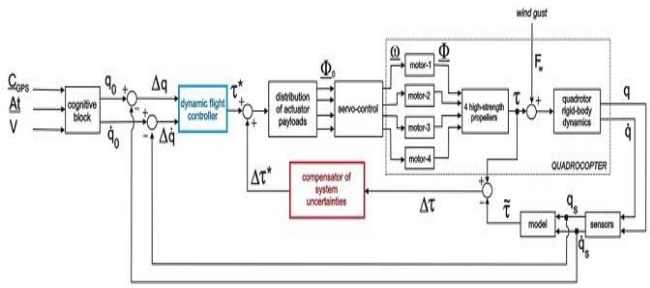
Introduction to Quadrotor Test Solution



The Quadrotor System Block Diagram

The flying controller debugging process by Oscilloscope

There are many comprehensive applications for Multi-rotor aircraft around worldwide in recent years, like the landscape video taking, the inspection of power transmission, safety defense and monitoring. Multi-rotor aircraft also become a hotspot of new business opportunity, it attracted more for experts, SOHO players and high school groups of teachers and students. Thus, the components of Multi-rotor aircraft testing become more important and the debug efficiency for each point will be the key factor during design and manufacture process. We will introduce several key parts of Quadrotor components testing in this article.

Flying control testing

The usage of flying control board is to receive the control signals from receiver side and transfer to gyro-speed information of four rotors. It implements the fast adjusting for flying state trough the gyroscope inside the aircraft control board, and control the balance state of the aircraft. For example, if we want to sustain the aircraft without moving in the air, the quadrotor will control the gyro-speed of four rotor engines and keep it balanced in the air continuously.

Flying control is the core controlled part of Quadrotor. It need more accurate controlled index by several bus communications inside. It usually spends more over than 90% debugging period for flying control of equipment assembly. So we can use test equipment to verify the performance and increase the debugging efficiency in advance.

The flying control testing package can be referred as below contents:

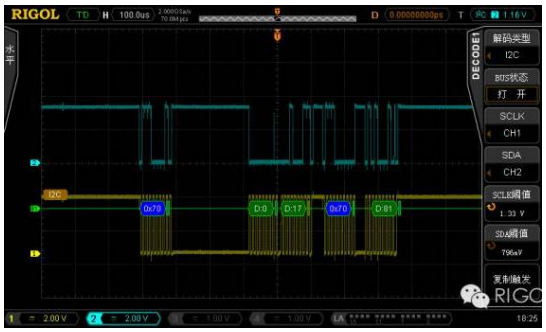
I2C Bus Testing:

The flying control board uses serial bus to communicate with other components inside the aircraft. For example, the height ultrasonic sensor module will send the information to flying control board timely, and the optical module will also feed the position information back to flying control board and keep the stuff on the right position. These communications will be adapted by I2C serial bus. The transmitted commands can be

verified by Digital Oscilloscope during debugging process, it will expedite to make sure and communication quality and what the corrected information send back during the data transmission.

I2C（Inter—Integrated Circuit serial bus is a kind of standard which is used in micro-electronic communication area comprehensively. It combines Serial Data lane and Serial Clock lane and supports up to 7bits or 10bits address mode. The I2C serial bus has three different kinds of transmission speed, the normal mode is 100Kbps, the fast mode is 400Kbps and the high speed mode is 3.4Mbps. It will be satisfied with 8bits to send to each word on SDA bus lane, the words quantity has no limitation on each transmission segment. Each transmission data will follow a proper response, the MSB is the high level address which is to be transmitted firstly.

I2C Initiative information: When the SCL is high, SDA is transferred from high to low.



The decoding information of Ultra-Sonic positioning

I2C Stop State: When the SCL is high, SDA is transferred from low to high.

The 9th bit is the ACK response from master device. The transmitter will generate a response at the last word data and the receiver end should be acknowledged as well. We can observe the I2C bus signal and decoding status through oscilloscope and well know the turning back information of height.

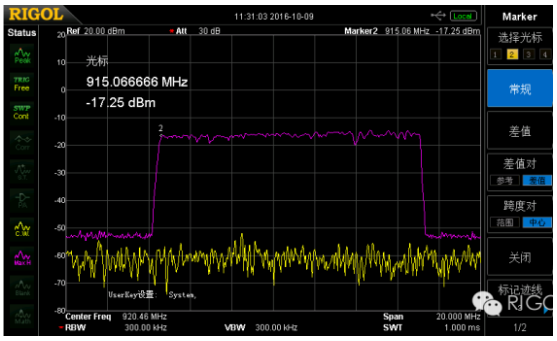
RS232 Serial Bus

The decoding information of optical positioning

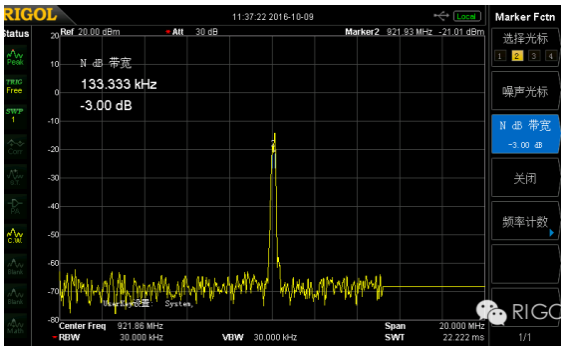
The other communication standard is still used by serial bus, like the RS232 standard that is used between Ultra-Sonic control boards and modules.

RS232 is a very popular communication standard recently. The transmission speed is 50, 75, 100, 150, 300, 600, 1200, 2400, 4800, 9600, 19200bit/sec and is usually used by 9 or 25pins inside the circuit. The RS232 of industrial control usually uses RXD, TXD and GND three lines and the transmission structure is as below:

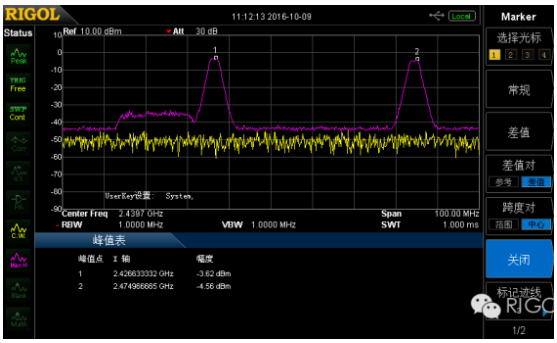
- One initiative bit.
- 7 or 8 data bits in each word data.



The transmission mechanism of Quadrotor control system



The Occupied Bandwidth of transmission system



- Arbitrary even/odd bits
- 1 or 2 restricted bits.
- It is different from other bus and adapts the negative logic. (The high level is logic “0”, and the low level is logic “1”)

We can check the communication qualities between Ultra-Sonic height positioning module and control circuit by using oscilloscope. The control circuit will send the commands to height positioning module timely, and then the height positioning module will send back the height value to control circuit and analyze in advance. So it can be verified if the correspondent height value or trigger information is corrected or not by RS232 Tx and Rx decoding status.

S-Bus

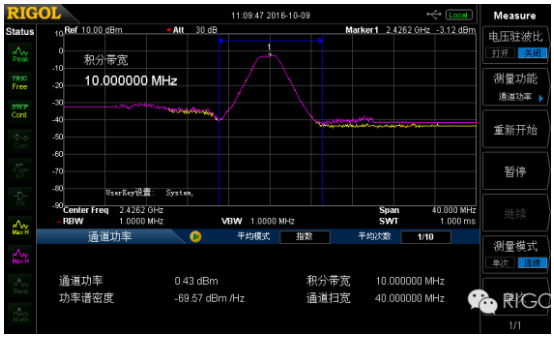
S-Bus is a protocol standard used by FUTABA. It is actually serial bus communication. It mainly used between the receiver remote controller and flying control system. The allocation of the serial bus is 100kbps Baud Rate, 8 bits data, even detection, 2bits stop bit and without flow control. The data interval is 14ms (analog mode) or 7ms (high Speed mode). 25 words for each data, the sequence is as below:

The starting byte is 11110000b (0XF0), but actually it gets the 0X0F value by STM32. The 22 bytes in the middle are 16 channels data. DATA1 is lower 8 bits of CH1, the lower 3 bits of DATA2 is the higher 3 bits of CH1, the higher 5 bits of DATA2 is the lower 5 bits of CH2, the lower 6 bits of DATA3 is the higher 6 bits of CH2 etc.

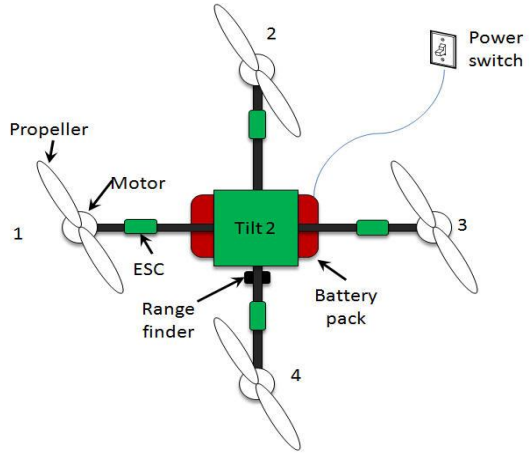
It can be positioned the control information by using decoding function of oscilloscope.

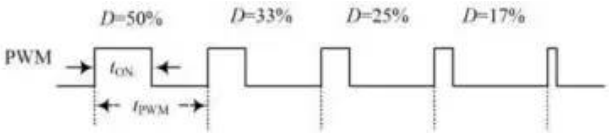
The Data Communication

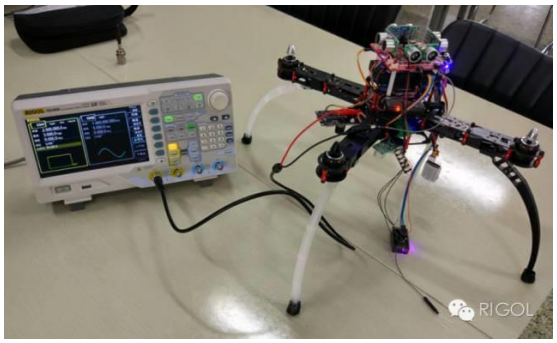
The Quadrotor will transmit the parameters of flying status to APP control terminal by wireless signal timely. Besides, some aircraft equipped with Video camera will also send the picture files through wireless signals. So it and flying distance by the quadrotor and can be measured by matched antenna with spectrum analyzer.



The channel power of remote controller testing







Remote Controller

There are three testing parts for remote controller of quadrotor:

- The frequency of wireless signal
- Occupied bandwidth
- Transmission Power

The signal quality of remote controller will impact the handling of quadrotor. So we need to do some parameters testing like the signal frequency stability, deviation, occupied bandwidth, and channel power during design and debugging procedures, it can make sure the signal quality of remote controller and the problem positioning.

This verification can be implemented by spectrum analyzer with frequency matched antenna.

The occupied bandwidth of remote controller testing can make sure if there is any interference or crosstalk under different signal channels. We can also make sure the power dissipation status by signal channel power.

Electrical Testing

There are several testing parameters for electrical testing as below:

- PWM Speed adjusting.
- Stability

The gyro speed of the Multi-rotor aircraft engine will impact the flying stability. Because the torque of brushless DC motor is large, the range of adjusting speed is wide, the volume is small, the noise is tiny, these are the key factors the multi-rotor aircraft used for firstly. The adjusting speed of electrical engine uses the control circuit to conduct the switching time accordingly. The adjusting speed of Multi-rotor aircraft uses the 3-phase full bridge circuitry to realize the duty cycle ratio of the signals, the signals include PWM, PPM and PCM.

We can use function generator to generate the duty cycle and speed adjustable PWM waveform and measure the adjustable range and speed stability of electrical engine.