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Study of Boost Converter With Inverter For Stand Alone Solar Applications

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***Abstract*— Electric power generation from solar system containing mainly a power electronics devices like power electronics switches, converter, controller and inverter. Solar power generation contents some basic fundamental problems that can be resolved by the present topology. The predefinition of this proposed system is that this is this study is related of stand-alone system specially, those type of unit which is active in day time and inactive after daytime. Here the boost converter boosting the voltage and maintain it constant with reference voltage value, next inverter invert it into AC quantity and it is finally given to the load. Controller plays main roll for the close loop control of constant voltage achieving.**

***Index Terms*—** PWM inverter, modulation, gate pulse, MOSFET.

I. INTRODUCTION

Solar power will be dominated because of its availability and reliability; it can provide electric energy up to 64% of total energy [1]. Power generation based on Photovoltaic (PV) is one way to utilize the solar energy into electrical energy by using appropeate inverter and converter with it. PV system mitigates energy and environmental related issues. The main objective of paper is to provide electrical energy based on solar energy system with the help of power electronics devices, converter and inverter configuration. Continuous power supply to standalone unit by solar system energy conversion. The other aim of this project is to industrial side like in non-operative mode that units are generate electric power and provide it into grid, for that standards and specification given by government also fulfilled.

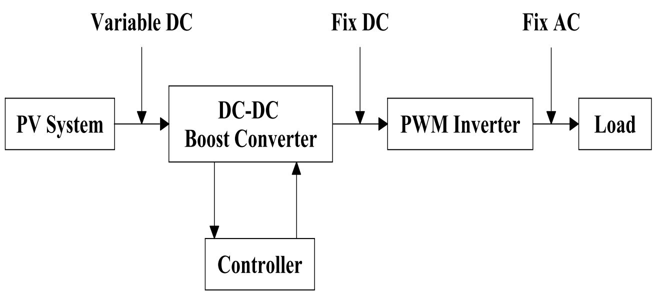

Fig. 1 Basic block diagram of whole system.

The mean of standalone system here is like, as in industrial sector the solar energy generating system is established.

Upper side or on trace. In normal working condition power is taken from it. And when that unit is not in working condition i.e. maintains, stop production, re-setting etc.

II. PHOTOVOLTAIC MODULE FOR SOLAR SYSTEM ENERGY CONVERSION.

Renewable energy sources like wind, tidal, solar etc. are non-polluted, it keep environment clean. It also reserved the fossil fuel. Due to this reason this area is becomes very teachable now a days [2]. The energy comes from sun is like free of cost, easy to available and not spared pollution as like fossil fuel [3].

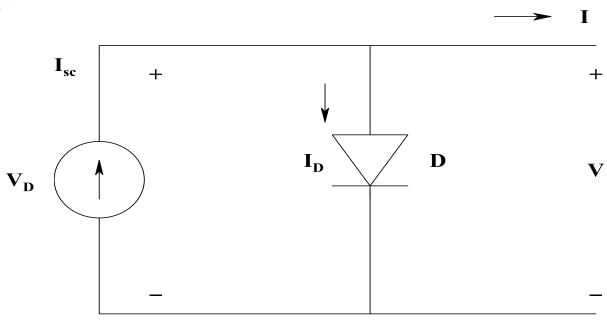

Fig. 2 Basic PV cell module [4]

$$I_D = I_{SC} - 1 \quad (1)$$

$$I_D = I_S \, . \, [e^{Vn.V_T} - 1] \quad (2)$$

$$I_D = I_{SC} - I_S \, [e^{Vn.V_T} - 1] \quad (3)$$

In all above equations I_{SC} is photo current, I_S denotes the reverse diode current, Diode ideality factor is define by **n** and it is normally taken between 1 and 5.

TABLE I
CHARACTERISTIC OF PHOTOCONDUCTIVE CELL

Photoconductor	Time constant	Spractal band
Cadmium sulphide	100 ms	0.47 – 0.71 μm
Cadmium selenide	10 ms	0.6 – 0.77 μm
Cadmium silicon	400 μs	1 – 3 μm
Cadmium silicate	10 μs	1.5 – 4 μm

PV cell give voltage from sun rays around 0.5 to 0.8 volts. This voltage range cannot be sufficient to produced desired voltage range. To get benefit of solar energy PV cell is connected to series with PV module. It this particular connected in the series manners then voltage added with same.

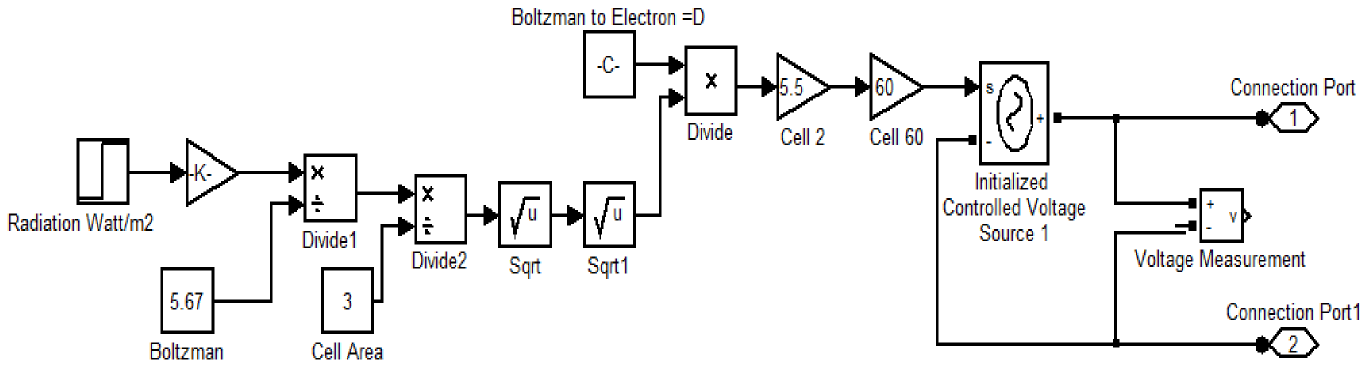

Fig. 3 MATLAB simulation of solar cell with change in solar irradiation

As shown in above figure, the MATLAB simulation of the solar cell is present in this stiffen boltzman constant is kept as a reference. To achieve the main goal of this paper, that is we want to keep output of the boost converter constant or desirable eventhaugh the solar irradiation is not constant [5].

The solar irradiation output that is in watt/m^2 is given to the division block in the MATLAB to fulfill the equation requirement. This simulation is of one cell, to applied it for other cell the cell number is multiply with it. And the final output is termed as the controlled voltage source.

III. BOOST CONVERTER

As described in above chapters the solar system generates the electrical energy by converting solar rays into electric power. Now it is depend upon the sun condition. i.e. solar irradiation. If sun rays dipaschares on 90^0 on PV cell then PV cell give maximum output [6]. But as per system requirement, unit need continues and boosted power as compared to it generate. To mitigate all discussed requirement boost converter is used. Which increase the voltage level given to inverter and continues giving voltage.

In case of DC-DC boost converter, Average output voltage is always higher then the input voltage.

$$V = V_s = \frac{1}{(1-K)} \qquad (4)$$

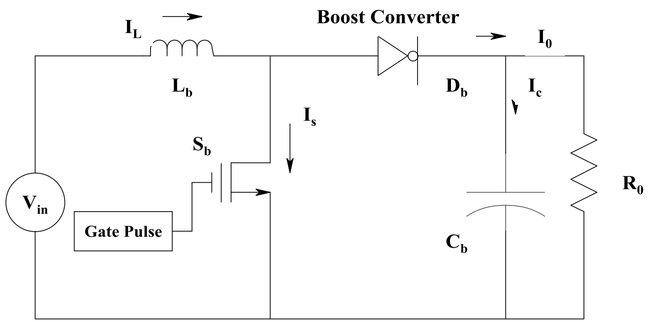

Fig. 4 Basic configuration of boost converter

The heart of controlling the boost converter is to susceptibility of an inductor to resists the change in current supplied. The boost converter is operating as follow. When switch **S** is close, Inductor stores the energy into it. Current is circulating in clockwise direction. Left side polarity of inductor is **+ve**. When switch **S** is open, current is decrease. And inductor opposes the change of current into it. For that polarity will be reverse. i.e. Left side of inductor is negative in this situation.

The main component of boost converter is inductor, diode and high frequency switch (Here it is MOSFET). The logic of control strategy in this type of converter is, duty cycle regulate the voltage change as per requirement.

Switch "S" is in ON state, current through inductor is increase. And diode is in off condition. Switch "S" is in OFF state, the current stored in inductor is now coming out through diode [7]. On the basic of Faraday's low we can conclude that,

$$V_{in}\,KT = (V_{in} - V_o)\,(1\text{-}K)\,T \qquad (5)$$

$$F_{trans} = \frac{V_o}{V_x} = \frac{1}{(1-K)} \qquad (6)$$

V_{in} = Input DC voltage, V_o = Output DC voltage, K = Duty cycle, T = Total time.

In the switch ON, state inductor is been charged as source voltage of V_g and capacitor will discharge. The equation of duty cycle (K) is become [8].

$$K = \frac{T_{on}}{T} \qquad (7)$$

Where $T = \frac{1}{F}$, As per voltage-second balance equation, we can see that

$$V_g\,(KT_s) + (V_s - V_o)\,(1\text{-}K)\,T_s = 0 \qquad (8)$$

$$V_g(KT_s) - V_g(KT_s) - V_gT_s + V_o\,KT_s - V_oT_s = 0 \qquad (9)$$

$$V_o = \frac{V_g}{(1-K)} \qquad (10)$$

When the MOSFET is in OFF condition then, the main aim of inductor is to regulate the flow of current inside it. This task cannot be performed by battery or any other types of Switch mode power supply. When the inductor is discharge, MOSFET switch becomes ON for the procedure further. Special needed MOSFET characteristic used in this type of application is to manage the inductor current very carefully. And the losses of MOSFET must be minimum as possible. The losses are mainly two types, conducting loss and the switching loss. The main function of boost converter here is to obtain very high frequency switching. That high operating frequency is possess to dynamic response and change in current and voltage

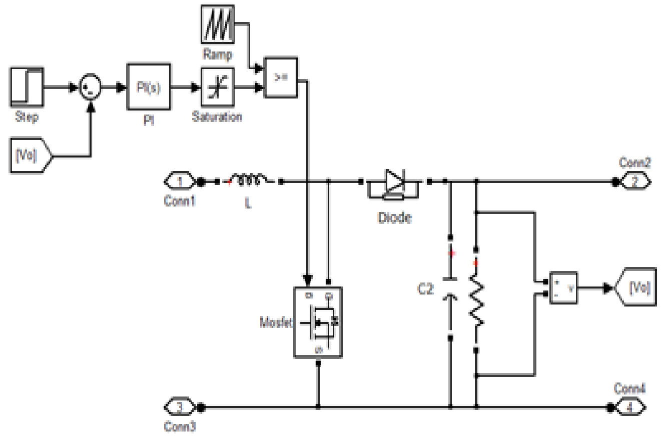

Fig. 5 MATLAB simulation of boost converter with PI controller close loop

The main function of boost converter here is to obtain very high frequency switching. That high operating frequency is posses to dynamic response and change in current and voltage.

Load time constant $\tau = \frac{L}{R}$

Duty ratio K is maintain the output voltage and current. In case of boost converter [9],

When switch ON then, $V_s = +V_L$

$V_L = V_S$

When switch OFF then, $V_S = - V_L + V_o$

$V_L = V_o - V_S$

$V_S T_{ON} = (V_o - V_s) T_{OFF}$

$V_S (T_{ON} + T_{OFF}) = V_o T_{OFF}$

$$V_o = V_S \left(\frac{T_{ON} + T_{OFF}}{T_{OFF}}\right) \quad (11)$$

$$= V_S \left(\frac{T}{T_{OFF}}\right) \quad (12)$$

$$= V_S \left(\frac{T}{T - T_{ON}}\right) \quad (13)$$

$$V_O = V_S \left(\frac{1}{1-K}\right) \quad (14)$$

The boost converter used with the solar application is used for the maintain and boosting the voltage coming from solar panel. In the basic boost converter energy storage capacity is utilized by using proper control technique. In the simulation of boost converter step signal is applied as per reference value. The input of the boost converter is comes from the solar panel.

If the switch is cycled fast enough, the inductor will not discharge fully in between charging stages, and the load will always see a voltage greater than that of the input source alone when the switch is opened. Also while the switch is opened, the capacitor in parallel with the load is charged to this combined voltage [10]. When the switch is then closed and the right hand side is shorted out from the left hand side, the capacitor is therefore able to provide the voltage and energy to the load. During this time, the blocking diode prevents the capacitor from discharging through the switch. The switch must of course be opened again fast enough to prevent the capacitor from discharging too much. For the protection of the boost converter many option is available [11]. For that protective circuit and protective devices are used. But in the standalone system which is not under effect of the grid voltage it is not hardly requirement of the protection.

TABLE II
TECHNICAL SPECIFICATION OF SOLAR PANEL

Electrical Parameter	Rating
Rated power – watt	230
Volt at maximum power – volt	29.2
Open circuit voltage – volt	37
Current at maximum power – ampere	7.9
Short circuit current – ampere	8.4
Module efficiency - %	14-15
Maximum system voltage - volt	1000

TABLE III
IEEE 1547 REQUIREMENTS

Nominal power	30 kW
Harmonic current	(2-10) 4%
	(11-16) 2%
	(17-22) 1.5%
	(23-24) 0.6%
	(>35) 0.3%
DC current injection	< 0.5% of rated output current
Abnormal voltage disconnection	V<50% or V>137% 6 cycles 50% < V<88% or 110% < V<137% 120 cycles
Abnormal frequency disconnection	f < rated – 0.7 Hz 6 cycle f > rated + 0.5 Hz 6 cycles

IV. PWM INVERTER

The inverter is power electronics device which can convert direct current into AC quantity at desirable output voltage and frequency. This operation is achieved by high switching frequency contains power electronics device like MOSFET, IGBT, MCT, SIT, BJT etc. Thyristor controlled rectifier is used whenever the operation is about high power.

The inverter is classified by voltage source inverter (VSI) and current source inverter (CSI). This inverter support much in solar power generation. VSI is maintaining output voltage and CSI maintain current quantity [12].

The solar inverter is use in application like convert DC into AC in solar electricity generation system. PWM inverter is use for the modulation purpose. In that sinusoidal, pulse width type modulation technics.

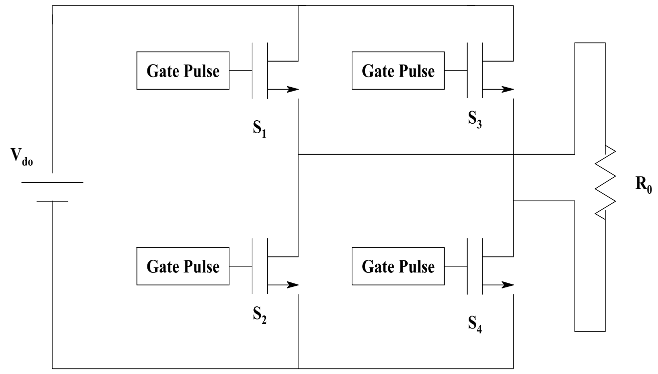

Fig. 6 Basic operation of inverter

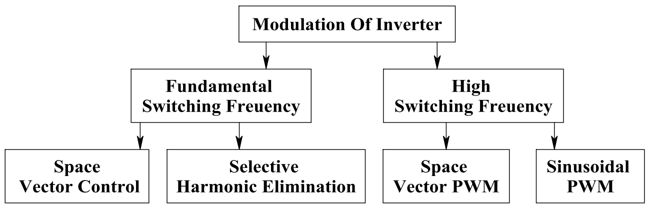

Fig. 7 Classification of modulation methods for inverter

This portion is all about modulation applied on the inverter. Here proposed inverter is about Sinusoidal pulse width modulation (SPWM). That keeps one reference signal. For the unit number level of inverter, less then its one unit triangular carrier is required. This can be directly compared with modulated quantity.

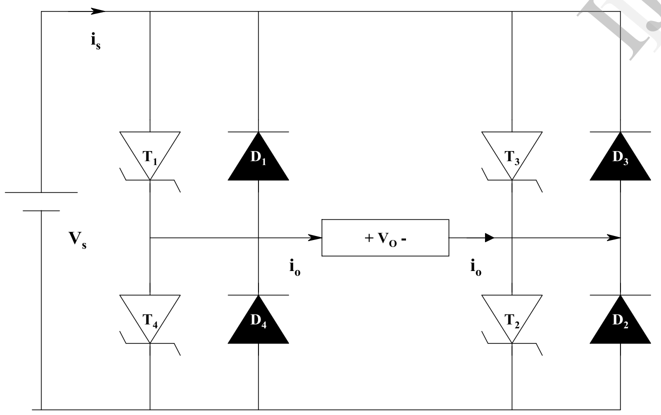

Fig. 8 Schematic of inverter circuit

Input voltage V_s

$$V_s = L \times \frac{(I_2 - I_1)}{t_1} = L\frac{\Delta I}{t_1}$$

$$t_1 = L\frac{\Delta I}{V_s} \quad (15)$$

$$-\frac{V_s - V_0}{L} \times t_2 \quad (16)$$

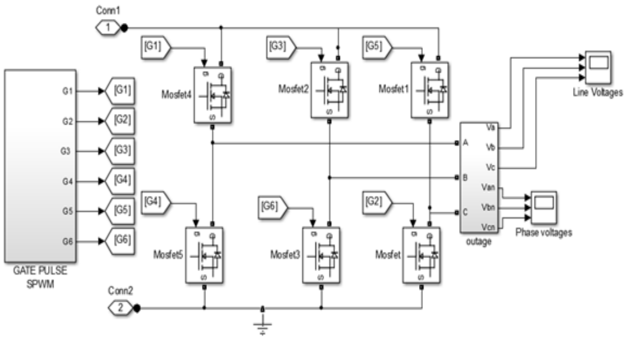

Fig. 9 MATLAB simulation of inverter

The output voltage is produced by combination between two types of signal like reference and carrier as below,

$V_o(\theta) = A_o + \sum_{n=1}^{\infty}(A_n Cosn\theta + B_n Sinn\theta)$

Suppose **P** is pulse rate per special span of time. B_n and A_o is zero. Then they can be written as, [13]

$V_o(\theta) = \sum_{n=1,3,..}^{\infty} A_n Cosn\theta$

The current supplied to the standalone load, is sensed and given to comparator as input and that may compare with reference value [14]

$I_{ref} = V_g \times m$

Here **m** is some of all modulated index. m= $m_1 + m_2 + m_3$ [15].

V. Results and Analysis

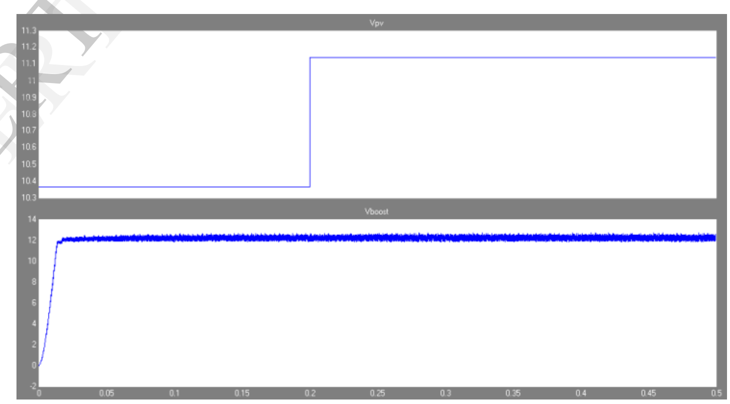

Fig. 10 Boost converter response at 11.136 volt input from PV cell. (constant 12 volt is obtained at boost converter)

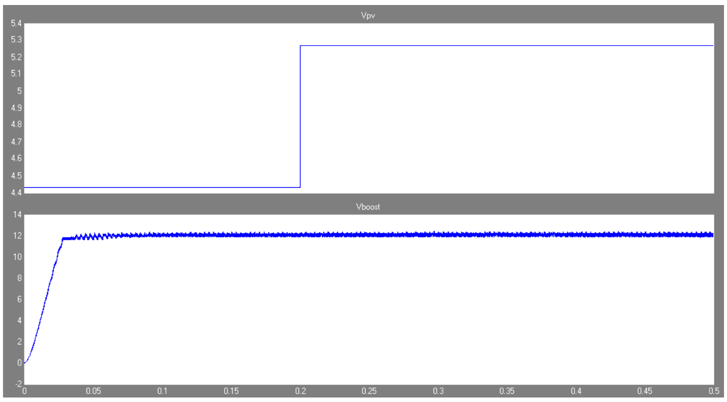

Fig. 11 Boost converter response at 5.267 volt input from PV cell. (constant 12 volt is obtained at boost converter)

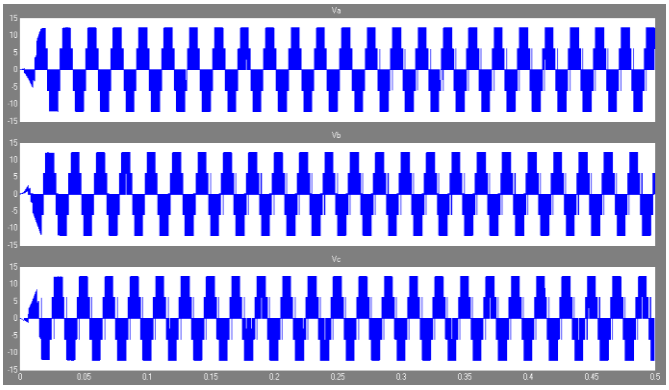

Fig. 12 Line voltage of inverter

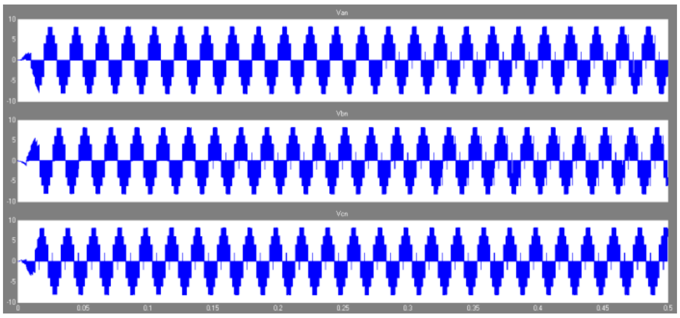

Fig. 13 Phase voltage of inverter

Here in this portion MATLAB simulation is present. It is proposed in trial version of the MATLAB. The aim of this paper is to obtain constant voltage at boost converter side, if solar irradiation is change. Because of the solar irradiation is change as per day. But we want constant voltage for the stand alone solar applications.

As shown in figure 10 and figure 11 we can clearly observed that input of the solar cell is changes and boost converter output voltage is remain constant. (desired voltage). Here it is around constant 12 volt.

In the figure 12 line voltage is given and in figure 13 phase voltage can see. The inverter is PWM inverter for that the modulation result is obtains for the stand alone application. The application of inverter here is to convert DC quantity into AC quantity

VI. Conclusion

Solar electricity can be generated by using boost converter and inverter. In that converter is maintaining the constant voltage as per solar irradiation is change and inverter convert DC output of boost converter into AC quantity. PI controller scheme can be adjustable as per appropeate requirement of system.

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