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Introduction to The Implementation Principle of A UAV Inspection Method Based on ADRC Control Mode

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Abstract: With the development of the economy and the requirements of all walks of life, the use of unmanned aerial vehicle inspection for operations has become inevitable, some by manpower can not be completed or more difficult, inefficient work by the UAV inspection has great advantages and better economic benefits. This article introduces a basic method to achieve UAV inspection, due to the limitations of conditions, only the relevant principles and implementation methods are introduced.

Keywords: UAV inspection, PID algorithm, ADRC control mode, Kalman filtering.

1. The Significance of The Question and The Research

With the development of the economy, the progress of science and technology, all walks of life on the convenience of inspection work, speed, safety and other aspects have higher requirements, UAV inspection methods can meet the requirements and have been developed rapidly, the use of UAV inspection for operation has been essential, some by manpower can not be completed or more difficult, inefficient work by the UAV inspection has great advantages and better economic benefits. The use of unmanned aerial vehicles to patrol can avoid omissions in manual inspections; Take advantage of the mobility and flexibility of unmanned aerial vehicles to enter pipeline occupancy and illegal construction areas for inspection, effectively avoid patrol blind areas, and expand law enforcement authority; The inspection results are more objective and true, and can be repeatedly queried, and the results can be traced, which can effectively avoid disputes and disputes; Provide real and objective on-site images for rapid and effective rescue work, and provide data support for guiding decision-making; Can provide true, objective and effective inspection report for safety and environmental protection work; Improve the level of automation and informatization of enterprise production, and promote the safe and stable operation of target pipelines.

2. The Realization of Autonomous Flight of Unmanned Aerial Vehicles

Use the C language to complete the basic program development of the UAV line patrol

Design routes and schemes for patrolling the line:

With a programmable OpenMV camera, logic applications can be implemented via the MicroPython language. And the camera itself has some built-in image processing algorithms, we can run machine vision algorithms on what OpenMV sees, in order to patrol and store photos in a short period of time. Zonal line patrol mode: The actual flight trajectory of the line patrol robot is fed back to the flight controller at the points in each area and the yaw angle of the cable to achieve the purpose of line patrol.

The structure of the line-patrol robot belongs to the X-shaped distribution. That is, the propellers 1 and 4 and 2 and 3 are symmetrical with respect to the X axis, and the propellers 1 and 2 with 3 and 4 with respect to the Y axis symmetry are shown in Figure 1:

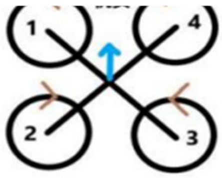

Figure 1. X-shaped structure distribution

The following two groups of solutions were discussed and demonstrated:

Scheme one: The PID algorithm is to form a control quantity by linear combination of the proportion, integral and differential of the deviation, and use this control amount to control the controlled object. However, PID is sensitive to environmental changes, the robot's propeller is subjected to strong compressed air resistance when rotating at high speed, and the force of PID must be very large to maintain a stable speed, but when it is at low speed, the air resistance is very small, and under the force of PID, the propeller will vibrate and be unstable.

Scheme two: ADRC control mode, inheriting the essence of the classic PID controller, there is almost no requirement for the mathematical model of the controlled object, and on its basis, the state observer technology based on modern control theory is introduced, the anti-interference technology is integrated into the traditional PID control, and finally a new controller suitable for wide application in engineering practice is finally designed. [1] While conventional PID control waits until errors occur before compensating for control, ADRC compensates for observed disturbances to the output in the first place. ADRC has a strong advantage over traditional PID controllers in the control performance of the system when it is anti-interference and the model parameters are changed.

Combine the above two schemes and select Scheme 2.

3. Control System Hardware Design

The line-patrol UAV consists of a quadcopter and a detection and identification module. The suitable brushless motor was selected as the system power unit, and the powerful and easy-to-develop TM4C123GH6PMI microcontroller was selected as the main controller, and the four-rotor Euler angle data was collected by the six-axis acceleration gyroscope ICM20602. The design uses SPL06 barometric pressure sensor and laser ranging module GY-53L1 for UAV flight altitude measurement; At the same time, the design uses an optical flow sensor to quickly detect horizontal movement. Designed to use OpenMV, a programmable microcontroller camera with image processing capabilities.

Flight controller integrated board schematic description:

(1) Power supply part:

①The power supply is provided by a 11.1~12.6V lithium battery, which powers the four ESC, and the power supply is stabilized by the voltage regulator module to 5V to power the flight controller and the expansion

board, which can meet the power requirements of each small system. By using LDO regulators: TPS7333, ADP150, pw6566, each consumer is powered by 3.3V.

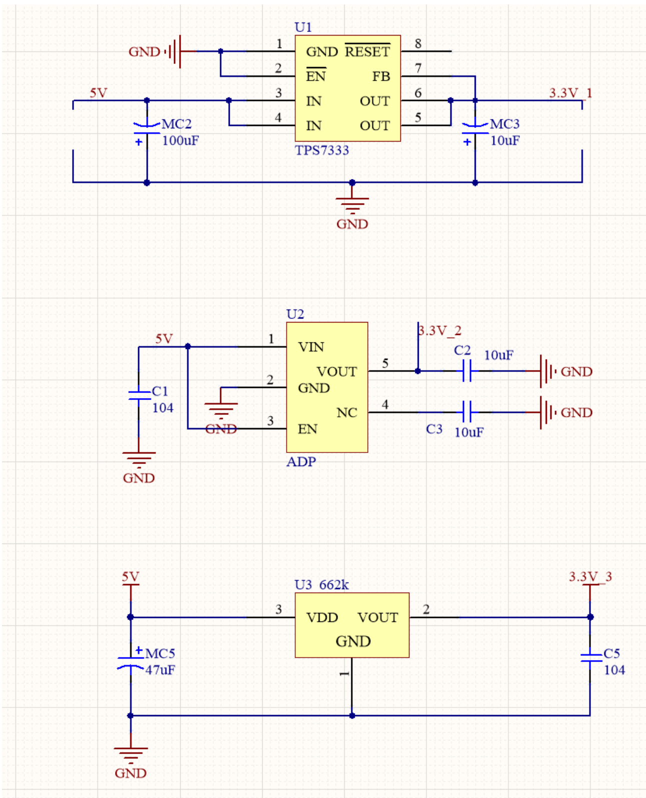

Figure 2. Power supply part

②Power supply voltage detection: Input voltage detection by connecting a microcontroller ADC for voltage sampling

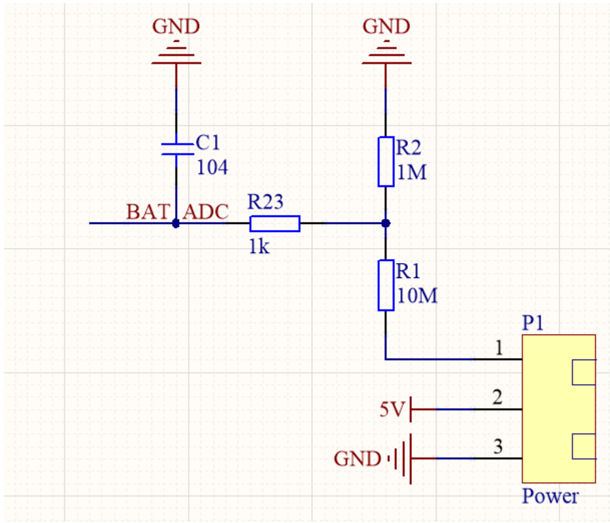

Figure 3. Power supply voltage detection

(2) Flight controller chip: TM4C123

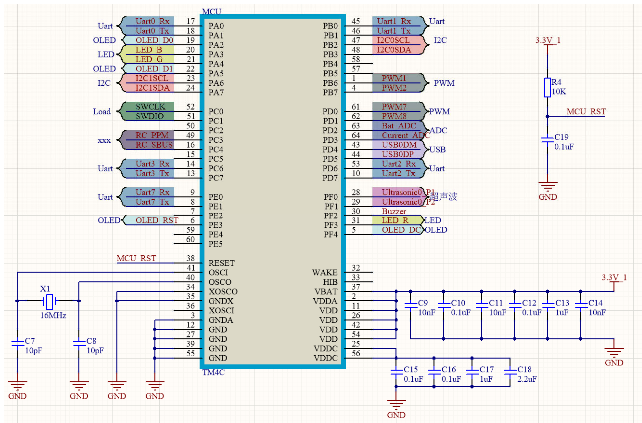

Figure 4. Flight controller chip: TM4C123

(3) Receiver interaction part:

The RC_PPM generated by the microcontroller interacts with the RC_SBUS signal and receiver

Among them, the S-BUS serial port communication protocol is reversed, so an NPN transistor is used for reverse action

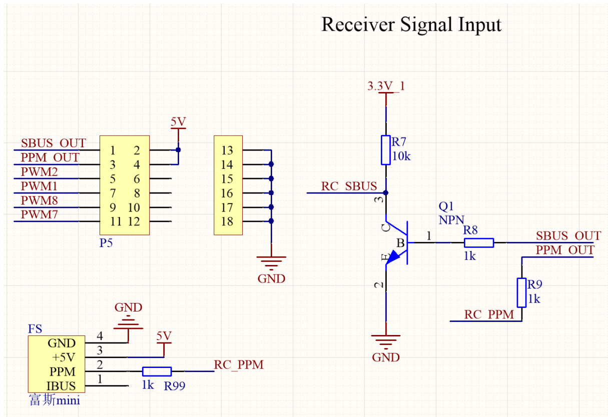

Figure 5. Receiver interaction part

(4) Serial port part:

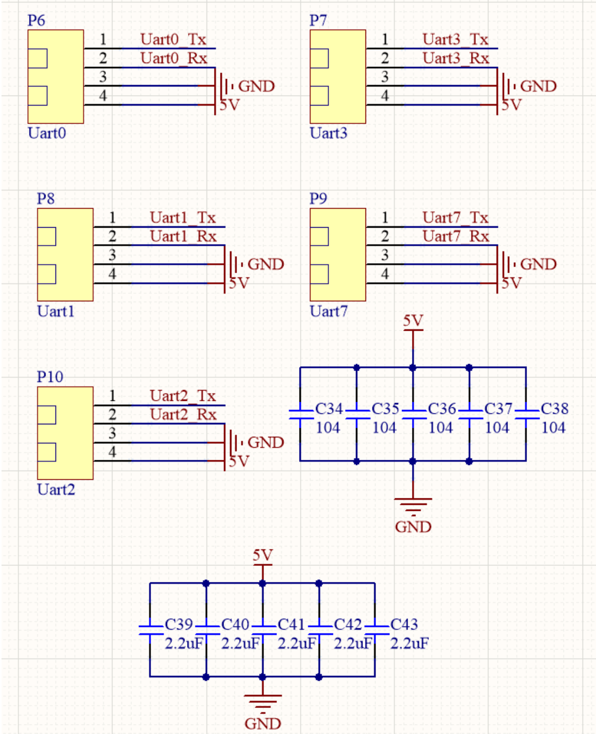

Figure 6. Serial port part

(5) Six-axis gyroscope: ICM20602

Measurements of triaxial angles and triaxial acceleration are performed

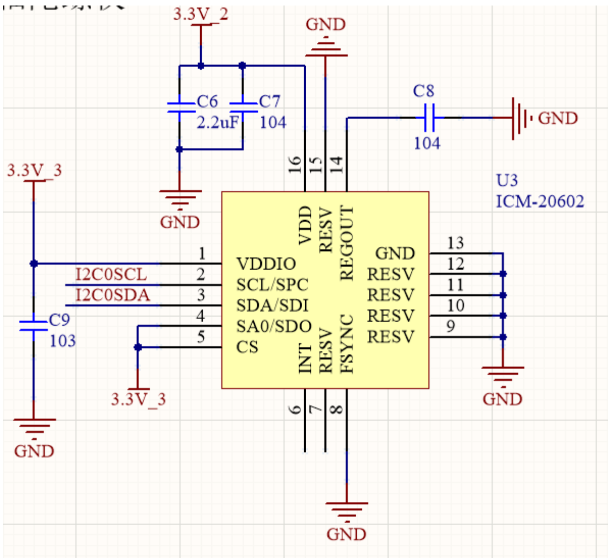

Figure 7. Six-axis gyroscope: ICM20602

(6) Geomagnetic sensor: IST8310

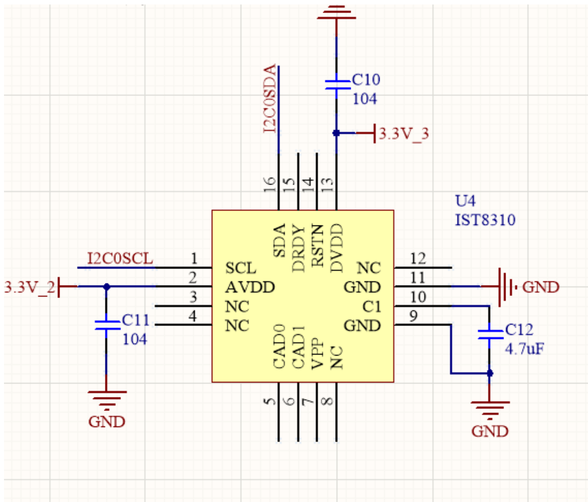

Figure 8. Geomagnetic sensor

Sensing geomagnetism, measuring the Earth's magnetic field, and compensating for rest through absolute pointing

(7) Barometer: SPL06

The height of the drone is determined by measuring the change in air pressure

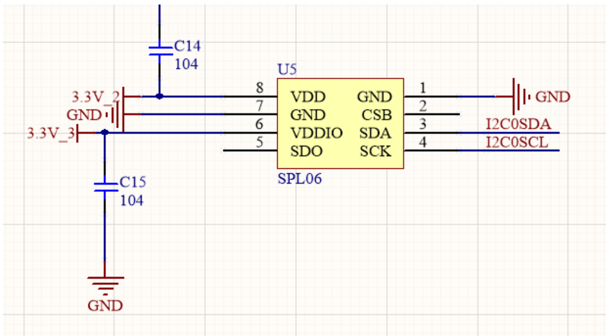

Figure 9. Barometer: SPL06

(8) Ultrasonic module:

The altitude is measured by ultrasonic waves and the ground are measured back and forth, and the altitude is determined by the drone in combination with a barometer

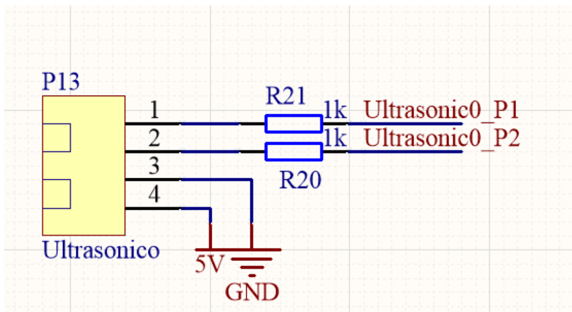

Figure 10. Ultrasonic module

(9) Indicator module: Specific indications are made for power supply and some microcontroller part pins through LED lights

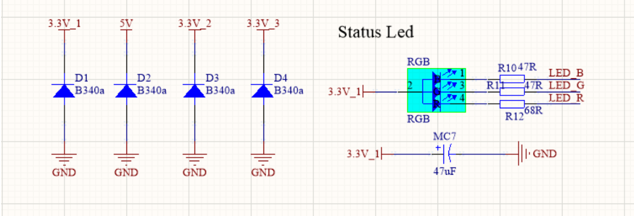

Figure 11. Indicator module

(10) Other electrical appliances:

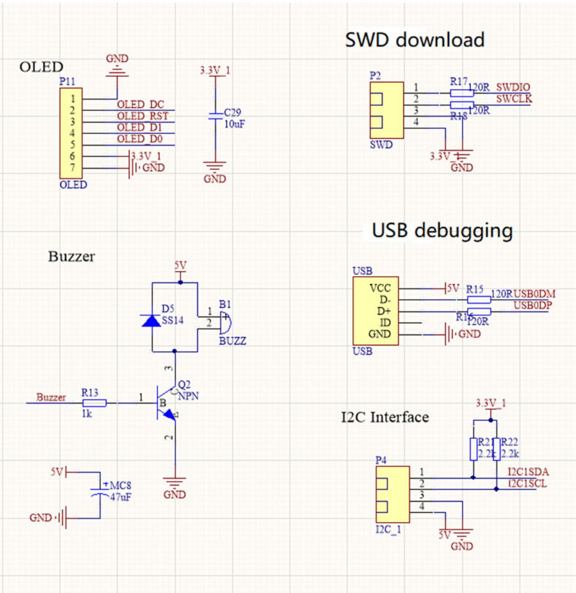

Figure 12. Other electrical appliances

4. Flight Control Module

This section is at the heart of the control system. It processes the data collected by the sensor and the attitude information of the aircraft in real time in each control cycle, completes the ADRC control algorithm, obtains the attitude and position information of the quadcopter, calculates the control amount, and converts it into the corresponding control signal to drive the four motors to work, maintaining the stable flight of the quadcopter. [2]

5. Control of Brushless Motor

(1) Advantages: Brushless motor is a device that indirectly controls the speed by the ESC, which has the advantages of small size, light weight and large torque. Moreover, escotone-controlled brushless motors have the advantages of fast response and high control accuracy.

(2) The 12V lithium battery powers the four ESC, and the ESC three-phase wire is connected to the brushless motor

(3) The line led by the main control board:

①5V ②GND ③pwm

6. Signal Filtering Method

In UAV control, there are many interference signals, so it is important to take an effective filtering method. In this study, the Kalman filter method was used. As a state-optimal estimation algorithm, Kalman filtering uses observational measurements and combined with the system's model to estimate the state of a system. The purpose of Kalman filtering is to use The Kalman gain to correct the state prediction, and the Kalman filter estimates the process state using a feedback control method: the filter estimates the state of the process at a certain point in time, and then obtains feedback in the form of a measurement variable. The Kalman filter can therefore be divided into two parts: the time update equation and the measurement update equation. The time update equation is responsible for estimating the current state variable and the error covariance estimate forward in time to construct a priori estimates for the next time state. The measurement update equation is responsible for feedback, that is, it combines the prior estimate with the new measurement variable to construct an improved posterior estimate. [3]

7. Conclusions and Prospects

7.1. Conclusion

The thesis study analyzes the following points:

1. The implementation scheme of different UAV inspections is compared and analyzed and the optimal scheme is selected

2. Control method and the function and schematic diagram of each part of the hardware

3. Reasons and advantages of choosing Kalman filtering algorithm.

7.2. Prospect

In recent years, with the development of UAV technology, data processing technology, software technology and in-depth application in the field of inspection, as far as the power industry is concerned, the power grid has formed an intelligent inspection business model of "helicopter / UAV line patrol + lidar scanning + data processing analysis + data application and visual display", which can effectively reduce labor intensity, improve inspection efficiency, expand coverage, and digitally display inspection results, which is of great significance for improving the safety, stability and operational efficiency of power grid operation. However, in the actual UAV power inspection process, there are still many problems, such as: the amount of data collected in a single time is limited, the collection effectiveness is low, and the large amount of information captured in the front end is mostly invalid information. I believe that with the development and improvement of related technologies, UAV inspection will become more efficient and have a broader application space.

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