

DIGITAL DIRECTIONAL UAV AIR DATA PROBE

User Manual



WARNING

Read this document before using the product.

This probe is an experimental prototype, for measurement purposes only.

This system is not certified for use on aircraft.

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Version Control

Version	Date	Summary of changes
1.0	11-2018	New document
2.0	09-2019	Updated content and specifications, reformatted

1 INTRODUCTION

Principle of operation

This probe system includes a seven-hole pressure-based directional velocity probe, referenced against local static pressure. The probe system also contains a pressure altimeter, a six-component inertial measurement unit, and one or two external temperature sensors for static temperature monitoring and/or heater temperature control, a case temperature sensor and a humidity sensor and an external comms/power module. The probe system can stream data over a network data line (with the comms/power adaptor module) once powered on, but may also be used together with a computer using the on-board USB terminal.

System description

Bespoke miniature multi-function air-data probe.

System components

1x Probe assembly	The probe assembly consists of a seven-hole probe core with a local static sampling sleeve, a sensor package and an enclosure.
1x USB cable	A low-profile USB micro->A connector is bundled with the system.
1x Power/ comms module (optional)	This is a microcomputer module, providing an RS-232 link to the probe system as well as a power control system for the on-board sting heater.
1x Power/ comms cable assembly (optional)	

Please ensure that all the system components listed above have been supplied, and that there is no apparent damage from shipping.

System requirements

To interface with a computer, the probe system requires 64-bit Windows 7 (or newer) operating system (not included). Note that computer interface is not needed for stand-alone streaming operation. The probe has been pre-loaded with firmware; the computer software drivers and data logging software will be provided electronically. Additional drivers may be required to run the software on older Windows machines.

2 DETAILED SPECIFICATION

7 x differential pressure transducers	ID8HP-160P	ID8HP-1K0	ID8HP-6K9
Standard pressure ranges	160 Pa FS	1 kPa FS	6.9 kPa FS
Maximum overpressure	33.5 kPa	37.5 kPa	69 kPa
Sensor accuracy ¹	± 0.1 % FS		
Total error band after auto-zero ²	± 0.5 % FS	± 0.25 % FS	± 0.25 % FS
1 x absolute (static) pressure transducer	Range 1 atm FS, error band ² ±0.25 % FS		
Compensated temperature range	-40° to +65° C	0° to +50° C	0° to +50° C
Operating temperature range	-40° to +65° C non-condensing		
Storage temperature range	-40° to +65° C non-condensing		
Vibration	Sensors rated to 15 g, 10 Hz to 2 Hz		
Maximum relative humidity	95 %		
Relative humidity sensor specification	0 % to 100 % RH, +/- 3%		
Ambient temperature sensor specification ³	0°C - 65°C ± 0.5°C		
Ambient absolute pressure sensor specification	30-110 kPa FS, +/- 0.1kPa		
Reference pressure	Integrated with static pressure ring on sting		
Standard sting material	CFRP		
Sting diameter	12 mm		
Standard tip geometry	Hemispherical		
Angular measurement range ⁴	± 45°		
Sting heater	Optional film heater located between sting tip and static ring		
Sting tip temperature measurement	-80°C - 150°C ± 1°C		
Remote temperature probe	2x -80°C - 150°C ± 1°C		
Absolute temperature limits	-80° to +65° C (expected) non-condensing ⁵		
Absolute pressure limits	0 - 1.5 atm		
Weight (approximate)	95 g		
Voltage	6-24 VDC system, 28 VDC sting heater Reverse-polarity protected ESD protected to ±2 kV		
Power	min. 310 mW heater off/ 2310 mW heater on		
Communications interface	USB2.0, RS232 or UDP Ethernet available		
Data acquisition rate	1 kHz (equivalent)		
Digital resolution	24-bit pressure, 16-bit environmental and IMU		
System requirements	Windows 7 or later, minimum 3GHz & 4Gb RAM		
Data output	Single-precision floats in SI units TTL 3.3V serial output or via USB TTL serial ESD protected to ±25 kV		
IMU specification	3 axis gyro, 125 °/s FS, ± 3.9 x10 ⁻³ °/s 3 axis accelerometer, 2g FS, ± 0.061 mg		

¹ Includes errors due to pressure non-linearity, pressure hysteresis, non-repeatability and calibration uncertainty.

² Total residual error after auto-zero, excluding residual temperature sensitivity.

³ Temperature is recorded at the location of the PCB. Waste heat from electronic components may distort temperature readings.

⁴ Angular range specified for hemispherical tip; depends on tip geometry.

⁵ Temperature limits are design limits, based on assumptions about heat transfer at high altitudes

3 SERIAL COMMUNICATIONS

When the probe system is powered on, it will undergo a brief system diagnostic test; if the test is passed, then a green LED will illuminate at the rear of the probe near the cable connections.

The sensors are factory-calibrated, and the calibration data is held in on-board memory. Data are converted into SI units by the firmware and streamed as single-precision floats.

Commands

Each data packet consists of 78 bytes, beginning with an unsigned-integer frame character ("#") and terminating with a checksum (both inclusive); the UART configuration is the typical 8-N-1. The data order is shown below.

byte index	Description	Type	Unit
0	Frame character '#'	uint8	-
1	+ Pressure 0 (abs)	float32	Pa
2			
3			
4			
5	- Pressure 1 (dyn)	float32	Pa
6			
7			
8			
9	- Pressure 2 (dyn)	float32	Pa
10			
11			
12			
13	- Pressure 3 (dyn)	float32	Pa
14			
15			
16			
17	- Pressure 4 (dyn)	float32	Pa
18			
19			
20			
21	- Pressure 5 (dyn)	float32	Pa
22			
23			
24			
25	- Pressure 6 (dyn)	float32	Pa
26			
27			
28			
29	- Pressure 7 (dyn)	float32	Pa
30			
31			
32			
33	External thermistor 0 temperature	float32	deg C
34			
35			
36			

37	External thermistor 1 temperature	float32	deg C
38			
39			
40			
41	Atmospheric pressure	float32	Pa
42			
43			
44			
45	Internal case temperature (sensor die)	float32	deg C
46			
47			
48			
49	Relative humidity	float32	%
50			
51			
52			
53	Accelerometer x component	float32	g
54			
55			
56			
57	Accelerometer y component	float32	g
58			
59			
60			
61	Accelerometer z component	float32	g
62			
63			
64			
65	Gyroscope x component	float32	deg / s
66			
67			
68			
69	Gyroscope y component	float32	deg / s
70			
71			
72			
73	Gyroscope z component	float32	deg / s
74			
75			
76			
77	Checksum	uint8	-

IMPORTANT NOTE: Data are transmitted using the little-endian convention, so that the first byte transmitted for each quantity is the least significant.

A partial data packet, having only 42 bytes and excluding less critical data, is also available from the probe. The data order for this data packet is shown below.

byte index	Description	Type	Unit
0	Frame character '#'	uint8	-
1	+ Pressure 0 (abs)	float32	Pa
2			
3			
4			
5	- Pressure 1 (dyn)	float32	Pa
6			
7			
8			
9	- Pressure 2 (dyn)	float32	Pa
10			
11			
12			
13	- Pressure 3 (dyn)	float32	Pa
14			
15			
16			
17	- Pressure 4 (dyn)	float32	Pa
18			
19			
20			
21	- Pressure 5 (dyn)	float32	Pa
22			
23			
24			
25	- Pressure 6 (dyn)	float32	Pa
26			
27			
28			
29	- Pressure 7 (dyn)	float32	Pa
30			
31			
32			
33	External thermistor 0 temperature	float32	deg C
34			
35			
36			
37	External thermistor 1 temperature	float32	deg C
38			
39			
40			
41	Checksum	uint8	-

Checksum & data corruption warning

A checksum byte is included with each data packet to provide a warning of data loss or corruption in transmission. To compute the checksum, add all the byte values in the array excluding the checksum byte at the end of the array, modulo 256. If the data has been transmitted correctly, this value will match the transmitted checksum. If the computed and transmitted checksums do not match, the entire data packet should be discarded.

An example function for computing the checksum is included below, where it has been assumed that the array and its length are global scope variables.

```
uint8_t CalcChecksum()
{
    uint8_t sum = 0;
    for (uint8_t i = 0; i < (Nbytes - 1); i++)
    {
        sum += ArrayOfBytes[i];
    }
    return sum;
}
```

By defining the sum variable as a `uint8_t` the addition will automatically be modulo 256. Otherwise more explicitly it would be

```
sum = (sum + ArrayOfBytes[i]) % 256
```

Note that additional details about the probe communications are appended to the end of this document.

4 PHYSICAL CONNECTIONS

The probe system is supplied as a single integrated unit. The probe sting should be mounted facing axially in the direction of nominal mean flow. Note that the on-board IMU will enable the roll-alignment of the probe to be matched to calibration conditions.

A small red dot was added to the tip of the probe, adjacent to the hole that was oriented upwards during the calibration process.

WARNING: Do not apply local stresses to the probe casing, or the casing may crack. The probe should be held in place with a friction collet, or other circular clamping arrangement.

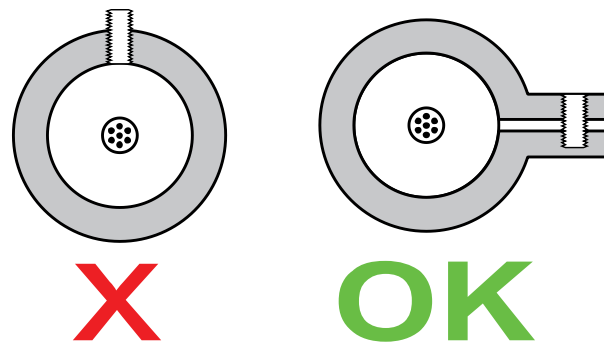


Figure 1: Correct probe mounting

It is recommended that the probe be fixed into the airframe by the sting, so that there are minimal loads transferred between the carbon-fibre sting and the nylon sensor enclosure. The sensor enclosure-sting junction cannot withstand large bending moments.

Probe assembly

The probe assembly consists of a seven-hole probe core surrounded by a static pressure sleeve, and has been machined with a hemispherical tip for maximum sensitivity to small flow angles. A slight narrowing of the sting around the static ring is included to improve performance at nonzero incidence.

The hole arrangement, when viewed from upstream, is as illustrated below. Note that the roll alignment is arbitrary. Note that this may vary for some probes. Please check the documentation included with the probe.

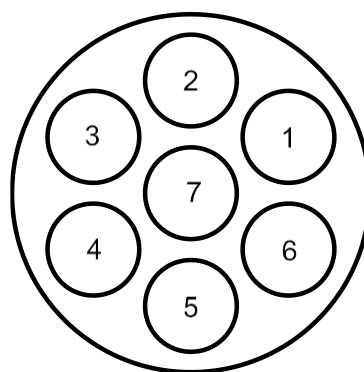


Figure 2: Hole numbering convention, looking at probe tip from upstream, with the probe body located behind.

Sensor package

There are two user-accessible ports on the sensor package- a micro-USB port and a serial comms port.

Micro-USB port: This allows the user to access the sensing and diagnostic functions of the probe system using a PC (with the appropriate drivers and software installed).

Comms port: This is the serial communications connection. There are four pins- V+ (1), GND (2), Rx (3) and Tx (4), where pin 1 is on the left when the probe is oriented such that the serial port is below the micro-USB port. The length of the data cables should be limited to 1.8 m or less, and should be routed away from the board and any cables carrying electric motor currents. When used with the power/comms module, the serial communications will be via the module.

IMPORTANT: The Tx line described is the transmit bus for the sensor package. This should be connected to the Rx of the unit receiving the data.

Power/comms module

The power/comms module provides fused power connections for the sting heater, as well as a data conversion system to communicate with the probe via the serial communications port. The power/comms module has been supplied in OEM configuration for customer installation.

There are five ports on the power/comms module for customer connection. Mating connectors have been supplied with the system. A detailed description of each of these is below.

WARNING: Use extreme care in soldering and connecting during customer installation. Damage from incorrect installation will invalidate the product warranty.

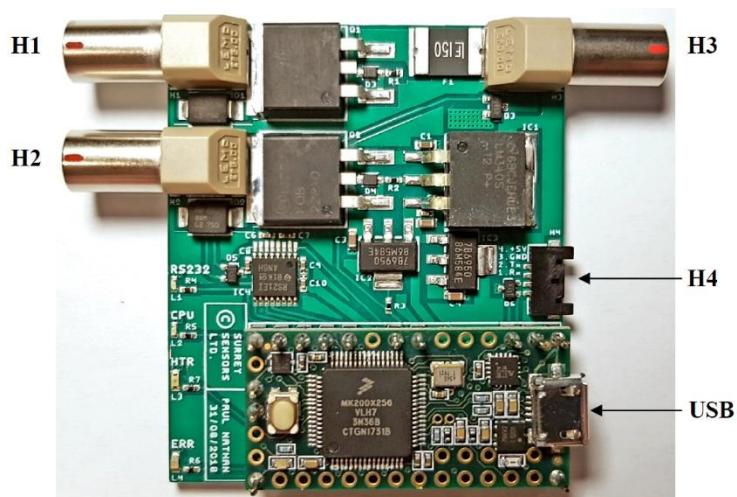
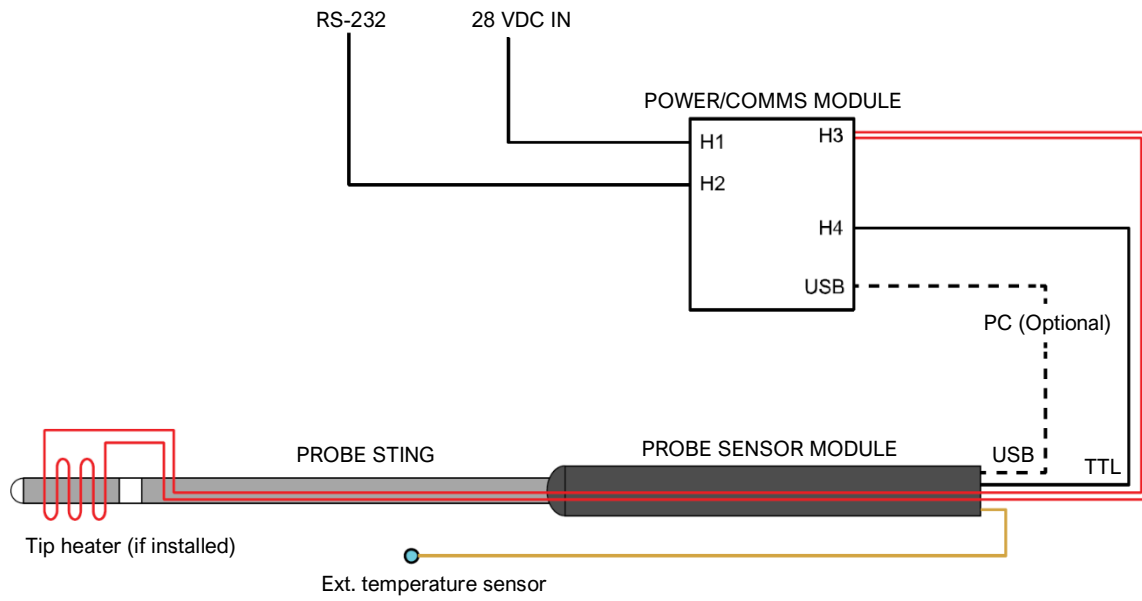


Figure 3: Schematic setup, and detail of the power/comms module showing the five connectors.

H1: 2-pole LEMO EPG.00.302.HLN, mates with LEMO FGG.00.302.CLAD35. This port receives the 28 VDC power for the probe tip heater.

Pin	Description	Direction	Notes
1	+28 VDC	in	+30 VDC max
2	GND	--	--

H2: 4-pole LEMO EPG.00.304.HLN, mates with LEMO FGG.00.304.CLAD35. This port supplies power to the power/comms module and probe, and carries RS-232 signals to and from the power/comms module.

Client

Pin	Description	Direction	Notes
1	+28 VDC	in	5.3 to 30 VDC max ¹
2	GND	--	--
3	DOUT	out	RS-232 comms ²
4	RIN	in	RS-232 comms ²

¹ Not including voltage drop along cable

² Referenced to GND

Host

Pin	Description	Direction	Notes
1	+28 VDC	in	5.3 to 30 VDC max ¹
2	GND	--	--
3	RIN	in	RS-232 comms ²
4	DOUT	out	RS-232 comms ²

¹ Optional; can use USB power

² Referenced to GND; crossed-over relative to client

H3: 2-pole LEMO EPG.00.302.HLN, mates with LEMO FGG.00.302.CLAD35. This port outputs power to probe tip heater.

Pin	Description	Direction	Notes
1	Heater	out	(no polarity)
2	Heater	out	(no polarity)

H4: 4-pole Molex 503763-0491; mates with Molex 15131-0403. This port outputs power to probe, and carries TTL signals to and from the probe. Note that, for best performance, the length of this lead should be minimized.

Pin	Description	Direction	Notes
1	TTL Rx	in	--
2	TTL Tx	out	--
3	GND	--	--
4	+5VDC	out	--

USB: The micro-USB port is used for configuring and testing the power/comms module. In the case of the host version of the module, it is also used to communicate probe and client module data with the host PC. For configuration, it is recommended to use the supplied software executable “Dongle config.exe”. A list of ASCII USB commands for module configuration is appended to this document; these can be used to configure the module using your own software.

Status indicators

There are four LED indicators on the power/comms module, used to provide visual feedback from the system to the user during testing and installation. Each is marked using the silk-screen layer of the printed circuit board.

Label	Indicator colour	Description
RS232	Green	Illuminates when a valid RS-232 link is established.
CPU	Green	Illuminates when the on-board processor has initialised successfully and the power/comms module is ready for operation.
HTR	Amber	Illuminates when the heater circuit is enabled by command.
ERR	Red	Illuminates if a data buffer overrun occurs, and remains lit until reset by user.

Important notes about the power/comms module

- At least one of the RS-232 nodes must have auto-powerdown disabled in order to be able to establish a RS-232 link. It is recommended that auto-powerdown on the host dongle be disabled.
- The RS-232 lines are ground-referenced, so the host and client modules must share the same ground. This is ensured by pin 2 in H2. However, if a host module is used powered only by the USB supply of the host PC, the user must also connect a lead to pin 2 of H2 between modules. As a rule of thumb, RS-232 signals should always consist of 3 lines: RIN, DOUT and GND.
- RIN and DOUT must be crossed over at either the host or client (see the pinout tables above).
- The heater circuit ground (pin 2 of H1) is not connected to the ground of the main circuit (pin 2 of H2). However since the solid-state switch for the heater power is ground-referenced, if separate power supplies are used for the heater and power/comms module circuits their grounds must be made common. It is recommended to do this at source rather than at the module. This ensures optimal current paths and allows smaller CSA wires to be used on H2.

Electrical requirements:

With a supply of 28 Vdc, the power/comms module and probe during operation will together draw 92 mA. With the heater enabled, this increases to 267 mA (not including the heater power draw). This should be taken into consideration when deciding on wire cross-sectional area (CSA) and length. Do not exceed 30 VDC on any power input terminal.

A tightly regulated power supply is not required. The power/comms module contains on-board regulators for the low voltage circuits but not for the heater power. The heater voltage will track the power supply's voltage. It is recommended to use a properly regulated power supply nonetheless. In an electromagnetically noisy environment it may be necessary to use shielded cable (with appropriate grounding of the shield) and, for example, common mode EMC suppressors (ferrite beads).

Power supply inputs are reverse polarity protected. RS-232 lines are ESD protected up to ± 8 kV contact discharge, ± 15 kV air-gap discharge. TTL lines are ESD protected up to ± 25 kV contact discharge, ± 30 kV air-gap discharge.

Other information

For information on the physical layout of the connector pins please refer to the LEMO product catalogue available online at:

https://www.lemo.com/catalog/ROW/UK_English/unipole_multipole.pdf

5 CARE AND HANDLING

WARNING: Do not allow any liquids to come into contact with the sensor package or power/comms module, or the system may be permanently damaged.

Do not hot-plug any of the probe or power/comms module connectors. This may result in damage to the probe system, and will void the product warranty.

- The probe system is a precision measurement instrument and should be handled and stored with care when not in use. Prolonged storage of the system is possible; this will not affect the calibration of the unit. For prolonged storage, cover the probe tip and keep in a sealed case with dessicant pouch. The probe system is not user-serviceable.
- The low-mass probe enclosure is made from sintered Nylon and is susceptible to solvents. The probe sting is not commoned to the system ground. Sensible ESD precautions should be taken before handling.
- Ensure that no dust, dirt or liquid enters the probe. This will alter the system performance. Any foreign material introduced into the sensors themselves may permanently damage the sensors.
- The sting heater should only be used under low temperature conditions, with high heat transfer. Tip temperature must be actively monitored when the heater is in use, noting that there is a time lag between activating the heater and registering a temperature change on the tip temperature sensor. Care must be taken to ensure that the temperature of the sting tip does not exceed 65°C, or internal damage may result.
- Do not polish or abrade the probe tip or static pressure ring, as this will alter the calibration of the sensor. It is recommended that the probe sting be covered during ground handling operations.
- Probes may be cleaned using a mild detergent solution and a fibre-free cloth. Do not use solvents or alcohol on the probe, and take care not to get any cleaning solution in the holes.
- In the event of water ingress, the probe may be dried by heating to 40°C in a dessicant environment. Water entering the probe ports will not damage the system, but will result in incorrect readings.
- To protect against shock and thermal expansion, the electronic components within the probe's sensor module are floating. Heavy vibration may affect sensitive pressure readings.
- Do not apply any bending moments on the probe sting, as the junction between the probe and the sensor package may be damaged.
- Connect cables to the probe with care, as the socket mountings are fragile. Ensure that appropriate strain relief is used: cable strain may cause erroneous sensor readings. Excessive cable bending will damage the probe.

6 SOFTWARE AND DRIVERS

Although this probe system was designed to function independently of a PC, it is possible to interface with a PC via the included USB port. This mode of operation is useful for data logging, calibration, testing and diagnostics.

Drivers

There are two external drivers which must be downloaded and installed on the computer in order for the PC to be able to interface with the probe system, in addition to the specific system driver for your probe.

- [National Instruments LabView Run Time Engine \(LVRTE\)](#)
- [National Instruments VISA Run-Time Engine \(NIVISA\)](#)

These drivers are freely available for download from National Instruments. Compatible versions of both of these drivers have been bundled with your software package.

Executable

An executable software package is provided with your probe system, which facilitates direct communication between your PC and your probe using the probe's micro-USB connector. After launching the software, you should see the window reproduced below (Figure 4).

Starting procedure

- 1) Connect the computer to the probe's micro-USB socket.
- 2) The probe will perform a power-on self-test, lasting a couple of seconds. If all tests pass, the rear of the probe will illuminate with a green LED.
- 3) Load the program. It will start in the [ACTION] tab.
- 4) Using the [COM PORT] drop down menu, select the appropriate COM port.
- 5) Press the white arrow near the top left corner of the window to run the application.
- 6) Ensure that there are no errors in the [ERROR] dialogue box. If an error has occurred at this stage, it is most likely an invalid COM port selection.

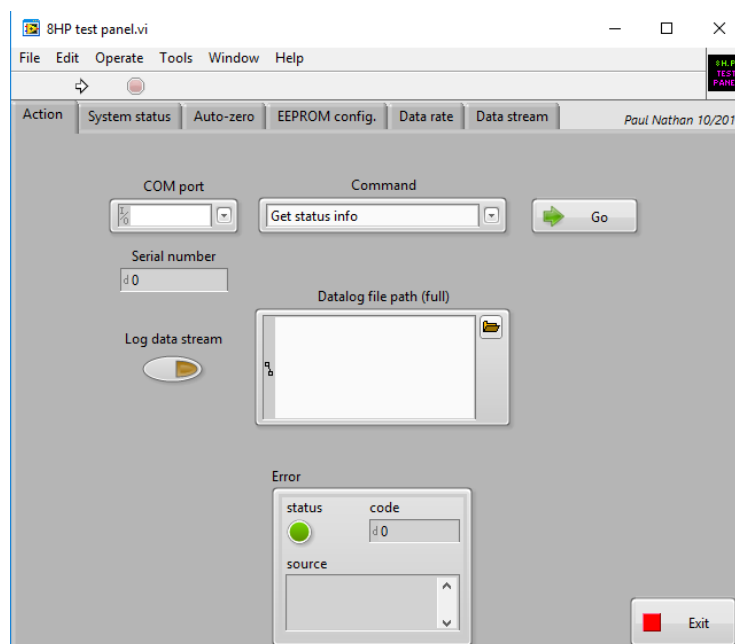


Figure 4: Probe system testing software screen-shot

Available commands

The [COMMAND] drop-down menu in the [ACTION] tab contains the following commands. A command is run by pressing the [GO] button to the right of the [COMMAND] menu. The application will automatically switch to the relevant tab. Once finished, return to the [ACTION] tab to select another command and run as desired.

- **Get status info:** running this command will activate the [SYSTEM STATUS] tab. The system will be queried for the status of the last self-test. Green indicators indicate the test was passed, while red indicates a fault. Descriptive text beside each indicator is provided.
- **Run self-test:** the system will be made to perform the power-up self-test again, and then query for the result. This allows the user to easily check any changes made without having to disconnect and reconnect the USB cable.
- **Perform temporary auto-zero:** this command should not be used under normal operating circumstances, and is included for development purposes only. It activates the [AUTO ZERO] tab and begins collecting samples from each pressure sensor to estimate the zero pressure reading. An offset is then temporarily stored in volatile memory that will remain until the system is powered down. During this procedure, ensure that the sensors are subjected to zero differential pressure.
- **Perform permanent auto-zero:** this command repeats the above, but this time writing the offsets permanently to non-volatile memory. **WARNING** – *this will overwrite the existing offsets that were used during probe calibration. Carrying out this procedure will invalidate your calibration!*
- **Get EEPROM values:** displays the [EEPROM CONFIG] tab and read off all the EEPROM values from the system.
- **Set EEPROM values:** this command should not be used under normal operating circumstances, and is included for development purposes only. To make changes to the EEPROM values, first run [GET EEPROM VALUES] to populate the table with the current values. Then, change the values as desired; return to the [ACTION] tab and run the [SET EEPROM VALUES] command. Finally, return to the [ACTION] tab and run the [GET EEPROM VALUES] command again to check the values are as desired and, importantly, that the EEPROM checksum indicator is green. A red indicator means the data has become corrupt in transit and should be re-transmitted. **WARNING** – *this will overwrite the existing EEPROM values that were used during probe calibration. Carrying out this procedure will invalidate your calibration!*
- **Set data rate:** This command allows the user to set the system sampling rate using a drop-down menu.
- **Get data rate:** This command allows the user to retrieve the current setting of the system sampling rate.
- **Enable USB streaming:** this command activates the USB data stream. The [DATA STREAM] tab is activated and a running plot of all seven pressure sensor values is displayed, along with values for all the other on-board sensors. This will continue indefinitely until the user presses the [STOP] button or selects another tab, or exits the

program by closing the window. Note that the data stream from the TTL serial output is not affected by enabling USB streaming.

- **Disable USB streaming:** this command stops data transmission over USB.
- **Get serial number:** Each probe is encoded with its own unique serial number, which is displayed in the window below the [COM PORT] drop-down menu. This function will retrieve the probe's serial number and display it in the [ACTION] tab. Note that the serial number is also retrieved as part of the normal startup operations. The serial numbers are decimal values; the probe having serial number "1234" will display as [d1234].
- **Exit:** this command stops the program from running, but leaves the window open so as to preserve settings for later use. This has the same functionality as pressing the [EXIT] button.

Data logging option:

A tab-delimited ASCII text output of a time history of all the sensor values can be saved to disk by enabling the [LOG DATA STREAM] switch on the [ACTION] tab prior to running the [ENABLE USB STREAMING] command. If the [DATALOG FILE PATH] box is left empty, the user will be prompted where to save the file. It is helpful to put a known extension on the file such as ".txt". Data is written to disk every second and stopped upon disabling USB streaming. If streaming is resumed and the filename is not changed, the user will be prompted to either replace the file or cancel. If cancel is chosen, a prompt will appear to allow a new filename to be chosen. If this is also cancelled, data streaming will begin but no log file will be created and the [LOG DATA STREAM] switch will be disabled.

Notes on data reduction

The probe outputs seven pressures and a static pressure for use in resolving the three components of velocity. There are a number of open-source techniques for data conversion, offering various levels of trade-off between accuracy and speed. Examples and advice on implementing this process for your application are available from your Surrey Sensors Ltd. representative. A directional calibration service is also available on request.

7 TECHNICAL SUPPORT

Full technical support is available for this product and its associated software.

If you experience any difficulty in installation or use, or if you need additional support in the operation of the system, please contact your Surrey Sensors Ltd. account manager or technical representative.

The content of this user manual is for general information only and is subject to change without notice. It may contain inaccuracies or errors and Surrey Sensors Ltd. expressly exclude liability for any such inaccuracies or errors to the fullest extent permitted by law. Your use of any information is entirely at your own risk, for which Surrey Sensors Ltd. shall not be liable.

Appendix: Additional communications details

Status bytes map

Byte num.	Bit	Description	Info
0	0	Pressure sensor 0 checksum okay	1 yes, 0 no
	1	Pressure sensor 1 checksum okay	1 yes, 0 no
	2	Pressure sensor 2 checksum okay	1 yes, 0 no
	3	Pressure sensor 3 checksum okay	1 yes, 0 no
	4	Pressure sensor 4 checksum okay	1 yes, 0 no
	5	Pressure sensor 5 checksum okay	1 yes, 0 no
	6	Pressure sensor 6 checksum okay	1 yes, 0 no
	7	Pressure sensor 7 checksum okay	1 yes, 0 no
1	0	Pressure sensor 0 temperature in range	1 yes, 0 no
	1	Pressure sensor 1 temperature in range	1 yes, 0 no
	2	Pressure sensor 2 temperature in range	1 yes, 0 no
	3	Pressure sensor 3 temperature in range	1 yes, 0 no
	4	Pressure sensor 4 temperature in range	1 yes, 0 no
	5	Pressure sensor 5 temperature in range	1 yes, 0 no
	6	Pressure sensor 6 temperature in range	1 yes, 0 no
	7	Pressure sensor 7 temperature in range	1 yes, 0 no
2	0	Pressure sensor 0 value in range	1 yes, 0 no
	1	Pressure sensor 1 value in range	1 yes, 0 no
	2	Pressure sensor 2 value in range	1 yes, 0 no
	3	Pressure sensor 3 value in range	1 yes, 0 no
	4	Pressure sensor 4 value in range	1 yes, 0 no
	5	Pressure sensor 5 value in range	1 yes, 0 no
	6	Pressure sensor 6 value in range	1 yes, 0 no
	7	Pressure sensor 7 value in range	1 yes, 0 no
3	0	BME280 ident pass	1 yes, 0 no
	1	BMI160 ident pass	1 yes, 0 no
	2	BMI160 acc self test pass	1 yes, 0 no
	3	BMI160 gyr self test pass	1 yes, 0 no
	4	External thermistor 0 value in range	1 yes, 0 no
	5	External thermistor 1 value in range	1 yes, 0 no
	6	EEPROM offsets checksum okay	1 yes, 0 no
	7	1	-

USB Command listAfter
@

Cmd. Byte	Description	Return	Additional information	Comments
s	Retrieve status bytes	4x uint8	P_chk_ok, P_tmp_ok, P_val_ok, BME280_ident, BMI160_ident, BMI160_acc_pass, BMI160_gyr_pass, T0_val_ok, T1_val_ok, EEPROM_chk_pass	
S	Perform self-test and retrieve status bytes	4x uint8	P_chk_ok, P_tmp_ok, P_val_ok, BME280_ident, BMI160_ident, BMI160_acc_pass, BMI160_gyr_pass, T0_val_ok, T1_val_ok, EEPROM_chk_pass	
z	Perform temporary auto-zero	7x float32	P_raw_offset(1 to 7)[28]	Excludes abs. pressure sensor
Z	Perform permanent auto-zero (write values to EEPROM)	7x float32	P_raw_offset(1 to 7)[28]	Excludes abs. pressure sensor
R	Read all EEPROM values	78x uint8	P_raw_offset(0 to 7)[32], P_atm_offset[4], T0_offset[4], T1_offset[4], 0[4], 0[4], acc_xyz_factor[4], 0[4], 0[4], gyr_x_offset[4], gyr_y_offset[4], gyr_z_offset[4], 0, Checksum[1]	
W	Write all EEPROM values (including new checksum)	-		
D	Enable USB/TTL streaming	78x uint8	'#[1], P0[4], P1[4], P2[4], P3[4], P4[4], P5[4], P6[4], P7[4], T0_ext[4], T1_ext[4], P_atm[4], Tint[4], RH[4], ax[4], ay[4], az[4], wx[4], wy[4], wz[4], chk[1]	Returns at [Datarate] until stream is disabled. USB or TTL enabled according to physical layer on which the command was sent
d	Disable USB/TTL streaming	-		USB or TTL disabled according to physical layer on which the command was sent
A	Enable USB streaming on power-up	-		
a	Disable USB streaming on power-up	-		
Y	Enable TTL streaming on power-up	-		
y	Disable TTL streaming on power-up	-		
P	Set TTL stream full data packet mode (power-up default)	-	Send 1x uint8. 1 = full data, 0 = partial data	
p	Get TTL stream full data packet mode	1x uint8	1 = full data, 0 = partial data	

F	Set data rate	-	Send 1x uint16, DataRate[2] containing one of the allowable integer data rates.	
f	Get data rate	1x uint16	Data rate (Hz)	
J	Set data rate (power-up default)	-	Send 1x uint16, DataRate[2] containing one of the allowable integer data rates.	
X	Set inertial sensor modes (power-up defaults)	-	Send 3x bytes, {acc_Range_Mode, gyr_Range_Mode, IMU_Rate_Mode}	
x	Get inertial sensor modes	3x uint8	{acc_Range_Mode, gyr_Range_Mode, IMU_Rate_Mode}	Refer to "IMU modes table.xls" for description of mode bytes
N	Get serial number	1x float32	Serial_num[4] (EEPROM index 44...47)	
G	Get current data packet (full)	78x uint8	'#[1], P0[4], P1[4], P2[4], P3[4], P4[4], P5[4], P6[4], P7[4], T0_ext[4], T1_ext[4], P_atm[4], Tint[4], RH[4], ax[4], ay[4], az[4], wx[4], wy[4], wz[4], chk[1]	
g	Get current data packet (partial)	42x uint8	'#[1], P0[4], P1[4], P2[4], P3[4], P4[4], P5[4], P6[4], P7[4], T0_ext[4], T1_ext[4], chk[1]	
B	Set TTL baud rate (bps) (power-up default)	-	Send 1 float32 (as 4 bytes), Baud[4]	
b	Get TTL baud rate (bps)	1x float32	Baud[4]	

IMU Mode bytes

Accelerometer range		
Mode (byte)	Eng. Value	Unit
0	±2	g
1	±4	g
2	±8	g
3	±16	g

Gyroscope range		
Mode (byte)	Eng. Value	Unit
0	±125	°/s
1	±250	°/s
2	±500	°/s
3	±1000	°/s
4	±2000	°/s

IMU refresh rate		
Mode (byte)	Eng. Value	Unit
0	6.25	Hz
1	12.5	Hz
2	25	Hz
3	50	Hz
4	100	Hz
5	200	Hz
6	400	Hz
7	800	Hz
8	1600	Hz

EEPROM Map

byte index	Description	Type	Unit
0	Pressure 0 raw offset	float32	-
1			
2			
3			
4	Pressure 1 raw offset	float32	-
5			
6			
7			
8	Pressure 2 raw offset	float32	-
9			
10			
11			
12	Pressure 3 raw offset	float32	-
13			
14			
15			
16	Pressure 4 raw offset	float32	-
17			
18			
19			
20	Pressure 5 raw offset	float32	-
21			
22			
23			
24	Pressure 6 raw offset	float32	-
25			
26			
27			
28	Pressure 7 raw offset	float32	-
29			
30			
31			
32	Atmospheric pressure offset	float32	Pa
33			
34			
35			
36	External thermistor 0 temperature offset	float32	deg C
37			
38			
39			
40	External thermistor 1 temperature offset	float32	deg C
41			
42			
43			
44	Serial number	float32	-
45			
46			

47			
48	TTL baud rate	float32	bps
49			
50			
51	Accelerometer xyz scale factor	float32	-
52			
53			
54			
55	Default data rate on power-up	uint16	(Hz)
56			
57	TTL streaming enabled on power-up	unit8	-
58	USB streaming enabled on power-up	unit8	-
59	TTL streaming full data packet	unit8	-
60	Accelerometer range mode	unit8	-
61	Gyroscope range mode	unit8	-
62	IMU update rate mode	unit8	-
63	Gyroscope x component offset	float32	deg / s
64			
65			
66			
67	Gyroscope y component offset	float32	deg / s
68			
69			
70			
71	Gyroscope z component offset	float32	deg / s
72			
73			
74			
75	0	-	-
76	Checksum	uint8	-
77			