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Implementation of Solar PV Array Fed BLDC Motor Driven Water Pump Using LUO Converter

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ABSTRACT: Nowadays solar energy is the best renewable energy resources when compared to the conventional energy resources. The operation of the solar powered pumps is cheaper to run, lower maintenance cost and lower operation. This project deals with the operation of the Luo(DC-DC) converter in solar PV array fed water pumping system as an intermediate DC-DC converter between the solar PV array and soft starting of BLDC motor. Among the several types of DC-DC converters, a Luo converter is selected and it is used to extract the maximum power which is available from the SPV array and BLDC motor. The intermediate Luo converter with semiconductor switches has the features of reducing ripple current in its output and provide endless region for maximum power tracking (MPPT). The positive output Luo converter performs the changes from positive input source to positive output load source .To avoid the high frequency switching losses the electronically commutated brushless DC with voltage source inverter can be operated at elementary frequency which results in higher efficiency. The various working conditions such as dynamic, starting and steady state performances has to be demonstrated and simulated by suitable simulated results using MATLAB/Simulink environment.

KEYWORDS: Renewable energy; solar powered pumps; LUO dc-dc converter; soft starting; BLDC motor;

I. INTRODUCTION

Nowadays solar water pumping is becoming the most widely used application of photovoltaic array [1]. In order to improve the efficiency of solar photovoltaic array and the entire system operating conditions, it becomes necessary to operate the photovoltaic array at its maximum power point by using maximum power point tracking (MPPT) algorithm [2-4]. Several DC-DC converters have been already employed to this action of Maximum power point tracking (MPPT). However a Luo converter based MPPT [5-8] is still unfamiliar in any kind of photovoltaic array based application. Perturb and observe algorithm [8] is used in this model in order to generate an optimum value of Luo converter, such that photovoltaic array is to operate at its maximum power point. Several topologies of Luo converter such as quadruple-lift, re-lift, super-lift and self-lift circuit using voltage-lift technique have been reported [5-6]. The above mentioned configurations have high voltage gain but the increased number of components and switching devices leads to high cost. Therefore these configurations of Luo converter does not suitable for this proposed water pumping application.

A positive output Luo converter performs the conversion from the positive input source to the positive output load source voltage [9-10]. Reduction of the value of duty ratio as well as the effect of parasitic elements can be easily acquired by the voltage lift technique. The positive output Luo converter has the characteristics of high power density, high voltage gain and reduced ripple current and voltage [9-10]. This positive output Luo converter has the unrestricted region for MPPT operation because of its identical output-input relationship as the buck-boost converter [10]. Likewise, the Luo converter is designed to work in continuous conduction mode of operation regardless of the different operating conditions offering the lower stress and it also achieve the maximum switch utilization of Luo converter has to be designed [10-11].

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The water pump is coupled to the shaft and the Permanent magnet brushless DC motor is used to drive the water pump. Because of the inherent advantages BLDC [5-8]motor is to be selected, it consists of the advantages of higher reliability and higher efficiency than an induction motor, low noise and low EMI , and hence it does not require frequent maintenance is employed in the proposed water pumping application. The various operating conditions is demonstrated and simulated by similar simulated results using MATLAB/ Simulink environment.

II. PROPOSED SYSTEM CONFIGURATION

The proposed photovoltaic array fed water pumping system configuration employing the positive output luo converter and BLDC motor drive is presented. The solar photovoltaic array feds the supply to the water pumping system, a positive output elementary luo converter as an intermediate DC-DC converter for maximum power point tracking (MPPT), and a three phase voltage source power to the motor pump. On the other hand the electronic commutation and speed control of BLDC motor are achieved by the PWM control of the VSI. An inbuilt encoder, mounted on the BLDC motor provides three hall signals following the rotor position which are further converted into six pulses. The operation, design and control methodologies of each and every stage has to be elaborated in the following proposed system.

III. PROPOSED SYSTEM DESIGN

The proposed water pumping system is designed based on the selection of pump and motor. The 12volts and 1200rpm power rating is selected for BLDC motor

A. Design of solar PV Array

The generated peak power capacity of Solar PV Array of P_{mpp}=280W is designed for proposed water pumping application. Belonging to the type of buck boost converter, the maximum switch utilization of Luo converter uses at the duty ratio of 0.5[11]. Therefore the output and input voltage of converter must be equal to the aforementioned condition. It is known that the DC link voltage of voltage source inverter (VSI) or DC voltage rating of permanent magnet BLDC motor, V_{dc} i.e. output voltage of Luo converter is 85V. For a 280W, 7.6 A (ratings at MPP) solar photovoltaic array, voltage at MPP, V_{mpp} is estimated as,

$$P_{mpp}=I_{mpp}*V_{mpp}$$

$$V_{mpp}=P_{mpp}/I_{mpp}=260/8= 32.5V$$

B. Design of Luo converter

Maximum switch utilization of Luo converter is already measured. The design includes estimation of intermediate capacitor C1, output inductor L_2, output capacitor C. The duty cycle of D = 0.5 is estimated for converter elements so that the Luo converter can be operated in continuous conduction mode of operation. A switching frequency of, f_{sw}= 600Hz is selected in order to get the reduced value of converter elements.

$$L_1= DV_{mpp}/f_{sw}\,\Delta I_{L1}$$

$$L_2= (1-D)V_{dc}/f_{sw}\,\Delta I_{L2}$$

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IV. CONTROL STRATEGY OF PROPOSED SYSTEM

A. MPPT of solar PV array

In order to achieve the efficiency of photovoltaic array, MPPT is compulsory due to unpredictable weather conditions. The proposed system adapts the P&O type of MPPT technique. In this method the controller adjusts the voltage by a small amount from the PV array and it also measures the power. It is the most commonly used MPPT method due to easy implementation. It may result in top level efficiency.

B. Electronic commutation of BLDC motor

According to the rotor position the hall signals are generated by the encoder, and it is mounted on the shaft. The voltage source inverter feeds the voltage the BLDC motor and it is performed in a predefined sequence is called electronic commutation. It is a procedure for converting the three Hall signals into six Hall signals i.e s1~s2. The conduction of only two switches at a time results in a reduced conduction losses.

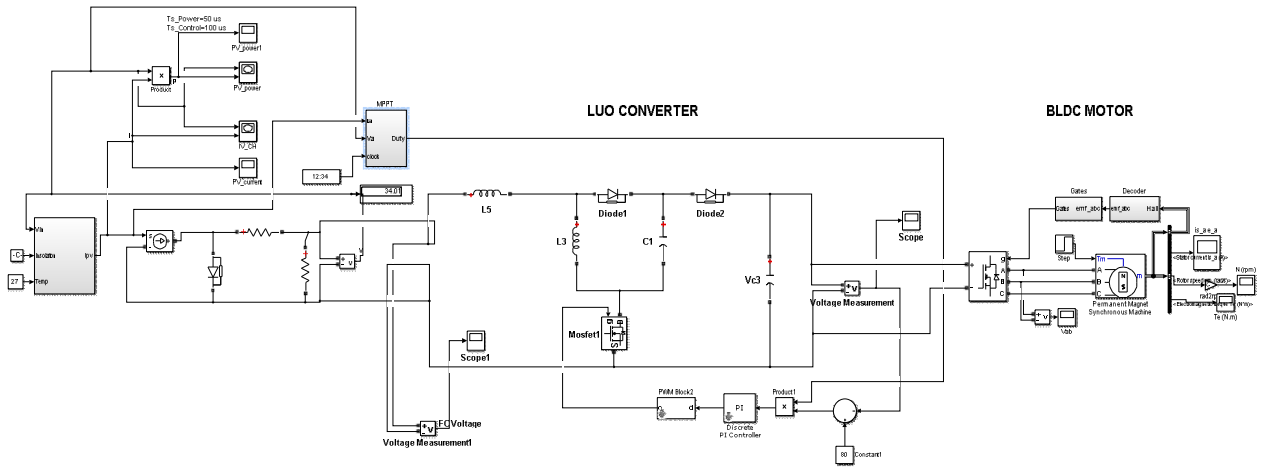
V. SIMULATED RESULTS AND PERFORMANCE ANALAYSIS

The configurations of proposed water pumping system is modeled, designed, and simulated by using MATLAB/SIMULINK environment. The proposed system is to demonstrate the steady state, dynamic and starting behavior subjected to rapid changes in weather conditions. The performance of solar photovoltaic array, Luo DC-DC converter and BLDC motor-pump as elaborated in the below sections. Various performance analysis of each stage can be described separately in the following sections of proposed water pumping system.

A. Performance of solar PV array& MPPT algorithm

At the time of starting, MPPT takes the time to reach the operation of photovoltaic array at maximum power point under the steady state operation in view of the reduced current starting of permanent magnet BLDC motor. The various solar photovoltaic array indices, solar PV array voltage (V_{pv}), solar PV array current (I_{pv}), solar PV power (P_{pv}), It is clearly visible that the maximum power point tracking technique is capable of optimizing the solar photovoltaic array power under dynamically changing the atmospheric conditions.

VI. PROPOSED SIMULATION DIAGRAM



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B. Performance of Luo converter

Several performance indices of Luo converter like, voltage across the intermediate capacitor, current flowing through the output inductor , voltage across the DC link of VSI, current flowing through the input inductor are illustrated.

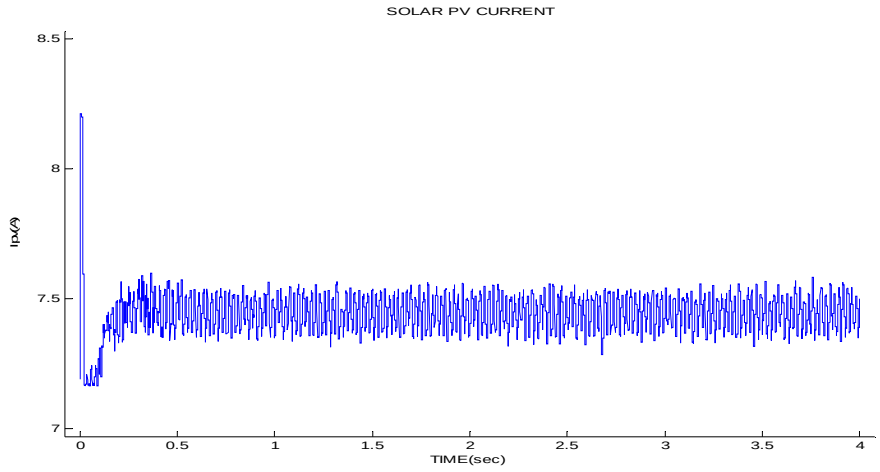
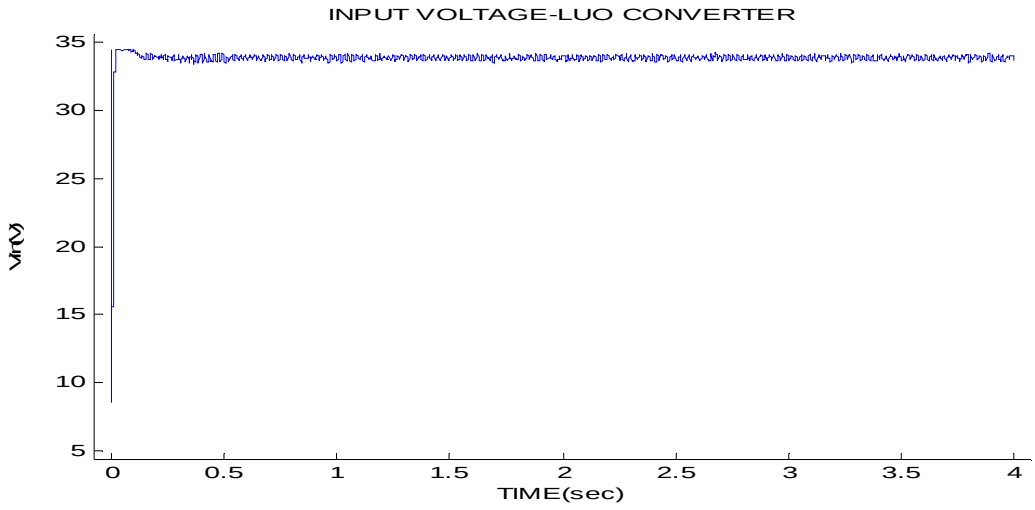


Fig1. Starting and steady state performance of solar PV array



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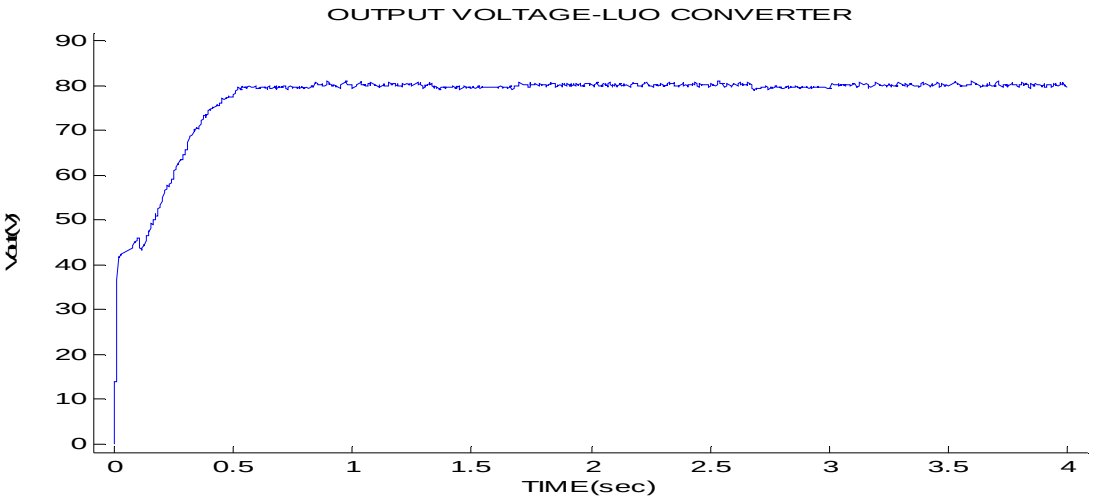

Fig 2.starting and steady state performance of Luo DC-DC converter

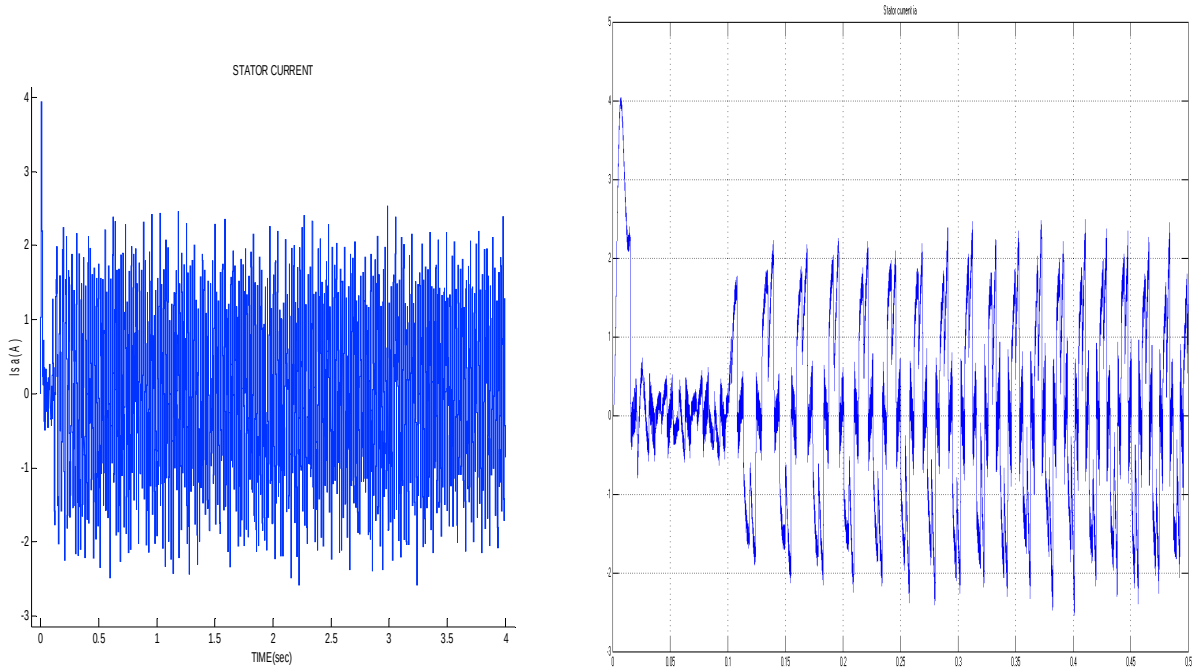

Fig3.Dynmaic performance of BLDC motor – Stator current

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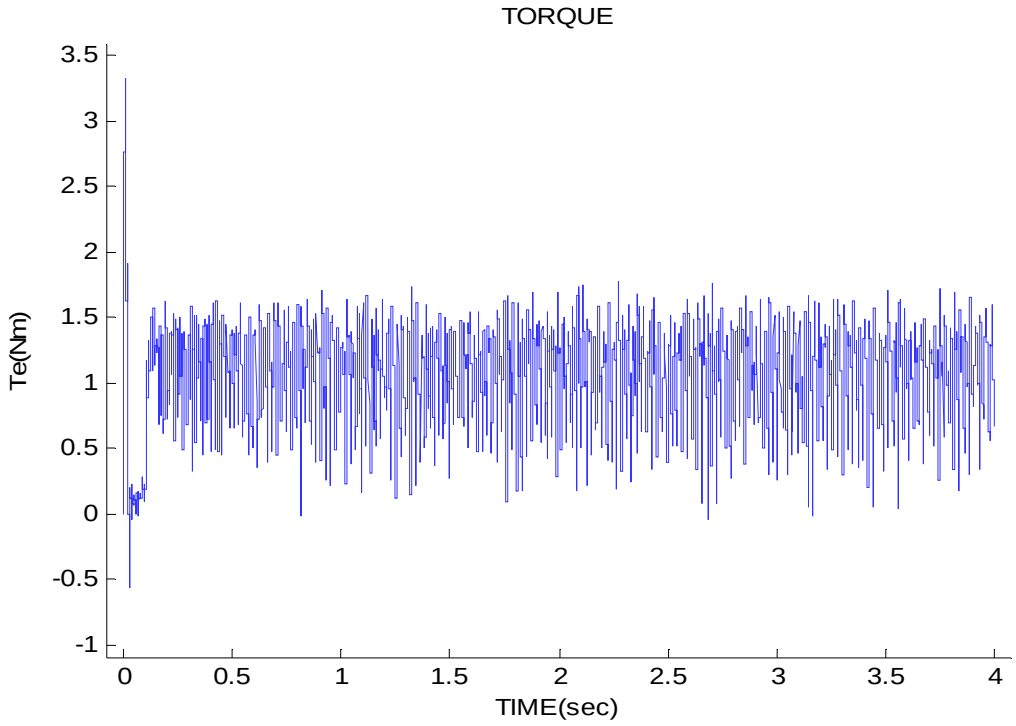

Fig4.Dynmaic performance of BLDC motor – Torque

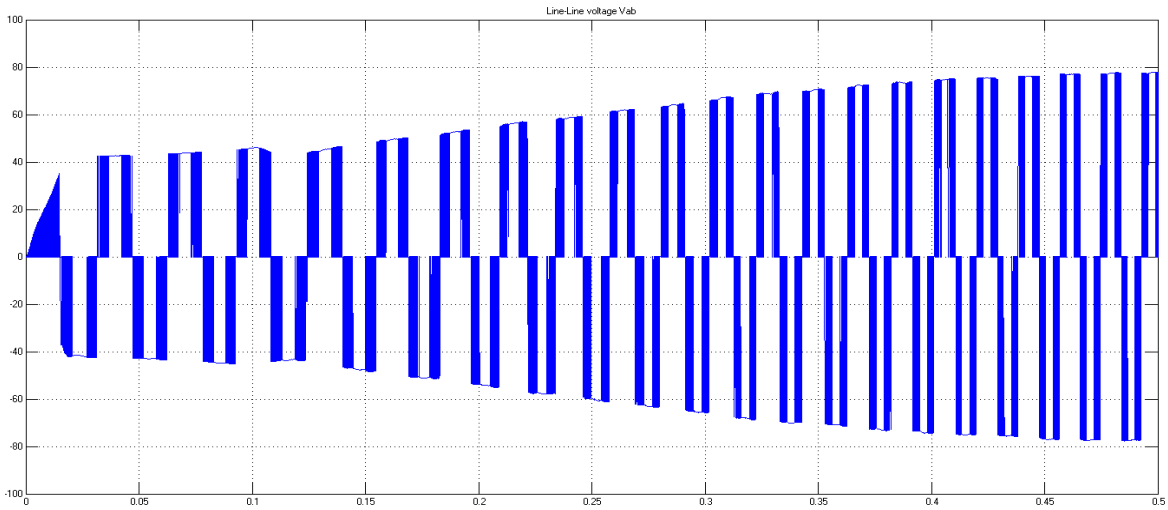

Fig5.Dynmaic performance of BLDC motor – L-L voltage

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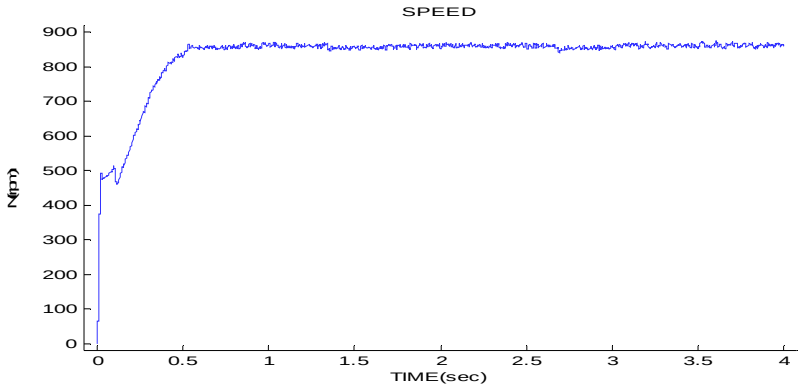
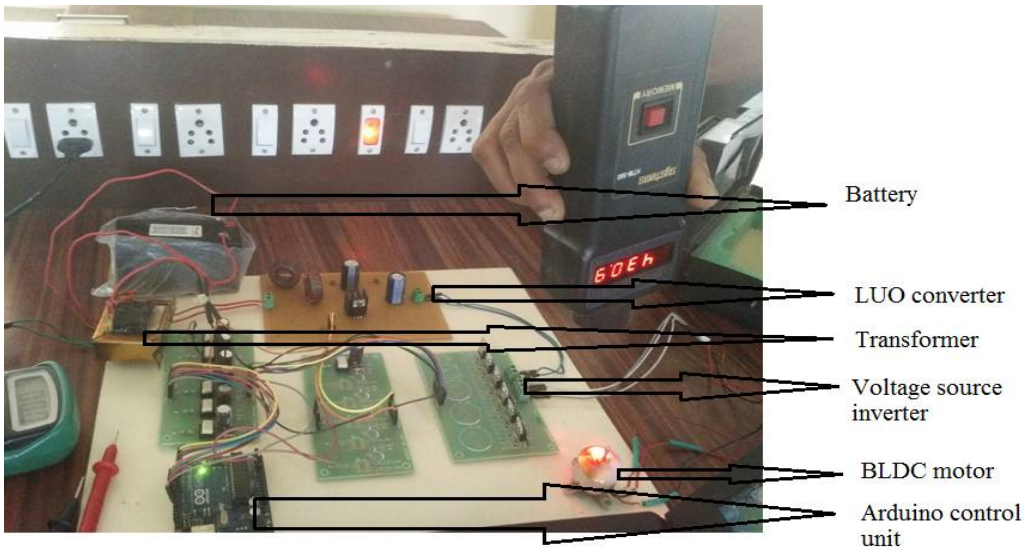


Fig6.Dynmaic performance of BLDC motor - Speed

C. Performance of BLDC motor

The presents the dynamic, steady state and starting performance of permanent magnet BLDC motor- pump system subjected to a quickly changing solar isolation level. As the DC link voltage varies, different motor pump indices the line to line voltage(V_{ab}), the electromagnetic torque(T_e) ,the stator current(I_{sa}) ,and the rotor speed, N changes accordingly. It is clear from the waveform of stator current that the high starting current of permanent magnet BLDC motor is controlled and the safe starting is achieved

VII. HARDWARE IMPLEMENTATION



The operation of the system is straight forward. The solar PV array appears as a power generating unit for the water pumping system. It feeds the energy to the LUO converter which further supplies, to the BLDC motor.The positive output LUO converter as an intermediate DC-DC converter which supplies the dc voltage to the voltage source inverter. The voltage source inverter has convert the DC voltage into AC voltage and then feds the voltage to the BLDC motor.On the other hand the electronic commutation and speed control of BLDC motor are achieved by the PWM control of the VSI. An inbuilt encoder is mounted on the BLDC motor and provides the three hall signals and the rotor position sensor will further converted into six pulses.

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VIII. CONCLUSION

The solar photovoltaic array fed BLDC motor driven water pump using l converter Luo has been proposed to drive the water pumping system. The proposed water pumping system has to be simulated, modeled and designed by using MATLAB along with its SIM-power system toolboxes and SIMULINK. The simulated results have demonstrated the suitability of proposed water pumping system. Solar photovoltaic array has been properly sized such that system performance is not influenced by the variation in atmospheric conditions and the maximum switch utilization and associated losses of Luo converter is achieved. Luo converter has to be operated in continuous mode of operation in order to reduce the stress on power electronic devices. The VSI can be operated in 120 conduction mode with fundamental frequency switching eliminates the losses caused by high frequency switching operation. Safe starting of permanent magnet BLDC motor and stable operation of water pump are the most important features of proposed system .

REFERENCES

[1] Fei Ding, Peng Li, Bibin Huang, Fei Gao, Chengdi Ding and Chengshan Wang, "Modeling and simulation of grid-connected hybrid photovoltaic /battery distributed generation system," in *China Int. Conf.Electricity Distribution (CICED)*, 13-16 Sept. 2010, pp.1-10.

[2] Zhou Xuesong, Song Daichun, Ma Youjie and Cheng Deshu , "The simulation and design for MPPT of PV System Based on Incremental Conductance Method," in *WASE Int. Conf. Information Eng. (ICIE)*,vol.2, 14-15 Aug. 2010, pp.314-317.

[3] B.Subudhi and R.Pradhan, "A Comparative Study on Maximum Power Point Tracking Techniques for Photovoltaic Power Systems," *IEEE Trans. Sustainable Energy*., vol. 4, no. 1, pp. 89-98, Jan. 2013.

[4] M.A.Eltawil and Z. Zhao, "MPPT techniques for photovoltaic applications," *Renewable and Sustainable Energy Reviews*, vol. 25, pp. 793-813, Sept. 2013.

[5] Muhammad H. Rashid, *Power Electronics Handbook*, 3rd Ed. Burlington, MA: Butterworth-Heinemann, 2011.

[6] B. Singh and V. Bist, "Power quality improvements in power factor correction Luo converter fed brushless direct current motor drive," *Int.Trans. Electr. Energ. Syst.*, 2014.

[7] Ms.Josily Jose ,Jayanand.B "Simulation and Implementation of Superlift Luo Converter" 2013 International Conference on Renewable Energy and Sustainable Energy [ICRESE'13].

[8] P. Pugazhendiran, U. Palani, S. Karthick, P. Arulkumar, "Implementation of Novel Hybrid Wind Solar Energy Conversion System", International Journal of Science, Engineering and Technology Research (IJSETR) Volume 2 Issue 5 ISSN: 2278 – 7798, 2015

[9] Pugazhendiran, P Vijaya kumar.J, "Power quality improvement in Distributed energy network interface to grid, International Journal of Science and Innovative Engineering & Technology", Volume 2, 2015.

[10] Nammalvar. P, "A Modified KY converter suitable for PV applications", International Journal of Engineering Research, Volume 4, Issue 2, Pages 364-373, 2016

[11] P Nammalvar, P Balaji, "High Performance Soft Switched DC-DC Boost Converter Suitable for PV Applications", International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, Volume 4 Issue 3 Pages 1821-1830, 2015