# An Overview of Some Important Issues and Recent Trends in BLDC Motor

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***Abstract -*** This paper presents a construction, operation, performance and advantage of BLDC motor over PMDC Motor. BLDC motor is the latest choice of researcher due to the high reliability and low maintenance for low power application. It is also called as electronically commutated DC Motor. In this stator of BLDC motor is supplied by inverter output. It is similar to the synchronous motor. This motor is ideal choice for low power application because it's high reliability, high efficiency, high torque and high power to volume ratio. It is used in railway fan, air conditioner etc.

***Index Terms -*** *Application, Electronic commutation, PMBLDCM, PMDC Motor, Speed control, Hall Effect sensor.*

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## I. INTRODUCTION

Energy neither be created nor be destroyed but it can be convert in one form in to another form. The concepts of converting electrical energy into mechanical energy have been known since the late 1820's when the first electric motor was successfully tested. Conventional dc motors are more efficient and their characteristics is such that them suitable for use as servomotors. but, their only drawback is that they need a commutator and brushes which are subject to wear and require maintenance. When the functions of commutator and brushes were implemented by solid-state switches, maintenance-free motors were realised. These motors are now known as brushless dc motors. The Brushless DC Motor was quite expensive when first introduced, the advancements in design and materials drastically lowered costs and made the Brushless DC Motor a popular selection for many different applications. As of today there are over 15 types of various DC and Ac motors that all serve the purpose of converting electrical energy into mechanical energy or vice versa. Permanent magnet motors with trapezoidal back EMF and sinusoidal back EMF have several advantages over other motor types. Most notably, they are lower maintenance due to the elimination of the mechanical commutator and high-torque-to weight ratio applications. The permanent magnet brushless dc (BLDC) motor is popularity being used in computer, aerospace, military, automotive, industrial and household products because of its high torque, compactness, and high efficiency. A conventional BLDC motor drive is now implemented via a six-switch, three-phase inverter and three Hall-effect position sensors that provide six commutation points for each electrical cycle. Recently, a four- switch, three-phase inverter (FSTPI) topology has been developed and used for a three-phase BLDC motor drive

## *II. Types of AC Motor*

### A. Permanent magnet AC Motor

Permanent magnet synchronous motor is now commonly known as Permanent Magnet AC (PMAC) motor. They are classified based on nature of voltage induced in stator as sinusoidally excited & trapezoidally excited. in the former induced voltage has a sinusoidal waveform & in the latter induced has a trpezoidal waveform. These PMAC motor are commonly known as sinusoidal PMAC & trapezoidal PMAC motor.

The speed of such motor is controlled by feeding these form variable frequency voltage /current. a rotor position sensor such as hall effect sensor is used for self controlled mode.

In past self controlled variable frequency drives employing a sinusoidal PMAC motor ware also called as brushless DC motor drives .They are now simply called as sinusoidal PMAC motor drive. The self control variable frequency drive employing a trapezoidal PMAC motor are now called brushless dc motor drive or trapezoidal dc motor drive.

### B. Sinusoidal PMAC Motor

Since the voltage induced in the stator phase of a sinusoidal PMAC motor are sinusoidal. The three stator phases are supplied by variable frequency voltage or current with the phase difference of 120° between them.[1] The torque in such motor is given by ,

$$T=K\ Is\ If \sin\partial \qquad (1)$$

Hens, torque is proportional to the Is,for given valu of Is, max. torque is obtained when,$\partial=\pi/2$

There are some applications which require speed control in wide range. The speed control of such motor is obtained by reducing air gap flux so that motor terminal voltage remain at the rated value as frequency is increased.

### C. Trapezoidal PMAC or BLDC Motor

Brushless DC motors are identical in construction to an AC motor. But controller implementation in BLDC motors is different and that is what that makes BLDC a DC motor. In AC motors sinusoidal current is supplied to each of the two legs with appropriate phase difference. But in BLDC motors, electronic controllers are used to feed full positive and negative current to two phases at a time. The major implication of this feature is that BLDC are very suitable for logic controllers and battery power sources that operate on DC. So BLDC are widely used in computers, cars etc.

In this motor stator has 3 winding placed at 120° displacement and rotor having permanent magnet located inside or around the stator. The reason for getting trapezoidal waveform can now explain: consider that when motor running counter clockwise direction, up to 120° rotation, all the conductor of one phase will be linking the S pole,& all the bottom conductor of same phase will be linking with N pole. Hens voltage induced in phase A will be the same during 120° rotation. Beyond 120° rotation some conductor in the top link north pole & other south pole.Hens the shape of that emf induced in the motor will be trapezoidal.

## III. *Construction of BLDC Motor*

BLDC motors have many similarities to AC induction motors and brushed DC motors in terms of construction and working principles respectively. Like all other motors, BLDC motors also have a rotor and a stator.

### A. *Stator*

Similar to an Induction AC motor, the BLDC motor stator is made out of laminated steel stacked up to plased the windings. Windings in a stator can be done in two patterns; i.e. a star pattern (Y) or delta pattern (Δ). The main difference between the two patterns is that the Y pattern gives high torque at low RPM and the Δ pattern gives low torque at low RPM.This is because in the Δ configuration, half of the voltage is applied across the winding that is not driven, thus increasing losses and, in turn, efficiency and torque.

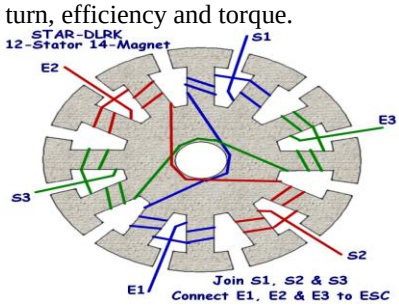


Fig.1 Stator lamination

Fig. Show Laminated Steel Stapings in Stator Steel laminations in the stator can be slotted or slotless as shown . A slotless core has lower inductance, thus it can run at very high speeds. Because of the absence of teeth in the lamination stack, requirements for the cogging torque also go down, thus making them an ideal fit for low speeds too The main disadvantage of a slotless core is higher cost because it requires more winding to compensate for the larger air gap.

### *B.Rotor*

The rotor of a typical BLDC motor is made out of permanent magnets. Depending upon the application requirements, the number of poles in the rotor may vary. Increasing the number of poles does give better torque but at the cost of reducing the maximum possible speed. Fig.,4 Pole and 8 Pole – Permanent Magnet Rotor Another rotor parameter that impacts the maximum torque is the material used for the construction of permanent magnet; the higher the flux density of the material, the higher the torque.

Fig.2 Permanent magnet rotor

do not have to be defined. Do not use abbreviations in the title unless they are unavoidable.

## *IV. Operation of BLDC motor*

Motor operation is based on the attraction or repulsion between magnetic poles. the process starts when current flows through one of the three stator windings and generates a magnetic pole that attracts the closest permanent magnet of the opposite pole. The rotor will move if the current shifts to an adjacent winding. Sequentially charging each winding will cause the rotor to follow in a rotating field. The torque in this example depends on the current amplitude and the number of turns on the stator windings, the strength and the size of the permanent magnets, the air gap between the rotor and the windings, and the length of the rotating arm.

## *V. Torque/Speed Characteristics*

The figure below shows an example of torque/speed characteristics. There are two torque parameters used to define a BLDC motor, peak torque (TP) and rated torque (TR). During continuous operations, the motor can be loaded up to the rated torque. As discussed earlier, in a BLDC motor, the torque remains constant for a speed range up to the rated speed. The motor can be run up to the maximum speed, which can be up to 150% of the rated speed, but the torque starts dropping. Applications that have frequent starts and stops and frequent reversals of rotation with load on the motor, demand more torque than the rated torque. This requirement comes for a brief period, especially when the motor starts from a standstill and during acceleration. During this period, extra torque is required to overcome the inertia of the load and the rotor itself. The motor can deliver a higher torque, maximum up to peak torque, as long as it follows the speed torque curve.

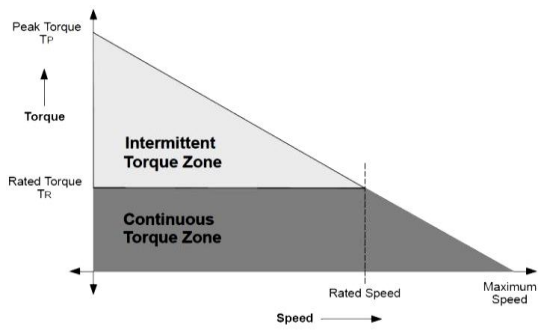


*Fig.3 T/N characteristics*

### *VI. The Role of Hall Effect Sensors*

Commutation feedback devices provide current rotor position information to the control unit in the form of U, V, and W signals. These feedback devices can also send other information to the control unit, e.g., speed, acceleration, rotational direction, number of revolutions, etc. Hall effect sensors are the most widely used devices.This encoder generates precise angular encoding signals and is often recommended where greater resolution is desired. This means the commutation tracks of the code disc need to be aligned to the rotor position. Hall sensors detect movement of the commutation magnet, while the optical commutation encoder senses movement of the codewheel. The commutation magnet pole pair and codewheel track patterns are fixed and matched to BLDC rotor pole pairs.

Hall Effect Theory: If an electric current carrying conductor is kept in a magnetic field, the magnetic field exerts a transverse force on the moving charge carriers which tends to push them to one side of the conductor. This is most evident in a thin flat conductor. A build up of charge at the sides of the conductors will balance this magnetic influence, producing a measurable voltage between the two sides of the conductor. The presence of this measurable transverse voltage is called the Hall effect after E. H. Hall who discovered it in1879.

### *VII: Advantages of BLDC*

1. High efficiency and reliability.
2. Lower acoustic noise.
3. Smaller and lighter weight.
4. Greater dynamic response.
5. Better speed vs torque characteristic.
6. High speed range.
7. Longer life.
8. Low maintenance.
9. Faster acceleration.

### *VIII. Disadvantages of BLDC*

1. Initial cost is more
2. It require complex circuit
3. It require additional system wiring

### *IX. Applications*

The cost of the Brushless DC Motor has declined since its introduction, due to advancements in materials and design. This decrease in price, coupled with the many advantages it has over the Brush DC Motor, makes the Brushless DC Motor a popular component in many different applications

1. Heating and ventilation
2. Industrial automation
3. Motion control
4. Positioning and actuating system
5. Aero modeling
6. Cooling fan

### X. *CONCLUSION*

In conclusion, BLDC motors have advantages over brushed DC motors and induction motors. They have better speed versus torque characteristics, high dynamic response, high efficiency, long operating life, noiseless operation, higher speed ranges, rugged construction and so on. Also, torque delivered to the motor size is higher, making it useful in applications where space and weight are critical factors. With these advantages, BLDC motors find wide spread applications in automotive, appliance, aerospace, consumer, medical, instrumentation and automation industries.

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