Team #5 VTOL Drone with Only Two Propellers

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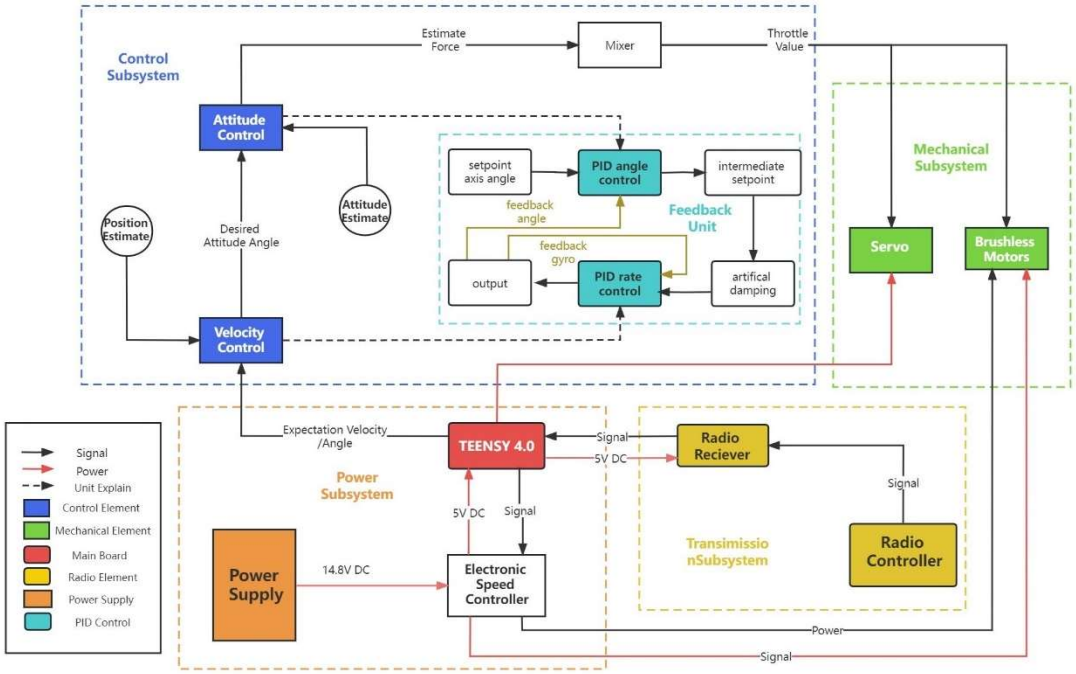
1. Block Diagram & Subsystem Introductions



2. High-level Requirements

- The two propellers combined must provide a force greater than 15N to ensure that the aircraft can take off vertically. Also ensure that the gravitational force on the aircraft itself is less than 15N.
- The wings need to provide at least 15N of lift to ensure that the aircraft can fly horizontally at the preset speed.
- The development board needs to reach approximately 2 kHz flight control loop rate in order to receive the attitude changes from the sensors in time and react quickly.

3. Requirements &Verification Tables

3.1 Mechanical subsystem

3.1.1 Brushless motor and propeller module

Requirements	Verifications	Point
1.When powered by a 14.8V supply, the brushless motor is capable of producing a maximum thrust of 1150g. After running continuously for 5 minutes, the motor's highest temperature should remain below 75℃.	1.Fixed the brushless motor in the six-component balance and connected it to the ESC, which relates to the 14.8V battery and receiver. Use the remote control to directly control the ESC to maximize the power and observe the display. 2.Use the infrared thermometer to keep monitoring the temperature during the 5-minutes operation and record the highest temperature. The temperature should below 75℃. 3.Two propeller should provide enough force for the airplane to takeoff.	5

3.1.2 Servo and gear set module

Requirements	Verifications	Points
1.The servo could rotate to any wanted angle smoothly. 2.The servo could provide a maximum torque of 5kg/cm to make sure brushless motor and propeller module can rotate smoothly at maximum throttle.	1.Connect the brown and the red wire to the positive and negative terminals of a 5V power supply. Connect the orange wire of the servo to a function signal generator. 2. Adjust the machine so that its output signal period is 20ms PWM signal. Adjust pulse width between 0.5ms and 2.5ms (Control channel 1 or 2 of the remote control). 3. Use channel 1 both propellers will turn synchronously. Use channel 2 both propellers will turn asynchronously. 4. Repeat 3 for all throttle value.	5

3.1.3 Carbon tube connector module

Requirements	Verifications	Points
The PLA connection part needs to withstand a torque of 20 Nm in x, y and z directions. And the deformation at the end of the connection is less than 2 mm.	1. Assemble two carbon rods in PLA connection part, assemble glassfiber plate. 2. Fix the end of one carbon tube near the connector to the vise. Measure and record the coordinates from the end of the connector to the bench vise with a vernier caliper. 3. Apply a force of 25 N (The throttle is quickly pushed to full) to the carbon tube with a tensiometer at the end of the principal connector of the other carbon tube. 4. Observe the PLA connector for deformation visible to the naked eye and measure and record the coordinates from the end of the connector to the bench vise with a vernier caliper. 5. Compare the deformation of the end of the connector before and after the applied force is greater than 2mm. 6. Repeat steps 3 to 5 for the other directions.	3

3.1.4 Aircraft body module

Requirements	Verifications	Points
1.The space is set up in such a way that the center of gravity of the aircraft is directly below the center of the wing attachment. 2.The connecting part must be able to withstand a torque of 20 Nm in the x, y, and z directions.	1.Complete assembly of all aircraft components. And the space of body section can contain all electronic components. 2.Find a roller to place on the bottom of the aircraft and roll it back and forth to a position where the aircraft is no longer tilted forward or backward. 3.Adjust the position of the battery until the point where the roll is tangent to the bottom of the aircraft falls right below the carbon fiber rod supporting the wings. Record the position of the battery next time. 4.Fix the bottom of the aircraft on the vise.	4

	Measure and record the coordinates from the screw holes of the connectors to the bench vise with a vernier caliper. 5.Apply a force of 25 N (The throttle is quickly pushed to full) to the carbon tubes with a tensiometer at the end of the principal connector of the other carbon tubes. 6.Observe the PLA connector for deformation visible to the naked eye and measure and record the coordinates from the screw holes of the connectors to the bench vise with a vernier caliper. 7.Compare the deformation of the screw holes of the connector before and after the applied force is greater than 2mm. 8. Repeat steps for both wing connectors and back connectors in the other directions.	

3.1.5Wings module

Requirements	Verifications	Points
The lift force reduce drag force is larger than zero and can satisfy the horizontal flying. Wing will not break down in testing.	1.Use 3d printing technology to construct a y-section wing with a chord length of 0.2m and a main length of 0.3m and fix it vertically on a sextant balance with a rotatable base. 2. Wing can support horizontal flying with a relatively high speed without break down.	3

3.2 Control subsystem

3.2.1 IMU

Requirements	Verifications	Points
1. The IMU should be able to input the signals of the drone's orientation, velocity, and acceleration into the Teensy board. 2. When the IMU send the signals into the board, after the PID controls from the Teensy board, the drone can show the corresponding movement.	1. Rotate IMU on three different spatial axes to simulate different attitudes of drone during flight. If the drones can react to the rotations of different axises correctly, then the IMU and the PID control codes are correct.	5

3.2.2 TEENSY4.0

Requirements	Verifications	Points
1.The TEENSY4.0 should have sufficient processing power to calculate flight trajectories, stabilize the drone, process sensor data in real-time, and execute flight commands quickly. 2.The TEENSY4.0 should support various sensors such as the IMU and provide accurate data to enable the drone to navigate and maintain stability.	1.When flying on the sky, the PID controls can make the drone fly smoothly and can take off and land vertically.	5

3.3 Transmission Subsystem

3.3.1Remote controller & Radio Receiver

Requirements	Verifications	Points
1. The remote control should be able to work within 100m 2. When we use the remote controller to control the drone, the drone will do the corresponding movement with the radio receiver on it.	1.Use the remote controller to send different signals to channel 1-4 of the radio receiver to simulate the control on the sky, the motors and servos do the corresponding movement that we want.	10

3.3 Power Subsystem

3.3.2 Power supply and transmission units

Requirements	Verifications	Points
1. When we turn the power supply on, all the components on the drone should be powered with the correct voltage.	1.Connect the power supply with the electronic speed controller, all the LEDs of the Teensy boards, IMU and radio receiver are on, and the motors will make the corresponding sound to show that they're powered with the corresponding voltages.	10