Grid Connected Photovoltaic Power Plant with DC Boost converter Using MPPT Technique

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Abstract - *The computation of Solar energy systems consist Photovoltaic (PV) installation, in which energy is redeem in the public electricity grid or power can be provided exactly to an electrical equipment. For the betterment of the efficiency of PV array in the photovoltaic system, there is requirement of power electronic conversion and also the firmness of system. The power circuit contains a Boost Converter (high step-up) DC to DC converter and a inverter with multilevel to transform DC to AC in these systems, as the voltage of grid is pulsating (AC) in nature. The requirement of Control circuit is to get constant (DC) voltage at output with PV systems output voltage at load side, it is continual varying in nature. This is the analysis of Grid connected solar power plant with DC boost converter using MPPT. Here, in this paper the modelling of Boost Converter, Battery Converter with MPPT Technique and A grid connected solar photovoltaic system represented by this paper and has been modelled and simulated by using the SIMULINK in the MATLAB. The results of simulation flaunt that the system can equipoise with stable operation under the converter control schemes during the swapping of grid from one operating condition to another.*

Keywords— **Boost converter, Battery converter, Photovoltaic Array, Grid, MPPT.**

1. INTRODUCTION

With the spreading apprehension of the non-renewable sources of energy, the prices of fossil fuel are increasing constantly, ecosystem damaging and environment, the renewable energy global warming is seemly more promoted and is attaining more attention as a designated to non-renewable sources of energy. Solar system energy is the most acute and sustainable sources of energy, throughout the renewable sources of energy in comparison with the other source of energy resources such that wind, tidal, fuel cell etc. The irradiation (rays of sun) of PV Array transform into electricity. In Grid Connected PV System, The PV system linked together with grid by using boost converter and MPPT for control of coordination in grid system. Grid connected PV plant have appropriately more promoted due to their various kinds of applications in distributed generation and as well the effective use of the PV array power plant. Transmission line contains higher voltage with long distance is no longer obligatory, when power is totally transferred by local renewable sources of power [1]. For the elevation of the connection of renewable energy sources of power to conventional ac systems, The AC micro grids [2]–[5] have been delegation. On the another hand, power generated (DC) with the help of fuel cells or photovoltaic (PV) panels has to be transform into ac by using, photovoltaic (PV) panels, dc/ac inverters and dc/dc boost converter for the purpose of connection with an ac grid. In an ac grid, there is requisite of ac/dc and dc/dc converters for various kinds of office facilities and home to escalate distinct dc voltages.

2. SYSTEM DEPICTION

The distinct types of components used in grid-connected photovoltaic plant with two levels to work out PV power and transmit to the grid. The composition of system is specially for, PV arrays matrix, which transforms irradiation that comes from sun into DC power, a boost converter (DC to DC) to boost up the voltage level of PV array to a modestly level DC Voltage and DC to AC multi level inverter which transforms the DC power into AC power. The established AC power from an inverter is booster into the grid and is accommodated by the local loads [6].

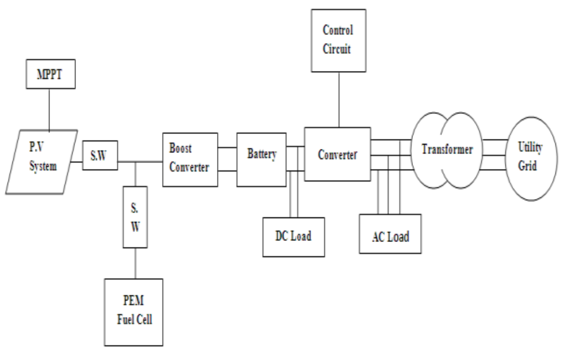

Fig.1. Components of Grid connected PV plant

3. SYSTEM COMPONENTS WITH THEIR OPERATING PRINCIPLE

3.1. PV Array

The equivalent circuit diagram of PV array can be represented with the help of a current source (light generated) and a diode that consists of internal shunt and series resistances as shown in fig. 2.

TABLE: I

C_1	Capacitor across the solar panel	1100uF
L_1	Inductor for the boost converter	70uH
C_2	Capacitor across the dc-link	6500uF
L_2	Filtering inductor for the inverter	75uH
R_2	Equivalent resistance of the inverter	25ohm
C_2	Filtering capacitor for the inverter	7uF
L_3	Inductor for the battery converter	2.5mH
R_3	Resistance of L3	0.2ohm
F	Frequency of the AC grid	50Hz
f_s	Switching frequency of power converters	10kHz
V_d	Rated DC bus voltage	400V
V_{ll_rms}	Rated AC bus line voltage(rms value)	400V
n_1/n_2	Ratio of transformer	2:1

A PV array is moderate of numerous PV cells and the analysis of the characteristics at its conclusion results in formulating its output current by using following equation [14];

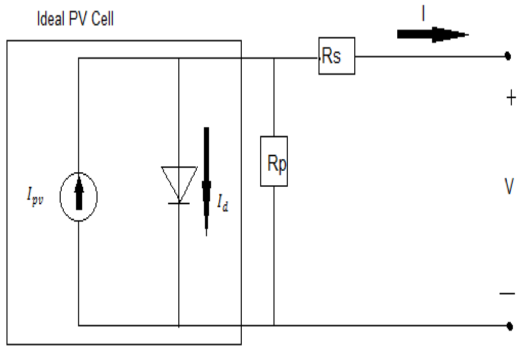

Fig. 2: PV cell single diode model

$$I_{pv} = n_p I_{ph} - n_p I_{sat} * [\exp\left(\left(\frac{q}{AkT}\right)\left(\frac{V_{pv}}{n_s} + I_{pv}R_s\right)\right) - 1] \quad (1)$$

Where,

I= the output PV array current (A), *Io*= the saturation current of the array (A), I_{pv}= the photovoltaic array current (I) *V*= the output PV array voltage (V), R_p and R_s= the internal parallel and series resistances of the PV array (Ohm), *a* = the idealistic constant of diode

$$V_t = N_s(T_q) \quad (2)$$

Where,

q = the electron charge (C),

k = Boltzmann constant (J/K),

T = the temperature of the *p*–*n* junction (K)

3.2. DC/DC Boost Converter

DC/DC Converters are used for transfiguring one level of DC voltage which is unregulated in nature to distinct level of DC voltage which is regulated in nature. This adaption is done with the help of a network consisting storage constituents such as capacitor and inductor [7].

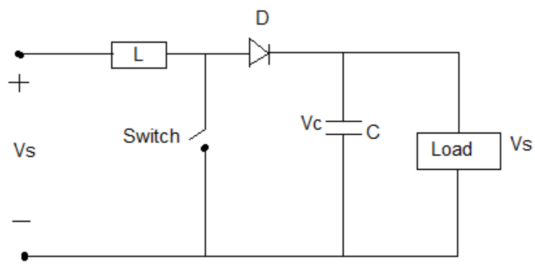

Fig. 3: Boost converter Configuration

The boost converter is driven by the main convention is the efficiency of an inductor to crick changes in current. In a boost converter, the output voltage of the converter is greater than the input voltage of the converter. As a switch, IGBT is used here. In the circuit, the current propagates through the inductor when the switch is turned-ON and energy is concentrate in it. The concentrated energy that circulates in the inductor tries to disintegrate when the switch is turned-OFF and inductor reveres its polarity in such a way that its voltage sums up with the input voltage. The boost converters design is shown in fig. 3, can be abstracted as follows [15];

$$V_{ph} - V_T = L_1 \frac{di_1}{dt} + R_1 i_1 \quad (3)$$

$$I_{pv} - i_1 = C_{pv} \frac{dV_{pv}}{dt} \quad (4)$$

$$V_T = V_d(1 - d_1) \quad (5)$$

Where,

V = the output PV array voltage *(V)*, fsw= the chopper switching frequency (Hz), $Vbattery$= the battery load voltage *(V)*, D = the duty ratio of the boost chopper, ΔV = the change in the PV array voltage *(V)*, ΔiL=the change in inductor current *(A)*, L= the chopper inductor and C = the chopper input capacitor.

3.3. MPPT Algorithms

I-V characteristics of PV array is non-linear is shown in Equation (1), that based on PV cells irradiance level and the temperature. The *I-V* and *P-V* curves of a PV array are presented in *Fig.* at peculiar cell temperature and irradiance level, on which it's observable that the PV panel has a largest (peak) operating point, which is known as the maximum power point (MPP). The PV current is relatively consistent in nature, in the left region to the MPP and the PV array can be approximately as a constant current (CC) source. Besides, the PV current starts a brink falling in the right region to the maximum power point (MPP) and the PV array can be about as a constant voltage (CV) source. With various irradiance levels, the MPP of PV array varies. Therefore, maximizing the adaptability of PV system, persistent tracking to the MPP is necessary. With the use of an MPPT algorithm, a greater level of voltage can be attained which actuates the applicable duty ratio (D) for regulating the gate pulse of the DC-DC converter positioned between the load and the PV module to ingrained that the maximum power of PV panel is extricated. A generously MPPT technique entertain between the tracking speed and steady-state accuracy and shows hurried response while sudden changes in environment. According to this protocol, the Incremental Conductance algorithm can be deliberate as a strong MPPT technique [8-12].

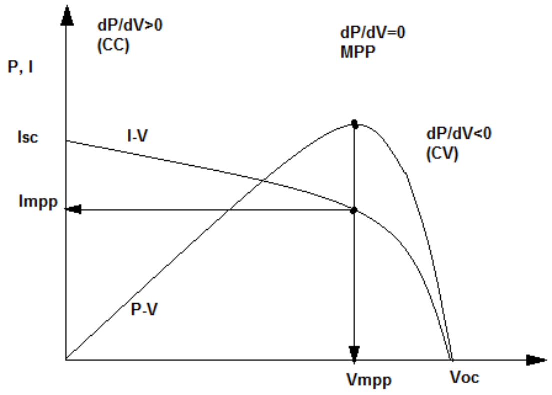

Fig. 4: *I-V* and *P-V* characteristics of PV array

3.4. The Battery Model

The battery model concludes the homogenous characteristics for the discharge and the charge cycles. By using a non-linear equation situated on the actual SOC of the battery, the open voltage source is actuated.

the controlled voltage source is describes by Equation (1) :

$$V_b = V_o + R_b . i_b - K \frac{Q}{Q + \int i_b dt} + A . \exp(B \int i_b dt) \quad (6)$$

$$SOC = 100 \left(1 + \frac{\int i_b dt}{Q}\right) \quad (7)$$

Where,

i_b= the battery charging current, V_o = open circuit voltage, R_b = internal resistance, Q = the battery capacity, A = the exponential voltage, K = the polarization voltage of battery, B = the exponential capacity, [13].

4. SIMULATION RESULTS:

A. Modelling of PV Array with Boost Converter using MPPT Technique

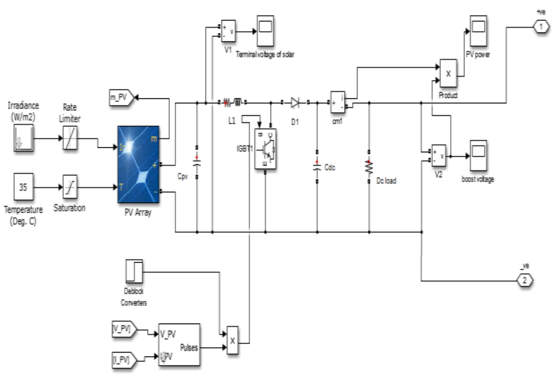

Fig. 7: Simulation of PV Array and Boost Converter

The PV array consists of 38 strings in parallel and 855 series-connected modules per string which are connected in series. The boost converter is connected with PV Array and run by MPPT controller after 0.1 s. Specifications for PV Array are:

Open-circuit voltage: Voc= 400 V

Short-circuit current: Isc= 3.25 A

Voltage and current at maximum power: V_{mp} =394.8V, I_{mp}= 2.80 A

The solar irradiation remains constant at 1000W/m2, from 0.0 s to 0.4 s. The initial voltage is obstinate at 250 V for the IC. Here, the IC is tracing the peak voltage continuously from 0 to 0.1 s. The algorithms tracing rate is very slow, due to which, the peak voltage search by the algorithm is only at 0.05s. The algorithm finds a new peak voltage from 0.2 s and gets the peak voltage at 0.4 s. The primitive (primary) algorithm can accurately follow the variation of solar irradiation but require some time to find the peak (maximum) voltage.

The Terminal voltage curve of PV Array and the output power of PV Array are shown in Fig. 6 and Fig. 7 and the output power changes from 15 kW to 35 kW, when the solar is work at fixed temperature and follows the level of solar irradiation approximately. The output voltage of boost converter is shown in Fig. 8. The voltage level of solar terminal is boosting up (step up) by boost converter. The load voltage is always larger than the source voltage (V_{load}>V_{source}) in boost converter.

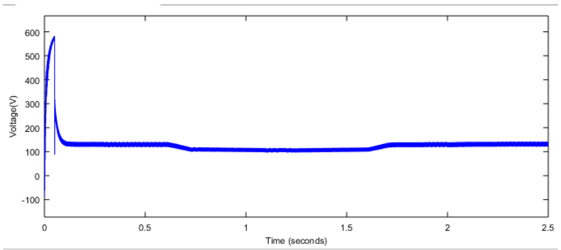

Fig. 8: Terminal voltage of PV Array

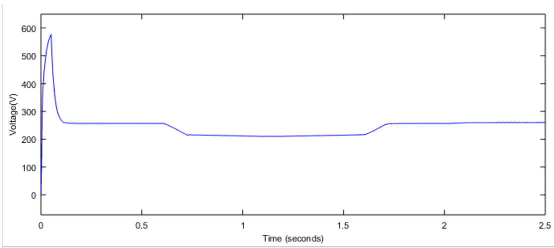

Fig. 9: Output of Boost Converter

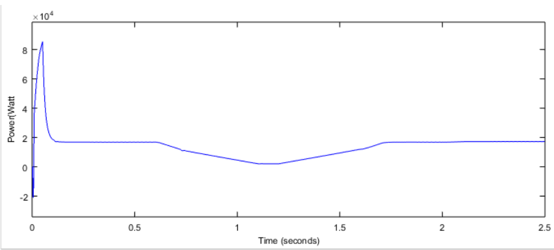

Fig. 10: Output Power of PV Array

4.1. Simulation of Grid Connected PV System

PV array, battery converter, boost converter and three phase converter are simulated and modelled separately. The combination is then joined to resistive load and grid through an LC filter. Fig.16 shows the complete simulation of grid connected PV system and Fig. 17, Fig. 18 shows the voltage and current of three phase converter. Here, it is noted that there is injection of voltage from PV system before 0.15 s and after that Grid provide the voltage to the loads.

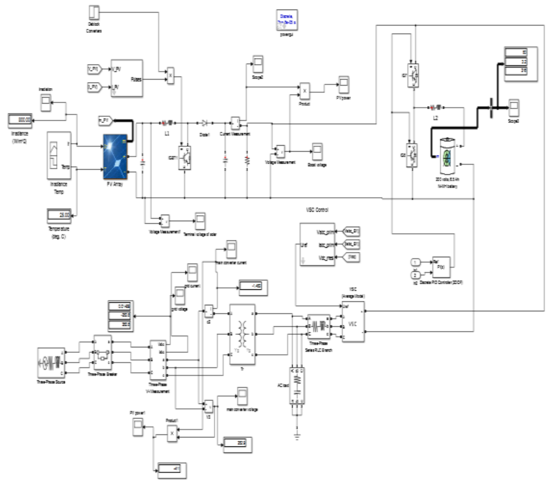

Fig. 16: Simulation of Grid connected solar system

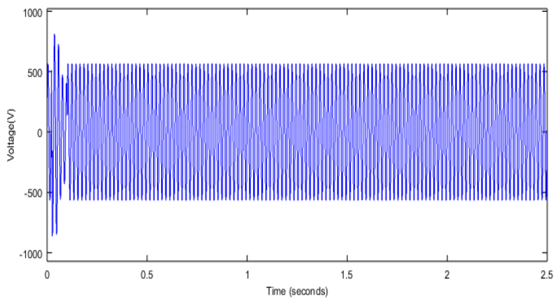

Fig. 17: Grid side voltage of main converter

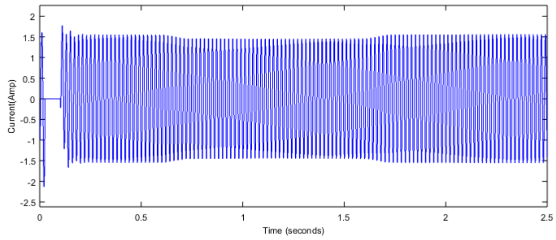

Fig. 18: Grid side current of main converter

5. CONCLUSION

In this work, the Simulation of Grid connected solar PV plant is entailed. The determination of Parameters of system and with the use of these parameters model is collected and simulation results are accorded. The result of simulation shows that the deliberated control execution controls the boost converter output voltage.

With the use of converters, the coordination control between grid and PV system is done. Load output voltage is exactly sinusoidal in nature, with the frequency value 50 Hz synchronised with grid frequency and voltage. And the overall efficiency, power quality and reliability of the system is enhanced.

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