Portable Data Acquisition System (PDAS)

User Manual

Firmware v1.3.1

Document Revision 1.7

Table of Contents

1 Technical Documentation

The following documentation and support software are included with PDAS and are available from our website, https://bolderflight.com/pdas, or by emailing support@bolderflight.com:

- **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 or MATLAB mat formats.
- **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.

2 Support

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 operation of our data acquisition system.

3 Introduction

3.1 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 Global Navigation Satellite System (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 serial external data interface for sending PDAS up to 40 single-precision and 5 double-precision floating point variables for data logging and real-time display. This can be used to interface with other avionics system components or extend PDAS functionality.
- 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 or MATLAB mat 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.

3.2 Measurement Outputs

Outputs from the PDAS include:

- Time (microsecond resolution)
- Test point number
- Whether the test point was active or inactive
- Inertial Measurement Unit (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
- External data:
    - Single precision floating point data
    - Double precision floating point data

3.3 System Modules

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

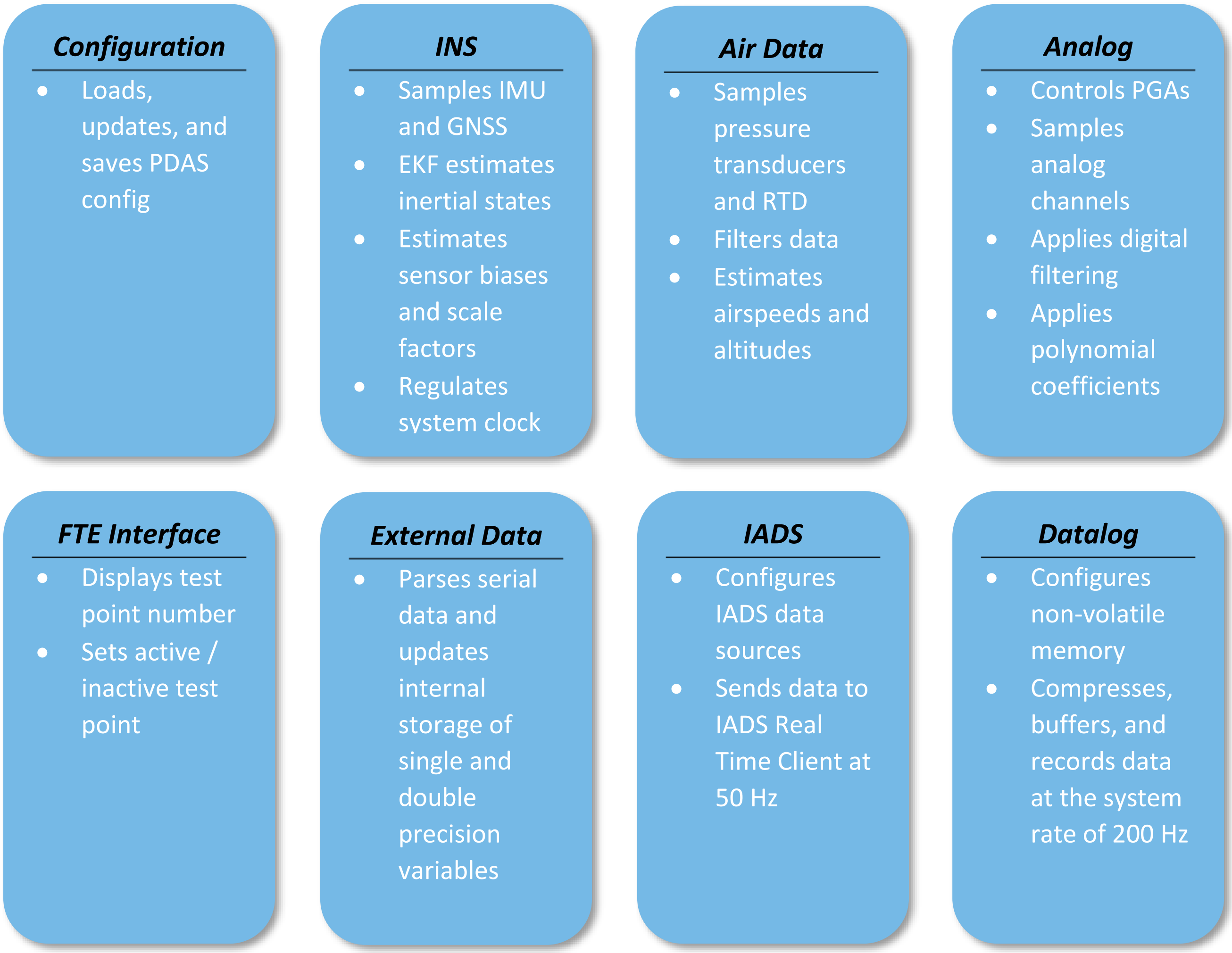


Figure 1: PDAS software modules.

3.3.1 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
- External data source baud rate

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.

3.3.2 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 tied 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.

3.3.3 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 ^{o}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.

3.3.4 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 of 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.

3.3.5 FTE Interface

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

3.3.6 External Data

The external data module parses serial data, if available, and on receiving a valid packet, updates the single and double precision values stored on PDAS. Up to 40 single precision floating point values and 5 double precision floating point values can be stored. These values are updated at the PDAS 200 Hz data logging rate and are also available in IADS.

3.3.7 IADS

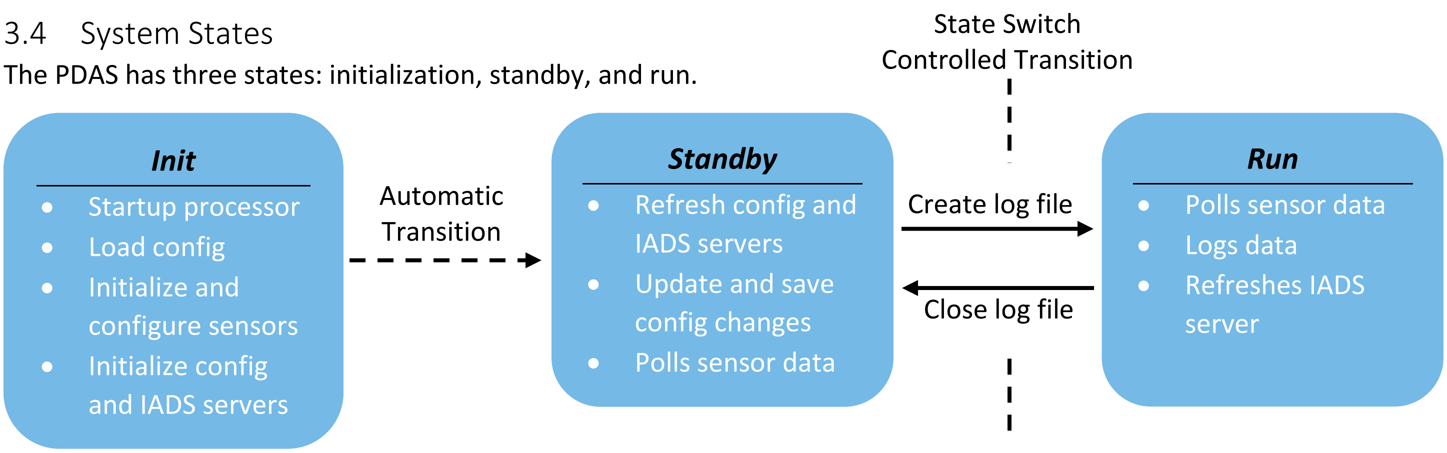
Symvionics IADS is a real-time test display and analysis suite. Our IADS module acts as a data source and IADS server to the real time display client. All of the PDAS data is available and transmitted to IADS at a rate of 50 Hz.

3.3.8 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 or MATLAB mat file that can be loaded into analysis software.

3.4 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.

4 Specifications

4.1 Electrical

4.1.1 Power

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

- **Voltage input:** 3.4 – 5.5V DC
- **Current draw:** 1A

4.1.2 FTE and External Data Interface

The FTE and external data 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. A pinout of the connector is below.

Table 1: FTE interface and external data pinout.

Pin	Description
1	PDAS Power Input Supply
2	FTE Interface RX (3.3V TTL)
3	FTE Interface TX (3.3V TTL)
4	GND
5	PDAS Power Input Supply
6	External Data RX (3.3V TTL)
7	External Data TX (3.3V TTL)
8	GND
9	GND

Note that the supplied power voltage is the PDAS input power voltage; while the input voltage range specified in Section 3.1.1 is adequate for PDAS and the FTE interface, please ensure it is suitable for any external data equipment powered from the DB9 cable. Also, note that all logic is 3.3V TTL and the pin descriptions are given for the PDAS (i.e. pin 6 is the PDAS receive pin), these will likely need to be crossed on the external data equipment for proper communication.

The format for sending external data to the PDAS is:

Table 2: External data format.

Byte	Description
0	Header 0x42
1	Header 0x46
2	Starting Single Precision Index
3	Starting Double Precision Index
4	Number of Single Precision Variables
5	Number of Double Precision Variables
X	Single Precision Variable Data
Y	Double Precision Variable Data
5 + X + Y + 1	Fletcher 16 Checksum LSB
5 + X + Y + 2	Fletcher 16 Checksum MSB

A two-byte header (0x42, 0x46) is used to find the start of the packet. The starting index is the 0-based index in the array of variables on PDAS where the data should be written to. For example, to write 10 single precision variables between index 10 and index 19 on the PDAS, the starting single precision index would be 10 and the number of single precision variables would be 10. This enables transmitting burst writes of partial data packets, which is useful in reducing bandwidth if there are multiple update rates for the external data sources (i.e. GNSS and IMU data updating at different rates).

Data is transmitted in little-Endian byte order. The Fletcher-16 checksum is computed over the entire packet, including the header, as:

```c
uint16_t Fletcher16( uint8_t *data, int count )
{
   uint16_t sum1 = 0;
   uint16_t sum2 = 0;
   int index;

   for ( index = 0; index < count; ++index )
   {
      sum1 = (sum1 + data[index]) % 255;
      sum2 = (sum2 + sum1) % 255;
   }

   return (sum2 << 8) | sum1;
}
```

Figure 2: Fletcher-16 checksum calculation

4.1.3 GNSS Antenna

The GNSS receiver interfaces with an active antenna via an SMA port, which is capable of suppling 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.

4.1.4 External Sensors

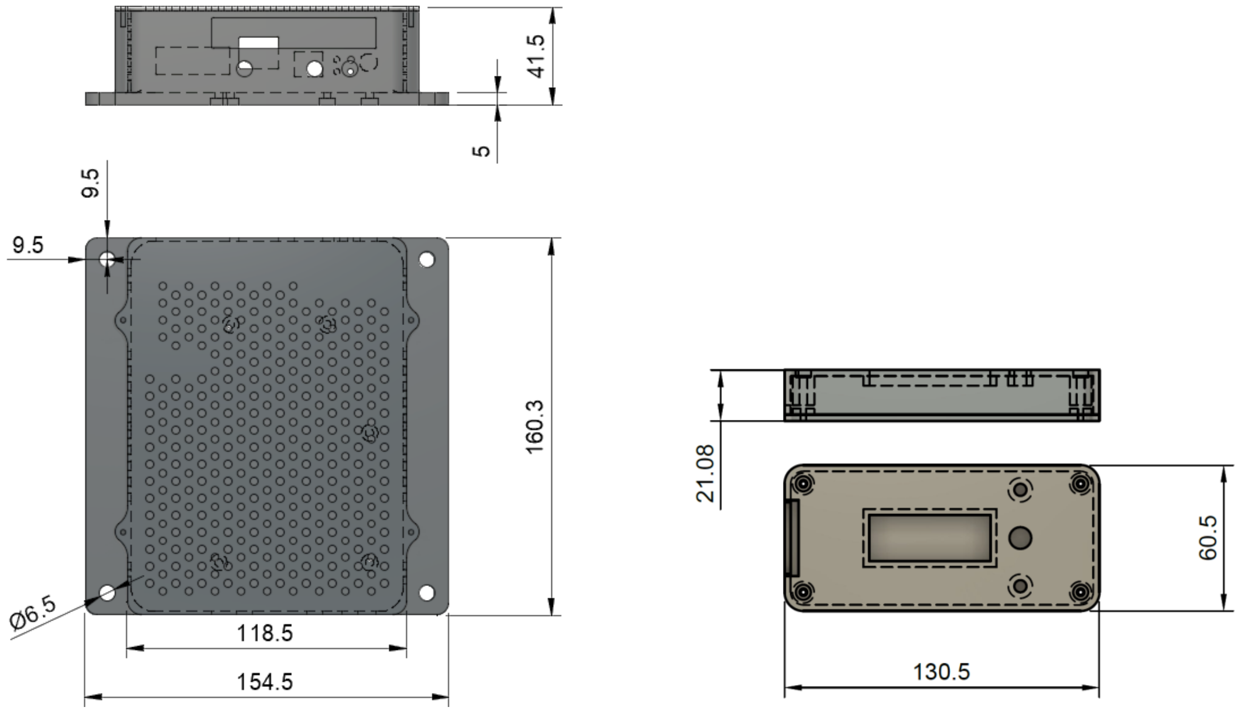
Analog and RTD sensors are connected via a 62 pin D-Sub connector. The pinout of this port is below. Limit the voltage on analog inputs to 0 - 5V and be aware that the ultra-low noise +5V supplies can source 50 mA of current per channel.

Table 3: 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		

4.2 Dimensions

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



(a) *(b)*

Figure 3: PDAS (a) and FTE interface (b) dimensions

4.3 Sensing

- 200 Hz data rate
- INS:
  - Pitch/Roll accuracy: 0.03°
  - Heading accuracy: 0.3°
  - Horizontal position accuracy: 8 ft
  - Vertical position accuracy: 8 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 µA, 10 µA, 25 µA, 50 µA, 100 µA, 250 µA, 500 µA, 1000 µA
  - Sense Resistor: 2kΩ
  - 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

- External data:
  - 40 single precision variables
  - 5 double precision variables

4.4 Maximum Ratings

- **Acceleration:** +/- 16 g
- **Rotation:** +/- 2,000 deg/s
- **Airspeed:** 0 to 340 knots
- **Altitude:** -10,000 to +70,000 ft
- **Temperature:** -10 to +50C

4.5 Coordinate System

The PDAS uses a right-handed coordinate system, Figure 4.

Figure 4: 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.

5 Operations

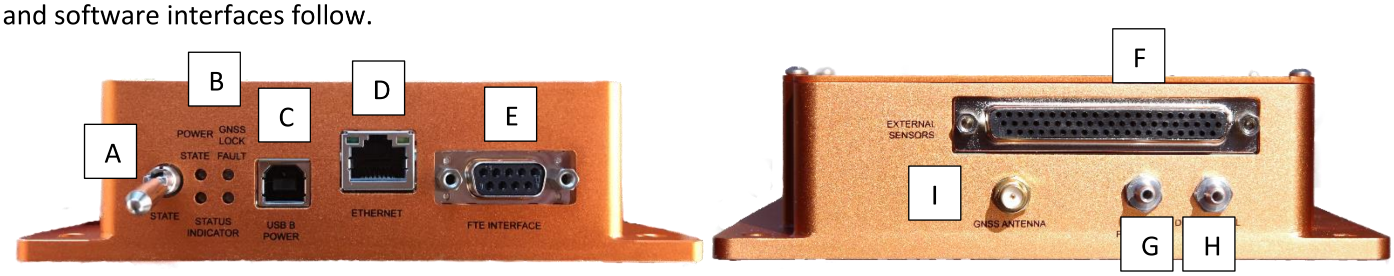
5.1 Overview

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 or MATLAB mat format
11. Load the data into your analysis tools and analyze the results

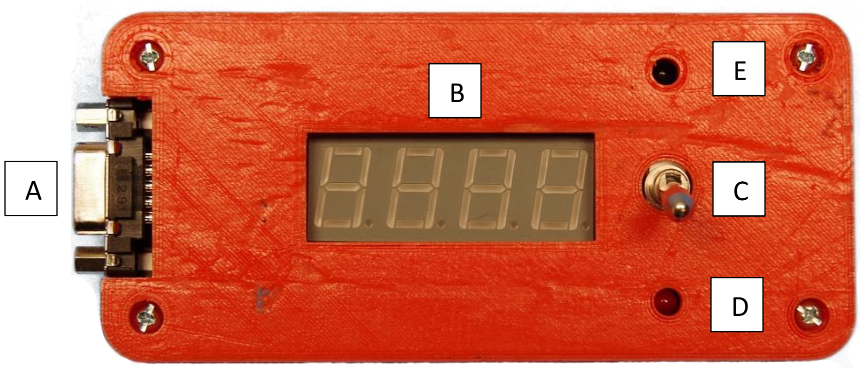
5.2 Interfaces

Depictions of the PDAS and FTE interfaces is in Figure 5 and Figure 6, 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 & External Data Interface	H	Differential Pressure
C	USB Type B Power Input	F	External Sensors	I	GNSS Antenna

Figure 5: 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 6: FTE interface overview

5.2.1 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.

5.2.2 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 lever 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.
Fault	Lower Right	Off	No faults encountered.
		Blinking	Fault during initialization, check config. More details provided below.
		On	Hard fault. Contact Bolder Flight Systems to troubleshoot.

5.2.3 Troubleshooting

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.

5.2.4 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 in Figure 7; if the switch were moved up again, test point 2 would be selected and active.

Figure 7: 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 recommended procedure is to:

1. Move the switch from inactive to active a few seconds before the start of a test point maneuver.
2. Note the test point number in your test cards.
3. 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.
- Enable you to get trim data at the start and completion of the test point by changing the test point active mode a few seconds before and after the maneuver; often this is useful for data analysis.

5.2.5 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 4.1.4, Table 3.

5.2.5.1 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 negative (-)Input signal to ground.

5.2.5.2 RTD Input

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

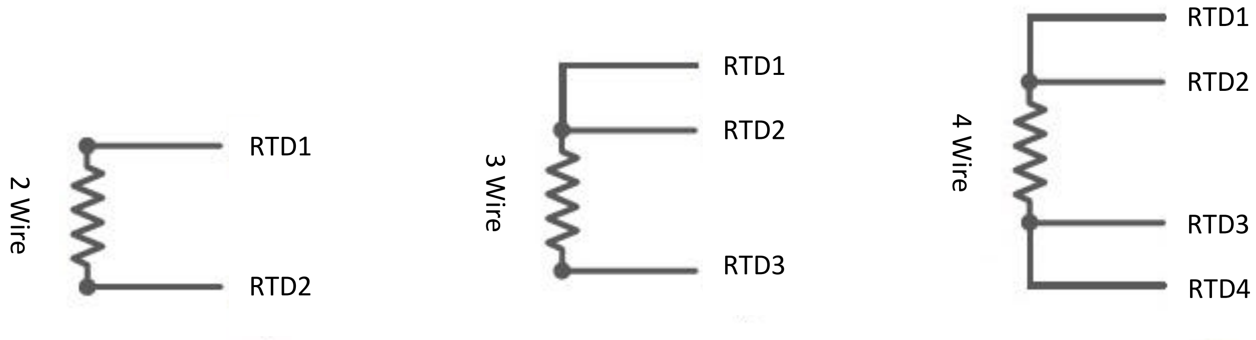


Figure 8: RTD wiring

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 2kΩ sense resistor is used in PDAS.

5.2.6 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.

5.2.7 Pitot-Static

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

5.3 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:

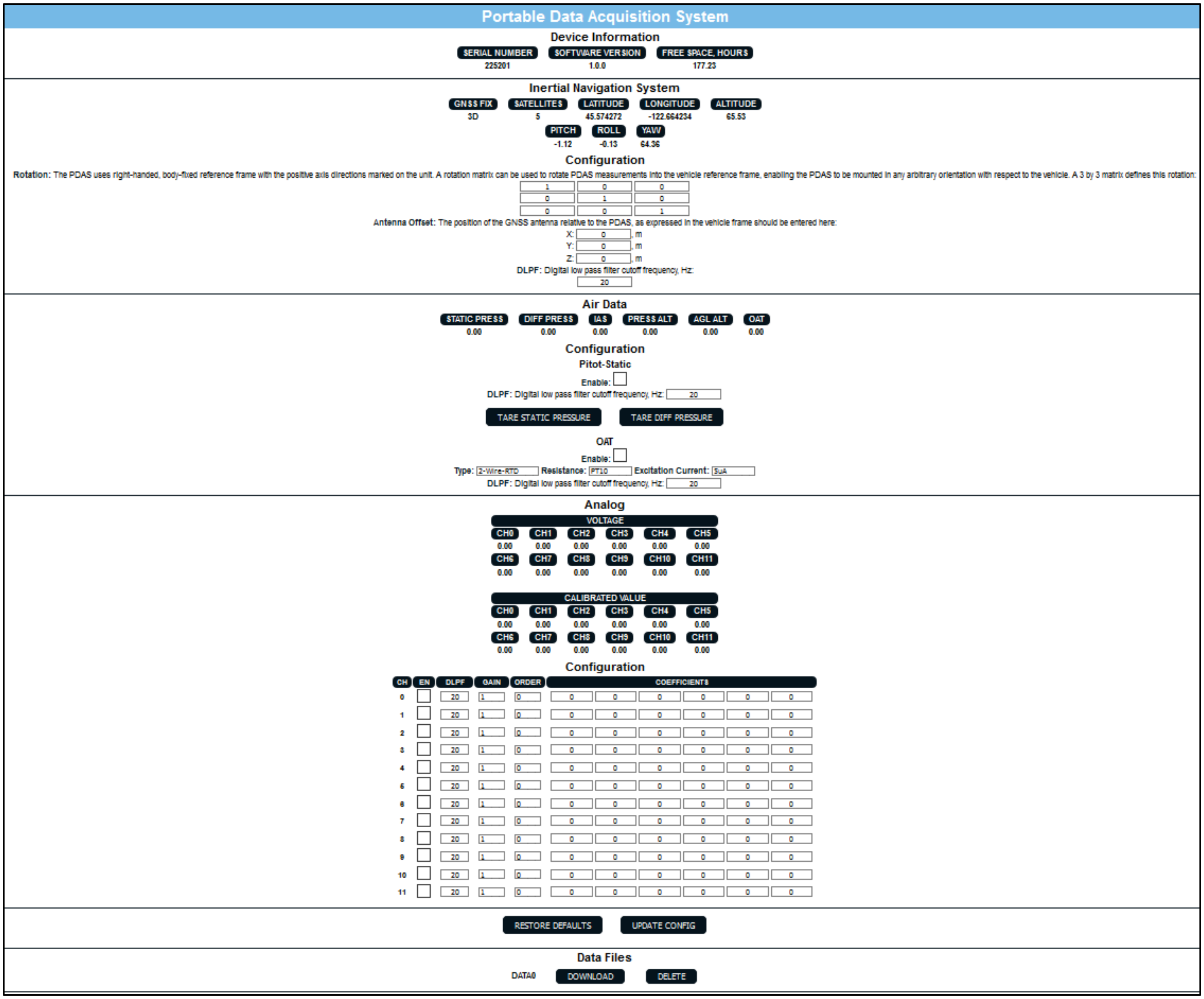


Figure 9: PDAS configuration web page

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.

5.3.1 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.

5.3.2 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 4.5, 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.

5.3.3 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 to 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 ^{o}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

5.3.4 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 5^{th} 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.

5.3.5 External Data

The baud rate of the external data interface can be configured with a drop-down menu.

5.3.6 Data Files

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

5.4 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

5.5 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 or MATLAB mat 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 MATLAB, and their column number in the CSV file is in Appendix A.

6 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

CSV Column	IADS Name	Description	Units
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

CSV Column	IADS Name	Description	Units
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.	
109	ext_single0	External data single precision channel 0.	
110	ext_single1	External data single precision channel 1.	
111	ext_single2	External data single precision channel 2.	
112	ext_single3	External data single precision channel 3.	
113	ext_single4	External data single precision channel 4.	
114	ext_single5	External data single precision channel 5.	
115	ext_single6	External data single precision channel 6.	
116	ext_single7	External data single precision channel 7.	
117	ext_single8	External data single precision channel 8.	
118	ext_single9	External data single precision channel 9.	
119	ext_single10	External data single precision channel 10.	
120	ext_single11	External data single precision channel 11.	
121	ext_single12	External data single precision channel 12.	
122	ext_single13	External data single precision channel 13.	
123	ext_single14	External data single precision channel 14.	
124	ext_single15	External data single precision channel 15.	
125	ext_single16	External data single precision channel 16.	
126	ext_single17	External data single precision channel 17.	
127	ext_single18	External data single precision channel 18.	
128	ext_single19	External data single precision channel 19.	
129	ext_single20	External data single precision channel 20.	
130	ext_single21	External data single precision channel 21.	
131	ext_single22	External data single precision channel 22.	
132	ext_single23	External data single precision channel 23.	
133	ext_single24	External data single precision channel 24.	
134	ext_single25	External data single precision channel 25.	
135	ext_single26	External data single precision channel 26.	
136	ext_single27	External data single precision channel 27.	
137	ext_single28	External data single precision channel 28.	
138	ext_single29	External data single precision channel 29.	
139	ext_single30	External data single precision channel 30.	
140	ext_single31	External data single precision channel 31.	
141	ext_single32	External data single precision channel 32.	
142	ext_single33	External data single precision channel 33.	

CSV Column	IADS Name	Description	Units
143	ext_single34	External data single precision channel 34.	
144	ext_single35	External data single precision channel 35.	
145	ext_single36	External data single precision channel 36.	
146	ext_single37	External data single precision channel 37.	
147	ext_single38	External data single precision channel 38.	
148	ext_single39	External data single precision channel 39.	
149	ext_double0	External data double precision channel 0.	
150	ext_double1	External data double precision channel 1.	
151	ext_double2	External data double precision channel 2.	
152	ext_double3	External data double precision channel 3.	
153	ext_double4	External data double precision channel 4.	
	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)	

7 Appendix B – Acronyms

a/c	Aircraft
AGL	Above Ground Level
DLPF	Digital Low Pass Filter
EAS	Equivalent Airspeed
EKF	Extended Kalman Filter
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