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Performance Comparison of a Canonical Switching Cell with SPWM and SVPWM fed Sensorless PMBLDC Motor Drive under Conventional and Fuzzy Logic Controllers

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Abstract

In this paper, speed control, torque ripple minimization and Power Factor Correction (PFC) of a Canonical Switching Cell (CSC) with Sinusoidal and Space Vector Pulse Width Modulated (SVPWM) sensorless Permanent Magnet Brushless DC (PMBLDC) motor drive system with varying load is discussed. The constant speed of operation with minimum torque ripples and Unity Power Factor (UPF) operation during transient state is the most difficult control part in the motor drive system. At the starting condition, the current is too high due to the absence of back EMF and therefore the motor will start with high torque ripples. In order to eliminate these torque ripples during starting condition by limiting the starting current of the motor, it is necessary to have properly designed Canonical Switching Cell (CSC) converter and an intelligent controller, which will improve the power factor of the supply system and reliability of the PMBLDC motor drive. Here, the speed control, torque ripple minimization and power factor correction of a sensorless PMBLDC motor during starting and running condition with conventional and fuzzy logic controllers are proposed. The performance parameters of a PMBLDC motor with these controllers is analyzed through MATLAB/ Simulink software.

Keywords: Canonical Switching Cell Converter, Sinusoidal and Space Vector Pulse Width Modulation, Sensorless PMBLDC Motor Drive, PI and Fuzzy Logic Controllers, Speed Control, Torque Ripple Minimization, Power Factor Correction.

1. Introduction

Permanent Magnet Brushless DC (PMBLDC) motors make a challenging environment with brushed DC motors; because of their high efficiency, flux density per unit volume, low electromagnetic interference and wide range of speed control. Hence PMBLDC motors are chosen for many low and medium power applications such as aerospace, electric traction, robotics, ventilation, air conditioning etc.

The BLDC motor is a three-phase synchronous motor with stator having three-phase concentrated windings and the rotor having permanent magnets. The BLDC motor is also referred as an electronically commutated motor will work with a three-phase supply which is generated by an inverter unit. For controlling the three-phase inverter bridge, rotor position signals from the Hall effect sensor [1] or sensorless back EMF zero crossing points [2] are utilized to determine the phase commutation in an inverter unit. The disadvantages of Hall effect sensor includes slow response time and increased electrical noise. To eliminate these difficulties in a PMBLDC motor drive by sensorless technique [3] i.e., back EMF zero crossing detection method is preferred.

A front-end Canonical Switching Cell (CSC) [4] not only control the DC link voltage but also make the inverter to operate at the low frequency so that switching losses are minimized and Unity Power Factor (UPF) is achieved at AC mains. Since the CSC converter operation is similar to a battery source, which stores DC link voltage for the motor drive from an AC source followed by a Diode Bridge Rectifier (DBR) circuit and provides complete isolation of PMBLDC motor drive from an AC source. So, the phase angle difference in voltage and current is approximately zero. Therefore, the CSC converter fed PMBLDC motor drive provides nearly Unity Power Factor (UPF) operation even at varying load conditions. Main objective of the CSC converter design in PMBLDC motor drive system is for improving the power factor at AC mains and to reduce the switching ripples [5] since the current does not change abruptly. The CSC converter has the benefits of high input and low output impedance with large energy storage capacity when compared with other non-isolated converters.

For controlling the three-phase voltage supply generated in an inverter unit, proper commutation of each phase with sinusoidal or space vector pulse width modulation [6] technique is employed. SPWM and SVPWM refer to a special switching sequence of a three-phase Voltage Source Inverter (VSI) is used in a PMBLDC motor drive system. Space Vector PWM (SVPWM) method is an advanced computation intensive PWM method and possibly the best technique for variable frequency drive applications. The SVPWM technique utilizes DC bus voltage by 15 % more than Sinusoidal PWM (SPWM) and generates less harmonic distortion [7] in a three-phase voltage source inverter. The SVPWM technique provides an improved commutation of electronic switches from one phase to another phase [8] and thereby the current pulsations in source current and torque ripples in a PMBLDC motor drive are eliminated.

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