SOLAR PHOTOVOLTALIC ARRAY FED LUO CONVERTER BASED BLDC MOTOR DRIVEN WATER PUMPING SYSTEM

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Abstract— **The proposed system consists of SOLAR PHOTOVOLTALIC ARRAY FED LUO CONVERTER BASED BLDC MOTOR DRIVEN WATER PUMPING SYSTEM, The proposed configuration is built with a LUO converter cascaded with PWM inverter through a high frequency transformer and auxiliary circuit. The merits of the proposed configuration are high boost output voltage level, modularity, reduced device parts, and better output. In this work, detailed construction and operation of the proposed configuration is presented. In order to validate the concept, simulation work is carried out through Matlab software and their results are presented**

I.Introduction

The drastic reduction in the cost of power electronic devices and annihilation of fossil fuels in near future invite to use the solar photovoltaic (SPV) generated electrical energy for various applications as far as possible. The water pumping, a standalone application of the SPV array generated electricity is receiving wide attention now a day for irrigation in the fields, household applications and industrial use. Although several researches have been carried out in an area of SPV array fed water pumping, combining various DC-DC converters and motor drives, the Luo converter in association with a permanent magnet brushless DC (BLDC) motor is not explored precisely so far to develop such kind of system. However, the Luo converter has been used in some other SPV based applications. Moreover, a topology of SPV array fed

BLDC motor driven water pump with Luo converter has been reported and its significance has been presented more or less in Nonetheless, an experimental validation is missing and the absence of extensive literature review and comparison with the existing topologies, have concealed the technical contribution and originality of the reported work.

II. PROPOSED SYSTEM CONFIGURATION

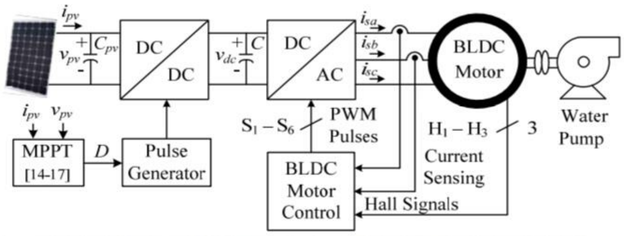

Fig. 2.1: Conventional SPV Fed BLDC Motor driven water Pumping system

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 in built 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 methodology of each and every stage has to be elaborated in the following proposed system.

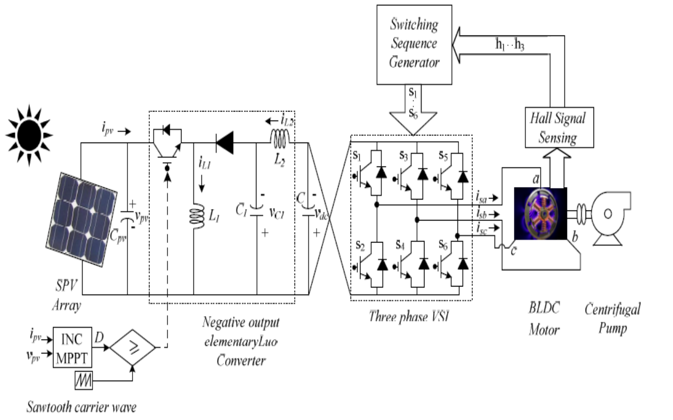

Fig. 2.1: SPV Array Fed BLDC Motor Driven Water Pumping Using LUO Converter

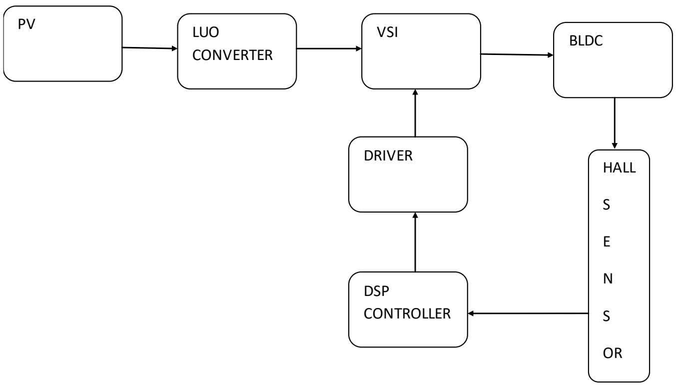

Fig. 2.2.: Block Diagram

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

2.1A. Design of solar PV Array

The generated peak power capacity of Solar PV Array of Pmpp=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, Vdc i.e. output voltage of Luo converter is 85V. For a 280W, 7.6 A (ratings at MPP) solar photovoltaic array, voltage at MPP, Vmpp is estimated as,

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

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

2.2 CIRCUIT OPERATION OF LUO CONVERTER

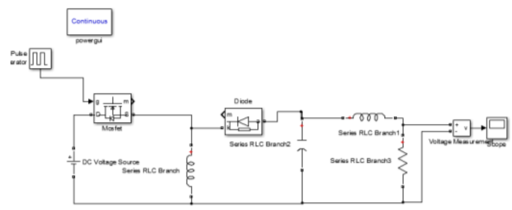

Fig.2.3: Circuit Operation of LUO Converter

The Circuit diagram of Luo converter is shown in figure In the circuit S is the Power switch and D is the freewheeling Diode .The energy storage Passive Elements are Inductors L1 and L2 and Capacitors C1,C2 R is the total resistance .To analyze the operation of the Luo Converter. The Circuit can be divided into two modes when the switch is On the inductors L1 is charged by the supply voltage E. At the same time inductor L2 absorbs the energy from the source and the capacitor C1. The load is supplied by the capacitor c2. The equivalent circuit of Luo in mode 1 operation, during the switch in off state the current is drawn from the source become zero. Current iL1 flows through the C2 and the free wheeling diode D to keep itself continuous if adding additional filter components like inductor and capacitor to reduce harmonic level of the output voltage.

Mode 1: When the switch is ON the inductor L1 is charged by supply voltage E at the same time the inductor L2 absorbs the energy from source and capacitor C1 the load is supplied by the capacitor C2.

Mode 2: Switch is in OFF state and hence the current is drawn from the source become zero current iL1 flows through freewheeling diode to charge the capacitor C1 current iL2 flows through C2,R circuit and the free wheeling diode D to keep itself continuous

Discontinues conduction Mode: output should be in the form of discontinues. In the mode diode is not present and inductor discharged through $v_0$and L_2 the output state of the Luo converter is comprised of an inductor and capacitor the output state stores and deliver energy to the load and smoothen out the switch mode voltage to produce a constant output voltage. Inductor selection directly influences the amount of current ripple seen on the inductor current, as well as the current capability of the converter itself. Inductors vary from manufacturer to manufacturer in both material and value and typically have tolerance of 20 percentage inductors have an inherent DC resistance known as DCR that impacts the performance of the output state. Minimizing the DCR improves the overall performance of the converter for that it requires high load current it is recommended to select an inductor with low DCR. The DCR is smaller for lower inductor values and there is a trade of between inductance and ripple current, the lower the inductance higher the ripple current through the inductor

2.3. Design of Luo converter

Maximum switch utilization of Luo converter is already measured. The design includes estimation of intermediate capacitor C1, output inductor L2, 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,

fsw=600Hz is selected in order to get the reduced value of converter elements.

$L1= DV_{mpp}/f_{sw}\Delta IL1$

$L_2= (1-D)V_{dc}/f_{sw}\ \Delta IL2$

2.5 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 easy implementation. It may result in top level efficiency.

MPPT method

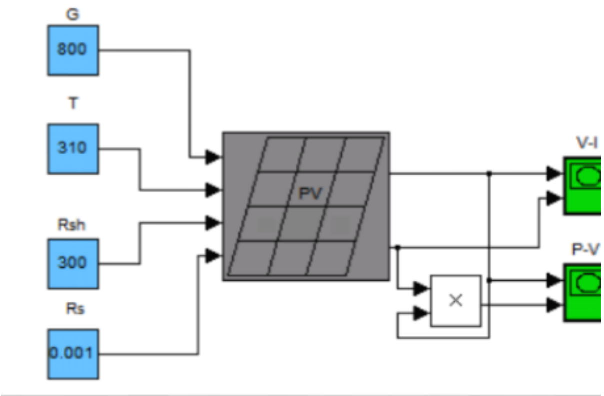

Fig.2.4: Circuit Operation of Solar PV Modeling

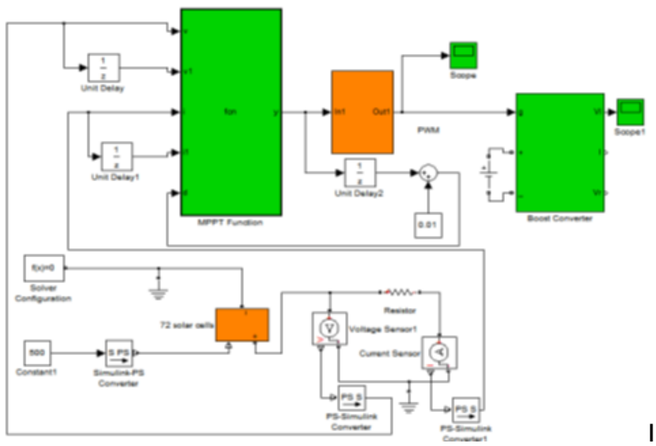

Fig.2.5: Circuit Operation of P&O MPPT Solar PV Modeling

III Simulation and Hardware Implementation

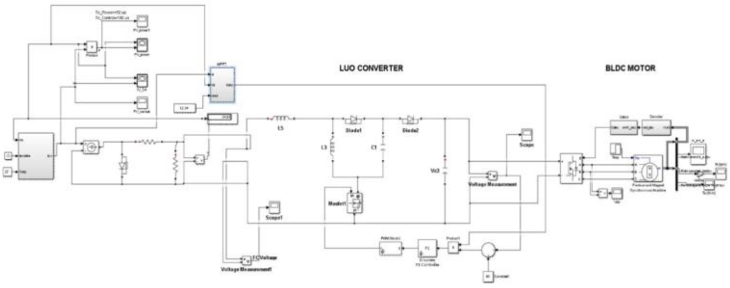

Fig. 3.1: Proposed Simulation Diagram

3.1 MAIN CIRCUIT

MOSFET – IRF 840

DIODE - IN4007

CAPACITOR AS PER THE CIRCUIT

INDUCTOR AS PER THE CIRCUIT (CORE-FERRO MAGNETIC)

TRANSFORMER (230/ STEP DOWN)+RECTIFIER(10A)

4.2 DRIVER CIRCUIT

TLP 250 DRIVER CIRCUIT

PIC 16F 877A MICRO CONTROLLER

IC 7805 --REGULATOR IC

CRYSTALL OSCILLATOR

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WIRING DIAGRAM OF SPV ARRAY BLDC MOTOR PUMPING SYSTEM

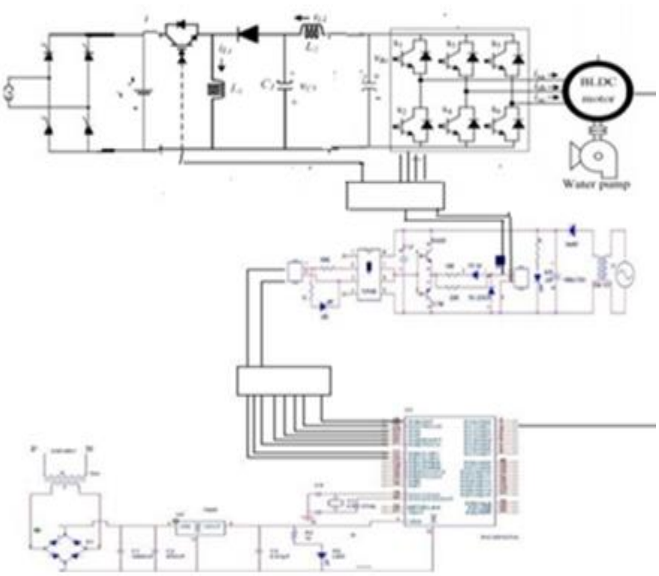


Fig 3.2 Wiring Diagram Of SPV Array BLDC Motor Pumping System

IV.Results

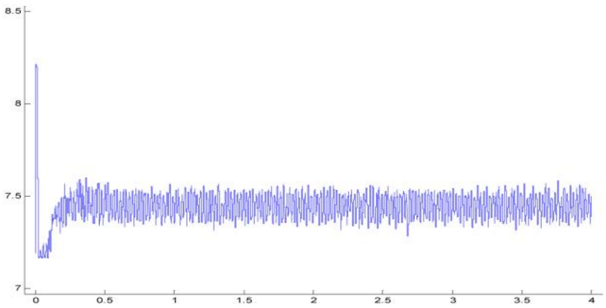


Fig 4.1: Starting and steady state performance of solar PV array

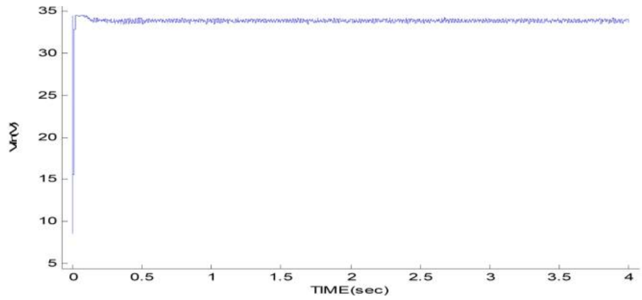


Fig 4.2: Steady state performance of solar PV array

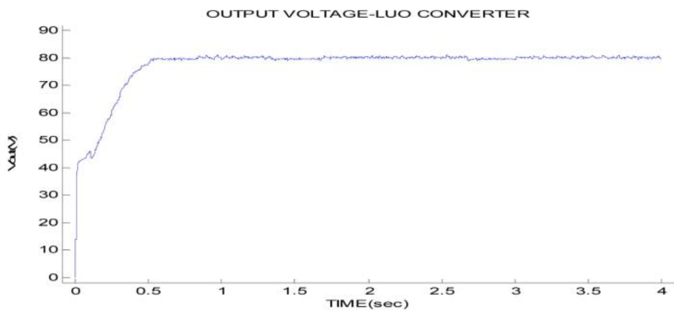


Fig 2.starting and steady state performance of Luo DC-DC converter

Fig 4.3: Starting and steady state performance of LUO DC-DC Converter

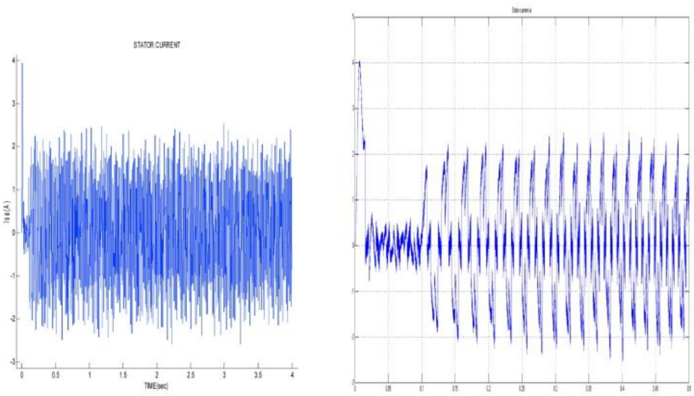


Fig4.4: Dynmaic performance of BLDC motor – Stator current

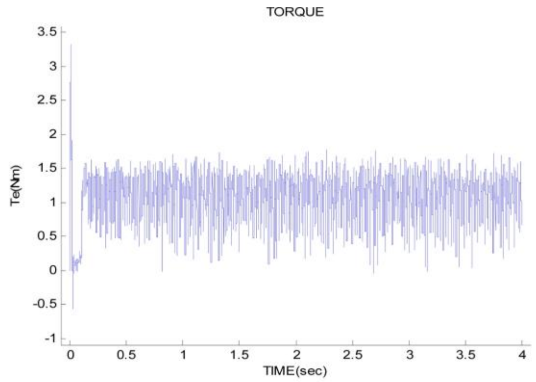


Fig 4.5 .Dynmaic performance of BLDC motor – Torque

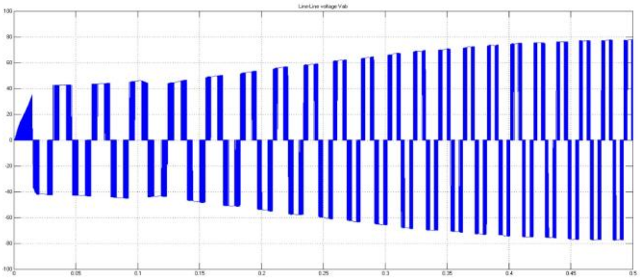


Fig 4.6:Dynmaic performance of BLDC motor – L-L voltage

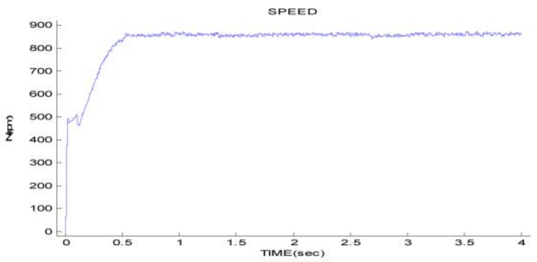
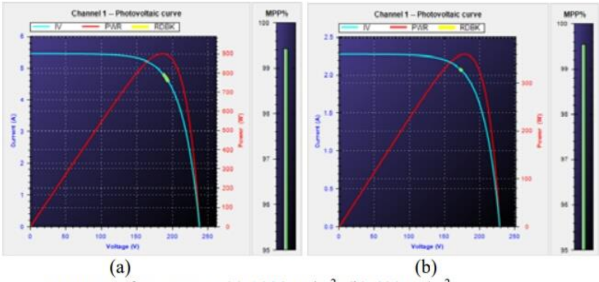


Fig 4.7: Dynmaic performance of BLDC motor – Speed

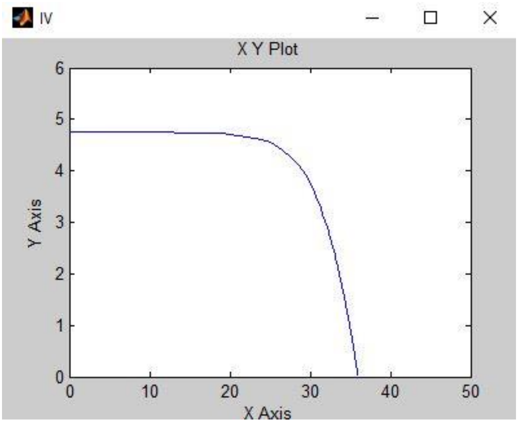
C. Performance of BLDC motor

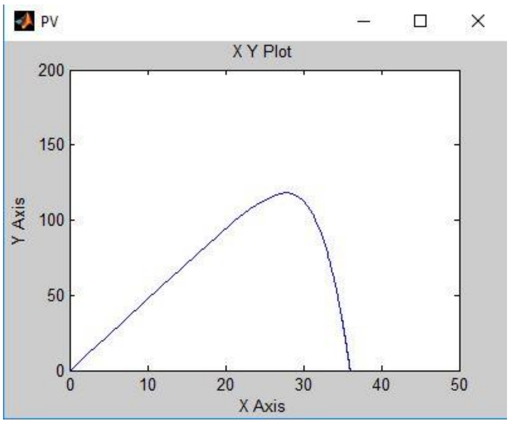
The presents the dynamic, steady state and starting performance of permanent magnet BLDC motor- pump system subjected to a quickly changing solar isolation level. As the DC link voltage varies, different motor pump indices the line to line voltage (Vab), the electromagnetic torque (Te), the stator current (Isa), 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

Fig 4.8 MPPT PERFORMANCE



MPPT performance at (a) 1000 W/m^2, (b) 400 W/m^2





The suitability of the system under dynamic condition, solar irradiance level is instantly reduced from 600 to 200W/m2 and then increased to 1000 W/m2

Performance of BLDC motor-pump is not deteriorated by weather conditions and it pumps the water successfully.

V. 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.

VI Reference

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