Review Article

A Brief Survey on Controlling of BLDC Motor System Drive

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ABSTRACT

This study provides an overview of the PMBLDC drive system basics, converter topologies, and the Fuzzy Logic Controlled PMBLDC Drive System for BLDC motor drives. Because of its excellent dependability, simple frame, high efficiency, and fast dynamic response, BLDC motors are frequently employed in domestic applications. responsiveness, compact size, low maintenance, and so on. The switches are electronically commutated depending on rotor position detection information. Sensor or sensor less approaches are used to identify the location of the rotor. As a result, it is an electrically commutated motor.

KEYWORDS

BLDC, Drive System, Speed Controlling, rotor, fuzzy logic, sensorless

1. INTRODUCTION

Brushless dc (BLDC) motors are often used in small-horsepower control applications due to their high efficiency, quietness, compactness, durability, and low maintenance requirements. However, as new technology in power semiconductors, microprocessors, adjustable speed drivers control systems, and permanent-magnet brushless electric motor production has developed over the past decades, these variable speed motors have encountered obstacles.

The end-product market share of electronic motor drivers in household appliances is expected to grow quickly during the next five years [4]. Refrigerators, washing machines, vacuum cleaners, and freezers are just a few examples. Single-phase alternating current induction motors, including split-phase, capacitor-start, and capacitor-run types, as well as universal motors, have traditionally been employed in domestic appliances. When these older motors are run at constant speed with mains AC power, their efficiency is ignored. Energy efficiency, increased performance, reduced acoustic noise, and more convenience features are becoming the norm for money-conscious consumers. Those antiquated technologies aren't up to the task.

Variable frequency inverters are used to adjust the shaft position of an excitation-emitting permanent magnet synchronous motor fed by a BLDC motor drive. Such BLDC motor drives' controllers appear to be lacking in commercial simulation tools. In particular, the high software development costs have not been justified for their typical low-cost fractional/integral kW application areas, such as NC machine machines and robot drives, even if it implies the possibility of demagnetizing rotor magnets during commissioning or tuning. Recursive prototyping of both the electric motor and inverter may be required for innovative drive configurations, resulting in a high development cost of the drive system for advanced and specific applications. The BLDC motor market has been pushed into tens of kW application regions where commissioning errors become prohibitively expensive thanks to improved magnet material with a high (B.H.) Therefore, modelling is necessary and could save money in the long run.

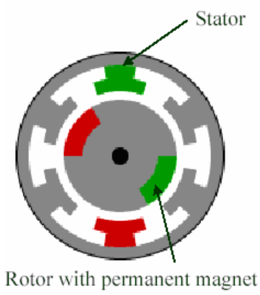

Fig. 1 Cross-section view of a brushless dc motor

The field is on the rotor and the armature is on the stator of a brushless dc motor, which is a dc motor turned inside out. An ac motor with permanent magnets and torque-current characteristics that closely match those of a dc motor serves as the basis for brushless dc motors. Electromagnetic commutation is employed instead of the traditional brush-based method. Brush-commutator difficulties like sparking and brush wear and tear are no longer an issue with BLDC motors, making them more durable than their DC counterparts. It is significantly easier to cool the armature windings with an ac motor since the armature is mounted on the stator, which allows heat to be transferred away from the windings.

Because the back-emf is trapezoidal rather than sinusoidal, a BLDC motor can be thought of as an improved version of a PMSM. When using a Current Source Inverter to drive a BLDC motor, the "commutation region" of the back-emf should be as tiny as feasible, yet at the same time it should not be so narrow as to make commuting a phase of that motor problematic. For a steady torque output, the back-flat emf's constant part should be 120 degrees.

Optical position sensors and their related circuitry can be used to determine the rotor's location. Revolving shutters and a light source are the components of optical sensors that detect location. A Logical signal is typically generated by an optical position sensor.

Principle operation of Brushless DC(BLDC) Motor

A brushless dc motor is a permanent synchronous machine with rotor position feedback. A three-phase power semiconductor bridge is commonly used to regulate brushless motors. A rotor position sensor is needed to start the motor and to provide the correct commutation sequence for the inverter bridge's power components. The power devices are commutated progressively every 60 degrees based on the rotor position. For this reason, the armature current is switched electronically rather than using brushes, making it an electronic motor. That means BLDCs are more robust than their dc counterparts because they don't have to deal with issues like sparking and brush wear, making them less susceptible to damage.

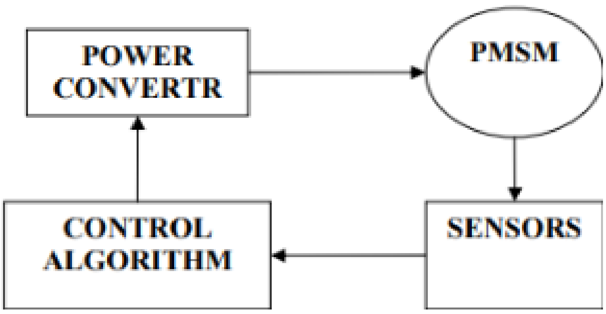

Fig. 2.2. Basic block diagram of BLDC motor

Power converter, permanent magnet-synchronous machine (PMSM) sensors, & control algorithm make up the fundamental block diagram for brushless DC motor depicted in Fig.2.1. The PMSM, which is responsible for converting electrical energy into mechanical energy, receives electricity from the power converter. Brushless dc motors feature rotor position sensors, which are used to determine the gate signal for each semiconductor in the power electronic converter based on the rotor position and command signals, such as torque, voltage, speed, and so on.

A brushless dc motor's type is determined by the structure of the control algorithms, which are categorised into voltage source-based drives and current source-based drives, respectively. Using either sinusoidal or non-sinusoidal back-emf waveforms, drives based on voltage or current sources are utilised with permanent magnet synchronous machines. To achieve almost constant torque, you can regulate the machine's sinusoidal back emf (Fig.2.3). It is possible to minimise inverter sizes and reduce losses for the same power level by using a machine with a non sinusoidal back emf (Fig.2.4).

2. APPLICATIONS OF BLDC MOTOR

BLDC motors are available in every industry category. This technique is useful in a wide range of sectors. There are three types of BLDC motor control:

- Constant load
- Changing weights
- Apps for positioning

2.1 Applications With Constant Loads

In certain instances, a varied tempo is more important than keeping an exact speed. In some applications, the load is directly connected to the motor shaft. Fans, pumps, and blowers are examples of this type of equipment. Low-cost, open-loop controllers are required for these applications.

2.2 Applications with Varying Loads

For these applications, a wide range of speeds can be used. These applications may necessitate high-speed control accuracy and rapid dynamic reflexes. This category of home appliances includes washers, dryers, and compressors.

Electric and hybrid vehicles are prime examples of this in the automobile industry. Fuel pumps can also be electronically controlled. Centrifuges, pump controls, robotic arm controls, gyroscope controls, and other aerospace applications are examples. Speed feedback devices can be utilised in a variety of semi-closed loop or entirely closed loop applications. The controller becomes increasingly complex to utilise as a result of the sophisticated control algorithms used by these programmes. This raises the overall cost of the system.

2.3 Positioning Applications

This covers the vast majority of industrial and automation-related use cases. Applications in this category use mechanical gears, timing belts, or a basic belt-driven system to transfer power. The dynamic reactivity of speed and torque is crucial in these applications. Furthermore, in many applications, the rotational direction is inverted. Cycles typically have three separate phases: a speed-maintenance period, an acceleration phase, and a braking phase. As the load on the motor changes, the controller must become increasingly sophisticated. Closed loop operation is the norm in these systems.

At the same time, the Torque Control Loop, Speed Control Loop, and Position Control Loop might all be active. The true speed of the motor is monitored using optical encoders or synchronous resolves. In some cases, relative position information can be retrieved using the same sensors. If desired, absolute locations can be determined by employing additional position sensors. CNC machines, for example, are an excellent example of this.

3. BLDC VS CONVENTIONAL DC MOTORS

On a traditional (brushed) DC motor, the armature coil windings and the DC power source are connected by a circuit established by mechanical contact between the brushes and the commutator. As the armature rotates, the stationary brushes make contact with various sections of the spinning commutator. When the commutator and brush-system are triggered successively, electrical power always flows through the armature-coil closest to the stationary stator (permanent magnet).

In a BLDC motor, the permanent magnets, not the electromagnets, rotate, leaving the armature immobile. This approach eliminates the need to transfer electricity from a stationary source. To do this, commutator assemblies are replaced with an intelligent electronic controller. The controller, like a brushed DC motor, distributes power using a solid-state circuit rather than a commutator. In terms of efficiency and performance, BLDC motors have several benefits over DC motors. These include:

• High reactivity to change.

• A high level of productivity

• Long life expectancy of the machine

• Low-noise performance

• Greater ranges of speed

The biggest disadvantage of BLDC is its higher price tag, which is due to two things. BLDC motors, for example, require complex electronic speed controllers to function. Controlling the speed of a brushed DC motor with a potentiometer or rheostat is inefficient but suitable for cost-conscious applications.

4. RELATED WORK

According to a recent study, permanent magnet motor drives (PMSM) and brushless DC motors (BDCM) could compete with induction motors in servo applications. To generate constant torque, BDCM requires rectangular stator currents, but PMSM has sinusoidal back emf and so requires sinusoidal stator currents. There is some confusion over which models should be used in specific situations, both in the commercial sector and in academic study. PMSMs are excited by permanent magnets rather than field windings, making them very similar to wound-rotor synchronous machines. With the damper winding and field current dynamics equations eliminated, it is possible to construct an equation-free [4] PMSM model from this well-known [4] synchronous machine model.

The transformation of the synchronous machine equations from abc phase variables to d, q variables forces all inductances that vary sinusoidally in the abc frame to remain constant in the d, q frame. Because a sine-wave back emf is impossible to represent in the BDCM motor's abc frame, it is not worth translating the equations to the d, q frame to retain constant inductances. As a result, the BDCM phase variables model abc is recommended. Because of this method, the torque behaviour of the BDCM can be analysed in great depth, which would not be feasible if simplifying assumptions were utilised in the modelling process.

Using the PMSM's D and Q models, the transient behaviour of a high-performance vector controlled PMSM servo drive was investigated [5]. This model was also used to examine the performance of a BDCM speed servo drive [6]. [7] discusses the application properties of both devices. In this paper, these two models will be shown side by side to illustrate that the d, q model is adequate for studying pmsm in depth, whilst the abc model should be used to explore BDCM.

4.1 BLDC Motor Control

The ac servo is a significant competitor to the brush-type dc servo in industrial applications. Brushless dc motors (BDCM), induction motors, permanent-magnet synchronous motors, and various ac servos are all available in fractional to 30-hp ranges [8]. With its trapezoid-shaped back EMF, rectangular stator currents are the only way to achieve continuous electric torque. Current controllers such as Hysteresis or pulse width modulated (PWM) current controllers are used to keep the actual current flowing into the motor as near to the rectangular reference values as possible. Despite some steady-state studies [9], [10], the modelling, detailed simulation, and experimental verification of this servo drive have been missed in the literature.

This study illustrates that, due to trapezoid back EMF and no sinusoidal change in motor inductances with rotor angle, transferring the machine equations to the d, q model is not necessarily the best strategy for modelling and simulation. Using a natural or phase variable technique instead has numerous advantages.

In order to direct the rotation of the rotor, the controller must be able to determine its direction and location (relative to the stator coils.) In some configurations, rotor position can be sensed directly using Hall Effect sensors or a rotary encoder. To produce high-current DC power, the controller has three bi-directional DC power drivers that are controlled by a logic circuit. In simple controllers, comparators are employed to determine the output phase.

Microcontrollers are used by advanced controllers to govern acceleration, speed, and efficiency. Controllers that use back-EMF to calculate rotor location encounter additional challenges when the rotor is static.

Time-consuming trial-and-error techniques are frequent in the performance design of the BLDCM servo system. The BLDCM drive must first be simulated before it can be designed and tested. The parameters can then be tweaked and tested. A BLDCM PI controller has been proposed. The usage of a PI controller can assist linear motor control. In practise, because the driver and load impose so many non-linear limitations, the PI controller is ineffective in non-linear systems.

5. PROBLEM STATEMENT

To get the motor to perform at its optimum, appropriate speed controls are required. A proportional-integral (PI) controller is commonly used to control the speed of permanent magnet motors. Because of their basic control structure and ease of implementation, nonlinearity, load disturbances, and parametric changes can pose problems for standard PI controllers, yet these controllers are nonetheless widely used in industry. Furthermore, PI controllers require correct linear mathematical models. Because of the nonlinear model of the PMBLDC machine, the linear PI may no longer be acceptable.

The use of a Fuzzy Logic (FL) method to speed control, which is more resistant to load disturbances and parameter changes, can improve the dynamic behaviour of the motor drive system. Fuzzy logic control can increase the quality of the speed response. The majority of these controllers are based on mathematical models and are particularly sensitive to parameter changes. These controllers' performance is unaffected by load disturbances. Fuzzy logic controllers can also be easily integrated into an existing system.

6. CONCLUSION

In this paper, an attempt has been made to review various literatures for the classical controller techniques introduced by the different researchers for tuning of different controller for speed control of DC motor to optimize the best result. This review article is also presenting the current status of tuning of ANFIS controller for speed control of DC motor using classical controller techniques.

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