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Design of UAV Flight Control System

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Abstract: *In order to improve the control performance of UAV. For a small UAV, the hardware design scheme of UAV flight control computer with STM32 as the processing core is proposed and implemented. The overall scheme design, specific hardware selection and interface design of the system are given in detail. STM32, as the main controller, expands the parallel A/D, D/A, asynchronous serial communication interface and memory around, enriches the system hardware interface resources, and selects the peripheral expansion circuit with complex programmable logic controller (CPID) to realize interrupt control. This flight control computer has the characteristics of small volume and strong autonomous navigation ability.*

Keywords: *UAV Modularization, Flight Control Computer*

1. Hardware Design of Flight Control Computer

The flight controller of UAV generally consists of main control module, signal receiving and complex flight control system. It has port modules such as autonomous navigation, operation and storage [1], communication module and driving module of several actuators. Although the core function of the controller is powerful, it has large volume, high power consumption and high price. Users and developers are the main control module. The function and interface of this module are possible while determining the high-performance and high-cost computer to be used as the control system of UAV. The main control module shall meet the following requirements in the active exploration and development of flight control computer with small volume, low power consumption and moderate price:

(1) It has the high-precision acquisition ability of multiple analog signals. For the three-axis angle digital signal processing device, it has the advantages of rich command system, angular velocity signal output by high-speed and high-precision speed gyro sensor, aircraft attitude calculation ability output by heavy vertical gyro and rich internal and external equipment resources. It has strong real-time signal and is easy to form analog signals such as engine speed, humidity and power supply voltage, with high precision Stronger autonomous navigation capability, miniaturization and low-cost flight control computer for acquisition and processing are the first choice of this project [2].

(2) With multiple analog signals, PWM pulses and other control signals output to STM32 core interpretation; it can meet the control requirements of accelerator, rudder and other actuators, so as to meet the requirements of low power consumption.

(3) It includes a plurality of communication interfaces, which can communicate wirelessly with GPS conventional system. It is specially based on the controlled electric altimeter system, remote control / rapid measurement system, ground detection and other systems for communication. The maximum running speed designed for application can reach 40mps.

(4) It has timer, "watchdog", power monitoring ability and data power-off protection ability, and has large program storage space to meet the development of complex control software. 25bs (40MHz) refers to improving the bus structure of Harvard University and greatly improving the running speed of UAV. It usually refers to the strong unmanned processing ability through wireless control or controlled by its own program, which is easy to realize the real-time performance of the system. The 2400A integrates many manipulators. In the early 1960s, the United States first used unmanned aerial vehicles for internal and external settings in the army. 16 channel 10 bit a/D converter: including the investigation of the local network of the controller. With the development of society, UAV has obtained (can) modules in military and civil fields: communication interface (SC) module; The 16 bit serial

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external has been greatly applied (SP1) interface module: up to 40 general I/O guidance modules that can be programmed and reused separately. The traditional UAV flight control system is mainly based on micro single machine or industrial performance pin: 5 external interrupts: powerful computers such as watchdog timing module (WDT). The former has weak computing power and small storage space, The UAV that can be used in the seat usually refers to the unmanned aircraft controlled by wireless remote control or according to its own program.

STM32 Series MCU is an open software and hardware development platform, and has an open source development environment and IDE. It can easily read and process the digital or analog signals of external systems (switches, sensors and other components or modules) through digital I/O port, ADC and other methods [3]. It can also output control signals and realize communication with PC through serial port. Combined with flash, processing and other software on the computer, it can realize rich functions such as communication and interaction between upper and lower computers. It can realize the rapid development of the flight control system and the generalization of the flight control system, which can realize the rapid and convenient transplantation from the flight control system of small four-axis aircraft to large and multi axis aircraft.

2. Hardware Design of Computer

The flight control device of UAV consists of main control module, signal adjustment and interface module, communication module and driving module of multiple actuators. The core of the controller is the main control module. The function and interface of the module determine the performance of the flight control computer. The main control module must meet the following requirements.

(1) It can collect and process high-precision analog signals such as multi analog signals, angular velocity signal output from triangular velocity gyroscope sensor, aircraft attitude signal output from vertical gyroscope, engine speed, temperature, power supply voltage and soon.

(2) It has the ability to output multiple analog signals, PWM pulses and other control signals in response to the control request of acceleration, rudder and other actuators.

(3) There are multiple communication interfaces, which can communicate with GPS conventional system, wireless altimeter system, remote control / remote measurement system, ground detection and other systems.

(4) It has timer, "watchdog", power monitoring ability and data power-off protection ability, and has large program storage space to meet the development of complex control software.

(5) The ability to have multiple discrete input and output interfaces.

2.1 Memory Expansion

A 32K word fIash program memory is built in STM32 chip. In order to develop the program code for many times, it can be used for many times in the form of program or electric elimination. In addition, the STM32 table also has 2.5k word data / program ram, 544 word dual port RAM and 2K word single port RAM, but these storage spaces are small, so the data memory of the system must be expanded. In addition, for aircraft for important data, such as anti-static requirements for aircraft posture and position information, the system uses 64K nvSRAM as data expansion memory. Discharge and low voltage can automatically protect data. Due to the slow reading and writing speed of NVRAM, standby states need to be inserted during bus access, and up to 7 standby states can be inserted.

2.2 Control Logic Design

When exchanging data with the peripheral equipment extended to the system, it is necessary to screen the components. If the data and address bus do not form a reasonable timing combination according to the predetermined control logic, it will not work normally. Although complex programmable logic device cpd is used in this system to meet the needs of multi control logic, CPID is generally surrounded by programmable logic macro unit and central programmable interconnection matrix unit. The designed control logic circuit program can be dynamically downloaded to CPID chip online through JTAG cable, and the hardware debugging can be carried out very easily.

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2.3 Analog Signal Collection

STM32 chip has 16 analog input channels, but its 10 bit conversion accuracy can not meet the requirements of several high-precision analog signals in the flight control system. In the system, the chip 8-channel 12 bit high-resolution parallel interface a / D converter MAX197 is extended. As a data bus, MAX197 contains three state data I/0 port, with high-precision reference voltage source, clock circuit and sample and hold. Since MAX197 uses an 8-bit 3-state data 1/0 port of the standard microprocessor interface unit, the data bus is 8 + 4 bus multiplexing mode.

2.4 Rudder and Throttle Drive

The control modes of rudder and throttle include analog control and PWM control. Here, the control of PWM mode can be provided by the PWM output circuit of 2407a. In 2407a[4], there are two event manager (EV) modules, which can generate 8 PWM outputs, including 6 ways generated by the comparison unit and 2 ways generated by two general programmable timers, which can fully meet the control requirements of steering gear and oil span. The control signal of motor actuator is realized by DA converter. In this system, a 4-channel 12 bit DA converter dac7625 is extended to meet the control of multiplexer and accelerator.

2.5 Serial Communication

STM32 cannot meet the communication request between the air control system including serial communication interface (SCD) and multiple foreign devices, so a tl16c 554A is selected for serial port expansion. TL 16c554a can be easily extended to four serial ports, which are four channel extended asynchronous communication components. It includes programmable baud rate generator, which can reach the maximum baud rate of 1Mbps, and it is easy to flexibly select the data transmission and reception frequency. Each channel comes from the peripheral equipment to monitor the execution of various commands and errors, so that M can query the status of each channel; Before transmission and reception in FIFO mode, buffer the data in 16 byte data packet; Reduce the number of CPU interrupts and improve the efficiency of the system. Its 3-state output provides FTI driving capability to the bidirectional data bus and control bus, and its output level is compatible with 2407a. Try to use patch components to improve the integration of the system; In order to effectively reduce parasitic inductance and noise radiation, PCB wiring not only thickens the grounding wire and power line as much as possible, but also forms "full grounding" by grounding all the area occupied on the circuit board with copper. In addition, it also separates digital grounding and analog grounding, and finally realizes single point connection through inductance to improve the stability of the system. The main controller LF2407A can access the program through JTAG, and can realize real-time online simulation debugging through software simulator. The following points are noted in hardware debugging.

(1) The programming adopts mixed programming: the algorithm is complex, the amount of calculation is large, the language is used, there are many hardware interface controls, and the assembly language is used.

(2) During cpd debugging, debug each module, simulate the matching results of each module, and verify that the simulation results meet the requirements

2.6 Power Monitoring and Reset

The core power supply voltage required by STM32 and the relatively stable 3.3V of I/O power supply request use tps76833 chip as the power supply chip. TPS 76833 chip is a low-voltage drop power regulator, which can obtain 3.3V voltage from 5V input voltage, provide the maximum 1A current, and fully meet the power supply request of 2407a and other 3.3V voltage chips in the system. Tps76833 has a built-in voltage monitoring module, which generates a low level in case of output voltage shortage, After the voltage deficiency state is completed, it becomes a high level after a low level delay of 200ms. This low level can be reset as the power supply voltage. In addition, in order to facilitate debugging, manual reset is set in the system. After the two reset signals are decoded by CPLD, two reset signals of low level and high level are output to reset the components with different requests for reset level.

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2.7 Switching Value Control

STM32 can control multiple switching volume requests in the system by changing or reading the status of peripheral switching volume signals using these I/O ports with 41 common and bidirectional digital I/O (GPIO) pins. In the input and output channels of switching value, it is necessary to set separation elements to suppress the influence of interference. In this system, the input of switching value is separated through optical coupling and solid relay to drive the output number of switching value.

3. Hardware Implementation and Debugging

In order to reduce the volume and weight of the system, the I0 pin used when manufacturing the system PCB must not be grounded. For example, grounding may damage the equipment, and the suspension method is adopted in the design and use.

(1) The reference voltage of DAC 7625 has high precision and appropriate bypass capacity. In operation mode, when the output voltage approaches zero, the establishment time becomes longer. In addition, the maximum reference voltage must be 1.25V higher than the minimum reference voltage [5].

(2) When MAX197 is turned on, the internal power circuit sets int to high level and sets the equipment to normal action/external clock mode. In unipolar mode, MAX197 output data is binary number. Binary complement is output in bipolar mode.

(3) During serial port debugging, tll6c554 can work in query mode, but it can reduce system performance, and can work in interrupt mode to achieve high-speed communication

4. Conclusions

After debugging, each module of the system meets the design requirements, and the overall operation of the system is stable. The design scheme of external logic expansion is realized by using DSP chip as the processing core and CPI, which improves the overall integration, stability and real-time performance of the flight control system, and enhances the overall performance of the UAV. At present, the control computer circuit has been preliminarily designed and debugged by the Institute. The following work is to write the control system software to gradually improve the hardware design of the control computer and the performance of its related interfaces.

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