

SEPIC Converter Based Induction Motor PV Water Pumping System

S.Venkatesh¹, K. Muthukumar²

Final Year, Department of Electrical and Electronics Engineering, Sri Krishna College of Engineering and Technology, Coimbatore, Tamil Nadu, India¹

Assistant Professor, Department of Electrical and Electronics Engineering, Sri Krishna College of Engineering and Technology, Coimbatore, Tamil Nadu, India²

ABSTRACT: This paper is about the implementation of SEPIC Converter and Induction Motor fed water pump analysis to improve the efficiency of the input and it act as a impedance matching network. SEPIC Converter is a newly invented chopper in which it has less no components. So, switches losses and conduction losses are reduced in turn it improves the efficiency and reduce the harmonics. When internal impedance of solar PV is matched with the impedance of SEPIC converter power is transferred to the load of Induction motor water pump fed by three phase voltage source inverter.

KEYWORDS: SEPIC Converter, Induction Motor.

I. INTRODUCTION

Solar energy extends its applications over a wide variety of fields that involves usage of renewable energy at the most and it's been very evident that solar energised equipments are highly preferred for their low running cost and compatibility that they also form a high efficient standalone and grid systems accordingly with usefulness and requirements. Some of the practical applications of solar energy involves power plants, homes made appliances, ventilation systems, commercial appliances, solar lighting, cars and other remote applications where transmission and distribution of energy gets complicated.

This project involves the implementation of photovoltaic water pumping system with the usage of SEPIC converter and induction motor and finds the usage of power electronics as a major field of importance.

The PV modules and the power electronics that convert the produced electric power by the PV modules are the basic parts of a PV installation. The PV modules comprise several solar cells which convert the energy of the sunlight directly into electricity, and are connected in a proper way (typically in series), to provide desired levels of DC current and voltage. They produce electricity due to a quantum mechanics process known as the "photovoltaic effect".

II. MAIN CIRCUIT TOPOLOGY

Many parts of the world as well as the western US are rural in nature and consequently do not have electrical distribution lines in many parts of villages, farms, and ranches. Distribution line extension costs can run from USD 10,000 to USD 16,000/km, thereby making availability of electricity to small water pumping projects economically make solar photovoltaic (SPV) powered water pumping more cost effective in these areas' small scale applications. Many western states including Wyoming are passing through the sixth year of drought with the consequent shortages of water for many applications. The Wyoming State Climatologist is predicting a possible 5–10 years of drought. Drought impacts the surface water right away, while it takes much longer to impact the underground aquifers. To mitigate the effect on the livestock and wildlife, Wyoming Governor Dave Freudenthal initiated a solar water pumping initiative in cooperation with the University of Wyoming, County Conservation Districts, Rural Electric Cooperatives, and ranching organizations. Solar water pumping has several advantages over traditional systems; for example, diesel or propane engines require not only expensive fuels, they also create noise and air pollution in many remote pristine areas.

Solar systems are environment friendly, low maintenance, and have no fuel cost. In this paper the design, installation, site selection, and performance this paper also presents technical, environmental, and economic benefits of the SPV water pumping system compared to stand alone generator and electric utility.

This paper presents a novel stand-alone solar-powered water-pumping system, especially suited for usage in rural or remote areas. The system is primarily designed to reduce both cost and complexity, while simultaneously guaranteeing optimal utilization of the photovoltaic generator. The proposed solution consists of a water pump driven by a permanent-magnet synchronous motor, controlled by a conventional field oriented control scheme. The photovoltaic array is directly connected to the dc bus of the inverter, with no intermediate power conversion stages. A perturbation based extremum-seeking controller adjusts the motor speed reference to attain the maximum power point operation of the photovoltaic array. Both simulations and experimental results on a full-scale prototype support the effect. This paper deals with a water pumping system which is powered by PV (Photo Voltaic) cell. A high level boost converter topology is being used between solar panel and the PWM inverter. The DC link voltage is maintained constant by controlling the duty cycle of the high level boost converter. Water pump is being driven by induction machine which is fed with the output of the high level boost. Performance of proposed system is obtained under fixed solar irradiation. The water pumping system is modelled in MATLAB/ SIMULINK environment using the Sim Power System and SIMSCAPE tool boxes. The performance of the system is analysed with both simulation and experimental setup. Real time simulation has been carried out using dSPACE 1103.veness of the proposed system.

This paper deals with a water pumping system which is powered by PV (Photo Voltaic) cell. A high level boost converter topology is being used between solar panel and the PWM inverter. The DC link voltage is maintained constant by controlling the duty cycle of the high level boost converter. Water pump is being driven by induction machine which is fed with the output of the high level boost. Performance of proposed system is obtained under fixed solar irradiation. The water pumping system is modelled in MATLAB/ SIMULINK environment using the Sim Power System and SIMSCAPE tool boxes. The performance of the system is analysed with both simulation and experimental setup. Real time simulation has been carried out using dSPACE.

This paper presents the modelling and simulation of electrical water pumping system using solar energy. Now-a-days PV array is increasingly employed for water pumping system. In this paper, the developed boost converter steps up the voltage produced by the PV array to a value which is suitable to run a single-phase induction motor. The inverter converts DC to AC is controlled by using sinusoidal pulse width modulation (SPWM) technique. By using a LC filter the harmonics are eliminated and pure sine wave is obtained which can be directly used to drive a single-phase induction motor and pump system. The Experimental investigation presented gives the utility of such a drive system. A design of directly coupled solar water pumping system powered from photovoltaic panels, DC to DC Boost converter, full bridge sinusoidal pulse width modulation (SPWM) inverter, LC filter, induction motor and centrifugal pump is presented. The PID feedback controller is used to control the voltage. The model was implemented using MATLAB Simulink with SPWM controlled inverter model.

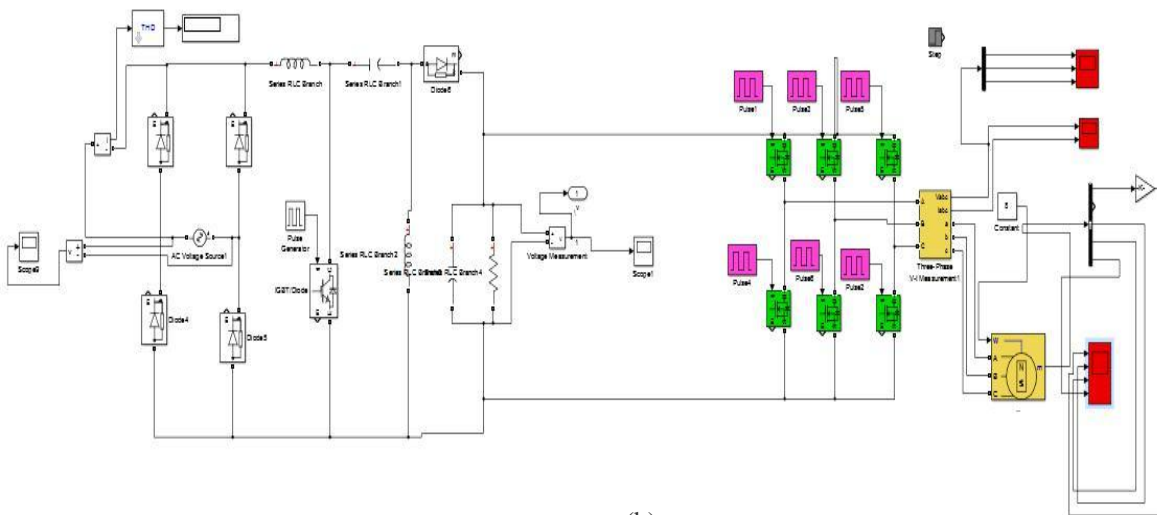
This paper deals with the application of a single ended primary inductor converter (SEPIC) in solar photovoltaic (SPV) array fed water pumping system. A permanent magnet brushless DC (BLDC) motor is employed to drive a centrifugal pump coupled to its shaft. Soft starting of the BLDC motor is achieved by controlling the SEPIC through the incremental conductance maximum power point tracking (INC-MPPT) algorithm. The SEPIC possesses the merits of non-inverting polarity output voltage, simple gate-drive circuit and low input current pulsation. Besides these, the SEPIC, operating as a DC-DC buck-boost converter can increase or decrease the input voltage level at its output. This property provides the flexibility of optimizing the operating point of the SPV array at any voltage level. The dynamic and steady state performances of the BLDC motor coupled to a centrifugal water pump fed by the SPV array-SEPIC is evaluated and its suitability is verified through simulated results using MATLAB/ Simulink environment.

(a)

This paper deals with the analysis, design and control of solar photovoltaic (SPV) array fed permanent magnet brushless DC (BLDC) motor drive for water pumping system which utilizes a canonical switching cell (CSC) converter as an intermediate DC-DC converter between the SPV array and the voltage source inverter (VSI). The CSC converter performs the functions of solar PV array power optimization and the safe starting of the BLDC motor by an adequate control. In addition to MPPT (Maximum Power Point Tracking) of SPV array, the CSC converter provides a variable

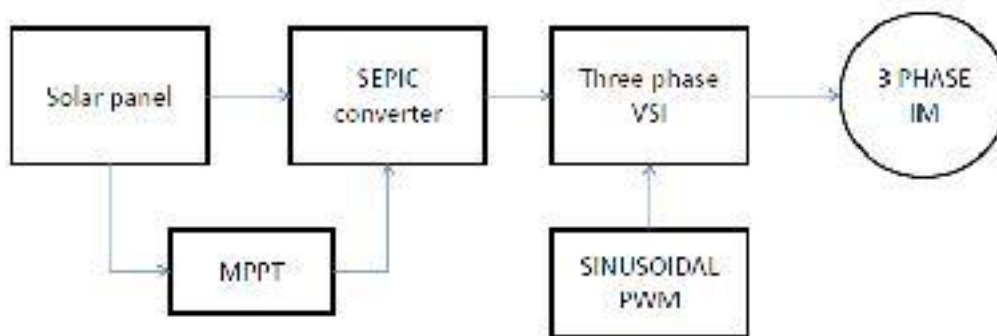
output DC voltage for the electronic commutation of VSI facilitating its fundamental switching for reduction in its losses and an elimination of its current sensors.

The detailed performance of the proposed water pumping system is demonstrated through simulated results obtained using MATLAB/Simulink based developed model subjected to various operating conditions such as the variations in the solar insulation level.



(b)

This paper deals with the stand alone solar PV (Photo Voltaic) supplied PMSM (Permanent Magnet Synchronous Motor) drive for water pumping system. An interlink Boost converter is used between solar PV panel and DC bus of PMSM drive. The DC bus voltage of PMSM drive is maintained constant by controlling the duty cycle of boost converter. Three phase VSI (Voltage Source Inverter) is controlled to supply PMSM under change in solar irradiation to regulate discharge of water. Solar PV stand-alone water pumping system employing PMSM drive is modelled in MATLAB/SIMULINK environment using the sim power system tool box.



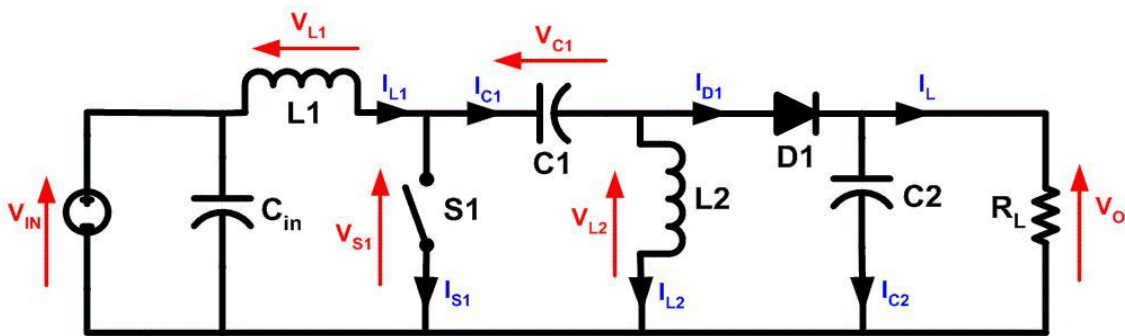
III. TEXT IMPLANTING

SEPIC CONVERTER

The single-ended primary-inductor converter (SEPIC) is a type of DC/DC converter allowing the electrical potential (voltage) at its output to be greater than, less than, or equal to that at its input. The output of the SEPIC is controlled by the duty cycle of the control transistor.

A SEPIC is essentially a boost converter followed by a buck-boost converter, therefore it is similar to a traditional buck-boost converter, but has advantages of having non-inverted output (the output has the same voltage polarity as the input), using a series capacitor to couple energy from the input to the output (and thus can respond more gracefully to a short-circuit output), and being capable of true shutdown: when the switch is turned off, its output drops to 0 V, following a fairly hefty transient dump of charge.

The main advantage of SEPIC Converter is that it does not invert the DC voltage as in the case of Buck/Boost converter. So it will be easy for us to handle the voltage delivered by the SEPIC converter. .



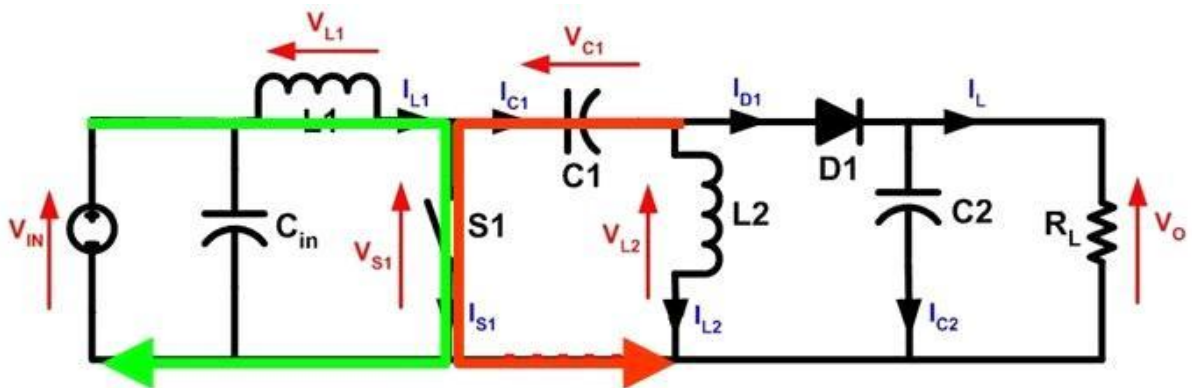
(C) SEPIC CONVERTER CIRCUIT

Even though, the SEPIC converter gives the output without inverting, the main disadvantage of SEPIC Converter is that the output current from the SEPIC Converter is discontinuous, which is avoided in CUCK converter. But considering cost constraint we are opting for SEPIC converter. Further, we can make the output current continuous by maintaining the inductor current to be continuous.

The average currents can be summed as follows (average capacitor currents must be zero):

$$I_{d1} = I_{L1} - I_{L2}$$

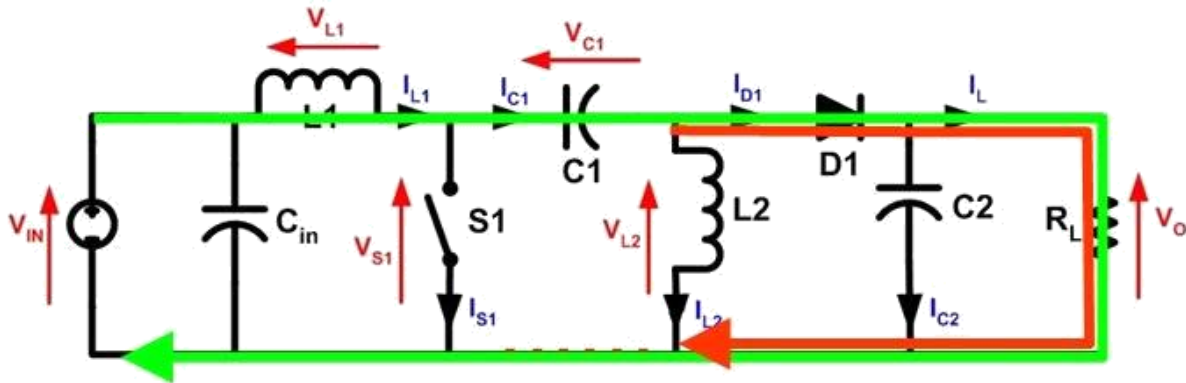
When switch S1 is turned on, current I_{L1} increases and the current I_{L2} goes more negative. (Mathematically, it decreases due to arrow direction.) The energy to increase the current I_{L1} comes from the input source. Since S1 is a short while closed, and the instantaneous voltage V_{C1} is approximately V_{IN} , the voltage V_{L2} is approximately $-V_{IN}$. Therefore, the capacitor C1 supplies the energy to increase the magnitude of the current in I_{L2} and thus increase the energy stored in L2. The easiest way to visualize this is to consider the bias voltages of the circuit in a d.c. state, then close S1.



(D) SEPIC CONVERTER CIRCUIT WITH SWITCH S1 OFF STATE

When switch S1 is turned off, the current I_{C1} becomes the same as the current I_{L1} , since inductors do not allow instantaneous changes in current. The current I_{L2} will continue in the negative direction, in fact it never reverses direction. It can be seen from the diagram that a negative I_{L2} will add to the current I_{L1} to increase the current delivered to the load. Using Kirchhoff's Current Law, it can be shown that $I_{D1} = I_{C1} - I_{L2}$. It can then be concluded,

that while S1 is off, power is delivered to the load from both L2 and L1. C1, however is being charged by L1 during this off cycle, and will in turn recharge L2 during the on cycle.

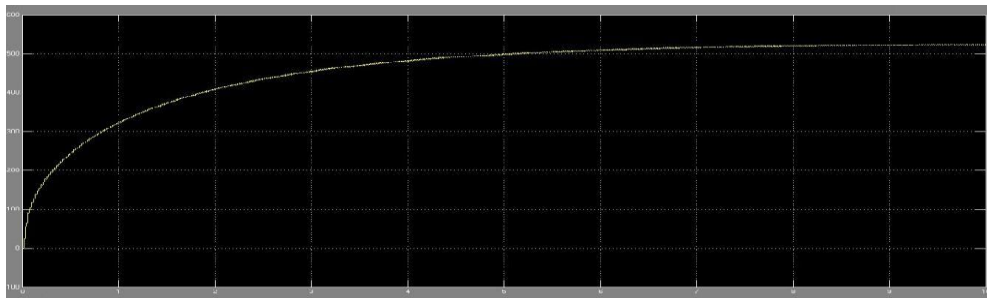


(E) SEPIC CONVERTER CIRCUIT WITH SWITCH S1 ON STATE

Because the potential (voltage) across capacitor C1 may reverse direction every cycle, a non-polarized capacitor should be used. However, a polarized tantalum or electrolytic capacitor may be used in some cases,[2] because the potential (voltage) across capacitor C1 will not change unless the switch is closed long enough for a half cycle of resonance with inductor L2, and by this time the current in inductor L1 could be quite large.

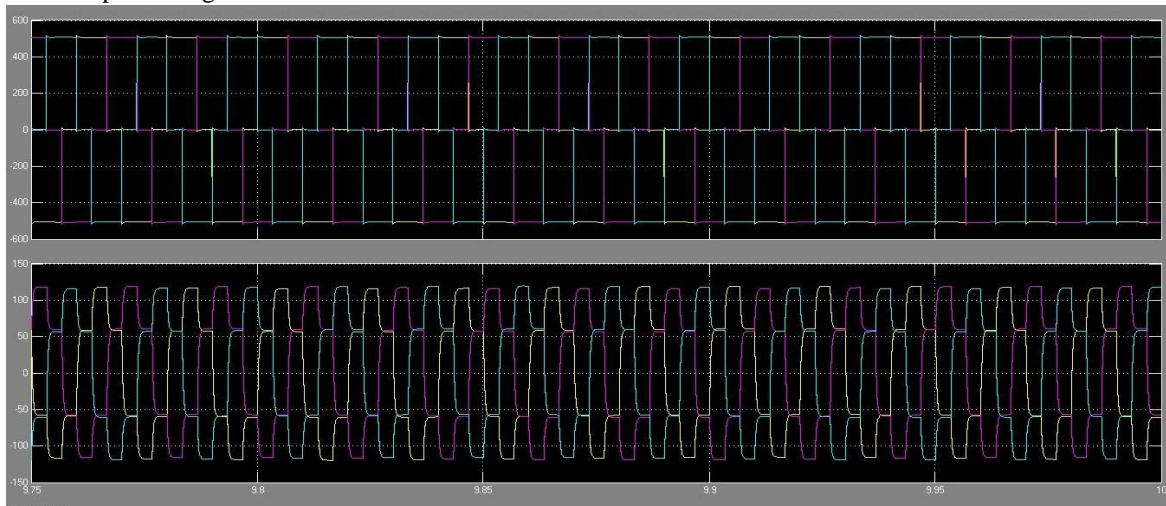
IV. EXPERIMENTAL RESULTS

SEPIC CONVERTER OUTPUT:



The above is the simulation output for the SEPIC Converter used in our Project. It can be clearly understood that there is a slow built up of output from the SEPIC Converter. And the output is higher than the input.

Inverter output Voltage and Current:



The above is the output from the Inverter used in our System. It is clearly visible that our system providing a perfect 3 phase output voltage and current, which can be used to run the Induction motor. Thus the output from the inverter is the final output of our system. It is said so because the inverter system is the last stage of power modification in our system

V. CONCLUSION

We have implemented an SEPIC Converter Based Induction Motor PV Water Pumping System. Our system successfully process the PV output to a perfect 3 phase ac output, which can be used to run an induction motor . We have run the system simulation and found that our system is able to produce perfect ac and it can run an induction motor.

REFERENCES

- [1] Roberto F. Coelho, Walbermark M. dos Santos and Denizar C. Martins, "Influence of Power Converters on PV Maximum Power Point Tracking Efficiency," 10th IEEE/IAS Inter. Conf. on Industry Applications (INDUSCON), pp. 1-8, 5-7 Nov. 2012.
- [2] M. H. Taghvaei, M. A. M. Radzi, S. M. Moosavain, Hashim Hizam and M. Hamiruce Marhaban, "A Current and Future Study on Non-isolated DC-DC Converters for Photovoltaic Applications," Renewable and Sustainable Energy Reviews, vol. 17, pp. 216-227, Jan. 2013.
- [3] Dylan D.C. Lu and Quang Ngoc Nguyen, "A Photovoltaic Panel Emulator Using A Buck-Boost DC/DC Converter and A Low Cost Micro-Controller," Solar Energy, vol.86,no.5, pp.1477-1484, May 2012
- [4] S. J. Chiang, Hsin-Jang Shieh and Ming-Chieh Chen, "Modeling and Control of PV Charger System with SEPIC Converter," IEEE Trans. Industrial Electronics, vol. 56, no. 11, pp.4344-4353, Nov. 2009.
- [5] Emilio Mamarelis, Giovanni Petrone and Giovanni Spagnuolo, "Design of a Sliding-Mode-Controlled SEPIC for PV MPPT Applications," IEEE Trans. Ind. Elect., vol. 61, no.7, pp. 3387-3398, July 2014.
- [6] Chihchiang Hua, Jongrong Lin, and Chihming Shen, "Implementation of a DSP-Controlled Photovoltaic System with Peak Power Tracking" IEEE Transactions on Industrial Electronics, vol. 45, no. 1, February 1998.
- [7] Eftichios Koutroulis, Kostas Kalaitzakis, and Nicholas C. Voulgaris , "Development of a Microcontroller-Based, Photovoltaic Maximum Power point Tracking Control System" IEEE Transactions on Power Electronics, vol. 16, no. 1, January 2001.
- [8] Azadeh Safari and Saad Mekhilef, "Simulation and Hardware Implementation of Incremental Conductance MPPT with Direct Control Method Using Cuk Converter" IEEE Transactions on Industrial Electronics, vol. 58, no. 4, April 2011.
- [9] Fangrui Liu, Shanxu Duan, Fei Liu, Bangyin Liu, and Yong Kang , "A Variable Step Size INC MPPT Method for PV Systems" IEEE Transactions on Industrial Electronics, vol. 55, no. 7, July 2008.