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Pixhawk Payload Bus Standard

Revision: 0.9.0
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Abstract

This document is the formal version of the Pixhawk Payload Bus industry standard that includes all aspects of the hardware standard required to build compatible products.

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Document Revisions

Revision	Editor	Reviewer	Comments
0.1.0	Lorenz Meier	David Sidrane	Initial specification
0.2.0	Cory Schwarzmiller, Raul Ramos	Arnaud Thiercelin	Addition of payload bus
0.3.0	Cory Schwarzmiller	Lorenz Meier	Final version, design intent description
0.4.0	Ramon Roche	Lorenz Meier	Clean up and release to the community
0.5.0	Nico van Duijn	Lorenz Meier	Update mechanical specs for dovetail
0.9.0	Cory Schwarzmiller		Updated for release as a result of testing. More detail on electrical considerations, added the SENSE signals for hotswap and added models of reference quick disconnect from Freefly.

Contact and Public Developer Call

This standard is being developed on a public developer call.
For further questions, please contact the maintainer of the standard, lorenz@px4.io.

Trademark Guideline

Trademark Guideline

License and Disclaimer

Pixhawk Payload Bus (PPB)

Executive Summary

Pixhawk Payload Bus is an open standard developed by the Pixhawk Special Interest Group during open collaboration throughout 18-months hosted by the Dronecode Foundation and its member companies. The main goal is to provide a standard interface to facilitate communication between the camera payload, onboard flight controller, and ground station.

The standard is based on open electrical and software interfaces to create mid-sized payload components such as gimbals or hard-mounted payload sensors for modern applications.

Both software and hardware interface specifications are listed in this document to allow adopters to create their full implementation on the electrical level. Adopters will get the benefit of plug-n-play interoperability if fully compliant with the standard.

Design Considerations

This bus is a mechanical and electrical system intended to be used either as a custom bus or, when using ethernet or serial, with the MAVLink camera protocol, providing full interoperability between different camera models. The mechanical and electrical design is intended to be used with mid-sized payloads like full-frame DSLR cameras, medium sized LIDAR scanners or other custom sensors.

Software Interface

The Pixhawk Payload Bus is supporting the software interfaces in the table below. Any other interface protocols are non-standard and should not be used.

Payload Type	Protocol	References
Cameras	MAVLink Camera Protocol	Camera specification v1
Gimbals	MAVLink Gimbal Protocol	Gimbal specification v2
General Payload	MAVLink Protocol	MAVLink Protocol
Actuators	DroneCAN	DroneCAN specification

Hardware Interface

It has these main interfaces:

- 100 base-TX Ethernet (connected to mission computer and flight controller)
- USB 2.0 (connected to mission computer)
  - 5V, 500mA USB VBUS (for low power USB uses)
- CAN (connected to onboard secondary aircraft CAN network, FD capable with minimum 1M baud support)
- UART (connected to flight controller)
  - Baud rates supporting 1M baud minimum
- TRIG (to camera, connected to flight controller)
- CAPTURE (capture pulse from camera / hot shoe, connected to flight controller)
- GNSS_PPS (e.g. GPS PPS signal generated by GPS module)
- VCC_BAT needs to be between 12V (4S empty) and 26V (6S HV full)

Power:

- Voltage: 12V-30V, 25V nominal
- Current: 6A burst, 5A continuous, with over current protection on the aircraft side
- Power ratings (current and voltage dependent):
  - Max: 25V / 6A burst (100 ms = 150W), 25V / 5A continuous (125W)
  - Min: 12V / 6A burst (100 ms = 72W), 12V / 5A continuous (60W)

Expected standard use cases:

- Ethernet + UART camera / gimbal payloads (ETH + VBAT + UART)
- USB + UART camera / gimbal payloads (USB + VBUS + UART)
- USB + VBUS + TRIG + CAPTURE (hot shoe) camera payloads
- UAVCAN sensor payload (CAN + VCC_BAT)
- MAVLink-UART camera / gimbal payloads

Signal Conventions:
All pin definitions are listed as from the perspective of the aircraft side. For example, UART_TX is from the aircraft, to the payload.

Interface Details

The following more fully defines the electrical specifications of the interfaces outlined above.

Power

Power is provided via the pins listed as VCC_BAT and

100 base-TX Ethernet

IEEE 802.3 Standard fast ethernet interface. Note that capacitive coupling can be used in place of traditional transformer based designs to save space and cost since the cable length is relatively short. Longer term these signals may be migrated to 1000base-T1 (single pair 1Gbit) Ethernet.

This is especially useful as a higher speed interface for things like video streaming, image transfer, lidar point data, etc.

USB 2.0

High speed, 480Mbit USB over a single D+/D- pair. This was chosen over higher speed USB3.x for better noise immunity and more forgiving wiring requirements, along with less interference on GPS.

This is typically connected to a mission computer on the aircraft side , either directly or through a USB hub. ESD protection should be added to both the aircraft and payload side. The mission computer may use any of the USB roles such as HID, CDC, PTP, MTP, etc. The aircraft side is the host, and the payload is a device.

Like Ethernet, this is also especially useful as a higher speed interface for things like video streaming, image transfer, lidar point data, etc.

Additionally, a 5V source providing up to 500mA is provided. This can be used to power low power USB devices.

CAN

CANbus is typically used for communication with actuators and some sensors. The transceivers on the aircraft and payload sides should have either built in ESD and fault protection (up to the battery voltage of the system) or added externally. Baud rates of 1M baud should be supported, along with CAN-FD when the devices are capable.

UART

The UART is connected to the flight controller on the aircraft side. This interface is very useful for controlling gimbals and cameras via mavlink. Baud rates are configurable in PX4. The payload interface should be designed to support a minimum of 1 Mbit connections. This uses 3.3V CMOS logic with a minimum logic high of 2.0V and a maximum logic low of 0.8V.

For protection, the aircraft and device sides should use current limiting series resistors and ESD protection diodes. The series resistors should be sized as low as possible (to support high baud rates) while still protecting the IO from the connected device (such as the FMU MCU). For example, a 220 ohm resistor on a 3.3V IO pin will limit current in a ground short to around 15mA, which is lower than the 20mA limit of many STM32 MCUs that are used in the Pixhawk FMU flight controllers.

Camera Trigger (TRIG)

This is a logic level output from the FMU on the aircraft that is used to trigger a camera to take a picture. The specific IO is selectable within PX4. This uses 3.3V CMOS logic with a minimum logic high of 2.0V and a minimum logic low of 0.8V. Note, many cameras require an open drain type output to pull a higher voltage signal low to command an image to be taken. This pin can thus be used to drive the gate of an NFET to implement this.

Capture (CAPTURE)

This input to the FMU is used to signal to the flight controller the precise point in time that a picture has been taken. This uses 3.3V CMOS logic with a minimum logic high of 2.0V and a minimum logic low of 0.8V. Cameras provide this signal via the “hot shoe” output. This is typically a logic low pulse in the us to ms range. An external pullup resistor (approx 2.2K) is required on the payload side.

GNSS PPS

This is a pulse per second signal from the GPS module on the aircraft that is used to synchronize time between the GPS, flight controller, and payload. This uses 3.3V CMOS logic with a minimum logic high of 2.0V and a minimum logic low of 0.8V. The duration of the pulse is typically 20us. The edge should be as sharp as possible since this affects overall accuracy of the pulse. We recommend a maximum rise/fall time of 1us.

PAYLOAD SENSE

This specification provides an option to allow the aircraft to sense the connection of a payload via a pair of signals. This is useful for implementing a hotswap controller on the aircraft side, which is critical if the load has a large amount of capacitance to prevent inrush of large amounts of current and sparking of the contacts.

The two signals in this interface are:

- SENSE_SUPPLY - This is a current limited VCC_BAT supply pin via a 1Mohm series resistor.
- SENSE_LOAD - This pin is pulled down to ground on the aircraft side via a 1Mohm resistor. Its possible voltage range is 0V up to VCC_BAT. It is pulled up via the SENSE_SUPPLY pin to VCC_BAT.

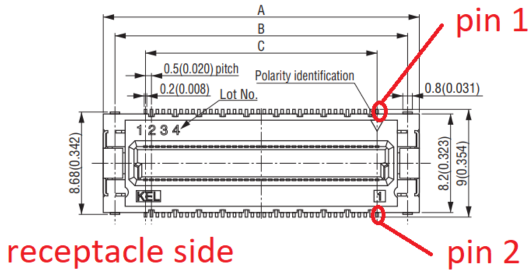
The payload side simply connects these signals together to form a voltage divider of battery voltage that is used on the aircraft side to control the hotswap controller switch.

If the aircraft doesn’t provide this interface, then VCC_BAT is supplied on the signals. In this configuration, hot swapping is not recommended unless further protection has been implemented on the payload side, such as controlling connection of significant payload side capacitance until a delay after power up. See the electrical considerations section for more details.

Connector PPB-40-100W-D

The 40-pin connector is automotive grade, low-cost, vibration resilient and allows very high density assemblies. It also has the ability to "float" to accept slight misalignment.

- KEL DY Series: [Product page]



The following table shows the pinout for the aircraft side connector.

GND	1	2	GND
ETH_TXP	3	4	GND
ETH_TXN	5	6	GND
GND	7	8	GND
ETH_RXP	9	10	GND
ETH_RXN	11	12	GND
GND	13	14	SENSE_LOAD/VCC_BAT
USB DP	15	16	SENSE_SUPPLY/VCC_BAT
USB DM	17	18	VCC_BAT
USB_VBUS	19	20	VCC_BAT
TRIG	21	22	VCC_BAT
GND	23	24	VCC_BAT
UART_RX	25	26	VCC_BAT
GND	27	28	VCC_BAT
UART_TX	29	30	VCC_BAT
GND	31	32	VCC_BAT
CAN_H	33	34	VCC_BAT
CAN_L	35	36	VCC_BAT
GPS_PPS	37	38	VCC_BAT
CAPTURE	39	40	VCC_BAT

[Reference Document for this table: Official Pixhawk Standard Pinout]

Side	Vehicle side (bottom)	Payload side (top)
Part Number	DY01-040S (Receptacle)	DY11-040S (Plug)
Product Page	KEL DY Series	KEL DY Series

Electrical Considerations

Hot-Swap Protection Mechanism

To enable safe hot-swapping of the PPB we require a mechanism to limit inrush current and supply voltage to the external device(s). This is required to prevent arcing between contacts in the connectors.

Options

1. Aircraft Side (Using the SENSE signals) :
    a. Use a MCU or hardware circuit to sense when the SENSE line has been pulled up. Then use a FET to switch power on to the PPB connector. The minimum time recommended to delay before powering up the connection is 40ms.
    b. An example of an IC to handle this is a LTC4231: Micropower Hot Swap Controller. This device controls back-to-back Mosfets (to protect the pixhawk from being back-powered) located between the power supply and the PPB connector. To turn this device on the SENSE_LOAD signal should be connected to the nSHUTDOWN pin. When it is pulled up to greater than 1.2V, it then provides a 40ms average debounce time before switching power to the load. It also has other important features such as over current and over/under voltage protection,
        i. Vin range: 2.7V - 36V; automotive rated

2. Payload Side (Not using the SENSE signals) :
    a. Use a MCU or hardware circuit to delay the switching of power to the majority of the payload circuit, most importantly any capacitance over 10uF. The minimum time recommended to delay before connecting this capacitance is 40ms.
    b. An example of an IC to handle this is a LTC4281: Hot Swap Controller with I2C with Compatible Monitoring of power out. This device controls a Mosfet(s) located upstream of the payload electronics. This device will switch the main FET on 50ms after power is applied. This device also has under/over voltage and over current protection and extensive monitoring of power via I2C.

Reference Implementations

Quick Release Mechanism

[Contributed by FreeFly Systems]

Scenarios

A quick release mechanism provides a quick and easy payload connection for both operation and maintenance.

In the field, this is essential if changing the payload for the task at hand or if the payload requires replacement after damage and/or malfunction. In maintenance, it allows even non technical personnel to service the aircraft. It also provides a common interface to allow aircraft and payload makers to interoperate successfully.

The ease of use of the mechanism is essential. The primary metric for a quick release is the speed of connection and disconnection during typical use. This ease of use must not be at the expense of the safety of the payload as we must make sure it remains secure during the flight. A safety mechanism that's easy to trigger is necessary to ensure this.

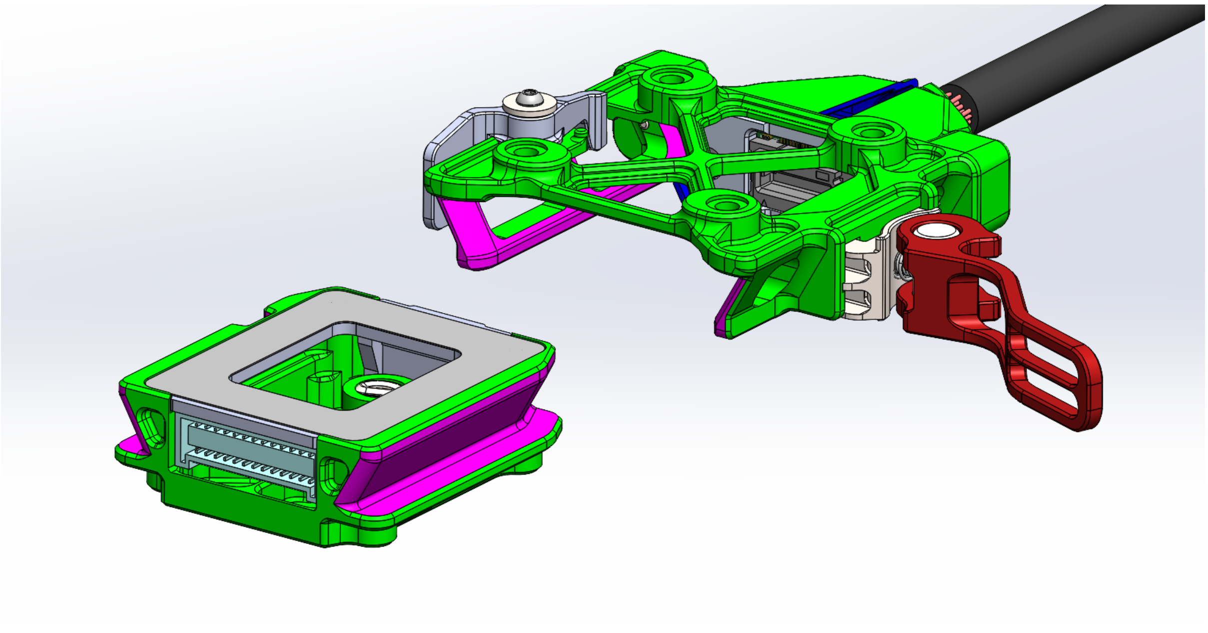
The payload may be exposed to the elements, such as dust at take off/landing and rain. The payload itself should observe solid weather proofing but we also need to make sure the electronic connector and quick release mechanism are weather resistant.

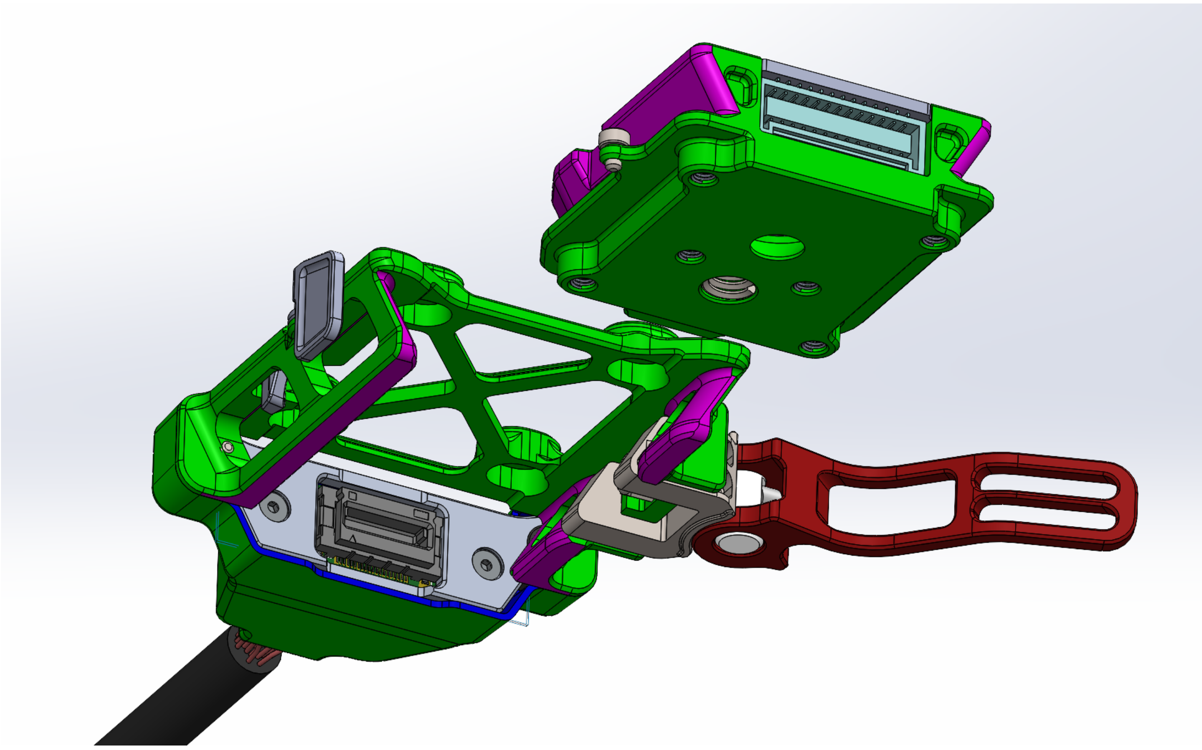
Higher weight capacity of the payload quick release mechanism opens the door to more applications but being an aerial vehicle, we can't just simply carry any weight. This quick release implementation has been designed for a 5 kg max payload, which provides ample room for advanced sensor and even actuator payloads while keeping the size and weight of the quick release mechanism manageable.

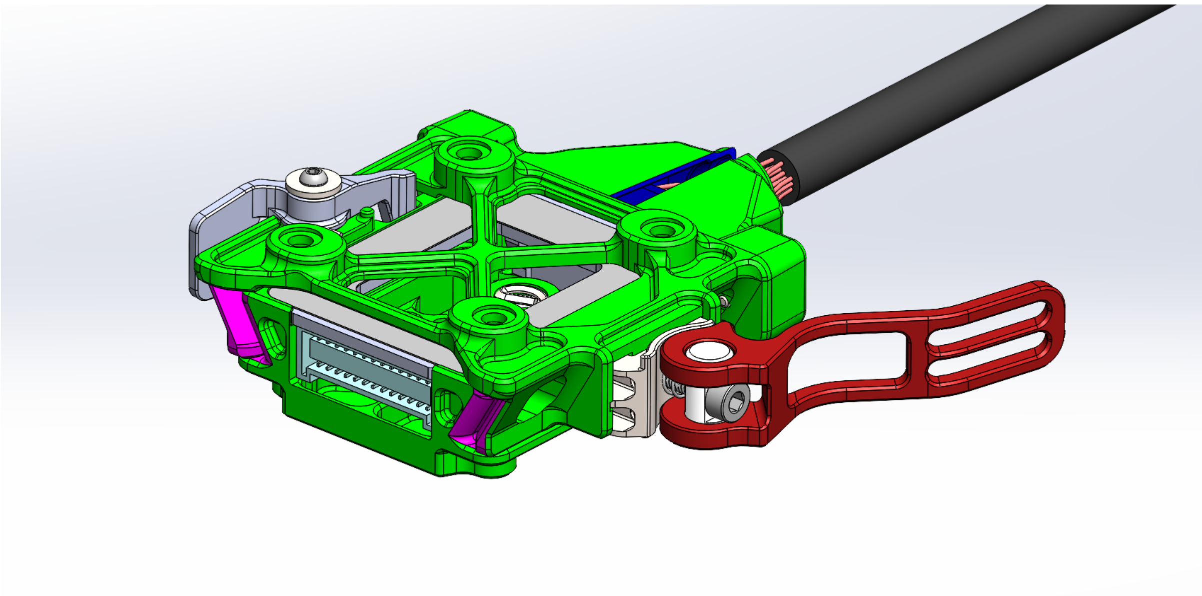
Requirements

	Minimum	Ideal
Weather Proofing Protection of connector during operation	None	IP56
Weight Capacity (grams)	N/A	5000
Time to assemble	2 min	Sub 30s
Mechanical Safety	Lock to prevent accidental drop	

Dovetail Design Reference Implementation







CAD files

A CAD file of the payload-side of the dovetail is available here: https://freefly.gitbook.io/freefly-public/products/astro/specs-and-interfaces/payload-mounting-interfaces

Attribution

This specification is available thanks to all of the **Dronecode Foundation** members who participated in the 2020 Payload Workgroup, with honorific mention to **Auterion** and **FreeFly Systems** for providing most of the engineering resources in creating this specification as well as testing the implementation.