



MPPT TECHNIQUES FOR EFFICIENT SOLAR GRID INTERFACED SYSTEM

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Abstract- This paper introduces a solar grid system with a smart power sharing concept so, the power from the solar array is efficiently used. In order to extract the maximum power from the photovoltaic array conventional MPPT technique is used. A perturb and observe MPPT technique and incremental conductance is used in order to meet the objective. The maximum energy obtained from the photovoltaic array is given more priority than the grid connected system. Appropriate control scheme is designed to make the system operate in three different modes they are standalone system, grid tied system and the hybrid mode of operation. Simulation is done in Matlab and the performance of the system is studied under the steady state and with varying condition. Comparison is made between the Perturb and Observe and incremental conductance method.

Keywords – Solar PV array, Maximum Power Point Tracking, Boost converter, Voltage source inverter, Induction motor

1. INTRODUCTION

The rapid increase in the demand for electricity and the recent change in the environmental conditions such as global warming led to a need for a new source of energy [1]. The replacement of the convention energy is suitable only by using the wind and the solar energy. Thus the best solution for environment are reduction in the emission of carbon, new energy resource for less dependence on coal. Therefore, the use of green energy to replace fossil fuels is a viable. These renewable energy sources is clean, pollution free, and endless.

Different methods are available to harvest the solar energy. In standalone system, batteries have been used to store the solar photovoltaic energy and it is reported in paper [2]. But the disadvantage with the batteries are low life, hazardous waste and leakage of acid in the batteries. Grid connected PV system are used because of this reason [3]. The hybrid system are used nowadays with intelligent power sharing concepts which is able to draw power from the solar photovoltaic array or from the grid. But in this method the transformer is bulky and costly. Solar photovoltaic array, wind energy and batteries are elaborated in [4]. But when wind energy is used the capital investment will be more, for the high power generation this wind energy will be suitable.

The maximum power from the solar PV module is transferred through the DC-DC converter to the load. By varying the load impedance the maximum power is transferred by the maximum power point tracking and when the duty cycle changes it keeps on matching the maximum power. Many MPPT techniques has been proposed in the literature such as Perturb and Observe (P & O), Incremental Conductance method(IC), Particle Swarm Optimization (PSO), Fuzzy logic method [5-7]. The conventional MPPT technique used is Perturb and Observe and Incremental Conductance algorithm [8-12].

2. PROPOSED SYSTEM

2.1 Solar grid interfaced system

The system configuration for the solar grid interfaced system is shown in the Figure.1. It consist of the Solar PV array, two boost converter one is the MPPT boost converter and the other one is boost converter on the grid side, voltage source inverter and a diode bridge rectifier. The AC voltage to the induction motor is given by the voltage source inverter (VSI). To step up the voltage on the grid side, boost converter is used. The output of the diode bridge rectifier is connected to the L-C filter to eradicate the ripple [13].

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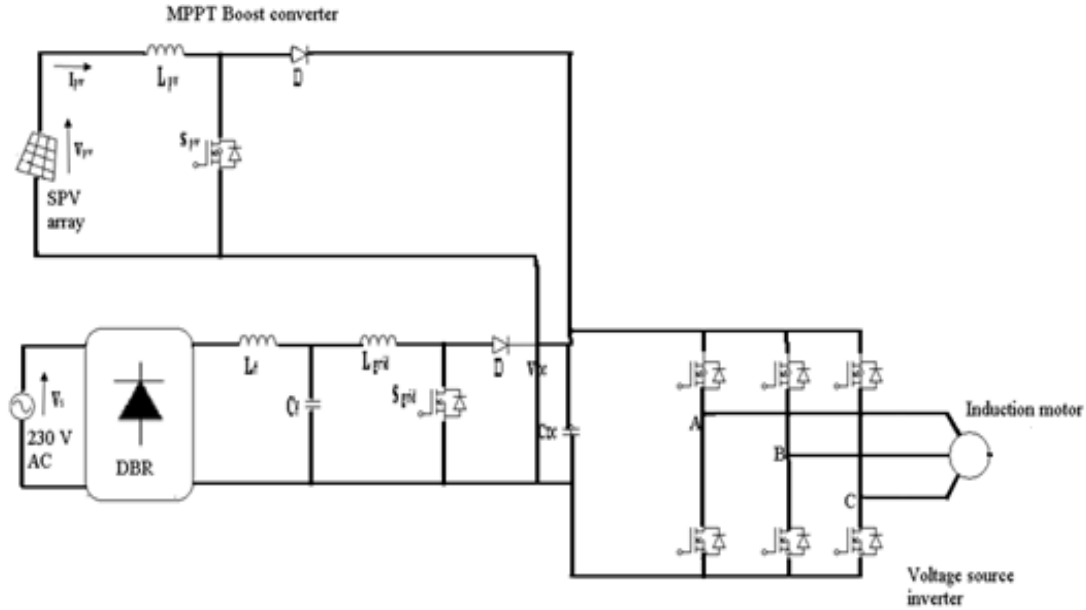


Figure 1. Grid connected Solar interfaced system

2.2 Design of the solar grid interfaced system

Design of solar PV array

The solar panel chosen is LG Electronics LG220R1W-G2, the maximum power obtained from this panel is 220W. There are 2 parallel string connected to increase the maximum current and 11 series connection to increase voltage. The maximum power obtained from the solar panel is 4.4KW. The power rating of the three phase induction motor is 4 KW.

$$P_{mp} = (N_p \times I_{m p}) \times (N_s \times V_{mp}) \tag{1}$$

$$= 4.4 \text{ KW}$$

Where V_{mp} is the maximum voltage of a module, I_{mp} is the maximum current of a module, P_{mp} is the maximum power of the array.

The calculation for the DC link capacitor is shown below

$$C_{DC} = \frac{6\alpha V_{LL} I t}{[V_{DC}^2 - V_{DC1}^2]} \tag{2}$$

Where V_{DC} is the DC bus voltage and V_{DC1} is the reference bus DC voltage.

For the boost converter the duty ratio is calculated by using (3), the inductor on the PV side is calculated is calculated by using (4), the inductor on the grid side is calculated by using (5)

$$D_{PV} = \frac{V_{DC} - V_{MP}}{V_{DC}} \tag{3}$$

$$L_{PV} = \frac{V_{mp} D}{\Delta I_1 f_s} \tag{4}$$

$$L_{grid} = \frac{V_{DC} D_a (1 - D_a)}{f_{sw} \Delta I_L} \tag{5}$$

Where V_{MP} is the maximum power voltage, f_s is the switching frequency, I_L is the inductor current, D is the duty ratio on the PV side, D_a is the duty ratio on the grid side.

2.3 Control scheme for the system

The solar grid interfaced system consists of the two power source. The power from the solar PV array is given priority than the grid connected system. In order to extract the maximum power from the solar PV array an incremental conductance (IC) algorithm is used.

Depending on the power source available the system is made to operate in three different modes by using the appropriate control scheme shown in the figure.2. The three modes of operation are explained below,

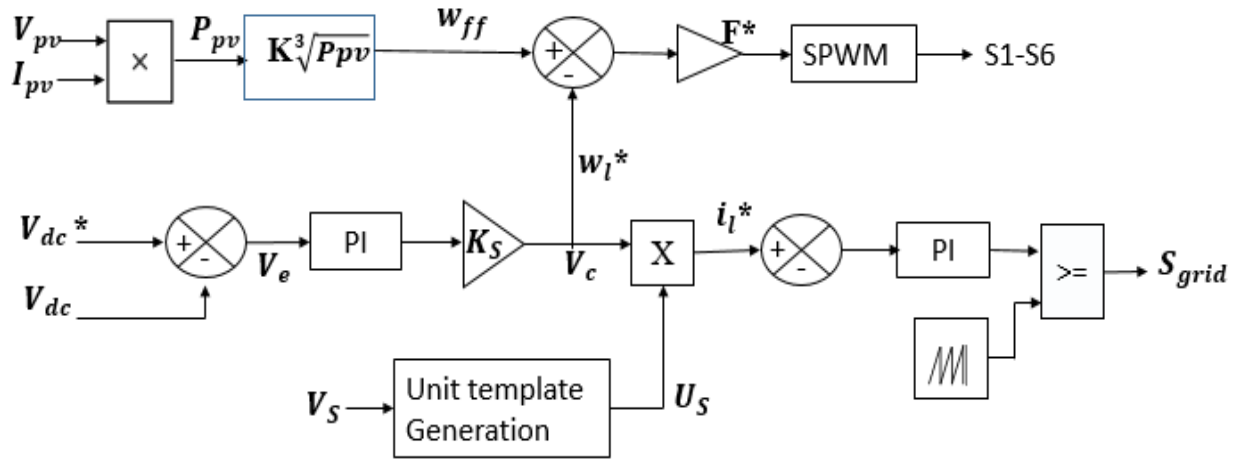


Figure 2. Control scheme for the System

3. MODE OF OPERATION

The mode I is called as the standalone operation, this mode is operated in the presence of the solar power. The PV side voltage is increased to the reference voltage by using the boost converter and the PV operating point is maintained at the maximum power point. The output from the boost converter is fed to the voltage source inverter which runs the motor at the rated speed. The simulation result of the Mode I is shown in the figure.6.

The mode II operates when there is no sufficient irradiance and during that period the system draws power from the AC mains. Grid supply is connected to the diode bridge rectifier, which is followed by the boost converter, capacitor, voltage source inverter and the induction motor. The simulated result of the Mode II is shown in the figure.7.

The mode III will operate when there is power available from both the solar photovoltaic array and grid. In this mode more priority will be given to the PV source and the remaining power has been taken from the grid. The consumption of power from the grid is less and thus we will be able to reduce our electricity bill. The performance of the system is done under the dynamic conditions. The simulated result of the Mode III is shown in the figure.8.

3.1 Maximum power point tracking algorithm

Perturb and Observe (P&O)

In the Perturb and Observe algorithm perturbation is introduced. The power of the solar module will change continuously because of the perturbation. The perturbation will be continued if the power increases. After the peak power is reached the power will decrease. When the steady state is reached it will start to oscillate at the peak point. In order to keep the power variation small the perturbation size will also kept small. The detailed explanation of P and O is explained in the flowchart fig.4.

Incremental Conductance Algorithm

The terminal voltage of the PV array is adjusted in accordance to the maximum power point voltage in the incremental conductance. And it will be based upon the incremental and instantaneous conductance of the photovoltaic Module. The PV curve for incremental conductance is shown below. The flowchart for incremental conductance is shown in the fig.5.

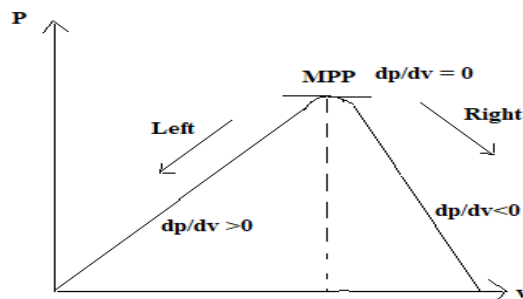


Figure 3. PV curve for incremental conductance

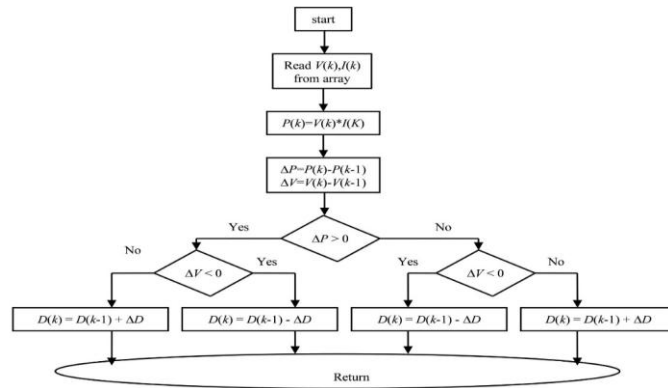


Figure 4. Flowchart for Perturb and Observe algorithm

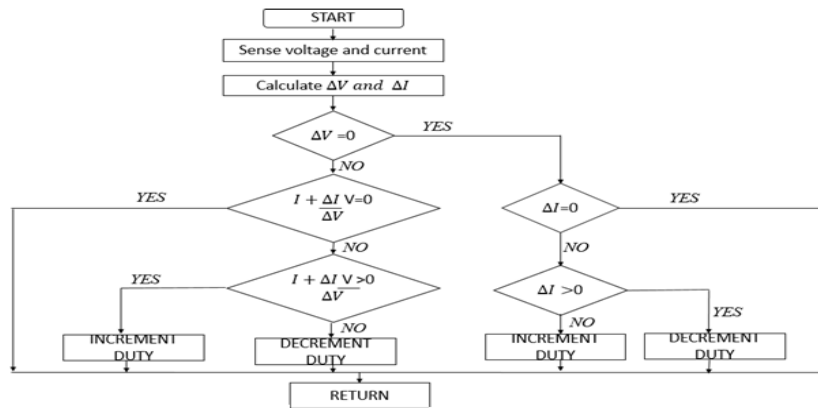
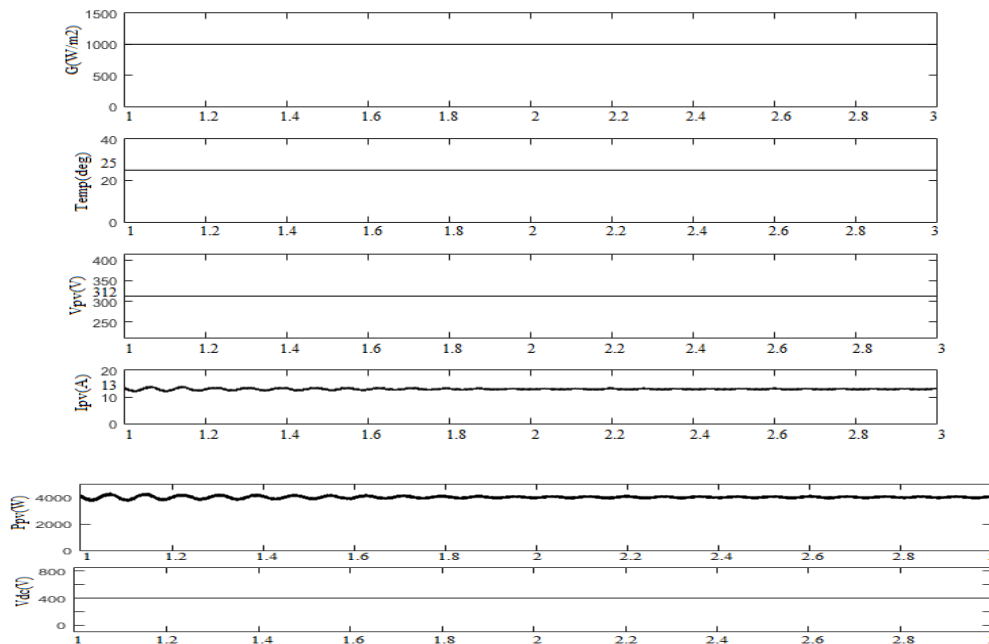


Figure 5. Flowchart for Incremental Conductance Algorithm

4. SIMULATED RESULT

The response of the solar grid interfaced system is simulated with the help of MATLAB and the results obtained are analyzed. The steady state performance of the system in different modes of operation are simulated in MATLAB. The step and slope changes for the solar irradiance are simulated to make the system operate in the dynamic condition.



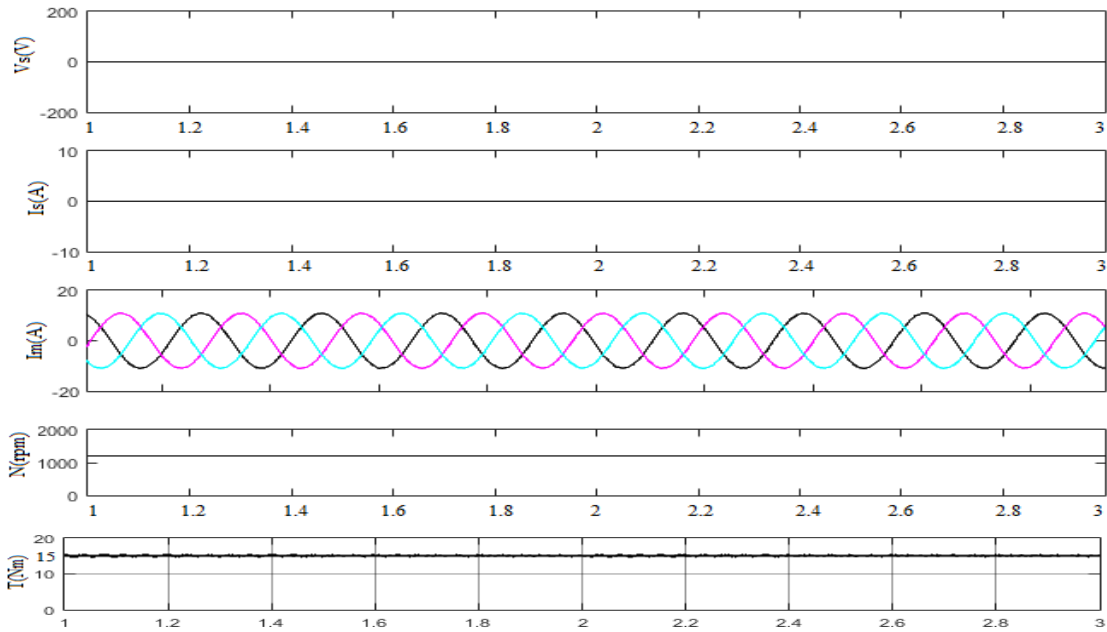
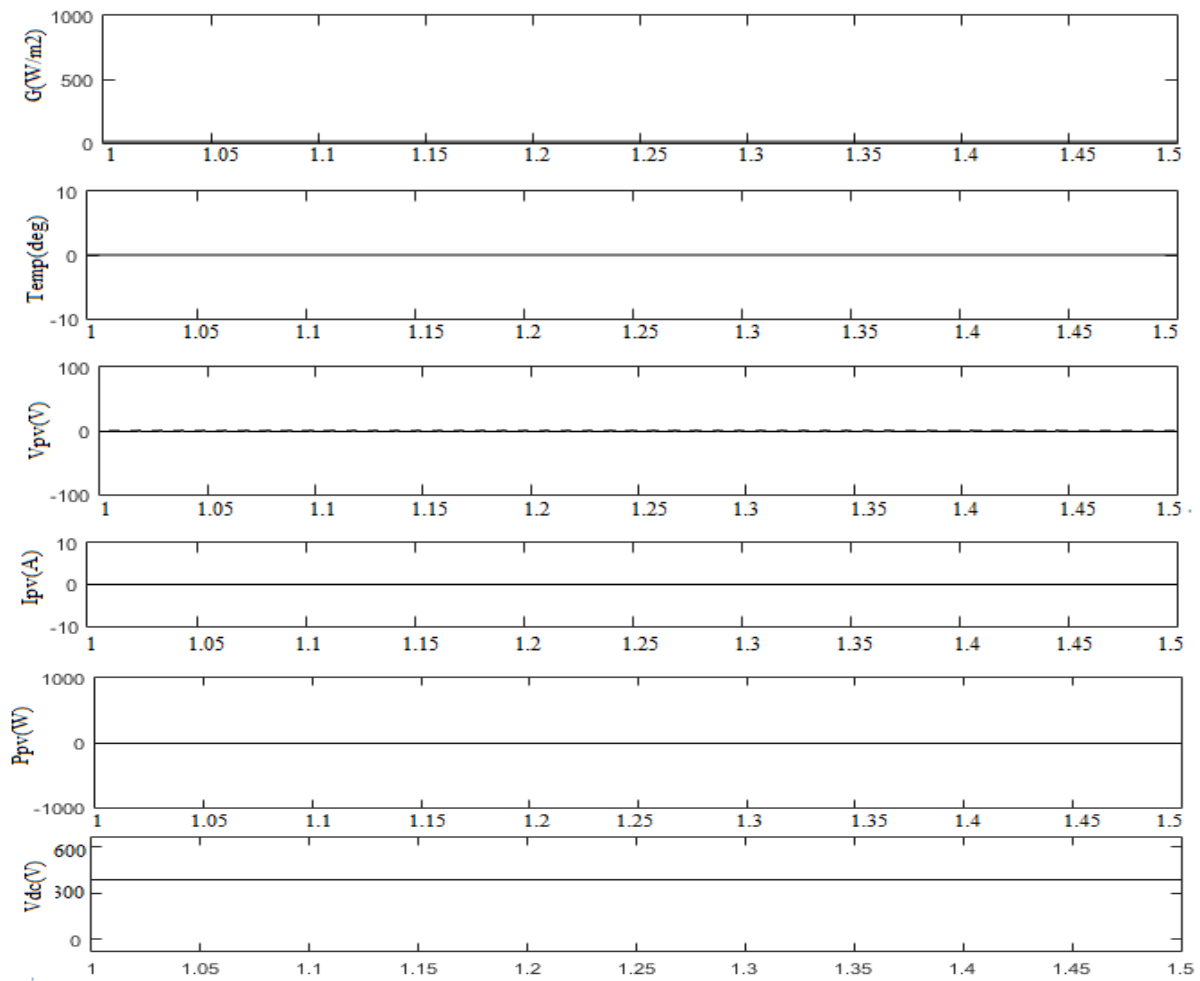


Figure 6. Steady state response of the system at standard test condition for Mode I



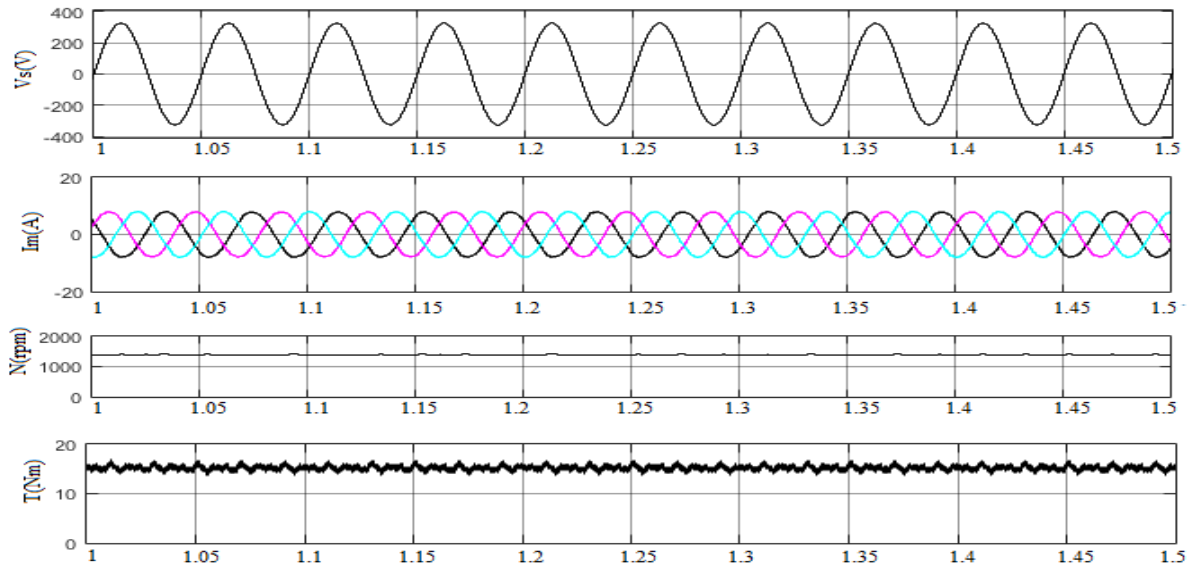


Figure 7. Steady state response of the system in Mode II

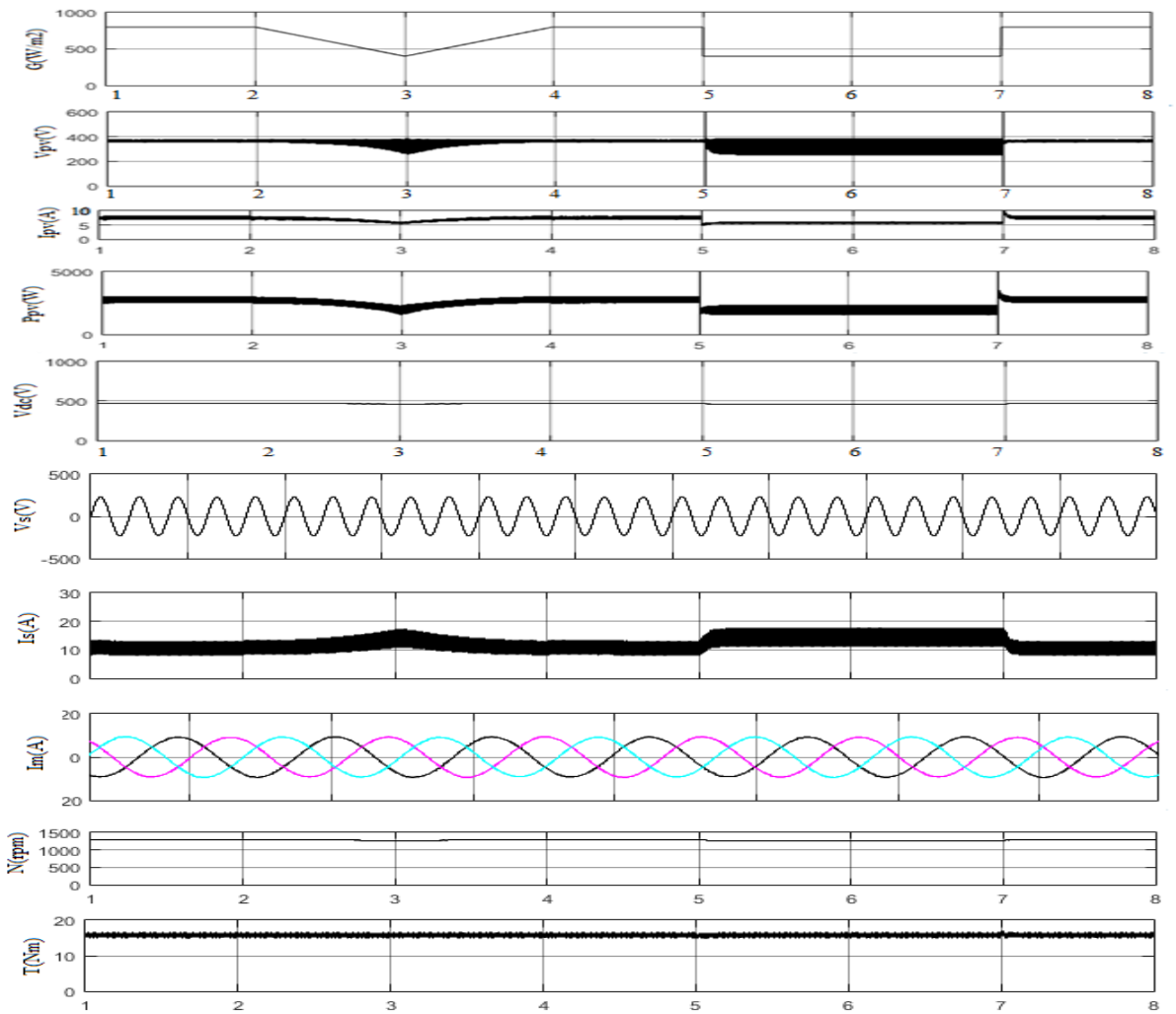


Figure 8. Dynamic response of the system in Mode III

Table -1 Comparison between the Perturb and Observe and Incremental Conductance
Perturb and observe Incremental Conductance

MODE	IRRADIANCE G(W/m ²)	V _{pv} (V)	I _{pv} (A)	P _{pv} (KW)	V _{pv} (V)	I _{pv} (A)	P _{pv} (KW)
I	800 & 20	304.58	13.5	4.120	306.2	13.5	4.137
II	10 & 0	0.2	0	0	0.3	0	0
III	800 400	314 305	14 8.0	4.2 2.4	314 307	14 8.2	4.396 2.517

Table 1 show the comparison between the Perturb and observe and the incremental conductance, the maximum power obtained from the incremental conductance is higher than the Perturb and Observe.

5. CONCLUSION

The solar grid interfaced system has been designed, modelled and simulated in MATLAB. The simulation performance of the system in steady state and with varying irradiance has been performed. The maximum power from the Solar PV array has been extracted by using the Perturb and Observe method and incremental conductance. The control scheme has been designed and is made to operate in three different modes standalone, grid tied system and the hybrid mode of operation. So the burden on the grid gets reduced and the electricity bill will get reduced. In this the incremental conductance is able to track more efficiently than the Perturb and Observe. The power obtained from the incremental conductance is slightly higher than that of perturb and observe.

6. APPENDIX

6.1 .Photovoltaic Array Parameters

Open circuit voltage (V_{oc}) = 36 ; Short circuit current(I_{sc}) = 8.06 ;Module in series=11;Module in parallel= 2; Maximum power point voltage = 315.7V ; Maximum power point current= 15.38A ;Power at maximum power point = 4.4KW.

B. Parameters of Induction Motor

4KW, 230 V, 50 Hz Three phase, 1430 rpm, 4 pole, R_s=1.405Ω , R_r=1.395Ω, X_s=1.007Ω, X_r= 0.9212Ω, X_m=23.56Ω .

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