International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 06 Issue: 12 | Dec 2019 www.irjet.net p-ISSN: 2395-0072

Comparative Study of Sensor and Sensor Less Control of Three Phase VSI Fed PMBLDC Motor Drive for EV Application.

Afroz Pasha[1], Surat Pyari Atti[2]

[1]*Assistant Professor, Dept. of EEE, HKBK College of Engineering, Bengaluru, Karnataka, India*
[2]*Assistant Professor, Dept. of EEE, HKBK College of Engineering, Bengaluru, Karnataka, India*

Abstract - *In this proposed paper voltage source fed Permanent Magnet Brushless DC (PMBLDC) Motor is used because it is more popularity due to its modest construction low cost, less maintenance, Improvements in PM materials, good performance, higher efficiency, soft starting will be achieved. PMBLDC Motor are widely used in commercial, industrial applications .The conventional dc motor having disadvantages like Mechanical commutation, low Efficiency and more Maintenance. In this paper VSI fed sensor based and sensor less control of PMBLDC drives are compared, the performance, reviewing the difference between sensor and sensor less control of six –switch VSI Inverter fed PMBLDC is discussed with Simulation results using MATLAB 2014b.*

Key Words: VSI, PMBLDC, SENSOR CONTROL, SENSOR LESS CONTROL, HYSTERESIS COMPARATOR.

1. INTRODUCTION

PMBLDC Motor are widely used in commercial, industrial and in electric vehicles. The conventional dc motor having disadvantages like Mechanical commutation, low Efficiency and more Maintenance. In PMBLDC motor having good performance, higher efficiency, soft starting will be achieved in the PMBLDC motor. In this motor Cost reduction of PMBLDC motor drives can be achieved by two methods one topological method is sensor based and second control method sensor less control. In the sensor less method, the number of [Hall sensors] sensors and associated circuitry used to compose the power converter is minimized. Normally for the BLDC Motor drive have six switches voltage source inverter. By reducing the no of sensors the cost also reduced. Advantages in sensor less control have is High efficiency, Reliability is good, Reductions system size,Noiseless opertion and less feed backs elements and High tempreture application also it is suitable there switching and conduction losses reduced. Overall drive cost also reduced in sensor less.

In paper [1] is to advancement control of permanent magnets brushless direct motor (PMBLDC) motor without sensor controls system for a locomotive applications. Without sensor control methods built on a hysteresis comparator technique with a extraordinary starting torque were proposed. In this comparator method is using to reimburse designed for the phase delay of then Back -EMF due to a LPF then similarly avoid multiples outputs of Transition noise, ripples content in output voltage. In [2] presented the replacing the brushed motor to brushless motor for application like low speed to high speed. The mechanical and electrical characteristic of this motor having extreme performance for different state like steady state, Transient state. Soft switching and operation in this paper speed is controlled without sensor through fuzzy logic control. Back EMF is used in sensor less control scheme by vary the PWM stator currents can each control is analyzed.

In [3] paper concerns the investigation on position control of low cost PMBLDC motor. Generally PMBLDC motors are controlled by using the hall-effect sensor in a low cost application. Based on the characteristics of back EMF the rotation information of rotor can be developed from the hall sensor. Through the one electrical cycle, the motor has six trigger signals for three phases. Speed and position of the rotor can be calculated by using hall sensor signal.

In this proposed paper developed mathematical Modeling of voltage source inverter fed PMBLDC Motor drive, Inverter performance controlling with six switches with the help of the gate pulses. In sensor control sensors gives output signal to the controller and in Senorless control the hysteresis comparator gives signal to the controller for generation of gate pulse depending on the output current, voltage, speed ,Torque of the motor. In both sensor control and sensor less control Performance analyzed, with the help of simulation and compared the results.

2. MATHEMATICAL MODELLING OF VSI FED PMBLDC MOTOR

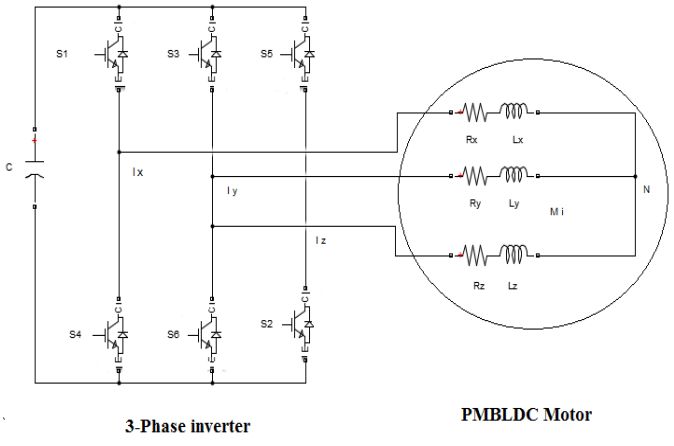

Figure:[1] Three Phase VSI fed PMBLDCM drive model.

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 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. 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 equations of PMBLDC motor aimed at a modeling scheme with inertia' 'J' friction coefficient 'B' and ' T_l' is load torque *is given by*

$$Te = Tl + J\frac{d\omega s}{dt} + B * \omega s \quad (4)$$

Where ω_s is speed of motor Rs, B and J are influence the speed response of the PMBLDCM, Where Kt = constant)

$$Te = Kt * I \quad (5)$$

Output power of motor is obtained by

$$P = Te * \omega s \quad (6)$$

Power is product of torque and speed is conclude

2.1 Six Switch Voltage Source Inverter

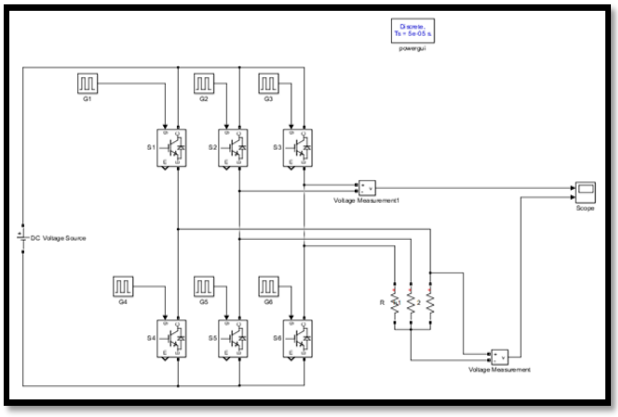

Figure:[2] Simulation model of six switch VSI

The above fig the shows six switch VSI [voltage source inverter]. Inverter converts dc to ac voltage (variable frequency voltage) commutations is achieved with the help of rotor position of the PMBLDC motor with the help of controller that generates switching pulses to VSI. The selection of power semiconductor switches is mainly depend upon the switching frequency and the application. In this proposed paper IGBT switches are used .The inverter switching is done in such a way that all the three phase's conduct at all the time. Current flowing through the switching is 60^0.

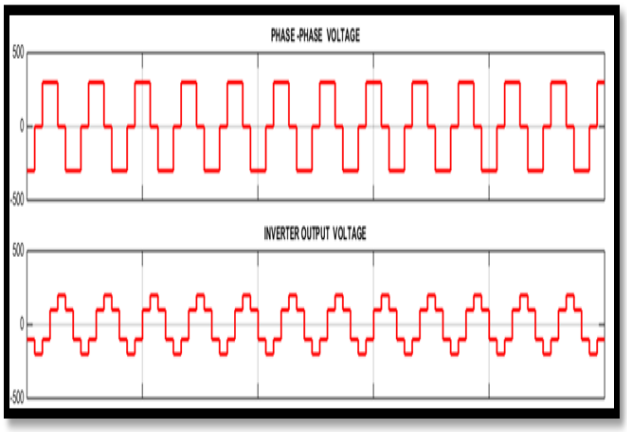

Figure: [2.1] Simulation results of VSI for input

3. SENSOR BASED CONTROL

PMBLDC motor used in excessive amount in the industrial application because theses motors are used suitable for many in application . In general induction motors are finest to uses as drives but compare to PMBLDC motor 10-15% efficency is less in Induction motor. The modeling is similar to Permanent Magnent DC motor and electromagnents do not rorates. The Permanent Magnents rotor rotates and armature circiuts remains stationary.In PMBLDC motor rotor position is sensed by position sensor and sensed signal is given feedback for commutation to energies voltage source inverter and inverter works consequently.

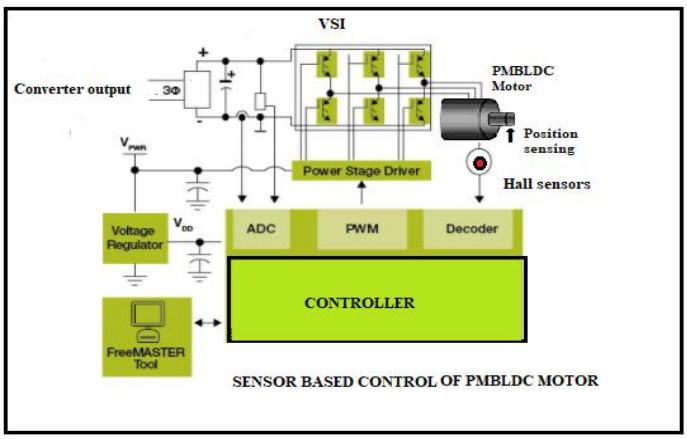

Figure:[3] Sensor control of PMBLDC Motor

Drawbacks Presence of stray magnetic fields, higher space requirements, effects of vibration, poor reliability and Costly, if sensor failure the entire system is disrupt and in high temperature application it is not suitable

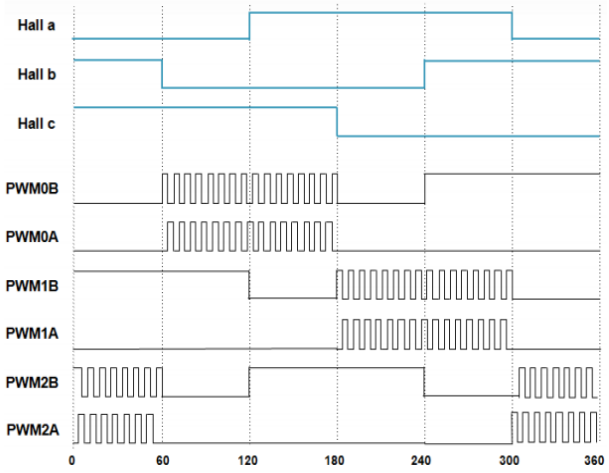

Figure:[4] Six-step control and PWM wave

Table -1: Position of hall sensor sequences and emf

Ha	Hb	Hc	emf a	emf b	emf c
0	0	0	0	0	0
0	0	1	0	-1	1
0	1	0	-1	1	0
0	1	1	-1	0	1
1	0	0	1	0	-1
1	0	1	1	-1	0
1	1	0	0	1	-1
1	1	1	0	0	0

It is easy to implement the six-step way commutation on this topology. The waveforms for PWM signals together with Hall sensor values during one 360 electrical degrees when driving PMBLDC are shown in the above figure. Besides, the duty cycle of the PWM changes the speed of the rotor.

4. SENSORLESS CONTROL OF PMBLDC MOTOR

Different types of sensor less control method.

1. Back EMF Method.
2. Position Estimation Using Motor Parameters.
3. Terminal Voltages and Current
4. Hysteresis comparator method

4.1 Hysteresis comparator method of sensor less control of PMBLDC Motor

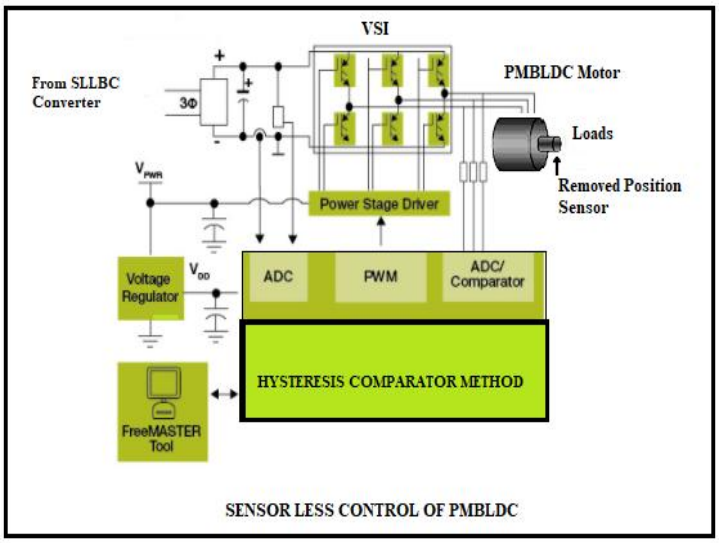

Figure:[5] Sensorless control of PMBLDCM

Sensor less controller of PMBLDC motor using hysteresis comparator technique is modest and easy to implement without position sensor, it contains of LPF for defeating then high switching frequency ripples, hysteresis comparator for generating the three –phase commutation signals, and a gating signals producing six PWM signal. Sensed three phases voltage are send LPF to overturn the high frequency ripples or else noise. Terminal voltages are used for electronic commutation for motor

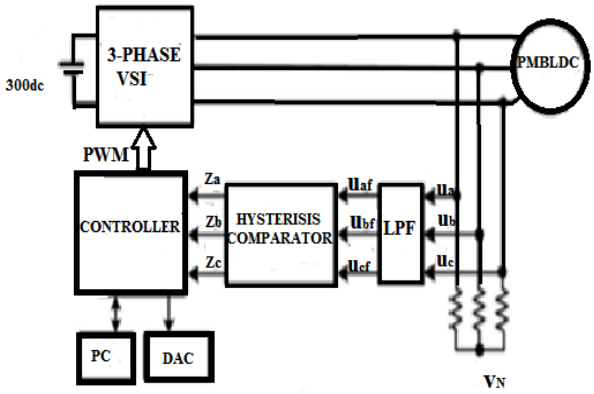

Figure: [6] Phase VSI Fed PMBLDC Sensor Less Control

The logic equations designed to generates six gate signals of 3 phase Voltage source PWM inverter Three commutation signals can be derived as

$$A+=(Z_a \oplus Z_b)\bullet \overline{Z_a} \ , \ A-=(Z_a \oplus Z_b)\bullet Z_a \quad \text{.....[1]}$$

$$B+=(Z_b \oplus Z_c)\bullet \overline{Z_b} \ , \ B-=(Z_b \oplus Z_c)\bullet Z_b \quad \text{.....[2]}$$

$$C+=(Z_c \oplus Z_a)\bullet \overline{Z_c} \ , \ C-=(Z_c \oplus Z_a)\bullet Z_c \quad \text{.....[3]}$$

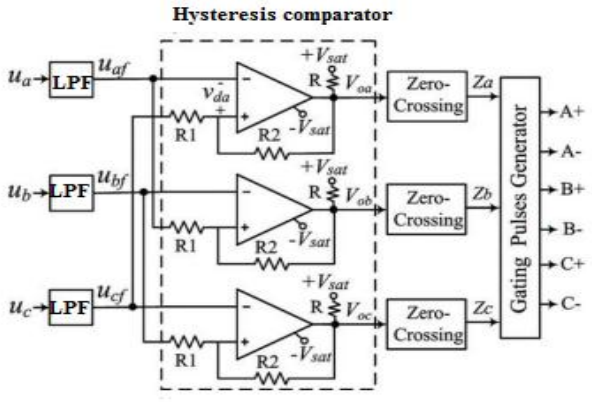

Figure: [7] Hysteresis comparator of Sensor less Control

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 of high 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. Advantages High efficiency. Reliablity is good .Reductions system size, Noiseless opertion and less feed backs elements and High tempreture application also suitable

4.2 Rotors Positions Alignment

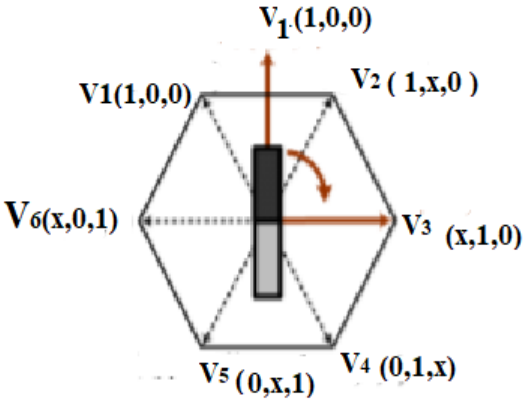

Figure: [8] Rotor position alignment of PMBLDC Motor

TABLE -2: SWITCHING SEQUENCES OF VSI

emf_a	emf_a	emf_a	S1	S2	S3	S4	S5	S6
0	1	1	0	0	0	1	1	0
1	1	0	0	1	1	0	0	0
1	0	1	0	1	0	0	1	0
1	0	1	1	0	0	0	0	1
1	1	0	1	0	0	1	0	0
0	1	1	0	0	1	0	0	1

5. SIMULATION AND RESULTS DISCUSSION

5.1 Performance analysis of sensor based VSI fed PMBLDC motor drive

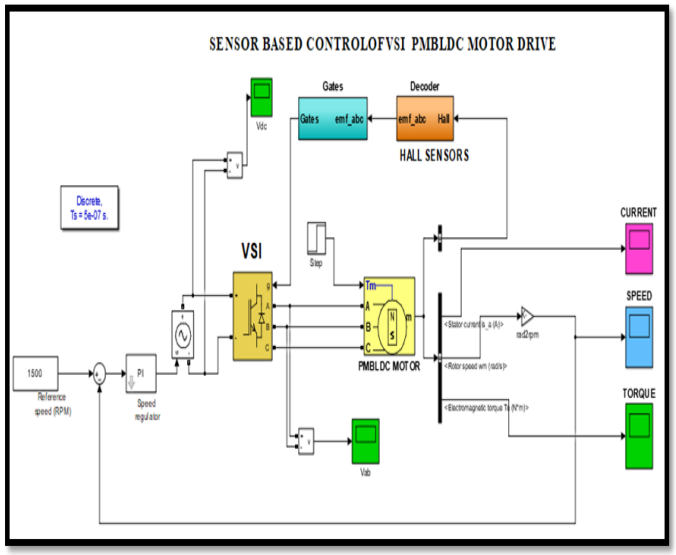

Figure: 5.1[a] simulation model of sensor based control of three phase voltage source inverter fed PMBLDC motor drive

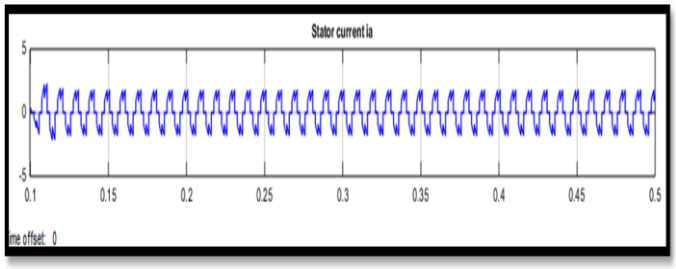

figure: 5.1 [b] Stator current of the PMBLDC motor

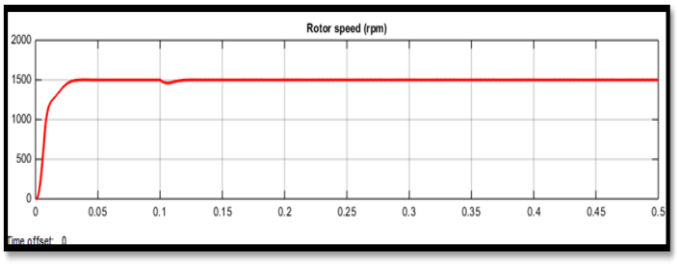

Figure:5.1 [c] Rotor speed of the PMBLDCM=1500rpm

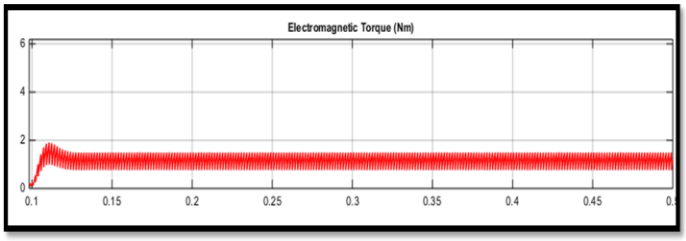

figure: 5.1 [d] Torque charecteristics of the PMBLDC motor 1.5Nm/A

5.2 Performance analysis of Sensor less control of VSI fed PMBLDC motor drive

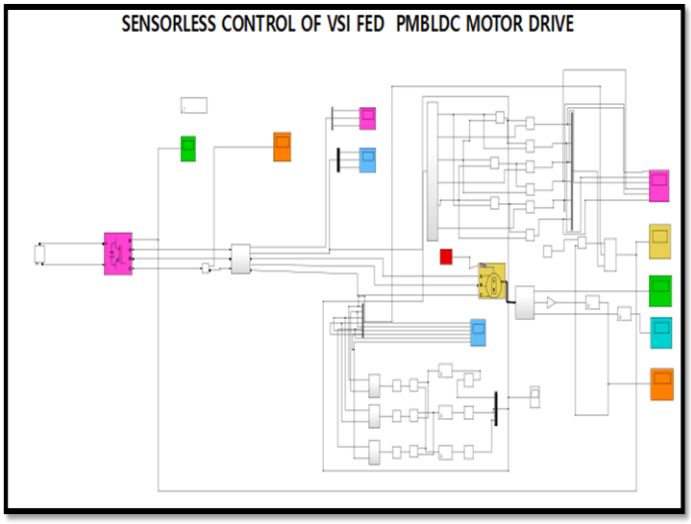

Figure: 5.2[a] Simulation model of sensor less control of three phase voltage source inverter fed PMBLDC motor drive

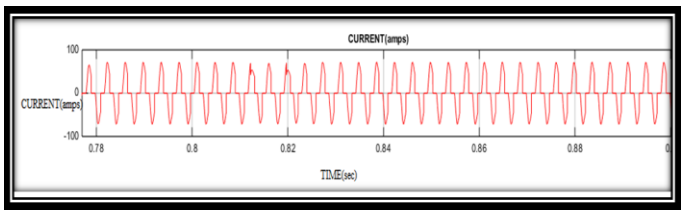

Figure: 5.2 [b] Stator current of the PMBLDC Motor

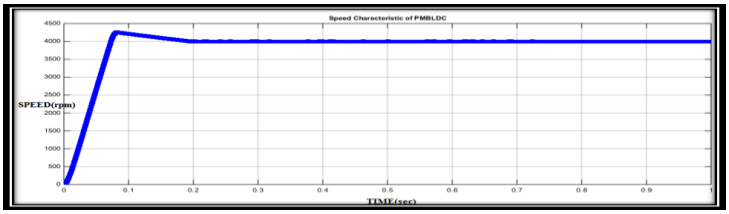

Figure:5.2 [c] Speed Charecteristic of PMBLDC Motor for reference speed 4000 rpm

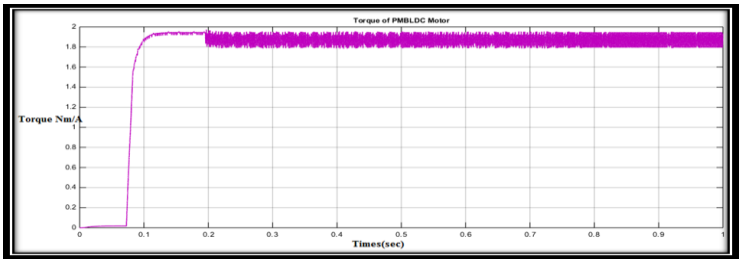

Figure: 5.2 [d] Torque Charecteristic of PMBLDC Motor for reference 2 Nm/A

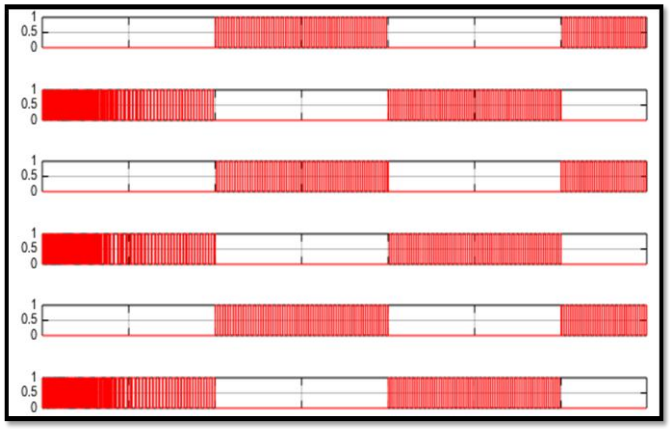

Figure: 5.2[e] Gate pulse to inverter fed PMBLDC Motor drive

TABLE: 3 PERFORMANCE ANALYSIS FED SENSOR LESS CONTROL OF PMBLDC MOTOR

PMBLDC Motor Performance Testing Report						
SL.NO	Voltage (Vdc)	Current (A)	Speed (RPM)	Torque (N*m)	Power (W)	Efficiency
1	50	15.5	4000	1.8	753.9267016	0.972808647
2	48	14	3800	1.6	636.6492147	0.947394665
3	46	12.5	3600	1.4	527.7486911	0.917823811
4	44	11	3400	1.2	427.2251309	0.882696551
5	42	9.5	3200	1	335.078534	0.839795825
6	40	8	3000	0.8	251.3089005	0.785340314

6. CONCLUSION

In this paper Comparative Study and Performance Analysis of Sensor based and Sensor less control of Three Phase Voltage Source Inverter fed PMBLDC Motor Drive were studied both having good performance as compare to the conventional DC motor .In sensor less control sensor are not using hence the cost of the system is reduced, Reliability is good, Reductions system size,Noiseless opertion and less feed backs elements and also it is suitable to High tempreture application there switching and conduction losses reduced.

7. FUTURE SCOPE

This proposed motor mechanism suitable used for applications alike water pumping, solar air conditioning, solar refrigeration, electrical vehicles, industrials automation and industrial applications.

REFERENCES

1. 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.

2. Sensorless Speed Control Of Brushless Dc Motor Using Fuzzy Controller K. S. Rama Raodepartment Of Electric And Electronic Engineering, Universiti Teknologi Petronas, 31750 Tronoh, Malaysia

3. Position Control of Low Cost Brushless DC Motor Using Hall Sensor 10.1109/ICEF.2012.6310322 Si Young YunDept. of Electr. Eng., Hanyang Univ., Seoul, South KoreaHo Joon Lee Dept. of Electr. Eng., Hanyang Univ., Seoul, South Korea

4. Sensorless control of brushless DC motor for low speed aerospace applications K Nithya DOI: 10.1109/ICCPCT.2014.7055008 M Tech Research Scholar, Jyothi Engineering College, Kerala, India

5. A Comparative Study of Sensor and Sensor less Control of Four-Switch Inverter Fed Permanent Magnet Brushless DC Motor Akhila R Nikhil S Assistant Professor Vidya Academy of Science and Technology Thrissur, Kerala Thrissur, Kerala.