Design of Brushless DC Motor's Control System Based on LS052A-Cb

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Abstract. The permanent-magnet brushless DC motor (BLDCM) has achieved a brilliant application in household equipment industries, since it has specific advantages. The cost control has become a main problem, on the low-end of the market whose customers were more sensitive to the price. To this a low-cost brushless DC motor control scheme based LS052A-Cb microprocessor is presented in this paper. This article introduce the hardware and software design scheme of the BLDCM's controller and implement space vector pulse width modulation (SVPWM). After verification, the program can ensure that the system is stable and reliable at low cost.

Introduction

The permanent-magnet BLDC motor has been widely used in the white goods Industry, because of the advantage of simple structure, reliable operation, energy efficiency and excellent speed performance, etc [1][2]. LS052A-Cb made in China, is a high-performance MCU, lower than the same chip prices, but has the advantage of multi-core parallel processing tasks. SVPWM be more effective than the traditional 120 ° conduction mode for reducing torque ripple. This system based on LS052A-Cb and SVPWM, meet the low-end market demand for low-cost and high-performance.

The overall design of system

The system was composed of upper computer and lower computer. The software of upper computer is used to display Adjust the motors' rotating speed. The lower computer is composed of a BLDCM equipped three Hall position sensors and a controller which adjust the speed depending on the instructions from the upper computer.

The design of system hardware

The system hardware includes six parts: the power module, main control circuit, power driving circuit, inverter circuit, detection circuit, over-load protection, as shown in figure 1[3]. After though a power circuit,AC power which is used as the power is changed into DC to power the main control circuit and the power driver circuitry. The main control circuit produces SVPWM signals according to the signals from Hall position sensors and current signals; Signal are converted voltage signals which control the motion of the motor through the inverter circuit after amplified by the power driving circuit.

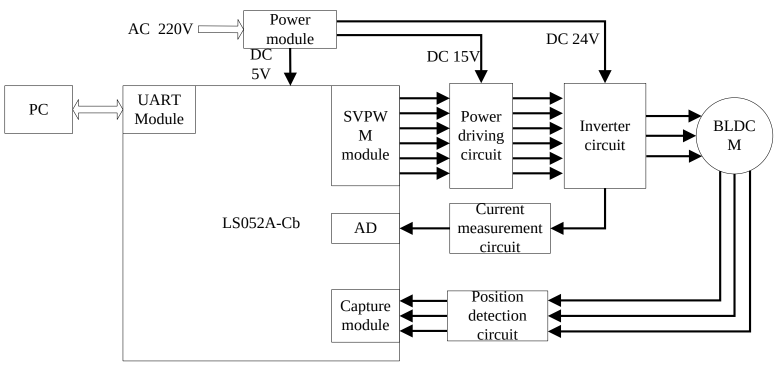

Fig.1: Hardware block diagram

The main control circuit. The main control circuit consists of LS052A-Cb and peripheral circuits. The chip is capable of outputting six paths SVPWM signal and supports 3-core parallel processing. The maximum operating frequency for each core is 40MHz [4]. In general, the chip can meet the design requirements.

The power module. 220V AC used as power is changed into 24V DC by the power module, and then 24V is converted to 5V and 15V by integrated circuit LM7805 and LM7815 for supply the main control circuit, isolation circuit and driving circuit.

The power driving circuit. The main function of power driving circuit is to amplify PWM signals from MCU, so power switches can be turned on and off reliably. MOSFET driver IR2101 has many advantages, such as small size and high speed. A kind of IR2101's boot strap circuit for a boost voltage is used in this design[5].

The inverter circuit. The inverter module is a three-phase full-bridge circuit which is constructed by six MOSFET pipes,as shown in figure 2. By controlling the switch state of each phase upper and lower arms , MCU enable a series of PWM signal to be produced in three-phase windings of the motor, which in turn drives the motor to run.

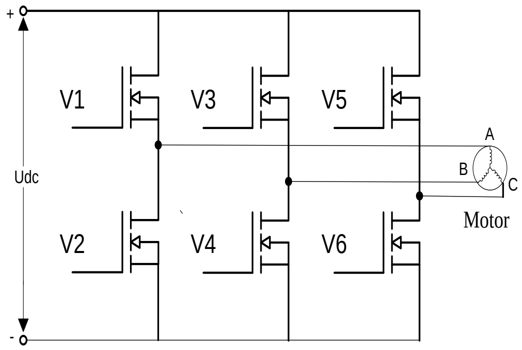

Fig.2: Three-phase full-bridge inverter circuit

The design of system software

Human-Machine Interface program developed in LabVIWE is to realize the startup, stop and speed regulation for the motor. The system software involves SVPWM algorithm module, position detection module, phase-changing module, speed estimation module, and communication module.

Introduction to the main program. Figure 3 is the program flow chart. First, MCU is reset on power, each module is initialized. And then the motor starts and accelerate until its speed reaches the default value. Next, if receiving the speed regulation command from the upper computer, the system will change the frequency and duty cycle of the waveform of SVPWM to realize frequency control of motor speed. In addition, the system will automatically shut down when the current exceeds its limits.

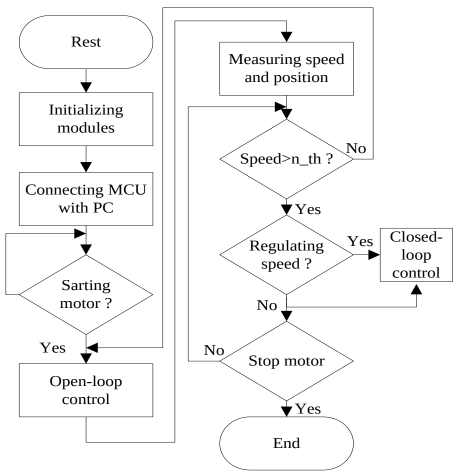

Fig.3: The main program flow chart

Implementation of SVPWM algorithm. According the SVPWM theory, a voltage space vector U_{out} is represented by a linear combination of linear time of vector U_{out} and $U_{x\pm60}$, as shown in figure 4. $t1$, $t2$ and T_{pwm} is the action time of U_x, $U_{x\pm60}$ and U_{out} respectively [3]. After the motor is started, the program enter break mode per PWM cycle and generate the required SVPWM signal, according to the system command. At the same time, the program calculates SVPWM signal values $t1$, $t2$ and period value T_{pwm} according to the rotor position. $t1$ and $t2$ can be calculated by equations (1). Their sine part is stored in advance.

$$\begin{cases} t1 = mT_{pwm}\sin(60^\circ - \theta) \\ t2 = mT_{pwm}\sin\theta \end{cases} \tag{1}$$

Where m is the modulation index (modulation ratio), $m = 2|U_{out}|/(\sqrt{3}U_{dc})$. U_{out} is the desired synthesized voltage vector and U_{dc} is the bus voltage. In order to ensure a circular motion trajectory of U_{out}, $|U_{out}|$ is not greater than $U_{dc}/\sqrt{3}$, so $m \le 1$; θ is determined by the product of rotational angular velocity ω of vector U_{out} and nT_{pwm}; each sector is divided into equal parts by N space voltage vectors. The value of N is 12, $n = 0,1,......11$.

This program uses the five-stage modulation strategy. Figure 5 is three-way wave of U_{out} in the first sector. The compare register T1CMPR and T2CMPR, period register T1PRL and compare mode control register ACTR need to be configured. Register configuration is as follows:

$T1CMPR = t1/2$,
$T2CMPR = t2/2$,
$T1PRL = T_{pwm}$,
$ACTR = 0x18$.

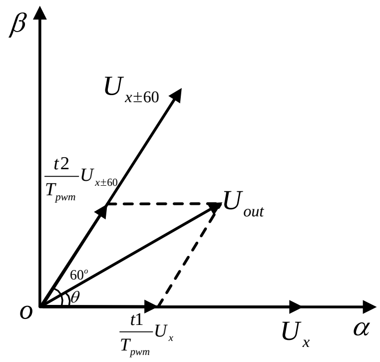

Fig.4: The linear combination of a voltage space vector circuit

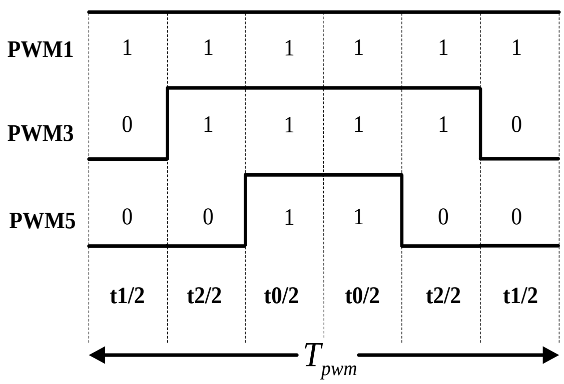

Fig.5: Three-way wave in the first sector

Position detection and speed estimation. MCU can determine which sector rotor locate in by output of three Hall sensors. The T method is chosen in the low speed and the M method is adopted to measure high speed [7].

Experimental results

Motor with its rated power of 18W is used in this experiment. Speed range from 0 to 6000r/min. After the motor starts, 5000r/min is set in the PC program. As shown in figure 6, the motor starts fast, speed fluctuate slightly when adjusted and is stable at constant-speed stage with a margin of error of less than 0.5 percent.

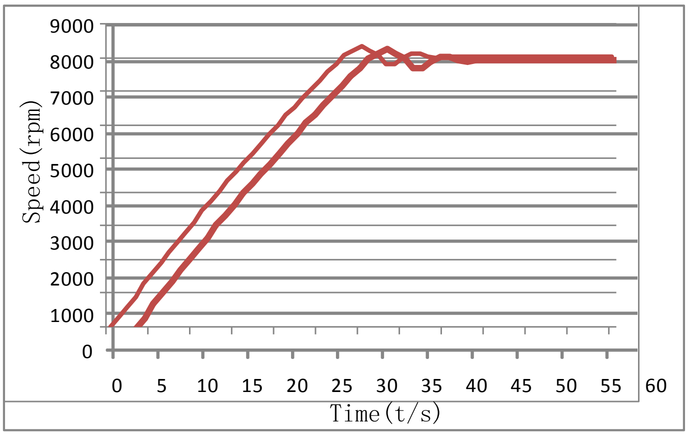

Fig.6: The velocity curve of motor

Conclusions

BLDCM controller based on LS052A-Cb has important practical values in electronics, medical and other industries, since it has the advantages of simple structure, reliable performance, low cost and low power consumption.

Acknowledgements

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