

# Low Voltage Transmission and Distribution System Based on Dynamic Voltage Conditioner with Solar Power Grid

<sup>1</sup>Shanti Priya Giri, <sup>2</sup>Er. Namita Jaiswal

<sup>1</sup>Student, <sup>2</sup>Assistant Professor

*Department of Electrical Engineering, Shepherd Institute Of Engineering And Technology, Sam Higginbottom University Of Agriculture, Technology And Sciences, Prayagraj(Allahabad)-211007, India.*

**Abstract**—Recently, demand of renewable energy is increasing and Solar PV System is most utilization in power system. Solar System can generate low power as requirement. In low power transmission system has a big problem of the power quality and stable the nominal voltage. This problem is usually solved by smart distribution transformers, hybrid transformers, and solid-state transformers, but dynamic voltage conditioners (DVC) can also be an innovative and cost-effective solution. A single-phase DVC system is capable of compensating the drift of the long-term voltages and utilize DVC system control the photovoltaic system. This paper is design dynamic voltage because irradiation and temperature are different rate. So that it is complex to control the dynamic voltage response. DVC performance is checked for mains voltage and load variation. The proposed solution is validated with simulation studies. The MPPT and DC-DC converter are implanted Matlab/simulink and all component are connected to each other and generate its result.

**Keywords:** PV system; Power Quality; Power conditioning; Power electronics; DVC; LV Distribution System; Grid.

## 1. INTRODUCTION

Sun and wind are an inexhaustible pollution free source of energy and solar cell have either low or no operating cost with lifetime on the 30 years, the only monetary investment is the initial manufacturing cost. By using photovoltaic effect, in which photons are converted into electricity, solar energy can be used for direct electricity generation. The efficiency of PV cell is affected by various atmospheric parameters like irradiance, temperature, humidity, dust, wind etc. However, solar energy is free and inexhaustible PV cell are not used commonly because of their initial cost and efficiency. Many engineers, scientists and researchers are trying to improve the solar cell efficiency by considering the effect of atmospheric parameter like radiation, temperature, humidity etc. and changing the material of PV cell such as Si, GaAS etc.

In this research work, an automated system has been developed for accurate and smooth plotting of I-V curve of solar cell over these parameters. Further, we analyzed the result; and then compare conceptual result to real experimental result to find out optimal condition for a particular photovoltaic cell. The use of Photovoltaic energy for power generation achieved importance due to increase in efficiency and reduced in cost. Among the other renewable source, the electrical energy from Photovoltaic are more useful, as it is abundant, clean, eco-friendly and free distributed over major portion of earth. It is estimated that solar energy incident on the surface of earth is of the order of ten thousand times greater than world energy consumption. The Photovoltaic module itself cannot deliver maximum power output, because it has nonlinear I-V curve. Maximum Power Point Technique is used to track Maximum Power Point in I-V curve.

## 2. DVC OPERATION PRINCIPLE

Hardware configuration of the DVC is equally the same as a DVR, only its control logic is updated by this article to add several new important functionalities and enable its continuous operating, in particular to compensate long duration voltage drifts, within smart grid system.

### A. DVC Injected Control Voltage

The hardware configuration of the proposed single-phase DVC is shown in Fig. 1. The system consists of a fullbridge converter with capacitor bank as DC bus. The converter is connected in series to the line by means of a coupling transformer. The system is equipped with Bypass switch in order to bypass the device in case of any fault of the DVC device and also to protect DVC inverter and other components against possible damages originated from LV network side. In Fig 1,  $V_s$  stands for grid voltage. The DVC is meant to keep PCC voltage ( $V_{PCC}$ ) at set value ( $V_{PCC\_ref}$ ) by injecting proper voltage ( $V_x$ ) in series to the line. So at any instance, the KVL (1) needs to be satisfied.

$$V_{PCC} = V_s + V_x \quad (1)$$

For the proposed DVC,  $V_x$  has to be perpendicular to the line current,  $I_L$ . So, the device can work with non-active power without absorbing active power from the grid. Fig. 2 shows the system working principle in steady state condition with inductive load for both under  $V_{s2}$  and over voltage  $V_{s1}$  events. From Fig. 2, using trigonometric equations in right triangle OAB, the injected voltage magnitude can be calculated as (2). In (2),  $i$  can be either 1 or 2 depending on compensation state and  $\gamma$  is the phase difference between PCC voltage and line current,  $\theta_i$  is the phase difference between network voltage and line current and  $V_{xi}$  is the calculated injected voltage magnitude. As it can be noticed from Fig. 2 and (2), the formula gives negative and positive values for  $V_{xi}$  in different compensation scenarios.

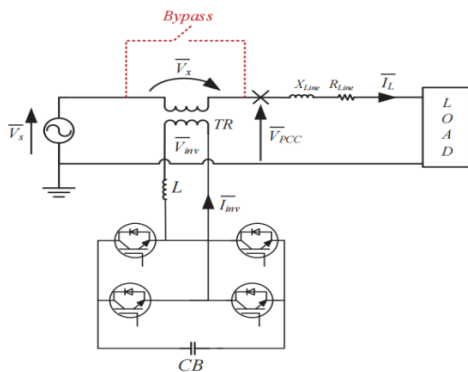


fig. 1. dvc single-phase configuration.

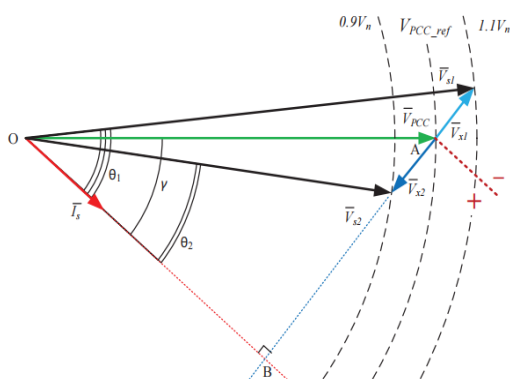


fig.2. dvc non-active operation principle.

The use of Photovoltaic energy for power generation achieved importance due to increase in efficiency and reduced in cost. Among the other renewable source, the electrical energy from Photovoltaic are more useful, as it is abundant, clean, eco-friendly and free distributed over major portion of earth. It is estimated that solar energy incident on the surface of earth is of the order of ten thousand times greater than world energy consumption. The Photovoltaic module itself cannot deliver maximum power output, because it has

nonlinear IV curve. Maximum Power Point Technique is used to track Maximum Power Point in IV curve.

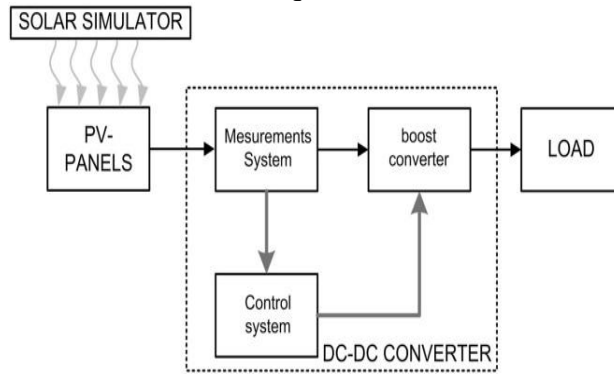


fig. 3. mppt based controller in pv system

MPPT algorithm can be applied to DC-DC converter to track the Maximum Power Point in the IV curve; control command is given to DC-DC converter by MPPT algorithm by measuring output voltage and current from Photovoltaic module.

### 3.1 Photovoltaic module modeling:

Solar cells are made of semiconductor that converts sunlight in to DC voltage process is known as photovoltaic effect. Silicon solar cells produces 0.5 to 0.6 volt depending on Temperature and independent of irradiance. The equivalent circuit of PV cell is shown in Fig-2

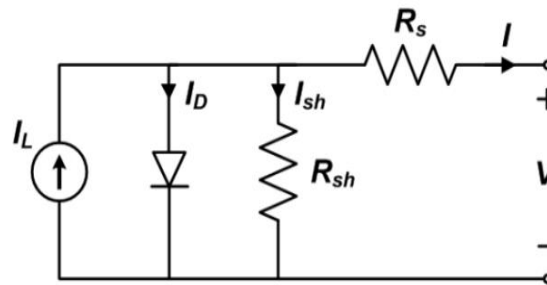


fig.4. equivalent model of photovoltaic module

Its mathematical equation

$$I = I_{pv} - I_0 \left[ \exp\left(\frac{V + IR_s}{aV_{th}}\right) - 1 \right] - \frac{V + IR_s}{R_{sh}} \quad (1)$$

where V is the output voltage of PV;  $I_{ph}$  Photon generated current;  $I_r$  Saturation current; q the electron charge ( $1.6 \times 10^{-19}C$ );  $n$  p-n junction quality factor; k the Boltzmann constant ( $1.38 \times 10^{-23}J/k$ ) and T the temperature (K)

### 3.2 Cell, Module and Array:

The photovoltaic panel generate higher voltage when it is connected in series and when higher current required then it is connected in parallel. As respective, single cell generate 1.5 volts and when it is connected in series then it is able to generate 12 or 24 volts. As respective, for higher voltage use array.

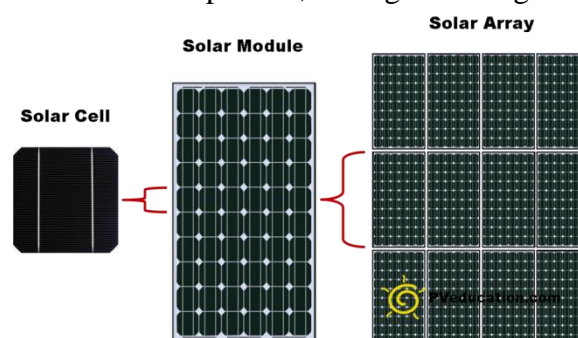


fig. 5 pv panel module

Here, Solar cell convert radiation energy into electrical. It directly dependent on radiation and temperature here as same radiation, changing the temperature. As respective 0<sup>o</sup>c, 25<sup>o</sup>c and 50<sup>o</sup>c and solar radiation 1000 W/m<sup>2</sup>

As same pattern below generates a table.

| S.No | Symbol | Parameter                                | Value                 |
|------|--------|--|-----------------------|
| 1.   | Mp     | Max. Power                               | 75                    |
| 2.   | Vmp    | Voltage at Max. Power                    | 17                    |
| 3.   | Imp    | Current at Max. power                    | 4.45                  |
| 4.   | Voc    | Open Circuit voltage                     | 21.08                 |
| 5.   | Isc    | Short Circuit current                    | 4.79                  |
| 6.   | A      | Temperature co-efficient I <sub>sc</sub> | 3.18x10 <sup>-3</sup> |

In a PV system DC-DC converter are widely used to interface load with PV module. These converters must be selected carefully to boost the module output for MPPT operation. To increase the conversion the conversion of PV module proper selection of DC-DC converter is required. Since the system required step up DC-DC converter in which PV module is followed by Boost Converter. For the given input voltage output can be varied upto desired level by varying D (t<sub>ON</sub>&t<sub>OFF</sub>)

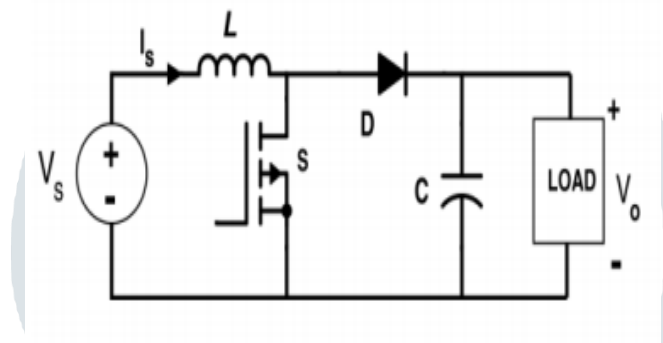


fig. 6. dc-dc boost converter

Value of component can be calculated as

$$V_0 = \frac{V_{in}}{1 - D} \quad (2)$$

This equation is showing the inductor and capacitor:

$$L > \frac{V_{in} \times D}{f \times \Delta I} \quad (3)$$

$$C_1 = C_2 = \frac{V_{out} D}{2f \Delta V_{out} R_{load}} \quad (4)$$

Where in these equations, output voltage is shown as V<sub>0</sub>, the input voltage is shown as V<sub>in</sub>, duty cycle value is shown as D, frequency is shown as f, current wave is shown as ΔI, capacitor capacitance is shown as C<sub>1</sub> and C<sub>2</sub>, output voltage ripple is shown as ΔV<sub>out</sub> and load resistance is shown as R<sub>load</sub>, given V<sub>out</sub>/I<sub>out</sub>

#### 4. MPPT Technique:

Solar PV Module are dependent on changing in operating temperature and irradiance. Radiation and temperature change with seasonal month. Parameter in which variation is observed are higher voltage or current by using of DC-DC boost converter. Maximum power point tracking applied on DC-DC boost converter for Maximum Power, Maximum Voltage, Open Circuit Voltage, Maximum Power Current & Short

Circuit Current. MPPT algorithm proposed applied to DC-DC converter to extract maximum available power to solar PV module output under variation in operating temperature & irradiance.

MPPT technique is more efficient under following operating conditions-

- Cold and cloudy weather
- Improved Efficiency

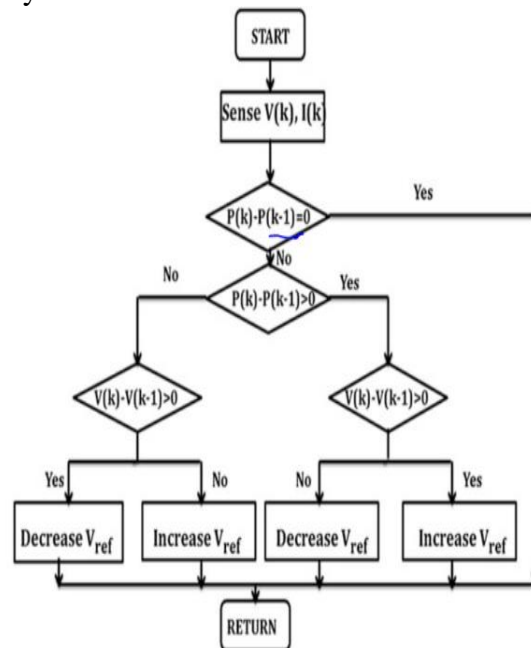


fig 7: incremental conductance algorithm of pv pane

Algorithm proposed in this section, it insures optimal operation of system under various condition. Fig 7 shows the proposed PV power control MPPT algorithm. Objective of MPPT algorithm is to automatically find the maximum operating voltage and maximum operating current on which PV module can operate at maximum power point under given Irradiance and temperature condition.

In P&O MPPT algorithm it starts from calculating of PV output power and its change in power by sampling both PV module current & voltage. The MPPT technique in this method periodically tracking increment or decrement in solar PV module voltage. If such perturbation generated in same direction and if its result in decrease in PV module power then perturbation is generated in opposite direction. The duty cycle is varied until the MPPT obtained however, the system oscillates around the MPPT point reducing perturbation step size reduces the oscillation but slow down its tracking.

### 5. Results and Description

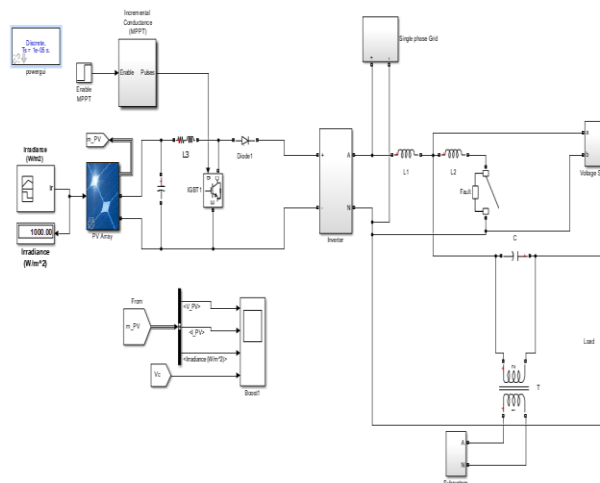


fig. 8. dynamic voltage conditioner with solar power grid

PV panel system controlled incremental conductance with grid is design on matlab/simulation. this system, PV system is the source and it is dependent on a irradiation and temperature as shown in figure. Solar PV system provide rough voltage and current. It is fluctuation so that we cannot directly attach with load. And,

dc-dc boost converter utilizes after the PV system and it can ability to control the fluctuation voltage and provide fix continuous dc voltage but it cannot convert dc to ac voltage. So that, we use inverter and it is convert dc to ac as required, frequency should be 50 Hz and supply 220 volts and this transmission system connected with grid system.

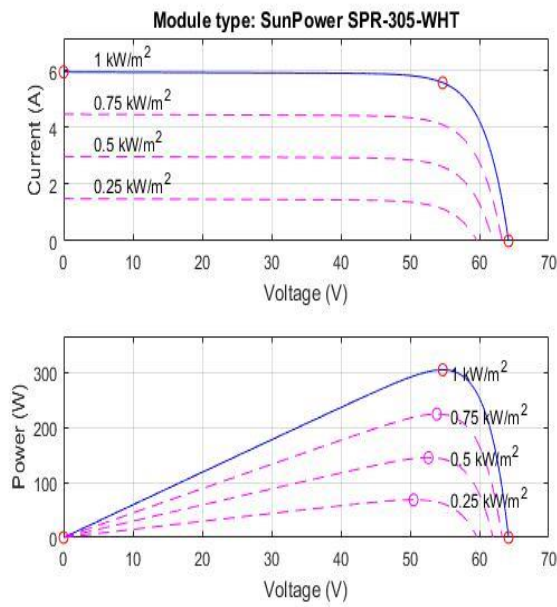


fig.9. single module of i-v curve and p-v curve

In this fig 9, current and voltage curve and also be find Power and voltage. Both curve has denoted as maximum output get at the solar PV panel. And in fig 10, panel connected in series so that only increase voltage as shown figure. But power should be increase as increase voltage.

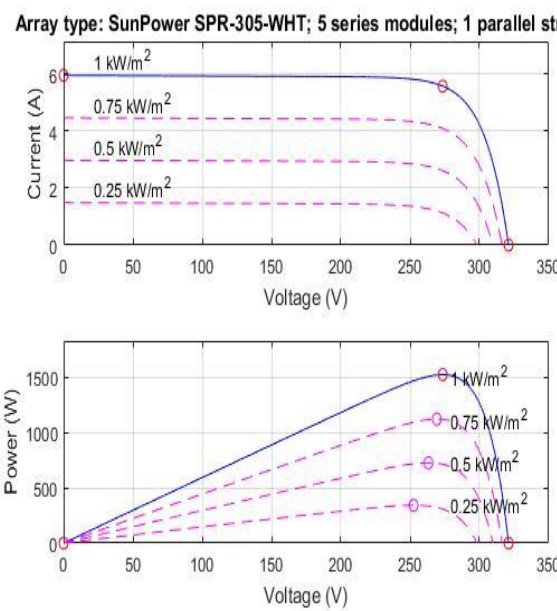
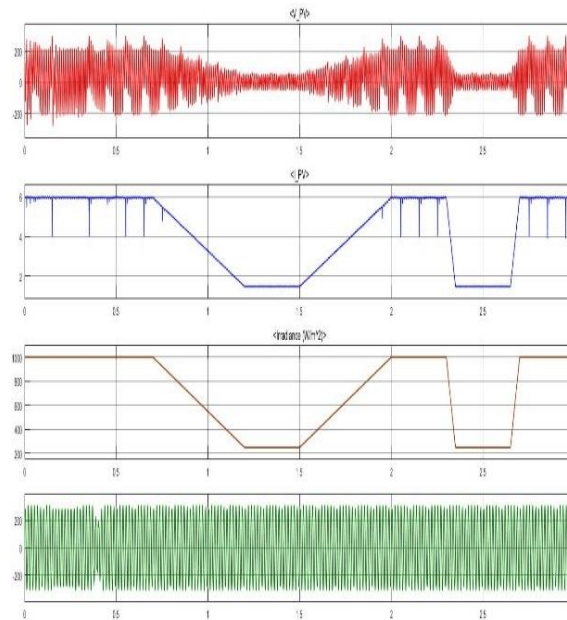


fig. 10. single module of i-v curve and pv curve



**fig.11.**results of panel current, diode current, irradiation and output voltage

In the PV system, the voltage and current are showing own value and its behavior that means how to implement irradiance in the system. Here, Fig.12 shows that three phase ac supply provide continuous signal at the grid. In first figure, single line shows without fluctuation voltage and second, single phase current shows due to change in radiation. Current is high at 0.7 S and 0.7 S to 1.2 S reduced the current and constant between 1.2 to 1.5 S, 1.5 to 2 S increase the current, 2 to 2.3 the value of system should be maximum. And instantly drop between 2.3 to 2.35 and go to the minimum voltage, 2.35 to 2.65 should be minimum power provide, and so on working shows and 2.7 to 3 S should be maximum as shows in fig 7.

## 6. FUTURE SCOPE

This paper analyzed single-phase ac distributed system. But this technique utilizes in three phase transmission line and also improve technology utilize artificial technology, hybrid technology and etc. And also, can improve the maximum power the utilize various type of the algorithm as artificial technology and hybrid technology of the solar pv system utilize .

## 7. CONCLUSIONS

In this paper, we analyzed single-phase ac distributed system with grid and all system simulated on MATLAB. We improved the quality of the single-phase supply. PV panel generate low voltage and change with environment. But DVC (Dynamic Voltage Conditioner) is control the variation of the voltage and provide continuous supply without fluctuation as shown in fig. 12. Dynamic Voltage Conditioner provide high active power so that the efficiency of the system high.

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