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Cosmo v1

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Abstract: Cosmo FC v1 is a lightweight, modular flight controller architecture designed for autonomous UAVs with a focus on cost-efficiency, reliability, and expandability. At its core lies the STM32H753 microcontroller, which integrates sensor fusion, digital motor control, and real-time telemetry handling. The system features a dual-stack architecture: an FMU (Flight Management Unit) for navigation and control, and a custom 4-in-1 65A ESC for motor driving and power regulation. Sensors such as an IMU, barometer, and current/voltage monitor are directly embedded in the FMU stack, while GPS, LiDAR, and magnetometer are interfaced via dedicated headers. By eliminating separate compute and I/O boards, Cosmo FC v1 achieves a smaller footprint and reduced weight, making it ideal for mid-sized quadcopters requiring autonomous flight capabilities.
Keywords: UAV, Flight Controller, STM32H753, DShot, Autonomous Drones, Sensor Fusion, LiDAR, ESC, Embedded Systems

I. INTRODUCTION

The demand for reliable and efficient UAV flight control systems has increased with the growth of autonomous aerial platforms. Traditional flight controllers often rely on multiple PCB layers or separate compute boards, adding to weight, complexity, and cost. Cosmo FC v1 addresses this by implementing a two-stack architecture: one for flight management and sensor fusion (FMU), and another for direct motor driving (ESC). Leveraging the STM32H753 microcontroller, known for its high-speed processing, large flash and RAM, and robust peripherals, the FMU performs real-time control, integrates multiple sensors, and communicates with a custom ESC system using digital protocols such as DShot and UART telemetry.

II. SYSTEM ARCHITECTURE

Cosmo FC v1 comprises:

1) *FMU Stack:*

- Core STM32H753 MCU
- SPI and I²C-based sensors (IMU, barometer, INA226)
- UART interfaces for GPS and LiDAR
- USB-C for configuration and flashing
- 4 PWM/DShot motor outputs
- 4 PWM/DShot motor outputs
- External headers for GPS+Magnetometer and TF-Luna

2) *ESC Stack:*

- Custom-built 4-in-1 65A ESC
- STM32G431 MCU for motor commutation
- N-channel MOSFETs with gate drivers
- DShot600 signal input from FMU
- UART telemetry output back to FMU
- Integrated 5V BEC to power FMU

III. SENSOR INTEGRATION AND CONTROL INTERFACES

A. Sensors

The FMU board integrates:

- ICM-45686 for 6-axis orientation (SPI interface)
- BMP390 barometer for altitude estimation (I²C interface)
- INA226 for current and voltage monitoring (I²C)

- External HMC5883L magnetometer via I²C
- External GPS module (u-blox NEO-6M) via UART
- External TF-Luna LiDAR via UART for precision landing and obstacle detection

B. Motor Control

The FMU sends DShot600 signals to the ESC stack via TIM1 channels (PA8–PA11). These digital signals are decoded by the STM32G431 and used to commutate BLDC motors. DShot enables precise control and supports telemetry.

C. ESC Telemetry

Each ESC sends back telemetry (current, temperature, RPM, voltage) to the FMU via UART. The STM32H753 processes this data in real-time for monitoring and failsafe triggering.

IV. POWER AND COMMUNICATION DESIGN

1) Power is supplied to the FMU stack as regulated 5V from the ESC board via a buck converter.
2) Onboard LDO (e.g., LD1117) provides clean 3.3V for sensors and MCU.
3) USB-C with ESD protection enables firmware flashing and serial debug access.
4) All communication buses (SPI, I²C, UART) are carefully routed and filtered for noise immunity.

V. PCB DESIGN AND LAYOUT

The PCB design prioritizes:

1) Noise isolation: separating power and sensor lines
2) Short trace lengths: especially for SPI and PWM signals
3) Decoupling: with low ESR capacitors on all supply rails
4) Thermal management: on the ESC stack with heatsinks and ventilation
5) Modularity: with stack-to-stack headers for ease of assembly

The FMU PCB measures approximately 60mm x 60mm, fitting standard 250–450mm drone frames. It's developed in both Altium Designer and KiCad for cross-platform compatibility.

VI. RESULTS AND DISCUSSION

Initial tests on a 4-motor quadcopter showed:

1) Stable autonomous navigation using GPS and LiDAR
2) Accurate altitude hold within ±0.5 meters
3) Reliable telemetry reporting (ESC current, voltage, temp)
4) USB-C configuration support with STM32Cube and custom bootloader
5) Low EMI impact due to careful signal routing and grounding

This validates the hardware and communication integrity under typical flight conditions.

VII. CONCLUSION

Cosmo FC v1 offers a compact and affordable solution for developers, researchers, and hobbyists building autonomous drones. By combining high-performance real-time processing, robust sensor integration, and digital motor control into a 2-stack PCB, it reduces complexity while maximizing functionality. Its design allows for future expansion to include image processing via Raspberry Pi CM5 or UAVCAN-based ESCs. The system is ideal for medium-lift quadcopters, VTOL research platforms, and educational robotics.

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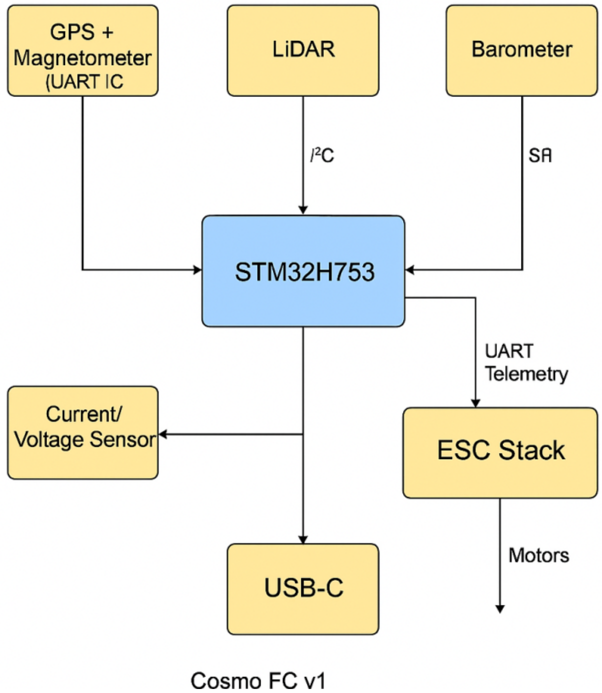

(i)Basic Working

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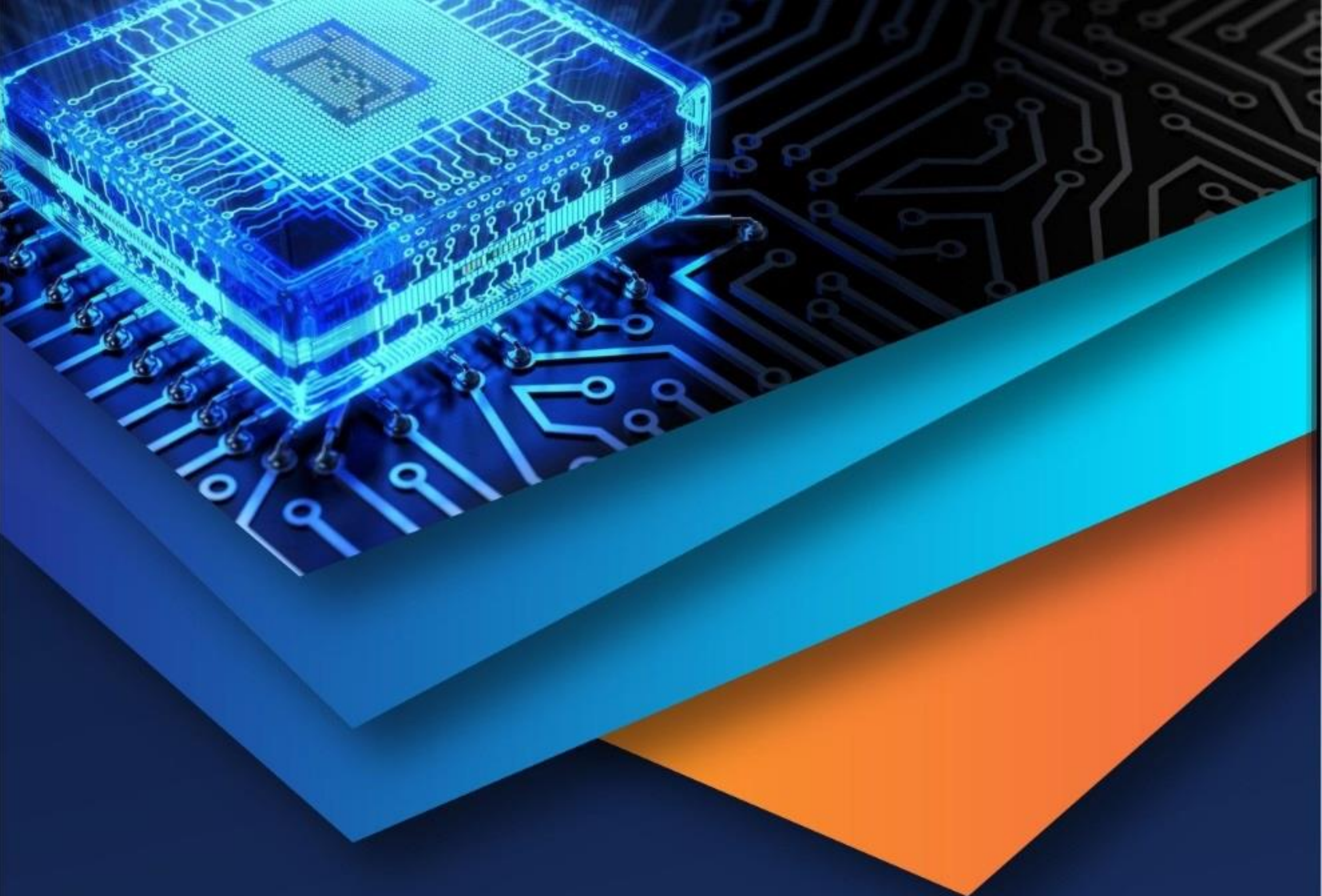

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