ArduMing Reference Manual

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1 Remote Control

RC transmitters are the first most important part that used to control the movement and orientation of the quadcopter. There are four essential control signals - throttle, pitch, roll and yaw that are applied for controlling the quadcopter. Each of these control signals are mapped to the transmitter - WFT06X-A, and the receiver - WFR06S are connecting to the core of the quadcopter - APM 2.5.

1.1 Radio Control System

1.1.1 WFT06X-A

WFT06X-A is a 6 channels radio control system which has function of both airplane and helicopter, and emphasizes more on airplane[7]. And this is the main remote control system Arduming used.

1.1.2 WFT06X-A Transmitter

As shown in Fig. 1.

1.1.3 WFR06S 6 Channel Receiver

As shown in Fig. 2.

1.1.4 Code Matching

The fisrt thing we need to do is matching the transmitter and receiver. The code matching step is as follows[7].

1. Receiver
   Press Set to Start the receiver or press SET and hold. The orange LED flashes, indicating the receiver waits for the code matching signal.

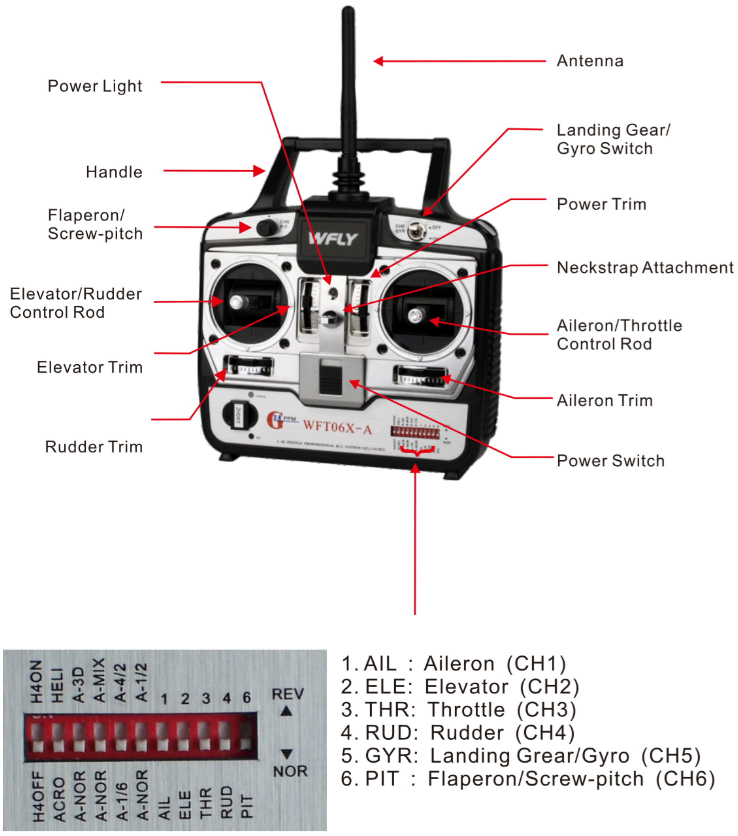

Figure 1: WFT06X-A Transmitter

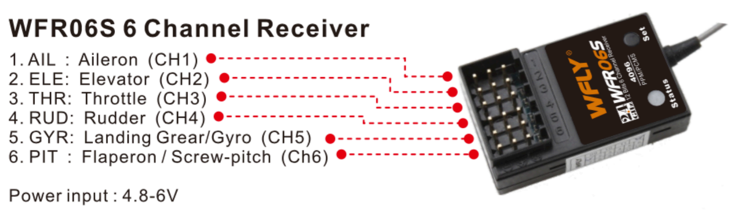

Figure 2: WFR06S 6 Channel Receiver

2. Transmitter
   Press and hold set of the module then start the transmitter. Press set again to enter the code matching function. The orange LED of the receiver lights up. Press Power and hold until the function. The orange LED of the receiver lights up. Press Power and hold until the orange LED flashes, indicating the receiver enters the code matching status.
3. Code Matching Successfully
   If the code matches successfully, the green LED of the transmitter lights up. The LED of receiver is off.

1.2 PPM Format

A complete PPM-Frame has a length of 22.5 ms. It exists of an overlong start information and 8 channel information. A stop information with 0.3 ms follows on every channel impulse. The length of a channel impulse ranges from 0.7 ms to 1.7 ms and corresponds to the stick position. Consequently, the illustration shows a transmitter with full amplitude right in channel 1, channel 2 on full amplitude left, channel 3 on middle. At last, the start impulse supplements the 8 channel impulses, so that the total length of 22.5 ms emerges[1], as shown in Fig. 3.

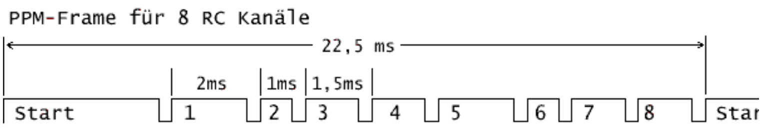

Figure 3: PPM Format

1.3 PPM Decoding

How to decode the PPM-Frame is the key for mapping the position of the sticks of the transmitter to the specific control signals such as throttle, pitch, roll, yaw or the signals of the other 2 channels - CH5 and CH6. The corresonding channels are as shown in Fig. 4.

1.4 Codes Anatomy

The Remote related codes are all in file named rc.ino. The ICR interrupt vector uses the Timer5 interrupt capture ability to capture the time length of each High/Low level of the PPM-Frames.

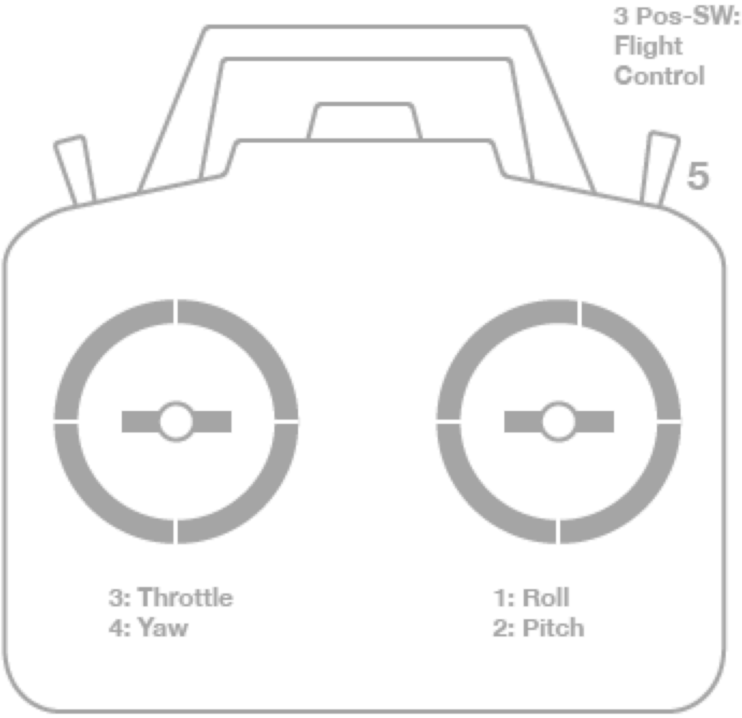

Figure 4: The channels

```
/* ICR interrupt vector */
ISR(TIMER5_CAPT_vect) {
  TCNT5 = 0; // reset the counter
  if (gate)
  {
    if (ICR5 > 20000)
      save = 1;
    if (save == 1) {
      results[index] = ICR5;
      index++;
    }
    if (index > 17) {
      index = 0;
      save = 0;
    }
  }
  TCCR5B ^= _BV(ICES5); // toggle bit to trigger on the other edge
}
```

As we known from the theory of the PPM signal, by reading the results[2], results[4], results[6], results[8], results[10], results[12], results[14] and results[18], and mapping them to a specific range, we can get all the 8 channels of one PPM-Frame indipendently.

```
...
roll = map(results[2], ROLL_MIN, ROLL_MAX, ROLL_MAP_MIN, ROLL_MAP_MAX) + roll_adjust;
pitch = map(results[4], PITCH_MIN, PITCH_MAX, PITCH_MAP_MIN, PITCH_MAP_MAX) + pitch_adjust;
throttle = map(results[6], THROTTLE_MIN, THROTTLE_MAX, MIN_SIGNAL, MAX_SIGNAL);
throttle = constrain(throttle, MIN_SIGNAL, MAX_SIGNAL);
...
ch6 = mapfloat(results[12], CH6_MIN, CH6_MAX, CH6_MAP_MIN, CH6_MAP_MAX);
ch6 = constrain(ch6, CH6_MAP_MIN, CH6_MAP_MAX);
yaw = map(results[8], YAW_MIN, YAW_MAX, YAW_MAP_MIN, YAW_MAP_MAX) + yaw_adjust;
...
```

2 ESC

Electronic Speed Control, a device controls the motors in an electric aircraft. And here, it serves for the quadcopter. It offers high power, high frequency, high resolution 3-phase AC power to the motors in an extremely compact miniature package[2].

2.1 Skywalker Quattro 20*4-UBEC

We mentioned that ESC is a high power system that connects to four motors. Therefore, ESC has two types. The first type is one ESC conecting to one motor. The other is N in one ESC. Skywalker Quattro 20*4-UBEC is one of the 4 in 1 robust speed controllers. It is designed in one board, and only one pair of battery wire is needed. Also, connecting to four motors in one go can decrease the space than the individual ESC does. Four signal control ports S1, S2, S3, S4 are provided for controlling the motor speed seperately, as shown in Fig. 5.

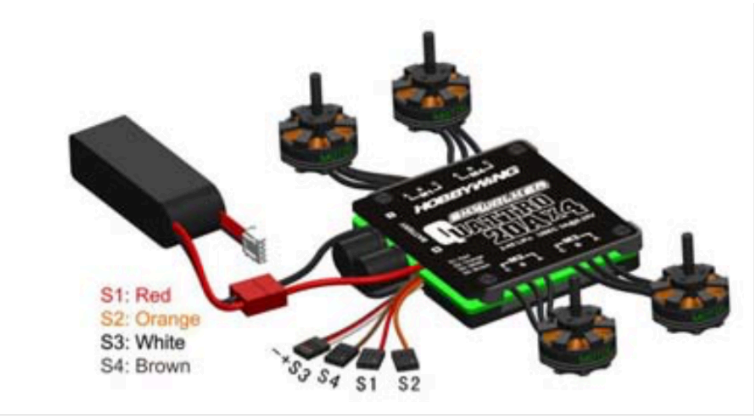

Figure 5: ESC

2.2 Calibrating the ESC

Refer to the [6] - Begin To Use Your New ESC;

3 IMU

Inertial measurement unit (IMU) is an electronic device which measures a body's specific force, angular rate and sometimes the magnetic field surrounding the body, using a combination of accelerometers and gyroscopes, sometimes also magnetometers[3]. In APM 2.4/2.5, we use a chip that provides above funcitons called MPU6000.

3.1 MPU6000

MPU6000 is the world's first integrated 6-axis (Integrate both accelerometer and gyroscope) motion processor solution. It provides a inter high resolution processor on board - Digital Motion Processor (DMP) which computate the position with the data acquired form accelerometer and gyroscope. The results can be read from the DMP's registers or can be buffered in a FIFO. Users can also read the data when interrupt occurs with the external pin of MPU6000.

3.2 MPU6000 driver

Using the DMP is a very convenient way to get all the data such as pitch, roll, yaw without hard calculation work. And because we can read MPU6000 with SPI, so transfer the I2C version (It has been developed by jrowbery form github[4].) to SPI version is the main task.

4 Motors

Refer to the Ardupilot's offical tutorial - connect escs and motors[5]. We use configuration Quad X.

References

[1] http://www.mftech.de/ppm_en.htm.

[2] https://en.wikipedia.org/wiki/Electronic_speed_control.

[3] https://en.wikipedia.org/wiki/Inertial_measurement_unit.

[4] https://github.com/jrowberg/i2cdevlib/tree/master/Arduino/MPU6050.

[5] http://copter.ardupilot.com/wiki/connect-escs-and-motors/.

[6] HOBBYWING. Manual of brushless motor speed controller.

[7] WFLY. Wft06x radio control system instruction v03.