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 “Rico’’ is Matek H743 WING V3 (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 V3 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.

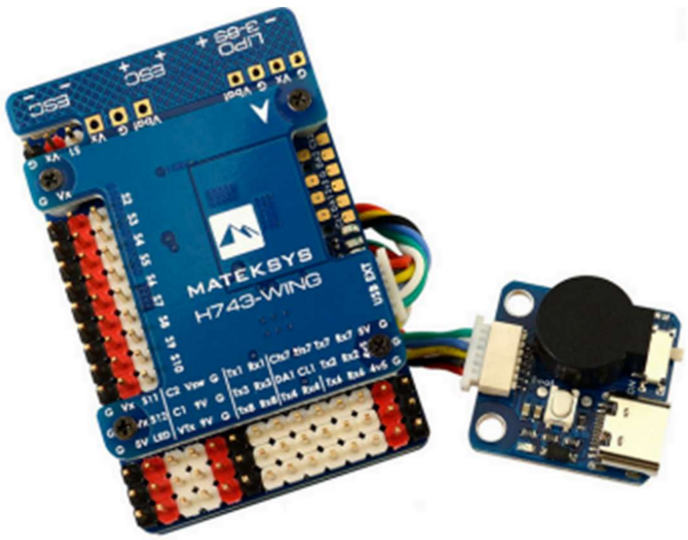

Figure 1 Mateksys H743-Wing [1]

GPS module

The **Foxeer M10Q 250 GPS QMC5883 Compass** (Figure 2) is a compact GPS and compass module designed for UAVs, autonomous robots, and RC aircraft. It integrates a high-performance **u-blox M10 GNSS receiver**, providing support for multiple satellite constellations, including **GPS, GLONASS, Galileo, BeiDou, and QZSS**, together with a **QMC5883 3-axis digital compass** for accurate heading determination. The module features a high-gain ceramic patch antenna and a low-noise RF front-end, ensuring reliable satellite reception and fast positioning even in challenging environments. The M10 GNSS receiver offers improved sensitivity, lower power consumption, and faster time-to-first-fix (TTFF) compared to previous M8-series receivers, with an update rate of up to **10 Hz** and horizontal positioning accuracy of approximately **1.5 m CEP** under open-sky conditions. The module communicates via the **UART** interface for GNSS data and **I2C** for the compass, making it fully compatible with popular flight controllers running **ArduPilot, INAV,** and **Betaflight**. Its lightweight and compact design makes it well suited for space-constrained UAV applications where precise navigation and heading information are required.

Figure 2 Foxeer M10Q 250 GPS QMC5883 Compass [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]

Servomotors

Three different digital servo models were selected for the aircraft, each chosen according to the mechanical and performance requirements of a specific subsystem. The **KST X10 Mini Pro-A** servos (Figure 4) are used to actuate the **ailerons and flaps**, where high torque, fast response, and precise positioning are essential to ensure accurate control during all phases of flight. These servos feature a coreless DC motor, hardened steel gears, and a CNC-machined aluminium housing, delivering up to **8.0 kg·cm** of torque over an operating voltage range of **4.8–8.4 V**, with a maximum speed of **0.08 s/60°** at 8.4 V. The **CHA Servo HV85** is installed in the **horizontal stabilizer** to control the elevator. Its high-voltage design, metal gear train, and high positioning accuracy provide reliable operation under aerodynamic loads while maintaining smooth and precise pitch control. The **X06H** digital servo is dedicated to the **payload release mechanism**, where its compact size, low weight, and sufficient output torque make it well suited for actuating the release system without adding unnecessary mass to the aircraft. All three servos are controlled using standard PWM signals and are fully compatible with the selected flight controller, ensuring reliable and accurate actuation of both the aircraft control surfaces and auxiliary mechanisms.

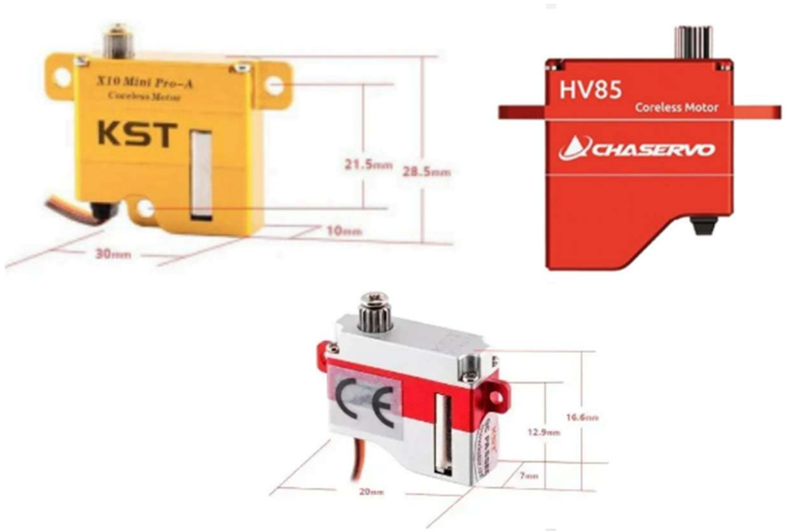

Figure 4 KST X10 mini pro-A, CHA Servo HV85, KST x06h

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).

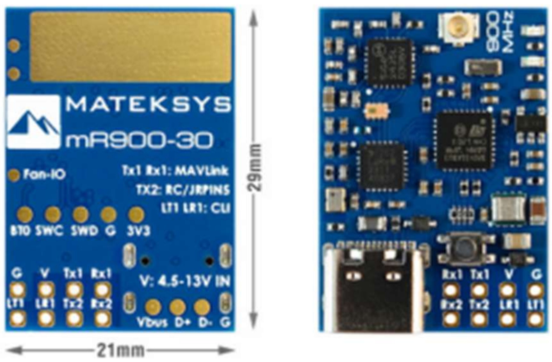

Figure 5 mR900-30 Receiver [5]

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

The camera selected for the onboard vision system is based on the **AR0234 Global Shutter** image sensor (Figure 8). It was chosen due to its compact size, low latency, and ability to capture distortion-free images during high-speed aircraft manoeuvres, making it well suited for real-time computer vision applications. The AR0234 is a **2.3-megapixel CMOS global shutter sensor** with a maximum resolution of **1920 × 1200 pixels** and supports frame rates of up to **120 frames per second** at full resolution. Unlike rolling shutter sensors, the global shutter architecture captures all pixels simultaneously, eliminating motion distortion and image skew caused by rapid movement or vibration. The sensor provides high sensitivity, a wide dynamic range, and low readout noise, enabling reliable operation under varying lighting conditions encountered during outdoor flights. Its compact dimensions, low power consumption, and support for high-speed digital interfaces make it suitable for integration with embedded vision systems, where the captured images are processed in real time by the onboard computer for navigation, object detection, and other autonomous flight tasks.

Figure 8 AR0234 Global Shutter sensor [10]

Lidar

The **Benewake TF-Luna LiDAR** (Figure 9) was selected to provide accurate short-range distance measurements for the aircraft. Its compact dimensions, lightweight design, and low power consumption make it well suited for integration into small UAV platforms. The TF-Luna is a single-point **time-of-flight (ToF) laser rangefinder** capable of measuring distances from **0.2 m to 8 m** under typical outdoor conditions, with a measurement frequency adjustable from **1 Hz to 250 Hz**. It provides a distance accuracy of approximately **±6 cm** within its optimal operating range and maintains stable performance under varying ambient lighting conditions. The sensor communicates via **UART** or **I²C** interfaces, allowing straightforward integration with the onboard flight controller or companion computer. Operating from a **5 V** supply, the TF-Luna consumes less than **0.35 W**, making it suitable for battery-powered applications where power efficiency is important. In the developed aircraft, the LiDAR is used to measure the altitude above ground during low-altitude flight and landing, providing accurate height information when GNSS-based altitude estimates are insufficient. Its fast response time and reliable distance measurements improve the precision and safety of autonomous flight operations near the ground.

Figure 9 Benewake TF-Luna LiDAR [11]

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 10 below.

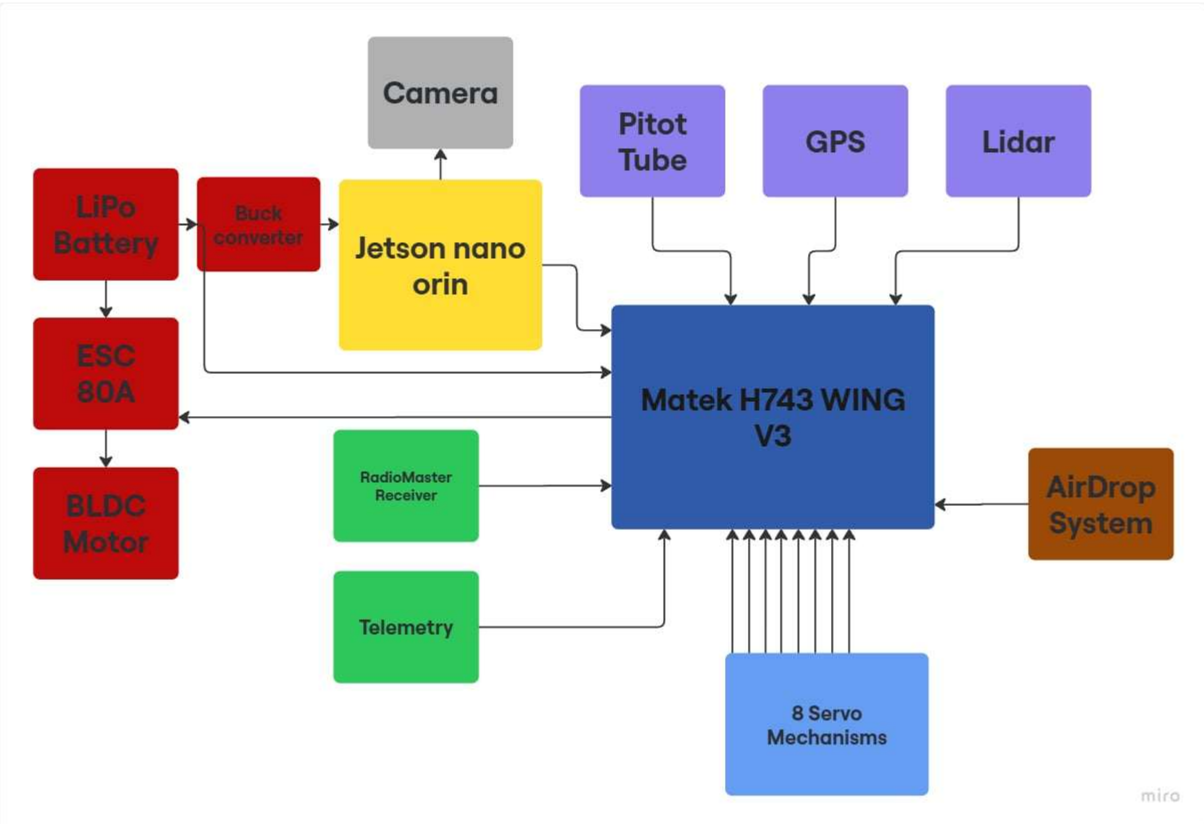

Figure 10 UAV electronic system connection diagram.

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.

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