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SOLAR AIR COOLER WITH MPPT TECHNIQUE AND BATTERY STORAGE FOR IMPROVED EFFICIENCY AND POWER STORAGE

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ABSTRACT Nowadays world energy demands are increasing, but fossil fuels are depleting. This leads to increase interest on alternative sources like solar, wind, tidal etc. Solar energy is a best alternative for conventional non-renewable energy source, so the application of solar PV is increased. This paper deals the idea of solar PV source using developing standalone air cooler system by considering the improving of life, reduce maintenance and better performance. This system is usable in country zones that have a lot of solar radiation and have no access to grid system. This system consists of a PV array, DC-DC boost converter, Perturb and Observe (P&O) MPPT, Bidirectional converter with battery and Load. The photo-voltaic array is associated with P&O that guarantees maximum power point operation. The proposed air cooling system is intended to acquire satisfactory system execution and performance even under dynamic conditions. Introducing a storage unit such for store the electric energy form the solar PV. This overcomes the disadvantage that the system can't work in night time or in the absence of solar irradiance. Appropriateness of the proposed system for different bothers is assessed by simulating the proposed framework by using MATLAB/Simulink.

KEYWORDS : Solar PV, Boost converter, Perturb and Observe (P&O), bidirectional converter

INTRODUCTION

The rate of energy utilization expanding quickly because of the expanding in population, industrialization and transportation, so the supply is draining because of the obliteration of fossil fuels. This cleared to investigate other accessible renewable sources, such as wind, solar, tidal. Among all the renewable sources solar is most inexhaustible and the effective use of this energy can fulfill the energy demand of the world. The decrease in the expense of power electronic devices and solar panels in the ongoing years leads expanded solar photo-voltaic based generation for industrial, household and modern applications. There are a few looks into have been completed on PV array fed automotive and irrigation systems frameworks consolidating different DC-DC converters and motor drives, however less work has been done on PV based home applications. Tracking the maximum power point (MPP) of a photovoltaic (PV) array is normally a essential process of a PV system. All things considered, numerous MPP tracking (MPPT) techniques have been created and actualized. The techniques change in intricacy, sensors required, combination speed, cost, scope of effectiveness, execution of equipment, popularity, and in other regards. The Perturb and Observe (P&O) based maximum power point tracking (MPPT) algorithm is utilized to control the DC-DC converter for the solar PV system dependably operate at its MPP. In this paper, a DC-DC bidirectional converter is used to drive the load by consuming energy from PV array. The reason behind of choosing this converter is its essential properties of less switching, better efficiency due to less smaller number of components and the input current is constant which is entirely desirable for sources like PV or battery. The other topologies of DC-DC converters have large number of components which results in the efficiency degradation, high cost, weight and size. These issues encourage to use a boost converter in this work. This system is only works at the presents of solar energy that means it doesn't works in night and absence of solar irradiance. This is a drawback is overcome by introducing a storage device for storing the electric energy obtained from the solar irradiance. This stored energy can be use in the night time and absence of solar irradiance.

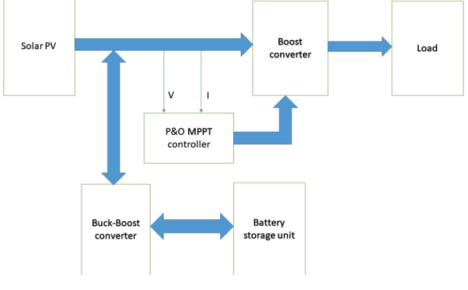


Figure 1: Solar based air cooler with MPPT and battery storage

MODELLING OF PV SYSTEM

The solar cells are low-voltage and high current generating devices. The equivalent circuit of a solar cell in figure 2. Here a diode is connected in parallel with the current source having shunt and series resistance. Iph is the generated current source,

$$I = I_{ph} - I_s[\exp(\frac{q(V+IR_s}{kT_cA} - 1] - \frac{V+IR_s}{R_{sh}} \quad (10)$$

$$I_{ph} = [I_{sc} + K_i(T_c - T_{ref})] \quad (11)$$

$$I_{rs} = \frac{I_{sc}}{\exp(\frac{qV_{oc}}{N_skAT_c}) - 1} \quad (12)$$

$$I_s = I_{rs}(\frac{T_c}{T_{ref}})^3 \exp[\frac{qE_g(\frac{1}{T_{ref}} - \frac{1}{T_c})}{kA}] \quad (13)$$

Where K: Boltzmann constant (K1= 1.38×10-23J/K). n: diode quality factor Rs: lumped series resistance. Rsh: lumped shunt resistance. Q: charge of the electron (q=1.6×10-19C) Is: reverse saturation current, Tc: temperature of the operating cell (°C), V: Open circuit PV voltage.

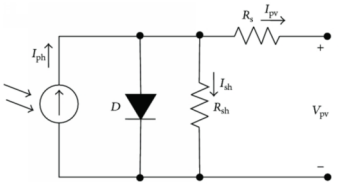


Figure 2: Equivalent circuit design of Single diode model of solar cell

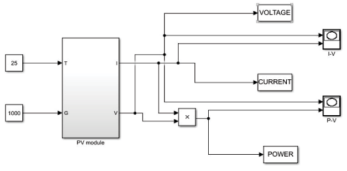


Figure 3: MATLAB model of PV system

TABLE – 1 PV SPECIFICATIONS

Parameters	Value
Cell's short circuit current, I_{sc}	8.1 A
Max power	121.5 W
Open circuit voltage, V_{oc}	20 V
Voltage at maximum power point, V_{mp}	16.2 V
Current at maximum power point, I_{mp}	7.5A

P&O MAXIMUM POWER POINT TRACKING ALGORITHM

Perturb and observe is the most regularly utilized MPPT method because of its simplicity of execution. Perturb and observe method may result in best dimension efficiency, gave that an appropriate prescient and versatile hill climbing system is adopted. In this method the controller alters the voltage just barely from the array and measures power; if the power increases, further alterations toward that path are attempted until power never again increases. Perturb and Observe method and is most common, although of the fact that this method can result in oscillation of power yield. It is referred to as a hill climbing method, because it depends on the rise of the curve of power against voltage below the maximum power point, and the fall over that point. In this algorithm a slight perturbation is acquainted with the framework. This perturbation causes the power of the solar module different. If the power increases due to the perturbation increments then the perturbation is continued in the same direction. After the peak power is achieved the power at the MPP is zero and the next instant decreases and consequently after the peak power is reached reverse. At the point when the steady condition is arrived the algorithm oscillates around the peak power point. In order to maintain the power variation the perturbation remains same. The technique is advanced in such a style, that it sets a reference voltage of the module comparing to the peak voltage of the module. A PI controller at that exchange the operating point of the module to that specific voltage level. It is observed some power loss because of this perturbation also it fails to follow the maximum power under quick changing atmospheric conditions. In any case, remain this strategy is extremely well known and straightforward. Fig.4 shows the flow chart of P&O MPPT.

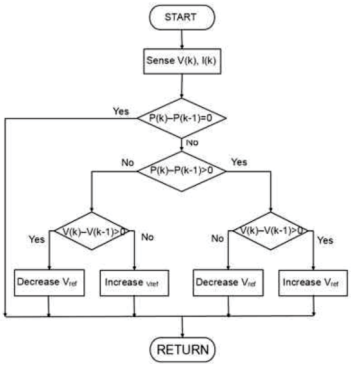


Figure 4: Flow chart of Perturb and Observe MPPT

DESIGN OF BOOST CONVERTER

A boost converter is a DC to DC converter that provides an output voltage greater than the source voltage. So it is also known as step-up converter or boost converter. Since power must be conserved, in this case the output current is lower than the source current. This type of converter can also be operated in continuous or discontinuous conduction mode depending up on the operating conditions. This converter is mainly used in regulated dc power supplies and regenerative breaking of dc motors. The operation of the boost converter circuit Fig.5 depending on whether the switch is ON or OFF.

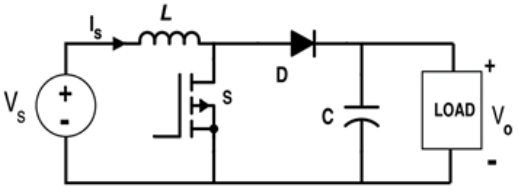


Figure 5: Equivalent circuit of Boost converter

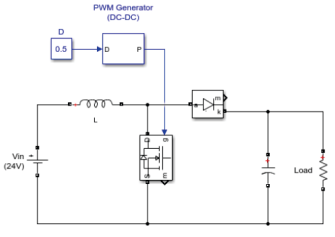


Figure 6: Modelling of Boost converter

TABLE – 2 BOOST CONVERTER SPECIFICATIONS

Variables	Value
Input Voltage V	24 V
Output Capacitor, C_2	700F
Inductance, L	355.3e^{-6}mh
Switching Frequency	20kHz
Load, R	23ohm

DESIGN OF DC-DC BIDIRECTIONAL CONVERTER

A Bi-directional converter is something where power can stream at both sides. That means it can feed power to the load and the load can also return the power back to the source. A bi-directional dc-dc converter is shown Fig.6

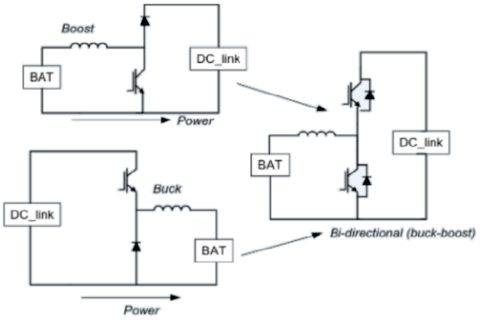


Figure 7: Bidirectional Buck-Boost converter

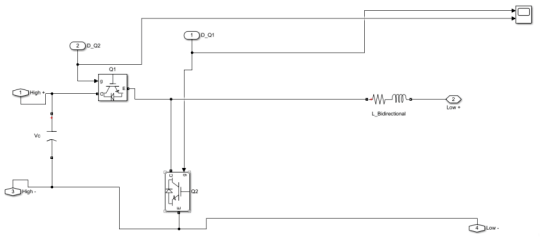


Figure 8: Simulation block of Bidirectional Buck-Boost converter

SIMULATION RESULTS

The following graph shows the simulation results in MATLAB. Figure 9&10 shows the V-I characteristics and P-V characteristics of solar PV. The designed PV panel has a current of 7.5A and a voltage of 20V.

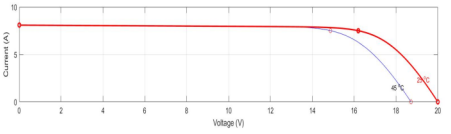


Figure 9: V-I Characteristics of PV

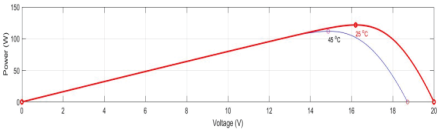


Figure 10: P-V Characteristics of PV

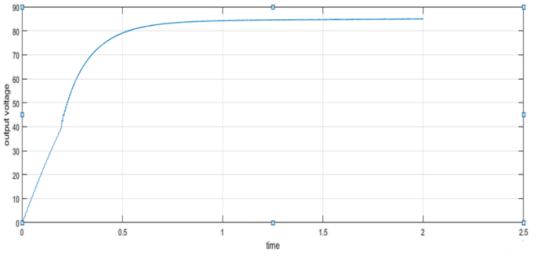


Figure 11: Output of Boost converter

Fig.11 indicates the output voltage curve of solar panel fed boost converter. The output voltage is obtained up to 85V.

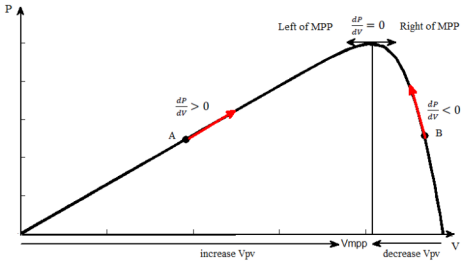


Figure 12: P-V graph of P&O MPPT

The voltage (V) versus Power (P) curve is indicates in fig.12.

CONCLUSIONS

In this paper, the modeling and simulation of solar PV, Perturb & Observe MPPT Algorithm and Boost converter was done. Implementation of this system done and the performance of solar panel fed boost converter with P&O MPPT is verified by using Matlab/Simulink Software and simulation results are presented.

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