Design Of Control circuit For Water Pumping Run By Solar PV Energy Using Super Lift Luo Converter For Domestic And Industrial Application.

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Abstract :----In this work represents design and working of BLDC motor water pump using positive output Luo converter fed from battery storage from solar photo voltaic system, now a day's increasing the use of solar energy because of shortage of non renewable energy sources and SPV has pollution free. BLDC motor has high power efficiency, high power density with compact size, and easy high-speed operation. during rainy season and night solar power is not available continuous for that reason here implementing a battery storage from pv array. Compare to other converters elementary super lift Luo converter is selected in order to extract the maximum available power from the SPV array , safe starting and reducing starting current of BLDC motor. reduced components of super lift Luo converter has single semiconductor switch inherent features of reducing the ripples in its output current and possessing a boundless region for maximum power point tracking (MPPT). The electronically commutated BLDC motor is used with a voltage source inverter (VSI) operated at fundamental frequency switching thus avoiding the high frequency switching losses resulting in a high efficiency of the system. The performance of the system has been validated using Arduino UNO , various operating conditions analyzed using simulation results.

Index Terms - super lift Luo converter; SPV array; BLDC motor; battery storage; Centrifugal water pump; MPPT.

I. INTRODUCTION

Solar pv cells has specific advantage compare to other energy source because oncee installed its operation is continuous it is free from pollution and no there is no emission of carbon. The output energy capacity from sun depends upon direct sunlight during rainy season, cloud, night, less amount of power is generated. more than 12-25% solar energy is lost if proper control tracking system is not used.[1] To store the power from solar energy battery storage is using it will help whep when direct sunlight is not available to gain maximum power from sun to attain MPP maximum power point tracker is used, it is an electronic DC to DC converter it convert a higher voltage DC output from solar panels[1][2][3].

In the recent years many DC to DC converters are present to gain the maximum power from solar energy Dr.Luo Fang Lin he invented more than 150 novels for DC to DC converter including series Luo converter ,positive, negative, Double output Luo converter etc[4][7][8]. Compare to all converter positive output elementary super lift Luo technique is used in this work because compare to other Luo converter it increases the voltage in geometrical progression manner[14][15]. Voltage lift technique in negative output Luo converter has its disadvantage because here voltage increases in arithmetic progression manner[6], by proper control Luo converter improves the starting current of BLDC motor. super lift Luo converter always operates in continuous conduction mode(CCM) hence switching losses can be reduces[12]. An inverter is an electronic device that exchanges direct voltage to alternating voltage, 3 phase inverters are generally used for high power application,120^0 conduction mode is selected in this work[9][10]. A brushless DC motor is a permanent magnet alternating current motor it is having fixed permanent magnet compare to other motor it is having following advantages.

- less maintenance because it is free from dust.
- less frequency, inertia is low, no sparking from commutator.
- less amount of radio frequency radio frequency interference and noise..

Suitability of the proposed SPV array fed water pumping system subjected to various operating and environmental conditions is demonstrated by satisfactory simulated results using MATLAB/Simulink(R2016a) environment.

II. PROPOSED BLOCK DIAGRAM CONFIGURATION

The below fig shows the battery storage solar photo voltaic array water pumping system .It contains solar panels, battery storage, super lift Luo cconverter,120^0 conduction mode voltage source inverter, electronically commutated hall signal sensors with inbuilt encoder, PWM modulation, P&O MPPT alogorithem.Here in this work super lift Luo converter makes the voltage increases in geometrical progression manner,by using proper control technique of Luo BLDC motor performance can be improved.

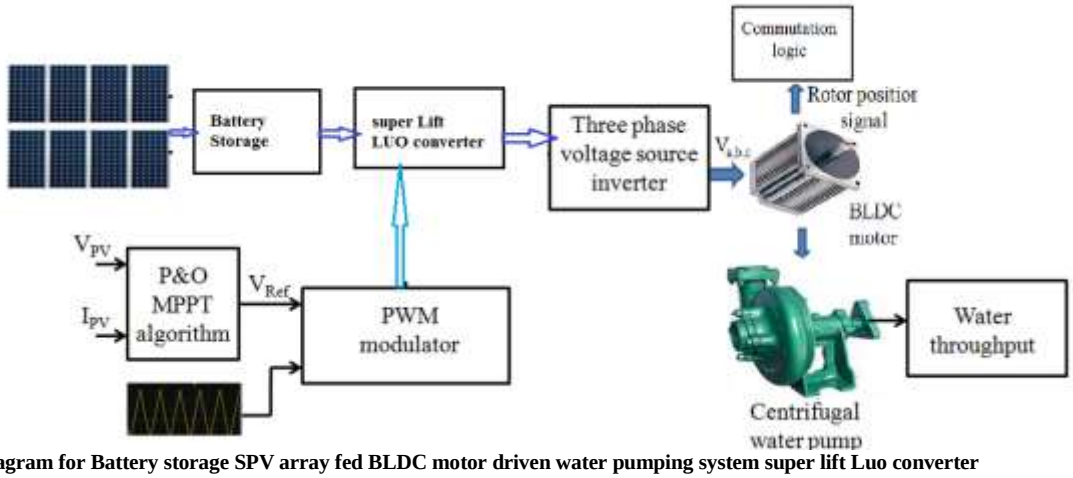

fig 1 block diagram for Battery storage SPV array fed BLDC motor driven water pumping system super lift Luo converter

III. DESIGN OF THE CIRCUIT COMPONENTS

the proper ratings of BLDC motor and centrifugal water pump is selected as 1.5kw power rating and no load speed is 3000rpm on the bases of these ratings every component is designed.

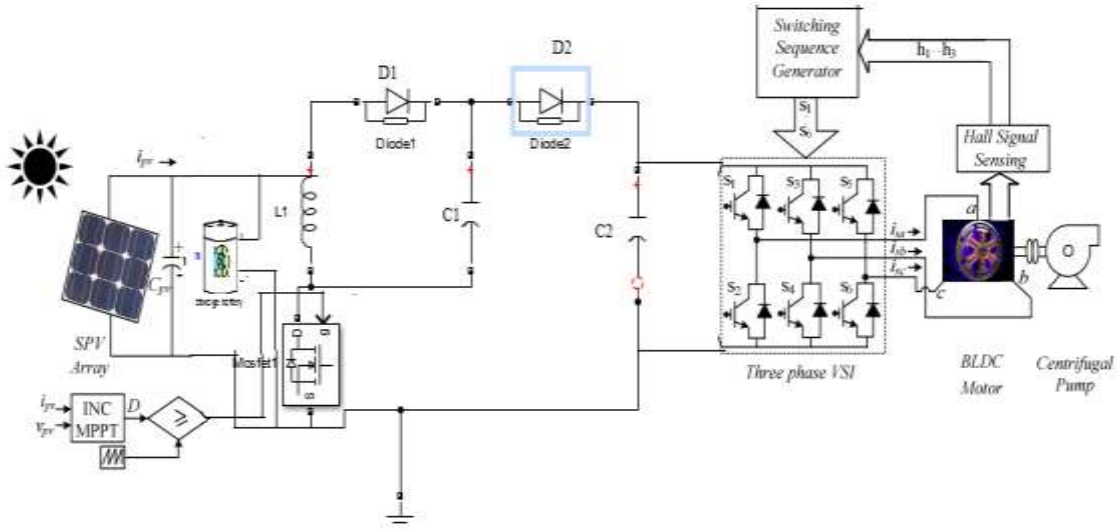

fig 2: circuit diagram for Battery storage SPV array fed BLDC motor driven water pumping system super lift Luo converter .

3.1 Design of Solar photo voltaic cell

The solar cell P_{mpp} = 4.5 kW it is a peak power capacity solar module consist total 36 number cells in series.
Vm = 0.78*14.5 = 11.31 V and Im = 0.8*3.5 = 2.8A the voltage and current of solar cell at MPP.

Voltage of the solar cell at MPP is , V_{mpp} = 140 V in from the VSI.
The maximum peak current of cell is $I_{mpp} = P_{mpp}/ V_{mpp}$ = 4000/140 = 28.57 A.

Number of modules required to connect in series are as, $N_s = V_{mpp}/ V_m$ = 140/11.31 = 12 -------(1)
Numbers of modules required to connect in parallel are as, $N_p = I_{mpp} / I_m$ = 28.57/2.8 = 10.2 ≈ 10 --- (2)

Based on the above estimated values, By connecting 12 modules in series and 10 modules in parallel complete solar design can be obtain. Detailed data of designed SPV array are given in table 1.

Table I. design of solar pv array

Peak power, Pm (Watt)	210
Open circuit voltage	36.3
Short circuit current	7.84
Voltage at MPP, V_m (V)	29
Current at MPP, Im (A	7.35
Number of cells connected in series	36

3.2 design of luo converter

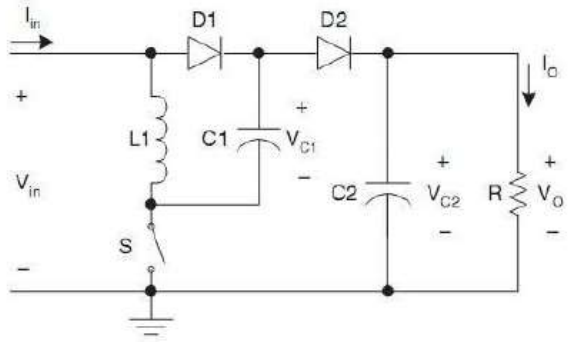

fig 3:Circuit diagram for super lift LUO converter

super lift Luo converter increases power gain stage by stage the above figure shows the super lift Luo converter, circuit consist of one inductor at input side ,two capacitor one capacitor is connected to input side and one is connected at the output side.

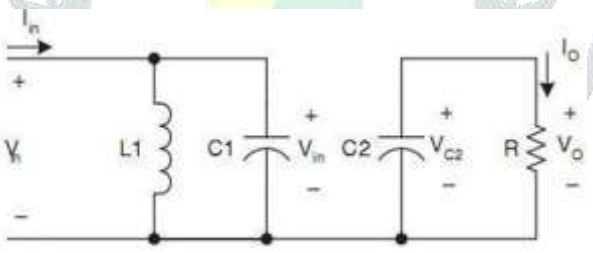

Fig.4.Equivalent circuit during switching-on

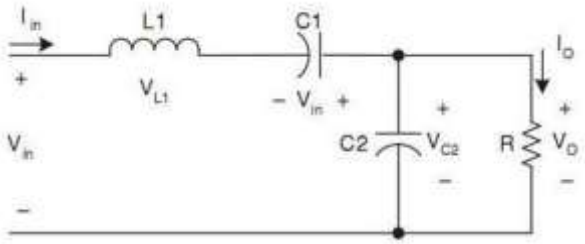

Fig 5.Equivalent circuit during switching-off

Super lift Luo converter operates in two modes.

Mode 1:During switch on condition the capacitor C_1 is charged to V_{in},the current flows through the inductor is i_{L1},indictor current increases with the supply voltage DT is switch on period.

Mode 2:when switch is off C_1 capacitor start to discharge the current to the load the switch off period is (1-D)T,D is the duty ratio.

$V_{pv} = V_{mpp} = 140$ V and $i_{pv} = I_{mpp} = 28.57$ A peak voltage and current rating of solar cell.
Therefore, the current flowing through the input inductor is as, $i_{L1} = i_{pv} = 28.57$ A.
Duty cycle, D of the Luo is calculates as 0.5,the average value of the DC link current is calculated as,
$I_{dc}=P_{mpp}/Vdc=4200/320=13.125A$

The ratings of an input inductor L1,an intermediate capacitor C1, and a DC link capacitor C2, are calculated in below Table II.

fsw is the switching frequency of the switch of super lift Luo; IL1 is an average current flowing through the input inductor; ΔIL1 is an amount of ripple allowed in iL1. ΔIdc is an amount of ripple allowed in the DC link current, ΔVC1 is the ripple allowed in the voltage across the intermediate capacitor. ΔVdc is an amount of ripple allowed in the voltage across the DC link of VSI, ω output voltage frequencies in rad/sec.

f is the frequency of VSI output voltage in Hz, , P is the number of poles in the BLDC motor, N_{rated} is the rated speed of the motor, N is the minimum speed required to pump the water.

Table II. design of super lift LUO converter

S.NO	Parameter	Expression	Design data	Value	Selected Value
1	L_1	$\frac{D*v_{mpp}}{f_{sw}\Delta I_{L1}}$	D=0.5 V_{PV}=140V f_{sw}=20kHz IL1=28.57A ΔIL1=10% of I_{L1}	2.6 mH	30 mH
2	w_{min}	$w_{min}=2*pi*f_{min}=\frac{2*pi*N_{rated}*p}{120}$	P=6 I_{dc}=20.98 V_{dc}=130V N_{rated}=3000rpm N=1100rpm	345.57 Rad/sec	350 Rad/sec
3	C_{min}	$C_h=\frac{I_{dc}}{6*W_{min}*\Delta V_{dc}}$	ΔV_{dc}=10%of V_{dc} I_{dc}=13.125 V_{dc}=320V	C=195 µF	200 µF

3.3 Design of Centrifugal Pump

The centrifugal pump is selected from speed and torque ratio [10].

$$k_w=T_L/W^2_m$$

$Kw=T_L/W^2_m=7/(2*pi*3000/60)=7.1*10^{-5}Nm/(rad/sec)^2$

T_L is the load torque, wm is the rotor mechanical speed , k_W is the constant., centrifugal water pump is selected as per the designed value for water pumping system

IV. CONTROL OF THE DESIGNED SYSTEM

The control at the various stages of the system is classified into two parts as follows.

A. By using direct duty ratio control method for maximum power point tracker to operate solar cells for its MPP reason using this method maximum power can be gained.

B. Voltage source inverter consist 6 switches it operates at 120^0 conduction mode, BLDC motor is electronically commutated by decoding the Hall effect signals generated by connecting inbuilt encoder based on the rotor position. After that decoded signals into switching pulses.

V. SIMULATION MODEL RESULT

The simulation prototype is obtained for battery storage from solar cell BLDC motor driven water pumping system using super lift LUO converter using MATLAB/Simulink(R2016a).The dynamic state behaviors of the circuit system are studied through simulated results.

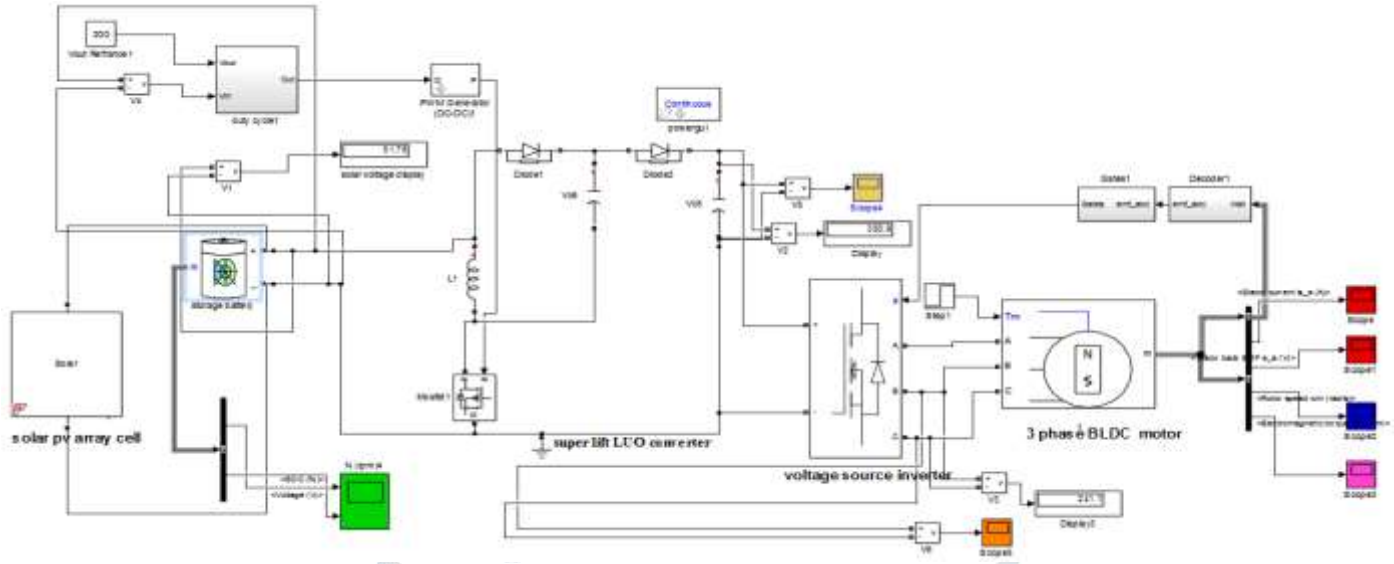

Fig. 6. battery solar cell based water pumping system using super lift technique using simulink(R2016a).

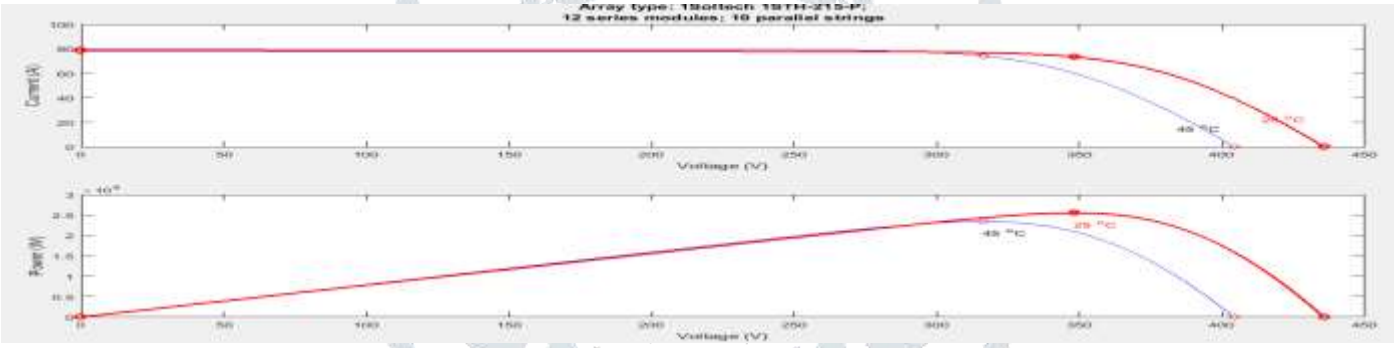

fig7:solar PV cell current and power values for different voltage level.

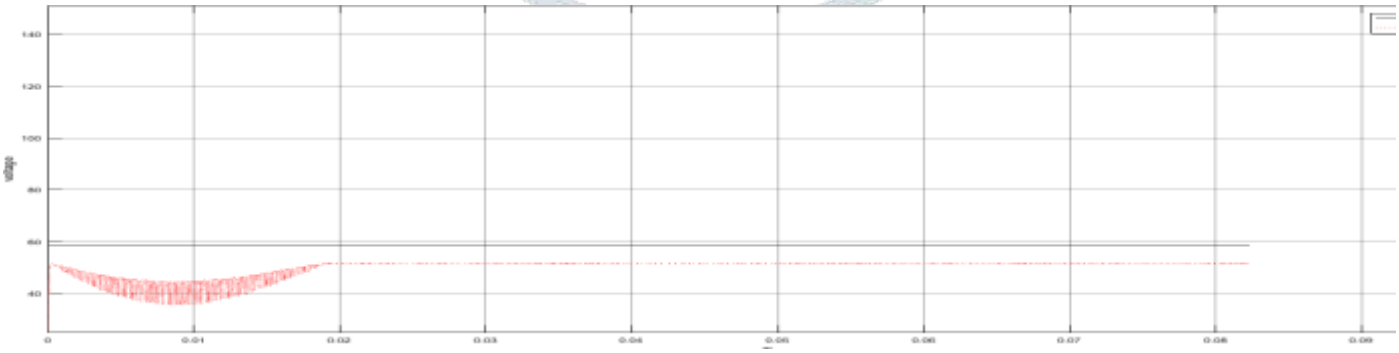

fig8: state of charge(SOC) in % and voltage level of battery

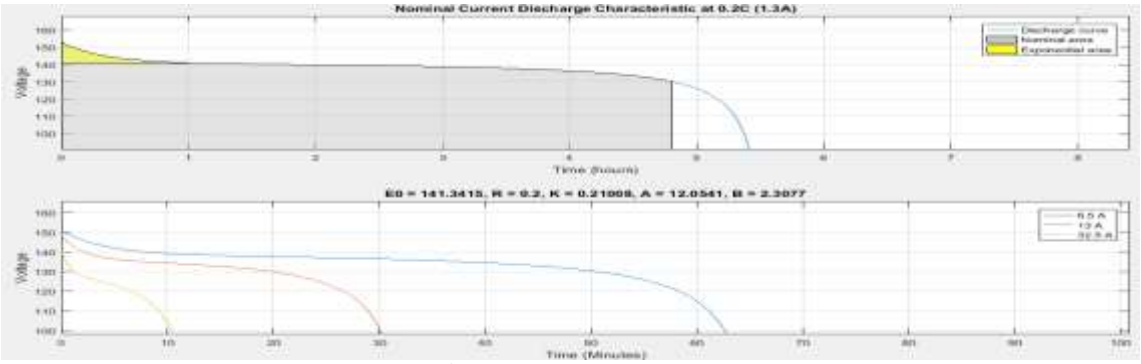

fig9:battery discharge time

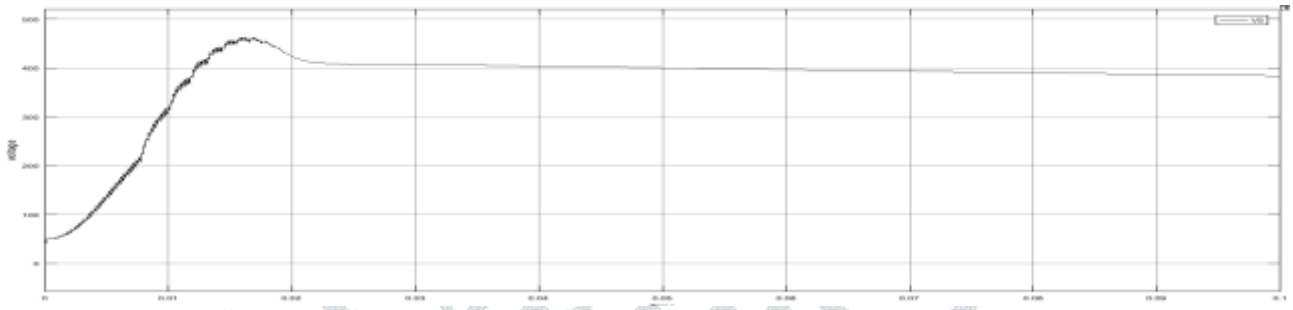

fig10: super lift luo converter out put voltage is increasing in geometric progression manner.

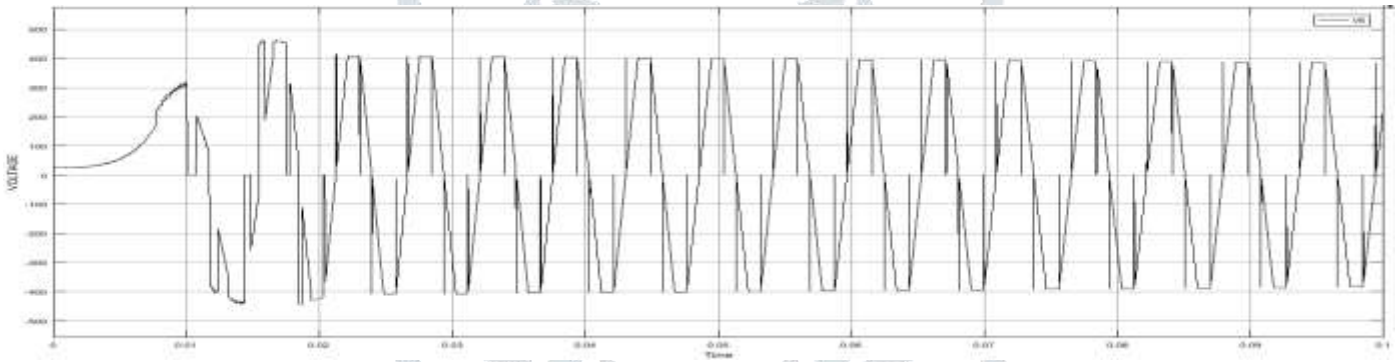

fig11: voltage source inverter output voltage change with time response

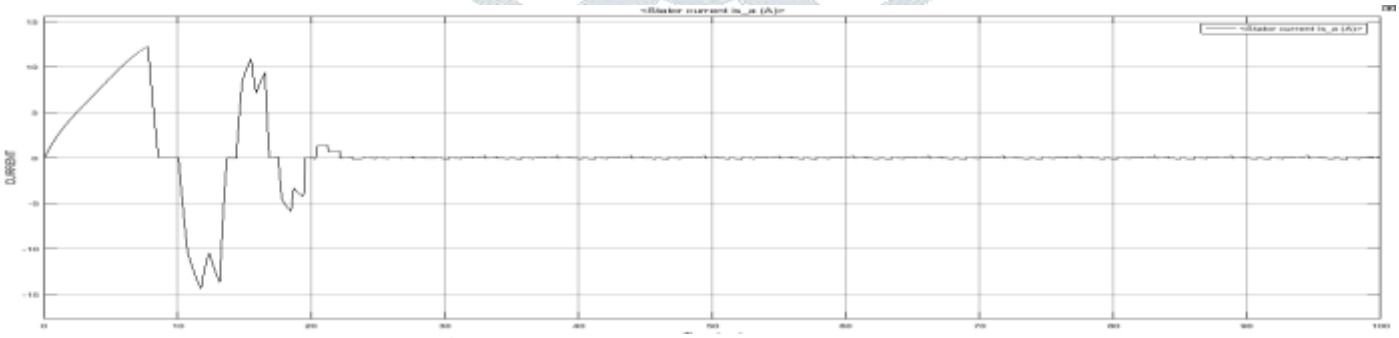

fig12:BLDC motor stator current i_a with time response

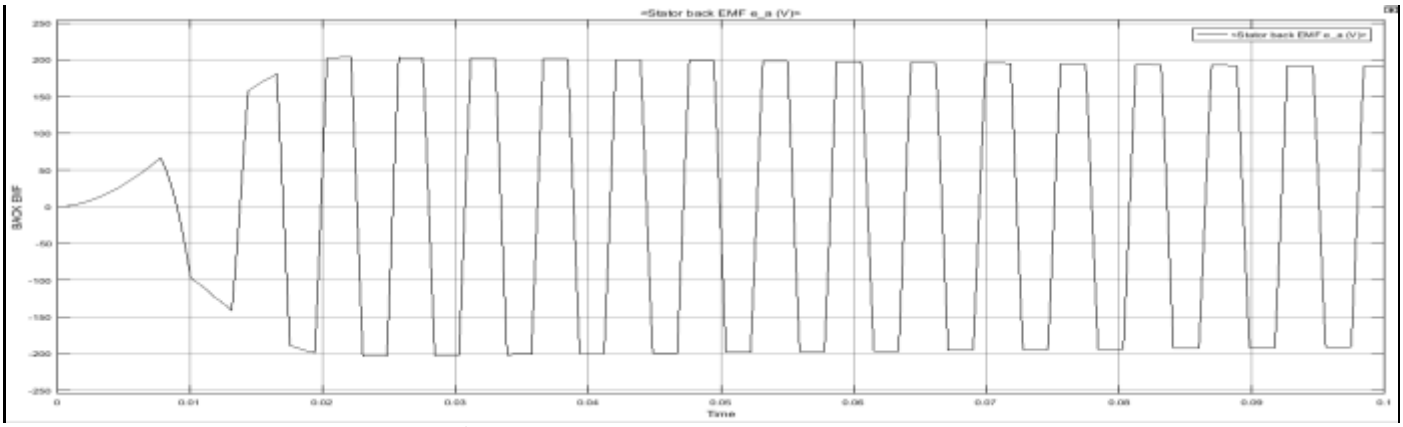

fig13:BLDC motor stator back EMF e_a with time respo

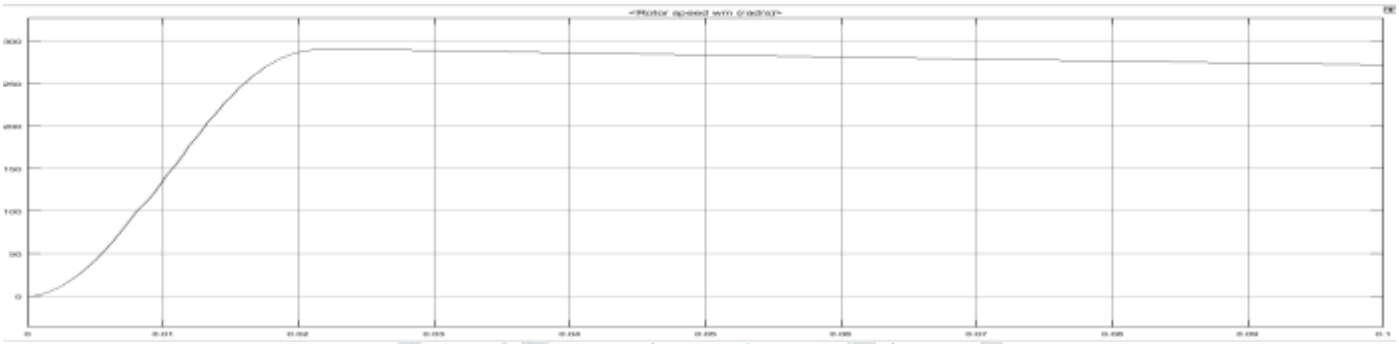

fig14:BLDC motor rotor speed W_m(rpm) with time response

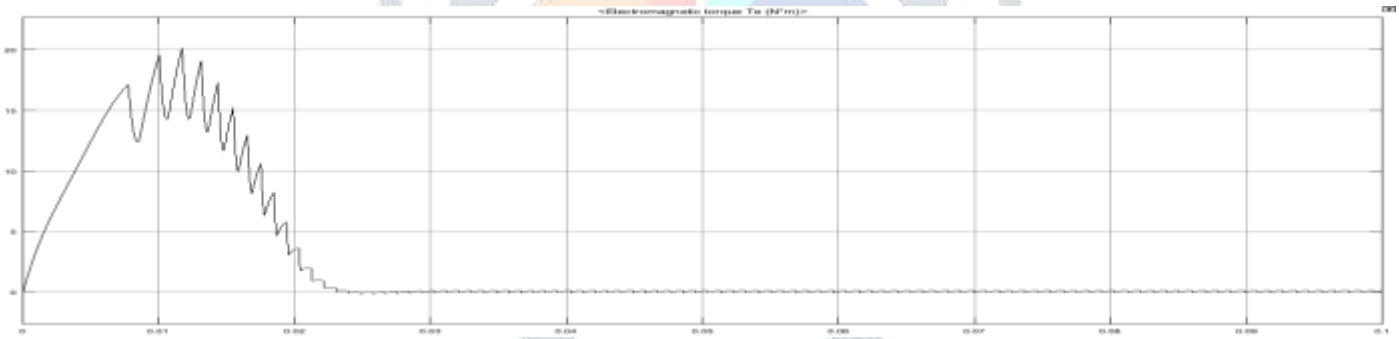

fig15:BLDC motor Electromagnetic Torque T_e(N-m) with time response

VI. CONCLUSION AND RESULTS

solar power is not available continuously to store power from solar energy battery is using in this work. super lift LUO converter increases the voltage in geometrical progression manner by using DC-DC converter BLDC motor runs continuously the dynamic conditions of the motor is verified using simulink. compare to other motor BLDC motor high power efficiency, high power density with compact size, and easy high-speed operation. Luo converter has been operated in CCM in order to reduce the stress on power devices. Operating the VSI in 120° conduction mode with fundamental frequency switching eliminates the losses caused by high frequency switching operation. BLDC motor Electromagnetic Torque T_e(N-m) , rotor speed W_m(rpm) , motor stator back EMF e_a ,stator current i_a dynamic performance is observed.

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