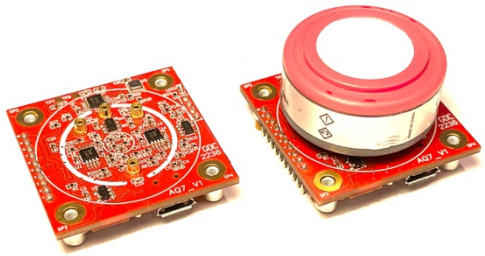
ESi-V1 / ESi-V2

Interface Board for Electrochemical Sensor

(DRAFT DATASHEET – subject to change)

The ESi-V1 and ESi-V2 boards manufactured by Technocomm-IoT are designed to work with 3 & 4 electrode electrochemical sensors measuring NO_2, SO_2, CO and O_3, up to ppb level sensitivity. The interface board provides multiple interface options including Analog (uncompensated) as well as digital (I_2C and UART) interfaces (compensated) for direct connection to a third-party host digital device. The units are designed to be easy to use and are configured using an online application to enter the device parameters and settings as well as the digital interface.

FEATURES AND BENEFITS

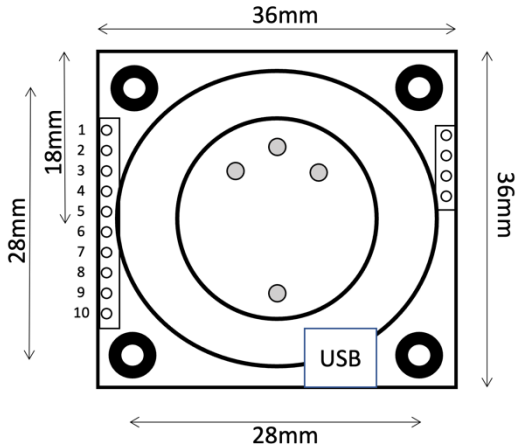


- **Compact size 36x36x25mm (with sensor)**
- **Analog and digital interfaces**
- **USB and BLE interfaces**
- **Sensor configuration on secure website**
- **Integrated data logger**
- **Threaded mounting hardware**
- **Pre-configured ready for use with Sensors**
- **Precision on board Temperature and Humidity sensors for compensation**
- **ESD protection on all pins and USB interface**

SPECIFICATION

- **5V DC @ <20 mA**
- **Operation from -25°C to 50°C**
- **ESD protection on all pins**
- **Weight <20g with sensor**
- **ESi-V1 for CO and SO_2 (Red PCB)**
- **ESi-V2 for O_3 and NO_2 (Blue PCB)**
- **Analog full scale ~1.5v @ 5000 ppb**
- **Full range of communications interfaces**
- **Communicates with other sensors**

Connections
1- GND
2- NC
3- AUX (AQ7)
4- SENSE (AQ7)
5- RESET
6- TX
7- RX
8- SCL
9- SDA
10- +5V



The correct connector for interfacing with the 10 and 4way 2mm headers are Wurth 62001011821 (10 way) and 62000411821 (4way)

User Interface

The ESi-V1 and ESi-V2 boards are designed to be used with electrochemical sensors like the Honeywell® AQ7 Series Sensors.
The ES-V1 should be used with the CO and SO_2 sensors, and the ES-V2 should be used with the O3 and NO_2 sensors. Sensors are plugged into gold plated pins and should be inserted carefully to avoid damage to the pins. The assembled unit should be connected with the 10x2mm spacing header, and the completed unit should be secured with 4x2mm screws into the threaded pillars.

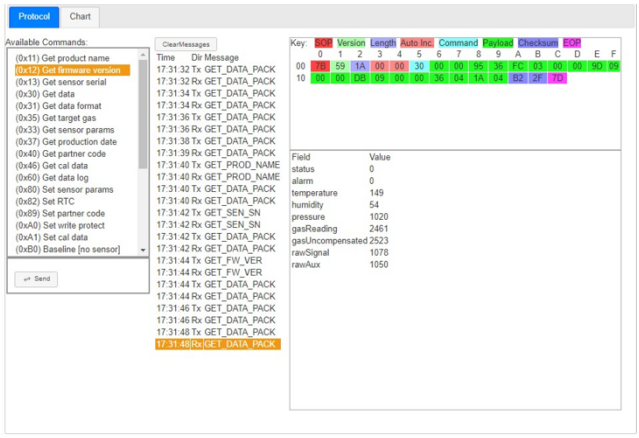
The ES-V1 and ES-V2 boards feature an ARM Cortex M4 microcontroller with Flash memory that can also be used as a data logger. The devices can be configured with a USB interface or wirelessly with a BLE interface

The user interface can be accessed at : https://aq7.technocomm-iot.com
When connected to the device, prior to inserting the sensor, a baseline reading should be programmed into the boards. Following this, the power should be disconnected, and the sensor should be carefully inserted. Once the sensor has been inserted, the unit should be allowed to stabilise for a minimum of 60 minutes and following this a sensor baseline should be recorded. The standard default setting is already pre-loaded into the units. Some sensors (SO_2) need to have special parameters inserted from the documents supplied by the manufacturer.

In addition, the SO2 sensors can be further calibrated by readings from other NO_2 and O_3 readings from other ESi boards on the same data bus by the user.

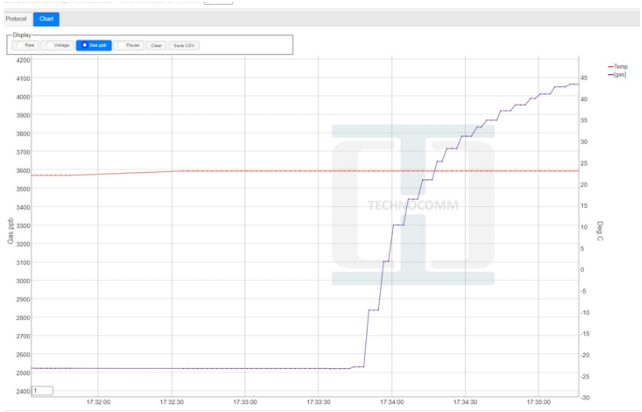
The user interface allows the user to configure the sensor

- Sensor type
- Sensor serial number
- Sampling interval
- Baseline data
- Data downloads
- Output alarm polarity (V2)



The chart tab allows:

- Visual presentation of data
- Zoom in/out for precision views



Full information on the data structure and configuration is available under NDA.

Please note that there must be NO electrical circuit connections to the 4way header other than for mechanical stability. Connecting to this pin can permanently damage functionality.

Communications Interfaces

The ESi-V1 & ESi-V2 device supports four communications interfaces. These allow host systems, PCs and smartphones access to the device for configuration and commissioning, and to collect data once the device is in operation. The interfaces are:

- UART – default baud rate 57600 (configurable), 8 data bits, no parity, 1 stop bit.
- USB – Communications Device Class (virtual com port).
- Bluetooth – Low Energy 5.1 in slave role, implements Serial Port Profile.
- I^2C – acts as a slave, default id 0x17 (configurable)

Note: All communication interfaces are enabled by default at production. Interfaces may be enabled/disabled by command sent from the host. The device will not accept a request to disable all interfaces and thus render itself isolated.

Communications Protocol

The same communications protocol is used over all four interfaces. The protocol is based on "SDCS: Smart Device Communication Standard" as used in the Honeywell® iSeries gas sensors. The protocol is packet-based; each packet being bounded by start and end markers and containing a CRC (cyclic redundancy check) to ensure data integrity. The format of the packets remains the same for both transmitted and received packets, however the length varies from command to command. For more details of the protocol, please refer to Honeywell document "sps-ast-sdcs-comm-protocol-iseries-external-002712-en.pdf".

Packet Format

The table below depicts the typical architecture of a received (or sent) data packet. The format of the data packets will remain the same for transmitted and received packets; nevertheless, the size of these would vary from command to command.

Item	SOP	Version	LENGTH	AI	CMD	DATA	CRC	EOP
Size	1	1	1	2	1	0-n	2	1
Content	0x7B	0x59	Number of bytes from AI to EOP	Auto increment 0..65535	Command code: various	Various (maximum 128 bytes)	CRC-16: Count from SOP to Data	0x7D

An SDCS packet is divided into eight different subsections: **SOP**, **Version**, **Length**, **AI**, **CMD**, **Data**, **CRC** and **EOP**; where **SOP** is the start of packet, Version corresponds to the firmware version, Length describes the size of the packet (from **AI** to **EOP**), **AI** is an auto-increment index that goes from 0 to 65535 (0xFF FF), **CMD** the command code, **Data** the data requested by the command code, **CRC** the error-detecting and correction code used to detect accidental change to raw data and **EOP** the end of packet.

Cyclic redundancy check implementation

A Cyclic Redundancy Check is a verification method used to ensure that data being sent is not corrupted during transfer. The sensor system calculates the verification or check code and adds it to the packet (CRC subsection). In the instrument, the data must go through the same process. If the CRC produced at the instrument does not match the sent CRC, then the data is corrupt. At this point, the instrument can request to either ignore the data or retransmit the request.

Instrument and sensor indexing

The auto-increment index featured in the device can be used together with a second instrument auto-increment index implemented at the instrument level. In this manner, if a packet is lost (either from the instrument to the device or the other way around), it will be possible to track the packet number that was not sent/received.

Available Commands

The following commands are currently implemented over the protocol:

Id	Command	Notes
0x11	GET_PROD_NAME	Returns the product name of the device in HEX to ASCII format. e.g. “AQ7V1”, “AQ7V2”, etc. Max 20 characters. Note: The product name data string ends with 0x00
0x12	GET_FW_VER	Returns the firmware version of the sensor in HEX to ASCII format. e.g. “1.0.2”. Max 12 characters. Note: The version string ends with 0x00
0x13	GET_SEN_SN	[0-1] Requested sensor index. Use 0 for single-sensor devices. Returns the AQ7 sensor serial number in HEX to ASCII format. Max 20 characters. Note: The serial number data string ends with 0x00 [0-1] Sensor index [2-21] Sensor serial
0x30	GET_DATA_PACK	[0-1] Requested sensor index. Use 0 for single-sensor devices. Returns the sensor’s status, alarm, gas reading and temperature/ humidity measurements. The order of the returned data is as follows: [0-1] Sensor index [2] Status (single byte): B0: Reserved B1: In warm up B2-B7: Reserved [3] Alarm (single byte): B0: Over range B1: Baselines have not been set B2: Time is not synchronized (RTC hasn’t been set) B3: Alarm triggered B4-B7: Reserved [4] Temperature: reading in degrees Celsius. = Decimal value – 127, e.g., 20°C = 147 (1 unsigned byte) [5] Humidity: % relative humidity (1 unsigned byte)

<table>
<tr><td></td><td></td><td>[6-7]Pressure: atmospheric pressure in hPa (2 bytes unsigned integer)

[8-11] Gas reading ppb: Concentration measurement is 4 bytes signed integer.

[12-15] Uncompensated Reading ppb: (For debugging purposes only). The uncompensated gas concentration measurement is 4 bytes signed integer.

[16-17] Raw count signal readings: 2 bytes (for debugging purposes only).

[18-19] Raw count aux readings: 2 bytes (for debugging purposes only).

_____
Note: All status, gas & environment readings are returned; the host cannot request just particular data items.</td></tr>
<tr><td>0x31</td><td>GET_DATA_FMT</td><td>[0-1] Requested sensor index. Use 0 for single-sensor devices.

Returns the unit of the current gas reading, always ppb.

[0-1] Sensor index
[2] Unit codes
0x00: ppm (parts per million)
0x01: % (gas percentage)
0x02: ppb (parts per billion)
0x27: % LEL (lower explosive limit)
0x28: % VOL (volume percentage)</td></tr>
<tr><td>0x35</td><td>GET_TARGET_GAS</td><td>[0-1] Requested sensor index. Use 0 for single-sensor devices.

Returns the target gas in HEX to ASCII e.g. CO, SO_2, NO_2, O_3. Max 6 characters. Note: The target gas string ends with 0x00 .
[0-1] Sensor index
[2-7] Gas</td></tr>
<tr><td>0x33</td><td>GET_SEN_PARA</td><td>[0-1] Requested sensor index. Use 0 for single-sensor devices.

Returns the sensor parameters such as gas type, the thresholds for the alarm output etc.

[0-1] Sensor index
[2] Gas type (1 unsigned byte):
<table><tr><td>0x01</td><td>CO</td></tr><tr><td>0x02</td><td>SO_2</td></tr><tr><td>0x03</td><td>NO_2</td></tr></table></td></tr>
</table>

		<table><tr><td>0x04</td><td>O_3</td></tr></table> [3] Alarm output polarity (0 = low when alarm active) (1 unsigned byte) [4-7] Alarm trigger threshold ppb (unsigned integer) [8-11] Alarm return threshold ppb (unsigned integer)
0x37	GET_PROD_DATE	Returns the production date of the device in the following order: [0] Year (0*-99) *Where 0 stands for 2000 [1] Month (1-12) [2] Day (1-31) [3-5] Reserved
0x40	GET_PARTNER_CODE	Returns the OEM code in HEX to ASCII string. Max 6 characters. Note: The OEM code string ends with 0x00. [0-5] OEM code Important: Once the code has been assigned, it won't be able to be modified.
0x46	GET_CAL_DATA	[0-1] Requested sensor index. Use 0 for single-sensor devices. Returns the AQ7 sensor compensation parameter table supplied with the AQ7 sensor. All compensation parameters are 4-byte floating point numbers (IEEE-754). The exact format depends on the type of sensor. For further details, refer to Honeywell AQ7 sensor characterisation notes. Bytes 4-9 of the response is the date & time when the sensor was last calibrated. Note that this will have no meaning unless RTC was set at the time. All Sensors: [0-1] Sensor index [2] Gas type (1 unsigned byte): <table><tr><td>0x01</td><td>CO</td></tr><tr><td>0x02</td><td>SO_2</td></tr><tr><td>0x03</td><td>NO_2</td></tr><tr><td>0x04</td><td>O_3</td></tr></table> [3] Calibration date validity (1 unsigned byte) [4]: Year (0*-99) *Where 0 stands for 2000 [5]: Month (1-12) [6]: Day (1-31) [7]: Hour (0-23) [8]: Minute (0-59) [9]: Second (0-59)

		[10-11]: Reserved [12-15] Signal baseline without sensor (mV) [16-19] Aux baseline without sensor (mV) [20-23] Signal baseline without gas(mV) [24-27] Aux baseline without gas(mV) [28-31] Signal span with gas (mV) [32-35] Aux span with gas (mV) [36-39] Span gas concentration (ppm) CO Sensor: [40-43]: A1 [44-47] B1 [48-51]: C1 [52-55]: A2 [56-59]: B2 [60-63]: C2 [64-67]: D2 NO_2 Sensor: [40-43]: A1 [44-47] B1 [48-51]: C1 [52-55]: A2 [56-59]: B2 [60-63]: C2 [64-67]: D2 SO_2 Sensor: [40-43]: A1 (-30oC <= T <= 20oc) [44-47]: B1 (-30oC <= T <= 20oc) [48-51]: C1 (-30oC <= T <= 20oc) [52-55]: A1 (20oC <= T <= 50oc) [56-59]: B1 (20oC <= T <= 50oc) [60-63]: C1 (20oC <= T <= 50oc) [64-67]: A2 [68-71]: B2 [72-75]: C2 [76-79]: D2 [80-83]: Cf1 [84-87]: Cf2 O_3 Sensor: [40-43]: A1 (-30oC <= T <= 20oc) [44-47]: B1 (-30oC <= T <= 20oc) [48-51]: C1 (-30oC <= T <= 20oc) [52-55]: A1 (20oC <= T <= 50oc) [56-59]: B1 (20oC <= T <= 50oc) [60-63]: C1 (20oC <= T <= 50oc) [64-67]: A2 [68-71]: B2 [72-75]: C2 [76-79]: D2 [80-83]: A0 (-30oC <= T <= 20oc) [84-87]: B0 (-30oC <= T <= 20oc) [88-91]: C0 (-30oC <= T <= 20oc)

<table>
<tr><td></td><td></td><td>[92-95]: A0 (20oC <= T <= 50oc)
[96-99]: B0 (20oC <= T <= 50oc)
[100-103]: C0 (20oC <= T <= 50oc)
[104-107]: R3</td></tr>
<tr><td>0x60</td><td>GET_EC_DATALOG</td><td>[0-1] Requested sensor index. Use 0 for single-sensor devices.

Return records from the gas concentration data log. The host specifies the starting timestamp of the returned log entries. The records are returned in chronological order.

Host to Device request:
[0-3] Start timestamp in Unix epoch format. Send a timestamp of zero to return the earliest records.

Device to Host reply:
[0-1] Sensor index
[2-3] Reserved
[4-7] Record 1 timestamp (4 bytes unsigned integer)
[8-11] Record 1 gas reading (4 bytes signed integer)
[12-15] Record 2 timestamp (4 bytes unsigned integer)
[16-19] Record 2 gas reading (4 bytes signed integer)

Etc. up to a maximum of 16 records per reply.
A host may retrieve all the records in the log by repeatedly sending the command, supplying the last timestamp returned in REPLY(N) as the start timestamp in REQUEST(N+1).

When there are no more matching records, the timestamp fields are returned as zeroes.</td></tr>
<tr><td>0x71</td><td>RECEIVE_ERROR</td><td>If the device receives a command packet but cannot perform the requested command or cannot prepare the information. It will return an error packet indicating the reason of the failure as a single byte. The following errors may be returned:

<table>
<tr><td>0x31</td><td>Unknown error</td></tr>
<tr><td>0x32</td><td>The command is not supported by this sensor</td></tr>
<tr><td>0x33</td><td>The command is supported by this sensor, but the data length in the command packet is not valid</td></tr>
<tr><td>0x34</td><td>The value to be set is not valid</td></tr>
<tr><td>0x39</td><td>The value to be set is protected, cannot be changed without deactivating write protect</td></tr>
<tr><td>0x3F</td><td>The operation wasn’t executed successfully</td></tr>
</table>
</td></tr>
</table>

<table>
<tr><td></td><td></td><td></td></tr>
<tr><td>0x80</td><td>SET_SEN_PARA</td><td>This command allows the user to change the sensor parameters such as the gas type, thresholds for the alarm output etc.

[0-1] Requested sensor index. Use 0 for single-sensor devices.
[2] Gas type (1 unsigned byte):<table><tr><td>0x01</td><td>CO</td></tr><tr><td>0x02</td><td>SO_2</td></tr><tr><td>0x03</td><td>NO_2</td></tr><tr><td>0x04</td><td>O_3</td></tr></table>[3] Alarm output polarity (0 = low when alarm active)

[4-7] Alarm trigger threshold ppb (unsigned integer)
[8-11] Alarm return threshold ppb (unsigned integer)</td></tr>
<tr><td>0x82</td><td>SET_SEN_RTC</td><td>Sets the internal Real Time Clock of the device, UTC+0, sent as six bytes:

(0) Year (0*-99) *Where 0 stands for 2000
(1) Month (1-12)
(2) Day (1-31)
(3) Hour (0-23)
(4) Minute (0-59)
(5) Second (0-59)

Caution: The RTC should be resynchronized after every power up.</td></tr>
<tr><td>0x89</td><td>SET_SEN_PARTNERID</td><td>Devices can have an OEM specific code programmed in, which is written during manufacture and cannot be modified.

Abbreviated partner ID (no more than 6 characters)

Warning: Once this command has been set, it won’t be possible to change it once again.</td></tr>
<tr><td>0xA0</td><td>WRITE_PROTECT</td><td>Write Protect is enabled by default, if Write Protect is not deactivated, the host will not be able to set any value, and an error code will be returned. Once Write Protect is disabled, it will be automatically re-enabled by the device after 300 seconds.

The host sends two bytes to enable/disable write protect, followed by a two-byte PIN

[0-1] Write protect<table><tr><td>0x0000</td><td>write-protect off</td></tr><tr><td>0x0001</td><td>write-protect on</td></tr></table></td></tr>
</table>

<table>
<tr><td></td><td></td><td>[2-3] PIN

The default PIN is 0x0000, meaning no PIN protection. If a PIN has been set, then write-protection will only be disabled if the host supplies the correct PIN in its “write-protect-off” command. If an incorrect PIN is supplied, attempts to disable write protect are locked out for 60 seconds.

To set a new PIN, the host must send a “write-protect-off” command with the correct PIN. If the supplied PIN is correct, then write protection is disabled, and the user may then send a “write-protect-on” command containing the new PIN.</td></tr>
<tr><td>0xA1</td><td>USER_CAL</td><td>Set the ESi sensor compensation parameter table supplied with the AQ7 sensor. All compensation parameters are 4-byte floating point numbers (IEEE-754). The exact format depends on the type of sensor.

Only a few parameters will have a different value for each sensor (applicable for AQ7OZ and AQ7SO2). These are marked with ‘*’. All other parameters will be ignored by the device.

For further details, refer to Honeywell AQ7 sensor characterisation notes.

All Sensors:
[0-1] Requested sensor index. Use 0 for single-sensor devices.

[2] Intended gas type. This <u>MUST</u> match the gas type currently configured within the sensor.
<table>
<tr><td>0x01</td><td>CO</td></tr>
<tr><td>0x02</td><td>SO_2</td></tr>
<tr><td>0x03</td><td>NO_2</td></tr>
<tr><td>0x04</td><td>O_3</td></tr>
</table>
[3-39] Reserved

CO Sensor:
[40-43]: A1
[44-47] B1
[48-51]: C1
[52-55]: A2
[56-59]: B2
[60-63]: C2
[64-67]: D2

NO_2 Sensor:
[40-43]: A1
[44-47] B1
[48-51]: C1
[52-55]: A2</td></tr>
</table>

		[56-59]: B2 [60-63]: C2 [64-67]: D2 SO_2 Sensor: [40-43]: A1 (-30oC <= T <= 20oc) [44-47]: B1 (-30oC <= T <= 20oc) [48-51]: C1 (-30oC <= T <= 20oc) [52-55]: * A1 (20oC <= T <= 50oc) [56-59]: * B1 (20oC <= T <= 50oc) [60-63]: * C1 (20oC <= T <= 50oc) [64-67]: A2 [68-71]: B2 [72-75]: C2 [76-79]: D2 [80-83]: Cf1 [84-87]: Cf2 O_3 Sensor: [40-43]: A1 (-30oC <= T <= 20oc) [44-47]: B1 (-30oC <= T <= 20oc) [48-51]: C1 (-30oC <= T <= 20oc) [52-55]: A1 (20oC <= T <= 50oc) [56-59]: B1 (20oC <= T <= 50oc) [60-63]: C1 (20oC <= T <= 50oc) [64-67]: A2 [68-71]: B2 [72-75]: C2 [76-79]: D2 [80-83]: A0 (-30oC <= T <= 20oc) [84-87]: B0 (-30oC <= T <= 20oc) [88-91]: C0 (-30oC <= T <= 20oc) [92-95]: A0 (20oC <= T <= 50oc) [96-99]: B0 (20oC <= T <= 50oc) [100-103]: C0 (20oC <= T <= 50oc) [104-107]: * R3
0xB0	BASELINE_NO_SENSOR	Store signal when no sensor plugged in. [0-1] Requested sensor index. Use 0 for single-sensor devices.
0XB1	BASELINE_NO_GAS	Store signal when sensor is present, but in clean air. [0-1] Requested sensor index. Use 0 for single-sensor devices.
0xB2	BASELINE_WITH_GAS	Store signal when sensor is present, in a known concentration of target gas. [0-1] Requested sensor index. Use 0 for single-sensor devices. [2-3] Reserved [4-7] Gas concentration ppm. 4-byte floating point

<table>
<tr><td></td><td></td><td></td></tr>
<tr><td>0xB3</td><td>RESET_DEVICE</td><td>Reset the device</td></tr>
<tr><td>0xB4</td><td>CLEAR_LOG</td><td>Clear the data log</td></tr>
<tr><td>0xB5</td><td>COMPENSATE_CROSS_GAS</td><td>Supply NO_2 and O_3 concentration readings to device using SO_2 sensor. Sent as 4-byte unsigned integers.

[0-1] Requested sensor index. Use 0 for single-sensor devices.
[2-3] Reserved
[4-7] AQ7 NO_2 concentration reading (ppb)
[8-11] AQ7 O_3 concentration reading (ppb)</td></tr>
<tr><td>0xB6</td><td>SET_SEN_SN</td><td>Sets the AQ7 sensor serial number in HEX to ASCII format. Max 20 characters. Note: The serial number data string ends with 0x00

[0-1] Requested sensor index. Use 0 for single-sensor devices.
[2-21] Sensor serial</td></tr>
<tr><td>0xB7</td><td>GET_COMMS_PARA</td><td>Returns the communications parameters such as baud rate etc.

[0] I^2C slave address (1 unsigned byte)
[1] UART baud rate (1 unsigned byte)<table><tr><td>0x01</td><td>9600</td></tr><tr><td>0x02</td><td>19200</td></tr><tr><td>0x03</td><td>38400</td></tr><tr><td>0x04</td><td>57600</td></tr></table>[2] Enabled communication interfaces (1 unsigned byte):
B0: UART
B1: USB
B2: Bluetooth
B3: I_2C
B4-B7: Reserved
[3] Reserved
[4-7] Log interval in seconds (unsigned integer)</td></tr>
<tr><td>0xB8</td><td>SET_COMMS_PARA</td><td>Sets the communications parameters such as baud rate etc.

[0] I^2C slave address (1 unsigned byte)
[1] UART baud rate (1 unsigned byte)<table><tr><td>0x01</td><td>9600</td></tr><tr><td>0x02</td><td>19200</td></tr><tr><td>0x03</td><td>38400</td></tr><tr><td>0x04</td><td>57600</td></tr></table>[2] Enabled communication interfaces (1 unsigned byte):
B0: UART</td></tr>
</table>

		B1: USB B2: Bluetooth B3: I_2C B4-B7: Reserved [3] Reserved [4-7] Log interval in seconds (unsigned integer) Note: All communication interfaces are enabled by default at production. The device will not accept a request to disable all interfaces and thus render itself isolated.

Note: The "BASELINE" commands correspond to the actions in the calibration procedure as outlined in the Honeywell AQ7 Gas Characterisation notes.

Security

By default, the device is left open at production. The user [or distributor performing device calibration] may set a PIN to protect the device configuration from being modified. The communications interfaces may also be individually enabled or disabled to restrict access.

Data Storage

By default, the device will store a timestamped record of the gas concentration every minute. The log interval is configurable between 10 seconds and 12 hours. The standard device has capacity to hold 22 days' worth of readings at a rate of one per minute. Enhanced versions of the device have capacity to hold almost four years' worth of readings at a rate of one per minute.

The log is maintained as a circular buffer. Once capacity has been reached, any new records will replace the oldest records in the log. The log may be read over the communications interfaces and cleared by request from the host.

Alarm Output

The device has a single alarm output pin. The pin operates at TTL level, and as such is not suitable for driving any kind of load. It may be used to switch a small relay or MOSFET. The pin responds to the gas concentration going above a configurable threshold. At this point, the pin is set until the gas concentration falls below the return threshold. The device has an internal 1K series resistor to the pin.

The thresholds and the polarity of the alarm pin are configurable.