ICEE 2019
27th Iranian Conference on Electrical Engineering
شهر تاریخی یزد | دانشگاه یزد
۱۰ الی ۱۲ اردیبهشت ۱۳۹۸
30 APRIL - 2 MAY 2019
بیست و هفتمین کنفرانس مهندسی برق ایران

Implementation of CSI-Fed Brushless DC Motor Drive using Space Vector Modulation Strategy

Abolfazl Halvaei Niasar, Saeed Paksaz
Faculty of Electrical and Computer Engineering, University of Kashan, Kashan, Iran

Abstract

Todays, the brushless DC motors (BLDCs) have been widely used in industry and consumer application due to their unique advantages. These motors are generally supplied from voltage source inverters (VSIs). These inverters have a very simple structure, but have problems such as unwanted short circuit across dc-bus and using bulky capacitor in the dc-bus. Using the current source inverters (CSI) is the one of ways to reduce the mentioned problems in VSI-BLDC motor drives. In this paper, the space vector modulation (SVM) strategy is employed for switching in BLDC motor drive supplied by CSI in order to reduce the switching losses and increase the reliability. An experimental setup system is designed and implemented to evaluate the motor behaviour at different speeds.

I. Introduction

There are different switching strategies in the CSIs that can be divided into two general categories with switching frequencies equal to fundamental frequency of load (or six-step switching strategy), and PWM switching strategies.

The six-step switching strategy is the simplest method that has the same problems of VSIs, which have considerable low-order harmonics that can cause torque ripple. Hence, PWM switching strategies are preferable to six-step strategy. There are several types of switching methods based on PWM for CSIs; that the trapezoidal PWM method (TPWM) is the basic PWM method. The SVM technique has recently been used in many applications of electrical drive of induction and synchronous motors and is expected to be used in future for other types of motors.

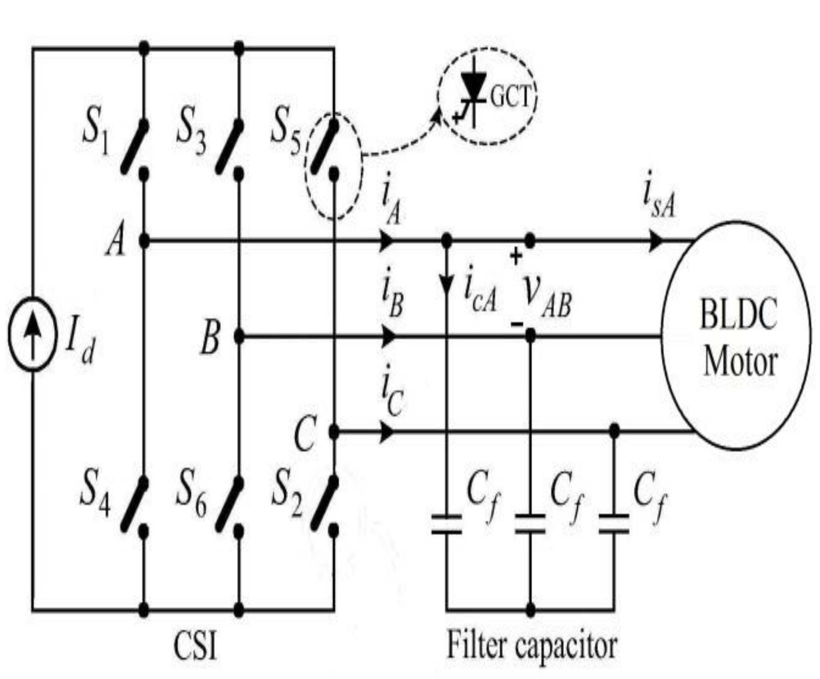


Fig. 1. Current source inverter fed brushless DC motor drive

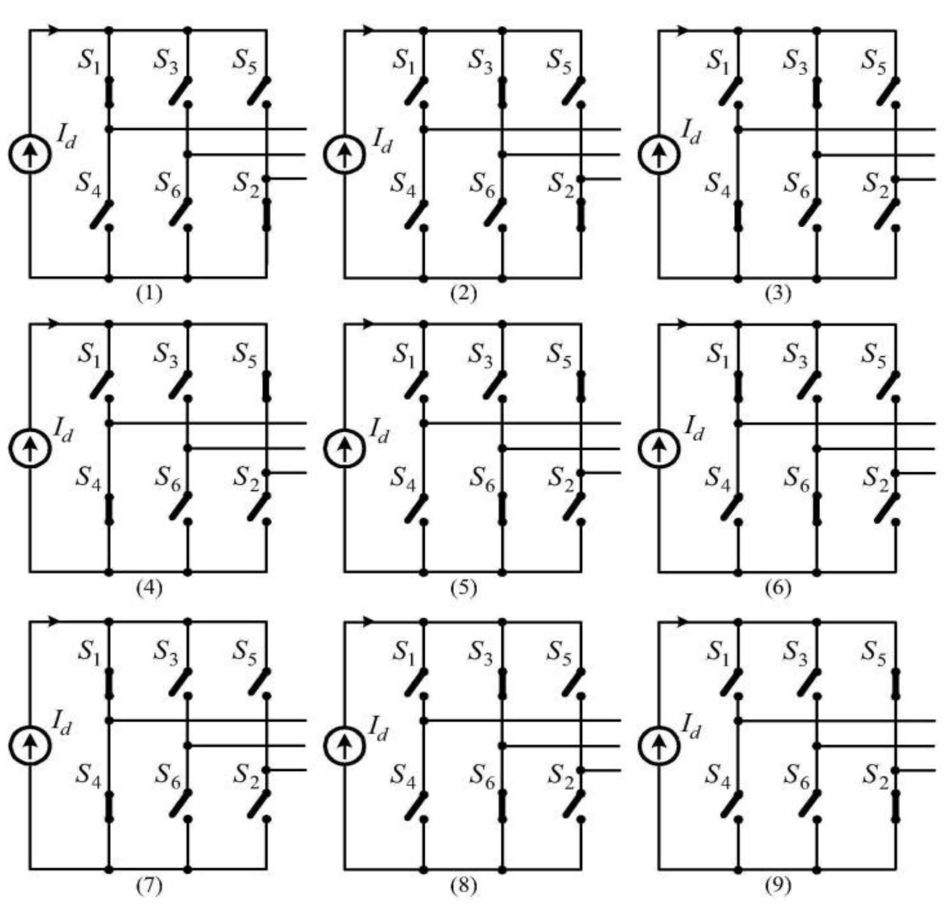


Fig. 2. Switching states in the current source inverter

II. Space Vector Modulation in CSI

Space vector modulation (SVM) in the CSI is similar to the VSI, with the difference that for VSI, there are 6 active switching state and 2 inactive switching states, but for CSI it has 6 active states (corresponding to the states 1 to 6 in Fig. 2) and 3 inactive states (the states 7 to 9). The dwell time calculation is based on ampere-second balancing principle as follows:

$$\vec{I}_{ref} T_s = \vec{I}_k T_1 + \vec{I}_{k+1} T_2 + \vec{I}_z T_0$$

$$\begin{cases} T_1 = m T_s \sin\left(\frac{\pi}{6} - \theta + (k-1)\frac{\pi}{3}\right) \\ T_2 = m T_s \sin\left(\frac{\pi}{6} + \theta - (k-1)\frac{\pi}{3}\right) \\ T_0 = T_s - T_1 - T_2 \end{cases}$$

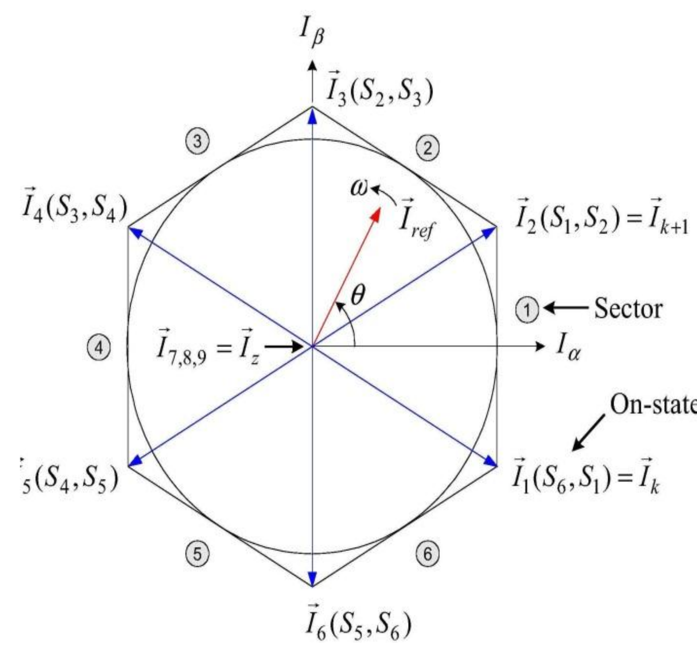
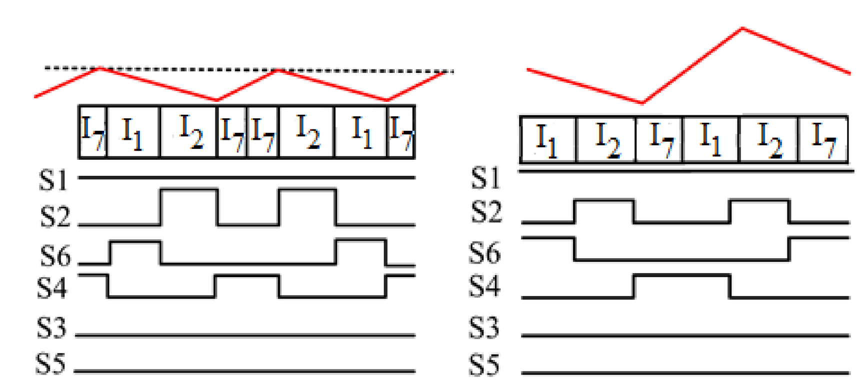


Fig. 3. Definition of sectors and space vectors in CSI



(a) Unsymmetrical pattern (b) Symmetrical pattern

Fig. 4. Two different switching patterns in sector 1

III. Implementation of SVM-based CSI-BLDC Motor Drive System

The schematic of overall block diagram of the system is shown in Fig. 5. In this system, the dsPIC microprocessor dsPIC33FJ12MC202 is used as controller and IC A3120 as switch driver. In the power circuit, a 36 mH inductor is used to generate the dc current source, and IRF1407 type MOSFET switches.

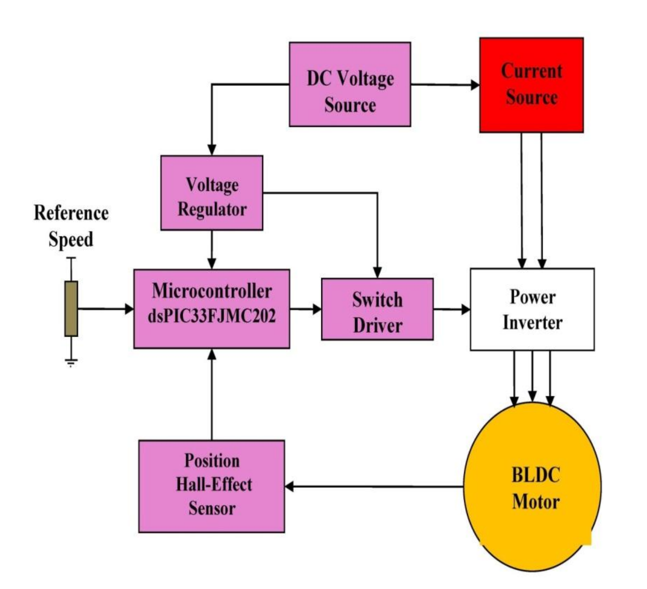


Fig.5. Schematic of experimental setup of SVM-based CSI-fed BLDC motor drive

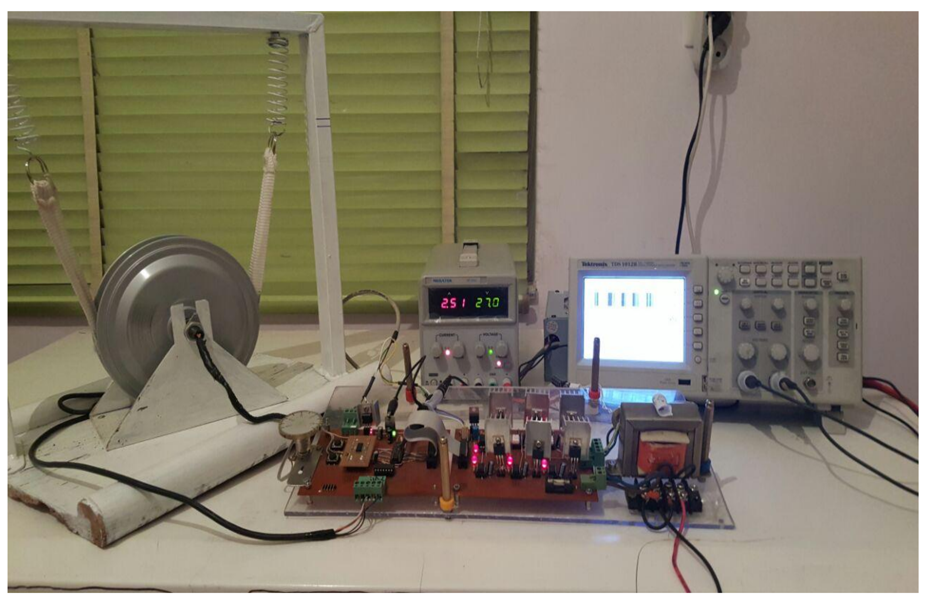
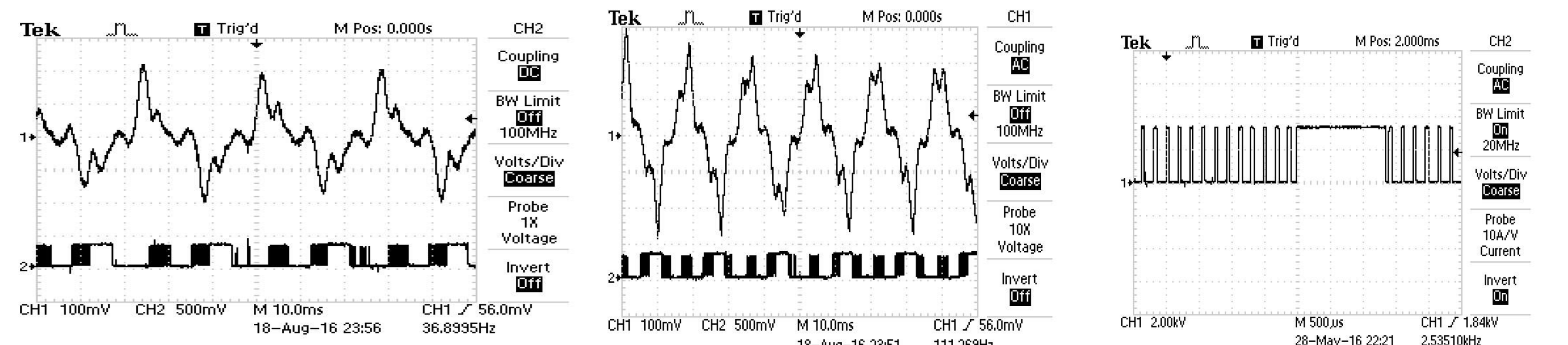
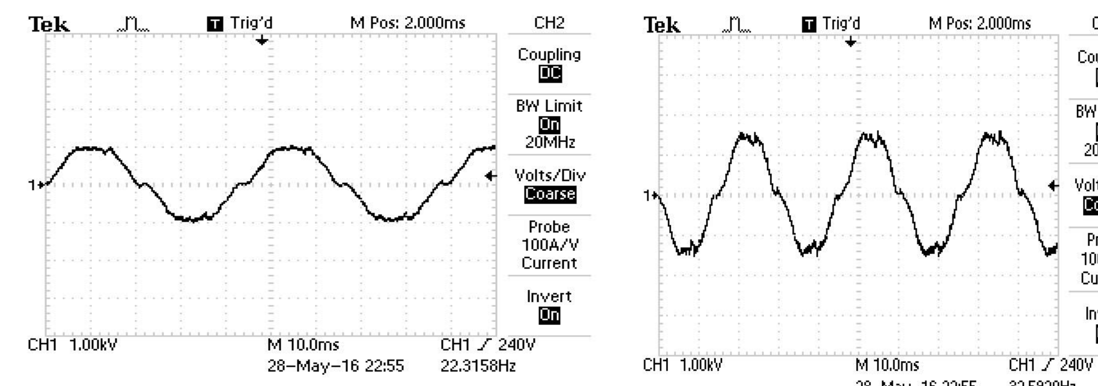


Fig.6. The experimental setup of SVM-based CSI-BLDC motor drive system



(a) Phase current and command to switch S_1 at speed 140 rpm (b) Phase current and command to switch S_1 at speed 250 rpm (c) The zoom of command to switch S_1 at speed 250 rpm

Fig. 8. Phase current and command to switch S_1 at different speeds under torque load 1 N.m



(a) at speed 140 rpm (b) at speed 250 rpm

Fig. 8. The filtered phase voltage at different speeds under torque load 1 N.m

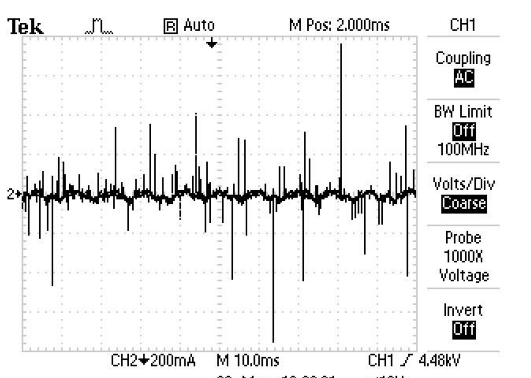


Fig. 9. DC link current

VI. Conclusion

To create the current source, the simple topology of the voltage-source in series with inductor was employed. But with increasing the power and current, current stabilization is very difficult and the use of CSI based on dc/dc converter is inevitable. Also, the symmetric switching pattern was used. The problem with the implementation of electric drive with a current source is that many existing microcontroller that are used in drive applications, have complementary output PWM ports with adjustable dead time unit. This feature is put to protect the short circuit across the dc bus, whereas in CSI, to create the zero current vectors, it is need to energize both switches of on the one leg. This problem should be solved witch programming technique.