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# Control Of Single-Phase Grid-Connected Inverters For Voltage Regulation With Non-Linear Loads: A Review

Ashish Sahu[1], Mr. Durgesh Vishwakarma[2]
[1]M.Tech Scholar, EEE department, RadhaRaman Engineering College, Bhopal
[2] Assistant Professor EEE departments, RadhaRaman Engineering College, Bhopal

## Abstract

This work is about the development of renewable energy sources. In this project we are going to present the working simulation model of a solar panel using SIMULINK in MATLAB. The main objective is the combined application of renewable energy concepts and control systems for the qualitative and quantitative improvement of the electricity generated from solar and wind sources. The energy generated from the common sources of solar and wind power is generally at some level. But the integration of solar and wind sources and control systems will certainly be greater in quantity and the use of electronic power converters will make the energy generated more efficient. By synchronizing this generated energy with the smart grid, both the consumer and the producer will benefit from it and be satisfied.

**Keywords:** PV System, Boost converter, Inverter, Filter, Grid synchronization, non-linear loads

## I. INTRODUCTION

Solar energy is generated from sunlight. Solar energy is used in 2 ways: 1) Active solar energy 2) Passive solar energy. Active solar energy is used effectively in activities such as washing clothes and heating the air. Modern technology has provided several ways to use these existing resources. Nowadays, due to the improvement of technology, people are using the maximum power of the rotating solar panel by using a light dependent resistor. Solar energy is only a source of direct current. It is important to have a basic understanding of the operation of the P-N junction diode to know the full working mechanism of the photovoltaic effect.

In ancient times, wind energy was used as a source for sailing boats in the direction of the wind. The generator present in the wind turbine generates an alternating current (AC). Some turbines contain an AC to DC converter. Direct current is converted from alternating current through a rectifier and then back to alternating current through an inverter. Its main function is to synchronize the frequency and phase of the network.

## II.PV SYSTEM

Operation of the photovoltaic panel: Solar panels work by consuming light from the solar photovoltaic cells or batteries, and after that conversion process, produce DC power, which is the energy generated into usable alternating current (AC) (since the usable form of energy is in the form of alternating current) due to the need to be a suitable nominal inverter. Then the alternating current is increased or decreased to get the correct rating. The solar panel's short working mechanism is that the photovoltaic cells are a mixture of n-type silicon and p-type silicon semiconductor material. The P-type semiconductor material is slightly doped, while the n-type semiconductor is a highly doped semiconductor material in which their interaction will be a potential barrier. It generates electricity by causing electrons to be excited across the transition (potential barrier) between the different levels of doped silicone with the help of sunlight. When the solar panel emits sunlight, the photons hit the top surface. Its photons carry the energy generated by the cell. The photons in the bottom p-type semiconductor layer give off their excited

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energy to the electrons. The electrons absorb this energy and prepare to move to the top n-type shell around the potential barrier and be bombarded. Since the flow of electrons is electricity, the activated electrons will flow and energy will be generated.

## III. BOOST CONVERTER

The regulation of the maximum current point, as mentioned in the introduction, is in fact a problem that adapts to the load. To match the input resistance of the panel to the load resistance; if a DC-DC conversion process (using a buck converter) is required (adjust the duty cycle). The efficiency of Buck Conversion has been studied so that it is maximum for a DC-DC conversion process converter, so a buck boost converter and minimal for a booster converter, but how we want to use our system to join the network or for a pumping station system that requires 230V at the end of production, we use a step-up converter [1-5].

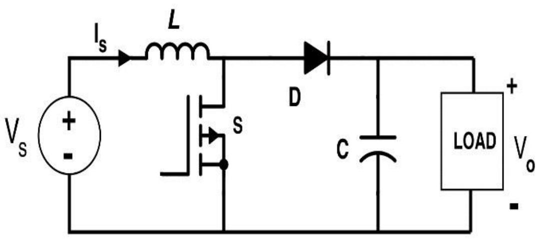


Fig 1: Circuit diagram of a Boost Converter

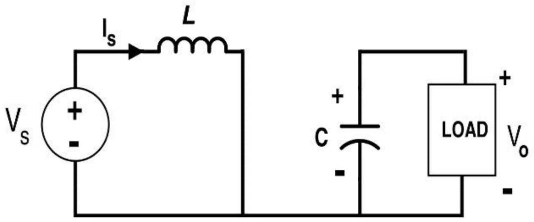


Fig 2: Mode I operation of boost converter (DC – DC)

Boost Converter Process Mode 1: Each time the switch is activated, the inductor is charged and energy is stored through the battery. In this mode, the inductor current increases (exponential speed), so we assume that the inductor charge and discharge is linear for greater precision. The diode prevents current from flowing and therefore the charging current remains static due to the discharge of the capacitor.

Mode II of the Boost Converter Process: Available Type II the button is not connected and therefore a diode shorted. The power collected around the inductor is released by the capacitor's reversed polarity. The charging current remains stable during service.

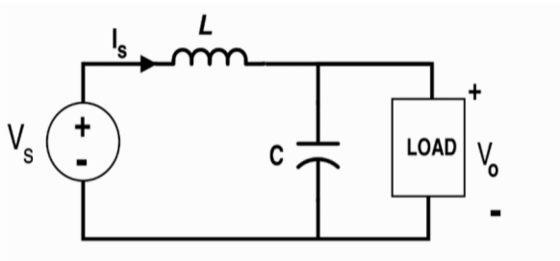


**Fig 3: Mode II operation of Boost Converter**

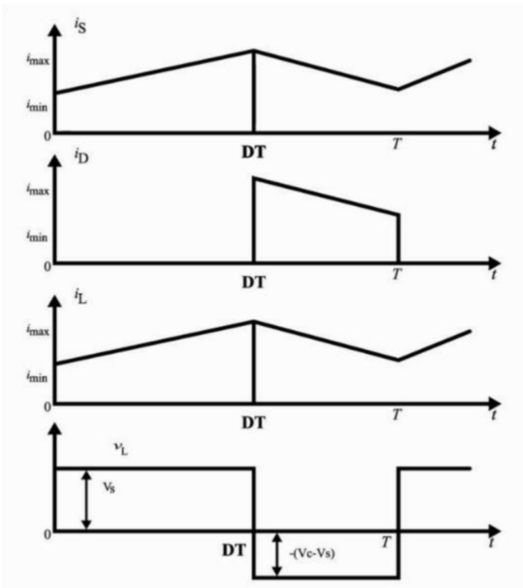


**Fig.4Boost converter waveforms**

## IV. GRID CONNECTED INVERTER

An electronic control circuit or system is an inverter or an inverter that converts direct current (DC) to AC. Input voltage, output voltage and frequency

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voltages, as well as general load capacity, depend on the specific device or circuit model. An electrical network is a network that is interconnected to provide energy to producers' customers. It consists of the following, as shown in Fig: 5. 1) generating stations that supply electrical energy; 2) electrical substations to increase electrical voltage for transmission; or down for distribution; 3) power lines transporting electricity from remote sources to demand centers; 4) distribution lines connecting individual customers; 5) Power plants can be placed

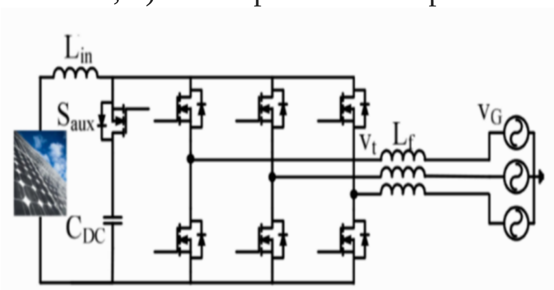


**Fig 5: Block diagram of Grid connected inverter**

This effective and reactive energy that is pumped into the substation is independently managed. Therefore, you are considering this 3 alterna ac output in a 2 dimensional dq structure combined with changing the q axis parameter so that it is zero. Considering that point, the next research step to decide how to disconnect this active power or reactive power is feasible by controlling the output inductor current. Since the current outgoing inductor will operate by controlling the inverter function, the document will discuss acceptable inverter control methods. The converter switches and the output generation is assumed to be lossless. The image above shows the block diagram of the circuit.

**CONTROL MECHANISM OF GRID CONNECTED INVERTER**

A Feedback Management Scheme, also called a Closed Loop Management Scheme, is presented as a monitoring approach that ideally uses a wide open ring system called the forward direction although it maintains 1 or more control loop directions between production and i / p. The reference to a "reaction" is referred to as a small fraction of production that remains "backward" to the source through the portion of the product upon activation of the device. The feedback control methods are designed to achieve and maintain the required performance situation using contrast. This will be achieved by producing a sign of inaccuracy that covers the gap between reference production and participation, or in other words, a "closed loop system" is a complete system.

To provide variable irradiance and variable temperature, we used a closed loop control path, one of the concepts in control systems, so that the two input parameters, irradiance and temperature, could be varied in the Simulink and the respective outputs would be generated [6-8]

**Incremental conductance MPPT Controller used:**

Using incremental conductivity form, MPPT was acquired after

$$(d/dV)(P) = 0 \text{ where } P = V*I$$

$$(d/dV)(V*I) = I + (V*(d/dV)(I)) = 0$$

$$(d/dV)(I) = -I/V$$

DV, dI = Specific components of ripples V and I, measured with a T MPPT skidding moment frame.

I, V = Imply standards of V and I were calculated using a T MPPT slipping moment frame.

Integrated controller minimizes error (d / dV)(I) + I / V)

Regulator output = Duty cycle correction

The electrical network consists of several components. The different components involved in the network can be shown in Figure 6, the shapes of the feeders by replacing them with the correct impedances and naming them as the feeders and the correct three phase loads are designed by the impedances of the original calculate and design taxes. The image above shows the simulation of the electrical network using a subsystem block and other load representations suitable for a network consisting of load.

**(b) Total algorithms for power point monitoring:**

A normal photovoltaic panel is converted into electrical energy between 30% and 40% of the incident sunlight. The MPPT monitoring procedure has been applied to increase the performance of this solar panel. According to the MPPT proposal, the output power of a circuit is the upper limit after this circuit's The venin impedance (source impedance) equals the load impedance. So our problem with measuring MPP comes down to a challenge in matching impedance. In the side power supply, we use a DC DC converter connected through a solar panel, so increase the output voltage for various applications such as motor load. By adjusting the boost converter duty cycle accordingly, we can balance the source impedance with the load impedance.

Different MPPT Methods: -

MPP is tracked with different techniques. There are some of the most commonly used approaches:

1) Perturb and observe (hill climbing method)

2) Incremental Conductance method

3) Fractional short circuit current

4) Fractional open circuit voltage

5) Neural networks

6) Fuzzy logic

This algorithm choosing alters that period difficulty that the procedure takings toward control the MPPT, the asking price of implementation then the comfort of operation.

**Perturb & Observe:**

The simplest technique is Perturb & Observe (P&O). For this we use 1 detector i.e. this voltage detector to detect the voltage of the photovoltaic array and the implementation cost is less because the implementation is easier. At the moment, the difficulty of this procedure is much less, so when you get close to MPPT it doesn't end in MPPT after that, it keeps interrupting both ways. While this is happening, the process is close to the MPPT and we can establish an acceptable failure regulation to make use of waiting work, which will ultimately increase the difficulty of the procedure [12-15]. However, the approach does not take into account the rapid change in the irradiation speed (due to what the maximum PowerPoint tracking settings are) and considers it a change of the maximum PowerPoint due to the interruption and ultimately measures this power. Incorrect maximum. Point. Therefore, we use a technique where the conductivity is gradually increased to avoid this problem.

**Incremental Conductance method:**

Gradual conductivity process uses both current as well as voltage detectors for measure electrical energy and flow power from photovoltaic collection output.

At MPP, the photovoltaic curve is 0.

(D/dV)(P) MPP = (d/dV)(VI)

I +VdI/dVMPP = 0

(d/dV)(I) MPP = - (1/(V/I))

The left side is the instantaneous conduction of the solar panel. If this instantaneous conduction is equal to the PV conduction before the maximum power point was reached. We feel this current and voltage at the same time. Eliminates errors due to variation during radiation exposure [9-11]. However, this is both the difficulty and the cost of completion. As protocol collection decreases, complexity and development costs continue to increase while adapting to a very complex schedule. Therefore, the most commonly used protocols are Perturb and Observe and the Step-up Conductivity process. We selected the Perturb & Observe protocol for our analysis between the two for its simplicity of implementation.

**Fractional SCC:**

The close linear relationship between VMPP and VOC of this photovoltaic array has resulted in the fractional VOC process at different rates of temperature and radiation exposure.

VMPP = k1 Voc

Here k1 emphasizes relentless proportionality. Because k1 depends on this characteristic for the photovoltaic collection used, they are typically pre-measured to experimentally determine VMPP and VOC at different irradiation and temperature rates that are the same photovoltaic collection. The variable k1 was confirmed to be between 0.71 and 0.78. After k1 has been determined, by briefly shutting down the power converter, VMPP can be calculated with periodically measured VOC. However, it has some drawbacks, including temporary power loss.

**Fractional open circuit voltage:**

The existing benefits of Tiny ISC actually are that the IMPP remains roughly proportional to this ISC in the PV range under various atmospheric conditions.

IMPP = K2 Isc

Here K2 remains proportionally stable. K2 should be calculated taking into account the photovoltaic capture that is used, as for the small VOC method. The constant K2 is generally found to be 0.78 - 0.92. During service, ISC measurement is difficult. Normally add an additional twist to the power transformer for regular shortening of the PV range, therefore the ISC will measure using a current device.

**Fuzzy logic:**

Over the past decade, control microcontrollers have popularized MPPT with the use of fuzzy logic control. Ambiguous logic devices have some advantages in dealing with fuzzy output; they lack an accurate statistical pattern and non-linear processing.

**Neural Network:**

Neural networks are another MPPT application method that is also suitable for integrated circuits. Normally neural grids have 3 levels: i / p, hidden and o / p. In each layer, these total connections differ and depend on the customer. The i / p variables can include photovoltaic factors such as VOC and ISC, information such as or any combination of radiation and temperature;

**Characteristics of different MPPT techniques listed in the table1**

| MPPT Technique | Convergence speed | Implementation Complexity | Periodic Tuning | Sensed Parameters |
|---|---|---|---|---|
| Perturb & Observe | Varies | Low | No | Voltage |
| Incremental Conductance | Varies | Medium m | No | Voltage, Current |
| Fractional Voc | Medium | Low | Yes | Voltage |
| Fractional Vsc | Medium | Medium | Yes | Current |
| Fuzzy logic control | Fast | High | Yes | Varies |
| Neural Network | Fast | High | Yes | Varies |

**Perturb & Observe Algorithm:**

This Perturb & Observe algorithm observes a small increase in the operating energy of the disturbed photovoltaic panels, so this resulting energy change also + ve, so these are directed this way from MPP and those who continue to disturb because of this usual way. In case ΔP - ve, we leave this path of maximum identification of current points if the given disturbance needs to be changed [16-25].

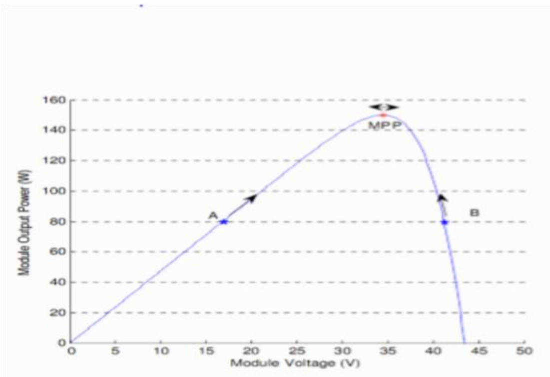


**Fig 6: PV Curve with MPPT point conditions**

Solar panel attributes show MPP and working points A and B shown in figure 6.

This shows the graph of the output energy of the battery versus the partial voltage at a given irradiance for a solar table. The point marked as MPP is the maximum power point, which is the maximum theoretical performance of the PV table. Taking the two action stages A and B 2. As illustrated in the figure above, point A is on the left side of the MPP. So we can switch to the MPP by supplying the voltage with a positive Trading Point B, while the MPPs are on the right side. After giving a + ve disturbance, the value of half p is negative, therefore it is necessary to change the direction of the disturbance to reach MPP. Below is the flow chart of the P&O algorithm shown in Figure 7.

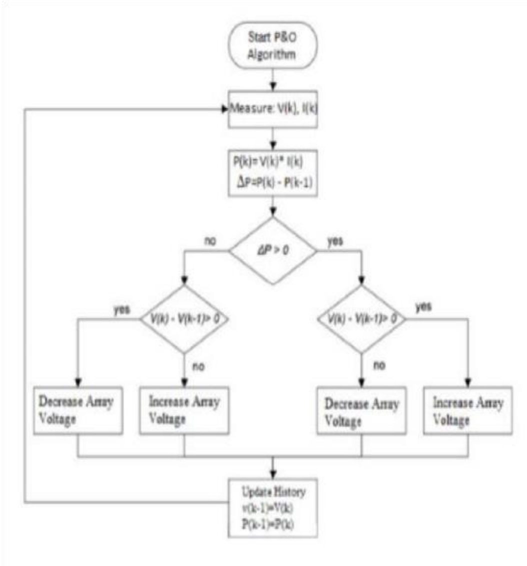


**Fig 7. Flowchart of Perturb & Observe algorithm**

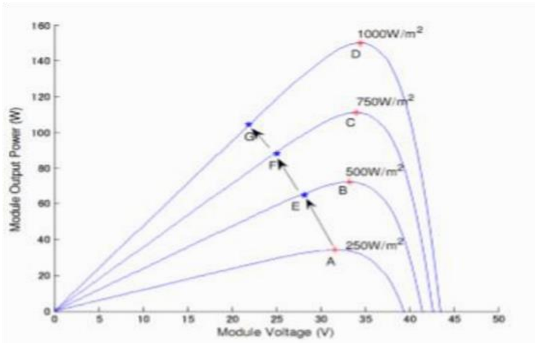


**Fig 8: PV Curves for different irradiations**

During the case where the solar radiation changes rapidly, the MPP also moves on the right side of the curve. The algorithm takes it as a change due to the disturbance and adjusts the path of the disturbance in the next iteration and thus leaves this point of maximum power in the same way as exposed in the previous graph shown in the Figure 9. However, we only use the detector in this algorithm, that there is voltage on the indicator, to sense the voltage of the solar panel, so the implementation cost will not be as effective as simpler to run. The complexity of the moment in this process is very negative, so it does not end in the MPPT after approaching MPPT and proceeds to break down in 2 ways. When this occurs, the algorithm has moved closer to MPPT and we can establish an acceptable error control or use a lag process that will eventually increase the time complexity of the algorithm.

**Fig 9. Irradiance considered**

The figure above shows the irradiation that has been taken into account for this project. It was a closed loop program that repeated around the same values from 1000 to 400 n times since it was written in that block. It was a 3-minute simulation in which the irradiance drops from 1000 to 400 W / m * m. Then it returns to its normal value and remains stable to the end, as shown in Figure 9.

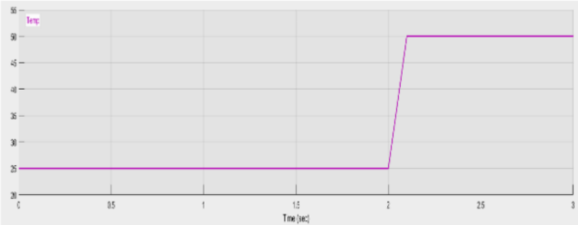

**Fig 10. Temperature considered**

The figure describes the temperature range and temperature pattern we considered for the third project. The range of values is from 20 to 55 degrees Celsius. Initially it was kept in a steady state at 20 degrees and then rose to 50 degrees Celsius. This was also a closed loop program that was repeated n number of times. This was a closed loop program for 3 minutes, as shown in Figure 10.

**Reference of PV panel ratings considered as base values updated in table 2:**

| | |
|---|---|
| Number of Cells Ns | 850 |
| Standard Light Intensity S0 | 1000 w/m$^2$ |
| Ref. Temperature | 25°C |
| Series Resistance | 0.008 Ohm |
| Shunt Resistance | 1000 Ohm |
| Short Circuit Current | 8 A |
| Saturation Current | 2.16e-8 A |
| Band Energy Eg | 1.12 |
| Ideality Factor A | 1.2 |
| Temperature Coefficient Ct | 0.0024 |
| Coefficient Ks | 0 |
| Maximum available power | 1.6 kW |

## V.CONCLUSION:

We study the operation of a grid-connected solar power inverter. Two main control issues have been investigated; the control is the output of the photovoltaic panel so that the use of the closed loop path constitutes the control systems. Based on the simulation, then if the inputs in that solar panel were made constant using the MPPT technique, the second type of control we could do is the inverter output power control. By using these two control techniques, therefore, the output power could be kept constant and could meet the load demand while maintaining the required power quality, and reliability in renewable energy sources could be improved.

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