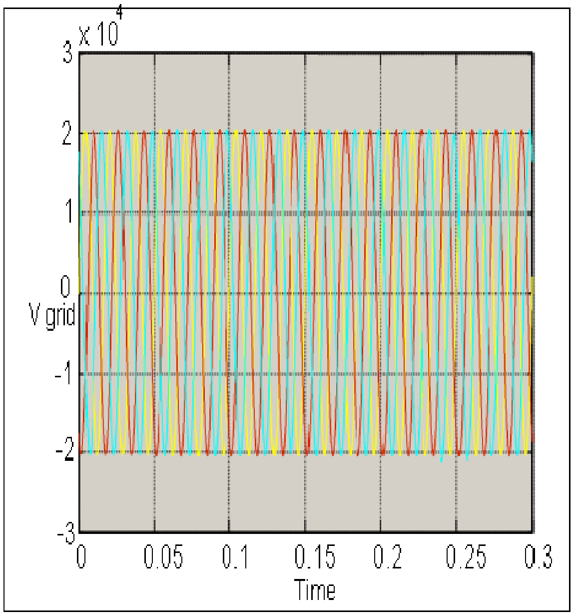



Figure 5.15: Grid voltage Vs Time

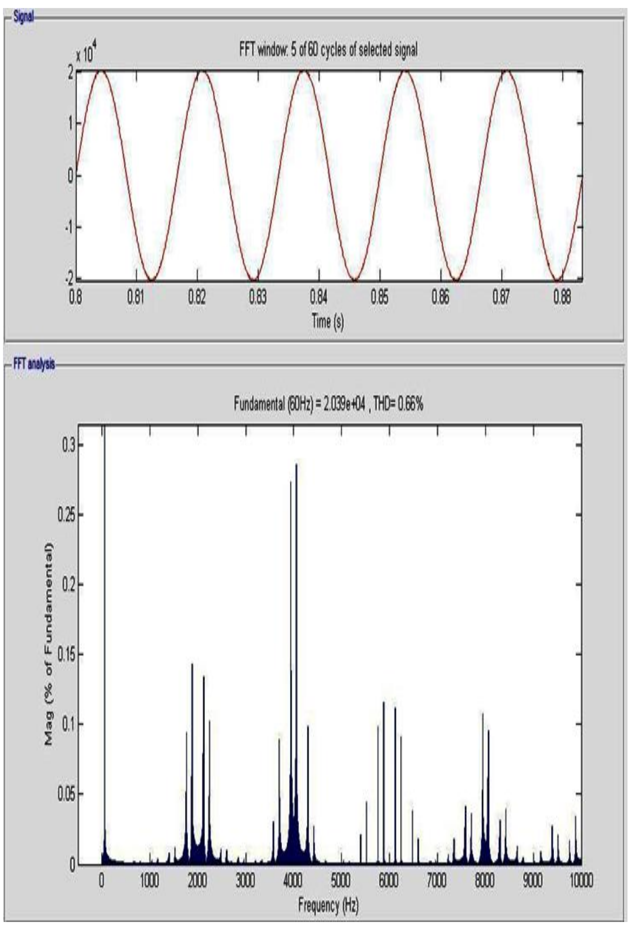



Figure 5.16: Total Harmonics Distortion [THD]

By using SVPWM technique applied to the voltage source Inverter of a PV connected system the following objective is achieved:

- Reduce THD of solar power system. (0.66%)
- Provide output voltage stability.
- Improve power efficiency.

## 6. COMPARATIVE ANALYSIS

| Sr.no | Algorithm | Irradiation | Input (KW) | Output (KW) |
|---|---|---|---|---|
| 1 | Incremental conductance | Constant irradiance | 38.32 | 550 |
| 2 | Incremental conductance | Step irradiance | 38.32 | 540 |
| 3 | Incremental conductance | Ramp up down(555 w/m$^2$) | 38.32 | 100 |
| 4 | Perturb & Observe | Constant irradiance | 38.32 | 140 |
| 5 | Perturb & Observe | Step irradiance | 38.32 | 130 |
| 6 | Perturb & Observe | Ramp up down(520 w/m$^2$) | 38.32 | 90 |

Table 2 comparative analysis of P & O and incremental conductance

## 7. CONCLUSION

The proposed Incremental conductance method is extracting the maximum power from photovoltaic cell. Incremental conductance can track maximum power than perturb & observe method even if solar irradiance is increase or decreased. In Constant and step irradiance condition, the Incremental conductance gives four times more output power than PO method. The proposed method reduced the THD value to 0.66%.The simulated model is connecting to a three phase inverter showing that, generate dc voltage can be converted to ac voltage and interface to AC load. The performance proposed Incremental conductance and PO algorithm are analyzed and simulated in MATLAB.

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