Computer Life (CPL) ISSN: 1819-4818
DELIVERING QUALITY SCIENCE TO THE WORLD

Hardware Design and Implementation of a Small UAV Flight Control System

Yongzhen Wang [1, a], Qingsong Lin [1, b] and Yanchang Li [1, c]

[1]College of Information Engineering, Henan University of Science and Technology, Luoyang, China

[a]hauster9211@163.com, [b]Lqs6501@163.com, [c]hongye_lyc@163.com

---

Abstract: For the UAVs characteristics of small size, light weight and high availability, design the flight control system of a small UAV. The system adopts modular design and TMS320F28335 chip is used as the core controller. And describes the hardware structure and functions of the system in detail. The experiment result shows that the flight control system can provide a reference for the design and application of small UAV with low cost and small power.
Keywords: UAV; TMS320F28335; flight control system.

---

1. INTRODUCTION

UAVs are one of the major achievements in the aviation field and were first used in the military field when they were born. In recent years, with the continuous development of drone technology, it has broad application prospects and very important practical significance in agricultural fields such as agricultural plant protection, disaster monitoring, terrain detection, film shooting, and meteorology. The flight control system of the drone (referred to as the flight control system) is one of its important subsystems. The performance of the UAV depends mainly on the performance of the flight control system [1]. The limitation of the design of the flight control system based on single-chip microcomputer is that the real-time performance of the single-chip microcomputer is poor, the computing power is weak, the storage space is small, and usually only some simple tasks can be completed. The flight control system based on PC has fast calculation speed, strong addressing capability and rich supporting resources, but the price is high and the interface capability is poor. It requires a large number of peripherals to cooperate, and it is difficult to achieve miniaturization. Aiming at the problems of the above systems, a flight control system based on TMS320F28335 was designed and developed. Digital signal processor (DSP) combines the advantages of the former two, with a rich command system, dual high (high speed and high precision) computing power and a wealth of on-chip peripheral resources, which satisfies the fly. The control system has a solid hardware foundation for the processing speed and miniaturization requirements, and provides a good platform for the development of the flight control system.

2. SYSTEM FUNCTION ANALYSIS

The UAV flight control system is one of the important subsystems of the UAV. It is mainly responsible for the flight attitude, navigation, track and automatic control of the UAV during flight. The main functions that the flight control system needs to have are: (1) signal acquisition and processing. Measuring aircraft attitude information, including real-time detection of the position, altitude, acceleration, airspeed, angular rate and other state parameters of the drone for processing and transformation; (2) outputting control signals. According to the various state parameters of the collected drones, the corresponding data processing and control rate are solved, and then the control signals generated by the processing are output to the corresponding control objects for precise control; (3) realization of the on-board Control and data connectivity for other electronic components and other extended applications.

3. THE OVERALL DESIGN OF THE FLIGHT CONTROL SYSTEM

According to the design requirements of the system and the analysis of the system functions, the system adopts a modular design to facilitate the later debugging and maintenance of the system. The flight control system is mainly composed of a central processing unit, a drive module (servo system), a sensor system, a GPS, a ground control center, and a power supply. The central processing unit is composed of TMS320F28335 chip, and realizes hardware connection with other devices through RS-485 serial port; sensor module includes gyroscope, accelerometer, magnetic heading sensor, GPS, barometric altimeter, etc.; servo system is driven by steering gear and drive for driving elevator surface The steering gear of the rudder surface, the steering gear that drives the throttle, and the steering gear that drives the aileron control surface are composed of four parts. The system thus constructed realizes the operation and stability of the flight attitude, heading and altitude of the drone [2]. The block diagram of the flight control system is shown in Figure 1.

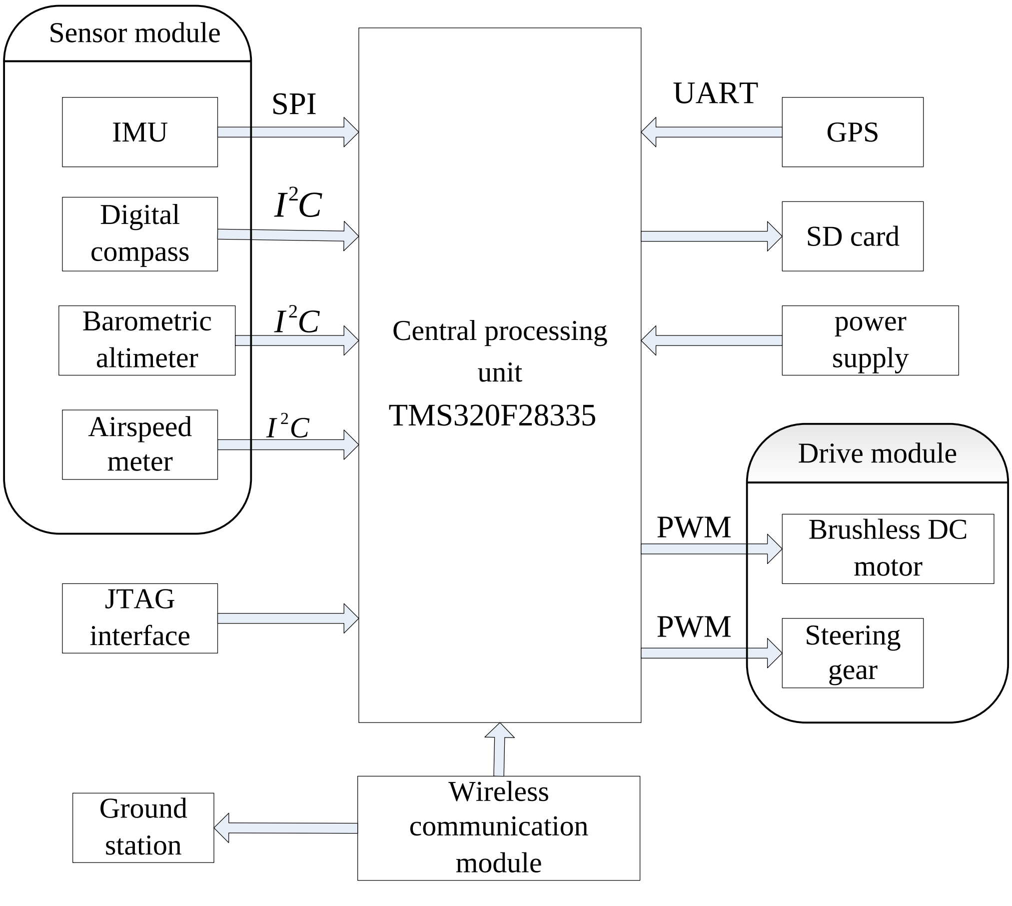

Fig. 1 Flight control system structure

The broad application of the rotary kilns in a variety of industrial branches for thermal processing of residual materials with a different origin and mostly for fire treatment of hazardous wastes [2-3]. The rotary kilns were used as rotary dryer to remove moisture and water from solid substances, primarily by introducing hot gases into a cylinder, it act as a conveying device and stirrer.

4. FLIGHT CONTROL SYSTEM

4.1 Central processing unit

In order to meet the requirements of the flight control system in terms of processing speed and miniaturization, the central processing unit needs to have both high-speed and high-precision data processing capabilities and a rich external interface. The currently widely used DSP chip is the 32-bit TSM320F2812 and TSM320F28335 produced by TI Corporation of the United States. The TSM320F2812 uses fixed-point calculation, while the TSM320F28335uses floating-point calculation. The peripheral integration is high, the data and program storage are large, the AD conversion is more accurate and faster, and there is one more MAC unit than the former. The latter has powerful digital signal processing capabilities, combined with high precision, low power, embedded control and complete event management capabilities. In addition, its rich external interface facilitates communication with peripherals. Therefore, I chose TSM320F28335 as the central processing unit of the control system.

TSM320F28335 adopts Harvard bus structure, has 32-bit floating-point processing unit, and has high-speed processing capability with working frequency of 150MHz, which ensures the fast and real-time performance of signal processing [3]. The motor control peripheral section has up to 18 PWM outputs, of which 6 are TI's unique higher precision PWM outputs (HRPWM) for connection to stepper or DC motors. The serial communication peripheral part includes UARTA programming serial port, USB to serial port and RS485, etc., which can communicate with peripherals. The storage part includes RAM: on-chip 34KB 16bit, external expansion 256KB 16bit SRAM; ROM: on-chip 256KB 16bit, external expansion 512KB 16bit NOR FLASH. The power board mainly provides power management for the entire hardware system, and a separate power system is used to reduce the heat generated by the power module. Since the F28335 only provides three serial communication interfaces, it cannot meet the communication requirements of the flight control system and multiple peripherals. Therefore, serial port expansion is required. Here, the author uses the serial port expansion chip GM8125 and 485 interface conversion chip to realize the requirements of the extended serial port. The GM8125 can simultaneously expand five standard serial interfaces to meet the communication requirements with peripherals. The hardware schematic is shown in Figure 2.

4.2 Sensor module

1) Attitude Measurement Module (IMU). The attitude measurement module is the most basic sensor unit, and its accuracy directly affects the control performance. The function of this module is to measure the attitude angle of the aircraft in real time, including the pitch angle, roll angle and heading angle. The conventional method is to measure the three-axis rotational angular velocity and the angular acceleration using a three-degree-of-freedom gyroscope and a two-axis accelerometer to obtain three attitude angles. This method has a serious zero drift phenomenon and is greatly affected by the environment [4]. Therefore, I decided to adopt the more mature inertial measurement scheme,

and choose ADI's latest ADIS 16355. This model of IMU includes a three-axis gyroscope and integrated three-axis accelerometer, providing complete three-axis inertial detection and built-in embedded processing. Sensor calibration and tuning. Its output is the angular velocity and acceleration measurements of the three axes. The module is connected to the F28335 chip via a standard digital SPI port.

2) Digital compass. The three-axis digital compass model HMC5883L is selected, which has high precision and low power consumption. By measuring the angle between the north pole and the sensor, the accurate heading angle is calculated. Connected to the F28335 chip via the IIC digital output interface.

3) Barometric altimeter. According to different measurement principles, methods for measuring the flying height of the drone include: barometric altimeter, sonar altimeter, radar altimeter and laser altimeter. The pneumatic barometer model BMP085 is selected. Its working principle is to measure the flight height by using the law of atmospheric pressure changing with altitude. The resolution of the air pressure can reach 0.03hPa, and the noise of the height (beating) is only 0.25. m, and the consumption electrode is low. Connected to the F28335 chip via the IIC digital output interface.

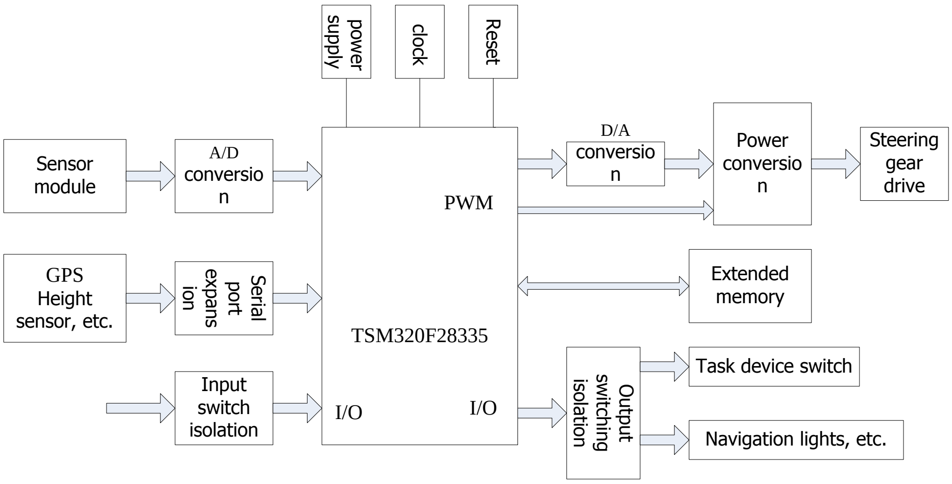

Fig. 2 F28335 Hardware schematic

4.3 Global positioning system (GPS)

The GPS module not only provides the position information (latitude/longitude) of the drone, but also provides the speed and altitude information of the drone in conjunction with the attitude measurement module. The GPS in this design uses the CJMCU-6M receiving module produced by Swiss u-blox. The sensor has the characteristics of small size, low power consumption, high reliability and fast positioning speed. It provides a serial port and a USB data interface, which can be easily connected to the main control chip, and output through the RS-232 serial port. The output is the standard NMEA0183 protocol. According to the protocol, the main control chip quickly calculates the geographic coordinates (latitude/longitude), flight speed and time of the drone [5].

4.4 Steering gear drive module

In the flight control system, the steering gear is the flying actuator, and the flight action of the drone is realized by the deflection of the steering surface driven by the steering gear. It is usually designed as a separate unit called the servo servo system [6]. The system is mainly composed of DC permanent magnet servo motor, PWM output control, reducer and potential feedback. The structure diagram is shown in Figure 2.

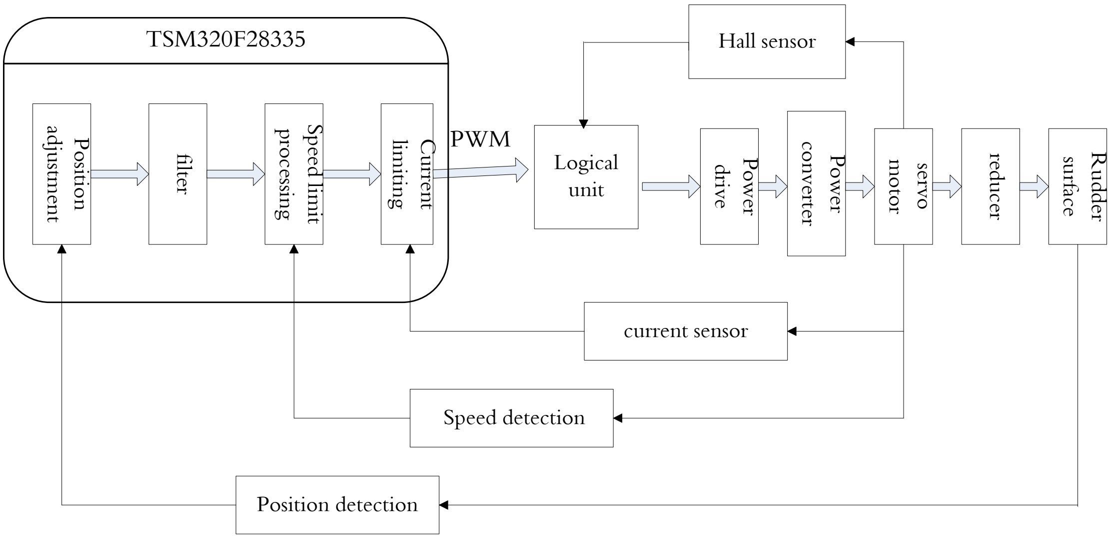

Fig. 3 Steering gear servo system block diagram

The servo actuator is mainly composed of a steering gear that drives the elevator surface, a steering gear that drives the aileron control surface, a steering gear that drives the rudder surface, and a steering gear that drives the throttle. The four servos must be synchronized during the flight and cannot be delayed. As mentioned above, the TSM320F28335 has up to 18 PWM outputs, of which 6 are TI's unique higher precision PWM outputs (HRPWM), and 4 of them can be selected to output PWM signals. The F28335 chip calculates the control amount of each rudder surface according to the control rate algorithm, sends it to the servo servo system through the I/O port, and then drives the output to the four servos, which greatly improves the real-time performance.

5. CONCLUSION

After debugging, the whole system is running stably, and the design of each module has achieved the intended purpose, which satisfies the performance indexes of modern drones and realizes small volume. The flight control system based on DSP has the characteristics of high reliability, fast calculation speed, easy operation and strong practicability, and has high integration, good real-time performance and high cost performance. The next work is mainly to use C++ for direct software development of the operating system and further improve the hardware design.

ACKNOWLEDGEMENTS

From the topic, research, and final writing and revision of the thesis, my tutor has devoted a lot of effort and helped me a lot. I would like to express my heartfelt thanks to Teacher Lin. At the same time, I would like to thank Yanchang Li for his help in this paper.

REFERENCES

[1] Jianwei Gao, Jingchao Lu, Jianguo Yan. Design and Simulation of a UAV Navigation/Flight Control System[J]. Journal of Computer Measurement and Control, 2006, 14(6): 759-761.
[2] Liu Yan. Research on UAV flight control system based on DSP [D]. Chongqing University, 2014.
[3] Jiwei Du, Zhang Zhen. Hardware Design of Small UAV Flight Control System[J]. Ordnance Industry Automation, 2014(9): 64-67.
[4] Yuanxuan Chen, Hailong Qi, Chen Yong. Hardware Design and Implementation of Small UAV Flight Control System[J]. Computer Engineering and Design, 2010, 31(10): 2159-2162.
[5] Jia Jie, Huanqiang Chen. Hardware design of UAV flight control system based on DSP[J]. Journal of

Automation, 2015(8): 79-80.
[6] Yinze Wang, Xunbo Li. Simulation and Analysis of Servo System of Unmanned Electric Steering Gear[J]. Mechanical Research and Application, 2010(5): 36-38.