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Space Vector Control Method for PM-BLDC Motor

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Abstract: Several methods have been proposed to eliminate the low-frequency torque pulsations for BLDC motor drives such as Fourier series analysis of current waveforms and either iterative or least-mean-square minimization techniques. Most methods do not consider the flux linkage control, therefore possible high-speed operations are not feasible. In this work, a novel and simple approach to achieve a low-frequency torque ripple-free speed and flux control with maximum efficiency based on dq reference frame similar to the permanent magnet synchronous motor (PMSM) drives are presented. The electrical rotor position is estimated using winding inductance, and the stationary reference frame flux linkages and currents. Moreover, this method also permits to regulate the varying signals. Simple voltage vector selection look-up table is designed to obtain fast torque and flux control. Furthermore, to eliminate the low-frequency torque oscillations, two actual and easily available line-to-line back- EMF constants (kba and kca) according to electrical rotor position are obtained offline and converted to the dq frame equivalents using the new Line-to-Line Park Transformation. Then, they are set up in the look-up table for torque estimation.

Keywords: Space Vector, Driver Circuit, BLDC Motor, Bridge Rectifier.

1. INTRODUCTION

In recent years, regarding their specific advantages, PMBLDC- equipped variable speed drives, have found multifarious usages in industry. Of these advantages, simple structure, ease of control, high efficiency, high power density and large torque-to-inertia ratio, can be enumerated. Aeronautics, Electric Vehicles, Servo Drives, military and domestic usages are the main industrial area that makes use of PM-BLDC motors.

To overcome the mentioned deficiencies, in the past two decades, Space Vector Modulation-based control methods like Direct Torque Control (DTC) were introduced. At first stages, these methods were used for controlling the induction machines, later they were employed to control PMBLDCs. In these methods, a series of voltage vectors are introduced, so that each represents a specific arrangement of switch states. Each vector, dependent on the position of the rotor, leads to an increase or decrease in the torque and the flux. By making a comparison between the actual torque and reference torque, and by taking account the rotor position and the error of torque and flux into account, the appropriate voltage vector will be selected, so that torque and flux stay closest to their reference values. Space vector based methods, such as DTC, switching frequencies are not equal in upper and lower switches of the same leg and the common mode voltage is usually high, which can get problematic in some cases. Severe ripples in rotor speed and torque can be other disadvantages of the aforementioned method.

In this project, an improved method is proposed to control PM-BLDC motors, which makes use of space vectors but mitigates the speed ripple problem. In addition to the parameters used in similar speed control methods, such as rotor speed and stator flux, this paper uses the slope of speed variations as an auxiliary control parameter to perform a more accurate speed control in the adjacency of reference speed and reduce speed ripples.

2. LITERATURE REVIEW

Salih Baris Ozturk et al., (2011) concluded the position-sensor less direct torque and indirect flux control of brushless dc (BLDC) motor with non-sinusoidal back electromotive force (EMF) have been extensively investigated. The sensorless method closely resembles the conventional DTC scheme used for sinusoidal ac motors such that it controls the torque directly and stator flux amplitude indirectly using *d*-axis current. This method does not require pulse width modulation and proportional plus integral regulators and also permits the regulation of varying signals.

Drawback: In this paper mainly focus the speed control of the motor using the indirect flux control. So the stator flux control needs direct torque control technique.

N. Parhizkar et al., (2011) presents a direct torque control technique for brushless DC motors with non-sinusoidal back electromotive force. In order to solve the problems associated with conventional PI speed controller, a speed control based on fuzzy logic controller is proposed to reduce starting current, eliminate overshoot in the torque and speed responses,

Drawback: In this paper, the direct torque control is applied using a fuzzy logic controller. The fuzzy logic controller is separately controlled to block motor, so the separate fuzzy designing is needed.

Alin and Stirban., (2012) proposes and investigates an offline finite element- method (FEM)-assisted position and speed observer for brushless dc permanent magnet (PM) (BLDC-PM) motor drive. The position between Commutation Points (CP) s is obtained by comparing the estimated line-to-line PM flux with the FEM-calculated line-to-line PM flux. The proposed observer relies on the fundamental model of the machine, a safe starting strategy under heavy load torque, called *I-f* control, is used, with a seamless transition to the proposed sensorless control.

Drawback: In this concept, they only focusing speed of BLDC motor using FEM. In this method, the flux control is not used, so the angle control between the stator controls is not possible.

J.E.MURALIDHAR., (2014) Investigated the position sensorless direct torque and indirect flux control of brushless dc (BLDC) motor with non-sinusoidal back electromotive force (EMF) has been extensively proposed. This method does not require pulse width modulation and need a proportional plus integral regulator with respective hysteresis current controlling technique and also permits the regulation of varying signals.

Drawback: In this concept to reduce the torque ripples using hysteresis control. This control needs to maintain speed, but ripples are high with comparing other methods.

3. PRINCIPLE OF SPACE VECTOR

The feature that makes voltage space vector based control stand out from other control methods, is its capability of direct and independent control of speed (or torque) and flux. In this method, regarding the deviations of speed (or torque) and stator flux from their reference values, the appropriate voltage vector is picked from switching table. Each vector represents a unique arrangement of power electronic converter switches being turned on or off. Obviously shows that the component of voltage which is perpendicular to flux vector contributes to the production of positive or negative torque. Nevertheless, the component of voltage vector which is tangent to the flux vector results in the increase or decrease in stator flux. This control method, makes the speed stay close to its reference value so that flux varies within a circle band around the reference flux.

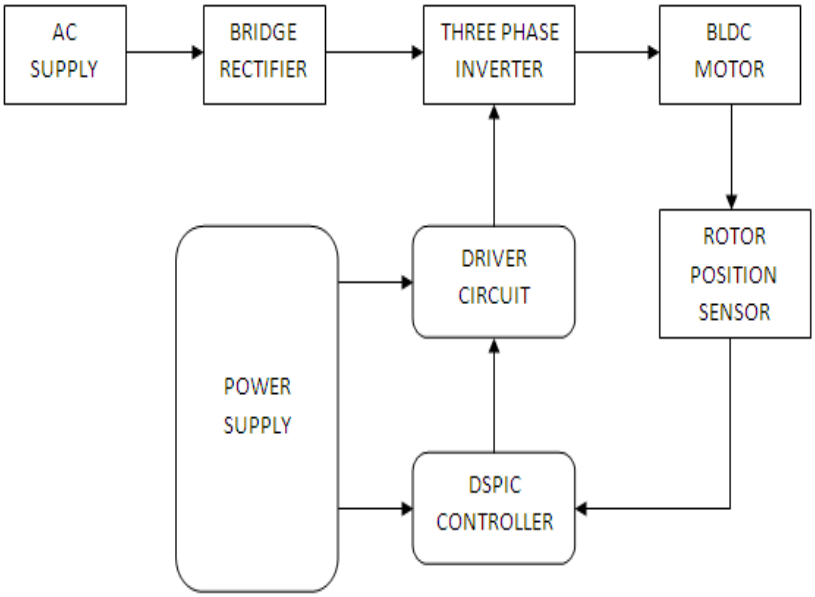

Fig. a block diagram of space vector

ADVANTAGES

- Simple structure,
- Ease of control,
- High efficiency,
- High power density
- Large torque-to-inertia ratio.

DISADVANTAGES

Bldc Motor Cost Is High.

APPLICATION

- Variable speed drives
- High-Speed applications
- Medical Analyser's
- Humanoid Robots

CONCLUSION

In this paper, a novel method was introduced for controlling PM-BLDC motors. This method is based on space vectors theory and utilizes speed variations' slope as an auxiliary control parameter, to efficiently control the rotor speed and reduce the speed ripple. The conventional speed control methods used for PM-BLDC motors, along with the proposed method, are presented.

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