

Portable Data Acquisition System (PDAS)

User Manual

Firmware v1.2.0

Document Revision 1.3

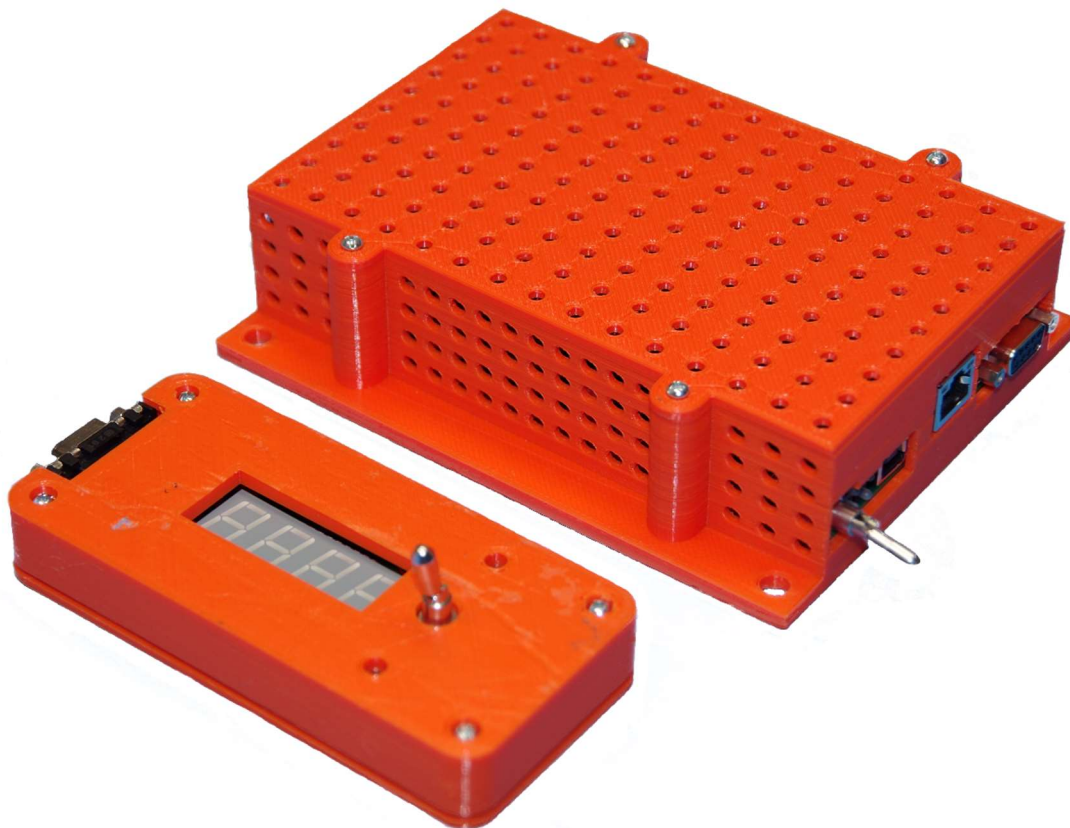


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1 Technical Documentation

The following documentation and support software are available from our website, <https://bolderflight.com/pdas>:

- **PDAS User Manual:** describes the PDAS, specifications, operations, and data.
- **PDAS Data Converter:** a stand-alone executable for the Windows operating system. This software converts PDAS generated data files to CSV format.
- **PDAS PRN file:** a file specifying the data packet sent by the PDAS to an IADS client. Used by the Symvionics IADS software to setup the PDAS as a data source for building real-time displays and analysis tools.

If you have technical problems or cannot find the information you need in the provided documents, please contact our technical support team by email at: support@bolderflight.com. Our team is committed to providing the support necessary to ensure that you are successful with the integration and operations of our data acquisition system.

2 Introduction

2.1 Description

The Portable Data Acquisition System (PDAS) is a portable, high-performance data acquisition system for aeronautics research. It is designed to quickly and easily integrate on a fixed or rotary wing aircraft and provide high quality flight data to support analysis of vehicle performance, dynamics, and control. PDAS consists of:

- A high-accuracy GNSS-aided Inertial Navigation System (INS), providing high-rate estimates of inertial position, attitude angles, linear and angular rates, linear accelerations, and uncertainty estimates.
- Pitot-static pressure transducers measuring differential and static pressures, altitudes, and airspeeds.
- A Resistive Temperature Device (RTD) analog front-end for supporting high-accuracy Outside Air Temperature (OAT) measurement.
- 12 analog channels with 16-bit resolution. Each channel features: an analog front end with integrated anti-alias filtering, a configurable amplifier, and an independent, ultra-low noise +5V supply for powering analog sensors. Six channels have configurable gains of 1, 2, 4, or 8 while the other six channels have configurable gains of 1, 10, 100, or 1000. Each channel can accept differential and single-ended inputs. Ideal for measuring strain bridges and potentiometers.
- A high-performance, hard real-time processor to sample sensors, apply real-time filtering and estimation algorithms, and log data to non-volatile memory.
- A hand-held Flight Test Engineer (FTE) interface for setting test point numbers and flagging whether a test point is actively under test. Extremely useful for correlating flight data to test cards and quickly selecting active test points for analysis.
- A Symvionics IADS interface for creating real-time displays and analysis tools.
- A convenient web-based interface for configuring the PDAS and managing data files.
- A Windows application for converting binary data logs to CSV files.

Data is sampled and recorded at a rate of 200 Hz. PDAS is powered from a USB port and consumes approximately 1 Amp of current. Included is a 20 Amp-hour battery and a DC/DC converter for optionally powering directly from the aircraft.

2.2 Measurement Outputs

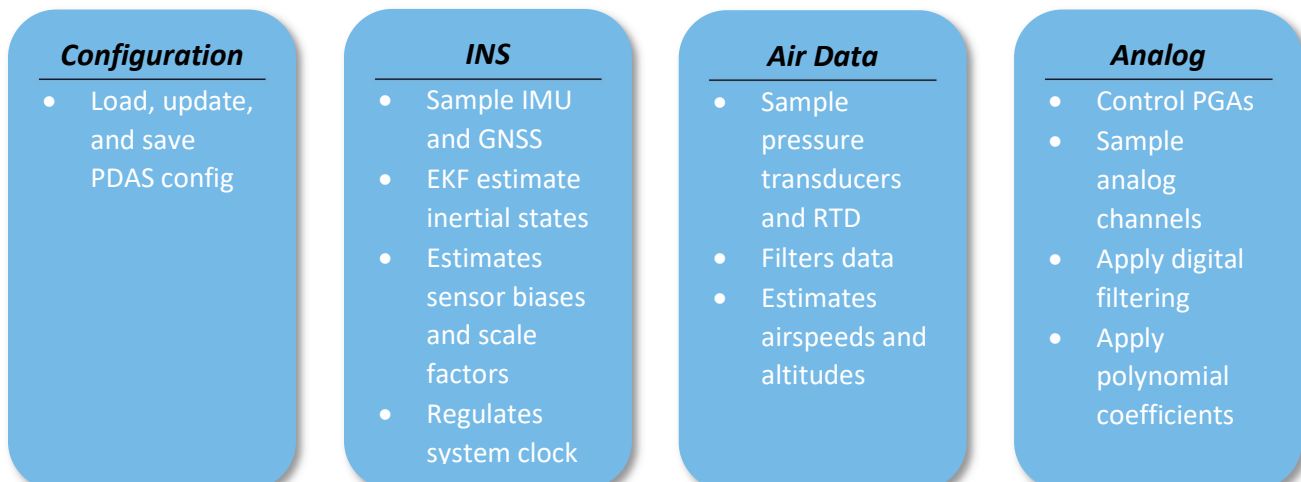
Outputs from the PDAS include:

- Time (microsecond resolution)
- Test point number
- Whether the test point was active or inactive

- IMU measurements:
 - Uncompensated accelerometer, gyro, and magnetometer
- GNSS measurements:
 - Time of week
 - GNSS week number
 - Fix type
 - Number of satellites
 - Latitude, longitude, and altitude
 - North, east, and down velocities
 - Estimated position and velocity measurement accuracy
- INS estimates:
 - Accelerometer, gyro, and magnetometer measurements compensated for estimated sensor bias and low pass filtered
 - Latitude, longitude, and altitude
 - North, east, and down velocities
 - Pitch and roll angles
 - Yaw relative to true north
 - Estimated attitude, position, and velocity uncertainty
- Air Data Measurements:
 - Static and differential pressures
 - Filtered static and differential pressures
 - Outside air temperature (OAT)
 - Filtered outside air temperature (OAT)
 - Indicated airspeed (IAS), equivalent airspeed (EAS), and true airspeed (TAS)
 - Pressure altitude, altitude above ground level, and density altitude
- Analog measurements:
 - Measured voltages
 - Filtered voltages
 - Calibrated values by evaluating a polynomial at the filtered voltage

2.3 System Modules

PDAS consists of seven modules: Configuration, INS, air data, analog, FTE interface, IADS, and datalog.



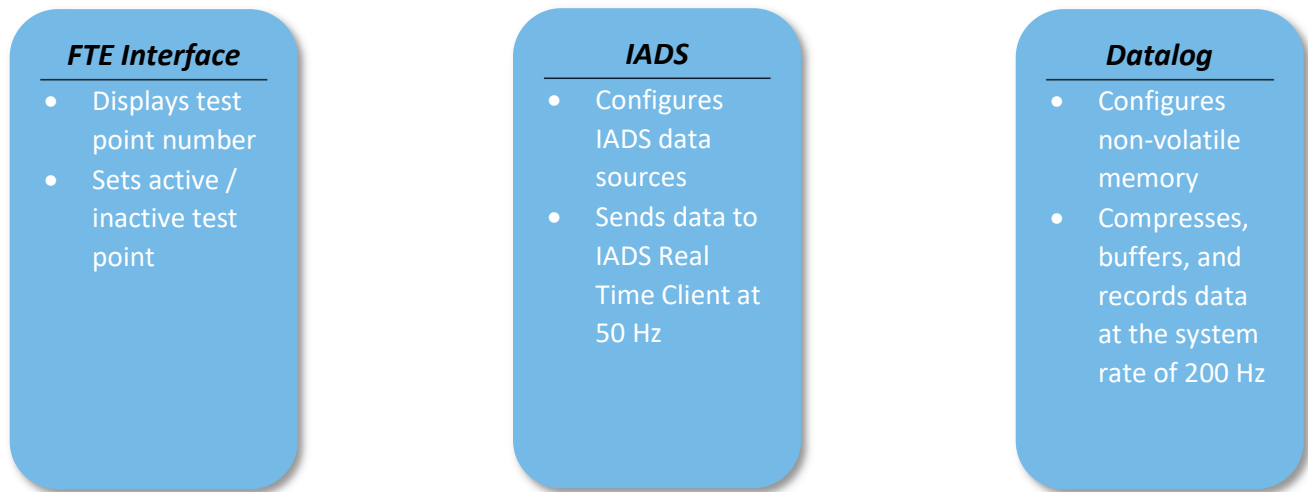


Figure 1: PDAS software modules.

2.3.1 Configuration

The configuration module is responsible for loading, updating, and saving the PDAS configuration. Configurable items include:

- PDAS orientation relative to the vehicle
- GNSS antenna offset
- Digital low pass filter cutoff frequencies for all sensors
- Whether the pitot-static, OAT, and analog channels are enabled
- OAT RTD configuration
- Analog channel calibration coefficients

This module is one of the first modules to run during the PDAS initialization sequence and loads the stored PDAS configuration from non-volatile memory. A web server is included, which enables the user to: view current PDAS sensor and estimation data, view the current PDAS configuration, and update the PDAS configuration. Configuration updates take effect immediately and are validated and saved to non-volatile memory.

2.3.2 INS

The INS module communicates with an inertial measurement unit (IMU) and a GNSS receiver in order to estimate the vehicle's inertial states in real-time. An Extended Kalman Filter (EKF) is used to estimate these states with the IMU providing data for the EKF time update and the GNSS data used as an EKF measurement update. This process leads to highly-accurate estimates of the vehicle inertial states; however, it requires GNSS lock and adequate vehicle motion. The estimated states include: vehicle attitude, heading, position, three-dimensional velocity, angular rate, linear acceleration, and sensor bias and scale factor estimates. In addition to the estimated and filtered states, the INS module provides the raw IMU and GNSS data.

The PDAS data collection loop is slaved to the INS module data ready interrupt. This ensures that updated INS data is available every frame and synchronizes all of the PDAS sensors, which provides more accurate data analysis by minimizing time skew between sensor measurements.

2.3.3 Air Data

The air data module samples pressure transducers to measure static and differential pressure. Several pressure transducers are used to minimize error while maintaining a large overall range. An analog front end for RTD sensors is

included for high-accuracy Outside Air Temperature (OAT) measurement. This front end supports 2-wire, 3-wire, and 4-wire sensors with 0 °C resistance values from 10 Ohms to 1000 Ohms and a selection of excitation currents. The module uses these measurements to estimate Indicated Airspeed (IAS), Equivalent Airspeed (EAS), True Airspeed (TAS), pressure altitude, Above Ground Level (AGL) altitude, and density altitude. Estimation of TAS and density altitude require the OAT sensor to be present and properly configured. AGL altitude is estimated with respect to the altitude when the PDAS static pressure was tared.

2.3.4 Analog

The analog module samples analog input data and applies a polynomial calibration to convert measured voltages to engineering units, such as control surface position, control stick position, or control stick force. Twelve analog channels are available. Each channel has a programmable gain amplifier, which can be configured for gains of 1, 10, 100, and 1000 on channels 0 - 5. These gain values are ideal for integration with strain bridges. Channels 6 - 11 have configurable gains of 1, 2, 4, and 8, which are more appropriate for analog position sensors.

An ultra-low noise +5V supply is available on each channel for powering analog sensors. Each channel can accept differential or single-ended inputs with a voltage range is 0 - 5V. Protection against overvoltage is included. A low-noise first order anti-alias filter is present on each channel with a cutoff frequency of 55 Hz along with independently configurable digital low pass filters.

Coefficients can be configured to apply up to a 5th order polynomial to the filtered voltage value for converting voltages to engineering units.

2.3.5 FTE Interface

The Flight Test Engineer (FTE) interface module manages communication with the FTE interface and updates the test point number and active status.

2.3.6 IADS

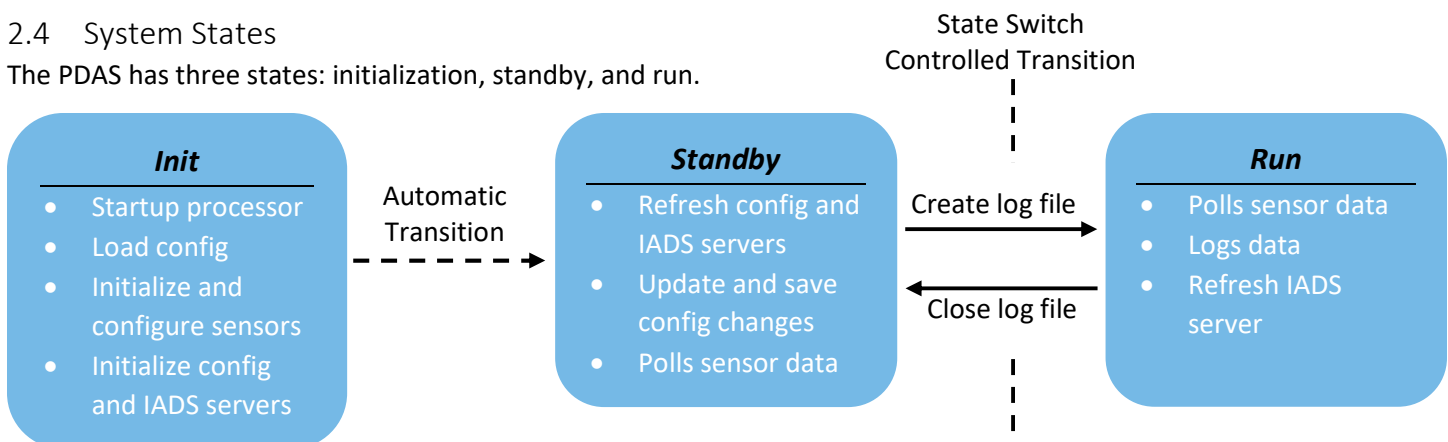
Symvionics IADS is a real-time test display and analysis suite. Our IADS module acts as a data source and IADS server to the real time display client. All of the PDAS data is available and transmitted to IADS at a rate of 50 Hz.

2.3.7 Datalog

The datalog module logs data to non-volatile memory in real-time. This module uses a compressed binary format optimized for file size and speed, while preserving data resolution. A converter is available as a stand-alone executable for the Windows operating system, which converts from this binary format to a CSV file that can be loaded into analysis software.

2.4 System States

The PDAS has three states: initialization, standby, and run.



Upon receiving power, the PDAS automatically transitions through the initialization state and enters the standby state. In the standby state, all of the software modules are active except for datalog. In this state, you can view PDAS data via the web server or IADS server, modify the PDAS configuration, and download or delete data log files from the PDAS storage.

A switch is used to command the PDAS to transition from the standby state to the run state. In the run state, all of the software modules are active except for the configuration module. Configuration changes are not allowed and the web interface is disabled while in the run state. IADS is still available to support real-time displays and analysis tools.

Data log files are created each time the PDAS enters the run state. These files are numbered sequentially starting from *data0.pdas* with the number incremented to prevent overwriting old log files.

3 Specifications

3.1 Electrical

3.1.1 Power

PDAS power is applied to the USB port, please do not attempt to supply power via any other port.

- **Voltage input:** 3.4 - 6V DC
- **Current draw:** 1A

A 20 Ah battery is supplied with the PDAS along with a charger and a DC/DC converter. The DC/DC converter is capable of powering the PDAS from a 9 - 48V source.

3.1.2 FTE Interface

The FTE interface is connected via a 9 pin D-Sub (DB9) cable. One of these cables is provided with the PDAS. Please be cautious if purchasing an after-market cable and ensure that a straight-through cable is used, rather than a crossover cable. Although a DB9 cable is used for the FTE interface, it is not a serial port, applying RS-232 or TTL voltages to this port may damage the PDAS or FTE interface. Only use this interface for connecting the PDAS to the FTE interface.

3.1.3 GNSS Antenna

The GNSS receiver interfaces with an active antenna via an SMA port, which is capable of supplying 3V and up to 40 mA of current to the antenna. The uBlox ANN-MS-0 active antenna is supplied with the PDAS, which is available from uBlox and electronics distributors if you need to replace or purchase additional antennas.

3.1.4 External Sensors

Analog and RTD sensors are connected via a 62 pin D-Sub connector. The pinout of this port is below. Limit the voltage on analog inputs to 0 - 5V and be aware that the ultra-low noise +5V supplies can source 50 mA of current per channel.

Table 1: External sensors pinout.

| Pin | Description | Pin | Description | Pin | Description | Pin | Description |
|-----|-----------------|-----|-----------------|-----|------------------|-----|------------------|
| 1 | CH 0: 5V Supply | 17 | CH 7: 5V Supply | 33 | GND | 49 | GND |
| 2 | CH 0: +Input | 18 | CH 7: +Input | 34 | CH 8: 5V Supply | 50 | GND |
| 3 | CH 0: -Input | 19 | CH 7: -Input | 35 | CH 8: +Input | 51 | CH 11: 5V Supply |
| 4 | GND | 20 | GND | 36 | CH 8: -Input | 52 | CH 11: +Input |
| 5 | CH 1: 5V Supply | 21 | GND | 37 | GND | 53 | CH 11: -Input |
| 6 | CH 1: +Input | 22 | CH 5: 5V Supply | 38 | CH 9: 5V Supply | 54 | GND |
| 7 | CH 1: -Input | 23 | CH 5: +Input | 39 | CH 9: +Input | 55 | GND |
| 8 | GND | 24 | CH 5: -Input | 40 | CH 9: -Input | 56 | GND |
| 9 | CH 2: 5V Supply | 25 | GND | 41 | GND | 57 | RTD1 |
| 10 | CH 2: +Input | 26 | CH 3: 5V Supply | 42 | GND | 58 | RTD2 |
| 11 | CH 2: -Input | 27 | CH 3: +Input | 43 | GND | 59 | RTD3 |
| 12 | GND | 28 | CH 3: -Input | 44 | GND | 60 | RTD4 |
| 13 | CH 6: 5V Supply | 29 | GND | 45 | CH 10: 5V Supply | 61 | GND |
| 14 | CH 6: +Input | 30 | CH 4: 5V Supply | 46 | CH 10: +Input | 62 | GND |
| 15 | CH 6: -Input | 31 | CH 4: +Input | 47 | CH 10: -Input | | |
| 16 | GND | 32 | CH 4: -Input | 48 | GND | | |

3.2 Dimensions

Dimensions for the PDAS and FTE Interface are below, all dimensions are given in mm.

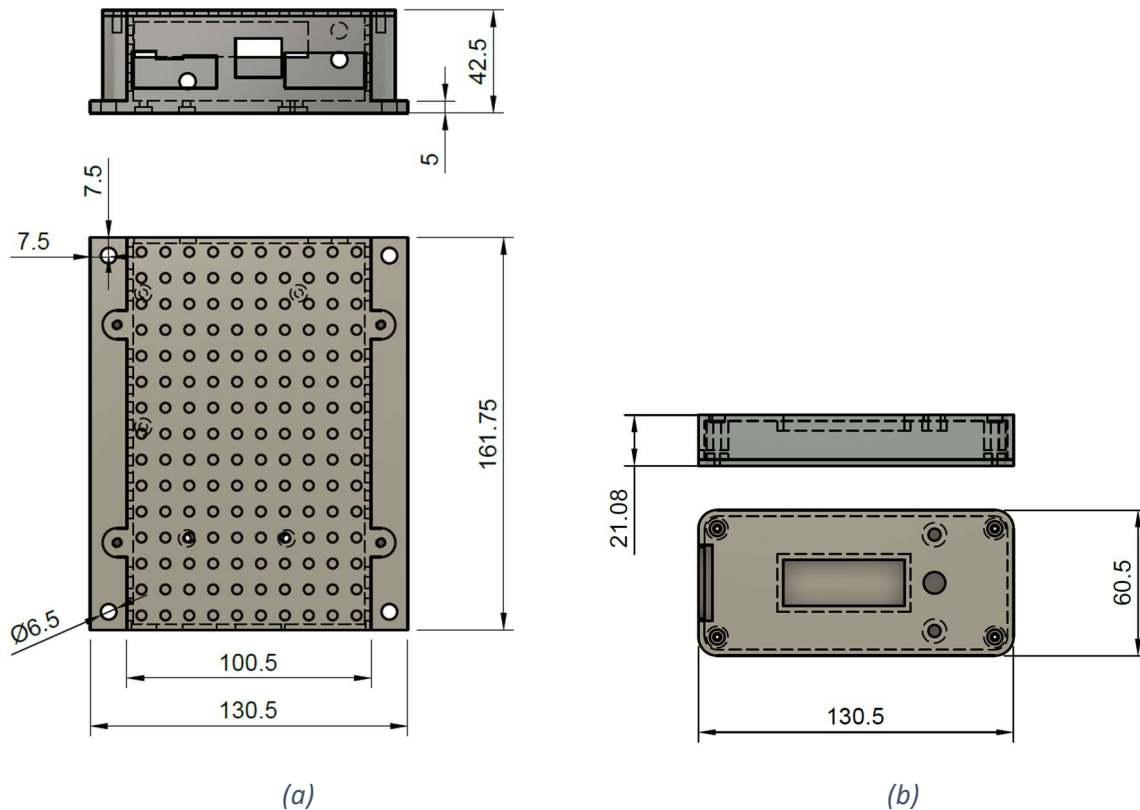


Figure 2: PDAS (a) and FTE interface (b) dimensions

3.3 Sensing

- 200 Hz data rate
- INS:
 - Pitch/Roll accuracy: 0.1°
 - Heading accuracy: 0.3°
 - Horizontal position accuracy: 8 ft
 - Vertical position accuracy: 16.5 ft
 - Inertial velocity accuracy: 0.1 knots
- Pitot-Static:
 - Airspeed range: 0 - 340 knots
 - Airspeed accuracy: 1 knot, typical
- RTD:
 - Type: 2-wire, 3-wire, and 4-wire
 - Resistance: PT10, PT50, PT100, PT200, PT500, PT1000
 - Excitation Current: 5 μ A, 10 μ A, 25 μ A, 50 μ A, 100 μ A, 250 μ A, 500 μ A, 1000 μ A
 - Sense Resistor: 2k Ω
 - 0.1 °C accuracy over full temperature range
- Analog:
 - 16-bit resolution
 - CH 0 - 5: Configurable gain of 1, 10, 100, or 1000
 - CH 6 - 11: Configurable gain of 1, 2, 4, or 8
 - Differential and single-ended input available on each channel
 - Anti-alias filter cutoff frequency: 55 Hz
 - Ultra-low noise +5V source on each channel
 - Configurable polynomial coefficients for converting voltage to engineering units

3.4 Maximum Ratings

- **Acceleration:** +/- 16 g
- **Rotation:** +/- 2,000 deg/s
- **Airspeed:** 0 to 174 knots
- **Altitude:** -10,000 to +70,000 ft
- **Temperature:** -10 to +50C

3.5 Coordinate System

The PDAS uses a right-handed coordinate system, Figure 3.

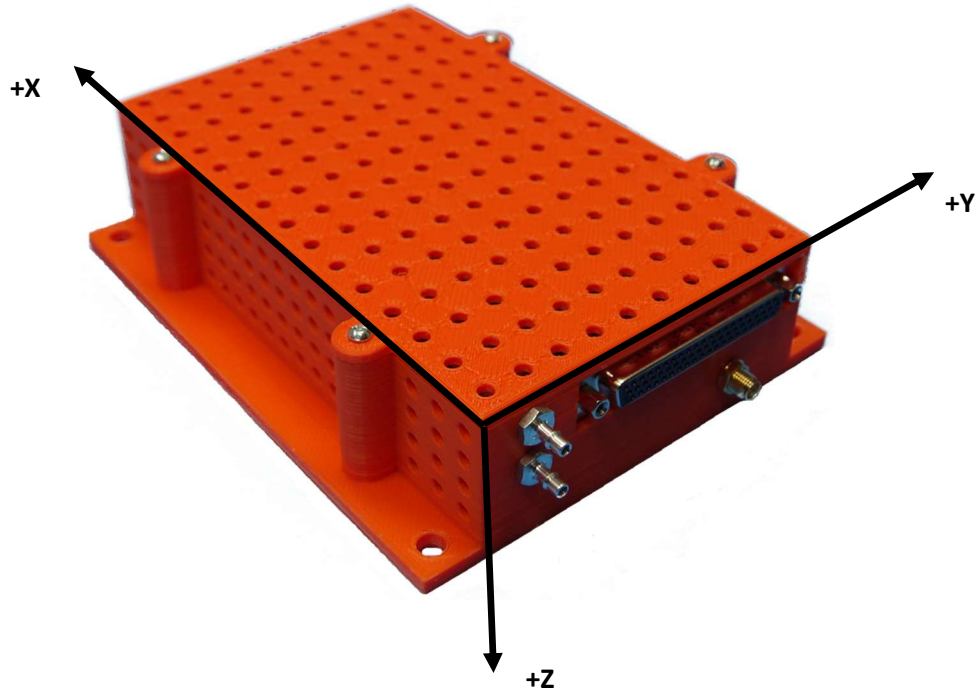


Figure 3: PDAS coordinate system

Where roll is defined as a rotation about the x-axis, pitch a rotation about the y-axis, and yaw a rotation about the z-axis. Inertial position is given in Latitude, Longitude, Altitude (LLA) format with respect to the WGS84 ellipsoid.

4 Operations

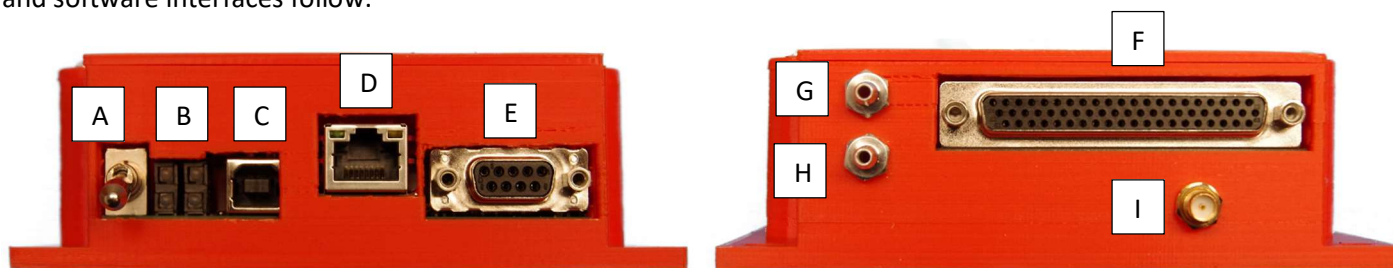
4.1 Overview

Typical operation of the PDAS would follow the sequence:

1. Apply power
2. Check PDAS configuration
3. Remove pitot-tube covers and zero the pitot-static system, if applicable
4. Wait for GNSS lock
5. Switch PDAS to the run state
6. Verify that PDAS is in run state with GNSS lock
7. Proceed to flight test operations using IADS displays and the flight test engineer interface as desired
8. Post flight, switch the PDAS to the standby state
9. Use the PDAS web interface to download the data file
10. Use the data file converter executable to convert the data file to CSV format
11. Load the data into your analysis tools and analyze the results

4.2 Interfaces

Depictions of the PDAS and FTE interfaces is in Figure 4 and Figure 5, respectively. Detailed descriptions of the physical and software interfaces follow.



| Label | Description | Label | Description | Label | Description |
|-------|------------------------|-------|------------------|-------|-----------------------|
| A | State switch | D | Ethernet | G | Static Pressure |
| B | Status Indicators | E | FTE Interface | H | Differential Pressure |
| C | USB Type B Power Input | F | External Sensors | I | GNSS Antenna |

Figure 4: PDAS interfaces overview



| Label | Description | Label | Description | Label | Description |
|-------|--------------------|-------|--------------------|-------|------------------|
| A | FTE interface | C | Active Switch | E | Active Indicator |
| B | Test Point Display | D | Inactive Indicator | | |

Figure 5: FTE interface overview

4.2.1 Power Input

Power is supplied via a USB type B port. The PDAS begins its initialization sequence and transition to the standby state automatically once power is applied.

4.2.2 State Switch and Status Indicators

The state switch commands the PDAS to the run state in the up position and the standby state in the down position. This switch is a locking-lever type, which requires the level to be pulled out before it is switched. There are four indicator lights on the PDAS as summarized below.

| Light | Position | Indication | Description |
|-----------|-------------|------------|---|
| Power | Upper Left | Off | PDAS power is off. |
| | | On | PDAS power is on. |
| State | Lower Left | Off | PDAS is in Standby. |
| | | On | PDAS is in Run. |
| GNSS Lock | Upper Right | Off | Inadequate GNSS fix. |
| | | On | 3D GNSS fix. |
| | | Off | No faults encountered. |
| Fault | Lower Right | Blinking | Fault during initialization, check config. More details provided below. |
| | | On | Hard fault. Contact Bolder Flight Systems to troubleshoot. |

A blinking fault light indicates that the PDAS encountered faults during initialization. This is typically caused by an RTD sensor configured, but no longer connected to the PDAS. You should check your PDAS configuration and wiring to ensure that the configuration is correct for the aircraft setup and that your RTD is properly connected to the PDAS, if you intend to use one during the flight tests.

A less likely cause of this fault is a corrupted PDAS configuration. The PDAS uses a checksum to protect against corruption, and in this case the PDAS detected an incorrect checksum and reset the configuration to default values. You should check and update the PDAS configuration prior to flight.

A hard fault is indicated when the PDAS fails one of its built-in tests during initialization or cannot communicate with one of its internal sensors. Please contact Bolder Flight Systems' support team at support@bolderflight.com to fix this fault.

PDAS state, GNSS lock, and soft fault status is available within IADS, see Appendix A for parameter names.

4.2.3 FTE Interface

The FTE interface has a numeric display, a switch, and two LEDs – one red and one indigo. The numeric display indicates the test point number. With the switch in the down position, the test point is inactive and the red light is illuminated. When the switch is moved to the up position, the test point number is incremented and the test point is active, as indicated by an illuminated indigo light. If the switch is moved down again, the test point is inactivated. This sequence is shown below; if the switch were moved up again, test point 2 would be selected and active.



Figure 6: Using the FTE interface to set the test point number and active mode

The test point number is always incremented as the switch is moved up to the active position. Our recommendation is to move the switch from inactive to active a few seconds before the start of a test point maneuver and then note the test point number in your test cards. A few seconds after the maneuver, move the switch back to inactive. This procedure will:

- Enable you to quickly correlate test point maneuvers with test cards and notes. You can search the data for the test point in active mode with the test point number corresponding to the number noted in the test cards.

- Changing the test point active mode a few seconds before and after the maneuver will give you trim data at the start and completion of the test point. Often this is useful for data analysis.

4.2.4 External Sensors

Analog sensors and the RTD are integrated with the PDAS via a 62 pin D-sub connector. The pinout for this connector is given in Section 3.1.4, Table 1.

4.2.4.1 Analog Input

Channels 0 - 5 have gain value options of 1, 10, 100, and 1000. Channels 6 - 11 have gain value options of 1, 2, 4, and 8. Each analog supply is capable of providing up to 50 mA of current. If a single-sided input is used, tie the -Input signal to ground.

4.2.4.2 RTD Input

The wire diagrams below depict the wiring for 2, 3, and 4 wire RTD's.

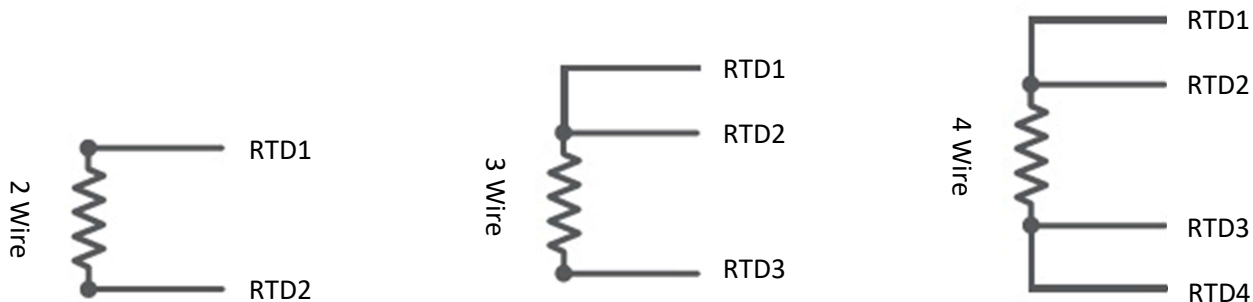


Figure 7: RTD wiring

Choose an excitation current such that the maximum voltage drop across the sensor or sense resistor is nominally 1V. The current selected is the total current flowing through the RTD independent of the wiring configuration. For 3-wire RTDs the current through the sense resistor is 2x the selected current. A 2k Ω sense resistor is used in PDAS.

4.2.5 GNSS Antenna

An active GNSS antenna should be connected to the PDAS using the supplied port via an SMA connector.

3V and up to 40 mA of current are supplied to the antenna. The uBlox ANN-MS-0 active antenna is supplied with the PDAS and meets these requirements. A GNSS antenna should always be used with the PDAS and a good fix achieved, as indicated by the green GNSS lock light illuminated, prior to starting flight. Due to the nature of using a GNSS aided INS, INS accuracy is highly dependent on good GNSS data.

GNSS antenna offset relative to the PDAS is a configurable item.

4.2.6 Pitot-Static

Pitot-static pressure ports are available for collecting air data information. Flexible tubing with an Inner Diameter (ID) of 1/8" and a maximum wall thickness of 5/16" should be used for interfacing to these ports. McMaster Carr supplies tubing, fittings, and reducers to interface with your aircraft pitot-static system.

4.3 Configuration

The PDAS is configured using a web-based interface. To access this interface, power the PDAS and ensure you are in the standby state. Connect an ethernet cable from the PDAS to your computer and manually change your IPv4 address settings to:

- Address: 192.168.1.1 to 192.168.1.253
- Netmask: 255.255.255.0
- Gateway: 192.168.1.1

Next, open your preferred web browser and navigate to 192.168.1.254 and you should see the following page:

Portable Data Acquisition System

Device Information

SERIAL NUMBER

225201

SOFTWARE VERSION

1.0.0

FREE SPACE, HOURS

177.25

Inertial Navigation System

GNSS FIX

3D

SATELLITES

5

LATITUDE

45.574272

LONGITUDE

-122.664234

ALTITUDE

65.55

PITCH

-1.12

ROLL

-0.13

YAW

64.06

Configuration

Rotation:

1

0

0

0

1

0

0

0

1

Antenna Offset:

X:

0

m

Y:

0

m

Z:

0

m

DLPF:

Digital low pass filter cutoff frequency, Hz:

20

Air Data

STATIC PRESS

0.00

DIFF PRESS

0.00

IAS

0.00

PRESS ALT

0.00

AGL ALT

0.00

OAT

0.00

Configuration

Pitot-Static

Enable:

☐

DLPF:

Digital low pass filter cutoff frequency, Hz:

20

TARE STATIC PRESSURE

TARE DIFF PRESSURE

OAT

Enable:

☐

Type:

2-Wire-RTD

Resistance:

PT10

Excitation Current:

3.0A

DLPF:

Digital low pass filter cutoff frequency, Hz:

20

Analog

VOLTAGE

CH0

CH1

CH2

CH3

CH4

CH5

0.00

0.00

0.00

0.00

0.00

0.00

CH6

CH7

CH8

CH9

CH10

CH11

0.00

0.00

0.00

0.00

0.00

0.00

CALIBRATED VALUE

CH0

CH1

CH2

CH3

CH4

CH5

0.00

0.00

0.00

0.00

0.00

0.00

CH6

CH7

CH8

CH9

CH10

CH11

0.00

0.00

0.00

0.00

0.00

0.00

Configuration

CH

EN

DLPF

GAIN

ORDER

COEFFICIENTS

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0

11

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20

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RESTORE DEFAULTS

UPDATE CONFIG

Data Files

DATA0

DOWNLOAD

DELETE

Figure 8: PDAS configuration web page

This page enables to you view real-time data from the PDAS, configure PDAS components, and download and delete data files. The following sections describe configuration in detail. The current configuration is always displayed in the fields; after you modify it, be sure to press the *Update Config* button for the changes to take effect. press the *Restore Defaults* button to return to the factory default configuration at any time.

4.3.1 Device Information

The PDAS serial number and software version is displayed along with an estimate of the storage space available for data logging, given in hours.

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4.3.2 INS

The INS configurable items include the orientation of the PDAS within the vehicle, the offset from the PDAS to the GNSS antenna, and the digital lowpass filter cutoff frequency.

A rotation matrix is used to transform inertial measurements from the PDAS reference frame, as described in Section 0, to the vehicle frame. For correct estimation of aircraft attitude angles, the PDAS x-axis should be aligned to point out the aircraft's nose and the PDAS y-axis out the right wing. The matrix is defined as:

$$\begin{Bmatrix} x \\ y \\ z \end{Bmatrix}_{a/c} = \begin{bmatrix} C00 & C10 & C20 \\ C01 & C11 & C21 \\ C02 & C12 & C22 \end{bmatrix} \begin{Bmatrix} x \\ y \\ z \end{Bmatrix}_{PDAS}$$

The *C* matrix must be orthonormal and right-handed, with coefficients between -1 and 1. By default this matrix is the identity matrix.

The GNSS antenna offset defines the antenna position, relative to the PDAS, expressed in the vehicle's reference frame.

Accelerometer, gyro, and magnetometer measurements are compensated for estimated biases and scale factors. Then a first order digital low pass filter is applied. This filter is applied after the EKF and does not affect other INS measurements. The cutoff frequency for this filtering is configurable and the default is 20 Hz.

4.3.3 Air Data

Pitot-static measurements and estimates can be enabled or disabled depending on whether the PDAS is integrated with the aircraft pitot-static system. First order digital low pass filters are applied the measured static and differential pressures, which are then used to estimate altitudes and airspeeds. The cutoff frequency for this filtering is configurable and the default is 20 Hz.

Static and differential pressure can be tared using buttons on the PDAS configuration. A tare on the differential pressure is essential for accurate differential pressure measurement and airspeed estimation. A static pressure tare enables estimation of the height above the tare location. A tare should be performed just prior to every flight that these measurements are desired. These systems should be tared with the pitot tube covers removed, the aircraft stationary, and not pointed into the wind.

OAT measurements and estimates can be enabled or disabled depending on whether an RTD sensor is integrated with the PDAS. RTD configurable items include the number of wires, 0 °C resistance, and the excitation current. A first order digital low pass filter is applied to the measured temperature; the cutoff frequency of this filter is configurable and the default value is 20 Hz.

If pitot-static is enabled, the following measurements will be available:

- Static and differential pressures
- Filtered static and differential pressures
- Pressure altitude
- Indicated airspeed
- Equivalent airspeed

If OAT is enabled, the following measurements will be available:

- OAT
- Filtered OAT

If both the pitot-static and OAT are enabled, the following additional measurements will be available:

- Density altitude
- True airspeed

4.3.4 Analog

Each analog channel can be enabled depending on whether analog sensors are integrated with that channel. Amplifier gain can be selected. Channels 0 - 5 have gains of 1, 10, 100, and 1000 available; Channels 6 - 11 have gains of 1, 2, 4, and 8. Amplifier gains are not removed in post-processing. For example, if a voltage of 0.1V is measured with a gain of 1, a voltage of 0.2V will be measured with the gain set to 2.

A first order digital low pass filter is applied to the voltage on each channel. The cutoff frequency of the filter is configurable and the default value is 20 Hz.

Up to a 5th order polynomial can be defined for each channel to convert the filtered voltage to engineering units, such as force and displacement values. The polynomial order should be selected and the polynomial coefficients are entered in order of descending power.

4.3.5 Data Files

Data files stored on the PDAS are displayed and can be downloaded or deleted using the buttons provided with each.

4.4 IADS

PDAS is setup to run as a Symvionics IADS data source in both the standby and run state. All PDAS data is available and data is streamed to IADS at 50 Hz. To configure PDAS as an IADS data source, ensure the PDAS is connected to your computer with an ethernet cable and is powered. Change your IPv4 address settings to:

- Address: 192.168.1.1 to 192.168.1.253
- Netmask: 255.255.255.0
- Gateway: 192.168.1.1

Select the following options while starting IADS:

- Data Source: IADS Custom
- Host Name: 192.168.1.254
- Port ID: 49000
- PRN File: download the prn file that was sent with PDAS and select it

4.5 Data Conversion

PDAS stores data in a compressed binary format that is optimized for file size and speed. A standalone Windows executable was shipped with PDAS to convert these binary files to CSV files. Double click the executable to start the command line program and select the data file to convert and the destination location. A progress bar is displayed and the program will let you know when it is complete. A list of available data channels, their units, their name in IADS, and their column number in the CSV file is in Appendix A.

5 Appendix A – Data File Description

| CSV Column | IADS Name | Description | Units |
|------------|--------------------|---|-------|
| 1 | | Time. | s |
| 2 | active | Test point active (1) or inactive (0) flag. | |
| 3 | test_point | Test point number. | |
| 4 | imu_accel_x_g | IMU x-axis accelerometer data. Uncompensated and unfiltered. | g |
| 5 | imu_accel_y_g | IMU y-axis accelerometer data. Uncompensated and unfiltered. | g |
| 6 | imu_accel_z_g | IMU z-axis accelerometer data. Uncompensated and unfiltered. | g |
| 7 | imu_gyro_x_dps | IMU x-axis gyro data. Uncompensated and unfiltered. | deg/s |
| 8 | imu_gyro_y_dps | IMU y-axis gyro data. Uncompensated and unfiltered. | deg/s |
| 9 | imu_gyro_z_dps | IMU z-axis gyro data. Uncompensated and unfiltered. | deg/s |
| 10 | imu_mag_x_ut | IMU x-axis magnetometer data. Uncompensated and unfiltered. | μT |
| 11 | imu_mag_y_ut | IMU y-axis magnetometer data. Uncompensated and unfiltered. | μT |
| 12 | imu_mag_z_ut | IMU z-axis magnetometer data. Uncompensated and unfiltered. | μT |
| 13 | gnss_tow_s | GNSS Time of Week (TOW). | s |
| 14 | gnss_week | GNSS week number. | |
| 15 | gnss_num_sat | Number of satellites used in GNSS Solution. | |
| 16 | gnss_fix_type | GNSS fix (3 = 3D fix, 2 = 2D fix, 1 = time only, 0 = no fix). | |
| 17 | gnss_lat_deg | GNSS latitude. | deg |
| 18 | gnss_long_deg | GNSS longitude. | deg |
| 19 | gnss_alt_ft | GNSS altitude. | ft |
| 20 | gnss_north_vel_kts | GNSS north velocity. | kts |
| 21 | gnss_east_vel_kts | GNSS east velocity. | kts |
| 22 | gnss_down_vel_kts | GNSS down velocity. | kts |
| 23 | gnss_horiz_acc_ft | Estimated GNSS horizontal position accuracy. | ft |
| 24 | gnss_vert_acc_ft | Estimated GNSS vertical position accuracy. | ft |
| 25 | gnss_speed_acc_kts | Estimated GNSS speed accuracy. | kts |
| 26 | ekf_accel_x_g | INS x-axis accelerometer. Compensated from EKF error estimate and filtered. | g |
| 27 | ekf_accel_y_g | INS y-axis accelerometer. Compensated from EKF error estimate and filtered. | g |
| 28 | ekf_accel_z_g | INS z-axis accelerometer. Compensated from EKF error estimate and filtered. | g |
| 29 | ekf_gyro_x_dps | INS x-axis gyro. Compensated from EKF error estimate and filtered. | deg/s |
| 30 | ekf_gyro_y_dps | INS y-axis gyro. Compensated from EKF error estimate and filtered. | deg/s |
| 31 | ekf_gyro_z_dps | INS z-axis gyro. Compensated from EKF error estimate and filtered. | deg/s |
| 32 | ekf_mag_x_ut | INS x-axis magnetometer. Compensated from EKF error estimate and filtered. | μT |
| 33 | ekf_mag_y_ut | INS y-axis magnetometer. Compensated from EKF error estimate and filtered. | μT |
| 34 | ekf_mag_z_ut | INS z-axis magnetometer. Compensated from EKF error estimate and filtered. | μT |
| 35 | ekf_lat_deg | INS latitude estimate from EKF. | deg |
| 36 | ekf_lon_deg | INS longitude estimate from EKF. | deg |
| 37 | ekf_alt_ft | INS altitude estimate from EKF. | ft |
| 38 | ekf_north_vel_kts | INS north velocity estimate from EKF. | kts |
| 39 | ekf_east_vel_kts | INS east velocity estimate from EKF. | kts |
| 40 | ekf_down_vel_kts | INS down velocity estimate from EKF. | kts |
| 41 | ekf_yaw_deg | INS yaw estimate from EKF. | deg |
| 42 | ekf_pitch_deg | INS pitch estimate from EKF. | deg |
| 43 | ekf_roll_deg | INS roll estimate from EKF. | deg |
| 44 | ekf_att_uncert_deg | INS attitude uncertainty estimate from EKF. | deg |
| 45 | ekf_pos_uncert_ft | INS position uncertainty estimate from EKF. | ft |
| 46 | ekf_vel_uncert_kts | INS velocity uncertainty estimate from EKF. | kts |

| | | | |
|----|----------------------|------------------------------------|-----|
| 47 | pitot_static_en | Pitot-Static Enabled. | |
| 48 | oat_en | OAT Enabled. | |
| 49 | static_press_pa | Static pressure. | Pa |
| 50 | static_press_filt_pa | Filtered static pressure. | Pa |
| 51 | diff_press_pa | Differential pressure. | Pa |
| 52 | diff_press_filt_pa | Filtered differential pressure. | Pa |
| 53 | temp_c | OAT. | C |
| 54 | temp_filt_c | Filtered OAT. | C |
| 55 | ias_kts | IAS. | kts |
| 56 | eas_kts | EAS. | kts |
| 57 | tas_kts | TAS. | kts |
| 58 | press_alt_ft | Pressure altitude. | ft |
| 59 | agl_alt_ft | AGL altitude. | ft |
| 60 | density_alt_ft | Density altitude. | Ft |
| 61 | ain0_en | Analog channel 0 enabled. | |
| 62 | ain0_v | Analog channel 0 voltage. | V |
| 63 | ain0_filt_v | Analog channel 0 filtered voltage. | V |
| 64 | ain0_cal_v | Analog channel 0 calibrated value. | |
| 65 | ain1_en | Analog channel 1 enabled. | |
| 66 | ain1_v | Analog channel 1 voltage. | V |
| 67 | ain1_filt_v | Analog channel 1 filtered voltage. | V |
| 68 | ain1_cal_v | Analog channel 1 calibrated value. | |
| 69 | ain2_en | Analog channel 2 enabled. | |
| 70 | ain2_v | Analog channel 2 voltage. | V |
| 71 | ain2_filt_v | Analog channel 2 filtered voltage. | V |
| 72 | ain2_cal_v | Analog channel 2 calibrated value. | |
| 73 | ain3_en | Analog channel 3 enabled. | |
| 74 | ain3_v | Analog channel 3 voltage. | V |
| 75 | ain3_filt_v | Analog channel 3 filtered voltage. | V |
| 76 | ain3_cal_v | Analog channel 3 calibrated value. | |
| 77 | ain4_en | Analog channel 4 enabled. | |
| 78 | ain4_v | Analog channel 4 voltage. | V |
| 79 | ain4_filt_v | Analog channel 4 filtered voltage. | V |
| 80 | ain4_cal_v | Analog channel 4 calibrated value. | |
| 81 | ain5_en | Analog channel 5 enabled. | |
| 82 | ain5_v | Analog channel 5 voltage. | V |
| 83 | ain5_filt_v | Analog channel 5 filtered voltage. | V |
| 84 | ain5_cal_v | Analog channel 5 calibrated value. | |
| 85 | ain6_en | Analog channel 6 enabled. | |
| 86 | ain6_v | Analog channel 6 voltage. | V |
| 87 | ain6_filt_v | Analog channel 6 filtered voltage. | V |
| 88 | ain6_cal_v | Analog channel 6 calibrated value. | |
| 89 | ain7_en | Analog channel 7 enabled. | |
| 90 | ain7_v | Analog channel 7 voltage. | V |
| 91 | ain7_filt_v | Analog channel 7 filtered voltage. | V |
| 92 | ain7_cal_v | Analog channel 7 calibrated value. | |
| 93 | ain8_en | Analog channel 8 enabled. | |
| 94 | ain8_v | Analog channel 8 voltage. | V |
| 95 | ain8_filt_v | Analog channel 8 filtered voltage. | V |
| 96 | ain8_cal_v | Analog channel 8 calibrated value. | |

| | | | |
|-----|--------------|---|---|
| 97 | ain9_en | Analog channel 9 enabled. | |
| 98 | ain9_v | Analog channel 9 voltage. | V |
| 99 | ain9_filt_v | Analog channel 9 filtered voltage. | V |
| 100 | ain9_cal_v | Analog channel 9 calibrated value. | |
| 101 | ain10_en | Analog channel 10 enabled. | |
| 102 | ain10_v | Analog channel 10 voltage. | V |
| 103 | ain10_filt_v | Analog channel 10 filtered voltage. | V |
| 104 | ain10_cal_v | Analog channel 10 calibrated value. | |
| 105 | ain11_en | Analog channel 11 enabled. | |
| 106 | ain11_v | Analog channel 11 voltage. | V |
| 107 | ain11_filt_v | Analog channel 11 filtered voltage. | V |
| 108 | ain11_cal_v | Analog channel 11 calibrated value. | |
| | state | State run (1) or standby (0) | |
| | gnss_lock | GNSS has 3D fix (1) or not (0) | |
| | fault | Soft fault occurred during initialization (1) or no faults detected (0) | |

6 Appendix B – Acronyms

| | |
|------|------------------------------------|
| a/c | Aircraft |
| AGL | Above Ground Level |
| DLPF | Digital Low Pass Filter |
| EAS | Equivalent Airspeed |
| FTE | Flight Test Engineer |
| GNSS | Global Navigation Satellite System |
| ID | Inner Diameter |
| IAS | Indicated Airspeed |
| IMU | Inertial Measurement Unit |
| INS | Inertial Navigation System |
| LLA | Latitude, Longitude, Altitude |
| OAT | Outside Air Temperature |
| PDAS | Portable Data Acquisition System |
| RTD | Resistance Temperature Device |
| TAS | True Airspeed |