IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE)
e-ISSN: 2278-1676,p-ISSN: 2320-3331, Volume 10, Issue 4 Ver. I (July – Aug. 2015), PP 77-81
www.iosrjournals.org

A Comparative Approach of Selecting a Suitable Power Conditioner for Photovoltaic Power Systems

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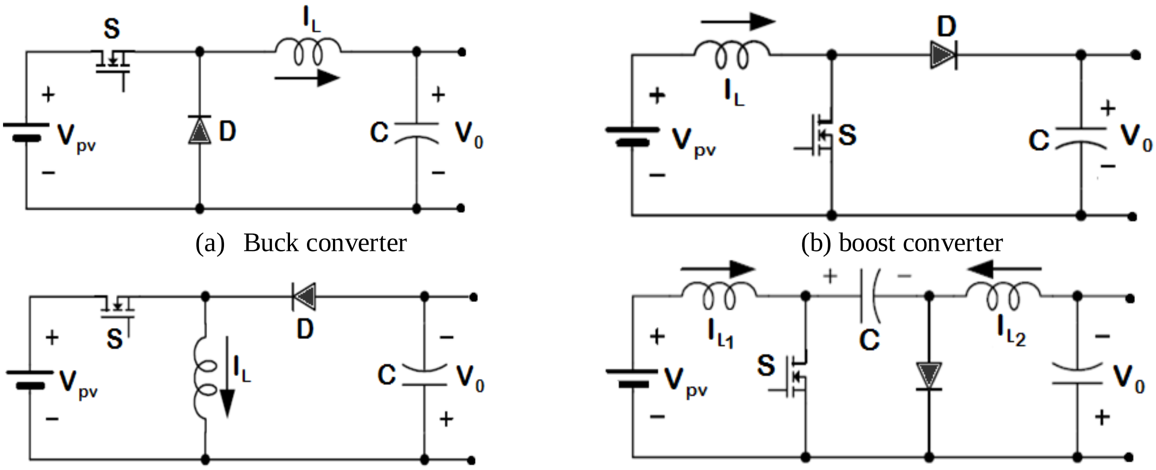
Abstract : *This research findings mainly focus on choosing a suitable power converter as a Photovoltaic (PV) interface. The standalone PV power systems mainly rely on the converter topology which basically supports Maximum Power point Tracking (MPPT) ability for extracting required power output in order to meet the load demand. Comparing both the buck and boost converter circuits which belong to the non-isolated converter family, is of primary focus of this paper to enhance the power harvesting capability of PV systems. Simulation results are shown to illustrate the purpose of using the boost converter by representing its output voltage tracking along with power output. The probability of using a boost converter circuit as PV interface is clearly explained by showing its suitability in non-uniform temperature and insolation conditions.*
Keywords - *MPPT, Non-isolated converter, PV interface, Power harvesting, Voltage tracking.*

I. Introduction

The Photovoltaic (PV) power system is considered to be one of the reliable technologies to reach the energy demand. It is well known fact that, solar energy is abundantly available and it has to be utilized for compensating the electricity crisis. Standalone PV systems are extensively employed in the areas where power transmission through cables is practically not feasible. But for the sustainability of standalone systems, it is essential to choose suitable components as PV interface. For simplicity reasons, it is better to choose commonly used simple non-isolated converters namely: buck or boost converters in order to enhance power extraction from PV system[1]. Keeping in view, the design aspects and economic constraints, it is better developing a standalone PV system with the above mentioned converter topologies. However, based on technical point of view, for ensuring continuous input current flow to the load, it is convenient option to select boost converter as PV interface as it enhances the voltage profile of the load as well [1],[2]. The following sections describe the complete schematic diagram of the system considering both the converters. The simulation has been done in MATLAB/SIMULINK software.

II. Selection of Converter Topology

The converters basically are of two types namely: Isolated and Non-isolated converters. The isolated converters are used in high power applications. It mainly consists of a transformer circuit which isolates the input and output circuit. But for low power applications, it is convenient to employ a non-isolated converter. There exist many commercially available non-isolated converters like buck, boost, buck-boost, sepic, cuk, and bidirectional converters with different configurations.



(a) Buck converter (b) boost converter

(c) Buck-Boost Converter (d) Cuk Converter

Fig. 1. Different non-isolated converter topologies for PV applications

The commonly used non-isolated converters for Photovoltaic applications are depicted in Fig. 1. Among all these available converters, buck and boost converters are simple to design and cost effective. The other converters are having few drawbacks like inverted output voltage, high cost implementation and circuit becoming bulky. Hence, Boost converter is considered owing to its advantages. The photovoltaic interface helps in optimizing the function of MPPT. The MPPT algorithm can be implemented in either digital or analog domain [3],[4],[5].

Based upon the MPPT algorithm, a duty ratio is generated and it is given as switching pulses to the converter switch. By varying the duty ratio (D), the output of converter is varied. Desired output whether low or high is obtained at the converter load terminals. For Buck converter, the output voltage is reduced and for boost converter, the output voltage is enhanced.

III. MODELING OF PV AND BOOST CONVERTER BASED SYSTEM

The block diagram of standalone PV system along with a boost converter is considered in this paper which is shown in Fig. 2. The main advantage of this type of architecture is that, continuous input current will flow to the load i.e. continuous power supply to the load is ensured. The duty ratio (D) is obtained from MPPT algorithm and pulses are generated, thereby given to the switch (S).

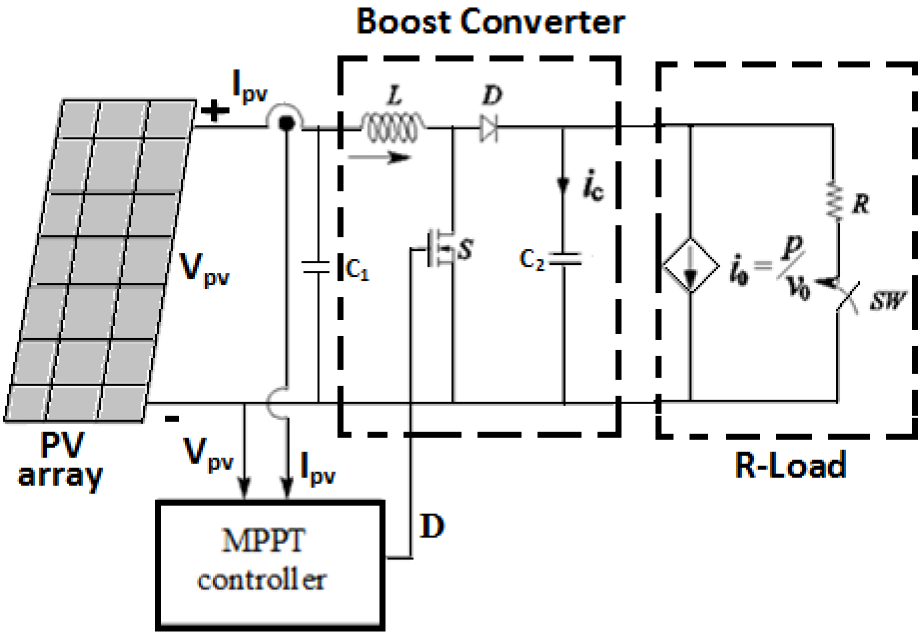


Fig. 2. Block diagram of PV array with Boost converter structure

Among several MPPT methods available in the literature [6], Perturb & Observe (P&O) MPPT method and Incremental Conductance (InC) MPPT Method became so popular because of their simple implementation. In this paper, Inc method is selected because of its better accuracy when compared to P&O method [7]. The design parameters are summarized below in Table. 1. The values of input capacitance, output capacitance and inductor are specified. The output voltage and output current of PV array is given as input to the boost converter. Clearly from simulation results it is observed that, the output voltage of boost converter is increased from 17.1V to 24.9V. The MPPT algorithm is tracking better and operating the PV array at that maximum power point (MPP) i.e. (17.1V, 3.5A). The product of Vmpp and Impp gives Power at MPP which is obtained as 60W.

Table. 1. Design parameters considered and output values obtained

PARAMETER	BOOST CONVERTER
Input voltage and current from PV array to the DC-DC converter	17.1V (Vmpp), 3.5A (Impp)
Output voltage	24.9V, 3.5A
Output power	60W
Inductor value	208.9e-6 H
Input Capacitor value (C_1)	10.44e-6 F
Output Capacitor Value (C_2)	60.58e-6 F

IV. SIMULATION RESULTS

The simulation has been performed in MATLAB/SIMULINK environment. The results mainly explain about the MPPT tracking of voltage (Vmpp) and current (Impp) to maintain these two values constant for the purpose of extracting maximum power as shown in Fig. 3 and Fig. 4. The output voltage and output power of boost converter are shown in Fig. 5 and Fig. 6. Also, the simulation has been shown under non-uniform temperature and insolation conditions which are depicted in Fig. 7 and Fig. 8 respectively. It is observed that, as temperature is increasing the power value is decreasing as shown in Fig. 8. Also, if the insolation value is increasing then there is increase in output power as shown in Fig. 7.

The simulation results are shown below:

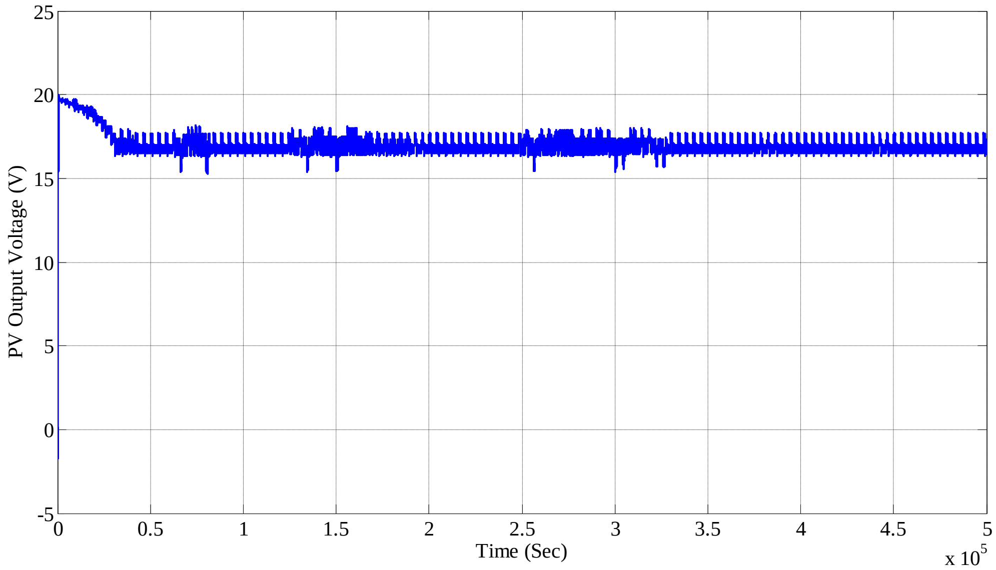


Fig. 3. PV output Voltage (Vmpp) Tracking

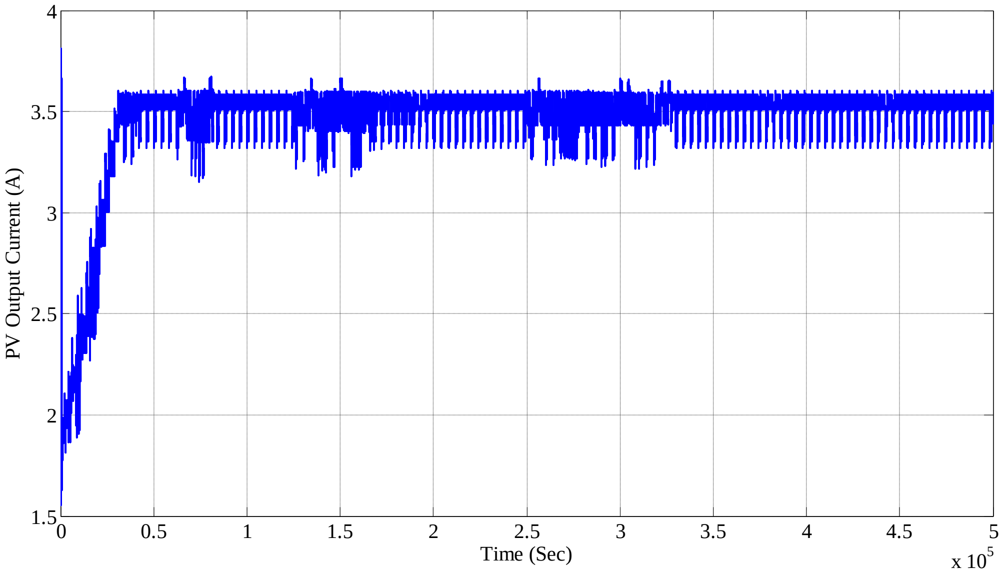


Fig. 4. PV Output Current (Impp) Tracking

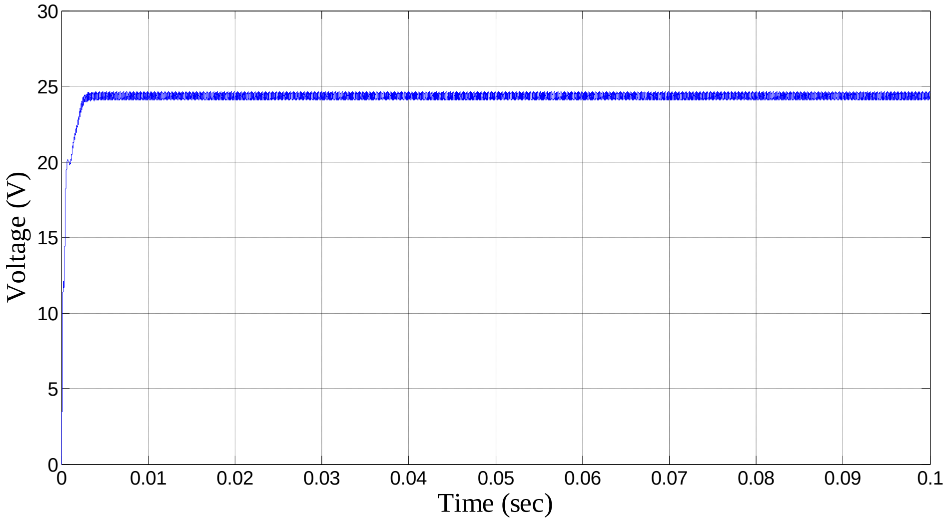


Fig. 5. Output Voltage of Boost Converter

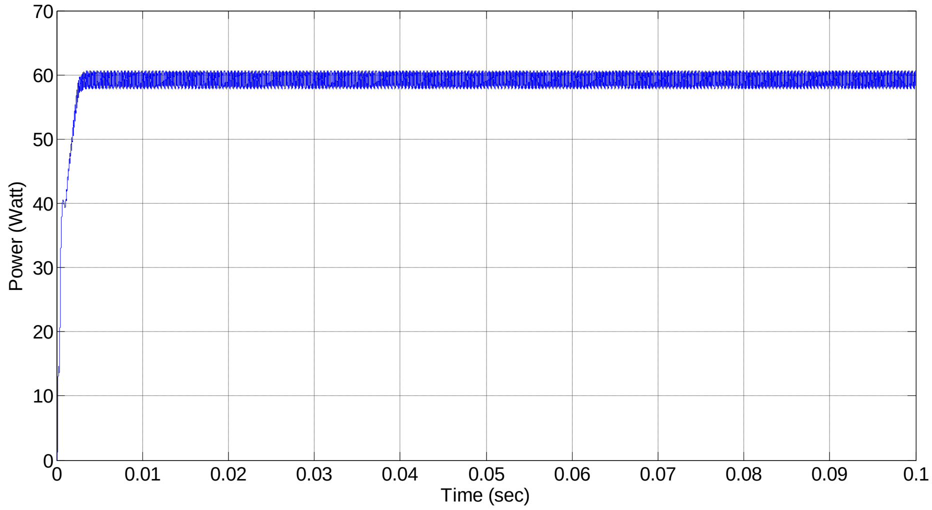


Fig. 6. Output Power of Boost Converter

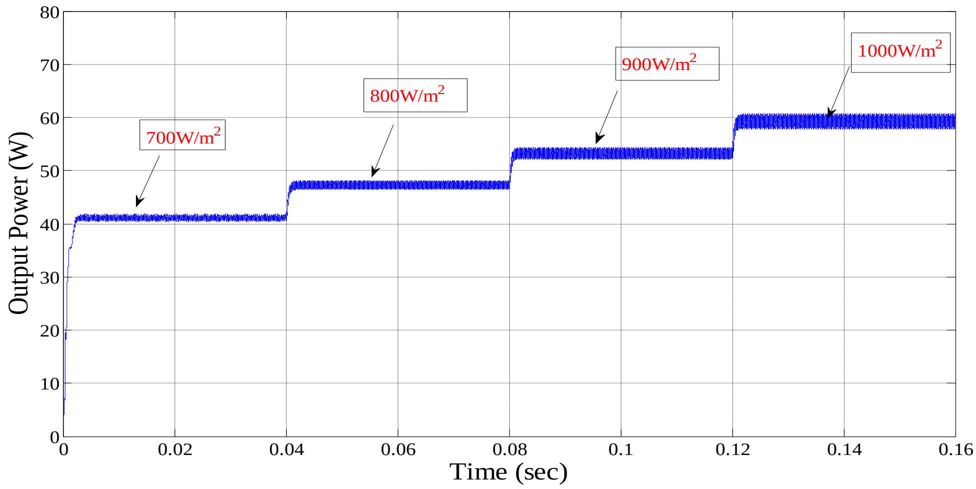


Fig. 7. Output Power of Boost Converter at different insolation values

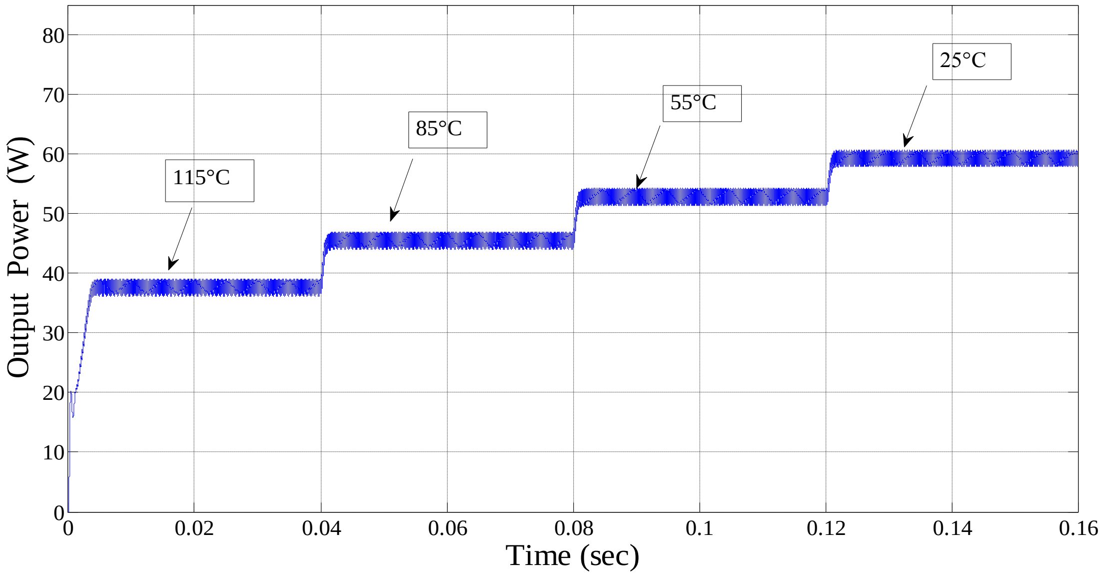


Fig. 8. Output Power of Boost Converter at different temperature values

V. CONCLUSION

In this paper, the merits of choosing boost converter as PV interface is explained with the aid of simulation results. The boost converter is facilitating the MPPT process by tracking Vmpp and Impp in a better manner. Even at different temperatures and solar irradiation values, the boost converter allowing the MPPT algorithm to track the voltage and current by keeping these values constant at all the instants of time. Thus, boost converter can be employed as power conditioner in order to enhance the output voltage at the load terminals and to meet the load requirement.

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