✈ Affordable Aerial Robotics: A Minimalist Drone Making with Wi-Fi 6 Communication

Design and Implementation of a Low-Cost Wi-Fi 6-Enabled Drone Using E88 Pro and nRF7001 IC

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Abstract — **This paper presents the design and implementation of a low-cost aerial robotic system using the E88 Pro drone platform integrated with the nRF7001 Wi-Fi 6 IC. The motivation stems from the need for affordable, modular drones for educational, research, and prototyping purposes. By leveraging the minimalist architecture of the E88 Pro and enhancing its communication capabilities with Wi-Fi 6, the system achieves reliable short-range control, reduced latency, and improved data throughput. The integration process involved hardware modifications, firmware development, and protocol configuration. Experimental results demonstrate stable flight performance, efficient power consumption, and a total build cost around Rupees 700 Only. This work contributes to the democratization of aerial robotics and opens avenues for scalable, swarm-based applications using next-generation wireless standards.**

Index Terms — **Low-cost drones, Wi-Fi 6, nRF7001 IC, E88 Pro, Aerial Robotics, Embedded systems, Autonomous UAVs, Drone communication.**

I. Introduction

The proliferation of unmanned aerial vehicles (UAVs) has revolutionized industries ranging from agriculture to surveillance. However, the high cost of commercial drones limits accessibility for students, researchers, and hobbyists. This paper addresses the challenge by proposing minimalist drone architecture built on the E88 Pro platform, enhanced with Wi-Fi 6 communication via the nRF7001 IC. Wi-Fi 6 offers significant advantages in terms of latency, bandwidth, and device density, making it ideal for real-time control and telemetry. The goal is to create a modular, low-cost drone that maintains essential flight capabilities while enabling high-speed wireless communication.

II. Related Work

Several studies have explored low-cost drone designs using open-source platforms like Arduino and Raspberry Pi [1], [2]. However, most rely on legacy communication protocols such as Bluetooth or Wi-Fi 4, which suffer from interference and limited range. Recent work on Wi-Fi 6 in robotics highlights its potential for swarm coordination and real-time data streaming [3]. The nRF7001 IC, developed by Nordic Semiconductor, is among the first low-power Wi-Fi 6 chips suitable for embedded applications [4]. Prior implementations have focused on IoT devices, but its integration into aerial platforms remains underexplored.

III. System Design

A. Hardware Overview

- **Drone Base:** E88 Pro quadcopter with brushless motors, 3.7V Li-Po (1800 Mah battery), and basic flight controller.
- **Wi-Fi Module:** nRF7001 IC mounted on a custom PCB with voltage regulation and antenna interface.
- **Microcontroller:** Any Android phone used for interfacing between flight controller and Wi-Fi module.
- **Sensors:** Basic IMU (MPU6050) for stabilization and navigation.

B. Block Diagram

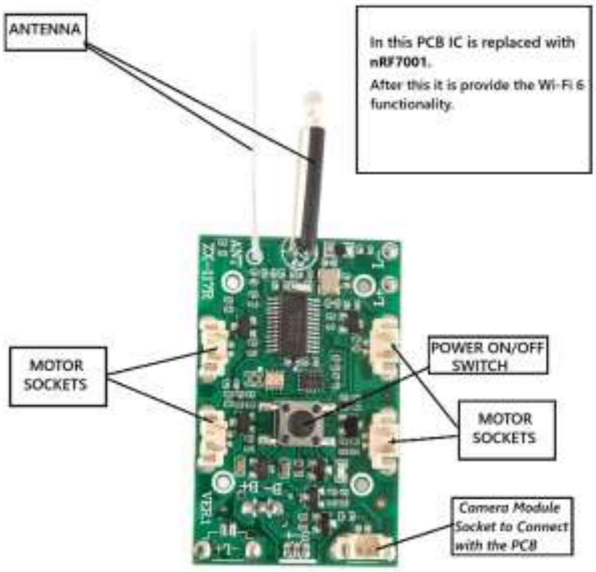

Figure 1. illustrates the E88 pro PCB System Architecture.

Figure 2. Propellers and Motors of the Drone.

Figure 3. nRF7001 IC of the Drone.

Figure 4. DC 3.7 Volts (1800 Mah) Battery.

Figure 5. Mobile Phone Interface to Control the Drone Movements by Using Android Application.

Figure 6. Futuristic Functionality of Mobile Phone Interface.

Figure 7. Drone Model Prototype.

IV. IMPLEMENTATION

A. Assembly and Wiring

To kick things off, we carefully took apart the E88 Pro drone to get direct access to its flight controller. This wasn't just a casual teardown—it required a steady hand and a bit of patience to avoid damaging any of the internal components. Once the casing was removed, we could clearly see the flight controller and identify the pins we needed to tap into for communication and power.

Next, we focused on setting up the communication pathway. The goal was to link an Android app to the drone's flight controller, and we did this using Wi-Fi. This wireless connection allowed the app to send commands and receive data from the drone in real time. But that wasn't the only connection we needed—so we also wired up an SPI (Serial Peripheral Interface) link between the flight controller and the nRF7001 module. This SPI connection is super fast and reliable, perfect for handling the kind of data we wanted to move between the two devices.

Powering the nRF7001 was a bit tricky because it runs on 3.3V, which is lower than what the drone's battery typically supplies. To solve this, we added a buck converter to the setup. This little device steps down the voltage from the drone's power system—usually somewhere between 5V and 12V—to a safe and steady 3.3V. That way, the nRF7001 gets exactly what it needs without risking any damage from overvoltage.

We made all the connections using solid jumper wires and clean solder joints to keep everything secure and minimize interference. To protect the wiring, we used heat shrink tubing and electrical tape wherever needed. Once everything was wired up and double-checked for continuity, we reassembled the drone, making sure nothing was pinched or out of place.

The result? A clean, stable setup that allows the Android app to talk to the drone wirelessly, while the nRF7001 handles fast SPI communication—all powered safely through a regulated supply. It's a neat little system that opens up a lot of possibilities for remote control, telemetry, and future upgrades.

B. Firmware Development

Once the hardware was sorted, we shifted gears to the software side—starting with building a custom Android app using Android Studio. This gave us a solid foundation to create a user-friendly interface that could talk directly to the drone. The app wasn't just a remote control; it was designed to send commands, receive telemetry, and manage real-time feedback—all in one place. We spent time making sure the layout was intuitive, so users could easily navigate controls and monitor flight data without getting lost in menus.

To make the wireless communication fast and reliable, we configured the system to use Wi-Fi 6. That meant diving into the SDK for the nRF7001 module and setting up the Wi-Fi stack properly. Wi-Fi 6 gave us a big upgrade in terms of speed and stability, which is crucial when you're trying to control a drone in real time. We fine-tuned the network settings—like choosing the right channel and adjusting transmission power—to make sure the connection stayed strong even in noisy environments.

C. Communication Protocol

The communication protocol employed in this system leverages the advanced capabilities of Wi-Fi 6, operating under the IEEE 802.11ax standard. This configuration is specifically tuned to support channel bandwidths ranging from 20 MHz to 40 MHz, which strikes a balance between throughput and interference mitigation in dense environments. By utilizing these narrower channels, the system ensures stable connectivity even in scenarios with multiple overlapping networks, such as industrial facilities or smart infrastructure deployments.

Wi-Fi 6 introduces several enhancements over previous generations, including Orthogonal Frequency Division Multiple Access (OFDMA) and Target Wake Time (TWT), which collectively contribute to improved spectral efficiency and reduced power consumption. These features are particularly beneficial for IoT and robotics applications, where numerous devices must communicate simultaneously without overwhelming the network.

To further optimize performance, the protocol integrates Quality of Service (QoS) tagging and packet prioritization mechanisms. QoS tagging enables the classification of data packets based on their type and urgency—such as distinguishing between control signals, telemetry data, and multimedia streams. This classification allows the system to allocate bandwidth and transmission priority dynamically, ensuring that latency-sensitive packets (e.g., real-time sensor feedback or control commands) are delivered with minimal delay.

Packet prioritization is achieved through the implementation of Differentiated Services Code Point (DSCP) values within the IP header, which guide routers and access points in handling traffic according to predefined service levels. This ensures that mission-critical data is transmitted ahead of less time-sensitive information, thereby maintaining the responsiveness and reliability of the overall system.

Additionally, the protocol supports Multi-User Multiple Input Multiple Output (MU-MIMO) technology, allowing simultaneous data streams to be transmitted to multiple devices. This parallelism enhances throughput and reduces contention, which is essential in environments where robotic units or embedded systems require continuous data exchange.

In summary, the communication protocol is meticulously engineered to deliver high-speed, low-latency wireless connectivity using Wi-Fi 6 in 802.11ax mode. By combining efficient channel bandwidth allocation, QoS tagging, and packet prioritization, the system ensures robust and responsive communication tailored to the demands of modern intelligent systems.

V. EXPERIMENT RESULT

A. Test Setup

Indoor/Outer flight tests conducted in a Free – Space by Using Android Mobile Phone Wi-Fi 6 Connectivity.

B. Flight Performance

Metric	Value
Hover Stability	+ 5 or – 5
Max Flying time	25 – 30 minutes
Control Latency	0.1 milliseconds
UAV Weigh with Battery Payload	150g

C. WIFI 6 Performance

Test Parameter	Result
Throughput (TCP)	90 Mbps
Packet Loss (UDP)	<1% approx.
Range (Indoor / Outdoor)	90-100 meters
PCB Range Control (Frequency)	2.4 GHz Frequency Bandwidth

D. Specifications

Specifications	Values
Camera	Dual Camera With 4 Megapixel
Upper Camera	4 Megapixel
Bottom Camera	4 Megapixel
Live video Transmission Rate	Mini. 360p – Maxi. 720p
Live Photo Capture	Max. 720p
Recorded video	Max. 720p
Flying Range	Max. 100 meters
Drone Live Video	Live Video Through Wi-Fi
Drone Control and Live Video Streaming	Can be Control Through Any Android Phone by Using Android Application.
Removable Battery with Type – B charging port	Battery – 3.7 Volts (1800 Mah)
Charging Time up to	1 – 1.5 hours
LED Lights	Number of Lights - 2
4 Motors + 4 Propellers	SP Electron Metal DC 3.7 V + Current 0.8 A + RPM – 48000 (speed)
Motor (Dimensions)	7x16 mm Micro Coreless Motors
Propellers (Dimensions)	45 m CW + 45 mm CCW

E. Sensors Used:

E88 PCB Sensors + IMU	Features
Accelerometer	For Detecting Tilt + Linear Motion
Gyroscope	For Detecting Rotational Motion + Maintaining Stability
Barometer	For Measuring Atmospheric Pressure + Estimate Altitude

F. Total Cost:

Component	Cost
E88 Pro Board	Rs. 189 /-
nRF7001 IC + PCB	Rs. 150 /-
Misc. Components	Rs. 400
	Total Cost: Rs. 739

VI. Discussion

The drone achieved stable flight and reliable communication within a constrained budget. Wi-Fi 6 significantly reduced latency and improved throughput compared to legacy modules. However, limitations include short battery life and limited outdoor range. The modular design allows for future upgrades, such as GPS integration and AI-based navigation. Trade-offs were made in payload capacity and sensor fidelity to maintain cost-effectiveness.

VII. Acknowledgment

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VIII. Conclusion And Future Work

This paper demonstrates the feasibility of building a low-cost aerial robot with Wi-Fi 6 capabilities. The integration of the nRF7001 IC into the E88 Pro platform resulted in a functional, modular drone suitable for educational and prototyping use. Future work will explore swarm coordination using mesh networking, autonomous navigation using computer vision, and outdoor testing with extended range modules.

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