
# Design (P and O) for standalone PV system based on iraqi irradiance

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**ABSTRACT**

Solar energy is one of the most important sources of renewable energy, and it is noted that due to future studies and programs that are presented in the production of electricity, its importance will increase, so it is a natural source in addition to providing economic consumption. . . A friend of the environment. Cost and reduce reliance on generators that rely on fossil fuels, oil, coal and natural gas to operate. It therefore reduces pollution from fuel combustion and greenhouse gas emissions such as waste emissions, including carbon dioxide.

Through this research, the levels of solar radiation falling in Iraq will be studied at stations spread in the governorates (Baghdad, Wasit, Basra and Muthanna) and a design proposal will be proposed to take advantage of the largest amount of radiation available to feed a solar energy system separated from the national grid with a certain load (kW).

**Keywords:** Solar radiation / renewable energy / inverter / PV / MPPT / P&O / photovoltaic system ..

**Abbreviations and symbols**

| NO. | Symbol | Meaning |
|---|---|---|
| 1 | **PWM** | Pulse Width Modulation |
| 2 | **MPPT** | Maximum Power Point Tracking |
| 3 | **(P&O)** | Perturb and observe |
| 4 | **MPP** | Maximum Power Point |
| 5 | **PV** | photovoltaic |

## 1 - Introduction

Global economic and environmental concerns have led to an increase in the global demand for electricity and, as a result, an increase in the production of renewable energy and its sources: energy from hydroelectric power plants, wind turbines, and solar energy. As for Iraq, the electricity consumption crisis has worsened at an annual growth rate of 6-7% since 2003, and the increase in electricity consumption is mainly due to the high temperatures that exceeded 50 degrees during the summer heat. And increase the density of housing and population. Iraq's reliance on electricity production has led to excessive combustion of fossil fuels, causing environmental challenges and putting the Ministry of Petroleum under significant pressure to meet demand. In order to maintain the current level of electricity generation from fuel and gasoline, this is not possible. Therefore, Iraq also needs to build power plants that will produce about 70 gigawatts by 2035, most of them from renewable sources, and according to estimates by the Energy Information Administration, the government's

priority should be to address the electricity problem[1][2]. since solar energy was considered one of the most important sources of renewable energies, being environmentally friendly as well as inexhaustible, however, renewable energy systems, especially (photovoltaic) faced two main problems (intermittence and lack of efficiency), as they efficiency less than 17% , when converting sunlight Falling into electrical energy, in addition to the weather conditions that change the generated energy as well" [3][5]

In order to know the characteristics and spatial and temporal distribution of solar radiation , since the solar radiation is affected by many factors, the most important of which are ( the extent of the presence of clouds and atmospheric particles, the difference in the fall angle of the sun's rays, the difference in the distance between the earth and the sun according to the seasons, the difference in the ground reflection coefficient, and the difference in the night and day periods in the different seasons [11]

Therefore, many academics and researchers have conducted research to study temporal variation in different regions of the world [15] .

NASA has published satellite images through which the spatial and temporal variation of the effect of solar radiation on different regions of the Earth's surface has been studied, through which high accuracy is shown when comparing solar radiation rates [12]. It has been observed that there is a difference in the seasonal and daily solar radiation in Nigeria due to the density of clouds that dissipate the radiation, especially during the wet seasons [13]. In Egypt, specifically the city of Helwan, the daily variation in solar radiation was studied due to environmental pollution and clouds [14].

In our research, the available data on the levels of solar radiation in Iraq were relied on for the governorates (Baghdad, Wasit, Basra, and Muthanna), which will be detailed through the tables shown below for the year 2022, and this data will be relied upon later.

**2- Solar Radiation Levels.**

Iraq is located in a northeastern part of the globe, at a line that is latitude (33° north) and longitude (44° east). It is characterized by a climate that differs from one region to another, depending on the geographical location; Where it is moderate in the regions of the northern parts, and semi-tropical in the eastern side, and the southeast, while in the south and southwest, the climate is continental desert,[16]. Table (1) shows the longitude and latitude of the four governorates that contain stations measuring radiation levels.

**Table(1): Shows latitude and longitude in the specified Governorates .**

| NO. | Governorates | latitude | longitude |
|---|---|---|---|
| 1 | Baghdad | 33° 19' 34" N | 044° 25' 16" E |
| 2 | Basra | 044° 25' 16" E | 047° 48' 59" E |
| 3 | Wasit | 32° 30' 18" N | 045° 49' 46" E |
| 4 | Muthanna | 31° 19' 00" N | 045° 17' 00" E |

In Table (2) shows the radiation percentage for each month in the year 2022 within the time of sunshine from 8:00 in the morning until 4:00 in the evening (W / m2) in the approved stations in the mentioned governorates.

It is clear that the radiation levels are high in the mild seasons, and the radiation peak increases in the summer. We also note that the station in Wasit Governorate, specifically in Zurbatiya district, topped all the specified stations with a high radiation rate in the months (May, June, July, August and September), followed by Al-Muthanna Governorate in Al-Khader district. And the province of Basra in the district of Fao and the province of Baghdad in the district of Rashidiya. As can be seen from the radiation level diagrams shown in Figure (1) below:

**Table (2): Monthly radiation percentage for the year 2022 from 8:00 am to 4:00 pm (W / m2) at the approved stations in the mentioned governorates.**

| NO. | month | Baghdad | Basra | Wasit | Muthanna |
|---|---|---|---|---|---|
| 1 | January | 281.21 | 333.95 | 292.11 | 416.12 |
| 2 | February | 350.32 | 236.98 | 391.86 | 447.11 |
| 3 | March | 493.81 | 553.96 | 522.98 | 641.03 |
| 4 | April | 524.82 | 553.75 | 525.88 | 743.94 |
| 5 | May | 603.85 | 635.89 | 715.09 | 867.08 |
| 6 | June | 751.39 | 802.28 | 1211.47 | 901.21 |
| 7 | July | 744.71 | 792.24 | 1601.27 | 889.89 |
| 8 | August | 676.95 | 830.98 | 1407.89 | 892.19 |
| 9 | September | 581.87 | 629.13 | 1298.97 | 738.04 |
| 10 | October | 474.92 | 486.27 | 523.18 | 572.02 |
| 11 | November | 314.93 | 326.95 | 347.09 | 453.21 |
| 12 | December | 263.01 | 281.04 | 255.83 | 366.97 |

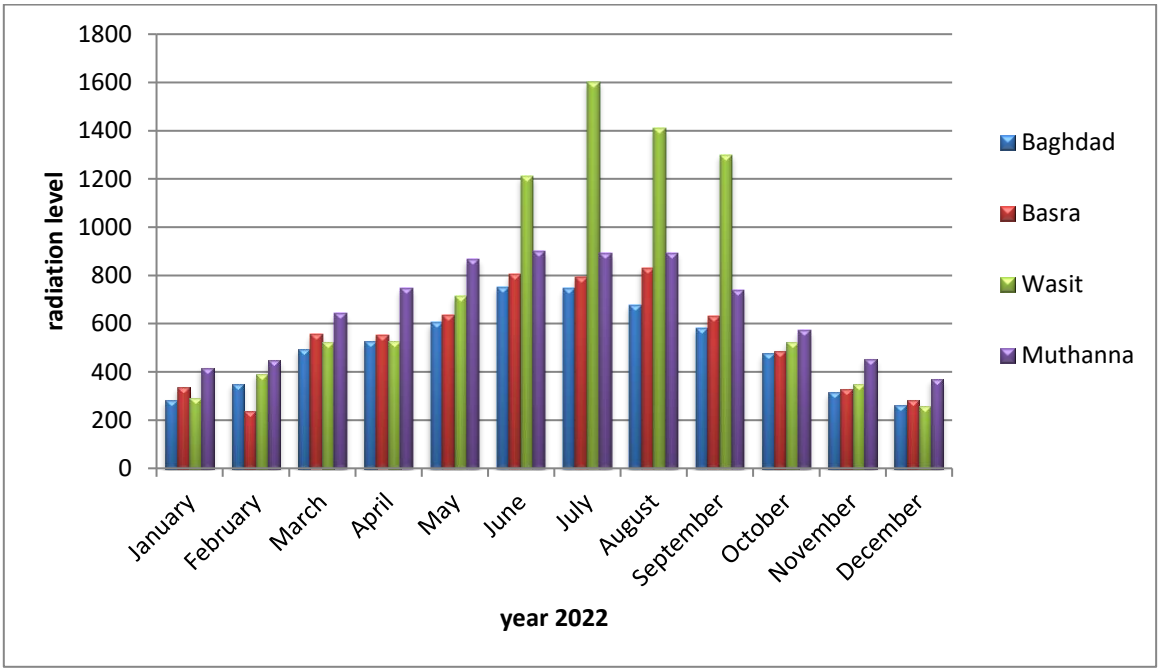


**Figure (1) Radiation level charts.**

**Table (3) The average solar radiation in Iraq**

| NO. | month | Average Solar Irradiance |
|---|---|---|
| 1 | January | 330.8475 |
| 2 | February | 356.5675 |
| 3 | March | 552.945 |
| 4 | April | 587.0975 |
| 5 | May | 705.4775 |
| 6 | June | 916.5875 |
| 7 | July | 1007.028 |
| 8 | August | 952.0025 |
| 9 | September | 812.0025 |
| 10 | October | 514.0975 |
| 11 | November | 360.545 |
| 12 | December | 291.7125 |

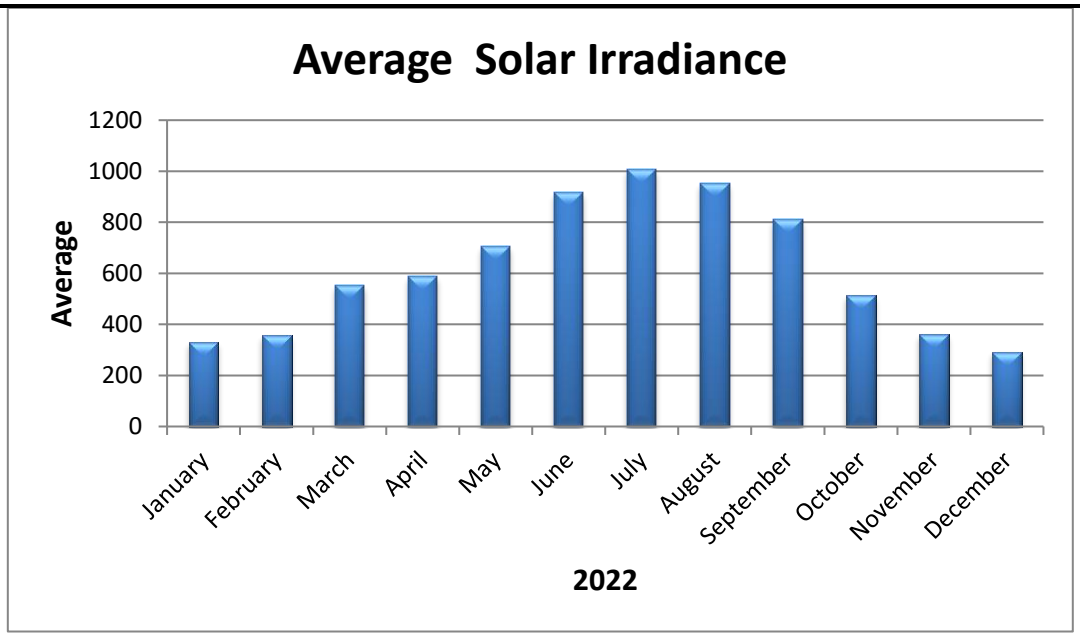


**Figure (2) Average Solar Irradiance level charts.**

Table No. (3) shows the radiation mean for each month in Iraq for the year 2022 during the time of sunshine from 8:00 in the morning until 4:00 in the evening (w / m 2), and as evidenced by the radiation level charts shown in Figure (2), it can be seen The radiation levels in the summer season are high compared to the rest of the seasons. As for the rest of the seasons, they are uneven from time to time. They reach a decrease, especially in the winter season, due to climate changes, the appearance of clouds, rain, the rise of dust, and many climatic factors.

After we got acquainted with the above and all of the above regarding solar radiation, it became necessary to exploit the data to benefit from energy generation from its alternative sources and to follow up and improve the maximum power point (MPPT). ) proposed a perturb and observe (P&O) design.

In order to know the standard specifications of a photovoltaic system, it is necessary to address the challenges facing designers and implementers for the purpose of achieving mutual success between the designer companies and the beneficiaries.

## 3- The challenges

In the independent photovoltaic systems, there are many challenges facing governments and institutions, summarized as follows:

1. The characteristics of photovoltaic cells represented by (I-V ) or (V-P) are non-linear and affected by temperature changes and solar radiation.
2. Solar panels for photovoltaic units are expensive, as well as energy storage batteries, which are the most expensive components.
3. The absence of protection systems against overcharging, which leads to a short life of the batteries and damage to parts of the system.
4. Most of the solar panels are fixed (non-moving), which leads to insufficient amount of falling light, which leads to a decrease in efficiency. .
5. 5 - The small space for installing cells on which solar energy panels can be installed to produce electricity, as in garages designated for parking cars, as well as rooftops of houses.
6. The lack of awareness programs in the use of clean and environmentally friendly energy
7. The number of independent houses is small when compared to other buildings, towers and factories.
8. Climate fluctuations from one region to another, which requires the design of photovoltaic systems according to the geographical area and according to climate variables.

**4- Standard specifications for the photovoltaic system**

When designing or installing energy (photovoltaic) systems , As shown in Figure (3), it is necessary to comply with the standard standards that relate to the following :

1. Installation requirements for photovoltaic (PV) panels.
2. Connecting loads with independent power systems through communication requirements through transformers.
3. Electrical installations and connections - for battery systems with power conversion equipment
4. Structural design of buildings and light direction.
5. Safety and security conditions must be met, such as protection systems represented in protecting the system, loads, buildings, lightning rods and the rest of the weather effects.

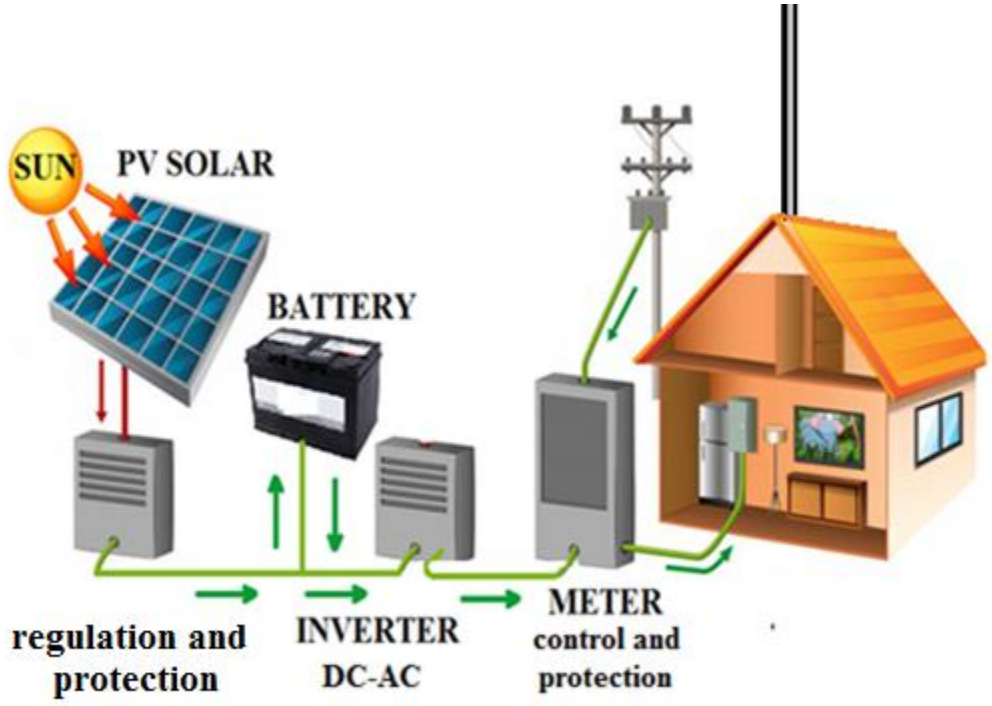


**Figure ( 3) Photovoltaic energy system isolated from the grid .**

**5- The proposed photovoltaic system .**

**Specifications and installation of the proposed photovoltaic system**

**A- Solar panel specifications** :- the main component and work to convert light and thermal energy into electrical energy. You must know the following specifications:

1. **Vmp**: the greatest voltage when the photovoltaic panel is connected to the load. (18 $V_{MP}$) & (36 $V_{MP}$) .
2. **Vo.c** : Maximum voltage when the breadboard is off grid
3. **Imax**: The maximum current of the plate when the load is connected to the plate.
4. **I s.c** : the greatest current when the board is offline.

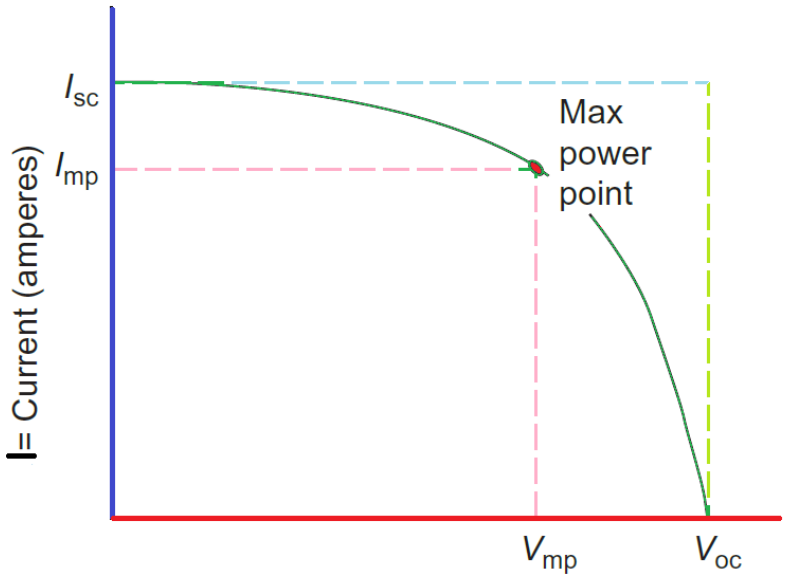


Figure ( 4 ) Fill Factor .

**B- Charging management and battery protection systems** :

It works to protect the battery by regulating the electrical energy coming from the solar panels and responding to fluctuations in conditions and disturbances in the amount of falling solar radiation and the difference in voltage, current and temperatures.

**Charging and regulation techniques for photovoltaic systems:**

There are two charging and regulating technologies available for photovoltaic systems designed according to a working mechanism that differs between them [17] , and they are:

**1- Regulator type (PWM) :-**

- It sends modified pulses of current to the batteries, and those pulses are compatible with the size of the battery current.
- It is preferable to use it in simple photovoltaic system applications because of its low economic cost and simplicity.
- Among its defects is that it is restricted to the value of the effort with which it was made, and thus it is not possible to fully exploit the maximum energy generated.

**2- Regulator type (MPPT):-**

- Most common in photovoltaic applications.
- Designed to regulate the current and voltage generated by the solar panels.

Excellent performance and high efficiency up to 98%.

- Preserves the generated energy by raising the current value and decreasing the voltage.
- Exploiting the maximum generated energy completely. Which makes it a model regulator that fits the atmosphere and conditions suitable for installing photovoltaic energy systems, as in Iraq.
- Designed to reduce energy losses, as well as to reduce economic losses because it does not need a lot of wires and electrical connections.

**C – Batteries** : their mission is to save energy at the time of generation and benefit from it at the time of absence of the sun. The preferred type is to choose a lithium iron phosphate battery pack (12 volts) (200 ampere) used for off-grid solar systems, as it has many advantages, including:

1. A long continuous service life of up to (10 years) and a system operation that lasts up to (5 days) without the need to recharge it.
2. Stable performance, higher energy density, and works with many different applications.

3. There is no pollution and it does not contain heavy metal components, so its weight is somewhat light.
4. Its outer cover works to protect the internal components, being made of rare metals, so it is considered to have a high level of safety and does not heat up or burn.
5. Easy to connect and install safely anywhere..

There are also other types of batteries used in solar and wind energy applications, such as: ((12 volts - 100 amps) and (12 volts - 300 amps)

**D – Inverter :** The inverter is intended for off-grid applications, which are mostly domestic, as it can deal with energy-saving home appliances and has many advantages, including:

1. It has high durability and ability to work in the most difficult conditions and has a long service life of up to 10 years at least.
2. The size of the physical inverter and the size of the electrical energy to match the size of the energy received from the battery.
3. Giving a pure and modified sine wave to ensure it works properly.
4. High efficiency up to 97% .

From the above, we can connect the components of the photovoltaic system shown in Figure (5) as follows:

1. Choosing suitable solar panels with a capacity of 280 watts (6 * 280 = 1680), these panels are available in the market, and they are connected in two groups (each group contains three consecutive panels), then we connect the two groups in parallel.
2. batteries preferably type (200 AH - 24 volts) connected in parallel to get ( 3*200= 600 AH - 24 volts(
3. Regulator (MPPT) Appropriate Type (Maximum Voltage = 24V - 60A - 150V - 1700W(
4. inverter type (24V DC - input) - (220V - 60Hz - output.(
5. It is necessary to have an AC and AC circuit breaker, and to take into account the size of the wires, preferably with a diameter of not less than (40 mm2).

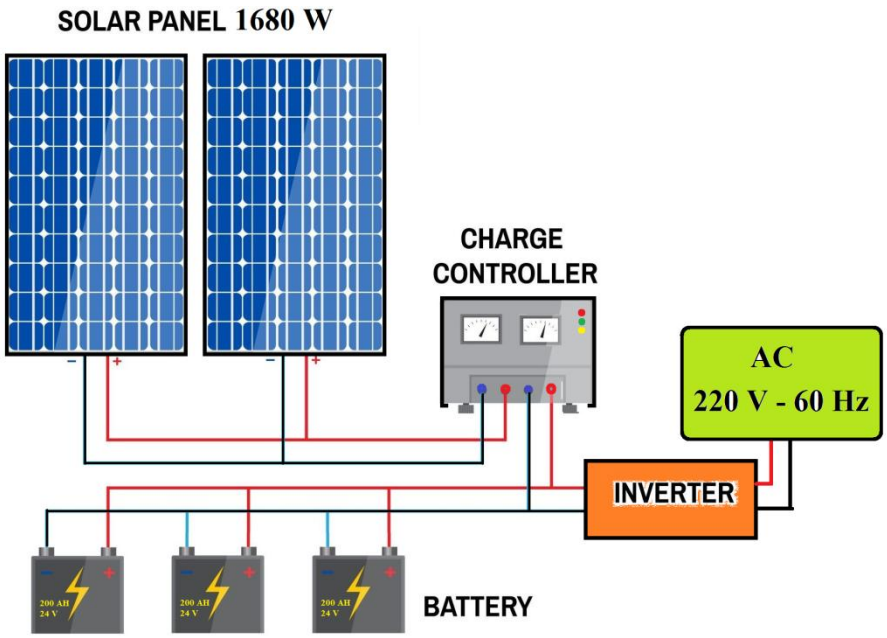


**Figure ( 5 ) Connect the components of the photovoltaic system**

The regulator (MPPT) is an important component of the photovoltaic energy system, due to its nature of work with many variables such as radiation variables and loads variables.

-Figure (6) shows the relationship between ( the voltage curve and the current curve ) under the influence of temperatures, where we notice that the curves begin to change with the change of the falling solar radiation, and they also change with the change of the temperatures . In Figure (7) (8) we can see that the capacity changes with (MPP) and voltage. for solar panels.

-When the event that the panels are connected directly with (PWM) or connected to the battery, then we will generate equal voltage between (solar panel and batteries) or between (solar panel and PWM), and this matter generates losses due to the dissipation of maximum energy and the lack of use of it, and it is Its efficiency is (70%) or less, depending on climate conditions and generation.

Therefore, it is necessary to design an algorithm (MPPT) that works to extract the maximum possible energy by taking into account the flexible nature of the voltage generated from the panels and converting the surplus into a current that can be used as a whole. The efficiency of the system (98%) is that which contains the (MPPT) algorithm.

Here we point out that (MPPT) can be implemented and applied as part of the (DC-DC converter) system or in the (microcontroller system), and in all cases the input voltage is sensitive to obtain the maximum effort .

The ( MPPT) algorithm used here is the direct algorithm, specifically the ( Perturb and Observe) (P&O) algorithm - this algorithm senses the momentary variables generated by the system in order to reach the maximum point of the ability to regulate those variables by increasing or decreasing in the voltage and in proportion to those variables .

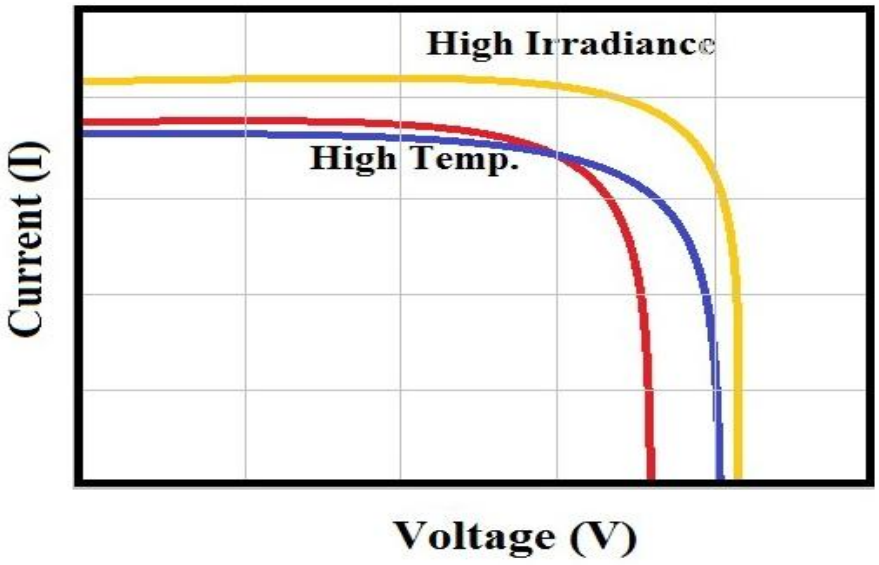


**Figure (6) Scheme (voltage curve and current curve) and temperature effect**

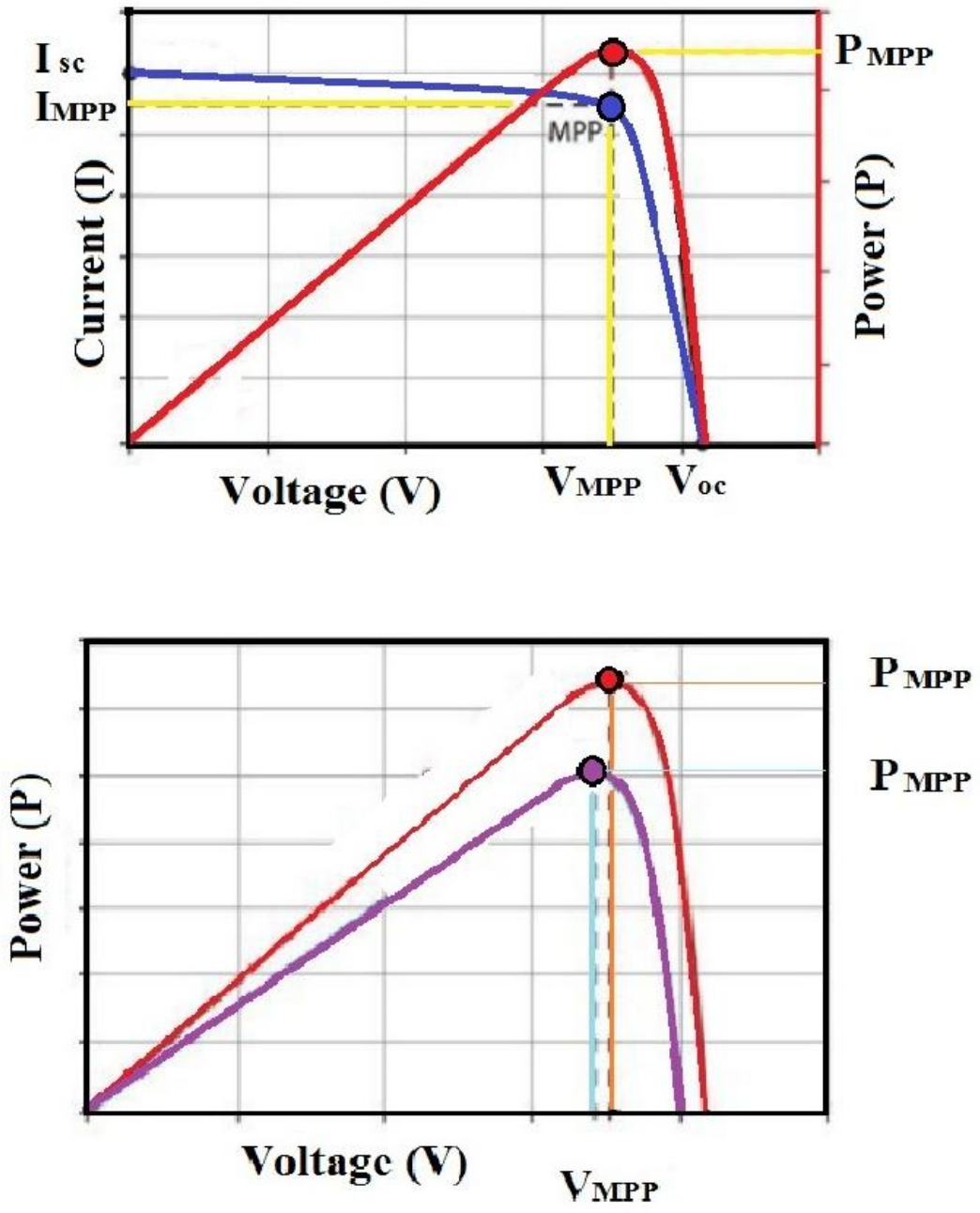


**Figure ( 6 & 7 ) charts showing the impact of (MPP) due to changing climatic conditions.**

**Discussion and conclusions:**

From the foregoing, in order to meet all ideal requirements it is the responsibility of engineers and designers to evaluate and study the environmental conditions of specific areas, and then design and provide a system and algorithms that suit those conditions and variables.. It turns out that there are basic types of ( MPPT) algorithms, which can be summarized as follows:

1. The perturbation monitoring algorithm (P & O) called (direct algorithms): It is easy in terms of implementation, so we note that it has been used repeatedly, and because it depends on adjusting the voltage towards (MPP), and therefore it is sensitive to the instantaneous voltage changes with the influence of conditions Atmospheric and radiation changes.

2. Constant voltage algorithm : This method relies on constant voltage by setting the current of the solar panels to = zero and measuring ($V_{OC}$), then adjusting the operating voltage to 75% of that value in a constant manner. Although this method is considered suitable to some extent, it is not suitable for the climate of Iraq, as it leads to wasting a lot of energy, especially in the summer, and it is not compatible with (MPP) , called (indirect. (
3. Behavior increasing algorithm: It is based on the (dV) / (dI) increasing behavior, it can track light faster than (P&O), but it can be fooled by different weather conditions.
4. - MPPT changes with the change of solar radiation and climatic variables.
5. It is important that the photovoltaic system be installed near the loads to reduce electrical connections and wires, and Reduce (physical system parts) and losses in electrical power as well.

Recommendations:

From the above, we note some recommendations in order to obtain high performance of photovoltaic systems, which we summarize as follows:

1- The use of system components with high reliability and from known origins to avoid damage and damage that results from poor systems.
2- The use of (MPPT) is within the regulator or within (DC-DC converter).
3- Choose the system specifications according to the available climatic data.
4- It is preferable to use it in remote areas far from the electrical Grid due to its stability and reliability.
5- It is necessary to monitor and study the environmental conditions, climate and radiation levels, and then proceed to develop appropriate designs.
6- Correct use according to the attached catalogs to ensure better performance and longer life.
7- It is preferable to install the system near the loads to get rid of losses: - (material losses represented by increased wires and connections) and (electrical losses as a result of energy dissipation.(
8- After presenting the recommendations, it can be used to develop the system for the better.

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