STUDY THE DESIGNING AND EFFECTIVENESS OF BLDC MOTOR DRIVE FOR HIGH POWER FACTOR

BanavathVenkateswarlu[1], Dr.Suchi Jain[2]
Department of Electrical and Electronics Engineering
[1,2]OPJS University, Churu (Rajasthan)

Abstract

This research paper gives the theoretical aspects of impact of Electric motors practically on every part of modern living. Likewise, they are additionally in charge of an extensive bit of mechanical process. The Permanent magnet brushless DC (PMBLDC) motor is getting to be noticeably mainstream in different applications due to its high effectiveness, high power factor, high torque, basic control and lower upkeep. BLDC motor is one sort of synchronous motor, which can be worked in perilous air condition and at high speeds because of nonattendance of brushes. What's more, the proportion of torque conveyed to the extent of the motor is higher, making it valuable in applications where space and weight are basic elements.

1. INTRODUCTION

An adaptive neuro-fluffy derivation system (ANFIS) based control is a flexible and successful way to deal with manage the non-straight and unverifiable system as it gives the controller parameters at some other stacking condition inside foreordained locale of operation. The drive circuits (power converters) neglect to fill in as 'perfect' interfaces between electrical systems and motors[1]. In a regular drive system controlled by the shut loop, causes a capricious time-variable current distortion which can deteriorate the drive execution. In the SHE technique, certain prevailing lower arrange harmonics are wiped out through higher request harmonics are sifted utilizing appropriate channel.

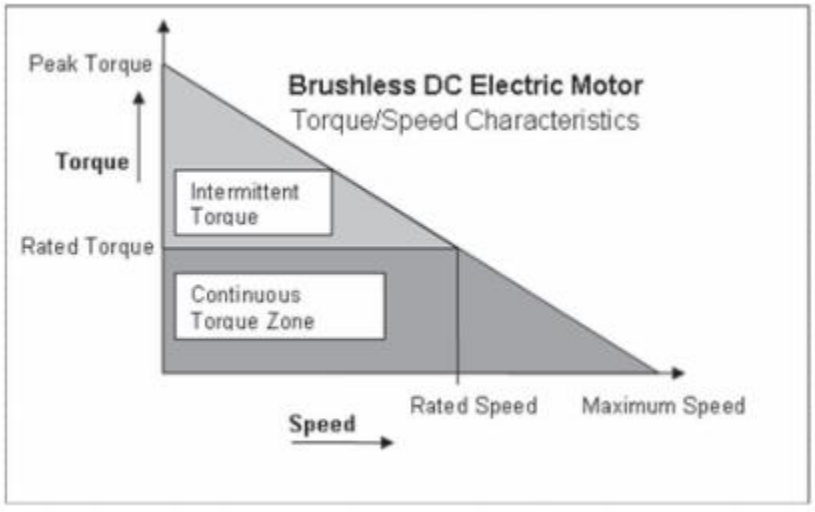

Figure 1: Brushless DC Electric Motor Torque-Speed Characteristic

An electronic controller replaces brush/commutator get together of brushed DC motor, which consistently switches the phase to the windings to keep the motor turning. The controller performs comparable planned power appropriation by utilizing a high state circuit as opposed to brush/commutator system[2]. BLDC motors create the greatest torque when stationary and have directly diminishing torque with expanding speed as appeared in Figure 1.BLDC motors offer a few advantages over brushed DC motors, including more torque per weight, more torque per watt (expanded proficiency), expanded dependability, decreased clamor, longer lifetime (no brush and commutator disintegration), end of ionizing sparkles from the commutator and general lessening of electromagnetic interference (EMI).

2. DESIGN ASPECTS OF BLDC MOTOR

BLDC motors can be built in a few diverse physical arrangements, in the 'traditional' (otherwise called 'in-sprinter') design, the permanent magnets are a piece of the rotor. Three stator windings encompass the rotor[3]. In the 'out-sprinter' (or outside rotor) arrangement, the spiral connection between the curls and magnets is turned around; the stator loops shape the middle (center) of the motor, while the permanent magnets turn inside an overhanging rotor which encompasses the center.

- **Types of BLDC Motor**

The BLDC motors are classified into various types. The classification is made according to the arrangement of permanent magnet in the rotor. The various type of BLDC motors are classified and as in Figure 2.

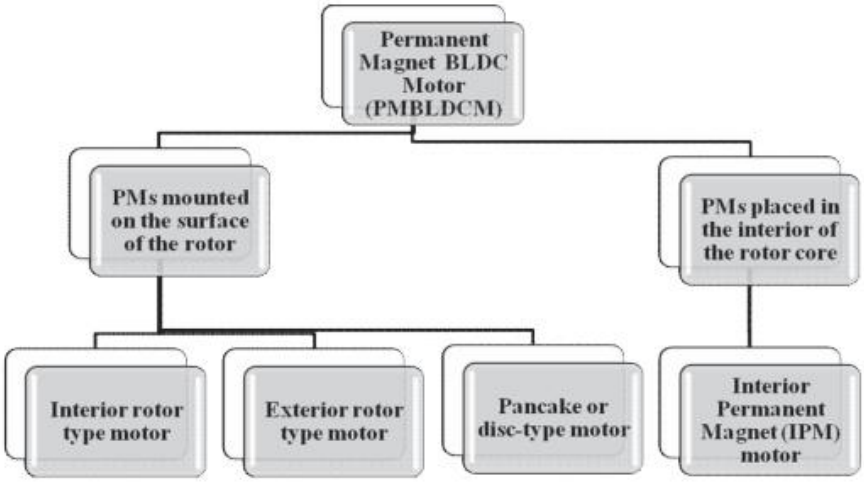

Figure 2: Types of PMBLDC motor

3. PMS MOUNTED ON THE SURFACE OF THE ROTOR

This kind of motor is ordinarily alluded to as surface PM (SPM), and the run of the mill manufacturing innovation includes sticking bend magnets as well as securing them with exceptional tape on the external surface of a rotor centre[4].

For this situation, the arrangement is more entangled because, to adapt to thin magnets and to limit vortex current misfortunes in the magnets, multiple littler magnets are regularly used to influence one to post. The inside rotor motor has the storeroom design to that of the traditional AC synchronous machine or the induction motor, in spite of the fact that the generation volumes of outside – rotor motors are significantly more noteworthy. The stator is like that of the three-phase induction motor.

It has two manufacturing disadvantages:

1. Magnet retention must be carefully implemented so that the rotor does not fly apart.
2. Although exterior stators are easily cooled, they are expressive to wind without automatic equipment.

The rotor shaft must be mounted in orientation. It conveys a delicate iron burden which has a polygonal or roundabout outside surface on which the magnets are mounted. The burden is either machined from low-carbon steel or gathered from a heap of covers.

4. POWER SUPPLIES

It's helpful to consider three types of motors:

1. Direct current (DC) motor: DC applied to both stator and rotor (via brushes and commutator), or else a permanent magnet stator. A BLDC motor has switched DC fed to the stator and a permanent magnet rotor [5].
2. Synchronous (or stepping) motor (AC): AC in one, DC in the other (i.e., rotor or stator). If it has a permanent-magnet rotor, it is much like a BLDC motor.
3. Induction motor (AC): AC in both stator and rotor (mentioned for completeness).

In spite of the fact that BLDC motors are indistinguishable to permanent magnet AC motors, the controller execution is the thing that makes them DC. While AC motors encourage sinusoidal current at the same time to each of the legs (with an hardware phase circulation), DC controllers just estimated this by bolstering full positive and negative voltage to two of the legs at once.

- **Applications**

BLDC motors satisfy many capacities initially performed by brushed DC motors. However, cost and control many-sided quality keep BLDC motors from supplanting brushed motors totally in the lowest-cost zones. By and by, BLDC motors have come to overwhelm numerous applications, especially devices, for example, PC hard drives and CD/DVD, players. Little cooling fans in electronic gear are powered only by BLDC motors. They can be found in

cordless power tools where the expanded effectiveness of the motor prompts longer times of utilization before the battery should be charged[6].

- **Transport**

High power BLDC motors are found in electric vehicles and mixture vehicles. These motors are AC synchronous motors with permanent magnet rotors. The Segway Scooter and Vectrix Maxi-Scooter utilize BLDC innovation. Various electric bikes utilize BLDC motors that are infrequently incorporated with the wheel centre point itself, with the stator settled unequivocally to the pivot and the magnets connected to and turning the wheel. The motor is wheel centre point of the bike.

- **Heating and ventilation**

There is a pattern in the HVAC and refrigeration ventures to utilize BLDC motors rather than different sorts of AC motors[7]. A huge motivation to switch to a BLDC motor is the emotional lessening in power required to work them versus a run of the mill AC motor.

- **Industrial engineering**

Modern engineering is a wide zone of engineering that incorporates design, manufacturing, PC control, automation and human variables integration. The utilization of brushless DC (BLDC) motors inside mechanical engineering principally concentrates on manufacturing engineering or modern automation design.

- **Motion control system**

BLDC motors are regularly utilized as pump, fan and shaft drives in customizable or variable speed applications. They can grow high torque with great speed reaction. Likewise, they can be effectively computerized for remote control. Because of their development, they have great warm qualities and high energy efficiency[8].

- **Recent Tends**

BLDC motors are a famous motor decision for model airship including helicopters. Their good power to weight ratios and the huge scope of accessible sizes, from under 5 gram to vast motors evaluated at a huge number of watts, have altered the market for electric-powered model flight.

- **Modelling**

Two models have been presented together to demonstrate that the d, q model is adequate to contemplate the PMSM in detail while the ABC model ought to be utilized as a part of a request to consider the BDCM[9]. The modelling recreation and examination of a BDCM drive are depicted in the two section paper.

5. POWER QUALITY IMPROVEMENT IN BRUSHLESS DC MOTOR DRIVES

Household appliances like washing machines, room air conditioners, refrigerators, fans, water pumps, vacuum cleaner and cooler are not out of the ordinary one of the fastest developing final results in the market throughout the following couple of years [10].

- **Torque Ripple Reduction Techniques:** Inferable from various applications of BLDC motors in ventures and additionally household applications, the performance of these motors is thought to be very critical. Because of manufacturing impediment and design consideration of magnetic materials, the generated back-electromotive power (EMF) waveform left from its unique shape.
- **Power quality issues:** The power quality has turned into the most vital factor to be considered at the point of BLDC motors. The global benchmarks, for example, International Electro technical Commission (IEC) 61000-3-2, recommended to such an extent that the harmonics in the supply current ought to be within the point of confinement.
- **PFC converter:** In the conventional PFC conspires the speed control can be accomplished by pulse width-regulated voltage source inverter (PWM-VSI) with consistent dc interface voltage. This outcomes higher switching misfortunes in the VSI which is the square capacity of switching frequency. The speed of the BLDC motor is directly corresponding to the DC interface voltage. So the speed control can be accomplished by a variable DC connect voltage of VSI with principal frequency switching.

6. OPERATION OF BLDC MOTOR WITH INVERTER

A trapezoidal PM machine gives performance closer to a dc motor. For this its known as a brushless dc motor (BLDC). It is an electronic motor and requires a three-phase inverter to the driving side for feeding power into the machine. The machine is represented by its hardware circuit, which consists of stator resistance, self-inductance, and a back-emf. The inverter works as an electronic commutation which performs the switching according to the output from the position sensors. The inverter operates in the following two modes:

1. $2\pi/3$ angle switch-on mode
2. Voltage and current control PWM mode

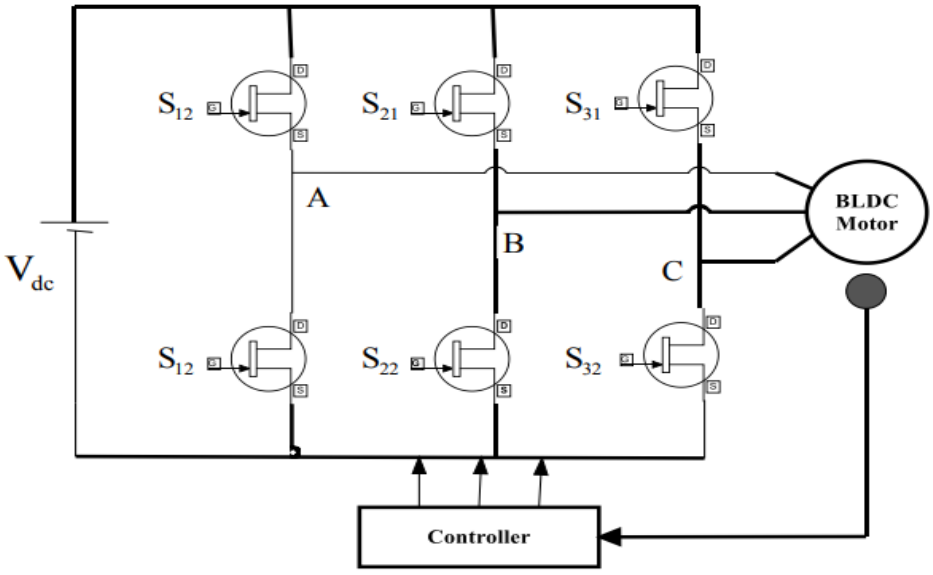

Figure 3: BLDC Motor Drive

- $2\frac{2\pi}{3}$ ***angle swtich mode***

In this mode of operation all inverter switching devices (T1 toT6) are switch on-off in such a way that the current input's is equally for the $2\pi/3$ angle at the centre of each induced back-emf voltage waveform[11]. At an instant only two switches are on, one from the positive group and one from the negative group. For example, from instant $t1, T1\ and\ T6$ are conducting then the supply voltage Vs and input dc current are applied across the AB phase of the inverter such that positive Is will flow in phase A and negative Is will flow in phase B.

Then, after $\pi\ /\ 3m$ interval T6 is turn OFF and T2 is turn ON, T1 continues conduction for $full\ 2\pi\ /\ 3$ angle. The conduction pattern changes every $\pi/3$ degree, with every switch has a conduction period of $2\pi/3$ degree. The switching sequence depends on the output of the position sensors.

- **Voltage and current control PWM mode**

In the past mode, each switch of the inverter is switched ON-OFF for $2\pi/3$ degrees point to produce the commutation work as it were. It is conceivable to control the voltages and currents persistently at the machine terminal by controlling the switches in PWM mode. There are two modes for the current and voltage control operations of the inverter. These two modes are feedback (FB) mode and freewheeling mode.

- **Rotor position sensor**

For powerful switching between phases, we need to detect the rotor position viably to sense the rotor position Hall sensors are utilized. Corridor sensors are set in the stator packaging of the motor 120° or 60° separated from each other. At whatever point lobby sensor comes in the

impact of magnetic rotor shafts it delivers a high or low signal as indicated by the extremity of rotor post. The signals from lobby sensor are utilized to speak with the electronic controller to turn the motor in the correct direction.

- **Dynamic Model of BLDC Motor**

The BLDC motor has three stator winding and a permanent magnet rotor. Due to rotation of rotor emf is induced in the stator windings. Hence the circuit equations of the three windings are

$$\begin{bmatrix} v_{as} \\ v_{bs} \\ v_{cs} \end{bmatrix} = \begin{bmatrix} R_s & 0 & 0 \\ 0 & R_s & 0 \\ 0 & 0 & R_s \end{bmatrix} \begin{bmatrix} i_a \\ i_b \\ i_c \end{bmatrix} + \frac{d}{dt} \begin{bmatrix} L_{aa} & L_{ab} & L_{ac} \\ L_{ba} & L_{bb} & L_{bc} \\ L_{ca} & L_{cb} & L_{cc} \end{bmatrix} \begin{bmatrix} i_a \\ i_b \\ i_c \end{bmatrix} + \begin{bmatrix} e_a \\ e_b \\ e_c \end{bmatrix}$$

Where we assume that stator resistance of all the windings are equal. The back-emf has trapezoidal shapes. Assuming that there is no change in the motors inductance with the rotation of motor, then

$$L_{aa} = L_{bb} = L_{cc} = L$$

$$L_{ab} = L_{ba} = L_{ac} = L_{ca} = L_{bc} = L_{cb} = M$$

Hence equation,

$$\begin{bmatrix} v_{as} \\ v_{bs} \\ v_{cs} \end{bmatrix} = \begin{bmatrix} R_s & 0 & 0 \\ 0 & R_s & 0 \\ 0 & 0 & R_s \end{bmatrix} \begin{bmatrix} i_a \\ i_b \\ i_c \end{bmatrix} + \frac{d}{dt} \begin{bmatrix} L & M & M \\ M & L & M \\ M & M & L \end{bmatrix} \begin{bmatrix} i_a \\ i_b \\ i_c \end{bmatrix} + \begin{bmatrix} e_a \\ e_b \\ e_c \end{bmatrix}$$

Where,

$$V_{as} = V_{ao} - V_{no}$$

7. DEVELOPMENT OF SENSOR LESS BLDC MOTOR DRIVE FOR PV SYSTEM

At the beginning time, just DC motors were utilized to drive pumps. Direct coupling of arrangement, shunt and independently energized DC motor to Photovoltaic systems were utilized as a part of various applications. The detriment of DC motors is that it requires upkeep, effectiveness is not as much as AC motor. In the current days, Induction motor is generally utilized as a part of different applications because of their advantages like higher productivity, robustness, and upkeep less operation. This air conditioner motors just require AC source, for which in PV system connection, it requires inverter for Dc to air conditioning change [12].

8. CONCLUSION

Torque throbs in BLDC motors realized by the deviation from perfect conditions are either identified with the design components of the motor or to the power inverter supply, consequently bringing about non-perfect current waveforms. Unwanted torque throb in the BLDC motor drive causes speed motions, and excitation of resonances in mechanical segments of the drive drives the perceptible clamor and unmistakable vibration designs in high accuracy machines. In this research, a five-level diode-clamped multilevel inverter with PI controller is presented for BLDC. Torque swells are expected to in dynamic phases. The torque swells have been reduced utilizing diode-clamped multilevel inverter with the Sinusoidal Pulse width modulation technique. PI controller is utilized to control the Speed. The BLDC motor comes about are broke down and the measure of torque swell likewise computed. From the re-enacted comes about it is obvious that the torque swells are reduced. The fundamental advantage of this strategy is it utilizes sensor less technique for the three phases, so it reduces the sensor cost. This paper presents the idea of Cascade H-Bridge multi-level inverter associated with three-phase stator winding of BLDCM with current control and speed control techniques to enhance the performance of BLDCM and reduce the torque swells and harmonics, computes the total harmonic distortion.

REFERENCES

1. F. Qiang, L. Hui, Z. Hai-tao, “Single-current-sensor sliding modedriving strategy for four-switch three-phase brushless DC motor,” inproc. ICTT 2006, 2007, pp. 2396-2401.
2. A. Sathyan, M. Krishnamurthy, N. Milivojevic, A. Emadi, “A low-costdigital control scheme for brushless DC motor drives in domesticapplications,” in proc. IEMDC’09, 2009, pp. 76-82.
3. H.A. Toliyat, T. Gopalarathnam, “AC machines controlled as DCmachines (Brushless DC machines/electronics),’’ In: SkvareninaTL,editor. The power electronics handbook, New York: CRC Press; 2002.

4. E. Peralta-Sanchez, F. Al-rifai, N. Schofield, "Direct torque control ofpermanent magnet motors using a single current sensor,'' InternationalConference on Electrical Machines and Drives IEMDC 2009 , pp. 89-94, 2009.
5. M. Bertoluzzo, G. Buja, and R. Menis, "Direct torque control of aninduction motor using a single current sensor," IEEE Transactions onIndustrial Electronics, vol. 53, pp. 778-784, 2006.
6. G.H. Jang and M.G. Kim, "A Bipolar-Starting and Unipolar-Running Method to Drive an HDD Spindle Motor at High Speed with Large Starting Torque," IEEE Transactions on Magnetics, Vol. 41, no.2, pp. 750-755, Feb. 2005.
7. F. Z. Peng, "Z-source inverter" IEEE Transactions on Industrial Applications, vol. 39, no.2,pp. 504–510, Mar./Apr. 2003.
8. Bimal K. Bose, "Modern Power Electronics and AC Drives" Prentice Hall, 2005.
9. A.k.Ali Othman "Elimination of harmonics in multi levelnverters with non equal DC [8]D. Soto, T. C. Green, "A comparison of high-power converter topologies for the Implementation of FACTS Controller," IEEE Transaction of Industrial Electronics, 49, N 5, p 1072-1080,2002
10. Y.S.Lai and F.S.Shyu. "Topology for hybrid multi level inverter", IEE Proc-Electr.PowerAppl.Vol 149,No 6 nov 2002
11. NasirUddin, M., T.S. Radwan and M.A. Rahman, 2004. "Performance analysis of four switch 3- phase inverter-fed IM drives," Proceeding of the CD-ROM of the 3 rd IEEE International Conference
12. CiroAttainese, Aldo Perfetto and Giuseppe Tomasso, June 2002, " A space vector modulation Algorithm for Torque control of Inverter fed Induction Motor Drive", proceedings of the IEEE Transactions On Energy Conversion, vol.17, no.2, 222-228