

STAND ALONE APPLICATION OF A PHOTOVOLTAIC SYSTEM WITH AN IMPROVED INVERTER TOPOLOGY

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Abstract— The solar photovoltaic system (PV) illustrated in this paper is a standalone system with a boost converter for MPPT tracking algorithm. The system uses the Buck –Boost converter as an intermediate conversion system of DC-DC between input and load. The Bidirectional DC-DC converter is used with a battery for bidirectional power flow when the normal PV output is not available all time to meet the load demand. The proposed system uses Perturb and Observe (P&O) type MPPT algorithm for continuous monitoring of output.

Key words—PV system, buck- boost converter boost converter, bidirectional DC-DC converter.

I. INTRODUCTION

Sunlight, in the broad sense, is the total spectrum of the electromagnetic radiation given off by the Sun. The world at first has not utilized solar energy availability because of lack of knowledge about it. But the reduction in the resources of conventional energy has made the world to realize the importance of non conventional energy available and its resources. Among all the renewable energy resources the solar energy is the most prominent energy because of its easy availability and its low cost of energy conversion system from solar to electrical.

The conversion technology employed for converting the available power from the solar to ac can be performed by Variety of converters, for supplying to house hold applications the converters used in this paper are boost converter for MPPT And a buck- boost converter with a full bridge inverter for ac load application, in addition it also requires a bidirectional converter for controlling the battery. It is required to operate battery in two states of operation. I.e.to charge the battery when there is surplus power from the solar and to discharge the battery when there is low solar output.

The continuous monitoring of the available PV output is required to vary the duty character of boost converter to give a constant input to the buck-boost converter. This can be achieved by using a MPPT tracking by the P&O algorithm.

II. THE PROPOSED SYSTEM OPERATION

The power from the solar module is the most cheaply available form of renewable energy system. The solar modules as they are a cheaply available and they are available in Variety of module configurations. The availability of solar energy abundantly in various countries has made the energy consumers to utilize this solar energy by employing these available solar modules. This solar power utilization has made the world to save the depleting non renewable energy resources, which are being used from decades without the knowledge of their harmful effects to nearby vegetation.

The power from the solar system can be fed to the dc loads directly when the available output power from the PV system is sufficient to meet the load requirement without any intermediate DC-DC converters. However most of the PV systems are not employed for such high output power ratings because of the drawbacks associated with this are the PV module employed with a high power rating costs higher than the low power PV module with a DC-DC converter of same output rating, and there is also a problem of causing danger to the operating person of the PV module of high power rating.

The system uses the Boost converter after the PV system as an DC-DC converter the purpose of providing Boost converter is to step up output of the PV system output which is normally around 24V or 36V to a constant dc output the other purpose of using the boost converter is for MPPT tracking as the output from the PV is not constant and it varies with varying irradiance and operating temperature the MPPT tracking system will make the complete system to operate at a operating point that normally shows maximum output power from the PV module. The output is normally stepped to 50V DC.

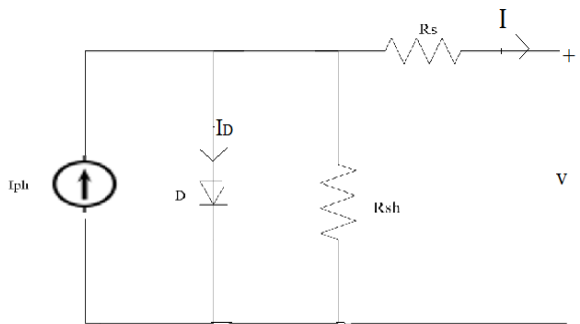
The paper also uses the Buck-Boost converter for the purpose of stepping up the voltage to a value required to meet the load demand the load is taken as a single-phase around 230V AC. The Buck- Boost converter serves the function of step-up operation or step down operation .The Buck-Boost converter steps up the voltage to a level required to meet the inverter output load demand.

The proposed system uses the full bridge inverter for converting the DC output voltage to AC form. The unipolar SPWM technique is used for providing the gate pulses to the inverter switches. The full bridge inverter provides a full control of the AC output voltage in both the cycles.

The bidirectional DC-DC converter used in this system provides the power to the Buck-Boost converter from a battery when the power from the PV integrated boost converter is unable to meet the Buck–Boost converter input power requirement. The same bidirectional converter is used in charging the battery when the solar output is around MPPT.

The battery is not allowed to charge or discharge around a value, the maximum charging value called as I_{bmax} and the minimum discharge value called as I_{bmin} .

III. Photovoltaic cell equivalent circuit:



PV module represents the fundamental power conversion unit of a PV generator system. The output characteristics of a PV module depend on the solar isolation, the cell temperature and the output voltage of the PV module. Since PV module has nonlinear characteristics, it is necessary to model it for the design and simulation of maximum power point tracing for PV system applications.

IV. Photovoltaic module equations:

$$V_{PV} = V_{OC}, \quad N_P = 1 \text{ and } N_S = 36$$

. The module photo current;

$$I_{ph} = [I_{scr} + K_i(T-298)] \lambda / 1000 \quad (1)$$

Module reverse saturation current

$$I_{rs} = I_{scr} / [\exp(qV_{oc}/N_S AKT) - 1] \quad (2)$$

The module saturation current I_O varies with cell temperature, which is given by

$$I_o = I_{rs} [T/T_r]^3 \exp[q*E_{go}/Bk] \{1/T_r - 1/T\} \quad (3)$$

The current output of PV module is

$$I_{pv} = N_P * I_{ph} - N_P * I_o [\exp\{q*(V_{PV} + I_{PV} R_s)/N_S AKT\} - 1] \quad (4)$$

PV module characteristics:

Temperature	Radiation	V_{pv}	I_{pv}
25	0.2	20	0.5
50	0.4	36	1.5

Equations for Boost converter design:

$$\text{The Inductor (L)} = V_{in} * D / F * \Delta I_L \quad (5)$$

$$\text{Duty ratio (D)} = 1 - V_{in} / V_{out} \quad (6)$$

Inductor ripple current,

$$(\Delta I_L) = V_{in} * D / F_s * L \quad (7)$$

$$\text{Capacitor (C}_{out}) = I_{out} * D / F_s \Delta V_O \quad (8)$$

Capacitor ripple voltage (ΔV_o) =

$$ESR * [(I_{out} / (1-D)) + (\Delta I_L / 2)] \quad (9)$$

Where D is the duty ratio and F_s is switching frequency

Parameters used in simulation study of boost converter:

Inductor(L_{PV})	2mH
Capacitor(C_{PV})	2000 μ F
Switching device	MOSFET
Switching frequency (F_s)	15KHz

Operating values of boost converter:

Input voltage(V_{in})	Duty ratio(D)	Output voltage(V_o)
36	30%	60
36	25%	50

A. Equations for Buck boost converter design:

$$\text{Output voltage } (V_o) = D \cdot V_{in} / (1-D) \quad (10)$$

$$\text{Inductor } (L_o) = (1-D) V_o / (\Delta I_{L_o}) F_s \quad (11)$$

$$\text{Capacitor } (C_o) = D / \{(R F_s) (\Delta V_{C_o} / V_o)\} \quad (12)$$

Parameter used in simulation study of Buck-Boost converter with Full bridge inverter:

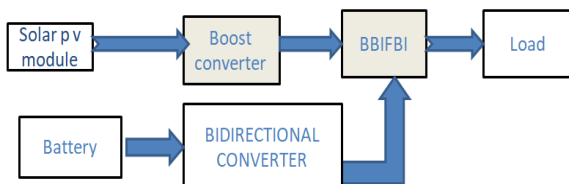
Parameter	Ratings
Inductor (L)	6mH
capacitor(C_{dc})	2700 μ F
capacitor(C)	2000 μ F
Switching device	MOSFET
Switching frequency F_s	1 KHz
Inductor(L_f)	2mH
Capacitor(C_f)	5 μ F
Battery	36V
Inductor (L_b)	2mH

Buck –boost integrated full bridge inverter operating values:

Output voltage of BB converter(v_{ob})	Duty ratio(D)of BB converter	Inverter output voltage (V_o)
350(V)	75%	300
330(V)	65%	280
300(V)	55%	230

V. BLOCK DIAGRAM OF PROPOSED SYSTEM:

The blocks below shows the complete circuit blocks of the presented PV system along with the other connected blocks.



VI. SCHEMATIC DIAGRAM OF THE PROPOSED SYSTEM:

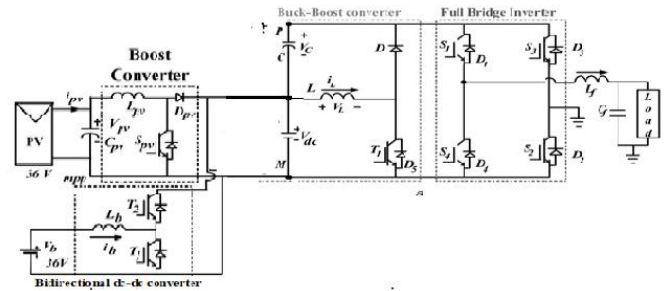
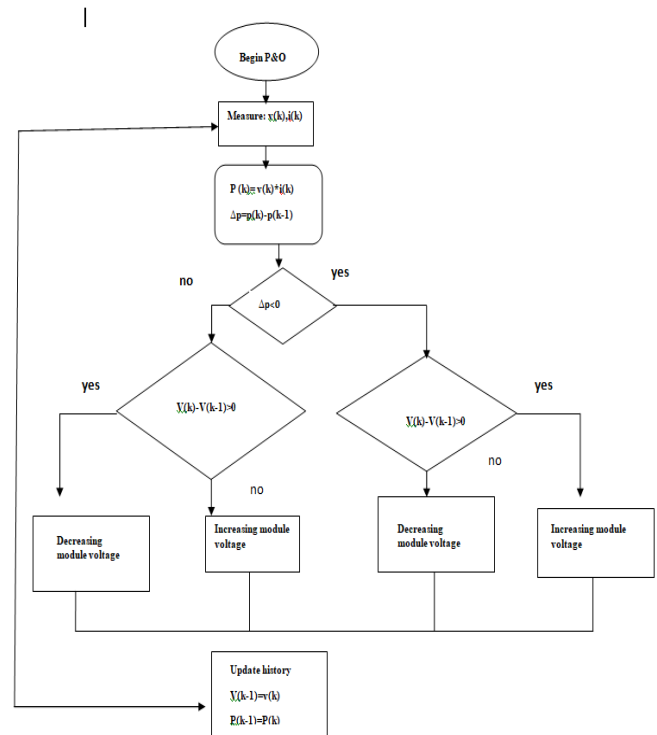


Figure 1. Proposed converter circuit

The above circuit shows the complete schematic circuit for the proposed system the full bridge inverter formed by four switches s1–s2 and having p and m as input to it from a boost converter gives an output as V_{dc} . Thus it can be observed as a combination of full bridge inverter connecting its input to a boost converter, having input source connected between p terminals and m. The process of combination of the two converters leads to the evolution of the proposed converter in this converter, the switches s1 and s4 are shared by both buck-boost converter and the full bridge inverter. The diode D is employed to ensure that the power flow through the buck-boost converter segment is unidirectional.

VII FLOW CHAT FOR THE IMPLEMENTATION OF P&O ALGORITHM



VIII SIMULATION MODEL OF THE PROPOSED SYSTEM

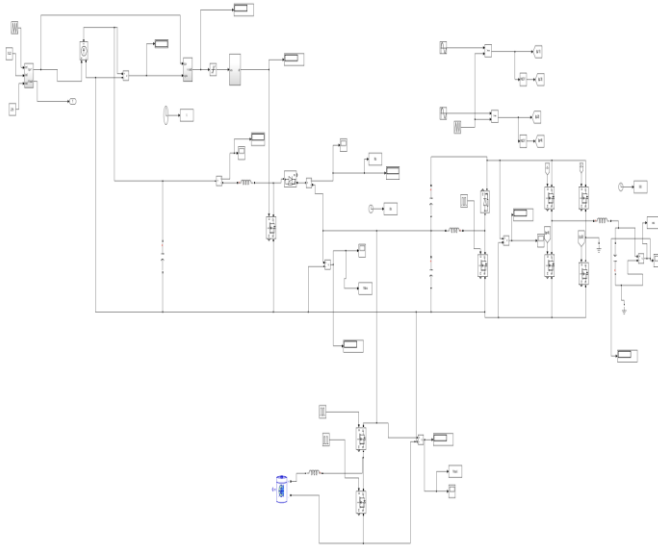


Figure 2 mat lab simulink model of the connected circuit

IX . SIMULATION RESULTS

PV array characteristics:-

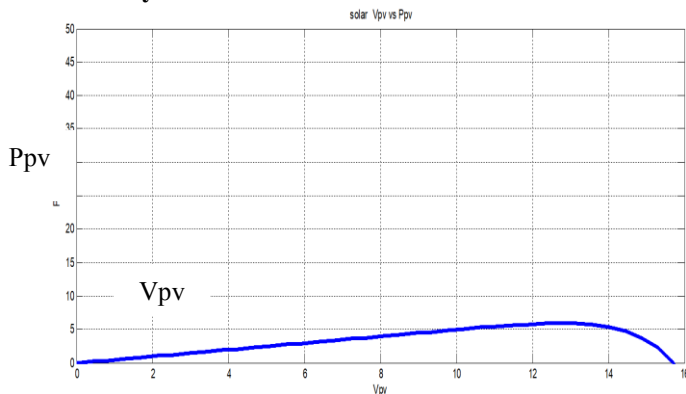


Figure 3 voltage vs. power

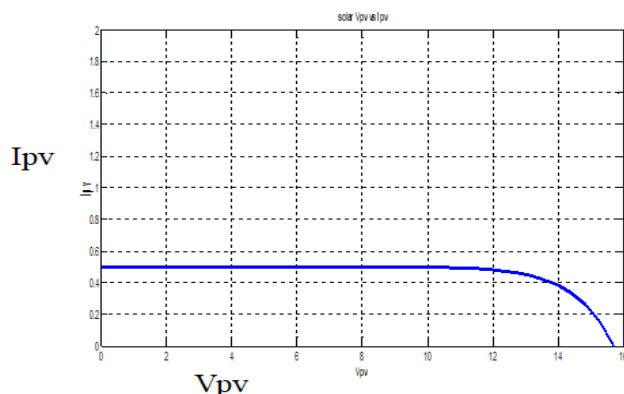


Figure 4.mat lab graph of voltage vs. current

Boost converter:-

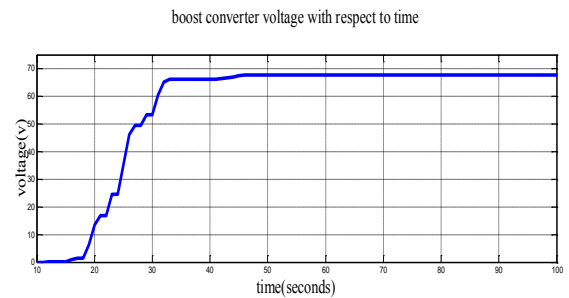


Figure 5. matlab simulink boost converter output voltage vs. time

Buck -boost integrated full bridge inverter:-

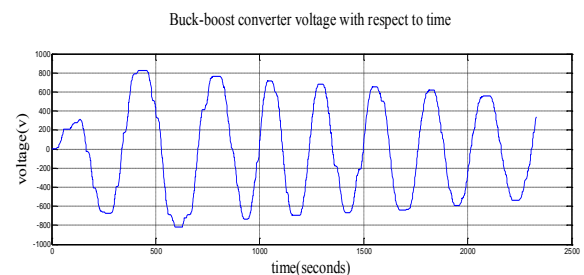


Figure 6.mat lab simulink Buck-boost integrated full bridge inverter output voltage vs. time

Bidirectional DC-DC converter:-

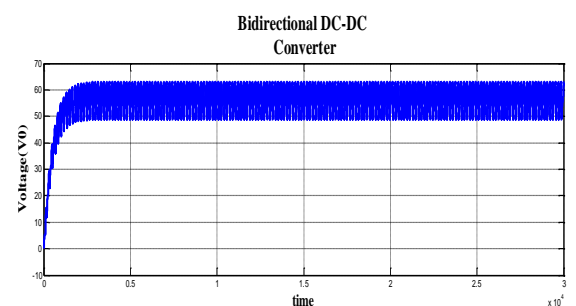


Figure 7.mat lab simulink of .bidirectional output voltage vs time

x. CONCLUSION

A solar PV-based stand-alone system utilising a Buck-boost type inverter is shown in this paper. This Buck- boost converter is operated in both buck mode and boost mode. The output of this Buck boost converter is connected to full bridge inverter .The gate pulses to the inverter is provided by the unipolar SPWM technique. The boost converter used in this paper is for MPPT tracking algorithm with Perturb and observe (P & O) algorithm is used for MPPT. The bidirectional DC-DC converter provides bidirectional power flow between battery and the circuit. The control structure of the overall stand-alone scheme is obtained and is presented through detailed simulation studies.

XI. REFERENCES

- [1] Lin, C.-C., Yang, L.-S., Wu, G.W.: 'Study of a non-isolated bidirectional DC-DC converter', IET Power Electron., 2013, 6, (1), pp. 30-37
- [2]Debnath, D., Chatterjee, K.: 'A buck-boost integrated full bridge inverter for solar photovoltaic based stand-alone system'. Proc. IEEE photovoltaic Specialists Conf., June 2013, pp. 2867-2872
- [3]Ribeiro, H., Borges, B., Pinto, A.: 'Single-stage DC-AC converter for photovoltaic systems'. Proc. IEEE Energy Conversion Congress and Exposition, 2010, pp. 604-610
- [4]Wu, W., Ji, J., Blaabjerg, F.: 'Aalborg inverter – a new type of “buck in buck, boost in boost” grid-tied inverter', IEEE Trans. Power Electron., 2015, 30, (9), pp. 4784-4793
- [5]Minh-Khai, N., Tuan-Vu, L., Sung-Jun, P., et al.: 'Class of high boost inverters based on switched-inductor structure', IET Power Electron., 2015, 8, (5), pp. 750-759
- [6]Chen, Y.M., Huang, A.Q., Xunwei, Y.: 'A high step-up three-port dc-dc converter for stand-alone PV/battery power systems', IEEE Trans. Power Electron., 2013, 28, (11), pp. 5049-5062
- [7] Matsuo, H., Kurokawa, F.: 'New solar cell power supply system using a boost type bidirectional dc-dc converter', IEEE Trans. Ind. Electron., 1984, 31, (1), pp. 1118-1126.
- [8]I. H. Altas and A.M. Sharaf, "A Photovoltaic Array Simulation Model for Matlab-Simulink GUI Environment," IEEE, Clean Electrical Power, International Conference on Clean Electrical Power (ICCEP '07), June 14-16, 2007, Ischia, Italy
- [9]N Pandiarajan and R Muthu. "Mathematical modelling of photovoltaic modules with Simulink". 2011, pp. 258-263
- [10]Altamir Ronsani and Ivo Barbi, "Three-phase single stage AC-DC buck-boost converter operating in buck and boost modes" in Proc. IEEE, 2011, pp. 176-182..
- [11]M. Orellana, S. Petibon, B. Estibals, and C. Alonso, "Four Switch Buck-Boost Converter for Photovoltaic DC-DC power applications," in IECON 2010 - 36th Annual Conference on IEEE Industrial Electronics Society, 2010, pp. 469-474.