Digital system of the aircraft - How does it work?

A flight controller is the most crucial part of any modern autonomous UAV. It allows for:

- precise flight control,
- real time data transmission,
- use of various sensors,
- flight support for the pilot,
- complete autonomy with minimal input from the pilot,
- fine tuning of UAVs parameters to guarantee good performance in any circumstances.

The model we have chosen for the UAV “Szczerbatek” is Matek H743 WING V2 (figure 1). The decision was dictated by the low cost when compared to alternative flight controllers (for example PixHawk Orange Cube) and its lightweight and good MCU – STM32H747The Matek H743-WING V2 is a high-performance flight controller tailored for fixed-wing UAVs and advanced FPV applications. It features a 480MHz STM32H743VIT6 processor, dual IMUs (MPU6000 and ICM42605), and an Infineon DPS310 barometer, ensuring precise flight control and stability. The controller supports 13 PWM outputs, 7 UARTs with built-in inversion, and includes a CAN bus interface, offering extensive connectivity for various peripherals. Power management is robust, with integrated BECs providing 5V, 9V/12V, and adjustable servo outputs up to 8A continuous current. Additional features include a microSD slot for blackbox logging, dual camera input switching, and compatibility with firmware platforms like ArduPilot and INAV, making it a good choice for aerial systems.

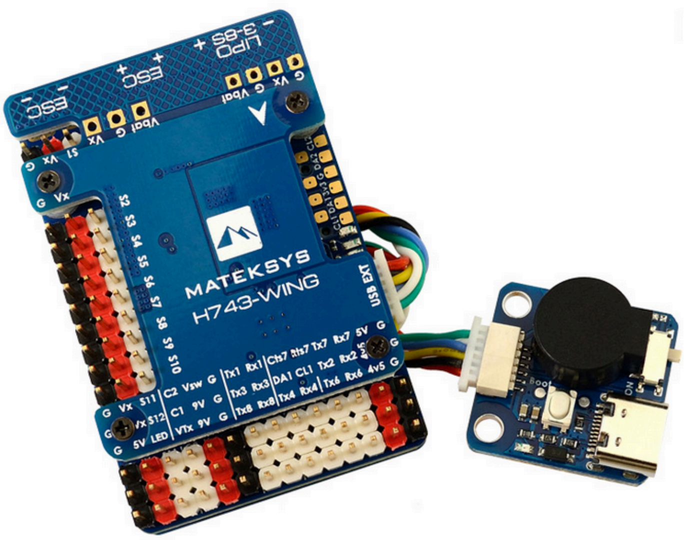

Figure 1. Mateksys H743-Wing [1]

GPS module

The Matek M8Q-5883 (figure 2) is a compact GPS and compass module designed for UAVs, robotics, and RC applications. It integrates a 72-channel u-blox SAM-M8Q GNSS receiver supporting GPS, GLONASS, Galileo, QZSS, and SBAS, along with a QMC5883L 3-axis digital compass. The module features a built-in 15x15 mm RHCP ceramic patch antenna, an ultra-low-noise 3.3V regulator, an LNA, and a SAW filter to enhance signal quality and reduce interference. It offers a maximum update rate of 18 Hz for single GNSS and 10 Hz for dual GNSS configurations, with a horizontal position accuracy of 2.5 m CEP and velocity accuracy of 0.05 m/s. The M8Q-5883 supports UART and I2C interfaces, operates within a 4–6V input range, and is compatible with flight control systems like INAV, Betaflight, and ArduPilot. Its compact dimensions (20 x 20 x 10 mm) and lightweight design (7 g) make it suitable for space-constrained applications.

Figure 2. GPS & Compass module M8Q-5883 [2]

Digital airspeed sensor

The Matek ASPD-4525 Pitot Tube Airspeed Sensor (figure 3) module is designed for accurate airspeed measurement in fixed-wing UAVs. It uses the TE 4525DO-DS5AI001DP differential pressure sensor, capable of detecting pressure ranges up to 1 PSI with a maximum limit of 20 PSI, delivering data via an I2C interface (SCL/SDA). Operating at 4–5.5V DC with a minimal current draw of 5mA, the module provides high precision with ±0.25% accuracy across a wide temperature range of -40°C to 125°C. The system includes a sensor board, pitot tube, silicon tubing, and wiring harness for seamless integration with flight controllers. Airspeed is determined by measuring the pressure differential between static and dynamic ports of the pitot tube, applying Bernoulli’s principle to convert this into a reliable airspeed value used for navigation and control.

Figure 3. Digital airspeed sensor ASPD-4525 [3]

KST Servomotor

The KST X10 Mini Pro-A (figure 4) is a high-performance digital servo engineered for precision control in competition and large-scale gliders. This model has hight enough power to precisely move each steer of the aircraft, even at its optimal speed of 25 ms. Featuring a coreless DC motor and hardened steel gear train housed within a CNC-machined aluminium alloy case, it delivers exceptional torque and speed across a wide voltage range. Operating between 4.8V and 8.4V, the servo provides up to 8.0 kgf.cm of torque and achieves speeds as fast as 0.08 seconds per 60° rotation at the highest voltage. Its programmable features, including soft start and adjustable travel angles, allow for tailored performance to meet specific application requirements. With a compact form factor of 30 x 10 x 28 mm and a weight of approximately 20 grams, the X10 Mini Pro-A is optimized for installations where space and weight are critical considerations. The servo accepts standard PWM signals with pulse widths ranging from 900 to 2100 microseconds, corresponding to a total travel angle of 120°, making it a versatile choice for advanced aeronautical applications.

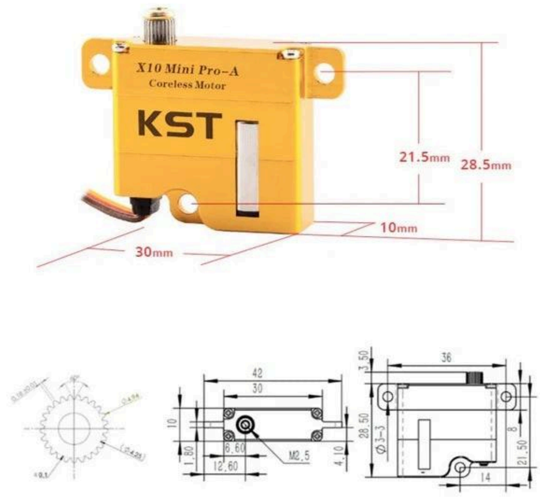

Figure 4. KST Servo - X10 Mini Pro-A Wing [4]

Telemetry modules

For long range radio communication we use 2 separate MAVLink based solutions for the telemetry and the Radio Control. This approach guarantees smooth and stable data transmission for even longer distances.

mLRS MAVLink 900MHz Receiver, mR900-30 – telemetry

The Matek MLRS module (figure 5) is a high-power, long-range LoRa-based telemetry solution designed for UAV communication systems. Built around the STM32G431KB microcontroller and LoRa SX1262 transceiver with a TCXO, the module supports RF frequencies cantered around 900MHz (868/915MHz depending on region) with selectable output power up to 30dBm (1W).

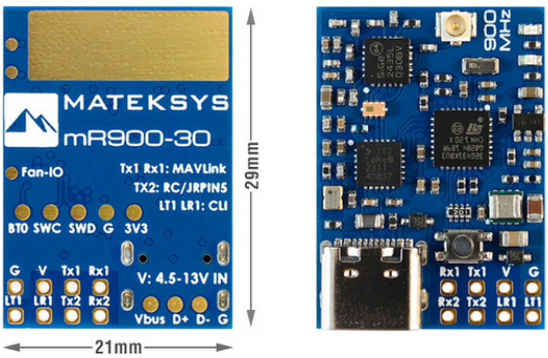

Figure 5. mR900-30 Receiver [5]

ExpressLRS 2.4ghz Nano Receiver – Radio Control

The RadioMaster RP1 V2 is ExpressLRS 2.4GHz (figure 6) nano receiver designed for high-performance FPV applications. Built around the ESP8285 microcontroller and Semtech SX1281 RF chip, it delivers latency and high refresh rates—up to 500Hz or F1000Hz—making it ideal for both long-range flights and competitive racing. The receiver features a U.FL connector paired with a 65mm T-style antenna for full-range signal reception, and a built-in temperature-compensated crystal oscillator (TCXO) ensures frequency stability across varying environmental conditions. Integrated Wi-Fi allows for firmware updates via the web.

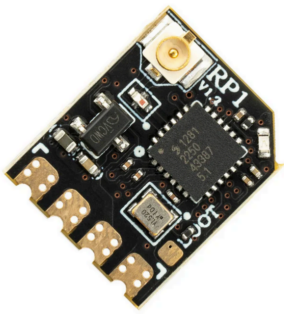

Figure 6. V2 ExpressLRS 2.4ghz Nano Receiver [6]

Ranger Micro 2.4GHZ ELRS – TX module compatible with RX eLRS

The RadioMaster Ranger Micro 2.4GHz ELRS Module (figure 7) is a powerful transmitter module, featuring a high-efficiency cooling system and supports packet rates up to F-1000Hz, delivering low-latency performance ideal for demanding applications. Powered by an ESP32 main MCU and an ESP8285 auxiliary MCU, it utilizes the SX1281IMLTRT RF chip to operate within the 2400–2480 MHz frequency range. The module offers adjustable RF output power, with 30dBm for FCC and 20dBm for CE regions, and supports both Wi-Fi and Bluetooth connectivity. The Ranger Micro fits JR-style micro module bays, making it compatible with a variety of radios. For users in Europe, the module is pre-installed with ExpressLRS CE EU domain LBT firmware, limiting the maximum power output to 100mW which is useful for our testing in Poland.

Figure 7. Ranger Micro 2.4GHZ ELRS Module [7]

Digital Camera

Camera used for vision systems by our software engineers needed to be small to accommodate aircraft sizes, durable to withstand pressure and the toughest of landings and with high resolution. The selected GoPro HERO11 Black (figure 8) is an action camera designed for capturing high-quality footage in various environments. It is a standalone device in the aircraft, meaning it does not interact with any of the mentioned digital components. Its only purpose is to capture video for later analysis on the ground. It features a 1/1.9-inch CMOS sensor capable of recording up to 5.3K video at 60 frames per second and capturing 27MP still photos. The camera supports multiple aspect ratios, including 8:7, 4:3, and 16:9, providing flexibility for different shooting needs. Advanced stabilization is achieved through HyperSmooth 5.0 technology, which includes Horizon Lock and AutoBoost features to maintain smooth and level footage even during dynamic movements.

Figure 8. GOPRO HERO 11 BLACK [8]

System setup

With all the digital components chosen, we connected them to designated flight controller pins and configured the aircraft through The Mission Planner software, having previously flashed the MCU with Ardupilot firmware. The connection diagram for the digital system is shown in figure 9 below.

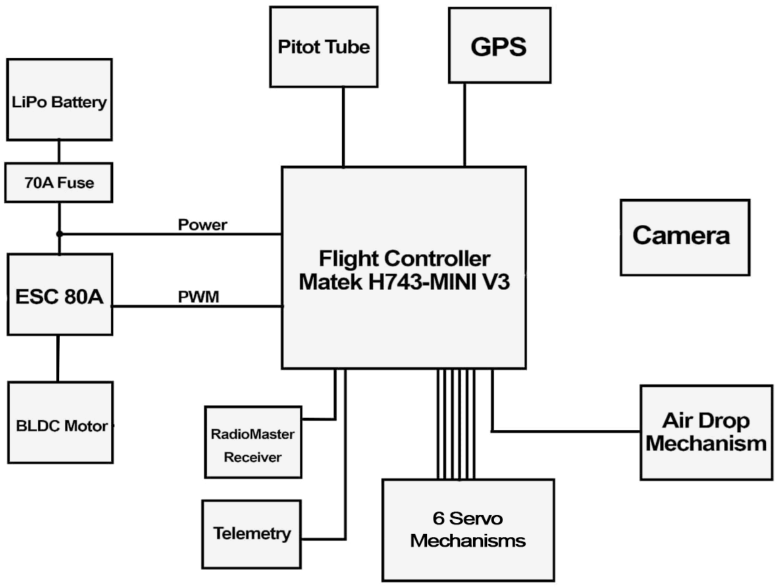

Figure 9. UAV electronic system connection diagram.

Although The motor, battery and ESC are all crucial parts of the aircraft, they have been presented in depth in other design documents. This one is only focused on digital sensors and communication systems.

Bibliography

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