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Design of a microcontroller-based quadcopter prototype module fly sky XL163RX take off and landing

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Abstract — This research addresses the growing demand for reliable and efficient quadcopter modules suitable for various applications, including aerial photography, surveillance, and delivery services. The problem domain centers around the need for advanced quadcopter technology that can safely and effectively perform take-off and landing operations while ensuring stability, responsiveness, and user-friendliness. In response to this problem, this research paper introduces the design and development of the Fly Sky XL163RX microcontroller-based quadcopter module. The primary objective of this study is to create a solution that meets the requirements of diverse applications and provides reliable performance. The research methodology involves a meticulous design process encompassing several crucial steps. These steps include the careful selection of appropriate components, the seamless integration of various sensors and actuators, and the development of sophisticated control algorithms. The quadcopter module leverages a combination of sensors, including gyroscopes, accelerometers, and altimeters, to gather real-time data crucial for flight stability. An integral part of the control algorithm is using a proportional-integral-derivative (PID) controller, ensuring precise motor speed adjustments during take-off and landing. A distinctive feature of the Fly Sky XL163RX microcontroller is its user-friendly interface, which supports multiple communication protocols. This feature enhances customization and control options for the quadcopter module. Furthermore, the module incorporates cutting-edge safety measures, such as emergency landing capabilities and collision avoidance systems. These safety features significantly enhance flight security and minimize the risk of accidents. Extensive flight testing was conducted to evaluate the performance and effectiveness of the Fly Sky XL163RX quadcopter module. The results conclusively demonstrate the module's capacity to execute stable take-off and landing operations while remaining highly responsive to user commands. Its compact size and lightweight design render it suitable for both indoor and outdoor applications. In conclusion, this research presents the innovative Fly Sky XL163RX microcontroller-based quadcopter module, showcasing its reliable and efficient take-off and landing capabilities. The successful integration of sensors, control algorithms, and safety features significantly contributes to the module's overall performance and usability. Future endeavors may explore enhancements, including the implementation of autonomous flight modes and improvements in battery efficiency, to further augment its capabilities and applications.

Keywords – actuators, control algorithm, FlySky XL163RX, quadcopter, microcontroller, sensors, PID controller

I. Introduction

The utilization of drones or unmanned aerial vehicles (UAV) in Indonesia has gained significant traction. UAVs are autonomous aircraft capable of remote operation through a control system [1]. These drones are primarily employed for surveillance purposes, equipped with real-time sensing cameras. Initially, drones found their roots in the military sector. For instance, in 1849, Austria developed unmanned blimps, serving as early prototypes. Nearly two decades later, during the US Civil War, unmanned blimps were deployed to contain rebel aggressions.

As delineated by Sivakumar and Malleswari [2], unmanned systems are categorized into three types:

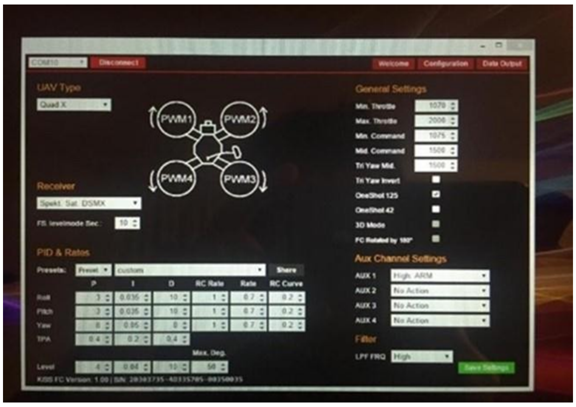

Fig. 1. Application to determine the PID value on the controller.

unmanned aerial vehicles (UAVs), unmanned ground vehicles (UGVs), and unmanned underwater vehicles (UUVs). However, UAVs have garnered the most recognition among these categories. Presently, UAVs have found applications in diverse fields, including agriculture [3]–[6], healthcare [7]–[9], disaster management [10]–[12], mining [13], [14], and marine operations [15]–[17].

The evolution of modern drones is closely tied to advancements in radio control technology. Radio control involves interaction between a controller (transmitter) and the controlled device (receiver) using radio waves. Historically, this control system did not incorporate AM or FM frequencies but has since transitioned to use the 2.4 GHz frequency primarily. Notably, a study conducted by Maulana *et al.* [18] introduced an innovative control system reliant on the user's body movements.

The radio control system comprises a transmitter and receiver. The transmitter sends a carrier input in the form of a frequency to be received by the receiver. Subsequently, Sivashankar *et al.* [19], the receiver processes this input and translates it into commands to operate the controlled device. In the context of this research, the focus lies on quadcopter drones. A quadcopter drone is an unmanned aircraft propelled by four rotors. Frequency plays a pivotal role in the input and output processes of quadcopter drones, representing an essential element in radio control technology. However, this study exclusively delves into the frequency aspects related to the take-off and landing procedures of quadcopter drones.

II. Research Method

This section discusses the software, hardware, dan frame designs.

A. Software Design

The integrated Kiss application on the flight controller and GUI functions make it easier for users to adjust the movement of the pitch, roll, and yaw axes, as well as measure angle parameters for proportional integral derivative (PID) control and other supporting sensors.

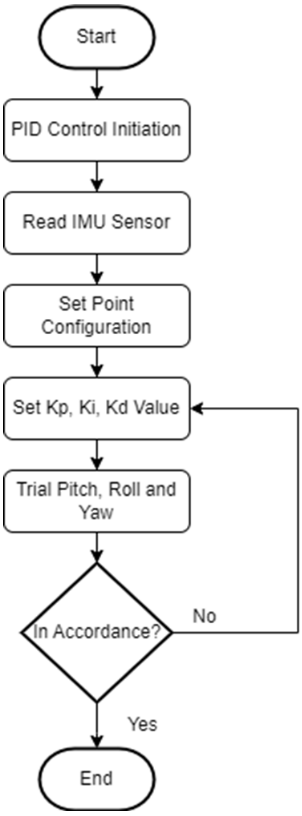

Fig. 2. Mechanism trial error PID flowchart.

B. Hardware Design

The design of the PID control system prototype on the quadcopter is a system that aims to control the four brushed motors found in the quadcopter. This system is regulated by the ARM microcontroller using the flysky module. The rotational speed of each motor is controlled by PID using commands sent from the controlling transmitter (pilot).

C. Frame Design

Order (frame quad) serves as a support. The frame is 300 mm in diameter with solid aluminum material to make it lighter and more robust to reduce vibration/shock. The structure consists of four wings with a motor at each end of the arm. In addition, there is a small landing gear at the bottom of each arm end. The goal is that other devices do not come into direct contact with the runway so that the flight controller can be protected and avoid ground impact in the event of a crash.

III. Result and Discussion

The physical form of the drone as a whole can be seen in Fig. 5. The drone system uses a microcontroller. This microcontroller functions as a flight controller. The frame used is a self-made frame for the quadcopter. It weighs 300 gr and features vibration dampening between the motors.

In a hover state, the flight controller will still receive vibrations generated by the motor. The flight controller

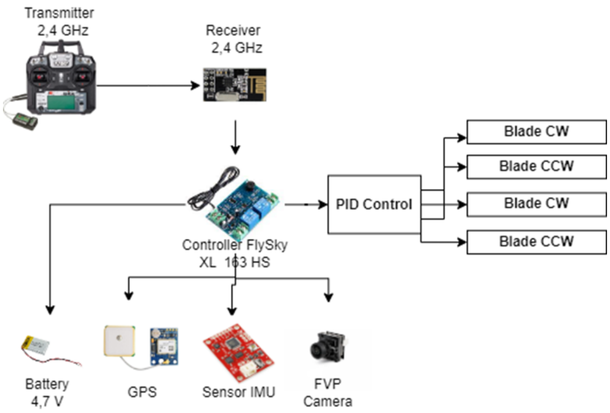

Fig. 3. Quadcopter control diagram schematic.

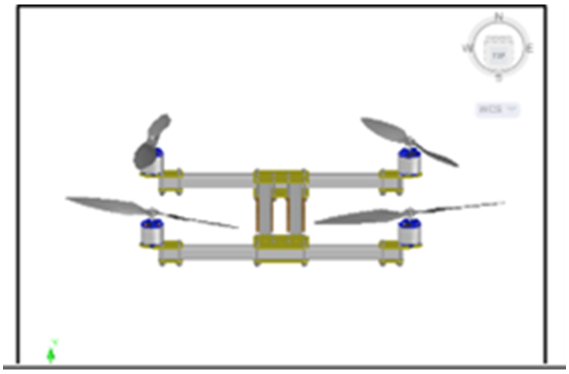

Fig. 4. Frame design quadcopter.

Table 1. Specification Frame Type

Parameter	Value
Weight	282 gr
Lenght	160 mm
Width	140 mm
Thickness	1 mm
Large	2240 mm
Diagonal Wheel Base	300 mm
Take Off Weight	800 gr – 1200 gr

Fig. 5. Drone protoype.

is connected to the frame using a plastic spacer. As a result, the drone becomes uncontrollable, so it is necessary to use vibration dampers. The damper used is a foam damper. This damper can dampen vibrations from motor rotation.

A. Motor Testing

The brushed motor is tested to determine the motor speed response. First, testing is done by measuring the speed of the motor using a minimum and maximum. Through the data obtained from the oscilloscope, it can be seen the speed of the brushed motor when it is given a minimum to the maximum input voltage. The resulting acceleration is about 2 to 4.7 Volts. Then the flight control output is connected to an oscilloscope to measure the motor speed response, as shown in Fig. 6, Fig. 7, and Fig. 8. It can be seen through testing the response data that the brushed motor's reaction is speedy. The response is about 3 s to reach maximum and steady.

B. Units

The EZ0 sonar is a linear proximity sensor. The sensor measures the distance of the quadcopter's height from the ground when it is in the flying position or control altitude. Sensor testing aims to determine the characteristics and response of the sensor. Testing is carried out by testing the detector at a certain distance and taking serial readings on a PC with a HyperTerminal. Table 2 and Fig. 9 show a graph of the EZ0 sensor test results.

Adjusting the pitch, roll and yaw angles can be done to control the forward (X), sideways (Y), and swivel (Z) positions, provided that the lift is zero.

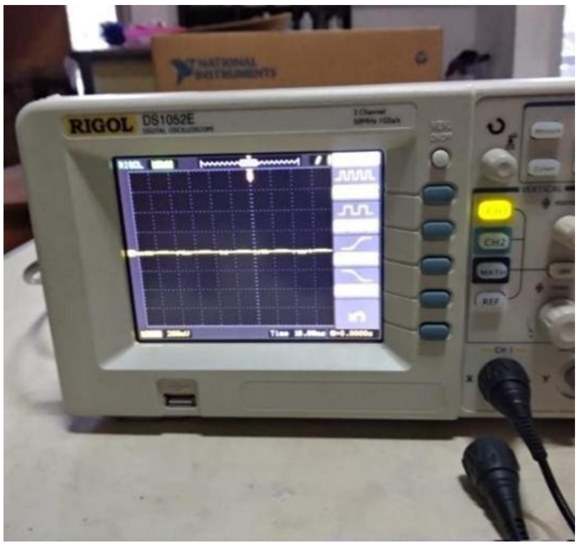

Fig. 6. Testing motor response using an oscilloscope during motor standby conditions (1 Volt).

C. Barometer Sensing Testing

This sensor has a working system based on the pressure and temperature of the environment. If the sensor position is high, the air pressure will be slight. This

Fig. 7. Testing motor response using an oscilloscope during motor standby conditions (2 Volts).

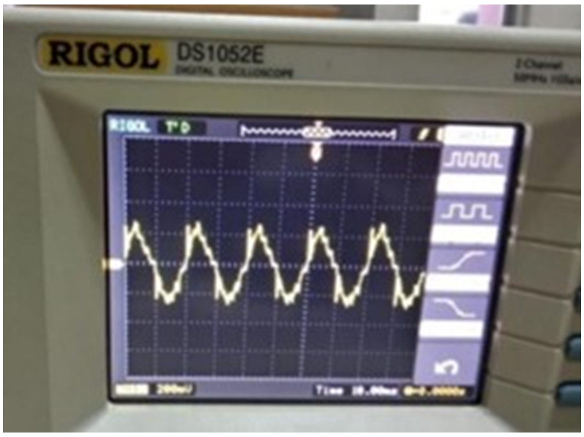

Fig. 8. Testing motor response using an oscilloscope when motor conditions take off.

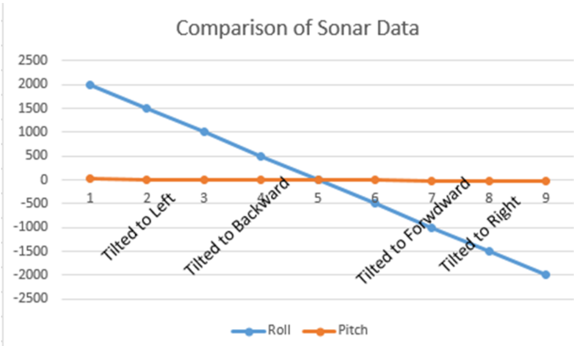

Fig. 9. Graph comparison of sonar data with actual distance.

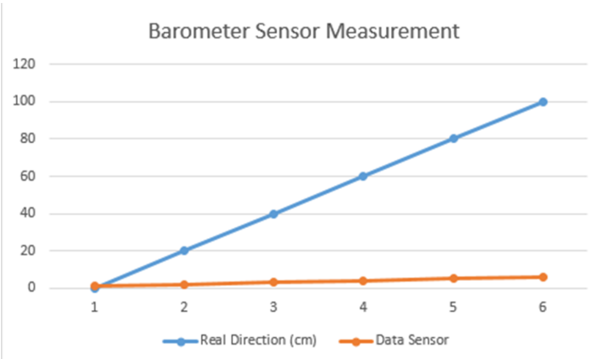

Fig. 10. Graph comparison of sonar data with actual distance.

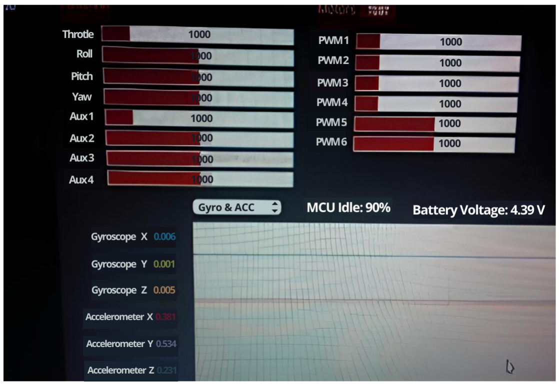

Fig. 11. Accelerometer graph when idle.

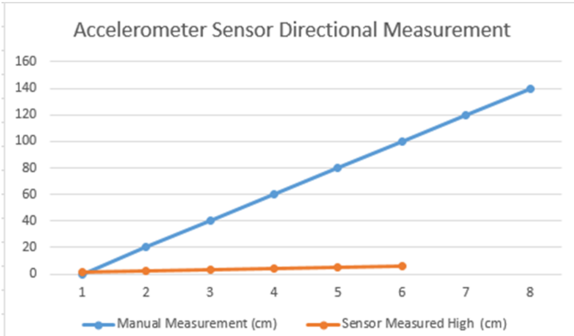

Fig. 12. Accelerometer sensor directional measurement graphic.

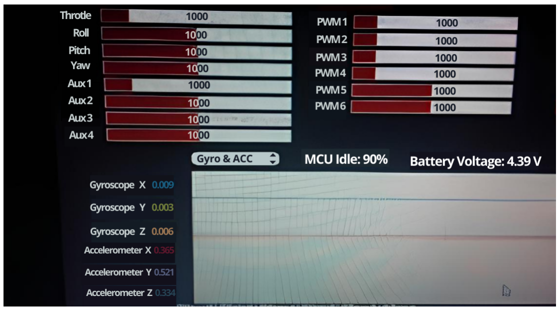

Fig. 13. Accelerometer sensor response.

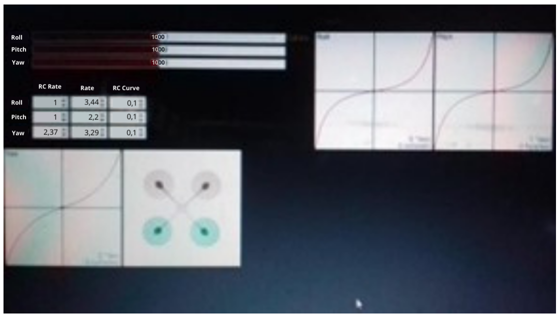

Fig. 14. Gyroscope sensor testing.

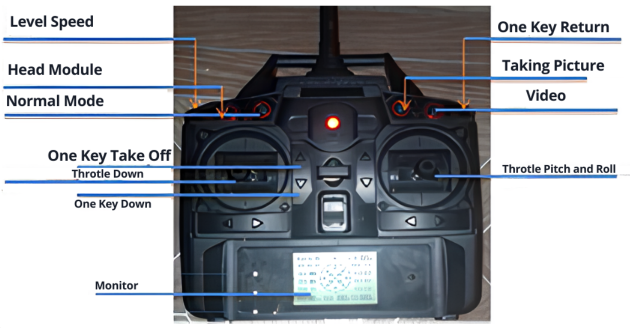

Fig. 15. Radio control.

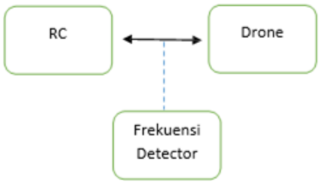

Fig. 16. Gyroscope sensor testing.

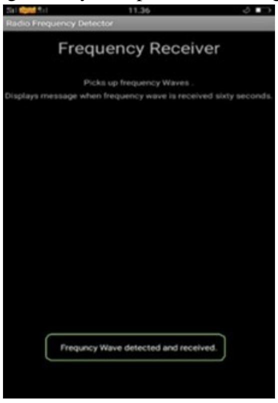

Fig. 17. Radio frequency detector confirms Tx received Rx.

sensor is susceptible to changes in altitude so that it can determine the height of an object. These barometer sensors are placed on the flight controller PCB. The sensors were tested by resetting the barometers and then measuring the quadcopter's height from the take-off area.

When the quadcopter is at 10 cm, the transmitter shows a quadcopter height of 13 cm. Furthermore, the quadcopter is at an altitude of 20 cm. The barometer shows a height of 21 cm. The results of testing Table 3 on the barometer sensor show that the measurements made are close to the actual height.

D. Accelerometer Sensing Testing

Sensor testing was conducted to determine the accelerometer's accuracy in reading quadcopter angle changes. The sensor is already on the flight controller PCB. The data obtained from the accelerometer will be input and output. The data is the torque of the brushed motor. The roll axis is the X axis of the accelerometer, and the pitch axis is the Y axis of the accelerometer.

When the quadcopter is tilted forward, the accelerometer shows the axis value of the pitch with a value of 150, while when tilted backward, it shows -150. Furthermore, testing on the roll axis is carried out by tipping the surface of the quadcopter. Testing

Table 2. Sensor Data with Actual Distance

Actual Distance (cm)	Sensor Data
10	13
20	22
30	31
40	42
50	51
60	63
70	74
80	83
90	91
100	102

Table 3. Height Measurement Result with the Sensor Barometer

Manual Measurement (cm)	Height Measured by (cm) on Remote Control
10	15
20	21
50	55
100	105
120	125

Table 4. Accelerometer Sensor Test Results

No.	Mechanic Direction	Roll (x)	Pitch (y)
1.	Lean forward	-100	1,500
2.	Lean back	30	-1,500
3.	Flat surface	0	0
4.	Lean to the right	500	20
5.	Lean to the left	-500	100

the roll axis gets results that match the character of quadcopter.

The table above shows that the value of each accelerometer axis is in accordance with the machine's direction.

E. Gyroscope Sensor Testing

The sensor test results show the level of accuracy in reading dynamic angular velocity changes from the quadcopter. The sensor will produce an output value when it rotates clockwise on the Y axis, decreasing the output voltage. Conversely, if it spins counterclockwise, the resulting output voltage is large. When the sensor is not turning (idle state), the output voltage is the same as the offset value.

Through data logs by the application and the graphical user interface (GUI) of the flight controller program and the manual measuring tools used. Proof of testing the flight controller application is shown in Fig. 14 and Table 5.

F. Radio Control Testing

The physical form of the radio control used is shown in Fig. 16. Radio control is used to control the drone. The Ch1 lever controls the aircraft to the left and right (roll), while the Ch2 lever raises and lowers the plane (pitching). The test results for each lever (Ch) are shown in Table 7.

In this paper, the Ch used by the author is Ch2, considering this research only focuses on take-off and

Table 5. Results of Stay Gyroscope Test

No.	Roll	Pitch	Yaw
1.	0	0	0
2.	0	0	0
3.	0	0	0
4.	0	0	0
5.	0	0	0

Table 6. Results of Gyroscope Test When Spinning Clockwise

No.	Rpm	Pitch	Yaw
1.	0	0	0
2.	0	0	0
3.	0	0	0
4.	0	0	0
5.	0	0	0

Table 7. Radio Control Test Results

Channel	Fly Mode	
	Up and Down	Left and Right
1	1	1
2	1	1
3	1	1
4	1	1
5	1	1

landing. To find out if the RC is connected, the author uses a frequency detector application from the Playstore. The following is a radio control calibration scheme.

IV. Conclusion

The findings of this study contribute significantly to our understanding of the performance of quadcopter drones at rest and during takeoff. The study's findings indicate that data on the quadcopter drone changes while it is resting or taking off for flight. These data changes suggest that the drone is performing properly, yet faults still arise in the drone due to gaps in the test settings. Furthermore, according to the results of radio frequency detector application testing, data transfer between transmitter and receiver using Ch1 and Ch2 proceeds well. The study implies that a greater understanding of quadcopter drone performance at rest and takeoff can aid in the development of more dependable and efficient drone technology. This data can be utilized to improve drone design and functioning, allowing them to be employed for a wide range of applications such as aerial photography, surveillance, and delivery services. Furthermore, the findings of this study demonstrate the significance of meticulous testing and testing in drone development. The faults detected in the drones in this study underscore the importance of identifying and addressing problems early to ensure optimum reliability and performance. In the context of the problems described in the introduction, this study provides a real solution in the form of a quadcopter module based on the Fly Sky XL163RX microcontroller. This module's take-off and landing capabilities are dependable and efficient. The creation of this module can support a variety of applications, including aerial photography, surveillance, and delivery services, as a result of this research. This module's safety features improve flight safety and help avoid potential accidents. This study also demonstrates the significance of using sensors, control algorithms, and safety features in the creation of quadcopter modules. This can serve as a model for future research and development to increase the module's capabilities, such as introducing an autonomous flight mode and improving battery efficiency. As a result, our research has made an important contribution to the advancement of more sophisticated and dependable quadcopter technology.

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