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Design and Implementation of Boost Converter for Photovoltaic Systems

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Abstract: This paper presents detail design of boost converter and proto-type development with optimized per turb (P&O) algorithms by using AT MEGA 8 microcontroller and the validation has been achieved by MATLAB/ Simulink. By using embedded function in sim power systems blocks the algorithms are developed, the developed algorithm which tracks point were the maximum power can extract from the PV panel or array through the designed boost converter which increases the input voltage with required output voltage with regulated manner, hence it maximizes the power generated by PV array.

Keywords: Photovoltaic system, Maximum power point tracking, Boost converter, solar cell.

I. INTRODUCTION

Due to the diminishing deposits of non-renewable energy resources such as coal, natural gas, fossil fuels etc, the entire world is facing a challenge of energy crisis, to overcome the problems caused by depletion of fossil fuels is to find the alternative means of energy generation source such as solar photovoltaic, it is one of renewable energy source which is inexhaustible clean and pollution free. Solar photovoltaic is a phenomenon where the solar irradiance is converted directly into electricity through solar cell. PV installations are growing day to day either as residential stand alone or grid connected. It is necessary to enhance the efficiency of a PV system irrespective irradiance and temperature the PV system should contain some form controller which is responsible for an optimization to extract maximum power from the panel, The major existing work done in this field is to find simple and efficient method to extract maximum power [1, 4] where analysis done with different irradiance and temperature. Several methods are proposed [5, 7] to extract maximum power and compared with their techniques performance are analysed by different authors. Recent works reflect the interest of designing of proper controller and extracting maximum power from the module through dc-dc converter [8][9]. The rest paper is organized as follows. Section II briefly describes the photovoltaic system and dc-dc converters III deals with consideration of design of Boost converter, Section IV proposes a Mat lab Simulink simulation result of boost converter with P&O algorithm using eembedded mat lab function, Section V describes the experimental proto type of boost converter for photovoltaic systems and conclusions are stated in section VI.

II. PHOTOVOLTAIC SYSTEM AND DC-DC CONVERTERS

A. Photovoltaic System

Photovoltaic systems are comprised of photovoltaic cells that convert solar radiation into electricity; the solar cell is made semiconductor material such as silicon. The PV cell shown in Figure-2.1is the basic component of a PV energy system. The PV cell usually produces less than 2 W at approximately 0.5 V DC, to get desired level of power and voltage raring it is necessary to connect PV cells in series-parallel configuration. Figure-2.2 shows the single PV cells are grouped to form modules and then modules are connected to build arrays.

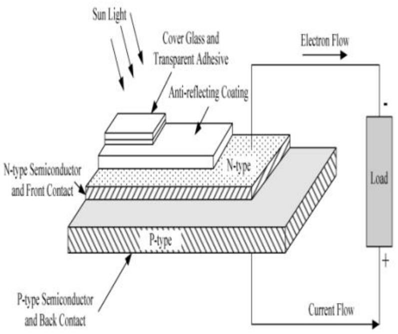

Figure 2.1: Structure of PV cell

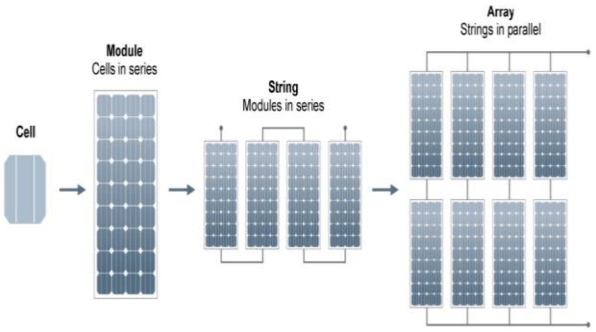

Figure 2.2: PV cell module& array

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B. Dc-Dc Converters

The Dc-Dc converters are used to convert the voltage one level to another level in regulated manner, the output voltage can be either lower or higher or both as compared to input voltage, with respect to level of changing output voltage the Dc-Dc converter are classified viz, Buck converter, Boost converter and Buck Boost converter.

III. DESIGN CONSIDERATIONS OF PROPOSED BOOST CONVERTER

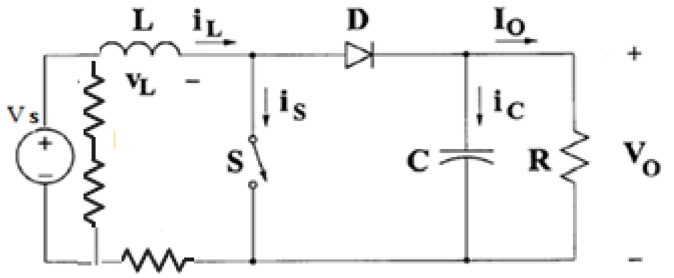

Figure 3.1 Basic diagram of DC-DC boost converter

The figure3.1shows a step up boost converter, which increase the output voltage without any use of transformer. It consist of dc voltage as input source 'V_s', inductor L it is also called boost inductor, filter capacitor 'C', diode D and power semiconducting device as switch 'S'. The power is delivered to load resistance 'R' at a higher voltage than input voltage. The control or the change of voltage can achieve by varying or changing the duty cycle of switch. There are two modes of operation of a boost converter viz, the charging mode operation when the switch is closed and discharging mode of operation when the switch is open.

A. Design Consideration Of Inductor And Capacitor

The selection of inductance and capacitance basically based on the output voltage and current required by load of a boost converter. The values of these elements are done by using the following formulae

$$L = \frac{D(1-D)^2 R}{2f} \quad \text{.................. .... (2.1)}$$

Where D is duty ratio, F is frequency in Hertz, and R is resistance in Ohm.

The Dc-Dc converter desirable to operate duty cycle as maximum as possible nearly 85% to 90%, The switching frequency of converter selecting by compromising with size of inductor and switching losses, considering this the duty ratio D=0.5 and, load resistance R = 29 Ohm and Switching frequency f = 5 KHz are chosen, The inductor L is calculated from the equation 2.1

$$L = 1.4 \text{ mH}$$

It is desirable to operate the DC-DC converter as close to the maximum duty cycle as possible the time period should be as long as possible to reduce switching losses. The tradeoffs between a longer switching period and a larger inductance,

The Capacitor 'C' value is calculated from following formulae

$$C = \frac{D}{R\left(\Delta V_0 / V_0\right) f} \quad \text{... .... (2.2)}$$

Where Vo is the output voltage and ΔV_o change in the output voltage

$\Delta V_o / V_o = 0.001$, C= 1200 µF (Electrolytic)

B. Selection Of MOSFET and power Diode

By considering the on state voltage drop as possible as low for boost converter the switching device MOSFET (IRFP 064N) is chosen and power diode which has reverse breakdown voltage is high, the switching losses are considerable reduced

C. Voltage Sensor (V_{Pv}) and Current Sensor (I_{pv})

For PV panel current sensing (I_{pv}) a resistor of 3.9Ω of 0.5W rating is used as current sensor and for input voltage V_{in} sensing a resistive divider network is used

$$V_{R2} = V_{in} \cdot \frac{R_2}{R_1+R_2} \quad \text{.............. (2.3)}$$

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Taking R_2= 1 K Ω and V_{R2} = 5V R_1 =3.2 K Ω

IV. MICROCONTROLLER (ATMEGA-8)

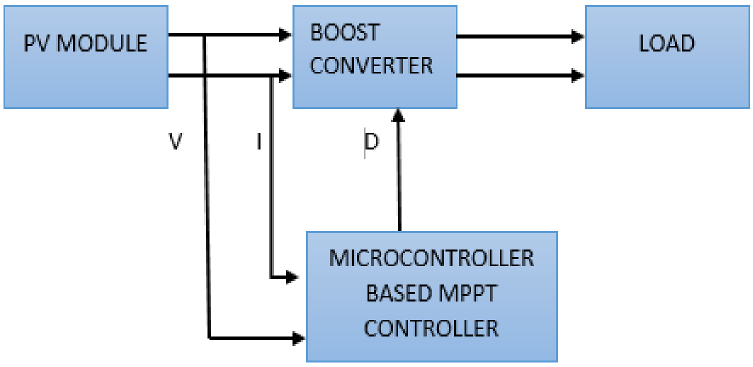

Figure 4.1.: Block Diagram of Proposed PV System

Main Sensing parameters V_{pv} and I_{pv} of the PV module are input to PORT C for ADC. Switching to Boost Converter circuit via MOSFET is controlled by PORT B. and Output Voltage is boosted based on optimized P&O Algorithm depending on the Duty Cycle (D), which is a function of the main sensing parameters V_{pv} and $I_{pv}$of PV module.

IV. SIMULATION RESULTS

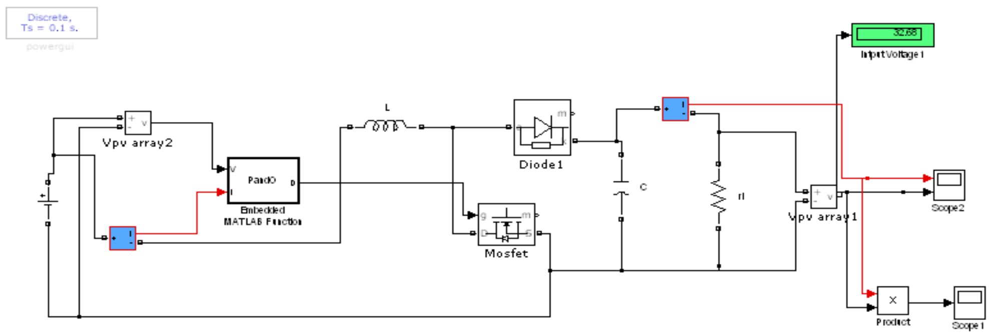

Figure 4.1: Simulink Model of Boost Converter

The fig **4.1**, shows the Simulink Model of Boost Converter,using Matlab/Simulink designed boost converter values are have been used and embedded mat lab function is used for P&O algorithm for controlling switching pulses, and fig 4.2 illustrated output simulation result of Boost Converter on Load. The load resistance of 176 Ohm, the output Voltage is boosted to 39 Volt for an input Voltage of 21 Volt.

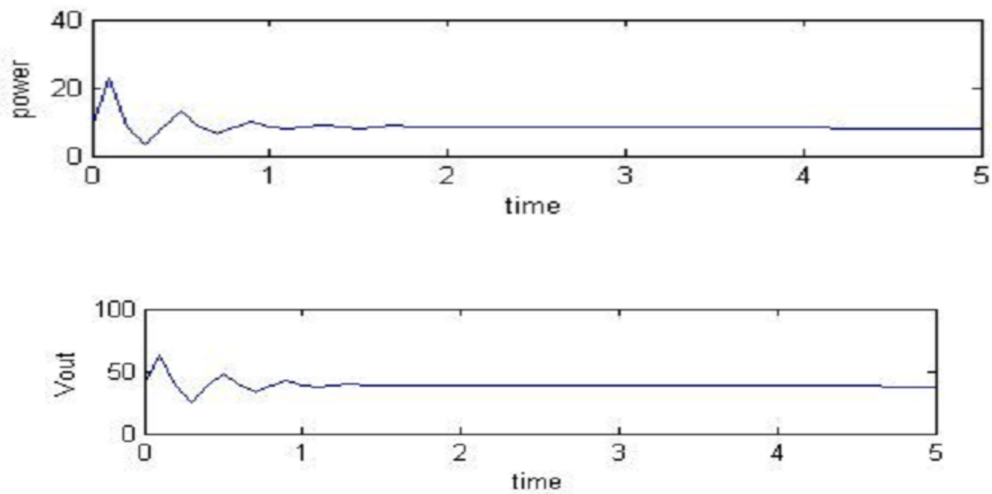

Figure 4.2 Characteristics of Boost Converter on Load

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V. EXPERIMENTAL PROTO TYPE OF BOOST CONVERTER FOR PHOTOVOLTAIC SYSTEMS

The Panel Details of photovoltaic module of WAAREE multi-crystalline silicon PV module with 10W, various parameters are from WAAREE are shown in table 5.1 and figure 5.1 illustrated Hardware Model of proposed boost converter

Table 5.1: Parameters of WAAREE WS-1O PV array at irradiance 1000W/m^2

Parameters	**Symbol**	**Typical Value**
Open circuit voltage	V_{oc}	21V
Maximum power voltage	V_{pm}	17V
Short circuit current	I_{sc}	.62A
Maximum power current	I_{pm}	.59A
Maximum power	Pm	10W
Short circuit current/Temperature coefficient	K_I	+4.4mA/°K
Open circuit voltage/ Temperature coefficient	K_V	-.123V/°K
Number of cells	-	72

This module is consists of 72 cells which are series connected

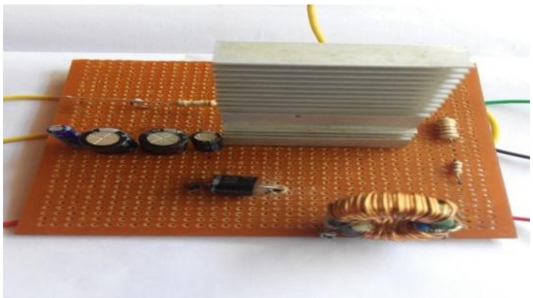


Fig.5.1 Hardware Model of proposed boost converter

The Current –Voltage and Power-Voltage characteristics of Load resistance for R_{Load} of 176 Ω have been given to Boost Converter Outputas shown in the Table 5.2. From this figure it is clearly evident that as R_{Load} increases, the panel current as well as the output power of panel also decreases.

Table 5.2 I-V and P-V characteristics for R_{Load} of 176 Ω

V_{panel}(V)	I_{panel}(A)	P_{panel}(W)	PWM	I_{load}(A)	$V_{Boosted}$(V)
18.50	0.15	2.775	0.70	0.12	22.2
18.40	0.17	3.128	1.00	0.12	23.10
18.10	0.20	3.62	1.20	0.13	24.70
17.10	0.30	5.13	1.60	0.16	28.80
16.80	0.32	5.376	1.75	0.16	29.60
16.00	0.36	5.76	1.90	0.17	30.70
14.80	**0.40**	**5.92**	**2.00**	**0.17**	**31.00**
9.60	0.43	4.128	2.40	0.14	25.30

Here it is observed that maximum power of 5.92 watts corresponding to 14.8 Volts obtained which is boosted to 31 Volts as per the Boost Converter design of inductor L=1.4mH and Capacitor C=1200 µF

VI. CONCLUSION

In this paper the author has investigated how the maximum power can be extract from PV module through the designed boost converter, The optimized P&O MPPT is developed by using microcontroller AT Mega 8 and validation has been achieved by MATLAB/Simulink.

It has been observed the controller track the optimum point where the maximum power can transfer from the source ie PV module to the load with at maximum power point (MPP) operating voltage. The paper described here is for constant load and this can be further improved to variable load by modifying algorithm.

Thus the solar panel works at MPP for any load with any value of irradiance. The design can also be extended to deliver power to AC system using a typical inverter at the output of boost converter.

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BIOGRAPHIES

Dr. Pinto Pius A J received the B.E. degree in Electrical Engineering from the Karnataka regional engineering college Mangalore (KREC) Mysore University in 1976 securing 3rd rank in the university, the M Tech degree from KREC Mangalore University in 1999 with 1st rank and awarded Ph.D by National Institute of Technology Karnataka (NITK) in 2008. He has professional with 36 years of rich and qualitative experience inclusive of 12 years in teaching. Currently, he is a Professor and head with the Electrical and Electronics Engineering Department, St.Joseph Engineering College Mangalore, and also guiding three research scholars under Visvesvaraya Technological University (VTU) Belgaum, research centre St.Joseph Engineering College Mangalore, His interests are in the areas of power distribution systems, Power electronic applications in renewable energy, Electrical machines and Electrical energy system.

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