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Experimental investigation and theoretical for the performance improvement of MPPT technique with PV systems connected to the grid

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Abstract

Many researchers have provided theoretical analysis of photoelectric (PV) energy systems connected to the electrical grid. This paper is concerned with experimental preparation in order to validate more and remains a major challenge in the field of practical research. In addition, the biggest problem with the PV energy system is how to get the utmost value out of the energy under a changing solar radiation. To take full power of the PV array output energy dependent on the change in solar radiation, Maximum Power Point Tracking (MPPT) techniques are used in the PV systems. The experimental and theoretical application of MPPT technology for grid connected PV system is suggested. This is done to track maximum energy under rapidly changing weather conditions in two states of PV radiation changes: the change of solar radiation in ramp profile and the width under change step. This article introduces the MPPT of a grid-connected PV system as a simulation and experimentally to track the speed of PV radiation change in different operating conditions. Through the results, an increase and correspondence in the output energy is shown using the MPPT technology between the experimental and theoretical side. Simulation results show the feasibility and power of control systems. Finally, a simulation result was compared with the experimental results for energy, current, and voltage coming out of the PV array as well as the electrical grid.

Keywords: Photoelectric system, maximum power point tracking, incremental conductance algorithm, experimental work and grid connected PV system

1. Introduction

In recent times, electric energy is not sufficient for the increasing demand for this type of energy. Electric energy is one of the most important factors on which economic development is based from a worldwide perspective. Thus, without energy, there is no production wheel, and therefore it is very necessary to search for new and renewable sources. This increased demand in the world encouraged the use of new and renewable sources of electricity. Among these sources there is solar energy, as it has been subjected to many previous studies. The electric energy generated by solar energy is accomplished through direct conversion of sunlight into electricity. Humans have been able to develop this energy in many ways to convert this solar radiation into electricity. The PV power is characterized as having clean energy that does not contain environmental pollution, a high degree of documentation, low maintenance costs, flexibility in size, and relatively low construction and operating costs [1-5].

Recently it has been noted that the use of the system connected to the network Photoelectric has become more advanced. In order to meet this increasing demand for electrical energy, there must be fairly large areas to produce much of this electrical energy. Therefore, new maximum energy extraction techniques must be used to track the power point of these arrays. There are many techniques that we can use to design maximum power point tracking (MPPT) [2] in order for the power converter circuits to operate at MPPT

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of the PV array. These techniques include; incremental conductance (IC) technique [3-7], perturb and observe (P&O) [8-10], modified perturb and observe technique [11-13] and sliding mode control and fuzzy logic control [14-20].

The performance of the P&O algorithm is less than IC because P&O algorithm performs high steady-state oscillations therefore wastage the energy especially in rapidly weather changes [3]. Thus, IC is used to improve the drawback of the P&O algorithm. The main advantage of the IC includes high stability under rapidly changing weather conditions [4]. Over the past few years, many articles have been listed as improving PV performance using MPPT methods and few articles have tackled the practical and experimental aspect. This prompted us to focus on the experimental and theoretical verification with one of the MPPT methods, namely the IC method.

This paper introduces experimental and theoretical verification of one of the MPPT methods which is IC method of simulating PV system procedures. This is done by tracking the maximum energy under rapidly changing weather conditions in two solar radiation changes. As well as by comparing the simulation result with the experimental results of energy, current, and voltage outside the PV array connected to the electrical grid, we will present the research in the following organization, theoretical and experimental proposed system, experimental results and discussion, simulation results and discussion and conclusions.

2. Theoretical and Experimental Proposed System

Figs. 1 and 2 illustrate the proposed theoretical and experimental system for grid-connected solar energy systems. Fig. 1 shows a step-by-step simulation modelling of a grid's photoelectric system. It is energy production and transmission from PV group. It starts with converting this energy, and then raising it to the network value, and finally connecting it to the electrical grid. The simulation model provides how to control this energy and connect it with the network. This is done by investigating the maximum possible amount of PV energy generated.

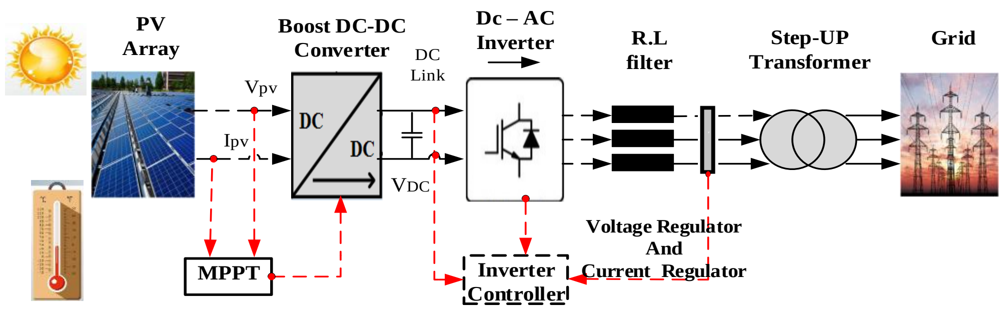

Fig.1. Simulation modelling of grid connected of PV system

Fig. 2 illustrates the experimental setup of grid-connected photovoltaic systems, which consists of a PV power supply, three phase transformer, three phase DC to AC inverter and MPPT unit. The aims of theoretical and experimental proposed system are to study the performance and analysis of grid-connected photovoltaic systems under the influence of variable solar radiation.

The proposed system is composed of the following: A group of PV cells to produce electrical energy, DC / DC Boost Convert, A voltage DC link capacitor, the inverter for Converts the PV voltage into a variable voltage, the harmonic filter circuit RL and the transformer to raise an electrical voltage used to raise the voltage to suit the voltage of the public electrical grid.

In order to generate the maximum power out of PV, An MPPT technology is needed. The second step involves transferring this energy to the inverter. As a result, the inverter converts the energy to AC. Therefore, it is highly required to find a way to control both the inverter output and input in a way that the full energy can be extracted without any obstacles caused, and then the grid is to be connected. The process of transferring the highest power obtained from the PV board to performance as efficiently as possible can be achieved by the control separating of the grid-connected inverter. The suggested control unit depends on the sizes of the variable phase. This can be done by comparing both the p-v curve and the slope that was again developed, especially as a result of the improved interaction within the system in this work. This allows us to locate the work point on the curve of the P-V. The work point may be far or near the MPPT. Therefore, when the working point is far from MPPT, the size of stepwise voltage is applied to a reference voltage in addition to that small step size from the MPPT operating point location.

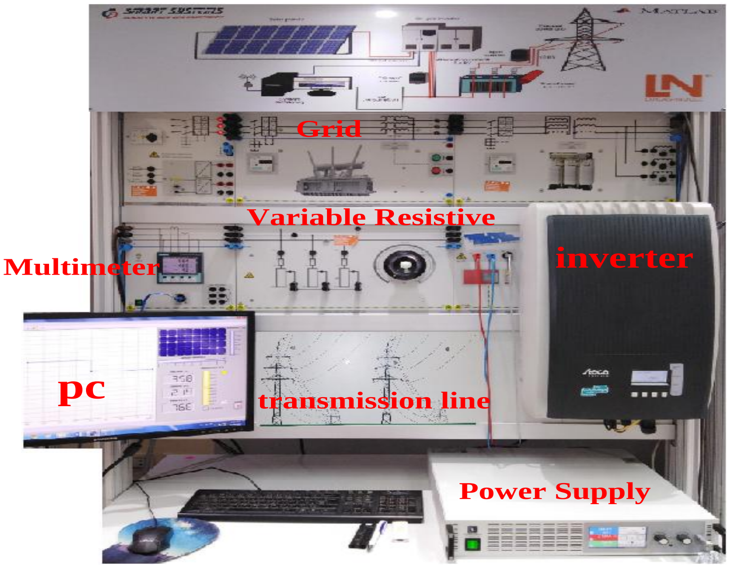

Fig. 2. Experimental setup of grid connected PV system.

2.1. PV array modelling

Fig. 3, displays the equivalent circuit model of a PV cell. Series–parallel combination of PV cells forms a PV array with specified rating of current and voltage.

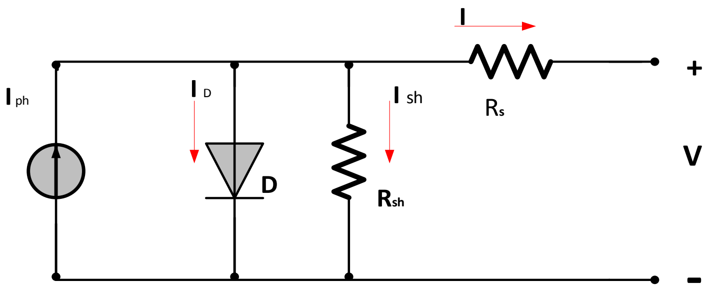

Fig. 3. PV cell equivalent circuit [17-23].

In the equation below, namely "the central equation depicting V-I curves for photoelectric cells", the production stream is defined by [1].

$$\mathbf{I = I_{Ph} - I_0\left[e^{\frac{q(V+IR_S)}{AKT_C}} - 1\right] - \frac{V + IR_s}{R_{Sh}}} \tag{1}$$

Where: I is the PV current of the PV module, I_0 is the saturation current of diode I_{Ph} is the -generated current from photo, R_S is the resistance of series in Ω, R_{Sh} is the resistance of parallel in Ω, n is the ideality factor, K is the constant of boltzmann, q is the charge of electron and T is the temperature [K].

The above equation shows the influence of PV current on temperature and thus reliance of energy drawn by PV array. The model under study is rated 200-kW PV array based on 660 Sun power modules. The array consists of 132 strings of 5 series-connected modules that is parallel- connected [5*132*305.226 W= 200 kW].

2.2. DC-DC boost converter

Employed to step up the PV output voltage, the DC/DC boost converter is concerned with investigating the required as well as the synchronized voltage level and with the electrical grid by DC/AC inverter as seen in Fig. 4. Fig. 4, displays the configuration of a boost DC-DC converter that contains an inductor; L with an internal resistance of R, a diode; D; and a DC-link-capacitor; C and (IGBT) switch. In the detailed model, voltage is increased from 280V to 500V by boost converter. The boost converter makes use of MPPT technique that automatically changes the duty cycle to generate the desired voltage to produce maximum energy from the PV array. In most MPPT techniques, the varying of booster duty cycle *D*s is a key for tracking process. The modulation index of the boost converter control maintains changing so that voltage output can track the desired voltage under variable solar radiation [17]

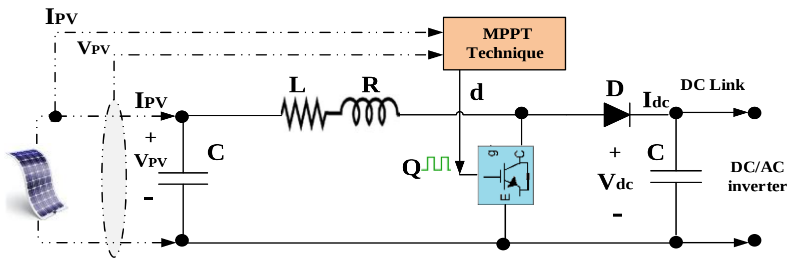

Fig. 4. The equivalent circuit of DC-DC boost converter [24-28].

Stepping-up its magnitude of input voltage to a value that is desired by means of electronic switching is the main purpose of DC-DC booster circuit. The output voltage from the PV array has a small value to be synchronized with the electrical grid through the DC/AC inverter. Therefore, the DC/DC boost converter is working to step up the PV output voltage and achieve the desired voltage equal (500 V). The output of the boost converter is specified to the three-phase inverter. The MPPT controller gives the PWM pulses to the IGBT to keep continuous output voltage [17-19].

2.3. Incremental of conductance (I&C)

In order to find a solution to some of the limitations of the P&O method (e.g., speed of convergence and steady-state error), IC has been proposed. Taken into account the noticeable advantages of IC (e.g. a response that is easy and fast to solar irradiances, which are changing rapidly), IC is frequently mentioned, based on the principle of disturbance and observation, as the best technique. Besides, the IC method is built on the power-voltage slope as exposed in Fig. 5.

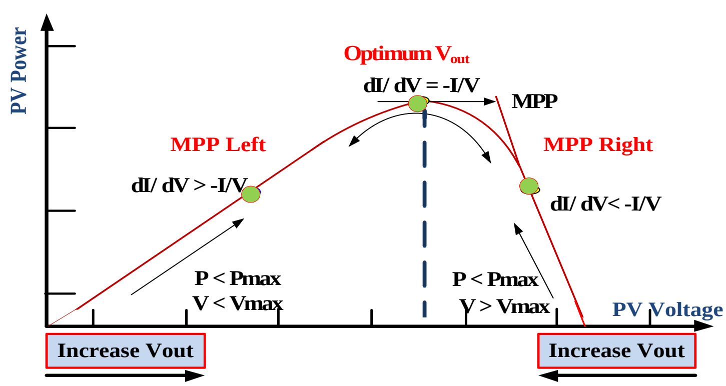

Fig. 5. Basic idea of incremental conductance technique [1].

The IC MPPT flow chart is shown in Fig. 6 The slope of the P-V characteristic is calculated, if the action point on the left side of the MPPT is positive, therefore it is stimulated to the truth by increasing the PV voltage. But if the slope of the typical curve is negative, the procedure assumes that the point of operating is located on the side of the MPP right and therefore it must be encouraged to the left by reducing the PV voltage.

The effective point is at MPP when the P-V curve slope is zero and the voltage adjustment algorithm will stop as in the following equation [1].

$$\frac{dI_{PV}}{dV_{PV}} = -\frac{I_{PV}}{V_{PV}} \quad \text{At MPPT} \tag{2}$$

$$\frac{dI_{PV}}{dV_{PV}} > -\frac{I_{PV}}{V_{PV}} \quad \text{Left of MPPT} \tag{3}$$

$$\frac{dI_{PV}}{dV_{PV}} < -\frac{I_{PV}}{V_{PV}} \quad \text{Right of MPPT} \tag{4}$$

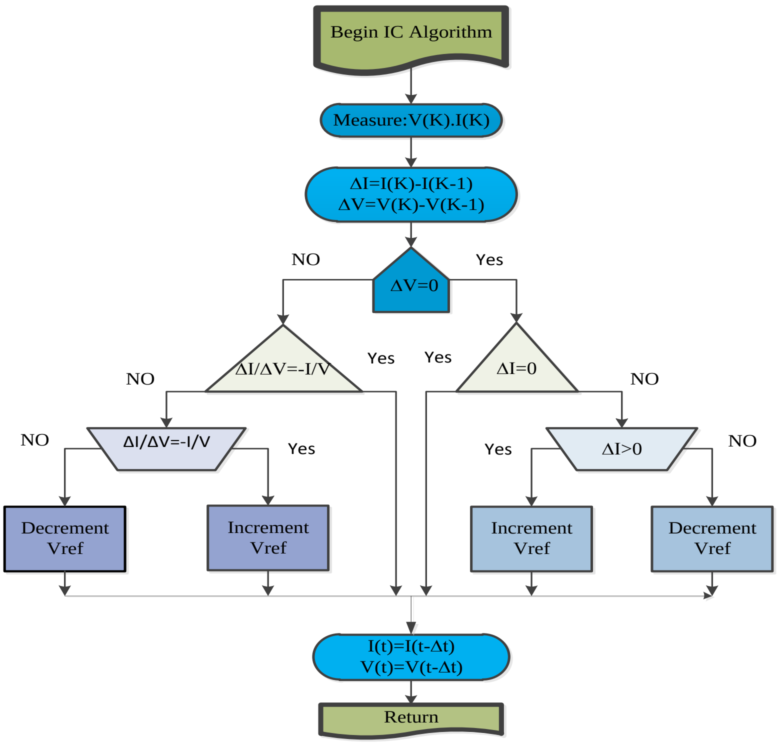

Fig. 6. Incremental Conductance MPPT Flow chart [3].

2.4. Interface of the grid inverter

Voltage Source Inverter (VSI) basically made use of in order to change the form of the generated DC power to AC that is accepted by public grid, it works on connecting PV-array to the grid. It is the function of VSI to get the direct current/voltage converted from the PV-array into alternating with utility frequency to be tied to public grid or feeding AC loads. VSI is characterized as being the critical part in this power system. Controlling the VSI switches using suitable controlled pulses is required in order to improve the performance of the system [20-21].

In this paper, The VSI is viewed as a multilevel bidirectional DC-AC voltage source inverter including

PWM modulation using IGBT/ Diode. The output of the active and reactive powers can be controlled by an appropriate control of the VSI power switches. In Fig. 7, the schematic diagram of the VSI connected to the public grid via a 3-phase tie line is displayed.

As of the Fig 7, the dynamic equation can be obtained as the following [1]:

$$\begin{bmatrix} V_A \\ V_B \\ V_C \end{bmatrix} = R_{(A,B,C)} \begin{bmatrix} I_A \\ I_B \\ I_C \end{bmatrix} + L_{(A,B,C)} \frac{d}{dt} \begin{bmatrix} I_A \\ I_B \\ I_C \end{bmatrix} + \begin{bmatrix} V_{gA} \\ V_{gB} \\ V_{gC} \end{bmatrix} \tag{5}$$

By synchronously revolving d-q axes transformation, the currents smooth from the VSI to the grid are obtained bestowing to [1, 20]:

$$I_d = \int \frac{1}{L_{(A,B,C)}} \left(V_{0d} - R_{(A,B,C)} I_d + L_{(A,B,C)} \omega_S I_q - V_{(A,B,C)q} \right) \tag{6}$$

$$I_q = \int \frac{1}{L_{(A,B,C)}} \left(V_{0q} - R_{(A,B,C)} I_q + L_{(A,B,C)} \omega_S I_d - V_{(A,B,C)q} \right) \tag{7}$$

The grid powers of active and reactive from the VSI are designed as:

$$P_{inv} = V_{od} I_d + V_{oq} I_q \tag{8}$$

$$Q_{inv} = V_{oq} I_d + V_{od} I_q \tag{9}$$

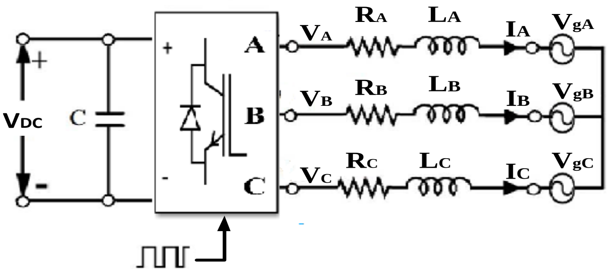

Fig. 7. The grid system graphic diagram [20]

3. Experimental Results and Discussion

The data and description of the experimental system are presented in Table 1. Fig. 8 shows and illustrates the change of solar radiation under the ramp profile. We observe in the form of solar radiation starting from 325 W/m^2 and gradually rise to 675 W/m^2 and then dome slightly and then the radiation gradually decreases Up to 260 W/m^2, then stability slightly, then gradually increase to 470 W/m^2 and then stability slightly.

Table 1. Experimental setup specifications for the PV system

Names	Values
Solar Panel emulator	
PV maximum power	1500 W
Rated current	7.2 – 11.7 A
Rated voltage	100 - 240 V
Output current	0-10 A
Output voltage	0-500 V
ON-grid inverter	
DC input voltage	250 – 1000V
DC MPP Voltage	300 – 800V
DC Max. current	11 A
DC Short circuit current	13 – 20 A
AC voltage	3*230 V

Frequency	50-60 HZ
Power Factor	0.8 – 1.0
AC Max. Current	7 A
Max. Power	3200 W
Step up transformer	
Primary Voltage	400 V
Secondary Voltage	450 V
Nominal Power	1000 VA
Frequency	50/60 HZ
Length of transmission line	150 km

Fig. 9 shows the experimental performance of PV voltage, PV current and PV power under ramp changes of solar radiation. As shown in this Fig. 9 (a) stable in the PV voltage coming from the solar energy, and the Fig. 9 (b and c) a change in the power and current coming from the solar energy with change is followed by a change in the sun's radiation. The output from the olfactory energy plate is constant, which indicates the efficiency of the MPPT system applied in the practical side.

Fig. 10, shows some results in the illustrated experimental system of grid voltage, grid reactive power & active power and grid current under ramp changes of solar radiation. Through Fig. 10, which was captured during the experimental aspect of connecting the solar energy system with the electrical grid, the grid voltage is fixed to the voltage required to connect. It also shows that the active and reactive power and the grid current changes in response to the change of solar radiation, and this indicates the accuracy of the proposed experimental system in the research.

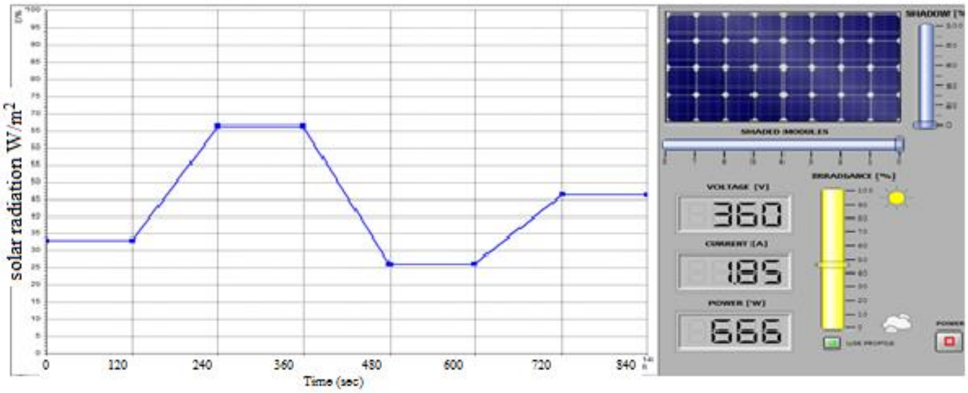

Fig. 8. Ramp changes of solar radiation of experimental PV system.

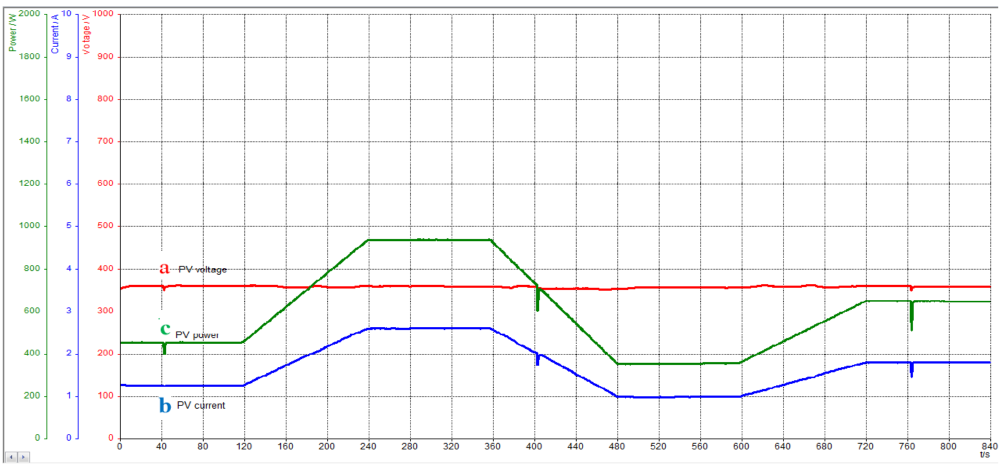

Fig. 9. Experimental performance of PV voltage, PV current and PV power

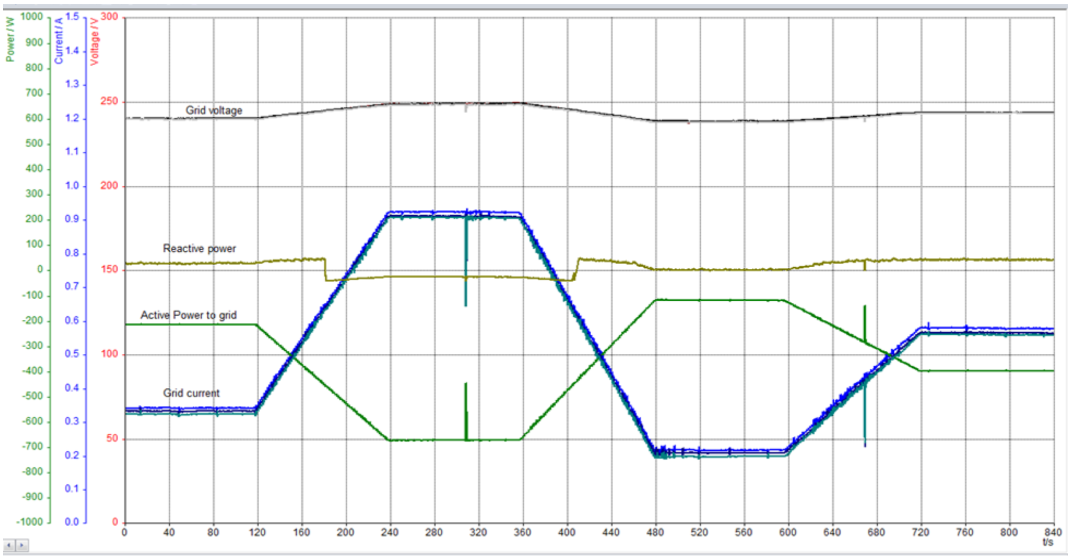

Fig. 10. Experimental grid performance of grid voltage, grid current and grid power

4. Simulation Results and Discussion

4.1. Ramp changes solar radiation profile

The data and description of the MATLAB simulation system are presented in Table 2. Figs. 11 and 12 illustrate the tracks variations of the operative point of PV system at I-V and P-V curves under increasing solar radiation.

From Fig. 11 and 12 show, at 660 w/m^2 solar radiation, PV voltage with controller is 280 V, PV array current with controller is 480 A, and PV array power is approximately 140 kW. At 470 W/m^2 solar radiations, PV voltage with controller is 280 V, The PV current with controller is 380 A and The PV power with controller is 90 KW. At 330 w/m^2 solar radiation, PV voltage with controller is 280 V, The PV current with controller is 220 A and The PV power with controller is 65 KW. At 260 w/m^2 solar radiation, PV voltage with controller is 280 V, The PV current with controller is 190 A and The PV power with controller is 50 KW.

Table 2. Simulation specifications for the PV system

Parameters	Values
PV maximum power of module	305.2 W
PV short circuit current of module	5.96 A
PV open circuit voltage of module	64.2 V
PV maximum current of module	5.58 A
PV maximum voltage of module	54.7 V
Parallel strings of PV array	132
Series-connected modules per string	5
Inductance of boost converter	5 mH
Resistance of boost converter	0.005 Ω
Capacitance of boost converter	100 µF
Converter switching frequency	10 kHz
Reference voltage of DC link	500 V
Inductance of filter	0.25 mH
Resistance of filter	0.015 Ω
Step up transformer	260V / 25 kV
Grid voltage	25 kV
Grid frequency	60 Hz

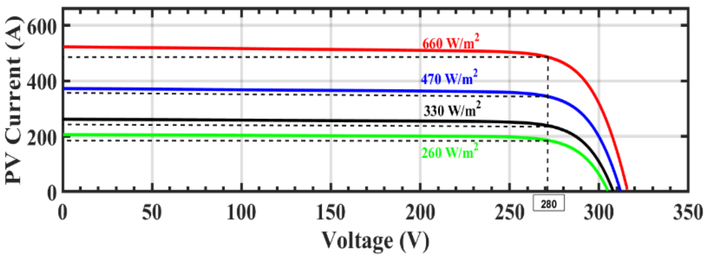

Fig. 11. I-V curves for different values of solar radiation at temperature of 25 ℃

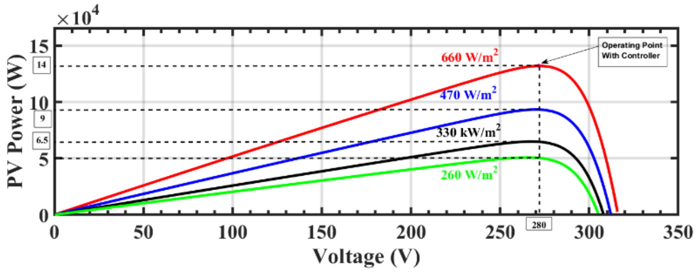

Fig. 12. P-V curves for different of solar radiation at temperature of 25 ℃.

Fig. 13 shows the value of solar radiation. That was at the beginning of 330 w/m2 settled at a time from 0 to 0.5 sec. Then it increased until it reached 660w/m^2 at a time from 0.5 to 1 sec, then a certain period of time also stabilized from 1to 1.5 sec and then it descended to 260 w/m^2 in time 1.5 to 2 sec then certain period of time stabilized, which is 2 to 2.5 sec, and then it increased to 470 w/m^2 from 2.5 to 3 sec and settled in time 3 to 3.5 seconds. This change in radiation values had more important results and effects on the current, voltage, and energy coming from the grid's solar power station as shown in the next three figures.

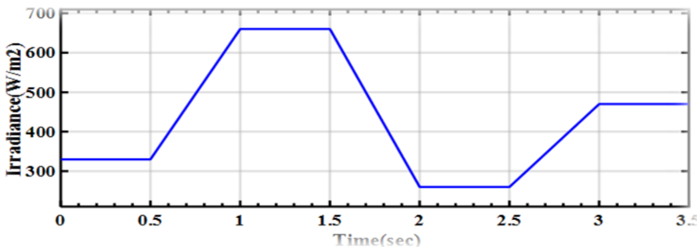

Fig. 13. Ramp changes solar radiation profile

Fig. 14 shows the change of PV current time per second through the existing solar radiation, which indicates the accuracy of the MATLAB simulation system. At the beginning, we notice fluctuation of the results, this is normal at the beginning of operation, then it starts to stabilize at a time of 0.5 seconds at 280 A. Then it gradually increased to 480A and then gradually decreased to 190A. It settled for 2 to 2.5 seconds. Then it began to increase until it became about 380 A. We note that the current values change following the change of radiation, that is, when the radiation increases, the current increases, and when the radiation decreases, the present value decreases, and also when the radiation is stable, there is stability in the current leaving the PV panels. PV voltage starting is unstable by a small percentage and ramp changes relatively small in the beginning, but it quickly settles between at 280 volts as shown in Fig. 15.a.

Fig. 15.b shows the performance of the PV array ability to change during ramp solar radiation. The PV power was initially at radiation of 330 W/m^2 and settled all the time from 0 to 0.5 seconds and it was 65 Kw and then began to increase gradually and was at 660 W/m^2. It was stable at a value of about 150 Kw. This direct change between the values of the solar radiation and the PV power values indicates that this change in PV power is the same as the radiation. That is, the more radiation, the greater the energy value

of the PV array. We also notice from this curve that it is also related to the value of the PV current and the PV voltage because it is the product of the current multiplied by the voltage.

Thus, it is noted that the radiation does not affect significantly the voltage of the PV panels. This stability in the output voltage of the PV panels leads to a stability in the voltage of the electrical grid, as will be subject to further research.

Fig. 16 shows the duty cycle for DC-DC booster convert under ramp changes solar radiation. DC-DC boost convert circuit is used in MPPT technology which is different automatically from the duty cycle to produce the required voltage to produce the maximum power of PV array. The boost convert control adjustment indicator maintains the change so that the output voltage can track the required voltage under the variable solar radiation. The main purpose of the DC-DC booster circuit in this research is to increase the size of the input voltage to the required value by electronic switch. The output voltage of the PV array has a small value that must be synchronized with the electrical network through the DC / AC inverter. Therefore, the DC / DC boost transformer is used to increase the array output voltage and achieve the required voltage level (500V).

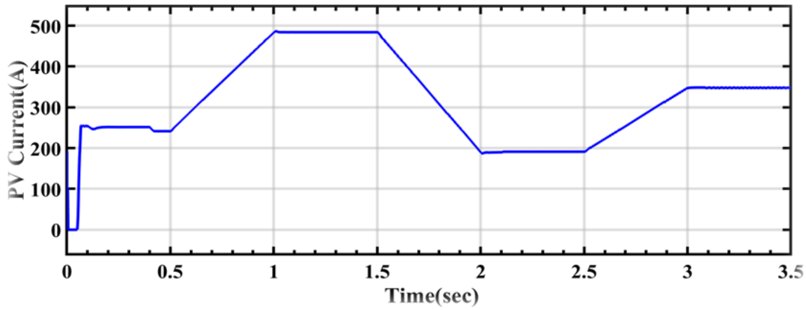

Fig. 14. Performance of PV current under ramp changes solar radiation

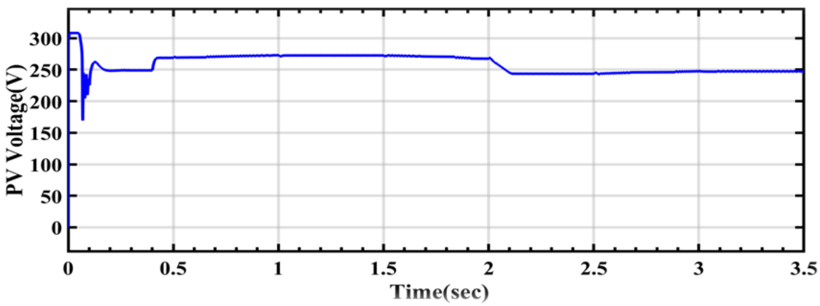

Fig. 15.a Performance of PV voltage under ramp changes solar radiation.

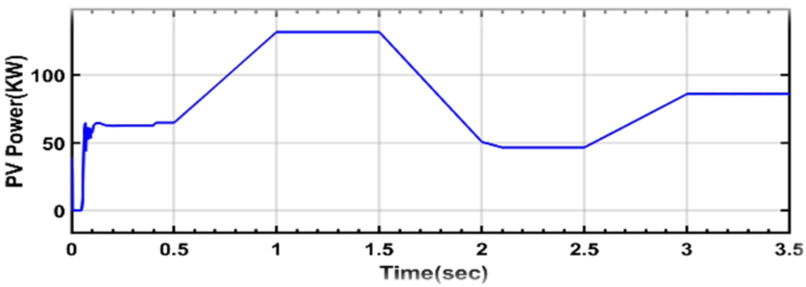

Fig. 15.b Performance of PV power under ramp changes solar radiation.

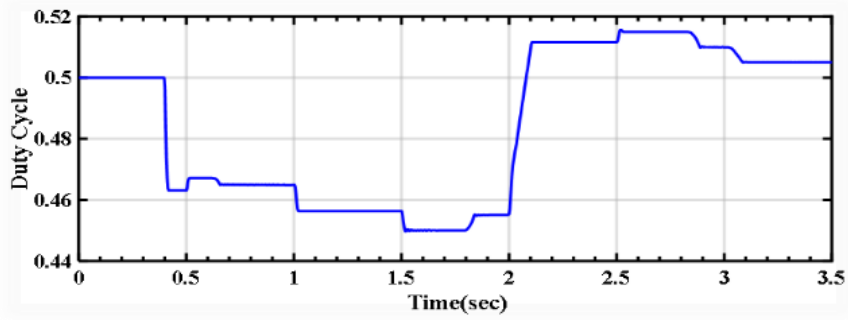

Fig. 16. Performance of duty cycle for boost convert under ramp changes solar radiation.

As shown in the Fig. 17, the performance corresponds to the voltage and current change condition on the MPPT of the IC algorithm according to di/dv = -i/v. This is based on the duty cycle DC-DC boost convert to produce the required voltage to produce the maximum power of PV array. This relationship is related to the IC that achieves the maximum power from the PV system. This change in voltage and current performance on the MPPT of the IC algorithm is the same as the change in solar radiation performance.

The main function of the circuit diode is to protect it from the reverse current. The value of what passes to the diode in the circuit through the circuit is very small, but it has the same change in value of the PV output current from the solar array as it is shown in Fig. 18.

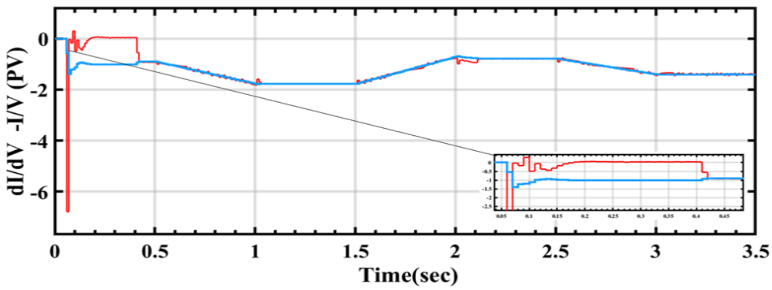

Fig. 17. Condition of voltage and current change on MPPT for IC algorithm.

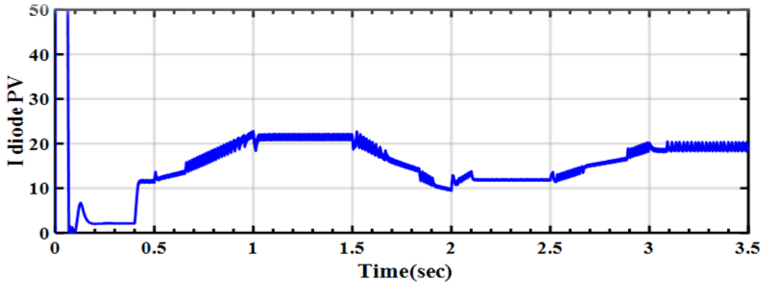

Fig. 18. Performance of PV diode current under ramp changes solar radiation.

The PV voltage generated by the PV array is connected to a boost converter to raise it from 280 V to 500 V. In order to maintain the voltage stability, a dc link is connected at 500V as shown in Fig. 19.

In Fig. 20, the performance of modulation index shows the control value of the three phase AC/DC inverter. The AC/DC inverter depends on the two reliable control methods, (i.e. PI controller to maintain the required grid voltage). The AC/DC inverter receives 500 volts from dc link. The purpose is to take advantage of the power generated by the photovoltaic cells and their ease of connection to the electrical grid. The AC output voltage of the inverter is 260 volts and then raised to 11 kilovolts using step up transformer to connect to the grid. Also, this voltage must be maintained stable throughout periods and not affected by solar radiation.

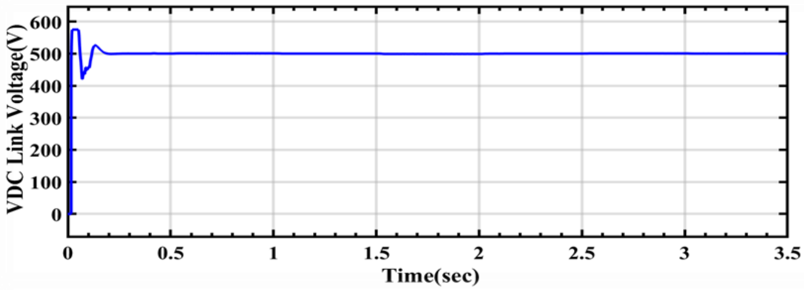

Fig. 19. Performance of DC link voltage.

Fig. 21 shows the I_d & I_{dref} changes the same value of the radiation change and I_q equal to zero, and this makes the control process depend on one variable, which is Id. I_d & I_q are the currents that depend on the process of converting from a,b and c phases to d and q axes, through which the inverter is easily controlled. The reason for relying on d & I_q is that they are not dependent on each other

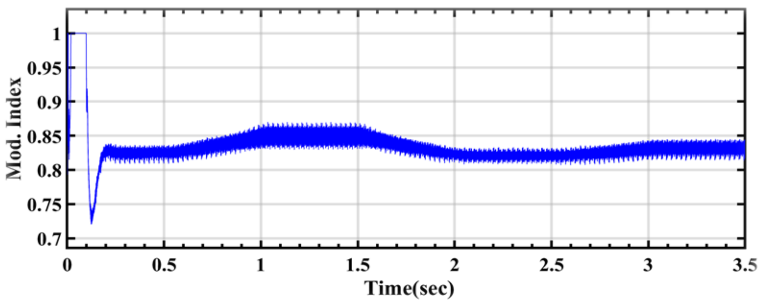

Fig. 20. Performance of control value of modulation index for AC/DC inverter.

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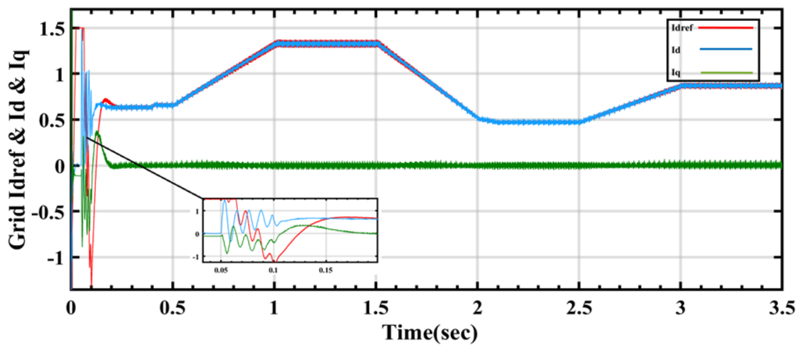

Fig. 21. Performance of Id & Iq are the currents e under ramp changes solar radiation.

Fig. 22 shows a change in the grid current under variable solar radiation. Initially, we notice fluctuating results, which is normal at the beginning of the process, and then begins to stabilize at a time of 0.5 seconds. Then it gradually increases, gradually decreases and settles for 2 to 2.5 seconds. It is noted that the current values change with the change of radiation, that is, when the radiation increases, the current increases and when the radiation decreases, the grid current value decreases.

The starting of the grid voltage is stable quickly as shown in Fig. 23. Thus, it is noted that the radiation does not significantly affect the grid voltage of the electrical grid. This voltage stabilization links the PV system to the uniform electrical grid.

Fig. 24 shows the performance of grid power initially at radiation of 330 W/m^2 and settled all the time from 0 to 0.5 seconds and it was 65 Kw and then began to increase gradually and was at 660 W/m^2 it was stable at a value of about 150 Kw. This direct change between the values of the solar radiation changes in grid power. We also notice from this curve that it is also related to the value of the grid current and the grid voltage because it is the product of the current multiplied by the voltage.

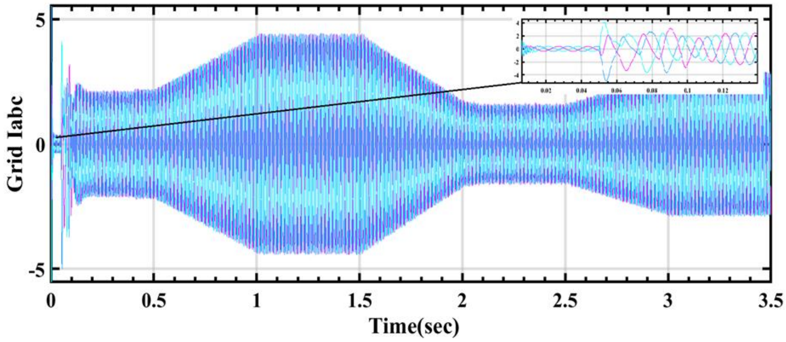

Fig. 22. Performance of grid current under ramp changes solar radiation.

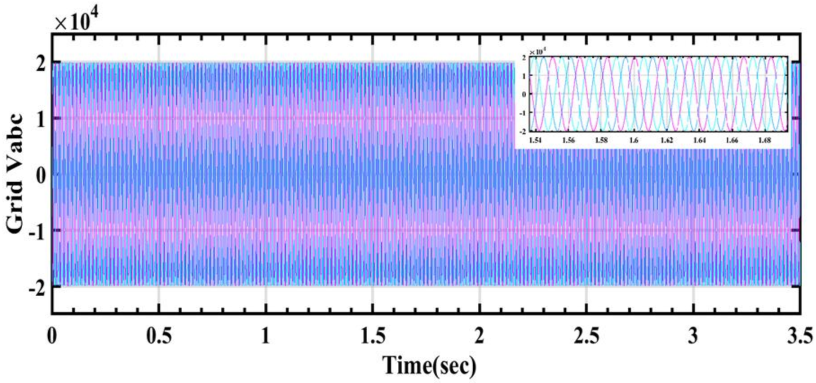

Fig. 23. Performance of grid voltage under ramp changes solar radiation.

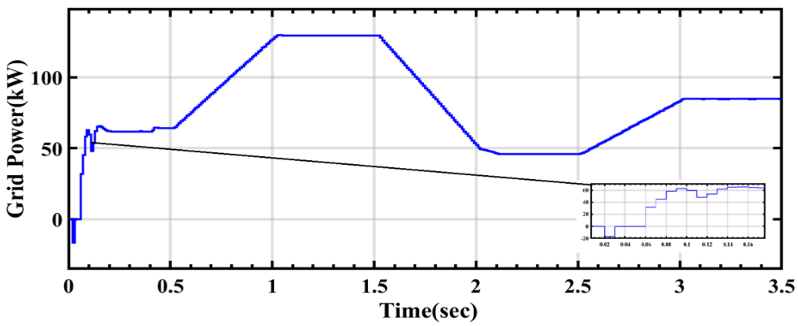

Fig. 24. Performance of grid power under ramp changes solar radiation.

4.2 Step changes solar radiation profile

The data and description of the MATLAB simulation system are presented in Table 2. Fig. 25 shows the value of step changing solar radiation profile, and that was at the beginning of 330 w/m2 settled at a time from 0 to 1 sec. Then it increased until it reached 660w/m^2 at a time from 1 to 2 sec and then it descended to 535 w/m^2 in time 2 to 3 sec. This change in radiation values had more important results and effects on the current, voltage, and energy coming from the grid's solar power station as shown in the next three figures.

Fig. 26 shows the change of PV current time per second through the existing step changes solar radiation, which shows the accuracy of the MATLAB simulation system. At the beginning, we notice fluctuation of the results, this is normal at the beginning of operation, then it starts to stabilize at a time of 1 seconds at 250 A. Then it increased to 490A and then decreased to 395A. We note that the current values change with the change of radiation, that is, when the radiation increases, the current increases and when the radiation decreases, the present value decreases and also when the radiation is stable, there is stability in the current leaving the PV panels.

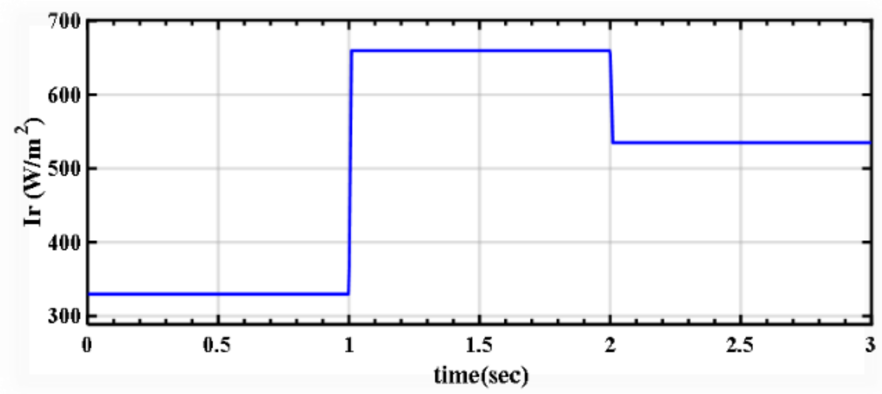

Fig. 25. Step changes solar radiation profile

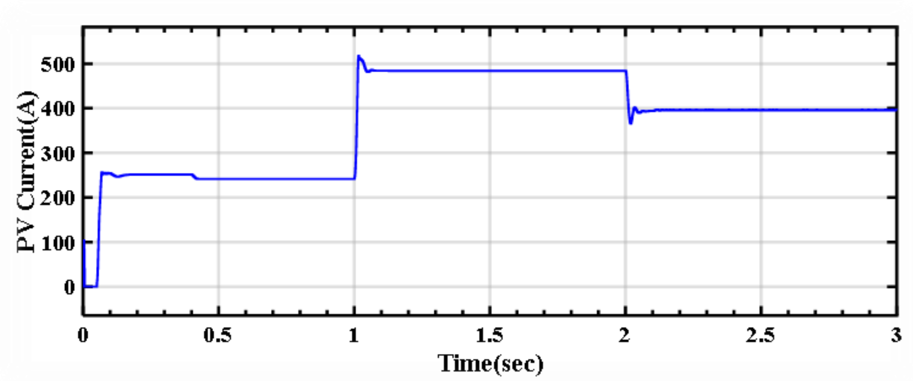

Fig. 26. Performance of PV current under step changes solar radiation.

Fig. 27 shown the Performance of PV current under step changes solar radiation. The PV voltage starting is unstable by a small percentage and changes relatively small in the beginning, but it quickly settles at 280 volts.

Fig. 28 shows the performance of the PV array ability to change during step solar radiation. This direct change between the values of step changes solar radiation and the PV power values indicates that this change in PV power is the same as the radiation. That is, the more radiation, the greater the energy value of the PV array. It is also noted from this curve that it is also related to the value of the PV current and the PV voltage because it is the product of the current multiplied by the voltage.

Fig. 29 shows a change in the grid current under step variable solar radiation. Initially, we notice fluctuating results, which is normal at the beginning of the process, and then begins to stabilize at a time of 0.5 seconds. Then it gradually increases, gradually decreases and settles for 1 to 2 seconds. It is noted that the current values change in response to the change of radiation, that is, when the radiation increases, the current increases and when the radiation decreases, the grid current value decreases

Fig. 30 shows the Performance of grid power under step changes solar radiation. This direct change between the values of the solar radiation change in grid power. We also notice from this curve that it is also related to the value of the grid current and the grid voltage because it is the product of the current multiplied by the voltage.

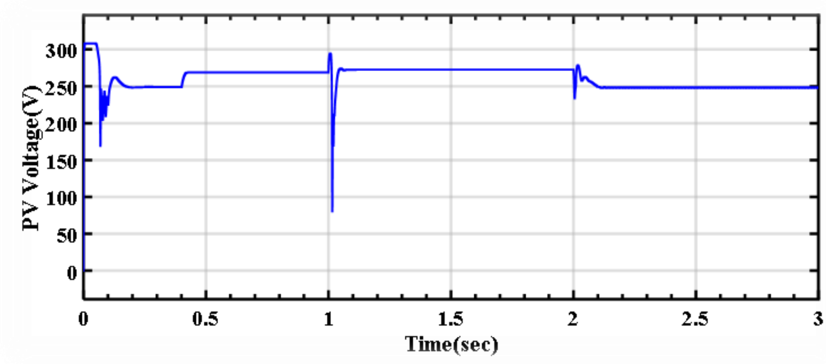

Fig. 27. Performance of PV voltage under step changes solar radiation.

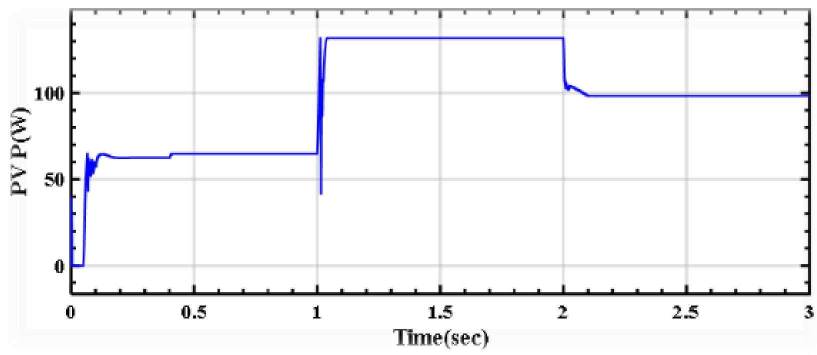

Fig. 28. Performance of PV power under step changes solar radiation.

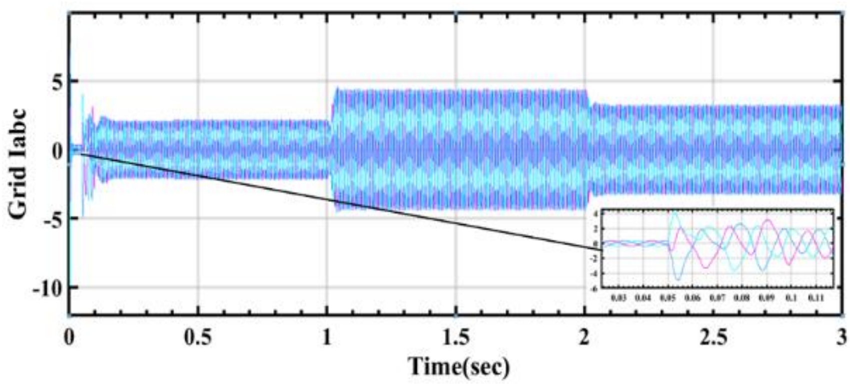

Fig. 29. Performance of grid current under step changes solar radiation.

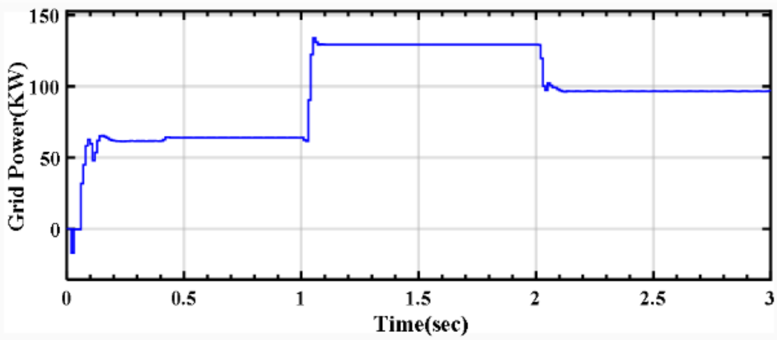

Fig. 30. Performance of grid power under step changes solar radiation.

5. Conclusions

This paper introduces experimental setup and provides a complete simulation in MATLAB / SIMULINK environment for grid-connected PV system. The MPPT technology based on the IC algorithm is applied to different environmental conditions in the change in sunlight. The proposed control system enables optimum solar radiation tracking required in order to maximize the output energy from the PV system. The results of the power, current, and voltage output from the solar system are displayed. The power, current, and voltage attached to the electrical grid were also shown. The results show the accuracy of the proposed system in the experimental and theoretical middle school. In addition, based on the results, all the previous curves indicate a good compatibility in the overall shape of tracking variable solar radiation between experimental results and simulation results.

Conflict of Interest

The author declares no conflict of interest.

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