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Comparison of SPWM and SVPWM Based Closed Loop Speed Control of BLDC drive

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Abstract:
Brushless DC Motor is a highly popular motor because of their high reliability; high efficiency , good dynamic response and very low maintenance so Demand for small & highly reliable motors is increasing. In the BLDC motor at low speed controlling the stator phase current is more effective peed but at high speed range ripple in torque reduction is not reliable in conventional technique. The two techniques sinusoidal PWM and Space vector PWM are studied for close-loop speed control of a BLDC Motor. MATLAB/Simulink simulation model is done for SPWM and SVPWM control scheme. The results of simulation shows the advantage of less harmonic distortion and lower switching of SVPWM is better than that of SPWM technique in losses the speed control of BLDC motor.

Keywords: BLDC motor- Brushless Direct Current Motor, SPWM, and SVPWM, Pi- Proportional Integrated Controller.

I. Introduction

In recent times There is increase in energy prices Due to heavy usage in every part of life also recent advancement in hybrid cars, based on hybrid drives, increases high demand for highly efficient PM motor drives, and it can be said to be the beginning of interest in study and making better BLDC motors. These motors are used in any safety critical applications because of their there architecture is suitable for any application So, better understanding of each part is a requirement for the study of overall system and predict the operations. Several simulation schematics on state-space, Fourier series, and the d-q axis based models have been given[1-6].

From a modelling point of view BLDC motor is same as synchronous motor, and it looks same to DC motor as it has a linear relationship between torque, current , speed and voltage. Only change in commutation technique. In the motor instead of electromagnets By removing the brush/commutator with an electronic controller to performs same power distribution as a brushed DC motor [3].BLDC is batter

than other motor because of their speed V/S torque features is better; dynamic response is high, Efficiency and reliability of BLDC motor is high, because of brushes being ommited erosion and wear and tear is low and motor life increases, operation is noise less, higher speed ranges, and reduction of electromagnetic interference (EMI).

BLDC motor operational control can be in sensor or sensorless mode, but sensorless control techniques is low cost so is used more in most cases. but disadvantages of sensorless control are requirements for complex control schemes and more complex arrangement of electronic switch in assembling the converter[3]. In electronic switches the power loss is very low in PWM method and this is main advantage of this method. As power is product of voltage and current ,there is almost no voltage drop across the switch when switch is on and almost no current present when switch is off , so in both cases loss is zero.

2. Proposed Concept Of Bldc Motor Drive

Figure-1 shows the constant dc voltage in 6 switch 3-phase inverter in 3-phase BLDC Drive . This study is based on the following idea [12]: Stator resistances, the motor is not saturated,. As well self and mutual inductance of all the windings are equal, and constant; Power semiconductor switches are ideal; Low Iron losses for the motor.

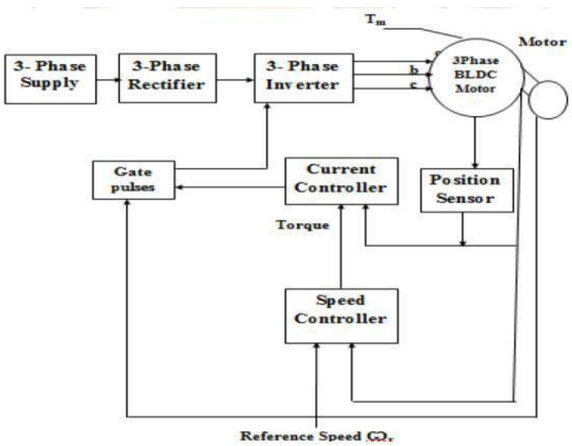

Figure.1: Speed regulation of BLDC motor

the SimPower Systems library of MATLAB is provide the 3-phase diode rectifier, BLDC motor speed controller, current controller and Inverter is shown in above block diagram. for fast simulation analysis results it use a simple version of drive comprising an avg value inverter.

3. Sinusoidal PWM

In the SPWM technique using the frequency and amplitude of a reference or modulating voltage we obtained required o/p voltage also produces a sinusoidal waveform by filtering an O/P wave waveform with varying magnitude.

In 3-phase Sine PWM, switching control of the electronic switches in each phase leg of the inverter block-set.is obtained by compared to triangular voltage waveform (V_T) with three sine control voltages of the phases (Va, V_b, and Vc), which are 120° phase apart with each other is shown in fig.

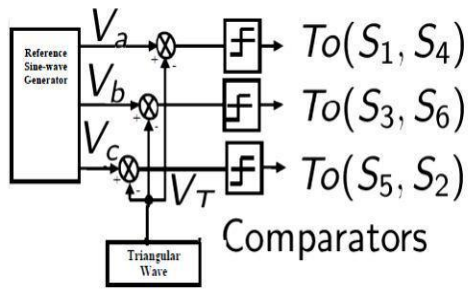

Figure-2 Generation of Control Signal

A 6-step 3-phase inverter is made of two switches per phase and O/P joined to the middle of each inverter leg as seen from that of Figure-3. In Figure-2 shows the o/p of comparator for the three legs of the inverter which form the control signals. Only one switch is active per leg at a time. This is done to avoid any problems to DC source voltage Short circuit as it can be highly dangerous for the switches and other equipment.

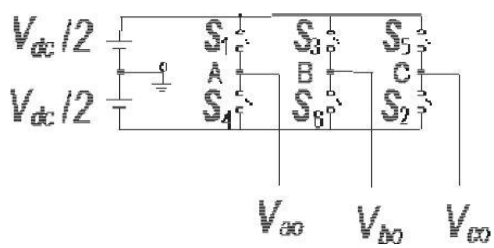

Figure-3 Three-Phase Sinusoidal PWM Inverter

3.1 Simulation Of SPWM

The close-loop speed control of PMSM simulated model is shown in Figure-4.In the fig shown the speed set is 700 rpm. In the second block show the PI-controller is used to get the stability in the O/P. By using parks transformation dq components converted from abc is shown in the third block. The next block SPWM is used as designed below. In Figure-5 shows the I/P of the block is a phase current I_{abc} and I_{ref} are given which are compared using comparator and o/p of this is fed to the motor controller.

Figure-5 shows sine and triangle comparison and the control signals is obtained from this comparator block it is the for the 3 inverter legs made of two switch (for each leg). O/P phase to neutral voltages is obtained using this switching waves and the DC bus voltage.

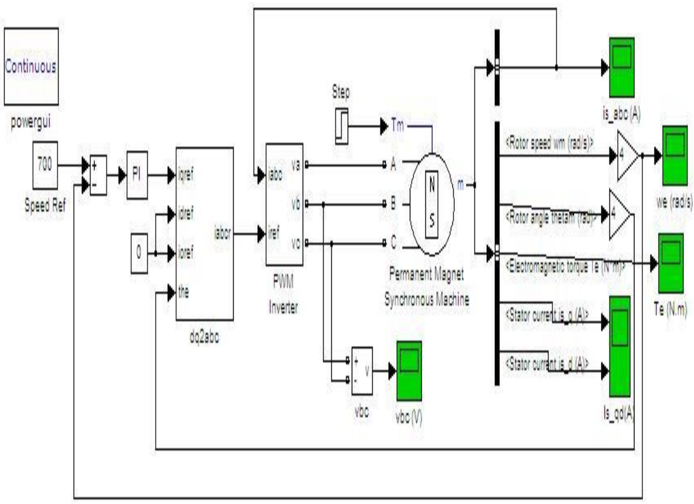

Figure-4 model of SPWM based PMSM drive

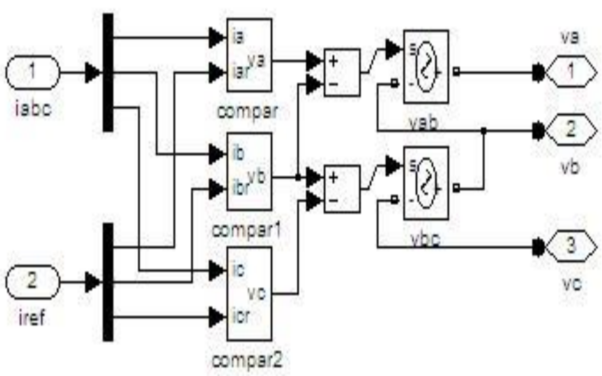

Figure-5 PWM Inverter

B. **RESULTS OF SPWM**

The simulation step is 0.04s and total simulation time is 0.2s. the signals are applied to the BLDC with The K_i=3 and K_p=40 is set for speed regulator. At period of sampling 0.0005s, carrier frequency for Sine PWM is 20Hz ,DC voltage is 310V, and the reference speed is 700rpm(desired).

At time 0.02s a 1 Nm torque is started. A slight fluctuation in current drawn in the motor is seen from the graph shown in figure-6. Each variation graph is shown in Figure-6, 7, and 8 respectivey phase current, load torque and Speed V/S time graphs.

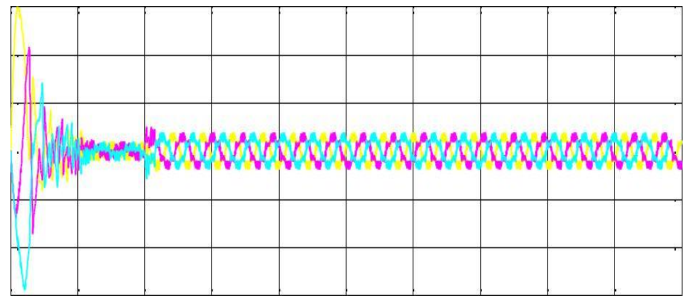

Figure-6 Phase Current waveform

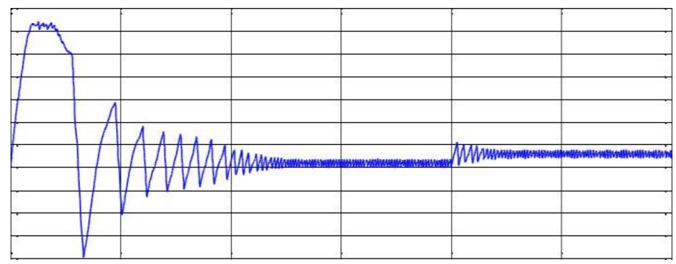

Figure-7 Lord torqe waveform

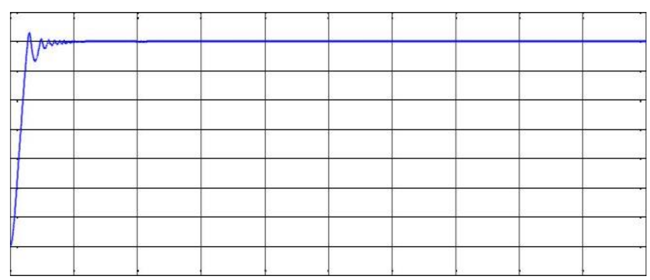

Figure-8 Speed Vs Time

As shown in above fig. the slight change in current drawn by the motor and the speed of the motor is same when applied the load torque of 1.1Nm. But when the load torque is increases from 1.1 Nm to 3 Nm the current drawn by the motor is increases but the speed of the motor is equal. In this way as the torque increases the speed of the motor is same but the current drawn by the motor is increases.

4. Space Vector PWM (SVPWM)

The space vector concept is used for modifying the inverter output voltage. Using the inverse Park's transform method one of the two states in inverter output which allows inverter to create 2^3=8 possible states of O/P at time of operation as shown in Table-I. SVPWM is used to create a voltage vector [4].

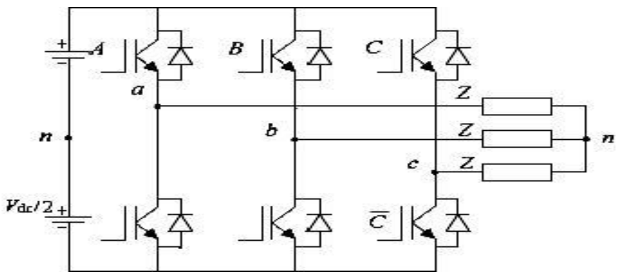

Figure-9. Voltage Source Inverter diagram

The O/P voltage is presented as[4]:

$V_A(S_A,S_B,S_C) = 2V_{dc}(S_A+\alpha S_B+\alpha^2 S_C)/3$

Here, α is $e^{j/20}$.and dv bus voltage is Vdc

By considering the 1 and 0 for on and off states for upper and lower arm switches, then eight possible combination voltage as seen in Figure-13. V_0(000) and V_7(111) are zero vector, and other are known as effective vectors with level of $2V_{dc}/3$.

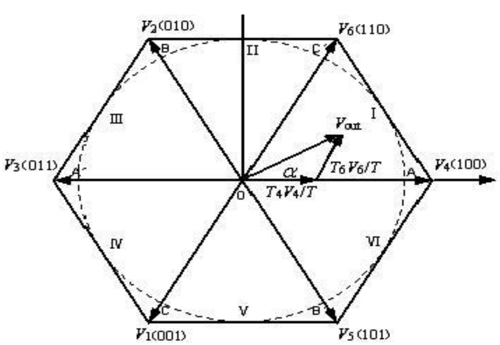

Figure-10. Space Vector Diagram of voltage

A.MATLAB simulation of SVPWM

Figure-11 shows the Model of the closed loop BLDC drive. In this fig show the speed is set at 700 rpm. For the required stability in the O/P we use to PI-controller is shown in 2^{nd} block . In the third block is of parks transformation for abc to dq transformation. The next block is of SVPWM joined to a PWSM. According to load the torque is increase or decrease by the motor but speed remains same with no ripple changes. Using this method we control the speed of BLDC motor.

B. **Simulation Results Of Svpwm**

In this simulation we consider the following parameter.
sampling period = 0.0005s,
DC voltage = 310V,
the carrier frequency = 20Hz
reference speed = 700rpm, The limitation of the speed regulator is set at K_i =40 and K_p=500. Total simulation time is 0.3s. At time 0.045s a load torque of 5.1Nm is applied. In the motor little change in current speed is fluctuates slightly. But if higher load torque from 5.1 to 8 Nm at t=0.16s then the phase current is surges but speed is same. Figure-12 shows phase current, speed, load torque against time.

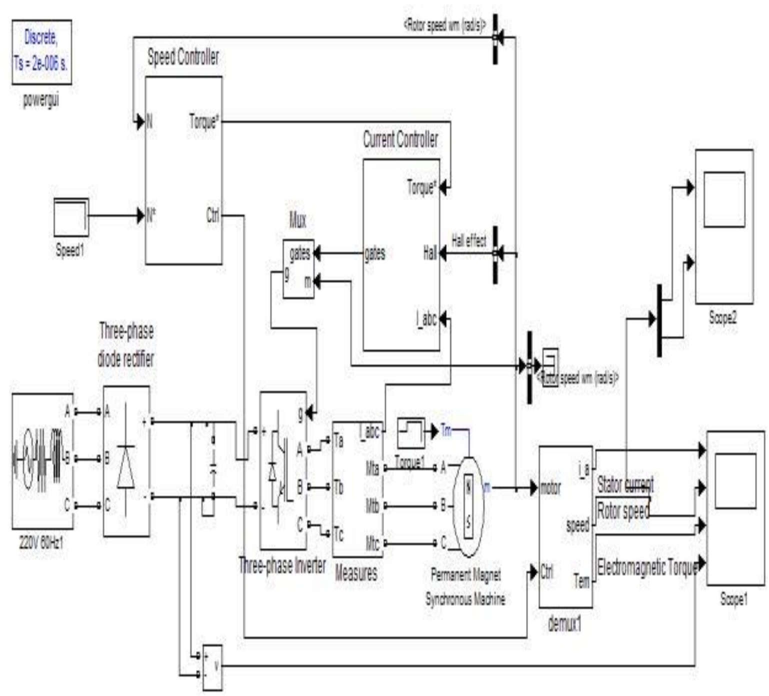

Figure-11 BLDC drive current controller.

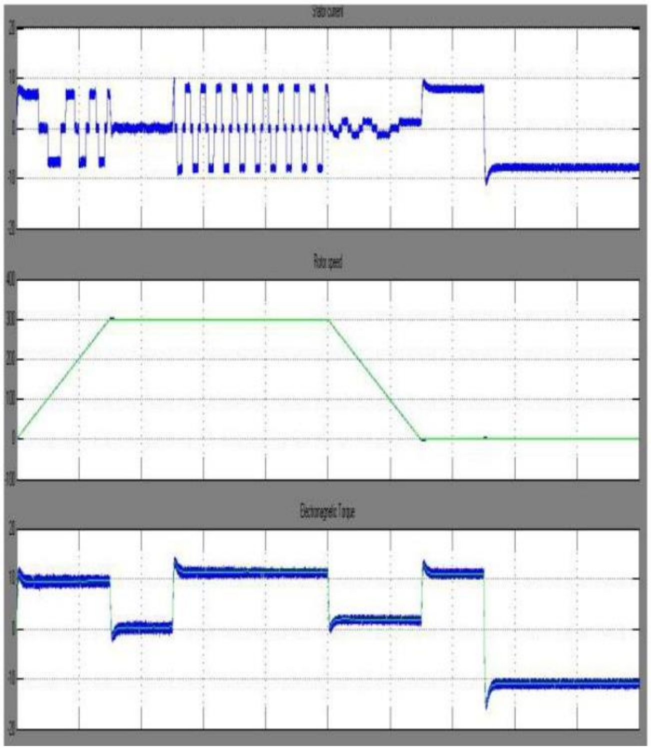

Figure-12 Shows the Simulink result of phase current, Rotor speed and Electromagnetic torque.

5. Comparison Of SVPWM Over The SPWM

FFT analysis in MATLAB is shown in Figure-13 and Figure-14. As seen in figures Space vector PWM is better method for the closed loop speed control of BLDC because of SVPWM produce less harmonic than SPWM.

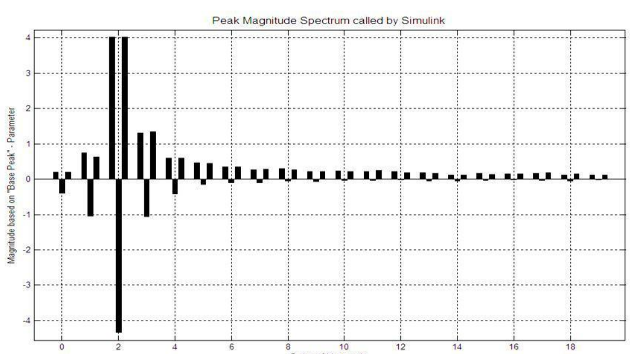

Fig. 13 Harmonic Spectrum of SVPWM

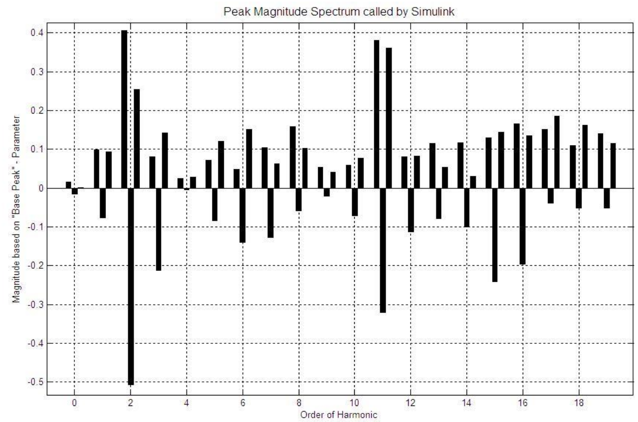

Fig. 14 Harmonic Spectrum of SPWM

Conclusion

This paper has shows the SVPWM and SPWM simulation. In the MATLAB this two techniques are study and tested their Simulink model. SVPWM method is batter than the SPWM is shown in simulation results. The SPWM technique is easy to modulate, understand and to make because of this it is very popular for industrial converters. In 1-phase and 3-phase inverters the SPWM technique can be use while The SVPWM technique can only used for 3-phase inverter. SVPWM technique is covers a higher modulation index, lower less harmonic distortion and switching losses as compared to SPWM [5]. SVPWM technique for 3-phase inverters is the most popular methods because of high fundamental voltage in difference to O/P than SPWM for the same DC bus voltage.

References

[1] B.K. Lee and M> Ehsani " A simplified functional model for 3-phase voltage source inverter using switching function concept,"IEEE Trans. On Industrial Electronics,vol.48,no2 pp. 309-321,April 2001.

[2] Qiu Shao-feng. Study of Permanent Magnet Coreless Brushless DC Motor Control

System Used in Electric Power Steering System [D]. Huazhong University of Science and Technology. May. 2006, (in Chinese).
[3] T.J.E. Miller, "Brushless permanent magnet and reluctance motor drive", Oxford, 1989.
[4] P. D. Evans and D. Brown, “Simulation of brushless DC drives,” Proc. of the IEEE, vol. 137, no. 5, pp. 299–308, September 1990.
[5] S. K. Safi, P. P. Acarnley, and A. G. Jack, “Analysis and simulation of the high-speed torque performance of brushless DC motor drives,” Proc. of the IEE, vol. 142, no. 3, pp. 191–200, May 1995.
[6] Halvaei Niasar “Modeling Simulation and Implementation of Fourswitch, Brushless DC Motor Drive Based on on switching function.”IEEE publication no. 978-1-4244-3861-7/09.