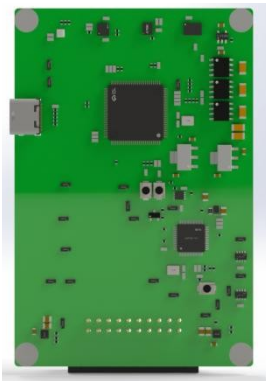
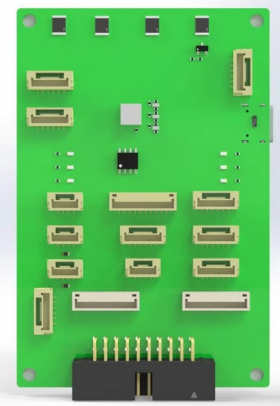
RIVO-X Technical Documentation

1. Overview



This document serves as the Hardware Technical Specification for the RIVO-X Autopilot. It defines the hardware architecture, core chip configuration, sensor parameters, external interface definitions, mechanical and electrical characteristics, protection circuit design, and the Bill of Materials (BOM) / hardware solution. It acts as the official technical basis for product R&D, testing, mass production, delivery, and customer integration.

2. System Architecture

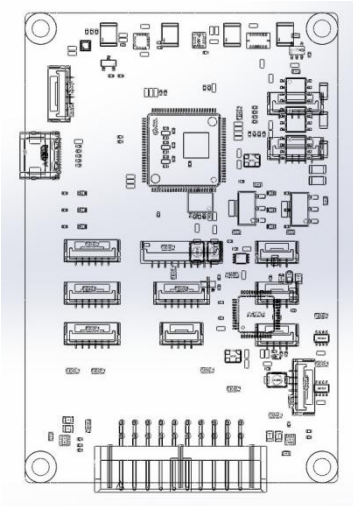


This specification defines the hardware architecture of the RIVO-X Autopilot, which is built around an STM32H743VIT6 main controller and an STM32F103C8T6 co-controller, and adopts a heterogeneous dual-IMU and dual-magnetometer architecture. The hardware integrates comprehensive TVS surge and ESD protection, together with TDK feedthrough capacitor-based EMC filtering circuits. It employs a triple-storage architecture comprising FM25V02A FRAM, 24LC64 EEPROM, and a MicroSD card. The board uses unified IDC and GH1.25 anti-loosening connectors, provides independent dual programming ports, and features a full onboard PCB vibration isolation design.

3. Terms and Abbreviations

Abbreviations and Acronyms	Full Name	Description
FMU	Flight Management Unit	
IMU	Inertial Measurement Unit	
EKF	Extended Kalman Filter	
GNSS	Global Navigation Satellite System	
RTK	Real-Time Kinematic	
SBUS	Serial Bus	
PWM	Pulse Width Modulation	
TOF	Time of Flight	
MAVLink	Micro Air Vehicle Link	
CAN	Controller Area Network	
I2C / SPI	Inter-IC Circuit / Serial Peripheral Interface	
DC-DC	Direct Current to Direct Current	
LDO	Low Dropout Regulator	
EEPROM	Electrically Erasable Programmable ROM	
FRAM	Ferroelectric Random Access Memory	
EMC	Electromagnetic Compatibility	
TVS	Transient Voltage Suppressor	
ESD	Electrostatic Discharge	
GH1.25	1.25 mm pitch wire-to-board connector	
IDC	Insulation Displacement Connector	

4. Overall Hardware Design Features



The layout and routing of this autopilot hardware adopt an industrial-grade design philosophy focused on anti-interference and high consistency. A comprehensive hardware architecture is built around high-precision sensor acquisition, stable signal transmission, electromagnetic interference (EMI) suppression, and vibration environment control. This architecture fundamentally ensures attitude acquisition accuracy and overall system stability, fully implementing four major design schemes: comprehensive EMC protection, multi-domain isolated power supply, triple-layer storage, and internal vibration isolation protection.

4.1. Sensor Partition Isolation Design

The BMI088, ICM42688, and onboard IST8310 are co-located at the head of the PCB, kept away from DC-DC converters, LDOs, and high-current power traces. The BMP390 is placed independently in an isolated area at the upper-right corner of the board. All analog sensors are powered by dedicated TI ultra-low-noise LDOs to isolate switching noise from digital circuits, thereby reducing disturbances in attitude and altitude sampling.

4.2. Sensor Equal-Length Routing for Timing Control

The SPI/I2C clock signal lines for the IMU, magnetometer, and barometric pressure sensors are strictly length-matched to eliminate sampling timing skew across multiple sensors. This ensures synchronized data fusion of the dual IMUs and dual magnetometers under the EKF algorithm, fundamentally resolving the "Accels inconsistent" error at the hardware level.

4.3. Multi-Domain Independent Power Isolation Design

The design adopts a power architecture combining the MPM3811 DC-DC step-down converter with three independent LDOs (LP5907, SPX3819, and MIC5332), partitioning the system into three distinct power domains: analog sensor, MCU digital, and peripheral group domains. Cross-domain power paths incorporate ferrite beads and feedthrough capacitors for filtering. The input circuit integrates self-recovering fuses and anti-reverse Schottky diodes, providing hardware-level overcurrent and reverse-connection protection.

4.4. Full-Link EMC ESD and Surge Protection Design

The board integrates over 24 TVS/ESD array devices covering all external-facing pins, with the USB Type-C port paired with a dedicated BQ24315 protection IC. The PCB employs split digital and analog ground planes along with an independent sensor ground plane, supplemented by six three-terminal feedthrough capacitors to suppress high-frequency conducted interference. This design is well suited for the complex electromagnetic environments encountered across various autonomous driving platforms.

4.5. Triple-Layered Storage Architecture

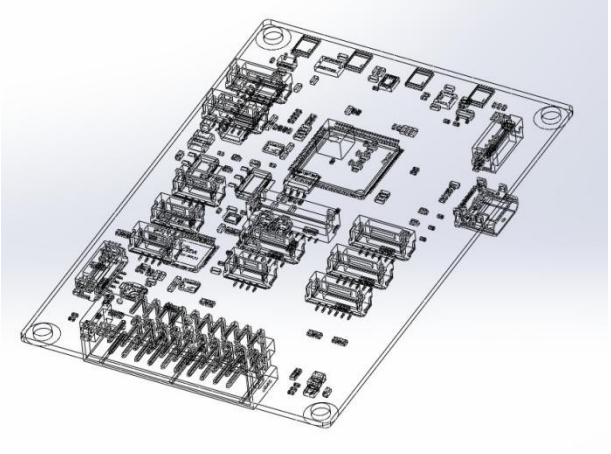
The FM25V02A SPI FRAM continuously retains real-time flight parameters such as PID gains, compass offsets, and EKF status, while the 24LC64 I2C EEPROM independently stores the hardware ID and factory sensor calibration data. A MicroSD card records the full-cycle operational logs and perception data for post-flight analysis. The three storage layers are isolated on separate physical buses, ensuring zero parameter loss on power-down and enabling complete fault traceability and post-event reconstruction.

4.6. Vibration Isolation Design

The hardware adopts a full-PCB internal vibration isolation design. By tuning the damping characteristics, high-frequency vibrations are rapidly filtered to reduce vibration-induced interference with sensors. Unlike IMU-only isolated mounting, full-board isolation protects not only the IMU but also the MCU, power modules, communication interfaces, and other sensitive components, thereby improving measurement consistency, structural reliability, and long-term robustness under complex vibration conditions.

The system can further be combined with an external secondary vibration isolation stage to attenuate low-frequency vibrations. While the internal full-PCB isolation primarily suppresses high-frequency vibration, the external stage provides secondary filtering of low-frequency mechanical vibration transmitted from large vehicle platforms. This dual-stage approach enables coordinated high- and low-frequency vibration suppression, significantly enhancing system resilience in heavy-duty vehicles, industrial machinery, and large autonomous platforms.

5. Hardware Architecture



This autopilot adopts a dual-MCU, task-decoupled redundant architecture built around an STM32H743 main controller and an STM32F103 co-controller. It features a heterogeneous dual-IMU configuration comprising a BMI088 and an ICM-42688, along with a BMP390 high-precision barometer. The magnetometer supports a dual-combination setup with an on-board IST8310 plus an external IST8310 or RM3100. Storage is implemented as a triple-layer solution consisting of FRAM, EEPROM, and an SD card. A dedicated GH1.25 programming port allows the main and

co-controller firmware to be flashed independently, supporting high-volume production programming. All connectors use a unified GH1.25 interface with IDC locking latches to prevent accidental disconnection, and the board layout features clearly partitioned interface zones.

Item	Specification
Main Control Unit	STM32H743VIT6 (Cortex-M7)
I/O Co-Control Unit	STM32F103C8T6 (Cortex-M3)
Inertial Measurement	BMI088 + ICM-42688-P heterogeneous dual IMU
Magnetometer	On-board IST8310 + external IST8310/RM3100 (selectable)
Barometric Altitude	BMP390
Storage	FM25V02A FRAM + 24LC64 EEPROM + MicroSD
Power Supply	MPM3811 DC-DC (3 A) + three isolated LDOs
Communication Interfaces	TELEM / GPS / I2C / SBUS + PPM / CAN / DSM / Type-C
Power Output	16-channel PWM (independent ESD protection)
Protection	24 TVS/ESD devices + BQ24315 USB protection + TDK feedthrough filtering

6. Electrical Specifications

6.1. Power Specifications

The main power input is DC 5.5 V, with voltage and current monitoring, and uses a standard 6-pin power input with full external step-down. The secondary power supply provides three isolated 3.3 V rails. The input circuit is protected by a 0.4 A self-recovering fuse. Ripple suppression is implemented using multi-stage LC filtering, ferrite beads, and feedthrough capacitors.

6.2. System Power Consumption

Under standby and no-load conditions, the system power consumption is ≤ 120 mA.

During normal flight, the current draw ranges from 180 mA to 260 mA. The peak current consumption reaches ≤ 350 mA when all sensors and the SD card are operating at full speed.

6.3. Signal Electrical Standards

Item	Specification
Logic Levels	All UART, I2C, SBUS, and PWM signals use 3.3 V TTL/CMOS levels. The CAN interface follows the ISO 11 898-2 high-speed CAN physical layer.
PWM Output Levels	High level ≥ 2.8 V; low level ≤ 0.3 V.
UART Baud Rate	1200–921 600 bps. The TELEM port defaults to MAVLink2, with a default baud rate of 57 600 unless otherwise configured.
ESD Protection	All ports support ±15 kV air-gap ESD protection per IEC 61 000-4-2, with transient surge protection.

7. Environmental Parameters

Item	Specification
Operating Temperature	–25 ℃ to +85 ℃
Storage Temperature	–40 ℃ to +85 ℃
Vibration Frequency Range	0–2000 Hz
Peak Vibration Acceleration	20 g peak
Operating Humidity	5% to 95% RH, non-condensing