Design of Motor Drive System for Four Rotor Unmanned Aerial Vehicle

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Abstract. The motor drive system is a servo mechanism to control the four rotor UAV (unmanned aerial vehicle) system, and it is also a key component to control the attitude and trajectory of UAV. Its performance directly affects the performance and safety of the flight control system. The working principle of the system is that the motor drive control signal can receive output of flight control computer and convert into current signal to coordinate control of four motor speed, thus the attitude and action of four rotor UAV flight are changed, and the mission set by the operator is completed to control the smooth flight of UAV.

Introduction

In recent years, with the development of electronic technology, multiple rotor unmanned aerial vehicle (UAV) are brought to the attention of the various countries in the field of civil and military fields because of its concealment and motor ability, low costs of manufacturing and maintenance and widely application[1-3].

In the production of UAV, not only electric energy is used, but also diesel power can be used, so there are two driving modes: oil driven and electric drive[4-5]. The power of the oil driven mode is more powerful. It is suitable for large aero models. The general aviation model only needs lithium polymer battery[6]. In the electric model, the motor drive device is mainly used in two aspects: the model of vehicle and the model of aviation[7-8]. The motor driving device used in the aero model is mostly sensorless. Compared with the motor driving device used in the vehicle model, it is not only light weight, small volume, small internal resistance, and the starting current and starting torque are smaller, but also the price is cheaper.

The four rotor UAV is powered by four motors, and the rotor symmetry is distributed in the body before and after the four direction by adjusting the motor speed control system under actuated flight. Four rotors are at the same height and radius of plane, and the structure of four rotors are the same before and after the two motor mounting anti paddle. Two motor is installed paddle and counterclockwise rotation, which can offset the aircraft during the flight of two adjacent motor torque. The main control board is placed in the middle position of the frame, which is used for receiving the control signal from the remote control transmitter. When the control signal is received four motor driving device is controlled by the operator after the digital control bus, and the control signal is converted into the motor speed by motor drive, so that the operator control request response.

Hardware Design of Motor Drive System

Motor drive system is the key to the normal operation and speed control of DC brushless motor[9], and it can detect the rotor position signal, produce and modulate PWM signal, and provide the driving chopping signal of the power switch circuit of the tube and the guide signal[10]. Finally, the motor speed is regulated by controlling the motor armature voltage. In addition, it can provide protection measures for faults such as short circuit, overcurrent, overvoltage and undervoltage that appear in the circuit. The hardware structure of motor drive system is mainly composed of voltage conversion circuit, power drive circuit, zero crossing detection circuit, status indicator circuit, voltage and current monitoring circuit, receiver processing circuit and so on. In the process of building real-time system in aviation model, the

selection of controller is particularly critical. We should consider not only the data processing speed of controller, but also the function of controller.

Minimum System Design. The monolithic integrated circuit is internally calibrated RC oscillator, and the internal RC oscillator is selected as the system clock source through the fuse bit programming. The monolithic microcomputer does not need to connect any components to form the system clock source externally, and the design of circuit for saving resources is simple. The design of the minimum system circuit is shown in Figure 1.
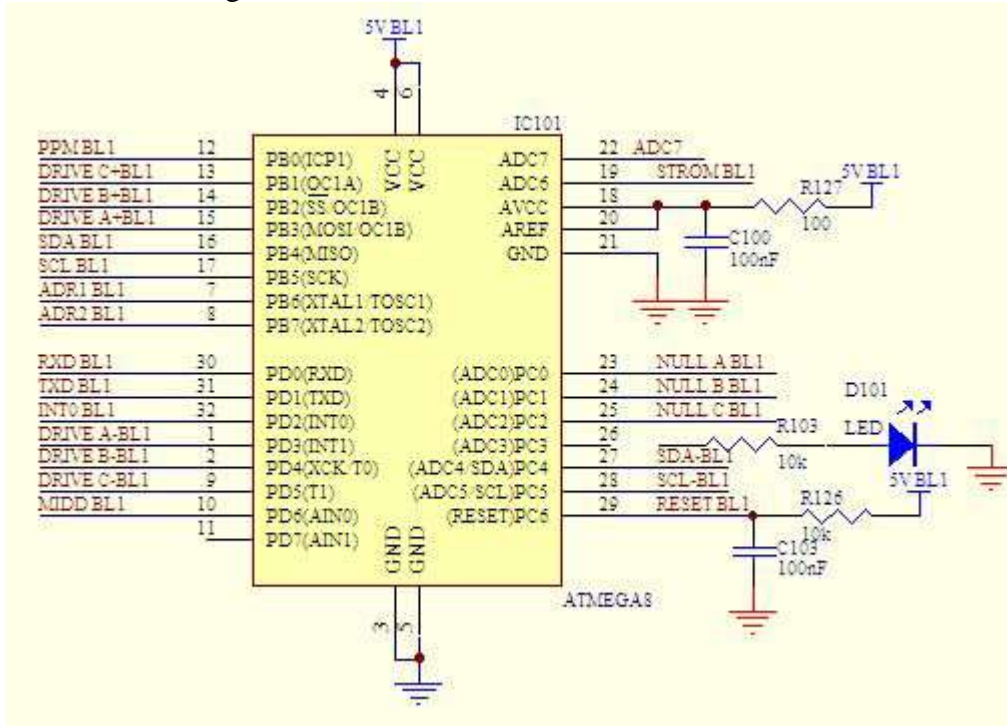

Figure 1. The minimum system circuit

Zero Crossing Detection Circuit. Back EMF detection requires continuous comparison of virtual neutral point voltage and A, B, C three-phase terminal voltage, thus the zero crossing event of each phase induced electromotive force is obtained, as shown in Figure 2.
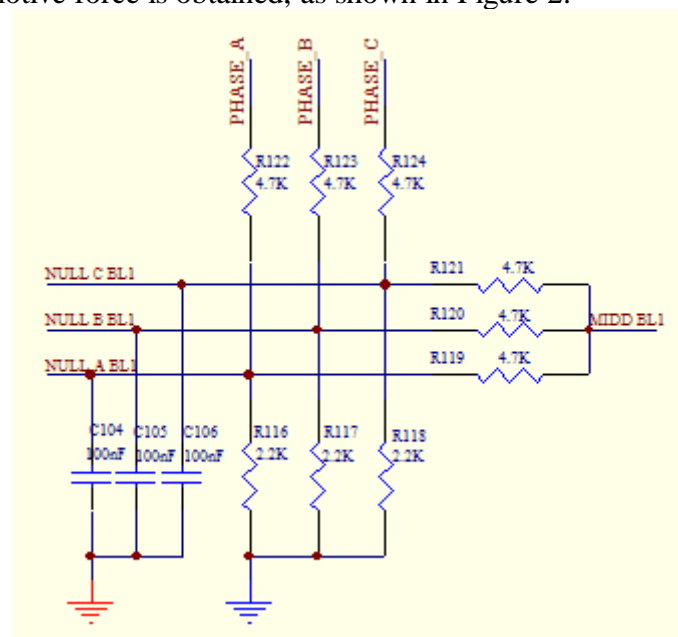

Figure 2. The zero crossing detection circuit

There is a high frequency signal and external interference in the three-phase voltage signal. The interference signal must be filtered through the filter circuit. The filter circuit is a frequency selective circuit, and its function is to pass through the appointed frequency signal and restrain the signal on the rest of the band. This design uses the RC low-pass filter circuit to filter out the occasional instantaneous high frequency components in the circuit and pass through the three-phase voltage signal at low frequency. Taking the A phase as an example, the transfer function of the RC low pass filter circuit is shown in formula (1).

$$\frac{U_A}{U_{PHA}} = \frac{R_{116}}{R_{122} + R_{116} + j2\pi f R_{122} R_{116} C_{104}}$$

(1)

$$f = \frac{1}{\frac{R_{122} R_{116}}{R_{122} + R_{116}} C_{104}}$$

(2)

Power Module Circuit. For any system, a stable and reliable power supply system is the foundation for the stable operation of the system. Especially in the aircraft system, if there is not a stable and reliable power supply system during the flight, it is easy to happen frying. In this design, three - core lithium polymer battery is used for power supply. Lithium polymer battery is widely used in the design of aircraft model because of its large capacity and light weight.

In this design, 78L05 is used for voltage conversion. 78L05 is small and the maximum output current is 500mA, and it has the functions of thermal protection and short circuit protection. Therefore, as 5V voltage conversion chip, there is a filter capacitor designed for filtering in the circuit. The power module circuit is shown in Figure 3.
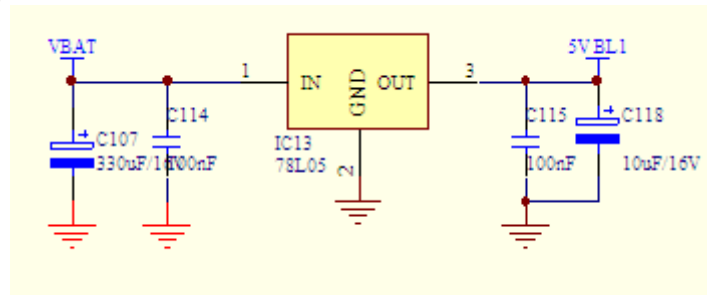

Figure 3. The power module circuit

Battery Voltage Detection Circuit. The battery voltage monitoring circuit is simple, and it plays the role of overvoltage protection, and its function is realized by software. The battery voltage monitoring circuit is shown in Figure 4. The voltage of the battery is collected through the resistor divider network, and then input to the ADC7 pin, where VBAT is connected to the cathode of the lithium polymer battery and the GND is connected to the battery negative pole. In the program, the actual voltage value of the battery is calculated according to the resistance ratio of the voltage divider. If it is lower than the lower limit voltage, the alarm indicator is issued. The capacitance C101 is used to eliminate the influence of high frequency ripple in the power supply.
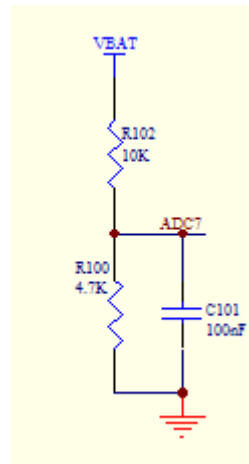
Figure 4. The battery voltage detection circuit

Summary

According to theoretical analysis and the actual demand of the motor drive system in four rotor unmanned aerial vehicle (UAV), this paper introduced the design process of motor drive unit from two aspects of hardware and software. In the term of hardware, we designed module circuits like power-driven circuit, counter electromotive force detection circuit, status indication circuit, etc. By analyzing debugging results, it shows that the motor drive system can better realize motor start up smoothly and the commutation process.

Acknowledgements

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