64-CHANNEL PRESSURE SCANNER SYSTEM

User Manual

WARNING

Read this document before using the product.

This is an experimental prototype, for measurement purposes only.

This system is not certified for use on aircraft.

Contents

Version Control

Version	Date	Summary of changes
1.0	05-2017	New document
2.0	09-2019	Updated content and specifications, reformatted. Addition of guidance on synchronisation of multiple scanners.
2.1	01-2020	Expansion of guidance on software and drivers.
2.2	04-2020	Updated multichannel connector pin assignment.
3.0	01-2023	Updated for version 2.0 of firmware and software.
3.1	02-2023	New commands added to command string table
3.2	12-2023	Hardware update - UART outputs and synch outputs

1 INTRODUCTION

Principle of operation

The system consists of a base unit (housing the base sensor array, the microprocessor and control hardware), a number of eight-channel pressure 'blades' designed to be self-detecting and customer-swappable, and a remote fluid temperature sensor and cable assembly. The base sensor array contains a pressure altimeter, a six-component inertial measurement unit, a case temperature sensor and a humidity sensor. The system's power and communications are all via USB or UART.

System description

Multichannel pressure scanner system.

System components

1x Base system	The base system contains all of the control hardware to drive the pressure sensor blades.
(X) Sensor blades	The quantity and range of the sensor blades will depend on the customer order. One blade is typically included with the cost of the base system.
1x Temperature probe	A fluid temperature probe and cable assembly is included with the base system.
1x USB cable	A low-profile USB micro->A connector may be bundled with the system.
Accessories	Accessories including an enclosure, pressure cables and connectors are available and may have been included in the shipment.

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 scanner system requires 64-bit Windows 10 (or newer) operating system (not included). The scanner has been pre-loaded with firmware; the computer software drivers and data logging software will be provided electronically.

2   DETAILED SPECIFICATION

Product code	DPS14-160P	DPS14-1K0	DPS14-6K9
Pressure range (custom ranges available)	160 Pa FS	1 kPa FS	6.9 kPa FS
Maximum overpressure	33.5 kPa	37.5 kPa	69 kPa
Sensor repeatability[1]	± 0.024 % FS		
Sensor accuracy[2], inc. calibration	± 0.25 % FS		
Total error band after auto-zero[3]	± 1.75 % FS	± 0.5 % FS	± 1 % FS
Ambient absolute pressure sensor specification	30-110 kPa FS, +/- 0.1 kPa		
Absolute pressure limits	0.2 - 1.5 atm		
Operational mode	Absolute and differential configurations available		
Operating temperature range[4] (extended ranges available)	-20° to +85° C non-condensing		
Compensated temperature range	0° to +50° C non-condensing		
Storage temperature range	-40° to +85° C		
Ambient temperature sensor specification	0°C - 65°C ± 0.5°C		
Remote temperature probe specification	-40°C - 150°C ± 0.5°C		
Vibration	Sensors rated to 15 g, 10 Hz to 2 Hz		
Maximum relative humidity	95 %		
Relative humidity sensor specification	0 % to 100 % RH, +/- 3%		
Communications - USB	Data streaming via USB2.0, external trigger and clock ports for scalable multi-system synchronization		
Communications - UART	Tx/Rx 3.3 V, 0.5 Mbps		
Power	via USB, < 200 mA, 1 W via UART, 5 VDC regulated, min. 250 mA required		
Data acquisition rate	1 kHz simultaneous (equivalent)		
Digital resolution	14-bit pressure, 16-bit environmental and IMU		
System requirements	Windows 10 or later, minimum 3GHz & 4Gb RAM		
IMU specification	3 axis gyro, 245 °/s FS, ± 8.75 x10^{-3} °/s 3 axis accelerometer, 2g FS, ± 0.061 mg		

[1] Includes errors due to pressure non-linearity, pressure hysteresis and non-repeatability.
[2] Includes errors due to pressure non-linearity, pressure hysteresis, non-repeatability and calibration uncertainty.
[3] Total residual error after auto-zero, excluding residual temperature sensitivity.
[4] OEM configuration only. Nylon enclosure maximum temperature 65°C.

3   PHYSICAL CONNECTIONS

If the scanner was supplied in an enclosure, then all of the pressure connections have been factory-installed. In OEM configuration, the pressure ports are directly accessible, as barbs on the blade-mounted sensor units. The barbs are suitable for 1 mm ID silicone air lines. The layout of the system (in OEM configuration) and locations of connectors is shown in Figure 1.
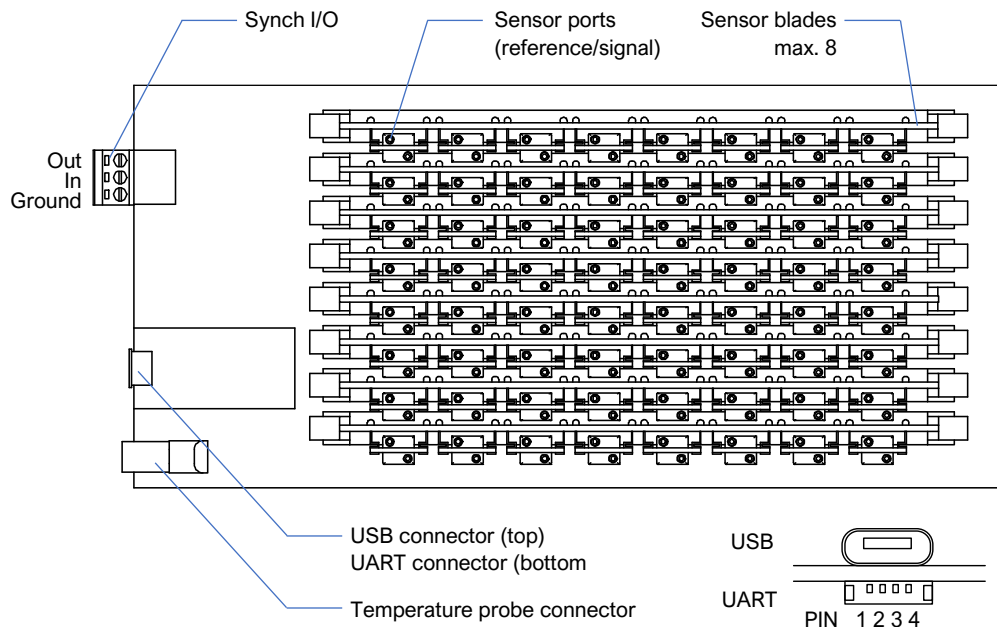

*Figure 1: System in OEM configuration*

To insert a blade into the base unit, ensure that the retaining clips are in the 'open' position (pushed outward); align the blade with the socket, and apply gentle pressure to the blade card until it snaps into place. The retaining clips should toggle into the 'locked' position. An alignment tab on the socket prevents backwards insertion of the blades.

Note that sensor card slots must be filled sequentially from slot '0'. The unit will not function properly otherwise.

WARNING: Do not apply force on the sensors themselves during blade insertion or removal, or damage may result. Strain relief must be used on hoses when the system is used in OEM configuration or in partial enclosure.

To remove a blade from the base unit, gently push the retaining clips outward into the 'open' position. The blade will pop out of the socket and can then be gently removed.

If the scanner was shipped in a full enclosure, the sensors have been connected internally to a bulkhead-mounted multichannel connector with a port numbering convention as shown in Figure 2. Note that there are no markings on the connector itself.
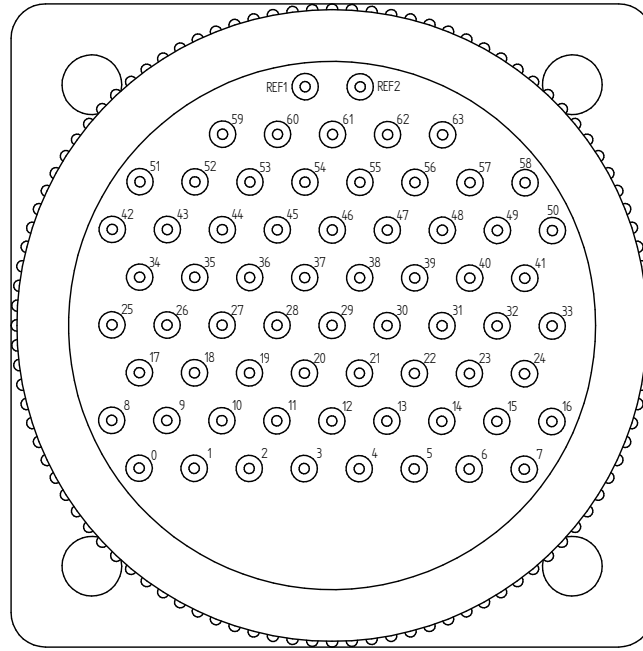
FRONT OF UNIT

Figure 2: QC66 Multichannel connector, showing numbering convention

The connections between the sensor ports and the bulkhead-mounted multichannel connector will depend on the configuration selected. The available configurations are listed in Table 1.

Table 1: Multichannel connector pin assignment

	Connector marking	Channel line
If using independent pressure reference for each channel	0	0
	1	0 (ref)
	2	1
	3	1 (ref)
	4	2
	5	2 (ref)
	6	3
	7	3 (ref)
	...	...
	REF1	NC
	REF2	NC
If using common pressure reference(s)	0	0
	1	1
	2	2
	...	...
	REF1	Reference 1
	REF2	Reference 2 or NC

4   CARE AND HANDLING

> **WARNING:** Do not allow any electrically conductive materials to come into contact with the system, or it may be permanently damaged.

- The printed circuit boards and sensor blades are not protected with any electrically insulating coating. Do not allow any liquid onto the board. It is recommended to wear latex or similar gloves when handling the board to prevent deposits. Sensible ESD precautions should be taken before handling.

- During fitting of silicone tubing to scanner and pressure sensor ports, ensure that no dust, dirt or liquid enters the lines. This will alter the system performance. Any foreign material introduced into the sensors themselves may permanently damage the sensors and will void the product warranty.

- If not enclosed, ensure that a protective cover is placed over the system when not in use, and handle with care.

- Protect any uninstalled sensor blades from moisture and dust, and store in an ESD-safe sleeve when not in service.

- Ensure that all electronic and pressure connections are appropriately strain-relieved.

- Do not use the pressure scanner system in wet or condensing conditions. Store in dry environment, or with desiccant pouch.

5   SOFTWARE AND DRIVERS

The system may be operated from a computer directly via USB, or may be operated via UART.

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 system, in addition to the specific system driver.

- National Instruments LabView Run Time Engine (LVRTE)
- National Instruments VISA Run-Time Engine (NIVISA)

These drivers are freely available for download from National Instruments (see Figures 3 and 4). Ensure that the 64-bit version of the LabView Runtime Engine is selected (note this is not the default option), and restart the computer following each installation. Correct download settings for each driver are shown in Figure 3 and 4 below.

The Surrey Sensors Ltd. 32-bit USB driver is required for USB comms. This can be freely downloaded from the product website.

Additionally, a further comms system install may be required for some older versions of Windows (not required for Windows 10).

Figure 3: Download settings for NI Labview Runtime Engine
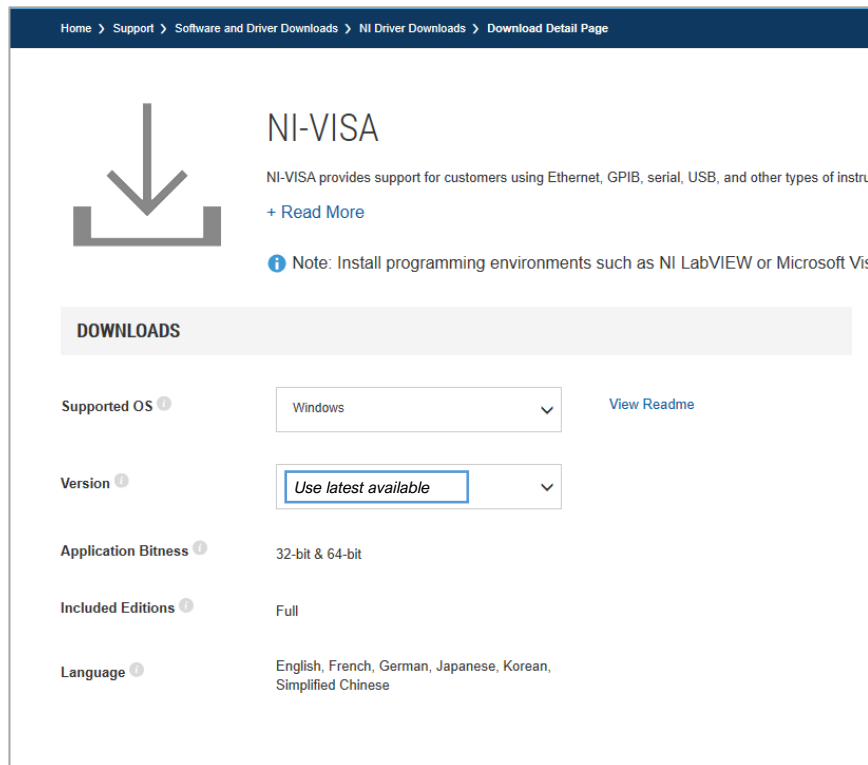
Figure 4: Download settings for NI VISA Runtime Engine

Executable

An executable software package is provided with your system, which facilitates direct communication with a PC using the micro-USB connector. After launching the software, you should see the window shown in Figure 5.

Starting procedure

1) Connect the computer to the scanner's micro-USB socket.
2) Load the program. It will start in the [ACTION] tab.
3) Using the [COM PORT] drop down menu, select the appropriate COM port.
4) Press the white arrow near the top left corner of the window to run the application. The scanner will automatically power on.
5) The scanner will perform a power-on self-test, lasting a couple of seconds. During this process, the green LEDs on the sensor cards will blink, and remain on if the test is passed (these LEDs are not visible if the scanner is supplied in an enclosure).
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. If using an older Windows version this may alternatively be a compatibility error requiring the additional installation described above.
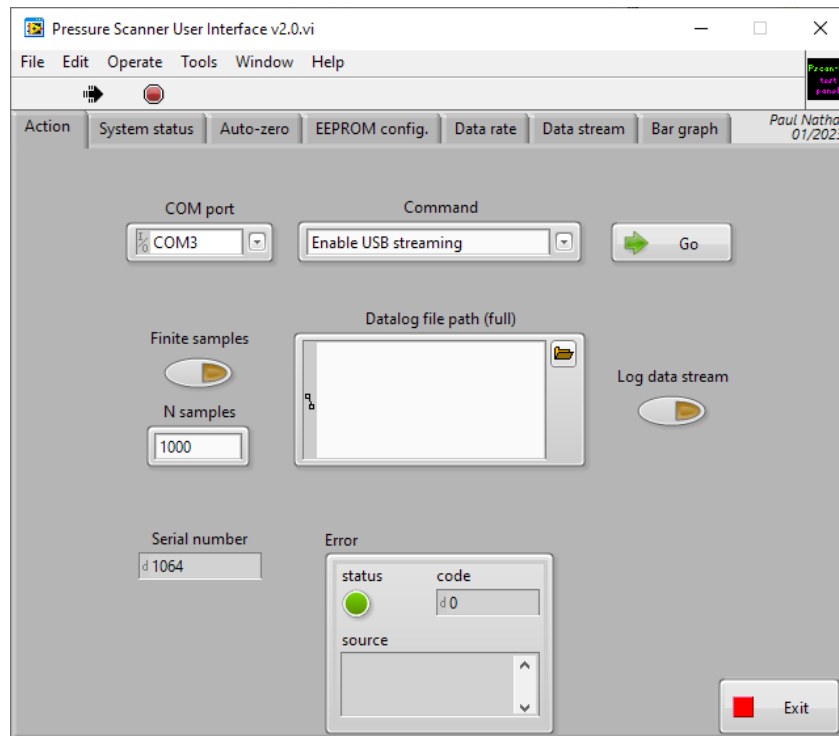
Figure 5: Start-up/ configuration window

Available commands

- **Enable USB streaming:** this command activates the USB data stream. The [DATA STREAM] tab is activated and a running plot of all pressure sensor values is displayed, along with values for other on-board sensors. This will continue indefinitely until either (a) the user presses the [STOP] button; (b) the user or selects another tab; (c) the user exits the program by closing the window, or (d) the number of samples has been acquired as specified on the action tab and the "Finite samples" function is enabled.

- **Enable USB streaming (HW-Trig):** this command activates the USB data stream, but instruct the system to wait for an external trigger command before beginning the acquisition.

- **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 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 or reset. 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 factory calibration. Carrying out this procedure may invalidate your warranty.*

- **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.

- **Get serial number:** Each scanner is encoded with its own unique serial number. 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 start-up operations. The serial numbers are decimal values; the probe having serial number "1234" will display as [d1234].

- **Disable USB streaming:** this command stops data transmission over USB.

- **Disable HW-Trig:** this command stops data transmission over USB and disables the wait-for-trigger command.

- **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. It is strongly recommended that you record and retain the factory-set 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 factory-set EEPROM values. Carrying out this procedure may invalidate your warranty.*

- **System soft reset:** this command restarts the system's firmware and clears any temporary auto-zero that was carried out.

- **Power OFF:** this command powers off the sensor array, and may be used to reduce the power consumption of the sensor system when not in use without physically disconnecting the pressure scanner.

- **Power ON:** this command powers on the sensor array. If the system has been powered off using the [POWER OFF] command, it must be powered on again before attempting any data acquisition or a system error will occur.

- **Get sensors range and offset:** this command reads and returns the ranges and offsets of each of the sensors installed in the scanner. The results will display in a window under the [SYSTEM STATUS] tab, selectable by sensor number.

- **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.

Bar graph

While the unit is streaming via USB, the [BAR GRAPH] tab will display values graphically for the user, in the form of a live bar chart. Note that the controls at the bottom of the plot area allow the user to control the plotting parameters.

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.

Source distribution

A LabVIEW source distribution is also available to download from the product website, to enable the user to integrate the pressure scanner into a National Instruments LabView VI environment.

6 UART OPERATION

The system can be operated via UART as well, although an independent power supply is required (not included). The pin connections for UART operation are as shown in Table 2.

Table 2: UART connector pin assignment

Pin	Name	Notes
1	V_{in}	Supply power; 5 VDC 250 mA, well-regulated
2	GND	Ground, should be common with signal ground
3	T_X	3.3 V
4	R_x	3.3 V (but 5 V tolerant)

WARNING: The absolute limit of V_{in} is +5.5 VDC above GND. Exceeding this level will destroy the product and void the warranty.

The R_X input is nominally 3.3 V, but is 5V tolerant and compatible with 5V logic levels. Note that the T_X level will always be 3.3 V regardless of R_X level. The baud rate is 0.5 Mbps.

The system may be configured to stream data over UART on power-up by setting the "TTL Streaming" parameter in the EEPROM to TRUE using the USB executable. When operating over UART, the system may also be connected via USB for power (but the USB ground an UART ground must be common).

The UART connector is a Molex Pico-Lock (compatible with Molex 15131-040 series cable assemblies). A UART cable assembly may be supplied with the scanner as an accessory.

7   SYNCHRONISATION OF MULTIPLE PRESSURE SCANNERS

Any number of pressure scanners can be tied together in order to start data acquisition simultaneously. This is achieved by making use of the green 3-way trigger I/O terminal opposite the USB connector. Since each scanner operates independently, the user is free to configure the master/slave relationship as desired. Alternatively, all pressure scanners may be configured as slaves, with the start trigger provided by a separate system altogether.

To synchronize four pressure scanners (for example) with one acting as master, the setup procedure would be as follows:

1. Connect all scanners to the computer via USB.

2. Ascertain the COM port number of each scanner. This is done by connecting one at a time and making a note of the COM port that appears under Windows device manager. Label the scanners as appropriate.

3. Choose any one of these scanners to be the "master". In this example, let it be COM3. The three slaves are then COM4, COM5 and COM6.

4. Wire the 3-way trigger terminals as illustrated below

out	out	out	out
in	in	in	in
gnd	gnd	gnd	gnd

Master   Slave   Slave   Slave

COM3   COM4   COM5   COM6
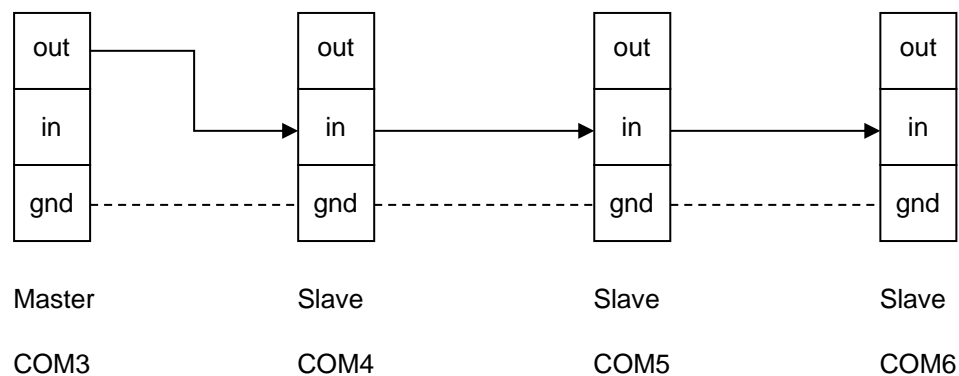
The trigger output from the master is tied to the input of each slave. The ground terminal inter-connections are required only if the scanners are on separate grounds. If the scanners are running off the same PC or USB hub, then this is not required.

5. Create four distinctly named copies of the software panel executable and run each copy

6. Configure the COM port and datalog directory and name for each scanner. Either use the same directory and different filenames or use the same datalog name under different directories for each scanner. For example, under the latter option this would be "C:\Datalogs\Scanner01.txt" for the master and then "C:\Datalogs\Scanner02.txt" through to "…Scanner04.txt" for the slaves. *Ensure each scanner's data filepath is unique otherwise there will be a file write access conflict.* Ensure that the "Log data stream" function is enabled.

7. Under the "Action" tab, ensure that the "Finite samples" button is enabled for all instances. Enter the required number of samples, also identical for all (though not required to be so)

Once all scanners are ready, the data acquisition starting procedure is as follow

1. On each of the 'slave' scanners only, select the [ENABLE USB STREAMING - HW TRIG] from the command drop-down menu and click [GO].   There should be no activity on the live traces as the slaves are now ready and waiting for the trigger from the master scanner. Note that there is a 15 second window between slave activation during which the trigger signal may be received, before a timeout error occurs and the system self-resets.

2. On the master scanner instance select the [ENABLE USB STREAMING] from the command drop-down menu and click [GO]. The live traces for each scanner should now commence simultaneously. Data will stop streaming after the specified number of samples has been acquired, or if the "Stop" button is pressed on a given scanner instance. The scanners can all be manually stopped by going through each instance and clicking the [STOP] button.

Repeat the above two steps for all future data acquisition cycles. Once the measurement is complete, the end-user can then combine the data from each scanner using their method of choice. The datalog directory and/or names can be changed and new measurements carried out as desired.

The modular nature of this system ensures that should one or more scanners suffer an error during a protracted measurement campaign, the data from the others will not be affected.

8 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.

APPENDIX: ADDITIONAL COMMUNICATIONS DETAILS

Command string table

Command string		Data string	Command description	Additional information
ASCII	HEX			
@P	0x4050		Power on the sensor array	
@p	0x4070		Power off the sensor array	
@D	0x4044		Start data streaming over USB	See "Serial data table.xlsx" for data format
@d	0x4064		Stop data streaming over USB	
@H	0x4048		Enable hardware trigger for data streaming start	
@h	0x4068		Disable hardware trigger for data streaming start	
@F	0x4046	float32 Data_period	Set serial data period (ms)	
@f	0x4066		Get serial data period (ms)	Returns float32 Data_period (4 bytes)
@N	0x404E		Get device serial number	Returns uint32 Serial_number (4 bytes)
@z	0x407A		Perform temporary auto-zero	Returns 64x float32 Sensor_offset (256 bytes). Offsets are restored to calibration defaults after system reset or power cycle
@S	0x4053		Run self-test and return system status bytes	Returns 17x uint8 Status_byte (17 bytes). See "Status bytes table.xlsx" for status byte formats
@s	0x4073		Return system status bytes only	Returns 17x uint8 Status_byte (17 bytes). See "Status bytes table.xlsx" for status byte formats
@W	0x4057		Get all sensors range and offset	Returns 3x float32 {P_min, P_max,P_offset} for each sensor (3 * 4 * 64 = 768 bytes)
@O	0x404F	uint8 N_active	Override number of active sensors	Only use the first N sensors in the array (sequential)
@R	0x4052		System reset	

All data string values, sent and received, are in Little-Endian byte order (least significant byte first). For example, the command to start data streaming over USB, '@D': the '@' char is sent first first followed by the 'D' char. Alternatively in HEX format, the 0x40 byte is sent first followed by the 0x44 byte. Similarly, the command to set the serial data period to 10000 ms (100 Hz) would be, in HEX format bytes sending order left to right: {0x40, 0x46, 0x00, 0x40, 0x1C, 0x46}.

Serial data table

Byte index	Description	Type	Unit
0	Frame character '#'	uint8	-
1	P0	float32	Pa
2			
3			
4			
5	P1	float32	Pa
6			
7			
8			
9	P2	float32	Pa
10			
11			
12			
13	P3	float32	Pa
14			
15			
16			
17	P4	float32	Pa
18			
19			
20			
21	P5	float32	Pa
22			
23			
24			
25	P6	float32	Pa
26			
27			
28			
29	P7	float32	Pa
30			
31			
32			
33	P8	float32	Pa
34			
35			
36			
37	P9	float32	Pa
38			
39			
40			
41	P10	float32	Pa
42			
43			
44			

Byte index	Description	Type	Unit
153	P38	float32	Pa
154			
155			
156			
157	P39	float32	Pa
158			
159			
160			
161	P40	float32	Pa
162			
163			
164			
165	P41	float32	Pa
166			
167			
168			
169	P42	float32	Pa
170			
171			
172			
173	P43	float32	Pa
174			
175			
176			
177	P44	float32	Pa
178			
179			
180			
181	P45	float32	Pa
182			
183			
184			
185	P46	float32	Pa
186			
187			
188			
189	P47	float32	Pa
190			
191			
192			
193	P48	float32	Pa
194			
195			
196			
197	P49	float32	Pa

45					198			
46	P11	float32	Pa		199			
47					200			
48					**201**			
49					202	P50	float32	Pa
50	P12	float32	Pa		203			
51					204			
52					**205**			
53					206	P51	float32	Pa
54	P13	float32	Pa		207			
55					208			
56					**209**			
57					210	P52	float32	Pa
58	P14	float32	Pa		211			
59					212			
60					**213**			
61					214	P53	float32	Pa
62	P15	float32	Pa		215			
63					216			
64					**217**			
65					218	P54	float32	Pa
66	P16	float32	Pa		219			
67					220			
68					**221**			
69					222	P55	float32	Pa
70	P17	float32	Pa		223			
71					224			
72					**225**			
73					226	P56	float32	Pa
74	P18	float32	Pa		227			
75					228			
76					**229**			
77					230	P57	float32	Pa
78	P19	float32	Pa		231			
79					232			
80					**233**			
81					234	P58	float32	Pa
82	P20	float32	Pa		235			
83					236			
84					**237**			
85					238	P59	float32	Pa
86	P21	float32	Pa		239			
87					240			
88					**241**			
89					242	P60	float32	Pa
90	P22	float32	Pa		243			
91					244			
92					**245**	P61	float32	Pa
93	P23	float32	Pa		246			

94				247			
95				248			
96				**249**	P62	float32	Pa
97	P24	float32	Pa	250			
98				251			
99				252			
100				**253**	P63	float32	Pa
101	P25	float32	Pa	254			
102				255			
103				256			
104				**257**	External thermistor temperature	float32	°C
105	P26	float32	Pa	258			
106				259			
107				260			
108				**261**	Atmospheric pressure	float32	Pa
109	P27	float32	Pa	262			
110				263			
111				264			
112				**265**	Relative humidity	float32	%
113	P28	float32	Pa	266			
114				267			
115				268			
116				**269**	On-board temperature	float32	°C
117	P29	float32	Pa	270			
118				271			
119				272			
120				**273**	Accelerometer x component	float32	g
121	P30	float32	Pa	274			
122				275			
123				276			
124				**277**	Accelerometer y component	float32	g
125	P31	float32	Pa	278			
126				279			
127				280			
128				**281**	Accelerometer z component	float32	g
129	P32	float32	Pa	282			
130				283			
131				284			
132				**285**	Gyroscope x component	float32	deg / s
133	P33	float32	Pa	286			
134				287			
135				288			
136				**289**	Gyroscope y component	float32	deg / s
137	P34	float32	Pa	290			
138				291			
139				292			
140				**293**	Gyroscope z component	float32	deg / s
141	P35	float32	Pa	294			
142				295			

143					296			
144					297	Bank 0 (P0….P7) status bits*	uint8	-
145					298	Bank 1 (P8….P15) status bits	uint8	-
146	P36	float32	Pa		299	Bank 2 (P16….P23) status bits	uint8	-
147					300	Bank 3 (P24….P31) status bits	uint8	-
148					301	Bank 4 (P32….P39) status bits	uint8	-
149					302	Bank 5 (P40….P47) status bits	uint8	-
150	P37	float32	Pa		303	Bank 6 (P48….P55) status bits	uint8	-
151					304	Bank 7 (P56….P63) status bits	uint8	-
152					**305**	Clock drift warning**	uint8	-
					306	CRC16-CCITT***	uint16	-
					307			

Byte order is little-endian (least significant byte first).

* For each bit: 0 = good data, 1 = stale data, >1 = sensor fault.

** 0 = good data, 1 = clock drift detected.

*** CRC16-CCITT 0x1021 polynomial. Initial value = 0xFFFF.

Status bytes table

Byte index	Bit	Description	Info
0	0	Sensor array power on	1 yes, 0 no
	1	MCU EEPROM checksum good	1 yes, 0 no
	2	External thermistor value in range	1 yes, 0 no
	3	IMU ident detected	1 yes, 0 no
	4	IMU accelerometer self-test pass	1 yes, 0 no
	5	IMU gyroscope self-test pass	1 yes, 0 no
	6	Environmental sensor ident detected	1 yes, 0 no
	7	0	-
1	0	Pressure sensor 0 present	1 yes, 0 no
	1	Pressure sensor 1 present	1 yes, 0 no
	2	Pressure sensor 2 present	1 yes, 0 no
	3	Pressure sensor 3 present	1 yes, 0 no
	4	Pressure sensor 4 present	1 yes, 0 no
	5	Pressure sensor 5 present	1 yes, 0 no
	6	Pressure sensor 6 present	1 yes, 0 no
	7	Pressure sensor 7 present	1 yes, 0 no
2	0	Pressure sensor 8 present	1 yes, 0 no
	1	Pressure sensor 9 present	1 yes, 0 no
	2	Pressure sensor 10 present	1 yes, 0 no
	3	Pressure sensor 11 present	1 yes, 0 no
	4	Pressure sensor 12 present	1 yes, 0 no
	5	Pressure sensor 13 present	1 yes, 0 no
	6	Pressure sensor 14 present	1 yes, 0 no
	7	Pressure sensor 15 present	1 yes, 0 no
3	0	Pressure sensor 16 present	1 yes, 0 no
	1	Pressure sensor 17 present	1 yes, 0 no
	2	Pressure sensor 18 present	1 yes, 0 no
	3	Pressure sensor 19 present	1 yes, 0 no
	4	Pressure sensor 20 present	1 yes, 0 no
	5	Pressure sensor 21 present	1 yes, 0 no
	6	Pressure sensor 22 present	1 yes, 0 no
	7	Pressure sensor 23 present	1 yes, 0 no
4	0	Pressure sensor 24 present	1 yes, 0 no
	1	Pressure sensor 25 present	1 yes, 0 no
	2	Pressure sensor 26 present	1 yes, 0 no
	3	Pressure sensor 27 present	1 yes, 0 no
	4	Pressure sensor 28 present	1 yes, 0 no
	5	Pressure sensor 29 present	1 yes, 0 no
	6	Pressure sensor 30 present	1 yes, 0 no
	7	Pressure sensor 31 present	1 yes, 0 no
5	0	Pressure sensor 32 present	1 yes, 0 no
	1	Pressure sensor 33 present	1 yes, 0 no
	2	Pressure sensor 34 present	1 yes, 0 no

	3	Pressure sensor 35 present	1 yes, 0 no
	4	Pressure sensor 36 present	1 yes, 0 no
	5	Pressure sensor 37 present	1 yes, 0 no
	6	Pressure sensor 38 present	1 yes, 0 no
	7	Pressure sensor 39 present	1 yes, 0 no
6	0	Pressure sensor 40 present	1 yes, 0 no
	1	Pressure sensor 41 present	1 yes, 0 no
	2	Pressure sensor 42 present	1 yes, 0 no
	3	Pressure sensor 43 present	1 yes, 0 no
	4	Pressure sensor 44 present	1 yes, 0 no
	5	Pressure sensor 45 present	1 yes, 0 no
	6	Pressure sensor 46 present	1 yes, 0 no
	7	Pressure sensor 47 present	1 yes, 0 no
7	0	Pressure sensor 48 present	1 yes, 0 no
	1	Pressure sensor 49 present	1 yes, 0 no
	2	Pressure sensor 50 present	1 yes, 0 no
	3	Pressure sensor 51 present	1 yes, 0 no
	4	Pressure sensor 52 present	1 yes, 0 no
	5	Pressure sensor 53 present	1 yes, 0 no
	6	Pressure sensor 54 present	1 yes, 0 no
	7	Pressure sensor 55 present	1 yes, 0 no
8	0	Pressure sensor 56 present	1 yes, 0 no
	1	Pressure sensor 57 present	1 yes, 0 no
	2	Pressure sensor 58 present	1 yes, 0 no
	3	Pressure sensor 59 present	1 yes, 0 no
	4	Pressure sensor 60 present	1 yes, 0 no
	5	Pressure sensor 61 present	1 yes, 0 no
	6	Pressure sensor 62 present	1 yes, 0 no
	7	Pressure sensor 63 present	1 yes, 0 no
9	0	Pressure sensor 0 self-test pass	1 yes, 0 no
	1	Pressure sensor 1 self-test pass	1 yes, 0 no
	2	Pressure sensor 2 self-test pass	1 yes, 0 no
	3	Pressure sensor 3 self-test pass	1 yes, 0 no
	4	Pressure sensor 4 self-test pass	1 yes, 0 no
	5	Pressure sensor 5 self-test pass	1 yes, 0 no
	6	Pressure sensor 6 self-test pass	1 yes, 0 no
	7	Pressure sensor 7 self-test pass	1 yes, 0 no
10	0	Pressure sensor 8 self-test pass	1 yes, 0 no
	1	Pressure sensor 9 self-test pass	1 yes, 0 no
	2	Pressure sensor 10 self-test pass	1 yes, 0 no
	3	Pressure sensor 11 self-test pass	1 yes, 0 no
	4	Pressure sensor 12 self-test pass	1 yes, 0 no
	5	Pressure sensor 13 self-test pass	1 yes, 0 no
	6	Pressure sensor 14 self-test pass	1 yes, 0 no
	7	Pressure sensor 15 self-test pass	1 yes, 0 no
11	0	Pressure sensor 16 self-test pass	1 yes, 0 no
	1	Pressure sensor 17 self-test pass	1 yes, 0 no

	2	Pressure sensor 18 self-test pass	1 yes, 0 no
	3	Pressure sensor 19 self-test pass	1 yes, 0 no
	4	Pressure sensor 20 self-test pass	1 yes, 0 no
	5	Pressure sensor 21 self-test pass	1 yes, 0 no
	6	Pressure sensor 22 self-test pass	1 yes, 0 no
	7	Pressure sensor 23 self-test pass	1 yes, 0 no
12	0	Pressure sensor 24 self-test pass	1 yes, 0 no
	1	Pressure sensor 25 self-test pass	1 yes, 0 no
	2	Pressure sensor 26 self-test pass	1 yes, 0 no
	3	Pressure sensor 27 self-test pass	1 yes, 0 no
	4	Pressure sensor 28 self-test pass	1 yes, 0 no
	5	Pressure sensor 29 self-test pass	1 yes, 0 no
	6	Pressure sensor 30 self-test pass	1 yes, 0 no
	7	Pressure sensor 31 self-test pass	1 yes, 0 no
13	0	Pressure sensor 32 self-test pass	1 yes, 0 no
	1	Pressure sensor 33 self-test pass	1 yes, 0 no
	2	Pressure sensor 34 self-test pass	1 yes, 0 no
	3	Pressure sensor 35 self-test pass	1 yes, 0 no
	4	Pressure sensor 36 self-test pass	1 yes, 0 no
	5	Pressure sensor 37 self-test pass	1 yes, 0 no
	6	Pressure sensor 38 self-test pass	1 yes, 0 no
	7	Pressure sensor 39 self-test pass	1 yes, 0 no
14	0	Pressure sensor 40 self-test pass	1 yes, 0 no
	1	Pressure sensor 41 self-test pass	1 yes, 0 no
	2	Pressure sensor 42 self-test pass	1 yes, 0 no
	3	Pressure sensor 43 self-test pass	1 yes, 0 no
	4	Pressure sensor 44 self-test pass	1 yes, 0 no
	5	Pressure sensor 45 self-test pass	1 yes, 0 no
	6	Pressure sensor 46 self-test pass	1 yes, 0 no
	7	Pressure sensor 47 self-test pass	1 yes, 0 no
15	0	Pressure sensor 48 self-test pass	1 yes, 0 no
	1	Pressure sensor 49 self-test pass	1 yes, 0 no
	2	Pressure sensor 50 self-test pass	1 yes, 0 no
	3	Pressure sensor 51 self-test pass	1 yes, 0 no
	4	Pressure sensor 52 self-test pass	1 yes, 0 no
	5	Pressure sensor 53 self-test pass	1 yes, 0 no
	6	Pressure sensor 54 self-test pass	1 yes, 0 no
	7	Pressure sensor 55 self-test pass	1 yes, 0 no
16	0	Pressure sensor 56 self-test pass	1 yes, 0 no
	1	Pressure sensor 57 self-test pass	1 yes, 0 no
	2	Pressure sensor 58 self-test pass	1 yes, 0 no
	3	Pressure sensor 59 self-test pass	1 yes, 0 no
	4	Pressure sensor 60 self-test pass	1 yes, 0 no
	5	Pressure sensor 61 self-test pass	1 yes, 0 no
	6	Pressure sensor 62 self-test pass	1 yes, 0 no
	7	Pressure sensor 63 self-test pass	1 yes, 0 no