USX51 Flight Controller Product Manual – Table of Contents

1.1.1 Overview

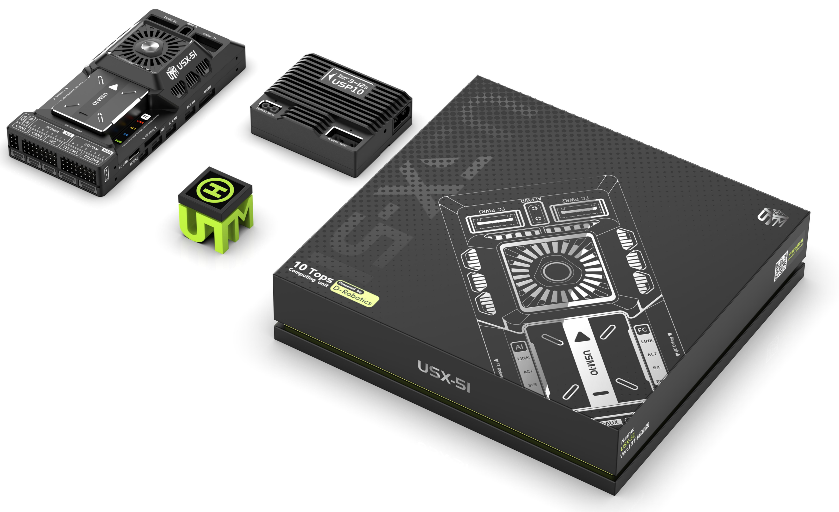
USX51 is a heterogeneous computing flight-control system designed for autonomous flight and intelligent perception applications. It is jointly built with the UTMTEK Pixhawk 6X flight controller and the D-Robotics RDK X5 compute module.

The RDK X5 module provides high-performance AI and general-purpose computing capability, handling compute-intensive workloads such as perception, localization, and decision-making. The Pixhawk 6X focuses on real-time flight control and execution-layer logic, ensuring stable and controllable flight behavior even when complex algorithms are running.

By connecting the two computing units through a high-speed data link, USX51 achieves system-level decoupling between control and perception, providing a reliable hardware foundation for complex autonomous flight applications.

These capabilities do not operate in isolation. They are built on the USX51 heterogeneous system architecture. By clearly defining the responsibility boundaries between flight control and high-compute processing, the system maintains flight stability while supporting the long-term, reliable operation of complex algorithms.

USX51 adopts a heterogeneous computing architecture in which different interfaces serve different computing units and data types. Before connecting peripherals, it is important to understand the design intent of each interface in order to avoid data conflicts or performance bottlenecks.



1.1.2 Functional Features

● High-performance main control processor
Powered by an STM32H7 series processor with a main frequency of up to 480 MHz and support for double-precision floating-point operations. It provides sufficient computing resources for flight-control algorithms, state estimation, and functional expansion, making it suitable for complex flight-control and mission applications.

● Triple-redundant IMUs and dual barometers
Equipped with three independent IMUs, each designed with separate buses and power domains, and integrated dual redundant barometers. The system supports automatic switching in the event of sensor anomalies, improving overall system stability and flight safety.

● 100 Mbps Ethernet communication interface
Integrated 100 Mbps Ethernet PHY, enabling high-speed data communication with mission computers or external payload devices, meeting the requirements for high-bandwidth data transmission and extended applications.

● Vibration isolation structure and low-noise IMUs
Designed with a dedicated vibration-damping structure combined with low-noise IMUs, effectively reducing the impact of high-frequency vibrations on sensor data, and improving attitude estimation stability and flight-control consistency.

● Dual firmware support
Supports both PX4 and ArduPilot firmware. Users can choose or switch flight-control firmware based on project requirements, suitable for research, development, and various professional application scenarios.

1.2.1 Technical Specifications

FMU Processor: STM32H753
32-bit Arm® Cortex®-M7, 480 MHz, 2 MB Flash, 1 MB RAM

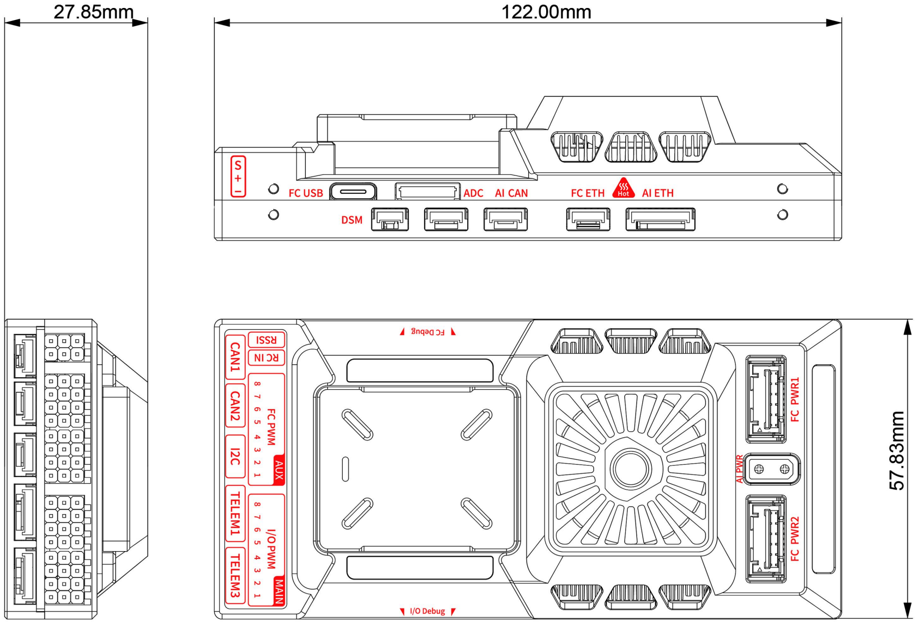
IO Processor: STM32F103
32-bit Arm® Cortex®-M3, 72 MHz, 64 KB SRAM

Onboard Sensors
Accelerometer / Gyroscope: 3 × ICM-45686
Barometers: ICP20100 and BMP388
Magnetometer: BMM150

Electrical Data
Rated voltage:
Maximum input voltage: 6 V
USB power input: 4.75–5.25 V
Servo rail input: 0–36 V

Current rating:
TELEM1 output current limiter: 1.5 A
All other ports combined output current limiter: 1.5 A

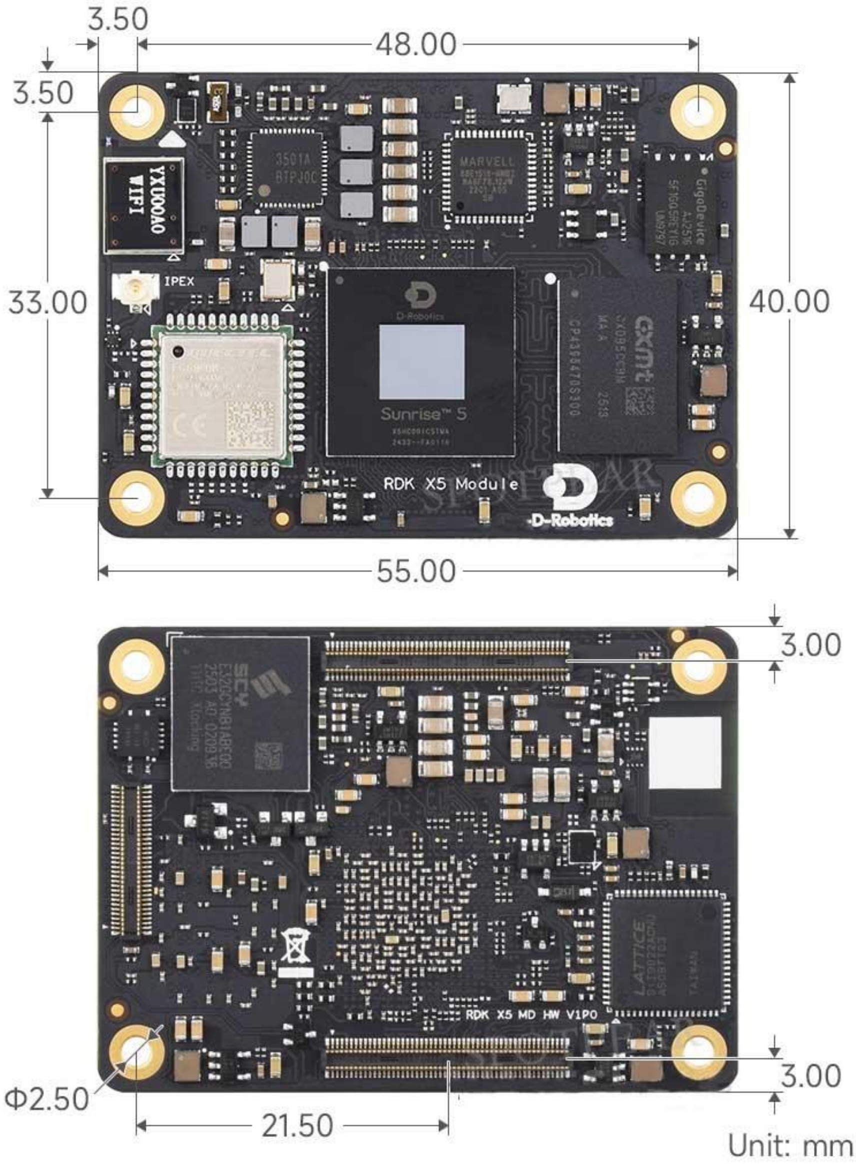
Mechanical Data
Dimensions: 57.83 mm × 122.00 mm × 27.85 mm
Weight: 170 g



2. RDK X5 Core Module

USX51 uses the D-Robotics RDK X5 Module as its onboard AI computing base module. The module is built on the Sunrise 5 intelligent computing chip, providing up to 10 TOPS of AI computing power, along with a mature software ecosystem. It is well suited for robotics and edge intelligent computing scenarios.

Within the USX51 system, the RDK X5 Module primarily handles high-level perception and AI inference tasks, such as object recognition, visual understanding, and intelligent decision-making. Flight control, real-time sensor fusion, and motion control are handled by the USX51 flight control system. The two work together through high-speed communication interfaces, forming a complete AI flight control system architecture.



2.1.1 Capability Description

Supported algorithm types include, but are not limited to:

- Object detection (such as YOLO, FCOS, Faster R-CNN, etc.)
- Image classification
- Semantic segmentation
- Multi-object tracking and speech processing

For detailed information on supported models and development methods, please refer to the official D-Robotics documentation:
https://developer.d-robotics.cc/rdk_doc/RDK

2.1.2 Specifications

- **CPU:** 8 × Cortex-A55 @ 1.5 GHz
- **RAM:** 8 GB LPDDR4
- **BPU (AI computing power):** 10 TOPS
- **GPU:** 32 GFlops
- **Storage:** 32 GB eMMC
- **Multimedia:** H.265 / H.264 hardware encoding and decoding
- **Power:** 5 V / 5 A
- **System:** Ubuntu 22.04

Provides an independent power input and supports peripheral expansion. Interfaces include Ethernet, USB, HDMI, and CSI camera, for running AI perception and high-level computing tasks. For detailed interface descriptions and development methods, please refer to the official documentation: https://developer.d-robotics.cc/rdk_doc/RDK *RDK X5 Module User Guide*

3. USX51 System Architecture

3.1.1 Core Modules and Role Allocation

USX51 adopts a **layered and collaborative AI flight control architecture**, composed of three core units, each with clearly defined responsibilities:

- **RDK X5 Module (AI Perception and Computing Unit)**

Responsible for high-level perception and AI inference tasks, such as visual recognition and environmental understanding
Supports dual CSI camera inputs and provides HDMI display output
Provides high-speed peripheral interfaces such as USB 3.0 / USB 2.0
Operates with an independent power input (5 V @ 5 A)

- **Pixhawk 6X (Primary Flight Control Unit)**

Responsible for flight control, navigation computation, mission scheduling, and system communication
Supports PX4 / ArduPilot flight control firmware
Provides multiple interfaces including ETH, CAN, UART, I2C, and SPI
Manages key peripherals such as GPS, RC receivers, and storage devices

- **STM32F103 (I/O Execution and RC Processing Unit)**

Responsible for PWM output and RC signal input (DSM / PPM / SBUS)
Acts as an I/O co-processor to offload real-time execution tasks from the main controller
Provides debug interfaces for system development and maintenance

3.1.2 Module Collaboration Method

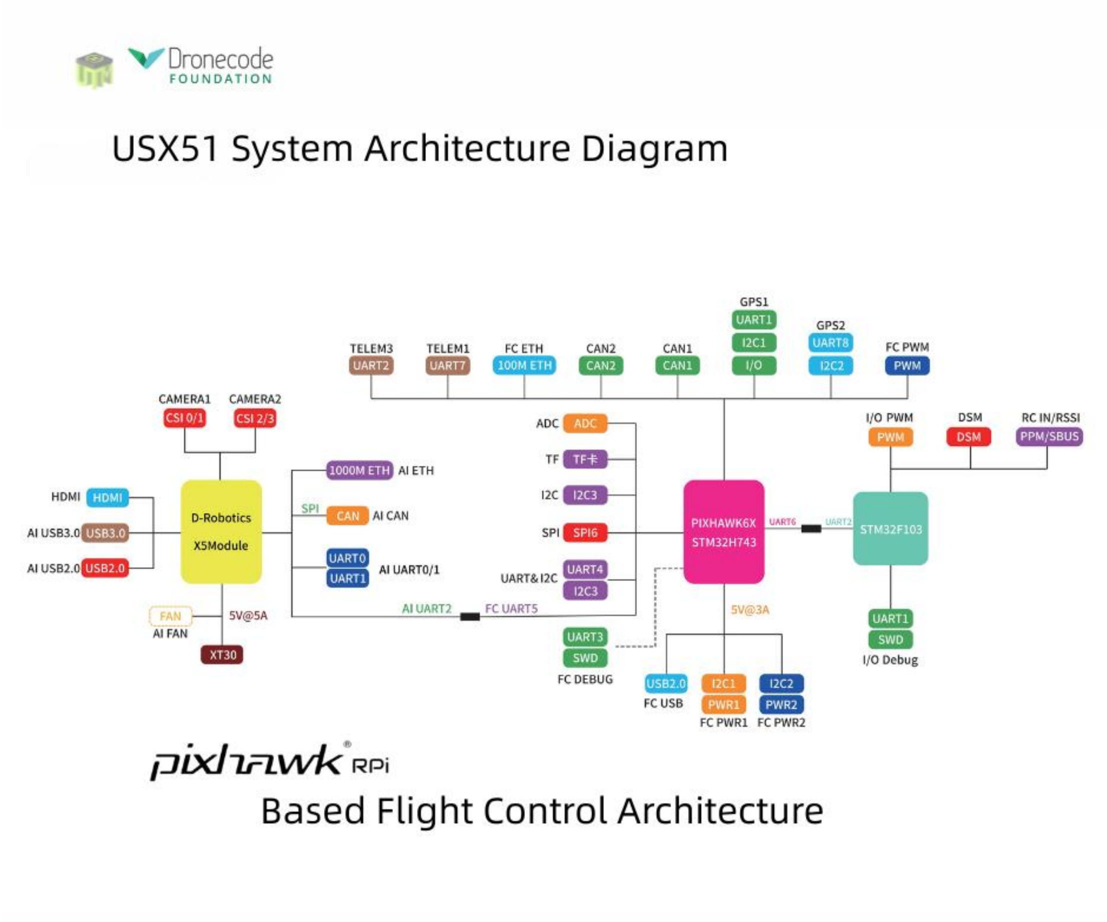
The modules work together through high-speed and serial interfaces to form a complete system:

● **AI module → Flight controller**
Perception and inference results are transmitted via high-speed interfaces

● **Flight controller → I/O unit**
Control commands are issued through serial interfaces

● **Peripherals (GPS, RC, storage)** are connected directly to their corresponding modules

This architecture decouples AI perception, flight control, and execution output, balancing real-time performance, stability, and expandability while avoiding redundant data paths.



●Architecture Characteristics

Layered design with clear role separation
High-speed interfaces and control interfaces are allocated based on data types
Supports collaborative operation between AI computing and traditional flight control systems

●Core Capability Support: Dual-System Collaborative Architecture

Flight control: Pixhawk 6X running PX4 / ArduPilot
AI computing: RDK X5 Module providing up to 10 TOPS of AI computing power
Enables deep collaboration between flight control and edge intelligence

•AI Computing and Algorithm Support

Supports AI tasks such as object recognition, multi-object tracking, and semantic segmentation
Specific algorithm implementation and deployment depend on user development configuration
For the complete AI framework, please refer to the official D-Robotics documentation

•Navigation and Localization Capabilities (Platform Support)

Supports visual odometry (VIO) and LiDAR odometry (LIO)
Supports SLAM mapping and path-planning algorithms
Actual functionality depends on sensor configuration and software implementation

•Industrial-Grade Reliability Design

Wide operating temperature range
Anti-interference design suitable for complex electromagnetic environments
Multiple redundancy and vibration-damping design to enhance system stability

4. Interface Overview

4.1.1 Basic User Interface Description

USX51 provides a complete combination of flight control and AI expansion interfaces, supporting multi-sensor integration, complex mission execution, and high-reliability communication. It is suitable for UAVs, robots, and intelligent vehicle applications.

Main interface capabilities include:

● 16 PWM servo outputs for connecting motor ESCs, servos, or robotic arm joint actuators

● RC receiver inputs supporting mainstream protocols such as Spektrum / DSM, PPM, and S.Bus, allowing direct connection to common receivers

● Multiple communication interfaces (UART / Telem) for connecting data radios, laser rangefinders, serial sensors, and other peripherals, enabling communication with ground stations or other computing units

● Dual GPS interfaces supporting primary and backup GPS connections for high-reliability positioning and redundancy configurations

● CAN bus interfaces (2 channels) for connecting CAN peripherals such as smart ESCs, CAN GPS, and CAN sensors

● Ethernet interface (100 Mbps) supporting high-speed data communication with mission computers or AI modules

● Power input interfaces (2 channels) supporting power module connections and providing voltage and current monitoring

(This section is intended for users who are new to USX51, helping them quickly understand interface capabilities and common usage scenarios. For detailed pin definitions and bus descriptions, please refer to the "Developer Interface Description.")

4.1.2 Developer Interface Description

PWM / Actuator Interfaces
16 PWM servo outputs for motor ESCs, servos, or other PWM-driven actuators.

R/C Input Interfaces
Spektrum / DSM input

PPM / S.Bus dedicated input
Analog / PWM RSSI input and S.Bus output

Serial Communication Interfaces
4 general-purpose serial ports (UART)
3 ports support full hardware flow control
1 Telem1 port with an independent 1.5 A current limiter
One port is multiplexed with I2C and an external NFC GPIO

GPS Interfaces
2 GPS interfaces
1 full GPS interface with safety switch support
1 basic GPS interface

Bus Interfaces
I2C ×1
SPI ×1
2 chip select (CS) lines
2 data-ready (DRDY) lines
1 SYNC line
1 RESET line
CAN ×2
Supports independent silent control or ESC RX-MUX

Network Interface
Ethernet (ETH)
Transformerless design
100 Mbps

Power and Analog Interfaces
Power input ×2 (SMBus supported)
Analog inputs:
1 AD / IO input
2 additional analog inputs
1 PWM / capture input

Debug and Expansion
2 dedicated debug / GPIO lines

Environmental Specifications
Operating and storage temperature: −40 to 85 °C