저가형 산업응용 제품을 위한 BLDC 전동기 알고리즘

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BLDC Motor Control Algorithm for Low Cost Industrial Applications

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Abstract

Electrical motors are an integral part of industrial plants with no less than 5 billion motors built word wide every year and the BLDC motor have been increased demand on industrial application. This paper presents BLDC motor control algorithm for cost effective motor application using general purpose microprocessor which have only one on-chip timer and describes how to realize pulse width modulation(PWM) signals with general input/output(I/O) ports to control a three-phase permanent magnet brushless dc motor using timer interrupt on MSP430F1232.

Keywords : BLDC motor, PWM, Industrial application, MSP430F1232..

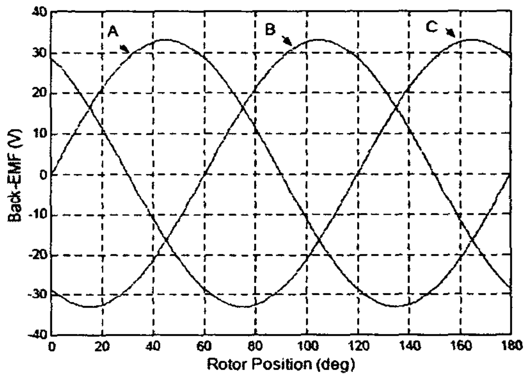
1. Introduction

The BLDC motor has been used in various industrial applications and increased demand on diverse fields because of high efficiency, simple control algorithm compared with AC motor, higher total system cost then DC motor, low EMI and high reliability(no brush wear). Most three-phase motor, including BLDC motor, applications need at least six PWM channels for power devices of inverter such as IGBT and FET. In order to meet those requirements, generally a special-purpose processors or a PLD (Programmable logic device) or drive device to generate control signal are necessary.

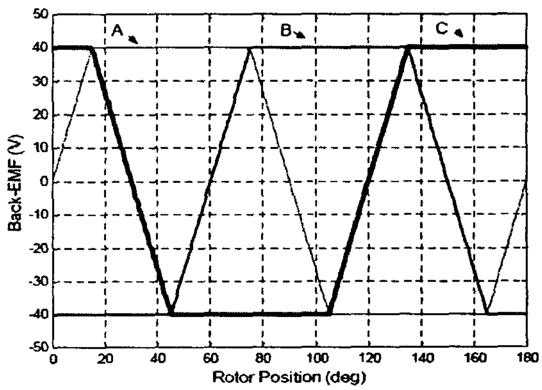
In this paper, for cost efficiency BLDC motor control algorithm a only general purpose micro processor, MSP430F1232 which is ultra-low-power 16-bit RISC mixed-signal processors from Texas Instruments (TI) provides the ultimate solution for battery-powered measurement applications, and simple drive circuit are used to generate PWM signal. To verify proposed algorithm, the operation of a three-phase BLDC motor which has three hall sensors under open-loop speed operation is described in this paper.

2. BLDC Motor

Permanent magnet (PM) motors are synchronous motors that have permanent magnets mounted on the rotor, and the armature windings located on the stator. PM motors are categorized into two types. The first type is referred to as PM synchronous motor (PMSM) which has sinusoidal back-EMF shown in Fig. (1-a). The other type has a trapezoidal back-EMF and is referred to as the brushless dc (BLDC) motor shown in Fig. (1-b) [1].



(a)Three phase back-EMF of PMSM



(b)Three-phase back-EMF of BLDC motor
Fig. 1 The back-EMF of PM motors

In the BLDC motor, the polarity reversal is performed by power transistor switching in synchronization with the rotor position. Therefore, the

BLDC motor has to use either internal or external position sensor to detect the actual rotor position. The rotor position can also be estimated without the need for position sensor. This paper uses three hall sensors to determine the actual rotor position.

In general, BLDC motor may use either 60 [deg] or 120 [deg] commutation. In this paper, 120 degree conduction is used. During one electrical cycle (6 steps), there are two intervals that the winding current is zero. This means that there are four intervals which there are currents in the phase and also in each step four switches are inactive and only two switches are active.

According to Fig. 2, from 30[deg] to 90[deg], phase A will be flowed the positive DC link current while phase_B will be flowed to the negative DC link current. Phase C will be left open. As a result, only two phase(phase A and B) are active, phase C is inactive. It means that there is no need for dead time to be considered. During every PWM cycle the current is turned on and off depend on hall sensor signals.

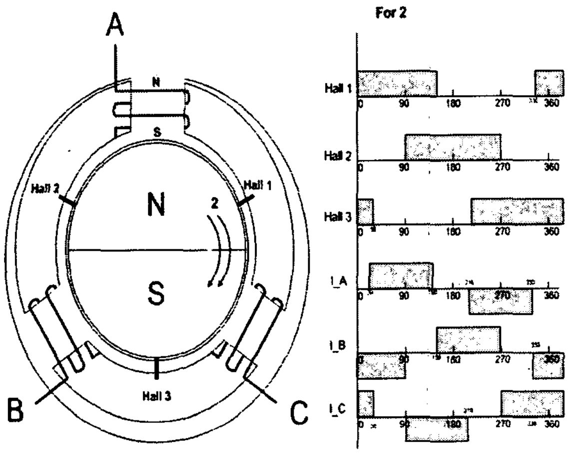


Fig. 2 Hall signals and currents waveform of BLDC Motor

3. Proposed Algorithm

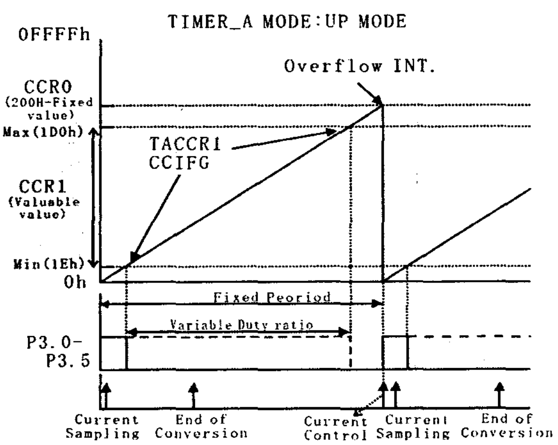


Fig. 3 Timer_A interrupt block diagram for the PWM signal using the digital I/O

Fig. 3 represents the interrupt block diagram for generating the PWM signal using the I/O port. To generate these PWM signals, P3.0 - P3.5 ports are used because the MSP430F123 micro-controller has only two PWM-channels. Timer_A is configured in up-mode with MCLK as timer clock source and Timer_A overflow interrupt and TACCR1 capture/compare interrupt are used to realize exact PWM signal.

In order to keep constant frequency, the CCR0 register has fixed value, which is 200h, and the CCR1 register has proper value to generate the desired duty ratio. The software checks the value of CCR1 register to ensure that it does not exceed the minimum or maximum value and prevents it form rolling over.

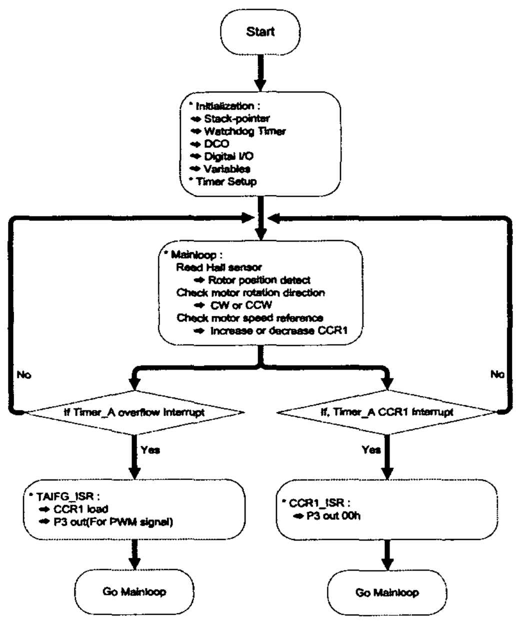


Fig. 4 Software flowchart

The software flow chart for the three-phase BLDC motor with three-hall sensors is described in Fig. 4. The initialization procedure includes the initialization of watchdog timer, digital I/O, Timer_A, ADC10 and variables. The main program consists of the intialization, start of conversion of the dc link current, hall sensor check for rotor position detection, signals check for increasing the current reference or decreasing the current reference and the check for motor rotation direction. To make constant PWM signal, P3.0-P3.5 port are used as PWM output port, and Timer_A underflow interrupt is served, which is called every 100msec. To control the motor current, we are adjusting the dc bus voltage level applied to the motor using proper PWM duty ratio, and Timer_A CCR1 interrupt is utilized for regulating this dc bus voltage.

All algorithms are developed in assembly language and it is using 422 bytes of flash memory. The flash memory address is from 0xE000 to 0xFFFF, the interrupt vector from 0xFFFF to 0xFFE0, and the main code memory from0xFFFF to 0xE000. The developed code is in the main code memory. So it is no need for extra memory and peripheral devices to be connected.

4. System Configuration

Fig. 5 shows the block diagram of the BLDC motor control system used in this paper. MSP430F123 processor receives feedback signal from the DC link current sensor. The rotor position information supplied by the hall sensors of the BLDC motor is estimated with the 3 external I/O port. Actual motor current and the direction of rotation can be changed by the push and toggle switches. Fig. 5 represents the schematic of the BLDC motor drive system. To control motor current, a P-controller is used and to supply proper switching pattern for inverter, three hall sensors is used. As we know this figure, to configure this bldc drive system, only MSP430F123 processor is used and external timer devices for pwm generation, memory for program download are never considered. Fig. 6 shows micro-processor used in this paper.

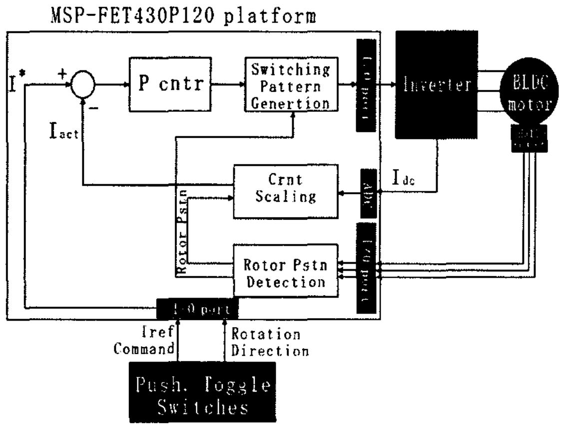


Fig. 5 The schematic of the BLDC motor drive system

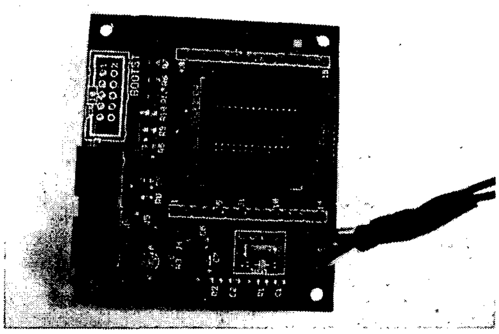


Fig. 6 The MSP430F123 board

5. Experimental Results

Fig. 7 shows the current waveforms, where Channel 1 illustrates the measured DC link current, Channel 2 represents the DC link current waveform using current prove and Channel 4 indicates the phase current waveform using current prove.

Fig 8 shows the PWM signal, Channel 1 is the A_upper signal, Channel 2 is the B_lower signal and Channel 3 is the C_lower signal using I/O port and A_phase current waveform with current prove. As it is seen in Fig.8, the upper leg and the lower leg switches are not on simultaneously. Therefore, there is no need for deadtime to be included in the this example.

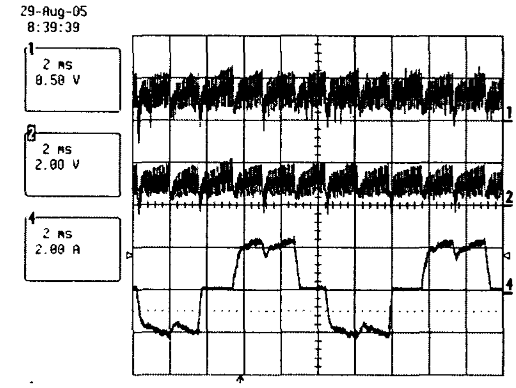


Fig. 7 DC link current and phase current

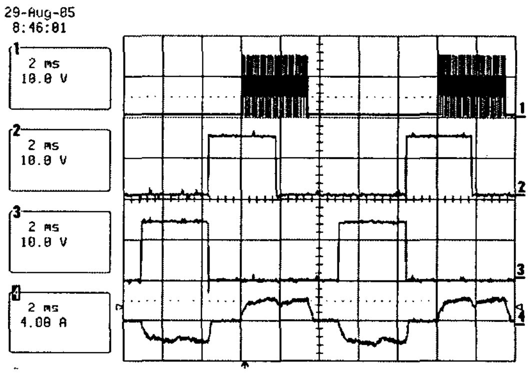


Fig. 8 PWM signals and current waveform

6. Conclusion

In this paper the efficiency algorithm, which employ I/O port for PWM signal generation, is proposed for bldc motor control with three hall sensors and general purpose processor, MSP430F123 by TI, is used without any peripheral devices, To verify this system setup is configured and experiment is achieved.

As a results, the proposed system can be satisfied cost efficiency drive for industrial application and get a good characteristics.

Reference

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