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Flying a Drone Using a KK Flight Controller

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Abstract

This paper presents the design, development, and testing of a quadcopter drone using the KK2.1.5 flight controller, with an emphasis on stability and educational value. The KK2.1.5 controller features an in-built LCD screen and in-built programming, enabling direct configuration and tuning without the need for a computer interface, which makes it highly suitable for beginners and students. The drone is built using a modular frame architecture, which allows for easy replacement and customization of components like motors, propellers, and arms. The drone's orientation, acceleration, and angular velocity are continuously monitored by the flight controller, which combines a three-axis gyroscope and accelerometer. To ensure steady flying and fluid reactions to pilot inputs, it employs proportional-integral-derivative (PID) control algorithms to dynamically modify individual motor outputs. Under a variety of environmental circumstances, such as wind gusts or abrupt shocks, these control techniques aid in maintaining altitude, orientation, and trajectory. To reduce the possibility of mishaps or hardware damage while in use, safety features including battery voltage monitoring, failsafe landing procedures, and throttle cut-off in the event of signal loss are included. Brushless DC motors are powered by a high-capacity Li-Po battery system that uses electronic speed controllers (ESC) to provide fine speed control, quick reaction, and effective thrust for dependable flight performance. The flight controller utilizes integrated gyroscopes and accelerometer sensors to maintain stable flight by continuously adjusting motor outputs via PID tuning, ensuring smooth response to user inputs. Safety features such as throttle cut-off during signal loss and failsafe landing protocols are implemented to prevent damage or injury during operation. Power is delivered through a Li-Po battery system, driving brushless DC motors through ESCs. Manual control is achieved via a transmitter-receiver, giving the real-time output. In the future, this project also explores the possibility of upgrades, including GPS-based autonomous navigation, telemetry integration, obstacle detection for semi-autonomous missions, and camera implementation. The drone serves not only as a functional aerial platform for tasks such as surveillance, aerial mapping, and environmental data collection, but also as an educational tool to introduce students and enthusiasts to core principles of flight dynamics, embedded systems, and wireless communication.

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INTRODUCTION

The quadcopter drone designed in this project was built using three primary components: a KK2.1.5 flight controller, BLDC (brushless DC) motors, and electronic speed controllers (ESCs). These components operate synchronously to provide a stable, responsive, and controllable flight experience. The choice of these components ensures a cost-effective, modular, and beginner-friendly platform for multi-rotor experimentation and learning [1].

The heart of the system lies in the KK2.1.5 flight controller, which was specifically developed for multi-rotor aircraft. It is equipped with an Atmel ATmega644PA microcontroller and features a built-in 6050 MPU that combines a 3-axis gyroscope and 3-axis accelerometer. This allows the controller to sense orientation and angular motion in real-time. KK2.1.5 used this data to calculate the necessary corrections to stabilize the drone during flight using PID control algorithms. One of its major advantages is the integrated LCD, which enables users to configure and tune the system without requiring an external computer. The controller processes the input from the Radio Controller (RC) receiver and sends the corresponding pulse-width modulation (PWM) signals to each ESC to adjust the motor speed and maintain the balance [2–6].

The propulsion system of the drone was handled by four brushless DC motors arranged in a quad-X-configuration. These motors are preferred for drones because of their high efficiency, lightweight construction, and quick response. Typically rated 1800 kV, the BLDC motors provide sufficient thrust to lift the drone while offering stability during hover and maneuvering. Opposite pairs of motors rotate in opposite directions, clockwise and counterclockwise, to balance the torque and control the stability. The flight controller adjusts the relative speed of each motor to perform movements, such as pitch, roll, yaw, and throttle control [7–12].

To drive these motors, the system used an ESC, one for each motor. The ESCs act as intermediaries between the flight controller and motors. They received throttle signals from the KK2.1.5 controller in the form of PWM signals and converted the DC battery voltage into a three-phase AC signal required to drive the BLDC motors. ESCs also ensure precise speed regulation, which is critical for a stable flight. Many ESCs have a built-in battery eliminator circuit (BEC), which can be used to power the flight controller and receiver system, eliminating the need for a separate power supply.

The overall system operates in a feedback loop, where the pilot's commands are received via the RC transmitter, processed by the KK2.1.5 controller, and translated into control signals that vary the speed of each motor via the ESCs. This results in the drone performing the desired movements, whether it is lifting off, hovering, or changing its direction. Real-time sensor feedback helps the controller continuously adjust motor speeds to maintain balance and compensate for disturbances, such as wind or sudden movement.

LITERATURE REVIEW

Introduction to UAV Flight Control

Drones, also called unmanned aerial vehicles (UAVs), are used in many fields, such as photography, security, and research. One of the most important components of a drone is its flight controller. This small circuit board helps maintain balance and stability during flight. The KK2.1.5 flight controller is a popular choice for beginners and students because it is easy to use, low-cost, and works well for small drone projects [13–15].

Overview of KK2.1.5 Flight Controller

The KK2.1.5 controller uses a microcontroller (ATmega644PA) and a motion sensor called MPU6050, which combines a gyroscope and an accelerometer. These help the drone to stay level and stabilize. A unique feature of KK2.1.5 is its built-in LCD screen and buttons, which allow users to adjust flight settings directly on the board, and no laptop or extra software is needed [16–18]. This makes it useful for quick testing and adjustment during drone development.

Past Research on Stability and Camera Use

Several studies have tested how well KK2.1.5 works for drone control. We showed that it provides stable flight and good manual control, which is helpful for tasks such as video recording and live camera streaming. Although it does not have features such as GPS or autopilot, it is still reliable for short flights and basic camera operations.

In other drone projects, cameras were mounted directly on drones using KK2.1.5. Researchers have found that drones can fly steadily enough to capture high-quality images and videos. While it does not support advanced camera stabilizers, such as gimbals, with proper weight balancing and tuning, the drone can reduce shaking during flight [19, 20].

Comparison with Other Controllers

Compared to advanced flight controllers such as Pixhawk or APM, KK2.1.5 has fewer features. These advanced controllers can follow GPS routes, send flight data to a computer, and perform autonomous missions. However, for students and simple projects focused on learning or camera testing, KK2.1.5 is an excellent starting point because it is easy to use and works well for basic control.

Why This Research is Important

This project focuses only on drone stability and camera performance and not on GPS or Internet of Things (IoT) systems. Because stable flight is necessary for clear videos or photos, this research will study how to tune the KK2.1.5 controller to reduce vibration and improve flight control. The goal is to obtain smooth and stable footage using a low-cost setup that is easy to build and test.

ADVANTAGES

1. *Affordable:* The KK2.1.5 is a cost-effective solution for hobbyists and beginners.
2. *Easy setup:* The onboard LCD screen allows configuration without the need for a computer.
3. *User-friendly interface:* Simple navigation via the built-in LCD screen.
4. *Multiple flight modes:* Supports Acro and Self-Level modes for different types of controls.
5. *Manual control:* Offers real-time manual control for experienced pilots.
6. *Stable flight performance:* Ideal for stable indoor and outdoor flights in moderate conditions.

DISADVANTAGES

1. *Limited features:* Lacks advanced capabilities like GPS and autonomous flight control.
2. *Limited sensor support:* Does not support external sensors such as barometers or GPS.
3. *Basic flight control:* Lacks advanced PID tuning and more sophisticated flight control features.
4. *Limited expansion:* Few options for adding extra modules or advanced sensors.
5. *No autonomous flight:* Does not support autonomous navigation, waypoint planning, or GPS.

PROPOSED METHODOLOGY

The proposed methodology for this project involves a systematic approach for designing and developing a quadcopter drone using a KK2.1.5 flight controller. The process begins by defining the objective, which is to achieve stable and responsive flight control through manual radio communication using optimized Proportional–Integral (PI) tuning parameters. The primary focus is to ensure smooth flight behavior, consistent stability, and controlled maneuvering by using low-cost yet effective components.

Initially, all the essential components were selected based on their compatibility, availability, and performance. These include the KK2.1.5 flight controller flashed with the Steveis firmware for enhanced functionality, four 1000 kV brushless DC motors (A2212), and 30 A SimonK ESCs for speed regulation. The power system includes a 3-cell 2200 mAh Li-Po battery connected via a power distribution board (PDB). Propellers sized 10×4.5 or 9×4.7 inches were used in counter-rotating pairs to ensure balanced thrust. A 6-channel RC transmitter and receiver system was used for manual control, and all components were mounted on a standard 450 mm quadcopter X-frame to maintain the proper center of gravity and balance.

The next step involves assembling the hardware. Motors were mounted symmetrically, and ESCs were wired to both the motors and output channels of KK2.1.5. The receiver was connected to the input channels of the controller using PWM cables. The battery is linked to the PDB, which distributes power to all the ESCs. Vibration-damping foam is placed beneath the KK2.1.5 to reduce the impact of frame oscillations during flight. Appropriate cable management is ensured to prevent loose connections and interference.

Once the hardware setup was complete, the flight controller was configured. Steveis firmware was installed using a USBasp programmer. The built-in LCD interface of KK2.1.5 was used to configure the motor layout in an X-configuration, calibrate the ESCs, and set the stick directions, endpoints, and flight modes. Two modes, Acro (for manual control) and Self-Level (for assisted stabilization), were activated for testing and comparison.

Subsequently, PI tuning was performed to optimize the flight response. The initial values were set to their defaults (P = 30, I = 20). The quadcopter was test-flown, and the proportional gain (P) was gradually increased until oscillations were observed, after which it was slightly reduced to achieve optimal performance. The integral gain (I) was adjusted to minimize long-term drift without introducing lag. This tuning process was repeated until a good balance between responsiveness and stability was achieved.

Following the configuration and tuning, the drone underwent a series of tests. The first test is a basic hover test to evaluate the lift, thrust balance, and stability. This is followed by directional testing to assess the pitch, roll, and yaw control. Mode switching was also tested in mid-flight to observe the behavior of the controller between Acro and Self-Level. Optionally, a lightweight payload, such as a camera, can be attached to test its effect on the flight characteristics and endurance.

Performance is evaluated using metrics such as flight time, system responsiveness, motor temperature, and stability during disturbances. Any instability, drift, or abnormal vibrations were diagnosed and corrected by re-tuning the PI values, balancing the propellers, or adjusting the mechanical alignments. Safety measures, such as propeller guards, proper ESC cooling, and battery voltage monitoring, were also implemented.

Finally, the project includes scope for future enhancement. Additional sensors, such as barometers or ultrasonic modules, can be integrated using external microcontrollers, such as Arduino or Raspberry Pi. These can be used for altitude-holding and obstacle detection. For more advanced features, such as GPS-based navigation, autonomous flight, and telemetry, upgrading to flight controllers such as APM or Pixhawk is recommended. However, for learning control dynamics and hands-on experience in UAV development, KK2.1.5 remains an excellent platform.

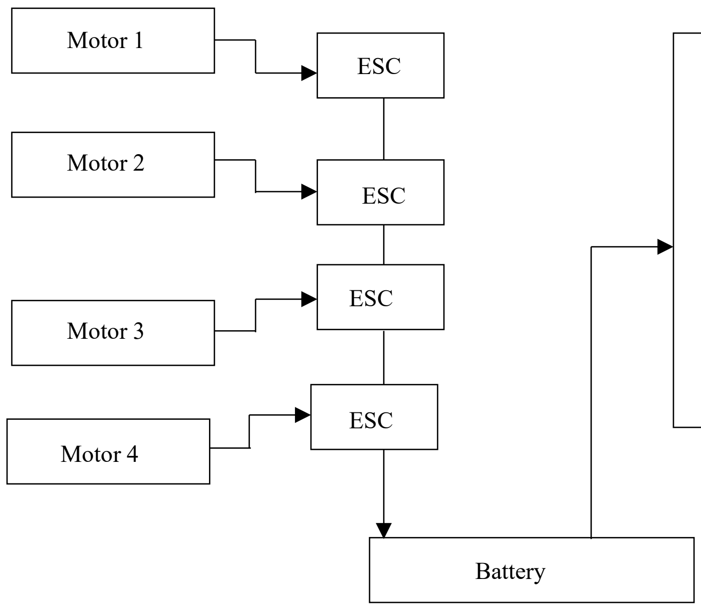

Figure 1. Proposed block diagram.

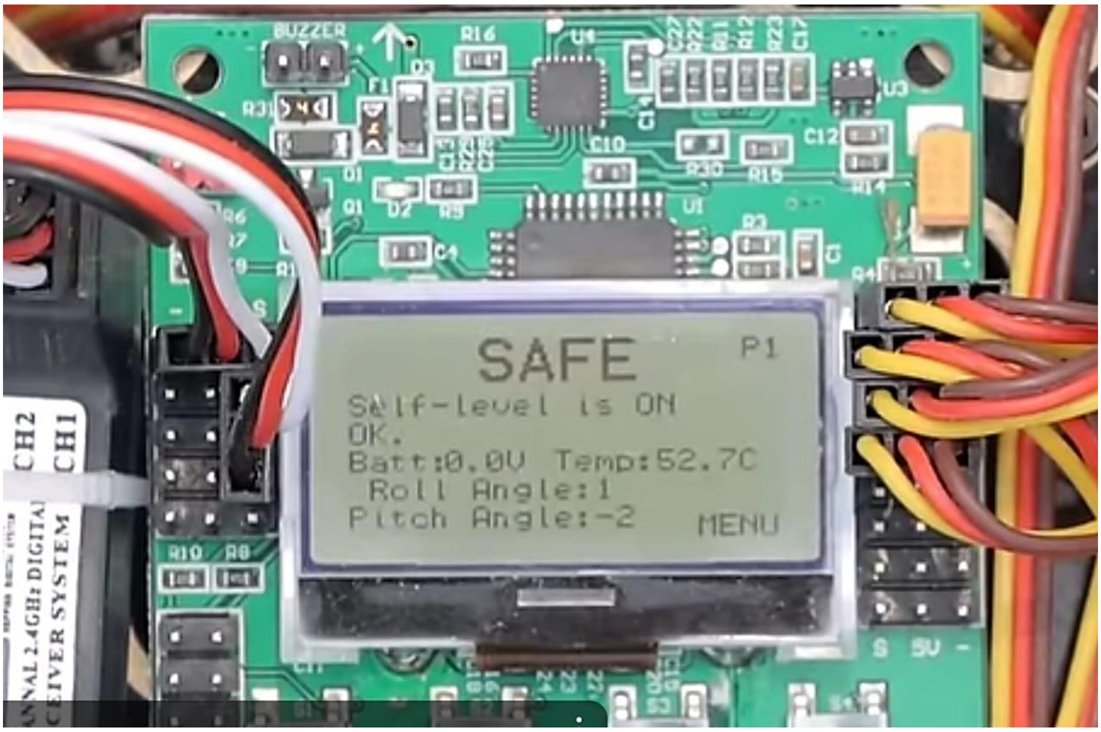

Figure 2. Experimental results of the proposed system.

RESULTS

Figure 2 shows experimental results of the proposed system.

CONCLUSION

A simple quadcopter drone was successfully built and tested to achieve stable flight and responsive control using a KK2.1.5 flight controller. The project effectively demonstrated the integration of key components, such as brushless motors, ESCs, Li-Po batteries, and transmitter-receiver systems. Through hands-on assembly and tuning, a solid understanding of the flight dynamics, PID control, and power management was achieved.

The drone performed well in basic flight tests, maintaining balance and stability during directional movements. The modular design makes it easy to troubleshoot and replace parts, adding to its educational value. Additionally, this project has helped develop practical skills in electronics, soldering, and flight safety.

Overall, the quadcopter served as a strong platform for further experimentation. With minor upgrades, it can be enhanced with features such as GPS-based navigation, obstacle detection, and autonomous flight, such as rolling, making it suitable for real-world applications such as aerial photography, videography, environmental monitoring, and surveillance.

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