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IMPLEMENTATION OF COMMAND SEQUENCES OF HYBRID STEPPER MOTOR WITH DSPICDEM MCSM BOARD

BY

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Abstract. In this paper we present the implementation the sequences of hybrid stepper motor control using the PWM technique. The HSM phases are powered by two H-bridge. The PWM signals are generated by dsPIC33fj32MC204 microcontroller.

Key words: hybrid-stepper-motor; full-step; half-step; driver-unipolar.

1. Introduction

With the advent of stepper motor, has occurred the need for operating systems to ensure that the positioning and reversing in the shortest time. From all electrical motors the stepper motor are more used once for the position systems.

The stepper motors belong to the category of synchronous motor without brushes. The name of synchronous operation is due to the fact that the speed of rotation of the stator field is synchronous with the speed of rotation of

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the rotor, and this speed is dictated by the frequency of the control pulses (Arcanley, 2007).

A very important property of the HSM is the conversion of a PWM pulse, in discrete shifts, precisely defined. Movement of the engine at each pulse is known as a step. The value of step is dependent of the construction and the type of the control sequence used: One-Phase-On, Two-Phase-On, Half-Step (Mihalache *et al.*, 2016). These sequences have been used to power a hybrid stepper motor with two phases.

2. One-Phase-On

One-Phase-On sequence implies sequential supply of the phases with voltage pulses. It is a sequence that can be implemented with the logic circuits. A mathematical model has been developed for this sequence is described in (Mihalache *et al.*, 2013). The sequential order to supply the phases with pulses of voltage is: B ,A-, B-,A. In Fig. 1 are illustrated control pulses of the sequence one-phase-on (Mihalache *et al.*, 2013).

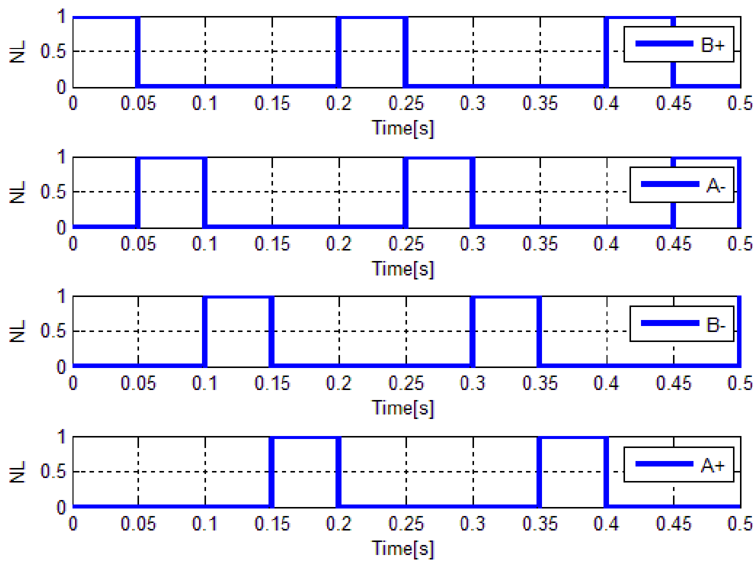

Fig. 1 – The one-phase-on pulses.

3. Two-Phase-On

An important contribution in the torque developed by the engine, bring the two-phase-on sequence. On this sequence they are simultaneous supply two of the phases. On the power off time, the rotor will make a move of a half of a step (Mihalache *et al.*, 2016). The control pulses of the sequence are shown in Fig. 2.

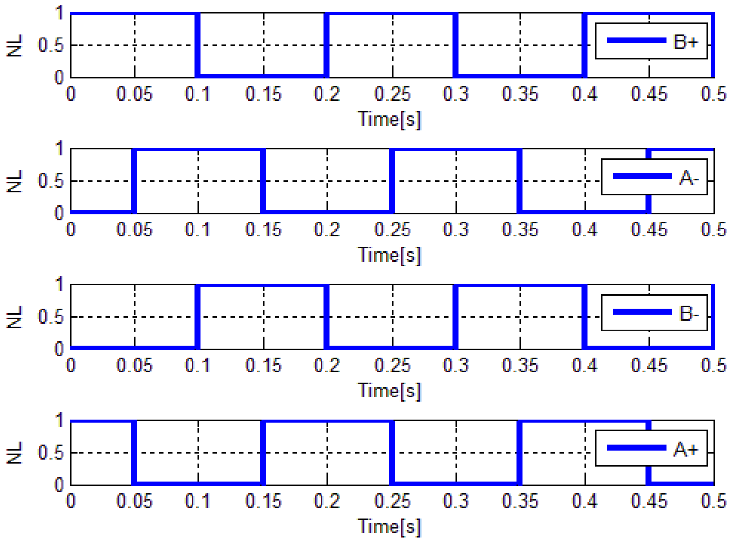

Fig. 2 – The two-phase-on pulses.

4. Half - Step

An important contribution on the resolution of the motor (number of steps for a spin) is making the Half-Step sequence. In this sequence the number of the phases alternates simultaneously (Mihalache *et al*., 2016). The control pulses of the sequence are shown in Fig. 3.

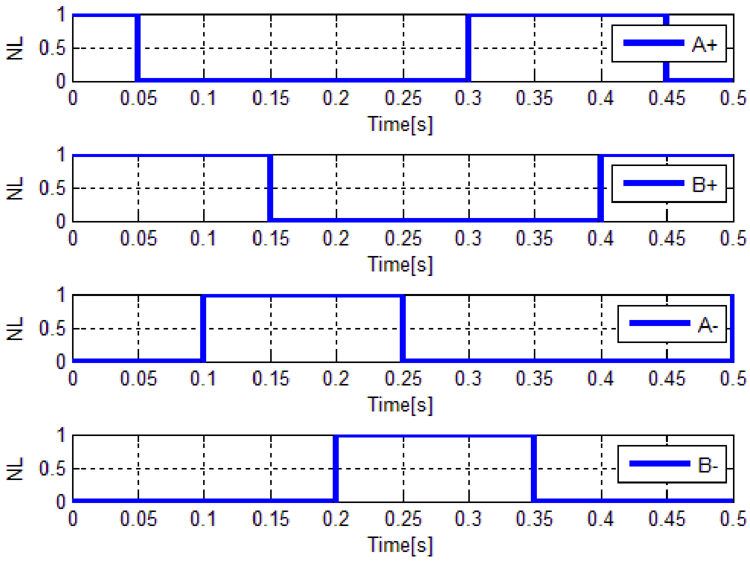

Fig. 3 – The half-step pulses.

5. Implement the Sequences on the dsPICDEM MCSM Board

The development board dsPICDEM MCSM produced by the Microchip, is dedicated to the development of the command and control algorithms of the stepper motors (Microchip, 2009). The Development Board has dual H bridge made with MOSFETS OF N and P TYPE, and each of the axle arm must be command with complementary PWM signals.

In this paper, it was desirable to obtain the average voltage of 5 V, for the supply phases of a hybrid stepper motor. The desired voltage has been achieved through the determination of the duty cycle of the PWM signal for each half-bridge. It was proposed the implementation of the unipolar control for the two H-Bridge.

The average value of the supply voltage is determined using the expression (Albu, 2007):

$$V_{\mathrm{med}} = V(2\mathrm{DRC} - 1) \tag{1}$$

where: V_{med} is the average value, V – the supply voltage of the H-Bridge, DRC – Duty cycle (may take the values from 0 to 1).

The supply voltage of the two H-Bridge is 24V. To determine the amount of the DRC has been carried out for the two situations:

a) for positive pulses:

$$\begin{cases} 5V = 24V(2\mathrm{DRC} - 1) \\ 29V = 48V\mathrm{DRC} \\ \mathrm{DRC} = 0.6 \end{cases} \tag{2}$$

b) for positive pulses:

$$\begin{cases} -5V = 24V(2\mathrm{DRC} - 1) \\ 19V = 48V\mathrm{DRC} \\ \mathrm{DRC} \cong 0.3958 \end{cases} \tag{3}$$

The value of the PWM duty cycle register is calculated with the following expression:

$$\mathrm{PxDCy} = 2 \cdot \mathrm{Max(PxDCy)} \cdot \mathrm{DRC} \tag{4}$$

where: PxDCy represents the PWM's duty cycle control register.

The PxDCy register value for positive pulses is:

$$\mathrm{PxDCy} = 2 \times 256 \times 0.6 \cong 307 \tag{5}$$

– whilst the value for negative pulses is:

$$PxDCy = 2 \times 512 \times 0.3958 \cong 203 \quad (6)$$

In order to obtain the average voltage value for the supplying pulse, the value for the PxDCy register must be determined for each H-bridge.

a) for positive pulses:

$$PxDC1 = 307 \quad (7)$$

$$PxDC2 = 512 - 307 = 205 \quad (8)$$

b) for negative pulses:

$$PxDC1 = 203 \quad (9)$$

$$PxDC2 = 512 - 203 = 309 \quad (10)$$

where: PxDC1 and PxDC2 represent the first and the second channel of the PWM module, respectively. The driver's schematic for powering a motor's phase is presented in Fig. 4.

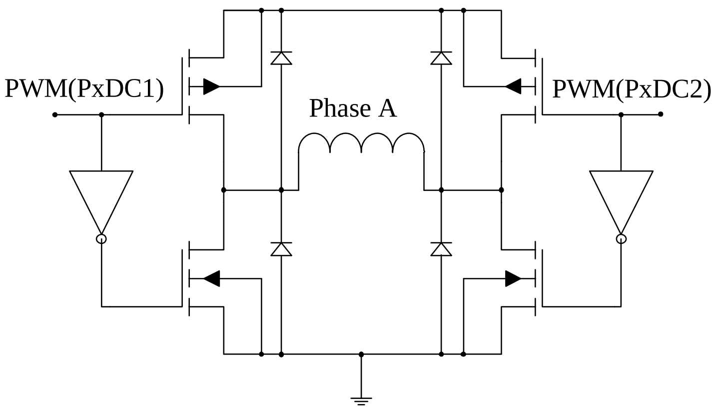

Fig. 4 – H-Bridge for supply phase A.

6. Experimental Results and Conclusions

The command sequences are generated by means of a dsPIC33fj32MC204 microcontroller. The PWM signal frequency was setup at 10 kHz, roughly. The simple sequence voltage pulses are graphically illustrated in Fig. 5. One can observe that each voltage pulse (made of PWM signal) is unipolar.

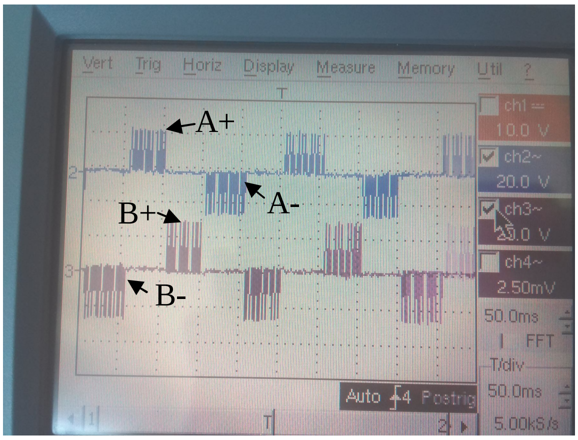

Fig. 5 – The one-phase-on voltage pulses.

The double sequence voltage pulses are presented in Fig. 6. The voltage pulses are unipolar and the period is double comparing to the period of simple sequence pulses. The power consumption in this case is double.

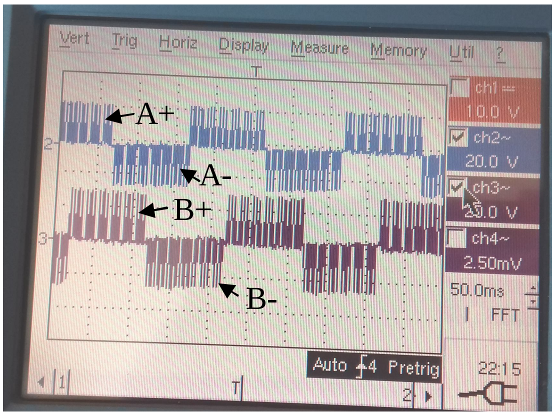

Fig. 6 – The two-phase-on voltage pulses.

The mixt sequence voltage pulses (made from PWM signal) are unipolar as well. The voltage pulses have a triple period than the other sequences (Fig. 7). The power consumption is dependent of the number of phases which are powered at some given moment.

The advantages of employing unipolar inverters for powering stepper motor phases are the following:

a) reduced current ripple;

b) small loses by hysteresis and swirling currents;

c) precise control of the currents within motor phases.

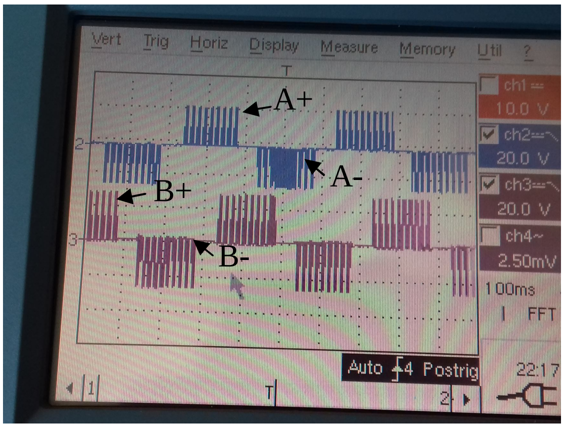

Fig. 7 – The half-step voltage pulses.

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CONTROLUL MOTORULUI PAS CU PAS HIBRID CU PLACĂ DE DEZVOLTARE DSPICDEM MCSM

(Rezumat)

In această lucrare se prezintă implemantarea secvențelor de comandă a motoarelor pas cu pas utilizand tehnica PWM. Alimentarea fazelor HSM se realizează prin intermediul a două invertoare. Semnalele PWM sunt generate cu ajutorul microcontrolerului dsPIC33fj32MC204 de la Microchip.