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Design and Simulation of SLLBC FED PMBLDC Motor Drive Using Solar PV Array

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ABSTRACT: Solar Pv arrays fed PMBLDC motor's drives is very popular now a days because of its applications like water pumping , solar air conditioning, solar refrigeration, electrical vehicles and industrial applications from low speed to high speed applications. In this paper solar pv array output fed to the Super Lift-Luo Boost converter for boosting the voltage gain and intended for eliminating the current and voltage ripple at output stage. Converter output is given to VSI (voltage source inverter) for dc to ac conversion. Inverter output is given to PMBLDC motor. PMBLDC motors are very popular because of its numerous application due to its good electrical and mechanical characteristic. In this paper PMBLDC motor sensor less control hysteresis comparator method to design to obtained high speed, noise free operation of PMBLDC drive systemand implementation and simulation analysis of suggested system is validated through MATLAB / SIMULINK 2014b based simulation results and obtained for various operating conditions.

KEYWORDS: SPV Array, INC MPPT, Super Lift Luo Converter, PMBLDCMotor, Hysteresis Comparator.

I.INTRODUCTION

Nowadays continuous shortage of electrical energy researchers are concentrating in the renewable energy sources, especially solar energy (solar photovoltaic array).to obtained maximum power across the PV panel different MPPT technique used i.e. Mechanical MPPT is the old technology it having many disadvantages like expensive, maintenances. Nowadays different MPPT algorithms are accessible in this paper INC method algorithm is used because of its so many advantages .in this method maximum power is obtained for different standard condition, irradiation's. The output of power is then boosting by dc –dc power conversion technique lift voltage lift technique, superlight technique, ultra lift technique.

In this paper [1] super lift technique is used because of its simplicity in nature. To get dc –dc maximum power across converter buck-boost converter [1], Luo converter [2] is used. The converteroutput is in form of dc its converted in ac by the help of VSI (voltage source inverter). This inverter (VSI) is fed to the PMBLDC motor for different application like Air-conditioning [3], electrical vehicle, water pumping [4], refrigeration etc. The run the PMBLDC motor it is important to now the rotor position of PMBLDC motor and it is achieving by the sensor, this sensors sensed the positions of the rotor and gives gate pulse signal to the inverter. In this paper sensor less control scheme is preferred because of its demerits like high space requirements, influence of vibrations, low reliability and if sensor is failure entire system is disrupt[5].using control algorithm position of rotor is obtained by using voltage and current or other motor constraints . in this paper hysteresis comparator technique is used to pulse generation to the inverter by comparing the voltage's, and Speed .Hysteresis comparator is very simple technique ,reliable, accurate technique used for sensorless control of proposed PMBLDC motor drives system.

In this proposed method inverter employed PMBLDC motor drive used because this motor have inherent features like High energy saving, high reliability, low-slung noise, less EMI (Electromagnetic interference), there is not at all spark problem like inn conventional direct current motor, high torque, size also a reduced, lifespan of the motor is good as compare to other motors, extensive best choice of speed control is possible this are few special features of PMBLDC motor.

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II. PROPOSED BLOCK DIAGRAM

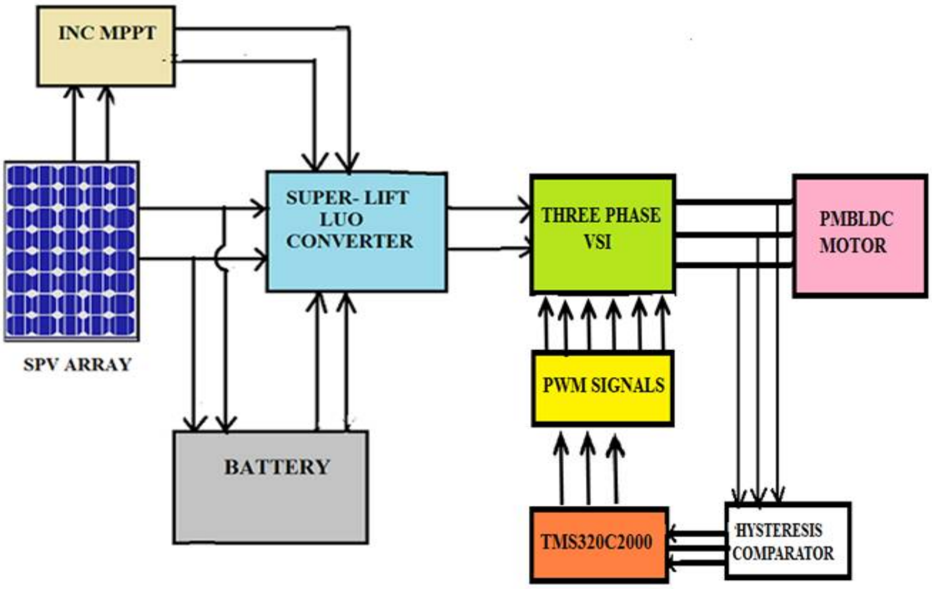

Fig 1: Proposed Block Diagram shows the SPV Fed PMBLDC Motor Drive System.

The SuggestedSPV (Solar Photo Voltaic) arrays based super lift-luo converter fed PMBLDC motor drive scheme consists the SPV array, Batteries,Super lift -luo converter (SLLC), volatge source invereter (VSI), PMBLDC motor. The solar photovoltaic array converts light energy in to dc power and then it feeds to input of dc-dc super lift luo converter. In this converter MOSFET is used as switch operated through an INC(Incremental conductance method) MPP tracking algorithm to get maximum power across the pv panel optimzed power is fed to the inverter through converter.
The gate pulse to inverter is given by rotor position of PMBLDC motorusing sensor less control (Comparator method). The super lift luo Boost convereters is continuouslyworking in continous conduction modes (CCM), to condense the stress on the power semiconductor Devices, The switching pulses to inverter is given by electronic commutation,In this method decoding the signals genarated by the sensor less control of hysterisis camparator affording by the rotor position of this motor.The design , control of suggested scheme are described in thesection VII.

III. DESIGN OF SOALR PV ARRAY

Solar Photovoltaic cells is mainly an made-up of PN junctioncutting-edge of thin wafers of a power semiconductor. The electromagnetic radiation fall on the of solar PV directly converted in to dcpower through photovoltaic effect. Meanwhile a typicalSPV cells produce less than 2Watts at 0.5Voltapproximately, this cell’s are to be connected in the arrangement of series and parallel configuration and arranged the modules to produce sufficient high power.

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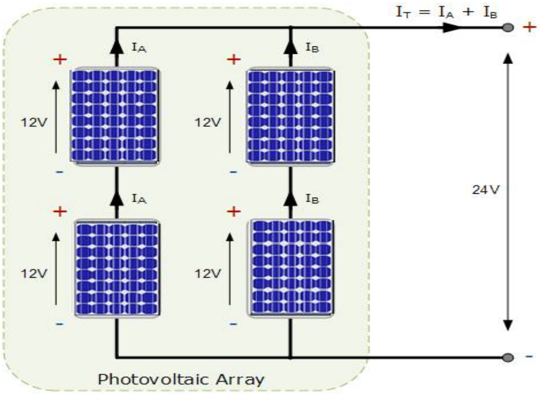

Fig 2: Selection of Solar Panel

Make: BP SOLAR SX3190	
V_{oc} (Open Circuit Voltage)	30.60 volts
I_{sc} (Short-Circuit Current)	8.55 amps
V_{mp} (Maximum Voltage)	24.3 volts
I_{mp} (Maximum Current)	7.8 amps
P_{mp} (Maximum Power Point)	190 watts
T (Cell temperature)	25^0 c
STC : Irradiance	1000W/m^2

Table 1: Solar Module Specifications

A SPV Stringsis a collection of numerous SPV arrays which remain electrically coupled in series or parallel circuits to make the essential current and voltage. Thenequi.circuit for the solar arrayset in " N_p"parallel cells and " N_s"series cells gives boosted voltage i.e. each panel voltage is 12volts now, they are connected in series give series voltage is 24 volts.In series circuit from the above example, this is calculated as

The modest solar PV array consists of four modules as shown, two modules are connected in series then two strings are in parallel as shown above . The series connection of the panels.

$$V_{out} = V_1+V_2 \qquad (1)$$
$$V_{out} = 12\ V + 12V = 24\ Volts$$

This output current (I_T) is equivalent to the sum of the parallel branch current,Let consider the PV modules produces 7.8 ampsonfull irradiance (STC), Total current (I_T) is equivalentto sum of branch current

$$I_T = I_A + I_B \qquad (2)$$
$$I_T = 7.8amps + 7.8amp = 16\ amperes$$

MPP of the SPV array at STC Irradiance 1000W/m^2 can be calculated as:

$$P_{out} = V_{out} \times I_T = 24.5 \times 16 = 390\ watts.$$

Solar PV array reaches its maximum power point of 190 watts/module.STC Irradiance 1000W/m^2 because the maximum power output of each PV panel or module consist of 50 cells ,190 watts (24.3Volts x 7.8Amps). But, due to varying in solar radiations, different temperature levels, power losses etc, the actual output power is usually less than the calculated 190 watts,to get maximum power by using INC method is proposed.

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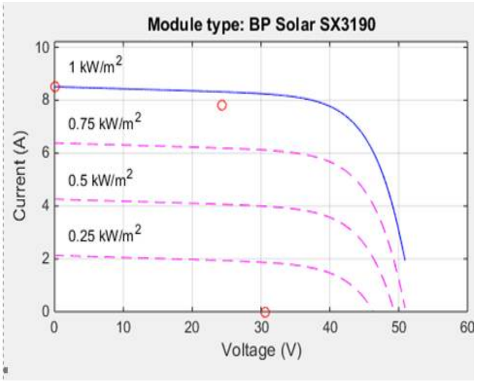

Fig-3: I -V Characteristic of SPV module At 25^{o}c

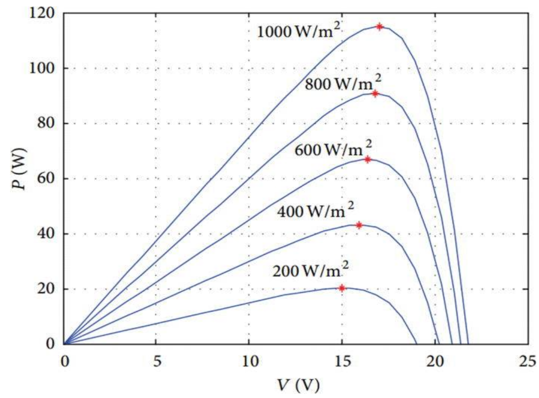

Fig-4: P -V Characteristic of SPV module At 25^{0}C

Maximum power point is obtained when $\frac{dp}{dv} = 0$ (Where $P = V * i$)

$$\frac{d(v*i)}{dv} = i + v * \frac{di}{dt} = 0 \qquad \text{(a)}$$

Elementary equation's of MPPT technique be present as follow.

$$\frac{di}{dv} = -i * V \qquad \text{(A Mpp)} \qquad (4)$$

$$\frac{di}{dv} > -i * V \qquad \text{(Left Of Mpp)} \qquad (5)$$

$$\frac{di}{dv} < -i * V \qquad \text{(Right of Mpp)} \qquad (6)$$

In the INC MPPT method SPV module terminals voltage is always used to allowing to get MPP voltage and this one is constructed by conductance based of the SPV modules. The simple technique of INC (incremental conductance method)set a P-V Curve to zero. The gradient of SPV array power curve is zero on the MPP, increasing and decreasing of MPP by adjusting from P-V curve to left and right respectively as shown in the curves.

IV.DESIGN OF SLLB CONVERTER

In SLLBC(Super lift-luo Boost converter) boost up the voltage gain stage-stage in geometrical evolution. This the voltage translation from source side -load side is positive -positive voltage and thus generous amplified output voltage obtained. The simulation has been achieved on the positive output SLLBC for SPV scheme using parameters Listed in Table 2.

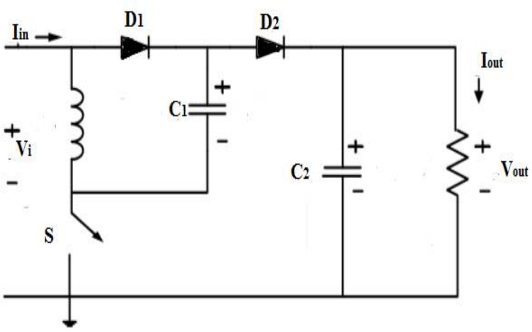

Fig 6: Equivalent Circuit Super-Lift Luo Converter

PARAMETERS	NAME SYMBOLS	VALUE
Input voltage	V_I	50 volts
Output voltage	V_O	300volts
Inductors	L_1	16.66µH
Capacitors	C_1	5mf
Capacitor	C_2	100mf
Switching frequency	f_s	50kHz
Load resistance	R	100ohms

Table 2. Parameters to design elementary luo converter:

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$$\Delta I = \frac{Vin*D*T}{L} = (Vin - 2Vo)\frac{(1-D)}{L}T \quad (1)$$

$$\frac{Vo}{Vin} = \frac{2-D}{1-D}\dots \quad (2)$$

$$T = \frac{L*\Delta I}{Vin} - \frac{L*\Delta I}{Vo-2Vin} \quad (3)$$

$$L = \frac{Vin*D}{f*R*\Delta Vc} \quad (4)$$

$$\Delta Vc = \int_{DT}^{t} Io\, dt\dots \quad (5)$$

$$C = \frac{V(1-D)}{f*R*\Delta Vc} \quad (6)$$

From the above equations super lift luo converter can design and for the proposed model select the parameter as shown in table 2.

V. MATHEMATICAL MODELING OF THREE PHASE VSI FED PMBLDC MOTOR

The three phase PMBLDC motor modeling is developed, it is similar to the 3-phase synchronous motor modeling. The dynamic characteristics of this model is having PM (permanent magnet) is surrounded the rotor of the PMBLDC. In the fig 7 shows the three phase VSI(Voltage Source Inverter) fed PMBLDC motor. In which the output voltage of the inverter is not essential to be sine wave or square wave can also used.

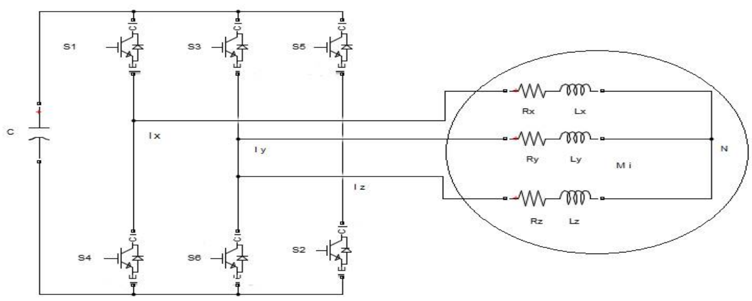

Fig 7: Three Phase VSI fed PMBLDC motor drive model.

The modelling of the 3 phase PMBLDC motor armature winding is [1]-[3],

$$Vx = RsIx + L\frac{dI}{dt} + Ex \quad (1)$$

$$Vy = RsIy + L\frac{dI}{dt} + Ey \quad (2)$$

$$Vz = RsIz + L\frac{dI}{dt} + Ez \quad (3)$$

Where *RS* and *L* are armature resistance [ohm] and armature self-inductance [H] of the stator phases winding respectively, *Vx*, *Vy*, and *Vz* are terminal voltages [volts], *Ix*, *Iy*, and *Iz*are motor currents [amps] and *Ex* ,*Ey*,and*Ez*are trapezoidal motor back emf [volts] respectively.

The phase variables of three phase winding [1]-[3], then circuit equations are,

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$$\begin{bmatrix} Vx \\ Vy \\ Vz \end{bmatrix} = \begin{bmatrix} Rs & 0 & 0 \\ 0 & Rs & 0 \\ 0 & 0 & Rs \end{bmatrix} \begin{bmatrix} Ix \\ Iy \\ Iz \end{bmatrix} + \begin{bmatrix} Lx & Lxy & Lxz \\ Lyx & Ly & Lyx \\ Lzx & Lzy & Lz \end{bmatrix} P \begin{bmatrix} Ix \\ Iy \\ Iz \end{bmatrix} + \begin{bmatrix} Ex \\ Ey \\ Ez \end{bmatrix} \quad (4)$$

Neglect the iron losses, let considered motor unsaturated and the stator resistance of three phases remainidentical, mutual inductance "Mi" is zero .

$$Lx = Ly = Lz = L \quad (5)$$

$$Lyx = Lyz = Lyx = Mi = 0 \quad (6)$$

$$\begin{bmatrix} Vx \\ Vy \\ Vz \end{bmatrix} = [Rs] \begin{bmatrix} Ix \\ Iy \\ Iz \end{bmatrix} + [LP] \begin{bmatrix} Ix \\ Iy \\ Iz \end{bmatrix} + \begin{bmatrix} Ex \\ Ey \\ Ez \end{bmatrix} + \begin{bmatrix} V0 \\ V0 \\ V0 \end{bmatrix} \quad (7)$$

The trapezoidal back emf three phases are,

$$Ex = kc * f(\theta e) * \omega s \quad (8)$$

$$Ey = Kc * f\left(\theta e - \frac{2\pi}{3}\right) * \omega s \quad (9)$$

$$Ez = Kc * f\left(\theta e + \frac{2\pi}{3}\right) * \omega s \quad (10)$$

Electromagnetic torque of PMBLDC motor is "Te"

$$Te = \frac{Ex*Ix + Ey*Iy + Ez*Iz}{\omega s} \quad (11)$$

The equations of PMBLDC motor aimed at a modelingscheme with inertias 'J'friction coefficient 'B' and 'T_l' is Load torque *is given by*

$$Te = Tl + J\frac{d\omega s}{dt} + B * \omega s \quad (12)$$

Where$\omega_s$is speed of motor Rs,B and J are are influence the speed response of the PMBLDCM,WhereKt= constant)

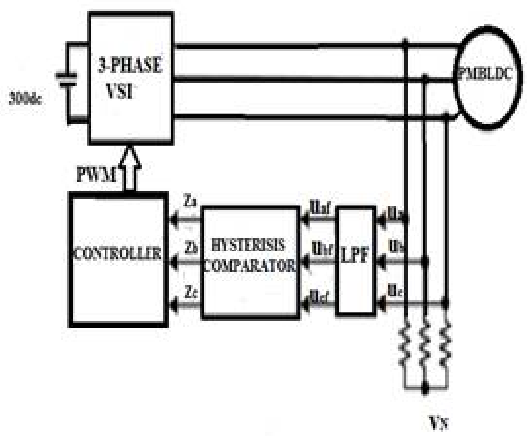
$$Te = Kt * I \quad (13)$$

Output power of motor is obtained by$P = Te * \omega s$ **(14)**

From eq. (14) power is product of torque and speed is concluded.

VI. HYSTERESIS COMPARATOR METHOD OF SENSOR LESS CONTROL

Hysteresis comparator method of sensor less control of PMBLDC Motor, Sensor less controller of PMBLDC motor using ZCD hysteresis comparator technique is modest and easy to implement without position sensor, it contains of LPF to eliminating the ripple ofhigh switching frequency signals.hysteresis comparator is compare and generates the commutation signals in the form of PWM. Sensed 3-phase voltage are send LPF to overturn the high switching frequencies ripples, noise. Terminal voltages are used for electronic commutation for motor.



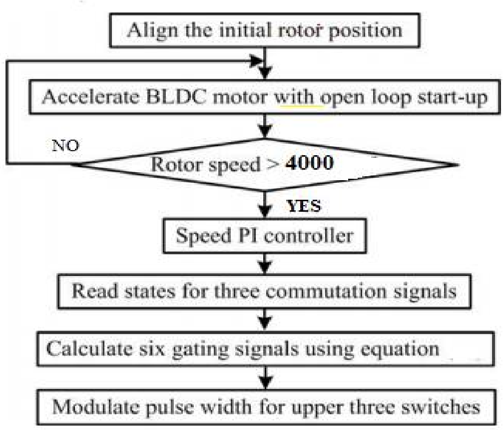


Fig 8: 3 phase VSI fed PMBLDC sensor less Control Fig 9 : Hysteresis comparator method of Sensor less Control flow chart

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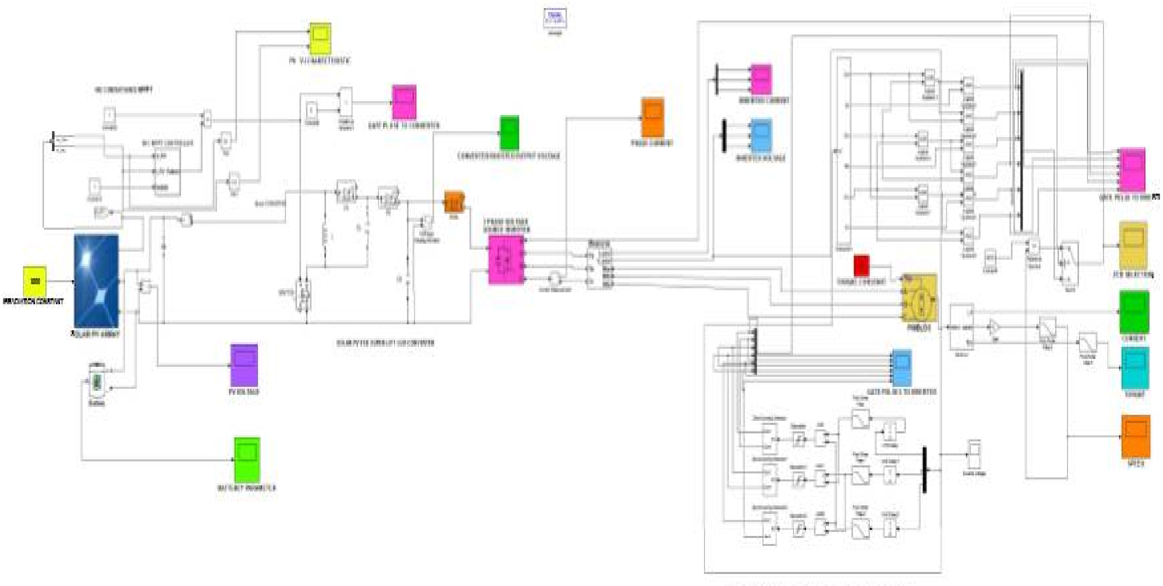

VII. RESULTS AND DISCUSSIONS

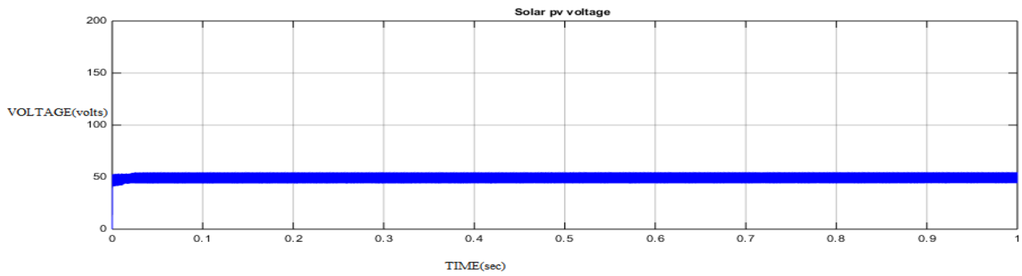

Fig:1 Solar pv voltage across panel =50 volts

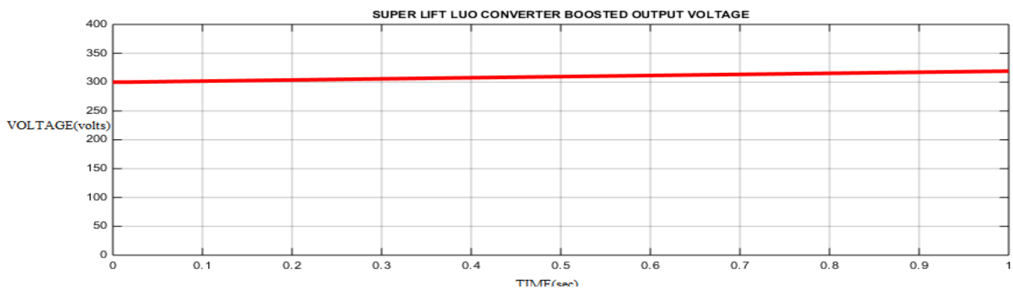

Fig:2 output boosted dc voltage of converter =300 volts.

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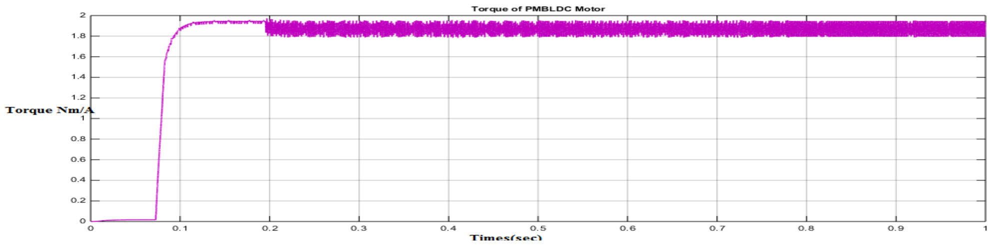

Fig:3 Torque Charecteristic of PMBLDC Motor for reference 2 Nm/A

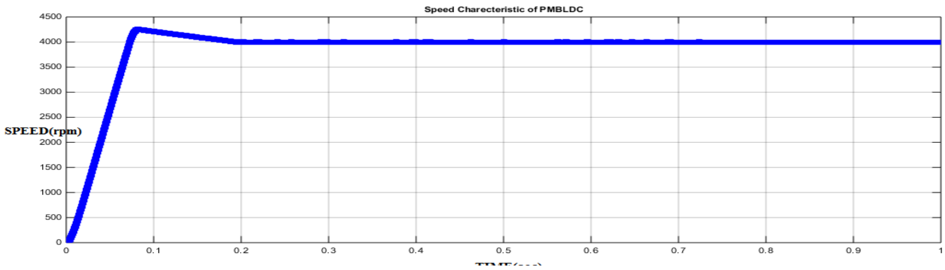

Fig:4 Speed Charecteristic of PMBLDC Motor for reference speed 4000 rpm

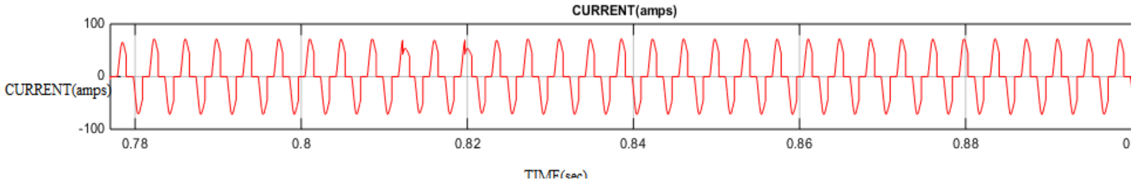

Fig:5 Current wave form inverter fed PMBLDC Motor drive.

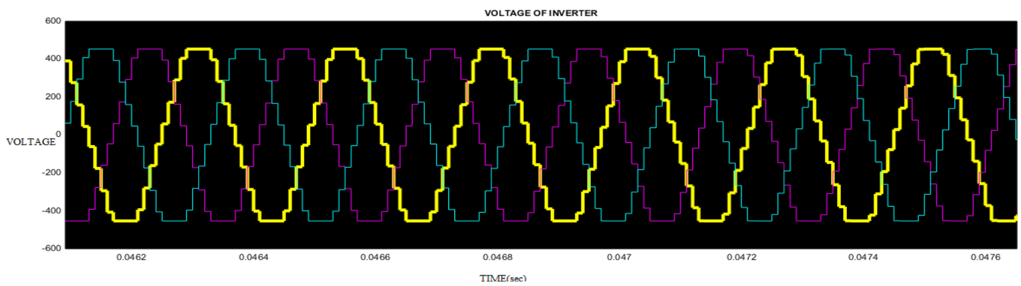

Fig:6 Three phase voltage to PMBLDC Motor drive =400volts

VIII..CONCLUSION

In this paper SLLBC converter is considered to work in the continuous conduction mode (CCM) and it is proved using MATLAB/SIMULINK.From this converter ripple freeoutput voltage and current is obtained, Without sensors speedcontrol of PMBLDC motor based on hysteresis comparator with ZCD Investigated using simulation and obtained Speed response without sensor and torque ripple content too reduced. The cost of the sensor less control is less as compared to sensor Control and with good dynamic performance, This proposed motor mechanism suitable used for applicationsalike water pumping, solar air conditioning, solar refrigeration, electrical vehicles,

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industrial automation and industrial applications.The main advantage is robust speed control, effective and easy to replace in sensor based control application.

REFERENCES

[1] Design of Positive Output Super-Lift Luo Boost Converter for Solar Inverter Ms. Anushka S. Tekade Dept. Of Electrical Engg. R. G. C. E. R. Nagpur, India anushka.tekade@gmail.com .

[2] Rajan Kumar and Bhim Singh, “Luo converter fed BLDC motor drive for solar PV array based water pumping,” IEEE International Conference on Power Electronics, Drives and Energy Systems (PEDES), 16-19 Dec. 2014

[3] Modeling and Simulation of Grid-connected Hybrid Photovoltaic/Battery Distributed Generation System Fei Ding\ Peng Li\ Bibin Huang\ Fei Gao\ Chengdi Ding1, Chengshan Wang1 lkey Laboratory of Power System Simulation and Control of Ministry of Education,Tianjin University, Tianjin 300072, China.

[4] Positive Output Elementary Superlift Luo Converter for PV Applications Dr.G.Justin Sunil Dhas1, Dr.D.Anto Sahaya Dhas2, and Sreesna M K3 3rd International conference on Innovative Engineering Technologies (ICIET'2016) August 5-6, 2016 Bangkok (Thailand).

[5] Sensorless Control BLDC Motor Drive for an Automotive Fuel Pump Using a Hysteresis comparatortae-Won Chun, Member, IEEE, Quang-Vinh Tran, Hong-Hee Lee, Senior Member, IEEE, and Heung-Geun Kim, Senior Member, IEEE Year: 2014, Volume: 29.

[6] Rajan Kumar and Bhim Singh, “BLDC Motor Driven Solar PV Array Fed Water Pumping System Employing Zeta Converter,” in 6th IEEE India International Conference on Power Electronics (IICPE), 8-10 Dec. 2014.

[7] B. Singh, V. Bist, A. Chandra and K. Al-Haddad, “Power Factor Correction in Bridgeless-Luo Converter- Fed BLDC Motor Drive,” .IEEE Trans. Ind. Appl., vol.51, no.2, pp.1179-1188, March-April 2015