Introduction to BLDC Motors

1 Permanent Magnet DC Motors

The term "DC motor" is traditionally used to refer to "brushed DC motors". In DC motors section, we have seen that *brushes* are required to convert alternating current generated in DC generators to direct current (and vice versa for DC motors). We have also seen that a "field winding" is used to produce the magnetic field required for energy conversion. If the winding is replaced by permanent magnets, the rotating magnetic field is then generated without the need of separate winding. Besides, the losses in the field will be eliminated. There has been a significant improvement in permanent magnet technology since last few years. The permanent magnets are alloys like Neodymium Iron Boron (NdFeB) and Samarium Cobalt have become popular in recent years.

Now, if permanent magnets are placed on rotor, the armature winding will be stationary and hence brushes can be removed. This has two advantages - 1. Resistive losses in brushes are completely eliminated 2. Maintenance and safety issues are also taken care of.

Thus, the DC motor with permanent magnets without brushes is called brushless DC motor or simply BLDC motor.

2 Operating principle

The operating principle of BLDC motor is same as that of the DC motor. Conductors facing a particular magnet pole (say N pole) carry current in one direction while those facing the other pole carry current in opposite direction. By virtue of this, the fields created by magnet and armature conductors are always orthogonal to each other as shown in the Fig. **??**. Note the naming convention "direct axis" and "quadrature axis".

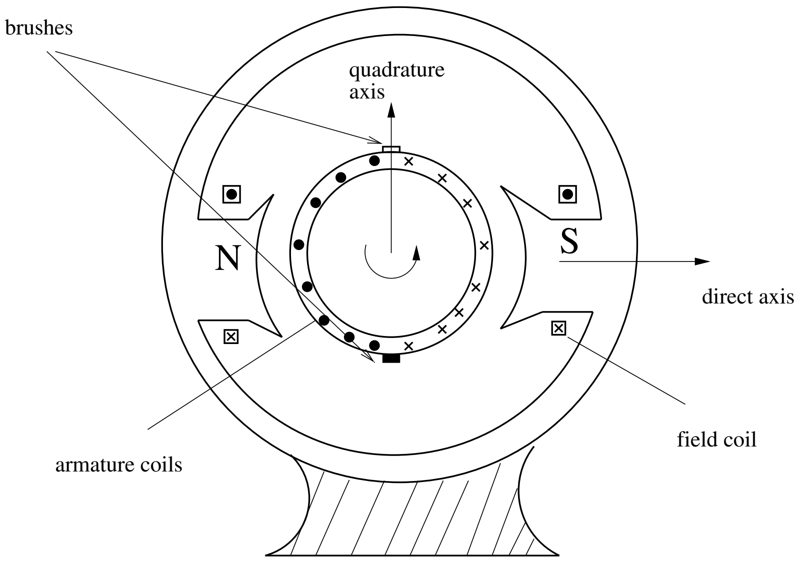

Figure 1: Orthogonal fields in a DC machine

Suppose a two pole rotor is rotating under an armature. When N pole passes completely across a conductor, some mechanism is necessary to change the direction of current in that conductor. Otherwise direction of force on the conductor will be reversed (*why*?). In a conventional DC motor, the number of commutator segments equals the number of conductors in the armature. When a commuatator segment switches from one brush to the other, there is a change in supply direction (in case of motor). In BLDC machine, this reversal of direction of current is done via power electronic switches. Now, the instant of reversing the direction is a function of position of rotor. Hence, sensing of position is required which is "fedback" to the power electronics drive which "drives and controls" the supply given to the motor.

Hence complete block diagram of a BLDC drive is as shown in Fig. ??. It consists of 3 parts

- BLDC machine
- Power electronics (DC-AC converter)
- Position sensing and drive control system

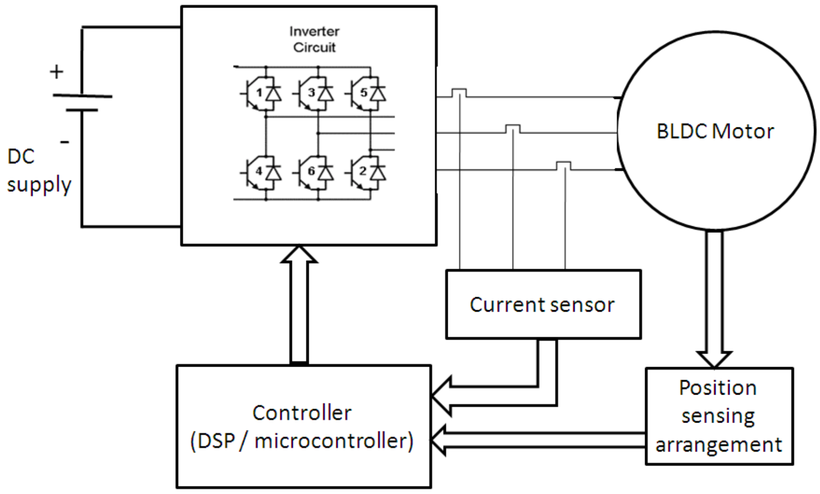

Figure 2: Complete block diagram of BLDC motor

3 Prevalence of BLDC Machines

Main advantages of BLDC machines are:

1. High power density (due to rare earth ND-Fe-B Magnets)
2. Greater efficiency
3. Lower maintenance cost as compared to conventional DC machines
4.

1. A half bridge inverter converts a DC supply into alternating square wave supply. Draw input and output waveform of half bridge inverter. Can it be used for inverting the current as required for BLDC motor.

2. As said in the theory, commutator segments facilitate the change of current direction in DC machine. Suppose this is to be achieved using half bridge inverter modules in BLDc motors. The armature of a 2 pole DC motor has 8 conductors under each pole. How many such half bridge modules will be required to drive this motor?
3. Suppose that the motor is rotating at speed of 3000 rpm. What will be frequency of switching in the half bridge inverter modules?
4. What will be difference (in radians and in seconds) between switching of consecutive inverter modules?

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