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A Review Article of Micro Grid Power Boosting Technique

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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.**

I.INTRODUCTION

The extensive use of DC power supplies inside most of electrical and electronic appliances leads to an increasing demand for power supplies that draw current with low harmonic content and also have power factor close to unity. DC power supplies are extensively used in computers, audio sets, televisions and others. The presence of nonlinear loads results in low power factor operation of the power system. The basic block in many power electronic converters are uncontrolled diode bridge rectifiers with capacitive filter. Due to the non-linear nature of bridge rectifiers, non-sinusoidal current is drawn from the utility and harmonics are injected into the utility lines.

The bridge rectifiers contribute to high THD, low PF and low efficiency to the power system. These harmonic currents cause several problems such as voltage distortion, heating and noises which result in reduced efficiency of the power system. Due to this fact, there is a need for power supplies that draw current with low harmonic content and also have power factor close to unity [1].

The AC mains utility supply ideally is supposed to be free from high voltage spikes and current harmonics. Discontinuous input current that exists on the AC mains due to the non-linearity of the rectification process should be shaped to follow the sinusoidal form of the input voltage. The conventional input stage for single phase power supplies operates by rectifying the ac line voltage and filtering with large electrolytic capacitors[2].

This process results in a distorted input current waveform with large harmonic content. As a result, the power factor becomes very poor (around 0.6). The reduction of input current harmonics and operation at high power factor (close to unity) are important requirements for good power supplies. Power factor correction techniques are of two types: passive and active power factor correction. While, passive power factor correction techniques are the best choice for low power, cost sensitive applications, the active power factor correction techniques are used in majority of the applications due to their superior performance [3].

Demand for electric power keeps on increasing nowadays; hence, the world is switching over to the

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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.

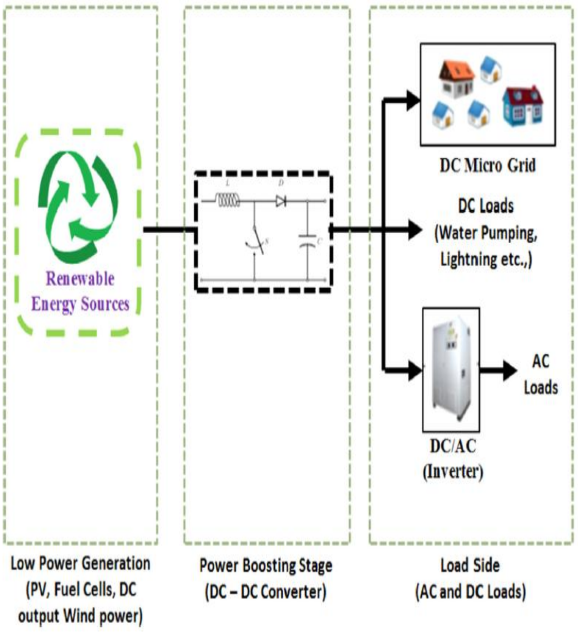

Fig.1 Typical renewable energy system with DC–DC converter.

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].

II .STRUCTUTRE OF PHOTOVOLTAIC CELL

The principle of the photovoltaic effect is simple The ray of light, assimilated to photons, passes through the top layer (N doped) of the photovoltaic cell. Then, electrons capture the photons' energy and help them to cross the potential barrier of the PN junction, which generates current. So there is a strong relation between the solar irradiance and the amplitude of the generated current, as in (1). As the solar cells characteristic is close to a semiconductor diode, a classical model can be found in literature [5].

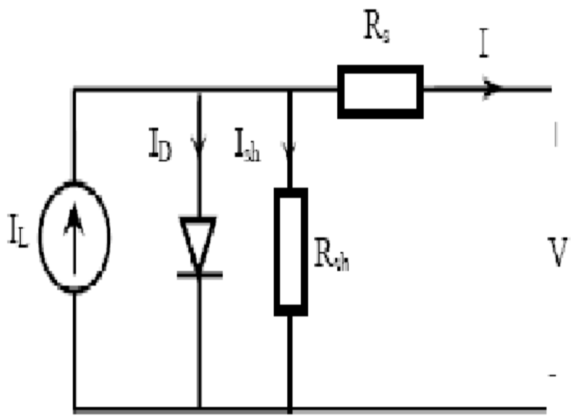

Fig.2 Diode principle circuit.

A or converter or RES inverter, converts the variable direct current (DC) output of a into a utility frequency alternating current (AC) that can be fed into a commercial electrical grid or used by a local, off-grid electrical network. It is a critical balance of system (BOS)–component in a photovoltaic system, allowing the use of ordinary AC-powered equipment. Solar power inverters have special functions adapted for use with photovoltaic arrays, including maximum power point tracking and anti-islanding protection.One of the most important parts in system architecture is the power converters.

The reason is that they play an important role in transforming the different types of electricity, to make the electricity convenient to the end users. Since the solar cell produces a DC type of electricity, there's room for various types of power converters. Here, some

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of the most commonly used power converter types are briefly describe according to their topology, function, efficiency, and the major global manufacturers.

1. Power optimizer-Commonly known as a DC-DC power optimizer in solar markets, a power optimizer is a module-level power converter. It takes DC input from the solar module and gives either higher or lower DC output voltage. Such a converter is equipped with an MPPT technology to optimize the power conversion from the solar panel to the DC load or a battery or central inverter. It is also considered one of the most efficient power converters, delivering up to 99.5% efficiency. However, it needs DC cabling from the array. Some of the major players in this power converter market are Solar 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.

III.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 powe Available from PV array decreases.

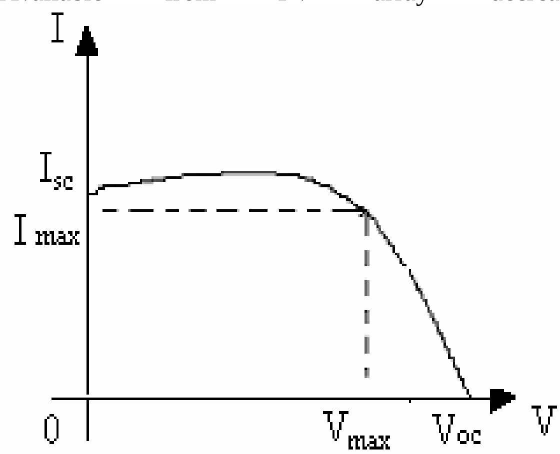

Fig.3 VI Characteristics in PV Cell.

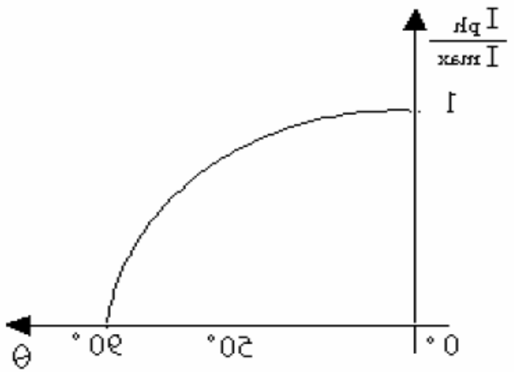

Fig.4 urrent variation.

IV.DIFFERENT TYPE METHODE 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

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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

- Perturb and Observe method.
- Incremental Conductance method.
- Parasitic Capacitance method.
- 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 iterativelyperturbing, observing and comparing thepower generated by the PV modules. It iswidely applied to the maximum powerpoint tracker of the photovoltaic system forits features of simplicity and convenience.

According to the structure of MPPTsystem shown in Fig. 1, the requiredparameters of the power-feedback typeMPPT algorithms are only the voltage andcurrent of PV modules. Shown in Fig. 2 isthe relationship between the terminalvoltage and output power generated by aPV module. It can be observed thatregardless of the magnitude of sunirradiance and terminal voltage of PVmodules, the maximum power point isobtained while the condition $dP/dV = 0$ isaccomplished. The slope (dP/dV) of thepower can be calculated by the consecutiveoutput voltages and output currents, andcan be expressed as follows.

2. Boosting Power Of Boost Converter-The figure 5 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.

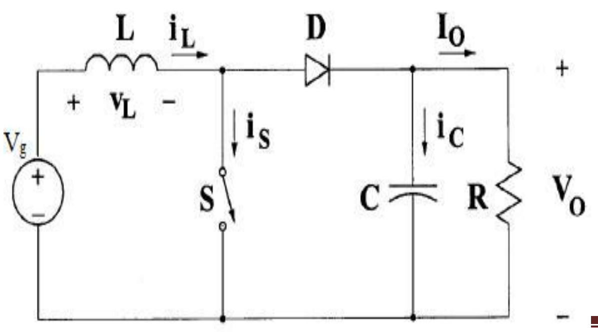

Fig.5 Circuit diagram of boost converter.

3. Steady State Analysis of the Boost Converter

3.1 Off State- In the OFF state, the circuit becomes as shown in the Figure 6 below [6].

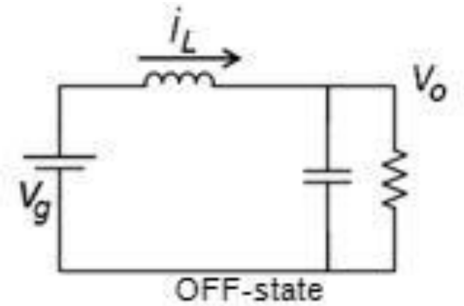

Fig.6 The OFF state diagram of the boost converter.

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

3.2 On State- In the ON state, the circuit diagram is as shown below in Figure 7

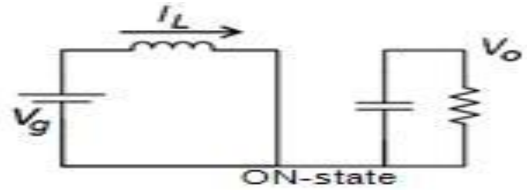

Fig. 7 the ON state diagram of the boost converter.

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

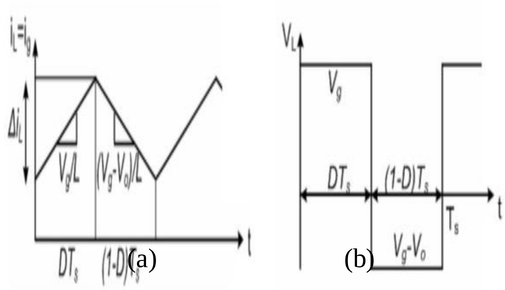

Fig. 8(a) Inductor current waveform. (b) Inductor voltage waveform.

From the inductor voltage balance equation, we have

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

⇒Vg(DTs)-Vg(DTs)-VgTs+VoDTs-VoTs=0

⇒Vo=Vg/(1-D)

⇒Conversion ratio, M=Vo/Vg=1/(1-D) (3.1)
From inductor current ripple analysis, change in inductor current,
Il=(Imax-Imin)
⇒ IL=(Vg/L)*(DTs)
⇒ IL = (VgD)/(fsL)
⇒ 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):
□ 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 = 300□ .
C=D/f * R0 *(V0/V)= (.9166)/(10^5)*(300)*(.05)= .611 µF.

IV.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:

1.Basic Configuration of a Boost Converter
Figure 1 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].

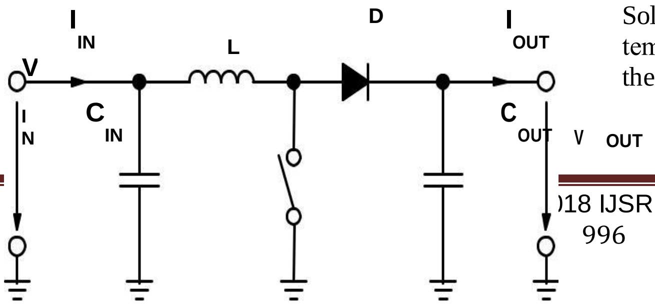

Fig. 5 Boost Converter Power Stage.

2.Necessary Parameters of the Power Stage
The following four parameters are needed to calculate the power stage:

- Input Voltage Range: $V_{IN\ (min)}$ and $V_{IN\ (max)}$
- Nominal Output Voltage: V_{OUT}
- Maximum Output Current: $I_{OUT\ (max)}$
- Integrated 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.

3.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.

$$D=1-(V_{IN(Min)}/V_{out})$$

$V_{IN\ (min)}$ = minimum input voltage, V_{OUT} = desired output voltage $^{\eta}$ = 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) Method is simple: the PV is supplied using a constant voltage. Temperature and Solar Irradiance impacts are neglected.

The reference voltage is obtained from the MPP of the P(i) characteristic directly. Here, the MPP voltage is about 16.3V for the studied PV. Figure 6 shows the CV algorithm and the code of the Matlab embedded function.The CV method requires the PV voltage measurement only. The Matlab embedded function is evaluated with a 1 kHz frequency. This Constant Voltage Method cannot be very effective regarding Solar Irradiance impact and certainly not regarding the temperature's influence. Thus, some enhancements of the CV methods exist.

The Open Voltage (OV) Method is based on the CV method, but it makes the assumption that the MPP voltage is always around 75% of the open-circuit voltage *vOC*. So mainly, this technique takes into account the temperature. But it requests a special procedure to regularly disconnect the PV and to measure the open-circuit voltage. Besides, this technique can partially take into account the cell's aging.

The Temperatures Method is also an improvement of the OV Method: the open-circuit voltage is now considered to be related to the temperature by a linear function. Then, with a temperature sensor, the open-voltage measurement is no more necessary, because its value can be identified from the temperature value directly.

3.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 *iSC* 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 buckboost 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 hasbeen 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.

VI.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 boostconverter, 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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