

MODIFIED SEPIC CONVERTER WITH SLIDING MODE CONTROLLER TO IMPROVE THE EFFICIENCY

D. Shobana¹, R. Nivedha², G. Monica³, D. Shalini⁴, V. Sangeetha⁵

¹Professor, Department of Electrical and Electronics Engineering, Panimalar Institute of Technology, Chennai
^{2,3,4,5}Ug Scholars, Department of Electrical and Electronics Engineering, Panimalar Institute of Technology, Chennai.

Abstract – In this paper modified SEPIC converter with sliding mode approach is used to control the output from the solar panels. Modified SEPIC converter consist of an additional single inductor and capacitor which improves the efficiency. The sliding mode control is a non linear control method that alters the dynamics of a non linear system. Conventional PI controllers are not so efficient for different loads and disturbances. In order to overcome the drawbacks a proposed SMC based equivalent controller is implemented on the modified SEPIC converter. It provides a non inverting output which is an added advantage compared to conventional buck boost converters.

Key Words: Modified SEPIC converter, Sliding mode control (SMC), PI controller, on Linear Control, DC-DC Converter

1. INTRODUCTION

Renewable energy sources have become popular in electrical grids due to environmental drawbacks of fossil fuels. DC-DC converter are vital devices for improving the efficiency and reliability of renewable solar PV panels. Moreover robust performance of the converter in a wide operating range is also crucial, since highly nonlinear variation in the generated PV voltage exist due to varying solar radiation and temperature. There are several methods to control dc-dc converters such as linear controllers, hysteresis control, Pulse Width Modulation voltage mode control, PWM current mode control, and Sliding Mode Control (SMC). The SMC is suitable for nonlinear systems such as switched converters to achieve the required dynamic response and steady state operating point. In addition, the SMC is not sensitive to changes in system parameters as it is a variable structure system. Moreover, The SMC is characterized by robustness, stability and fast dynamic response. SEPIC converter is a buck or boost DC-DC converter circuit that the output can be lower or higher than the input voltage. Diverse modifications are applied to the SEPIC circuit to improve the efficiency and performance. Conventional PI control techniques in linear control methods are well known procedures. These methods are frail against external disturbances and cannot guarantee a wide stability margin under different operating regions due to the nonlinear behaviour of DC-DC Converter.

In order to overcome the disadvantages of the conventional PI controllers modified SEPIC converter is used in this paper. It has an additional inductor and capacitor which improves the efficiency. Apart from this Sliding mode approach is implemented on the SEPIC converter so the nonlinearities in the output could be easily handled and hence this method provides more efficiency compared to other conventional techniques. Matlab/Simulink results of the SEPIC converter with SMC approach is also added in this paper.

The advantage of a SEPIC converter is its non-pulsating input current and can be used as an alternative to a boost converter, with a higher efficiency and a noninverting output. Traditional control of a SEPIC converter uses a Proportional Integral Derivative (PID) algorithm. This control technique is a linear control technique. But since the converters are non-linear and time variant, their efficiency can be improved when the control is also non-linear.

1.1 Analysis of Modified Sepic Converter

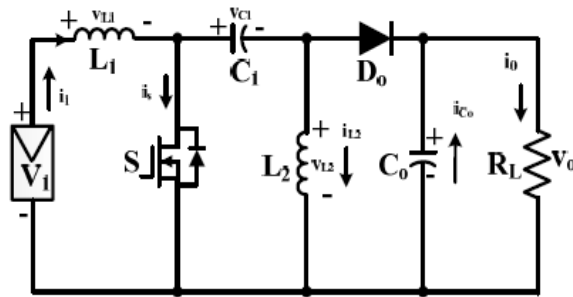


Fig -1: Conventional Sepic Converter

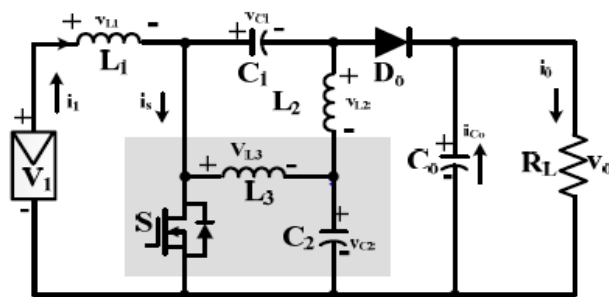


Fig -2: Modified Sepic Converter

The conventional SEPIC converter consist of static switch S diode (Do), and capacitor (C1-Co) .An addition of a single inductor L2 and Capacitor C2 reconfigures the SEPIC converter circuit.When the Switch(S) is turned on the diode Do is blocked inductors L1,L2 and L3 stores the energy and the capacitor Co discharges the stored energy.At the instant of S is turned off energy is transferred to the load through the diode Do and capacitors.

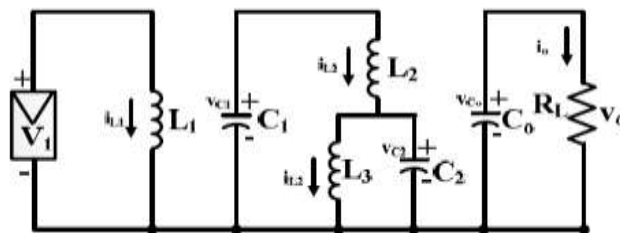


Fig-3: On state of modified Sepic converter

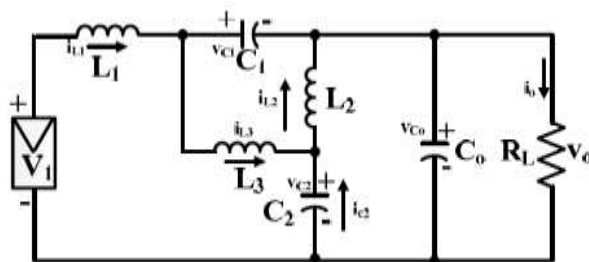


Fig-4: Off state of modified Sepic converter

When the switch S is turned on, the inductance, voltage equations given below can be written to the circuit over one period in steady state.

Similarly when the switch S is turned off, the inductance, voltage equations are varied over one period in steady state.

1.2 OPEN LOOP BLOCK DIAGRAM OF SYSTEM

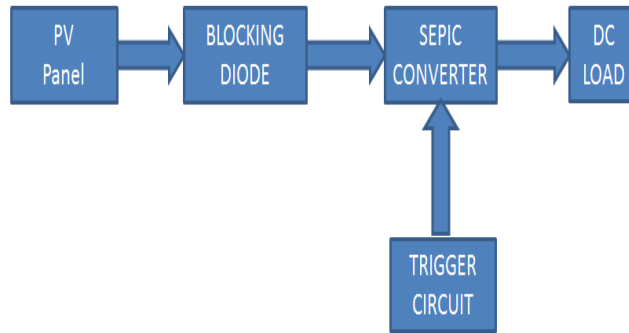


Fig-5: Open loop diagram of the system

The pv panel consist of array of cells which convert the solar energy in to electrical energy. The output of the panel is fed to the blocking diode. The blocking diode prevents the power flow in reverse direction to the panels during night time. The output of the pv panel is fed to the SEPIC converter. The SEPIC converter is a DC-DC converter that converts the signal from the panel in to a form suitable for the load. The trigger circuit is used to trigger the semiconductor switches that exist inside the sepic converter. The major disadvantage of the open loop system is that the output of the SEPIC converter could not be controlled based upon the changes in the load. This disadvantage could be avoided by using the closed loop model of the system.

1.3 CLOSED LOOP BLOCK DIAGRAM OF THE SYSTEM

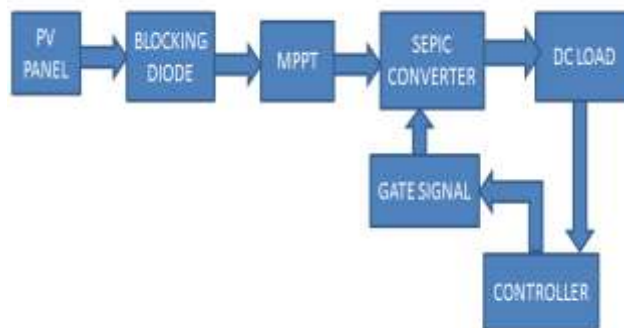
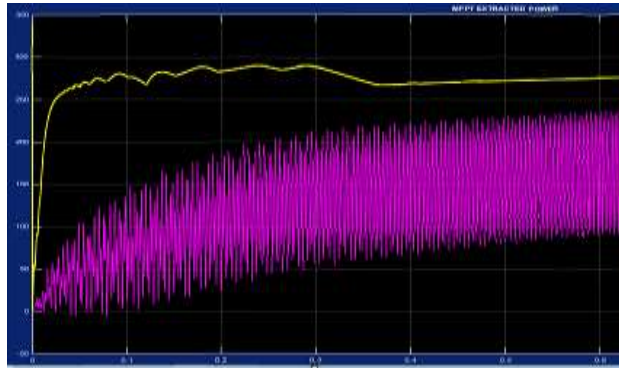


Fig-6: Closed loop block diagram of the system

SEPIC converter is a modified form of Cuk converter, with a non-inverting output. A hysteresis controller is used here to control the SEPIC converter during closed loop operation. The hysteresis controller uses a PI controller and a hysteresis block which controls the switch. The actual current value is compared with the output of the PI controller and the error signal is given to the hysteresis block. The output is limited within the hysteresis band using the switch. The output of the hysteresis block is decided by the error input given to the hysteresis block. When the error is greater than the limit ζ (a small value) given in the hysteresis, the pulse goes high. When the error signal is below the limit ζ then the pulse is made low. The MPPT is used to achieve maximum power from the solar panels.

1.4 SIMULATION RESULTS

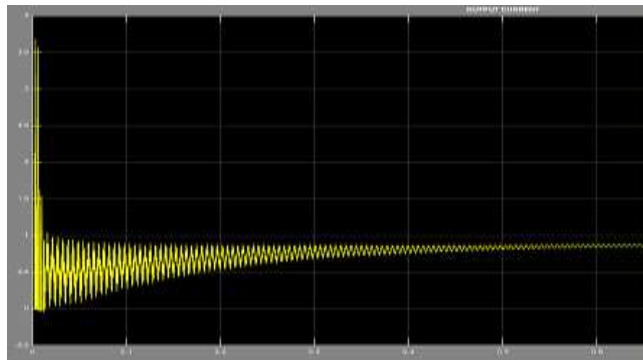
The simulation results shown below shows the various input signals, output signals and control signals.



Time(s)

Fig-7: MPPT Output

The simulation results are given which includes the input current signal, output voltage signal, output current signal, MPPT output and Control signal. From the simulation it is clear that the input current to the controller contains more oscillations. But the output current from the SEPIC has less oscillations and becomes constant after a particular time interval.



Time(s)

Fig-9: Output current

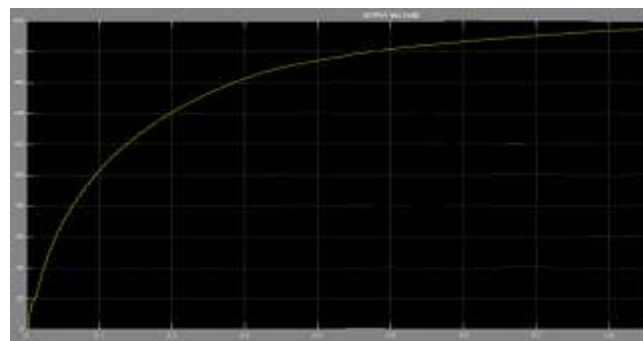
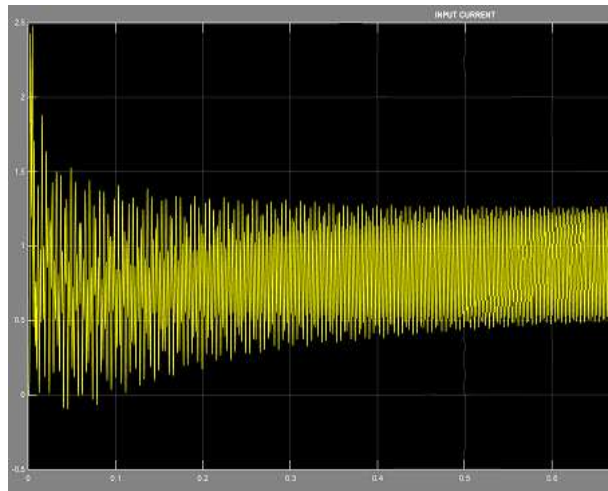
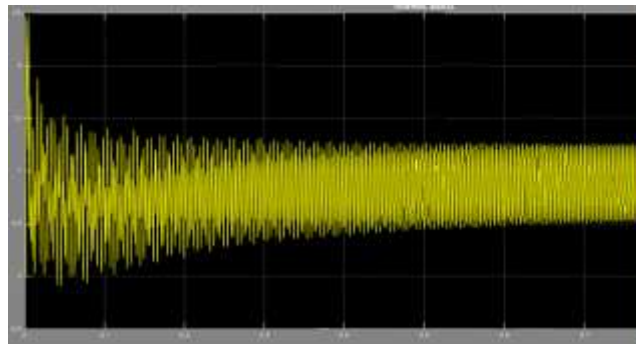


Fig 10: Output voltage

**Fig -11:** Input current

Time(s)

Fig-12: Control signal

1.5 CONCLUSION:

The modified SEPIC converter with Sliding Mode Control approach is thus explained in this paper. Thus by including an inductor and capacitor to the conventional SEPIC converter the efficiency of the converter is improved to a great extent. The simulation results prove that modified SEPIC converter is efficient than conventional controller. Apart from this constant switching frequency could be achieved by making dynamic hysteresis control method on the existing system.

REFERENCES:

- [1] F.Ahmad, A.Rasool, E.E.Ozoy, A.Sabanovic, M.Elitas, "Robust Cascaded Controller for DC-DC Boost and Cuk Converters" World Journal of Engineering, Emerald Insight, Vol. 14,No.5,2017(in press).
- [2] S.B.Mahajan, P.Sanjeevikumar, F.Blaabjerg,"Multistage DC-DC Step up Self Balanced and Magnetic Component –Free Converter for photovoltaic Application: Hardware Implementation", Vol.10 (5), 719,Energies Journal, MDPI publication Switzerland, May 2017.
- [3] S. B. Mahajan, P. Sanjeevikumar, P.Wheeler, F.Blaabjerg, M. Rivera, R. Kulkarni, "XY Converter Family: A New Breed Of Buck Boost Converter for High Step-up Renewable Energy Applications ",Proc. Of IEEE Intl. Conf. on Automatica XXII Congress of the Chilean Association of Automatic Control IEEE-ICA/ACCA'16,2016

- [4] S. B. Mahajan, P. Sanjeevikumar, F. Blaaberg, R. Kulkarni, S. Seshagiri, A. Hajizadeh, "Novel LY Converter Topologies for High Gain Transfer Ratio-A New Breed of XY Family", 4th IET Intl. Conf. On Clean Energy and Technology (IET_CEAT16), 2016.
- [5] S. B. Mahajan, R. Kulkarni, P. Sanjeevikumar, F. Blaabjerg, V. Fedak, M. Cernat, "Non Isolated and Non-Inverting Cockcroft Walton Multiplier Based Hybrid 2Nx Interleaved Boost Converter For Renewable Energy Applications", IEEE Conf. on 17th The Power Electronics and Motion Control, 2016.
- [6] S. B. Mahajan, P. Sanjeevikumar, F. Blaabjerg, O. Ojo, S. Seshagiri, R. Kulkarni, "Inverting Nx and 2Nx Non Isolated Multilevel Boost Converter for Renewable Energy Application", 4th IET International Conf. On Clean Energy and Technology, 2016.
- [7] P. Sanjeevikumar, G. Grandi, P. Wheeler, F. Blaabjerg, J. Loncaraki, "A Simple MPPT Algorithm for Novel PV Power Generation system by High Output Voltage DC-DC Boost Converter", Conf. Proc., 24th IEEE Intl. Symp, on Industrial Electronics, 2015, Rio de Janeiro (Brazil), pp. 214-220.
- [8] R. Gules, W. M. Santos, T. A. Reis, E. F. R. Romanelli, "A modified SEPIC converter with high static gain for renewable applications", IEEE Trans. Power Electron., vol. 29, no. 11, pp. 5860-5872, Nov. 2014.
- [9] C. Restrepo, J. Calvente, A. Cid, A. Aroudi, R. Giral, "A non-inverting buck-boost dc-dc switching converter with high efficiency and wide bandwidth", in IEEE Trans. Power Electron., vol. 26, no. 9, Sep. 2011 pp. 2490-2503.
- [10] F. Blaabjerg, F. Iov, T. Kerekes, R. Teodorescu, "Trends in power electronics and control of renewable energy systems", 14th Int. Power Electro & Motion Control Conf., EPE-PEMC'10, Ohrid (Macedonia), pp. K-1, K-9<6-8 Sep. 2010.
- [11] M. H. Rashid, "Power electronics; circuits, devices, and applications", Pearson Education, India, 2009.
- [12] K. K. Leung, H. S. Chung, "Dynamic hysteresis band control of the buck converter with fast transient response, IEEE Trans. on Circuits and Systems II: Express Briefs, vol. 52, No. 7, pp. 398-402, Jul 2005