TEST Engineering & Management

March - April 2020
ISSN: 0193-4120 Page No. 2002 - 2005

A Simulation Study of DC to DC Converter Topology suitable For Photovoltaic Interface

S. Masum Basha[1], Dr.K. Nagaraju[2]
[1](*Research Scholar, JNTUA, Anantapuramu*)
[2]*Professor, Department of EEE, ST. Johns College of Engineering and Technology, Yemmigannoor, AP, INDIA)*

Article Info
Volume 83
Page Number: 2002 - 2005
Publication Issue:
March - April 2020

Article History
***Article Received**: 24 July 2019*
***Revised**: 12 September 2019*
***Accepted**: 15 February 2020*
***Publication**: 18 March 2020*

Abstract
The DC-DC Converter topology is considered to be the important and most convenient circuit interfacing option for the Renewable Energy related applications. Enhancing the Efficiency of the non-conventional Energy based System is of the major concerns in recent days. Keeping in view of the fact that, there shall be rapid extinction of fossil fuels in coming nearby years, it is very crucial aspect to study about the renewable energy based interfacing circuitry which is suitable for facilitating MPPT as well as other related applications to Photovoltaic systems. As far as Renewable Energy Systems is concerned, the DC-DC converter topology should facilitate the energy harvesting option to the maximum extent which should be extracted from PV Array respectively. The DC-DC Converter along with Solar Photovoltaic Array connecting the Load is simulated in MATLAB/SIMULINK Environment. The comparison between the buck and boost converter topologies which is connected as photovoltaic interface to PV array is presented in this paper.

Keywords: *dc-dc converter, efficiency, energy harvesting, photovoltaic interface.*

I. Importance of DC-DC converter topology

The Standalone photovoltaic systems necessarily require a dc-dc converter option [1] in order to ensure the photovoltaic interface with Photovoltaic (PV) array in order to maximize the energy generation and optimization of energy output from photovoltaic array. Many researchers have already been examined and analyzed the importance of investigating the best suited dc-dc converter circuit [2] which specifically supports the proper functioning of entire standalone or Grid connected Photovoltaic system. This implies that, this research domain has particularly got huge potential in order to explore further. The main idea of this paper is to study and investigate the two basic modes of dc-dc converter operation i.e. buck as well as boost modes of converter operations. The buck mode of operation basically explains about the charging phenomenon where in the boost mode of operation basically tells about the discharging phenomenon. Section I is all about a brief introduction regarding importance of dc-dc converter topology. Section II describes about the dc-dc converter circuits which are suitable for PV systems and comparing their voltage and current parameters. Section III explains about the block diagram of standalone photovoltaic array system. Section IV throws light on the single diode PV array model. Section V deals with the MPPT algorithm employed in the simulation process and Section VI deals with the simulated results and followed by conclusion as well as reference sections.

II. DC-DC Converter Suitable for Photovoltaic systems

It is well known fact that, the dc–dc converter allows the power flow to the load by

March - April 2020
ISSN: 0193-4120 Page No. 2002 - 2005

acting like an interface between PV array and load in particular. The converter plays a vital role in extracting the maximum power from PV array [3] and further effectively managing the power flow among PV source and load. In Fig. 1, the buck dc-dc converter is represented. In Fig. 2 boost dc-to converter is shown. The topologies shown in Fig 1 and Fig. 2 have their own advantages and disadvantages. But according to authors in [4], the topology represented in Fig. 2 is having more merits when compared to Fig. 1 respectively.

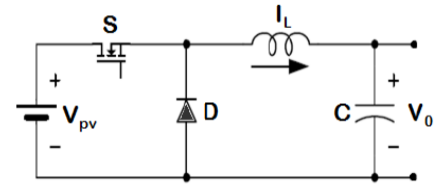

Fig.1. Buck dc-dc converter topology used in PV systems

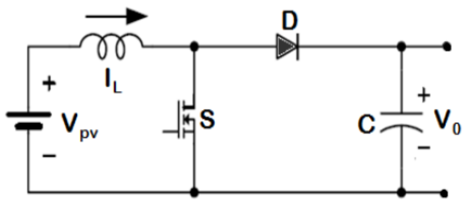

Fig.2. Boost dc-dc converter topology employed for PV systems

Both the converters represented above are belonging to category of non-isolated converters. The non-isolated converters require less power consumption, since they do not require a transformer in their circuitry. When the converter interfaces with a transformer, then that particular converter is referred as isolated converters. The isolated converters are useful in high power applications where as the non-isolated converters are applicable for low power applications. The commonly employed non-isolated converters for Photovoltaic applications are buck or boost converters because of their design simplicity and cost effectiveness.

III. Block Diagram Of Standalone PV array System

The block diagram of standalone PV system along with the converter circuit is depicted in Fig. 3. The converter usually will generate the duty ratio (d) such that, the load voltage and output power could be controlled and varied owing to the required power requirement.

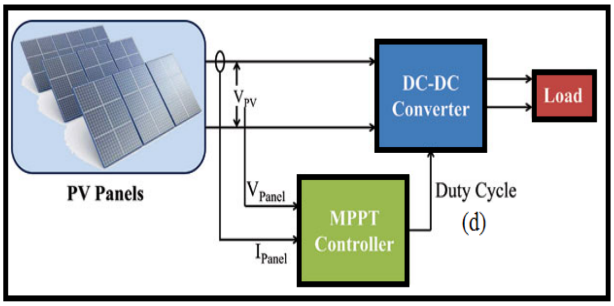

Fig.3. Block diagram of Standalone PV array with dc-dc converter interface

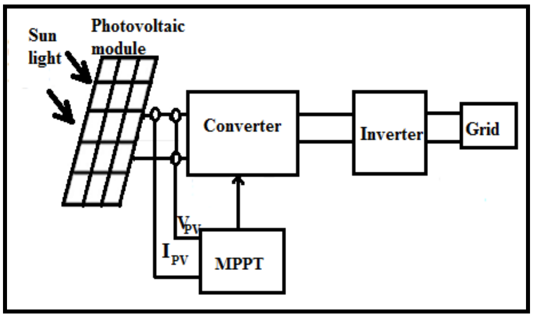

Fig.4. Block diagram of Grid connected PV array with dc-dc converter interface

In this paper, focus is given on simulating the standalone type of PV array system along with an MPPT algorithm.

Based on the MPPT algorithm adopted, a duty ratio (d) shall be generated and it is given as switching pulses to the converter switches. By varying the duty ratio (d), the output of converter is varied further. The Desired output whether low or high is obtained at the converter load terminals end. For Buck converter, the output voltage is decreased and for boost converter, the output voltage is increased.

IV. Single Diode Model Of PV Array

The equivalent circuitry of a single diode model of PV array is considered from [5], since it is a simple circuit and easy to study the characteristics.

Published by: The Mattingley Publishing Co., Inc.

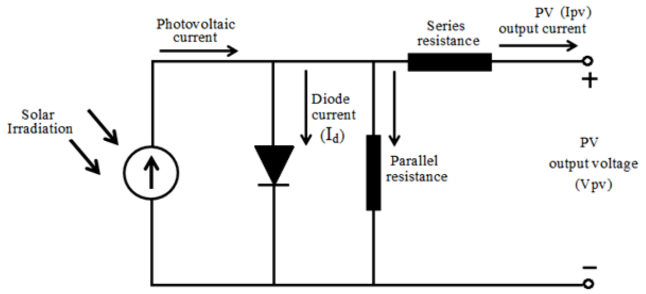

Fig. 5 Equivalent circuitry of PV array

The basic equation of the PV array could be represented as follows:

$$i_1 = I_{ph} - I_0\left[\exp\left(\frac{v_1 + R_s i_1}{v_t a}\right) - 1\right] - \frac{v_1 + R_s i_1}{R_p} \quad (1)$$

where i_1 (Ipv) and v_1 (Vpv) are the output current and voltage of the PV module

V. MPPT Algorithm

The simulation is carried out by using the Incremental and conductance algorithm as this method is having few advantages in tracking the Maximum power point (MPP) with better accuracy [6,7]. The flow chart representation of the Incremental and Conductance algorithm is represented below:

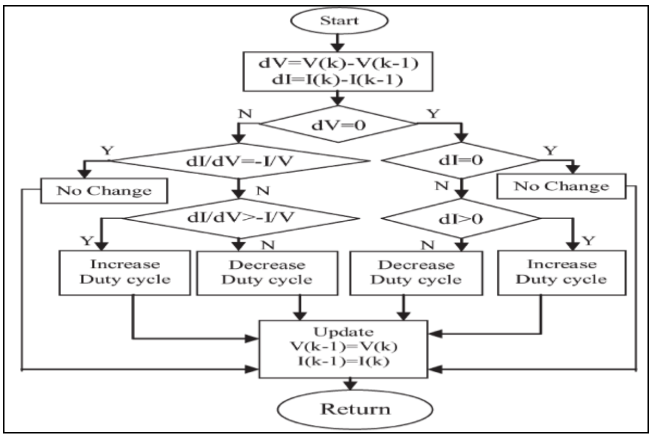

Fig. 6 Incremental and Conductance algorithm flow chart

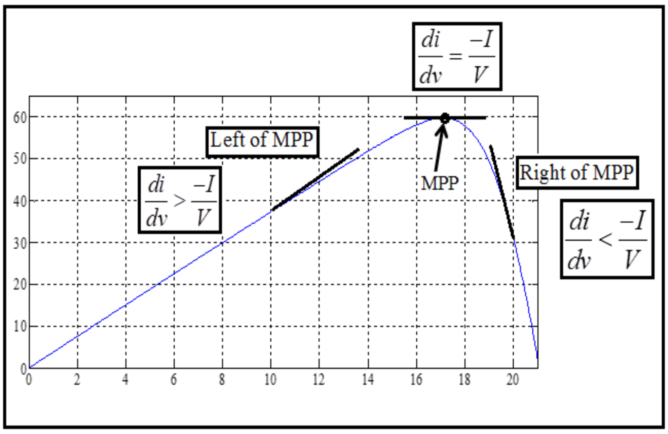

Fig. 7 Tracking of MPP by Incremental and Conductance algorithm

VI. Simulation Results

The simulation of buck and boost converter circuits have been simulated in MATLAB/SIMULINK. The results show the tracking of voltage and power in the case of step down (buck) and step up (boost) converters.

a) **Buck Converter Simulation Results**:

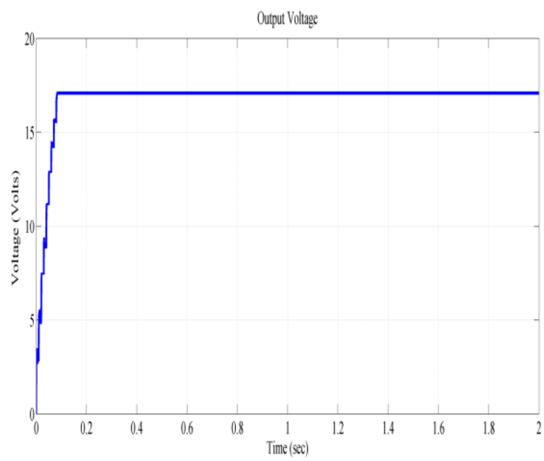

Fig. 8 Output Voltage of buck Converter

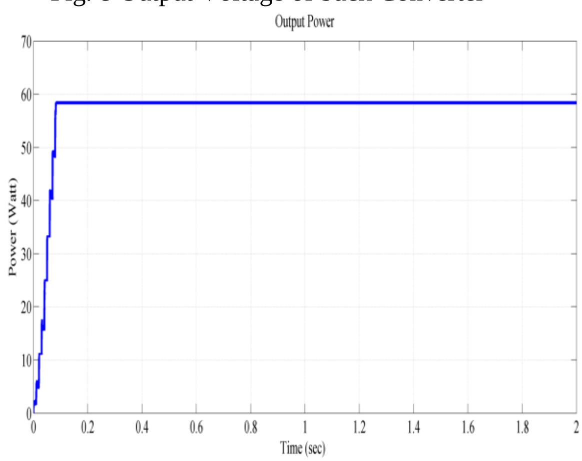

Fig. 9 Output power of buck Converter

Published by: The Mattingley Publishing Co., Inc.

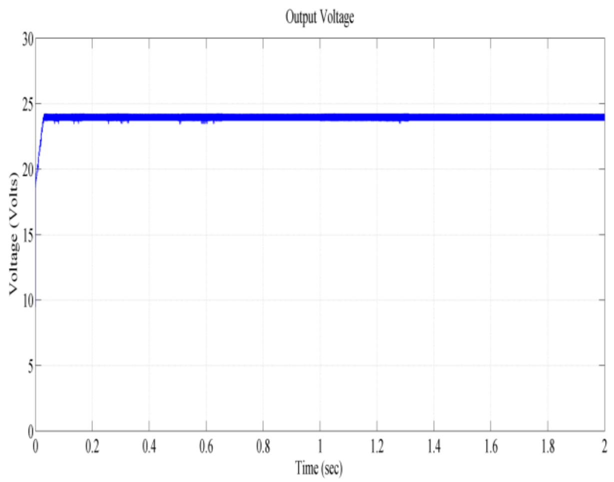

Fig. 10 Output Voltage of boost Converter

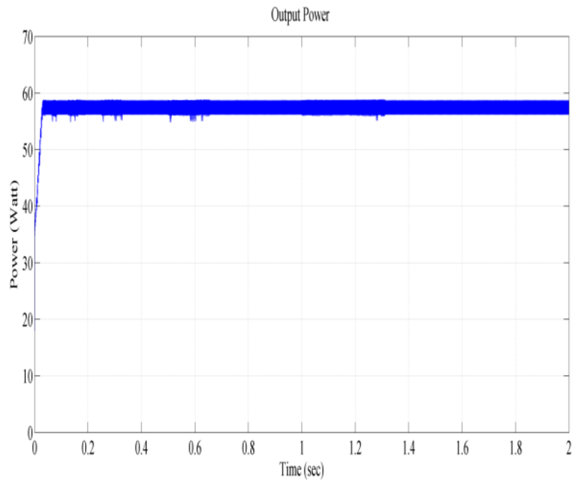

Fig. 11 Output power of boost Converter

VII. Conclusion

In this paper, the main focus is on examining the output characteristics of suitable dc-dc converters in a standalone Photovoltaic system in particular. The dc-dc converter plays a crucial role in harvesting the maximum power from PV array. The scope of this paper is to study about the output parameters like voltage and power of buck and boost converter circuits. The algorithm clearly tracking the voltage and power and it is maintained at a particular value of output around 17V, 59.4W for buck converter and 24V, 59.5Watt in the case of Boost Converter.

References

[1] S. J. Chiang, K. T. Chang, and C.Y. Yen, "Residential Photovoltaic energy storage system," IEEE Transactions on Industrial Electronics, volume. 45, no. 3, pp. 385–394, June, 1998.

[2] A. Szumanowski and Y. Chang, "Battery Management System Based on Battery Nonlinear Dynamics Modeling", IEEE Trans. on Vehicular Tech. , Volume - 57, No. 4, 2008.

[3] M. Chen, A. Gabriel and M. Rincon, "Accurate electrical battery model capable of predicting runtime and I-V performance", IEEE Transactions on Energy Conversion, Volume. 21, No. 2, pp. 504-511, June, 2006.

[4] S. J. Chiang, H. Shieh, and M. Chen, "Modeling and control of PV charger system with SEPIC converter", IEEE Transactions on Industrial Electronics, Volume. 56, No. 11, pp. 4344-4353, November, 2009.

[5] M. G. Villalva, J. R. Gazoli, and E. R. Filho, "Comprehensive approach to modeling and simulation of photovoltaic arrays", IEEE Trans. on Power Electronics, Volume. 24, No. 5, pp. 1198-1208, May, 2009.

[6] R. Gules, J. D. P. Pacheco, H. L. Hey, "A maximum power point tracking system with parallel connection for PV stand alone applications", IEEE Trans. on Industrial Electronics, Volume. 55, No. 7, pp. 2674-2683, July, 2008.

[7] A. Safari, S. Mekhilef, "Simulation and hardware implementation of Incremental Conductance MPPT with direct control method using cuk converter", IEEE Transactions of Industrial Electronics, Volume: 58, issue: 4, p no: 1154-1161, April, 2010.