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Original Research Article

A COMPARATIVE ANALYSIS OF SOLAR BASED MPPT SYSTEMS WITH GRID CONNECTED MODELLING

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Abstract: Energy, especially alternative source of energy is vital for the development of a country. In future, the world anticipates developing more of its solar resource potential as an alternative energy source to overcome the persistent shortages and unreliability of power supply. In order to maximize the power output the system components of the photovoltaic system should be optimized. For the optimization maximum power point tracking (MPPT) is a Promising technique that grid tie inverters, solar battery chargers and similar devices use to get the maximum possible power from one or more solar panels. Among the different methods used to track the maximum power point, Perturb and Observe method is a type of strategy to optimize the power output of an array. In this method, the controller adjusts the voltage by a small amount from the array and measures power, if the power increases, further adjustments in that direction are tried until power no longer increases. In this research paper the system performance is optimized by perturbs and observes method using buck boost converter. By varying the duty cycle of the buck boost converter, the source impedance can be matched to adjust the load impedance to improve the efficiency of the system. The Performance has been studied by the MATLAB/Simulink.

Keywords: Maximum power point tracking, Photovoltaic system, Buck boost converter, Perturb and Observe method, Direct current, Photovoltaic Panel.

Introduction*:* The intensive use of DC power provides within most of electrical associated electronic appliances ends up in an increasing demand for power provides that draw current with low harmonic content and even have power issue about to unity. DC power provides area unit extensively utilized in computers, audio sets, televisions *et al*. The presence of nonlinear hundreds ends up in low power issue operation of the facility system. The

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fundamental block in several power electronic converters area unit uncontrolled diode bridge rectifiers with electrical phenomenon filter. Because of the non-linear nature of bridge rectifiers, non-sinusoidal current is drawn from the utility and harmonics area unit injected into the utility lines. The bridge rectifiers contribute to high doctor's degree, low PF and low potency to the facility system. These harmonic currents cause many issues like voltage distortion, heating and noises that end in reduced potency of the facility system. Because of this truth, there's a necessity for power provides that draw current with low harmonic content and even have power issue about to unity [1].

The AC mains utility offer ideally is meant to be free from high voltage spikes and current harmonics. Discontinuous input current that exists on the AC mains because of the non-linearity of the rectification method ought to be formed to follow the curved kind of the input voltage. The standard input stage for single section power provides operates by rectifying the ac line voltage and filtering with giant electrolytic capacitors [2].

This method ends up in a distorted input current undulation with giant harmonic content. As a result, the facility issue becomes terribly poor (around zero.6). The reduction of input current harmonics and operation at high power issue (close to unity) area unit vital necessities permanently power provides. Power issue correction techniques area unit of 2 types: passive and active power issue correction. While, passive power issue correction techniques area unit the most effective alternative for low power, value sensitive applications, the active power issue correction techniques area unit utilized in majority of the applications because of their superior performance [3].

Demand for electric power keeps on increasing nowadays; hence, the world is switching over to the field of renewable energy sources as it is pollution-free, free of cost, and easy to access in remote areas.

A DC/DC converter is class of power supply that converts a source of direct current (DC) from one voltage level to another. There are two types of DC/DC converters: linear and switched. A linear DC/DC converter uses a resistive voltage drop to create and regulate a given output voltage, a switched-mode DC/DC converts by storing the input energy periodically and then releasing that energy to the output at a different voltage. The storage can be in either a magnetic field component like an inductor or a transformer, or in an electric field component such as a capacitor. Transformer-based converters provide isolation between the input and the output.

Switch mode converters offer three main advantages:

- The power conversion efficiency is much higher.
- Because the switching frequency is higher, the passive components are smaller and lower losses simplify thermal management.
- The energy stored by an inductor in a switching regulator can be transformed to output voltages that can be smaller than the input (step-down or buck), greater than the input (boost), or buck-boost with reverse polarity (inverter).
- Unlike a switching converter, a linear converter can only generate a voltage that is lower than the input voltage. While there are many advantages, there are also some disadvantages with switching DC/DC converters. They are noisy as compared to a linear circuit and require energy management in the form of a control loop. Fortunately, modern switching-mode controller chips make the control task easy [4].

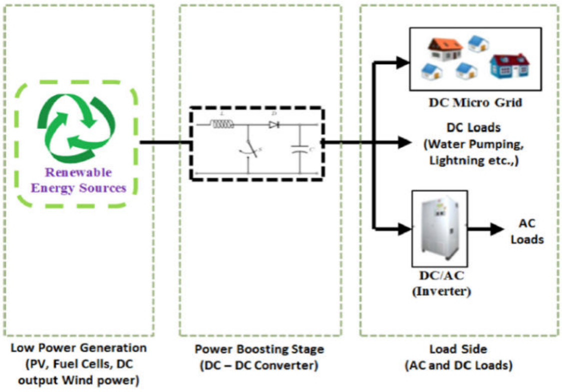


Fig. 1. Typical renewable energy system with DC–DC converter.

Structure of Photovoltaic Cell: The principle of the electrical phenomenon result is simple: The ray of sunshine, assimilated to photons, passes through the highest layer (N doped) of the cell. Then, electrons capture the photons' energy and facilitate them to cross the potential barrier of the PN junction that generates current. Thus there's a powerful relation between the star irradiance and therefore the amplitude of the generated current, as in (1). Because the star cells characteristic is near to a junction rectifier, a classical model are often found in literature [5]

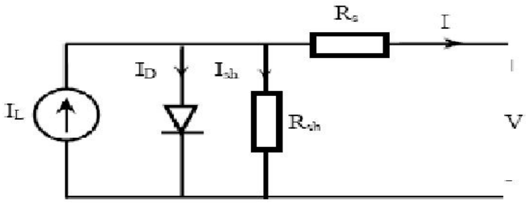


Fig.2. Diode principle circuit.

A or device or RES electrical converter, converts the variable electricity (DC) output of a into a utility frequency electricity (AC) which will be fed into a poster electrical grid or employed by an area, off-grid electrical network. it's a essential balance of system (BOS)–component during a electrical phenomenon system, permitting the employment of standard AC-powered instrumentation. Alternative energy inverters have special functions custom-made to be used with electrical phenomenon arrays, together with most wall plug following and anti-islanding protection.

One of the foremost vital elements in system design is that the power converters. The explanation is that they play a vital role in remodeling the various sorts of electricity, to form the electricity convenient to the tip users. Since the electric cell produces a DC sort of electricity, there's area for varied sorts of power converters. Here, a number of the foremost ordinarily used power device varieties concisely describe in keeping with their topology, function, efficiency, and therefore the major world makers.

1. **Power optimizer:** Ordinarily called a DC-DC power optimizer in star markets, an influence optimizer may be a module-level power device. It takes DC input from the star module and offers either higher or lower DC output voltage. Such a device is supplied with Associate in Nursing MPPT technology to optimize the facility conversion from the solar battery to the DC load or electric battery or central electrical converter. It's additionally thought of one in all the foremost economic power converters, delivering up to 99.5%potency. However, it wants DC cabling from the array. A number of the key players during this power device market are star Edge and Tigo Energy.

2. **Module inverter/micro-inverter:** This is also a module-level power converter. It takes DC input from the solar module and converts it into AC electricity, which is then ready to be connected to the load or single-phase main grid or to a central inverter. It is also equipped with MPPT technology to detect the maximum power point of each module. Even though it doesn't requires any DC cabling, it is more expensive than the power optimizer due to its advanced.

3. **String inverter**: As an extension of a module-level power converter is the string inverter, which is suitable for a string or parallel strings of modules connected in series. Such a power converter is used for small RES systems up to 10 kW in capacity and is usually connected to the main grid. The output of such a power converter is 3 phase lines which are ready to be connected to a low voltage main grid. Even though it is incorporated with MPPT technology, due to the connection of a large RES array, it has a global maximum power point (MPP) which then degrades the efficiency of the RES system.

4. **Central inverter:** In large RES power plants (10 kW and higher), central inverters are used instead of string inverters. However, the central inverters' functionality remains the same (i.e, to produce a 3-phase high voltage output for grid integration), which is why this power converter is considered essential for connecting with the main grid. In many large RES power plants, central inverters are inevitable. But there are many losses within the RES system due to their large and complex configuration. However, to

mitigate such losses, some of the manufacturers, like Siemens, have developed a master-slave arrangement, such that at low irradiance the system efficiency will increase.

V-I Characteristic of PV Cell Model: The Current – Voltage characteristic curve of a PV cell for certain irradiance at a fixed cell temperature is shown in fig.3. The current from a PV cell depends on the external voltage applied and the amount of sunlight on the cell. When the PV cell circuit is short, the current is at maximum and the voltage across the cell is zero. When the PV cell circuit is open, the voltage is at maximum and the current is zero. 2.3. Power – Voltage curve for PV cell The Power – Voltage curve for PV cell is shown in fig.3. Here P is the power extracted from the PV array and V is the voltage across the terminals of the PV array. This curve varies due to the current isolation and temperature. When isolation increases, the power available from PV array increases whereas when temperature increases the power Available from PV array decreases.

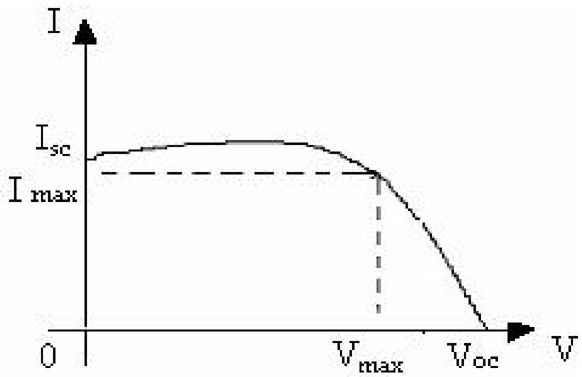


Fig. 3(a) VI Characteristics in PV Cell.

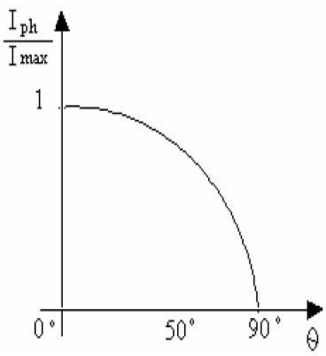


Fig. 3(b) Current variation.

Different Type Method of Boost Converting System

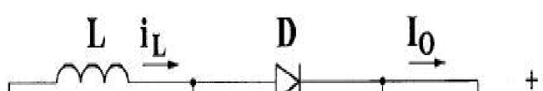
1. MPPT TECHNIQUES: The motivation behind developing the various maximum power point tracking techniques was to increase the efficiency of the PV system at power stage i.e. an improvement in power efficiency. By considering this factor, different MPPT methods were proposed by the researchers. Each method is having their own features but some of them faces difficulties while tracking during rapidly change in the environmental condition. Maximum power point plays an important role in photovoltaic system because they maximize the power output from a PV system for a given set of conditions, and therefore maximize the array efficiency. There are different methods used to track the maximum power point are

1. Perturb and Observe method
2. Incremental Conductance method
3. Parasitic Capacitance method
4. Constant Voltage method

P&O method [3], [4], [5] is the most frequently used algorithm to track the maximum power due to its simple structure and fewer required parameters. This method finds the maximum power point of PV modules by means of iteratively perturbing, observing and comparing the power generated by the PV modules. It is widely applied to the maximum PowerPoint tracker of the photovoltaic system for its features of simplicity and convenience.

According to the structure of MPPT system shown in Fig. 1, the required parameters of the power-feedback type MPPT algorithms are only the voltage and current of PV modules. Shown in Fig. 2 is the relationship between the terminal voltage and output power generated by a PV module. It can be observed that regardless of the magnitude of sun irradiance and terminal voltage of PV modules, the maximum power point is obtained while the condition $dP/dV = 0$ is accomplished. The slope (dP/dV) of the power can be calculated by the consecutive output voltages and output currents, and can be expressed as follows.

2. Boosting Power of Boost Converter: The figure 4 below shows a step up or PWM boost converter. It consists of a dc input voltage



source V_g, boost inductor L, controlled switch S, diode D, filter capacitor C, and the load resistance R. When the switch S is in the on state, the current in the boost inductor increases linearly and the diode D is off at that time. When the switch S is turned off, the energy stored in the inductor is released through the diode to the output RC circuit.

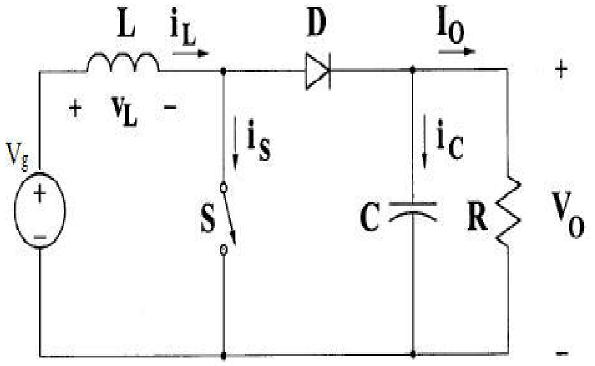


Fig 4 Circuit diagram of boost converter.

3. STEADY STATE ANALYSIS OF THE BOOST CONVERTER

(a) OFF STATE: In the OFF state, the circuit becomes as shown in the Figure (5) below [6].

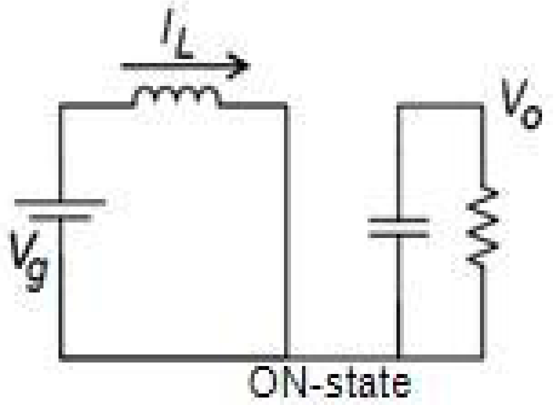


Fig (5) The OFF state diagram of the boost converter.

When the switch is off, the sum total of inductor voltage and input voltage appear as the load voltage.

(b) ON STATE: In the ON state, the circuit diagram is as shown below in Figure (6):

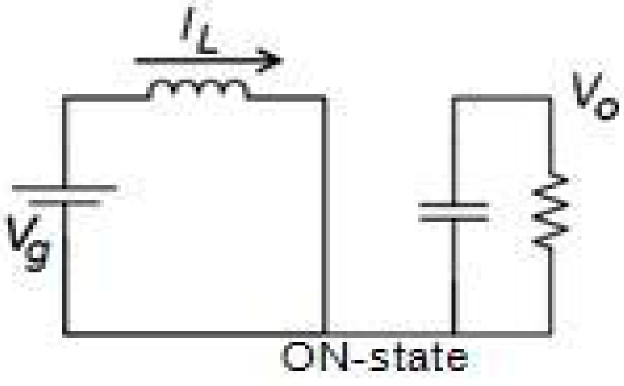


Fig (6) the ON state diagram of the boost converter.

When the switch is ON, the inductor is charged from the input voltage source V_g and the capacitor discharges across the load. The duty cycle, D where T From the inductor voltage balance equation, we have

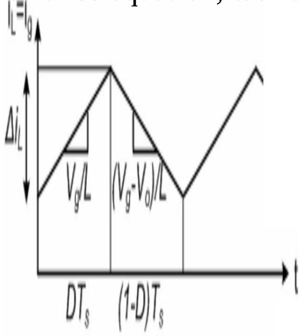


Fig (7.a) Inductor current waveform

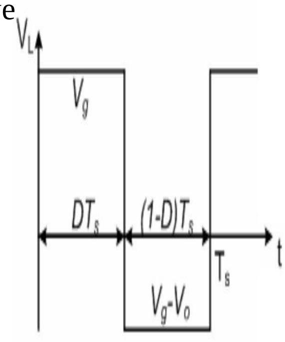


Fig (7.b) Inductor voltage waveform

From the inductor voltage balance equation, we have

$$Vg(DTs) + (Vs-Vo)(1-D)Ts=0$$

$$\Rightarrow Vg(DTs)-Vg(DTs)-VgTs+VoDTs-VoTs=0$$

$$\Rightarrow Vo=Vg/(1-D)$$

$$\Rightarrow \text{Conversion ratio, } M=Vo/Vg=1/(1-D) \qquad (3.1)$$

From inductor current ripple analysis, change in inductor current,

$Il=(Imax-Imin)$

$\Rightarrow IL=(Vg/L)*(DTs)$

$\Rightarrow IL = (VgD)/(fsL)$

$\Rightarrow L=VgD/fs(IL)$

The boost converter operates in CCM (continuous conducting mode) for $L>L_b$ where:

The current supplied to the output RC circuit is discontinuous. Thus a large filter capacitor is used to limit the output voltage ripple. The filter capacitor must provide the output dc current to the load when the diode D is off.

(1) CURRENT RIPPLE FACTOR (CRF):
According to IEC harmonics standard, CRP should be bounded within 30%.

(2) VOLTAGE RIPPLE FACTOR (VRF):
According to IEC harmonics standard 5%.

(3) SWITCHING FREQUENCY (f_s):
F_s= 100 KHz

GIVEN DATA:

- Input voltage, Vg=25V
- Output voltage, Vo=300V
- Output load current, Io=1A

Step 1 : Calculation of Duty cycle (D):

$\Rightarrow D=11/12=.9166$

Step 2: Calculation of Ripple Current

IL= 1 A

=(0.3 * 1)A=0.3 A

Step 3: Calculation of Inductor value (L):

L = (25*.9166)/ (0.3 *10^5) = 7.63 * 10^ -4 H

Step 4: Calculation of capacitor value(C):

R0 = 300Ω.

C=D/f * R_0 *(V0/V)= (.9166)/(10^5)*(300)*(.05)= .611 μF.

4. INTERFACING OF THE RES ARRAY WITH BOOST CONVERTER:

The RES array has been interfaced with the boost converter using a controlled voltage source as shown in the circuit diagram below:

- **Basic Configuration of a Boost Converter**

Figure 8 shows the basic configuration of a boost converter where the switch is integrated in the used IC. Often lower power converters have the diode replaced by a second switch integrated into the converter. If this is the case, all equations in this document apply besides the power dissipation equation of the diode[7-8-9-10].

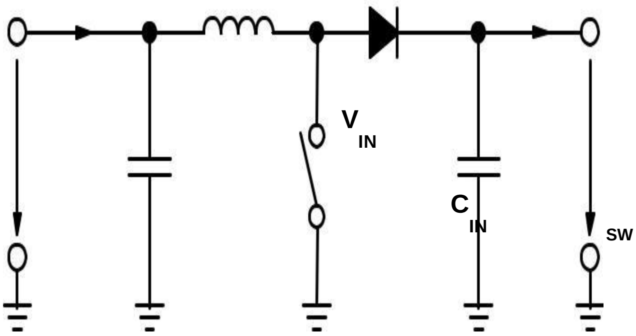


Fig 8 Boost Converter Power Stage.

- **Necessary Parameters of the Power Stage**

The following four parameters are needed to calculate the power stage:
1.1Input Voltage Range: $V_{IN\ (min)}$ and $V_{IN\ (max)}$
1.2Nominal Output Voltage: V_{OUT}
1.3Maximum Output Current: $I_{OUT\ (max)}$
1.4Integrated Circuit used to build the boost converter. This is necessary, because some parameters for the calculations have to be taken out of the data sheet. If these parameters are known the calculation of the power stage can take place.

- **Calculate the Maximum Switch Current**

The first step to calculate the switch current is to determine the duty cycle, D, for the minimum input voltage. The minimum input voltage is used because this leads to the maximum switch current.

$$Dbuck = \frac{Vout \times \eta}{Vinmax}$$

$$Dboost = 1 - \frac{Vinmin \times \eta}{Vout}$$

$V_{IN\ (min)}$ = minimum input voltage, V_{OUT} = desired output voltage

η = efficiency of the converter, e.g. estimated 80%

The efficiency is added to the duty cycle calculation, because the converter has to deliver also the energy dissipated. This calculation gives a more realistic duty cycle than just the equation without the efficiency factor.

Either an estimated factor, e.g. 80% (which is not unrealistic for a boost converter worst case efficiency), can be used or see the *Typical Characteristics* section of the selected converter's data sheet.

The principle of the Constant Voltage (CV) technique is simple: the PV is provided employing a constant voltage. Temperature and star Irradiance impacts are neglected. The reference voltage is obtained from the MPP of the P(i) characteristic directly. Here, the MPP voltage is regarding sixteen.3V for the studied PV. Figure half dozen shows the CV formula and therefore the code of the Matlab embedded perform.

The CV technique needs the PV voltage measure solely. The Matlab embedded perform is evaluated with a one kc frequency. This Constant Voltage technique can't be terribly effective relating to star Irradiance impact and definitely not relating to the temperature's influence. Thus, some enhancements of the CV ways exist.

The principle of the Constant Voltage (CV) technique relies on the CV technique, however it makes the idea that the MPP voltage is usually around seventy fifth of the open-circuit voltage so mainly, this system takes into consideration the temperature. However, it requests a special procedure to frequently disconnect the PV and to live the open-circuit voltage. Besides, this system will part take into consideration the cell's aging.

- The Temperatures technique is additionally AN improvement of the terrorist organization Method: the open-circuit voltage is currently thought-about to be associated with the temperature by a linear perform. Then, with a temperature detector, the open-voltage measure isn't any a lot of necessary, as a result of its price may be known from the temperature price directly.

Short-Current Pulse (SC) Method:

The principle of the Short-Current Pulse (SC) Method is based on a simple relation: the MPP current is proportional to the Short-circuit current *iSC*, with some temperature and solar irradiance conditions. To simplify the *is* estimation, it is often considered as constant, even if the temperature varies between 0 and 60°C. The determination of the Short-circuit current *iSC*is in fact, done just before connecting the PV systems to the grid.

In this paper, the simulation model is developed with MATLAB/SIMULINK. The simulation model of the proposed method .and the waveforms are shown in fig .1. The proposed circuit needs independent dc source which is supplied from photovoltaic cell. The inputs are fed by voltage and current of the PV terminals, while the output provides duty cycle for the buck boost converter. The input voltage is 24V and the output voltage after being buck boosted up is 48.2V and shown in fig.1. Buck Boost converter controls the output voltage by varying the duty cycle *k*, of the switch and the value of k is 0.67 which is calculated using the formulae **Vo = Vs*k / 1- k.** If we vary the pulse width of the pulse generator various voltage ranges at the output can be obtained. Once the buck boost converter injected the power from the pv panel and the PID controller starts function, it varies the value of duty cycle which will change the input value that is sensed by the PID controller. By using the PID controller the error has-been minimized in the system and the efficiency is improved. Below shows the output values for PV panel [10].

V.PREVIOS RESULT AND SIMULATION

The PV cell temperature is maintained constant at 25 degree Celsius and the solar intensity is varied in steps up to the rated value of 1200W/meter square. That the current slightly increase with increasing intensity thereby increasing the power output of the solar cell.

Conclusion: In the Present Work, the maximum power point tracking is successfully carried out by this research using perturb and observe method. The PV module working on photovoltaic effect actually improves the system efficiency. Compared to other methods of maximum power point tracking, the perturb and observe method seems to be easy for the optimization of the photovoltaic system using buck boost converter. By varying the duty cycle of the buck boost converter, the source impedance can be matched to adjust the load impedance which improves the efficiency of the system. The Performance has been studied by the MATLAB/Simulink. In future, the maximum power point tracking could be carried out without the use of controllers in order to reduce the cost and complications of hardware can be removed.

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