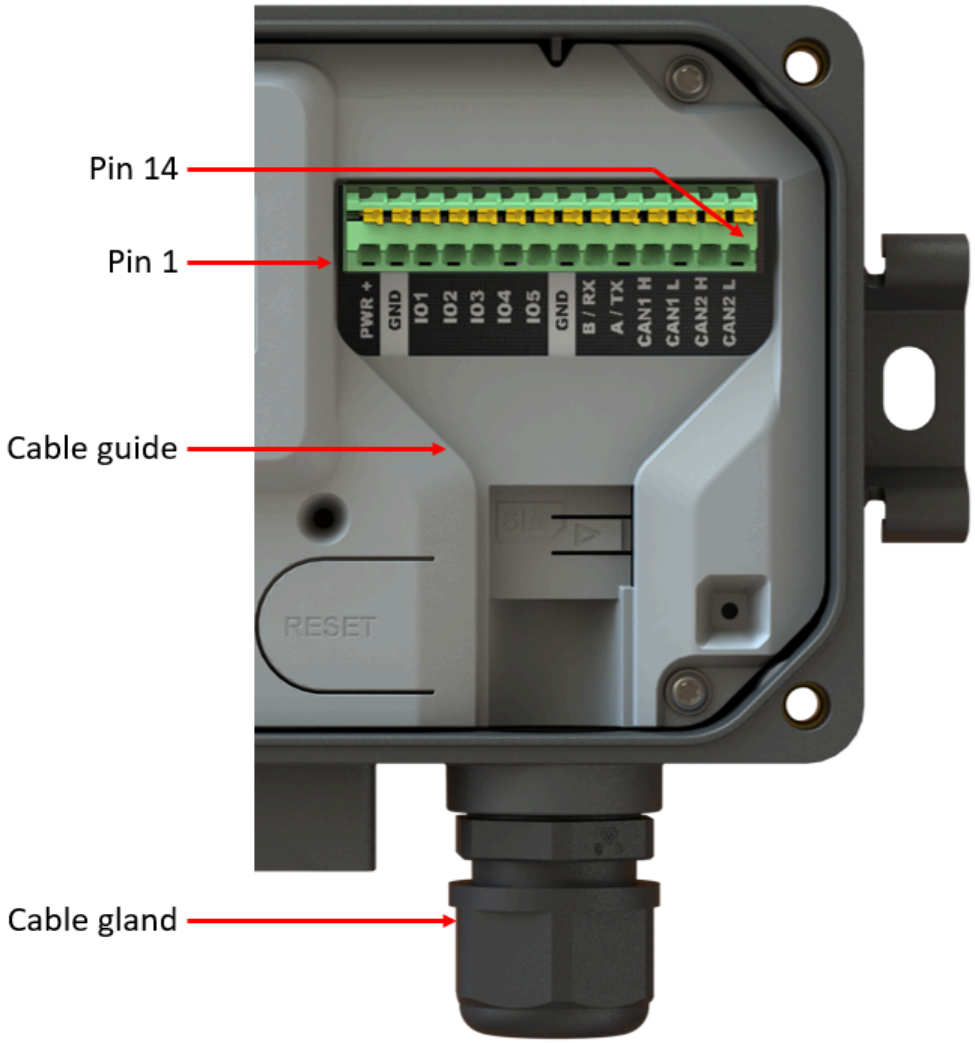

Figure 2.13. Interface pin numbers

The following pinout applies to the 14 way terminal block:

Pin number	Name	Terminal block marking	Application
1	Positive voltage in	PWR+	Positive system power; either permanent or intermittent such as from a solar panel
2	Negative voltage in (ground)	GND	Negative system power or ground
3	General purpose input output 1	IO1	Voltage, current, frequency, pulse input and sink or source output
4	General purpose input output 2	IO2	Voltage, current, frequency, pulse input and sink or source output
5	General purpose input output 3	IO3	Voltage, current, frequency, pulse input and sink or source output
6	General purpose input output 4	IO4	Voltage, current, frequency, pulse input and sink or source output
7	General purpose input output 5	IO5	Voltage, current, frequency, pulse input and sink or source output

8	Ground	GND	Spare ground for sensor connection
9	Serial in	B / RX	RS485B in RS485 mode and receive in RS232 mode
10	Serial out	A / TX	RS485A in RS485 mode and transmit in RS232 mode
11	CAN 1 High	CAN2 H	CAN bus 1 CAN high input
12	CAN 1 Low	CAN2 L	CAN bus 1 CAN low input
13	CAN 2 High	CAN2 H	CAN bus 2 CAN high input
14	CAN 2 Low	CAN2 L	CAN bus 2 CAN low input

The terminal block allows for push-in connection, meaning that no tools are required. A defined contact force ensures that the contact remains stable over the long term and is high vibration environments. A finger operated release button for each terminal allows for convenient, tool-free operation.

Wire Specification:	
Wire stripping length	8 mm
Conductor cross section solid min.	0.2 mm
Conductor cross section solid max.	1.5 mm
Conductor cross section flexible min.	0.2 mm
Conductor cross section flexible max.	1.5 mm
Conductor cross section AWG min.	24
Conductor cross section AWG max.	16

Warning Please ensure that all external power is removed from the device before wiring fitment begins.

Power and ground wires must be rated to at least 1A and should have a voltage rating suitable for the application. A 1A fuse in-line with the power connection is recommended. Signal wires should be chosen based on the application and may require specific features such as individual shielding, twisted pairs or impedance matching. In extremely noisy electrical environments, it is recommended that a shielded cable be used and that the shield only be connected to ground on the power supply end. Do not ground the shield on both ends.

The material from which the chosen cable is manufactured should be suitable for the environment in which it is used. Be sure to check chemical resistance, UV stability and flex durability of the cable being used.

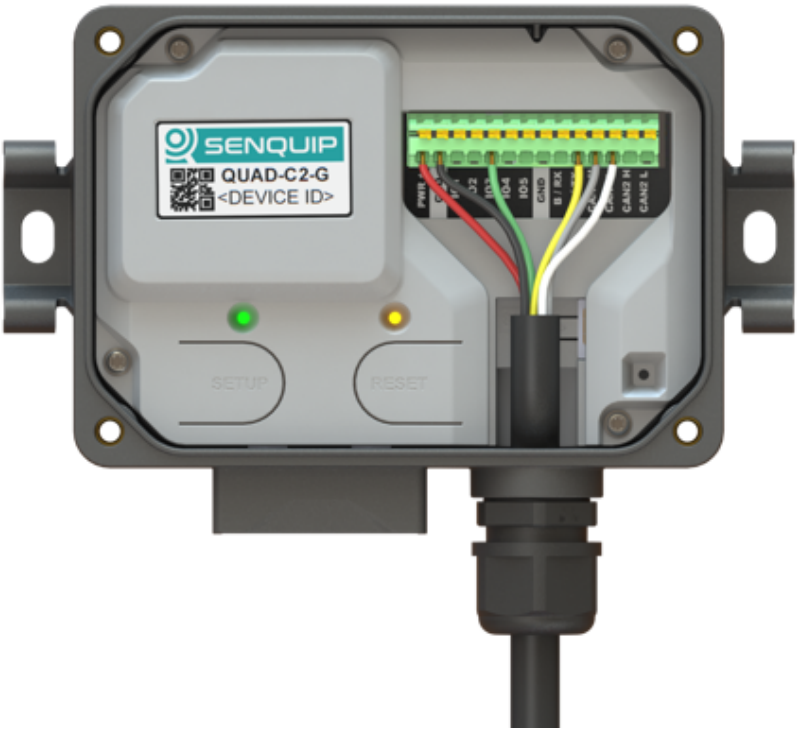

Figure 2.14. Wiring example with a sheathed cable

To ensure IP rating is retained, a sheathed cable with diameter suitable for use with the cable gland insert should be used. Three cable gland seals are supplied as specified in the table below. The gland with the single hole should be used when a single cable is required; the gland with two holes should be used where two cables are required etc. Cable seals are manufactured using NBR (Nitrile Butadiene Rubber) and are resistant to oils and biological oils, solvents and most industrial chemicals. Always check the suitability of the cable gland insert with all chemicals found in the operating environment.

Part No	No. holes	Hole diameter	Cable	
A	1	11mm	6-11mm	
B	2	5mm	3-5mm	
C	3	4mm	2-4mm	

2.7 Fitting the antenna

Every Senquip QUAD is shipped with a dual GNSS and 4G LTE antenna. The antenna is fitted with 2 FAKRA plugs that engage with the matching sockets at the base of the Senquip QUAD. FAKRA connectors were chosen for use on the Senquip QUAD because:

- They offer vibration tolerant operation
- The colour coding and keying make it simple to match the antennas with the correct connectors

- FAKRA connectors avoid the opportunity to over tighten the RF connectors, causing damage

Figure 2.15. GNSS and 4G LTE combination antenna

To connect the GNSS or LTE antenna lead to the Senquip QUAD, press the antenna connector into the socket until you hear it click. To remove the connector, depress the small tab and pull.

Warning When removing the antenna, do not pull on the RF cable.

Figure 2.16. Press the tab to remove the connector

The GNSS and 4G LTE antenna cables are colour coded and are keyed. Connector details are given in the table below.

Function	FAKRA Type	Colour	Position
4G LTE	FAKRA D	Purple	Left
GNSS	FAKRA C	Blue	Right

2.8 Initial setup

Initial setup can be performed using the integrated web-server using any Wi-Fi enabled phone, tablet or computer. Once the device is connected to a network, configuration can be performed remotely using the in-built webserver or via the Senquip Portal.

Note For volume opportunities, devices can be pre-configured to connect immediately to a network; please contact Senquip to discuss this option.

With the cover open, two push-button switches (setup and reset) and two LEDs (network and status) are available. The switches and LEDs are used to configure the device.

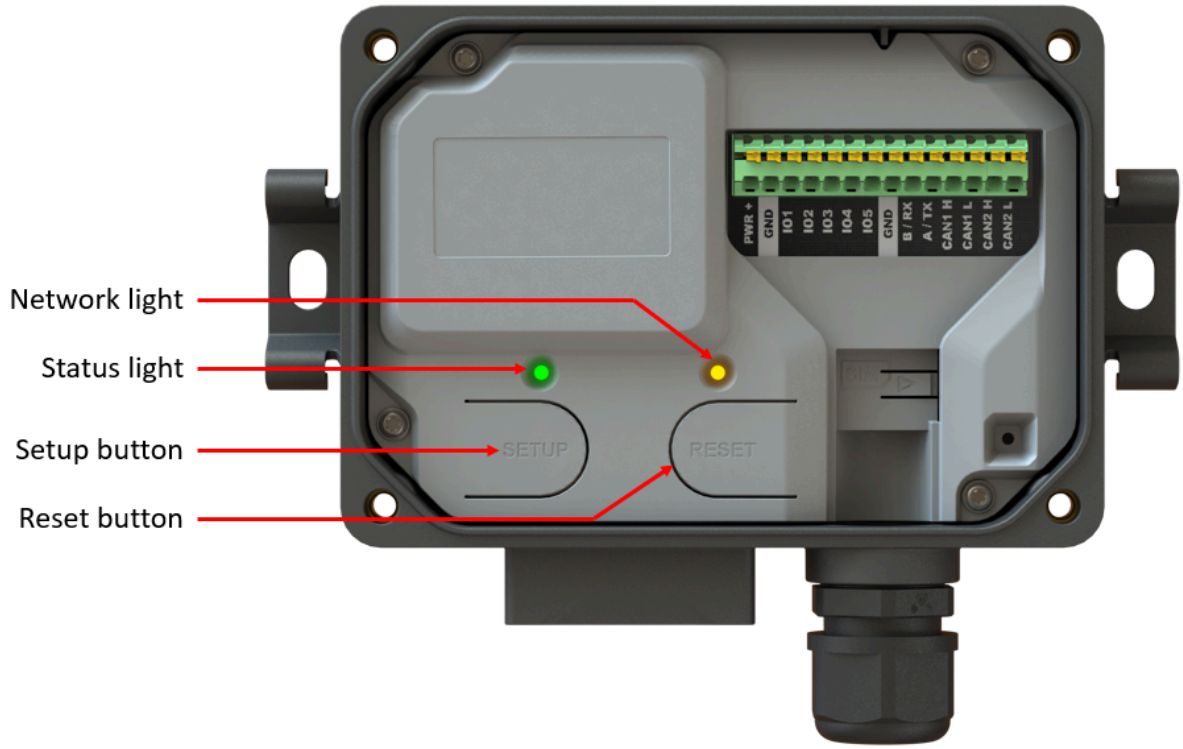

Figure 2.17. Buttons and LEDs for setup

The status and network LEDs indicate the current state of the device. These LEDs are only active if the lid is open. When the lid is closed, the LEDs will remain off to conserve energy. A summary of LED function is given in the table below.

Note During normal operation, the LEDs will be off when the device is sleeping or hibernating and will not turn on when the lid is opened until the next measurement interval.

Status LED (Green)	Network LED (Orange)	Meaning
Off	Off	Device is sleeping or lid is closed
Flash (1Hz)	Off	Setup Mode
On	Flash (1Hz)	Device has been configured, but no network connection
On	On	Network connection via Wi-Fi or 4G LTE
Fast Flash	Fast Flash	Factory reset in progress
Off	Fast Flash	Firmware update in progress
Slow Flash	Off	Pre-charge mode

Note The LEDs turn on when the lid is opened because an internal sensor detects light. If the lid is opened in dark conditions, the LEDs will not turn on.

Firmware Updates The latest firmware version and a description of changes to firmware can be found in the Senquip Device Firmware Changelist. Updating to the latest firmware can be performed from the Senquip Portal by selecting *Settings* and *Update* and then pressing the *Update Firmware* button. To update to a specific firmware version, enter the firmware number as shown in the figure below and press *Update Firmware*. During the firmware update, the orange network LED will flash fast. After a firmware update, the LEDs may freeze or remain off for a few minutes. This is normal behaviour and occurs shortly after firmware update when the ORB is encrypting the memory.

The firmware update can be seen in the command queue and has been received by the device when the status shows as success. Receipt of the firmware update by the device does not always mean that the update is correctly applied. To ensure that the update has occured, check the firmware number in the *Device Info* widget on the device Portal page. You may need to refresh the browser window.

Factory Reset To perform a factory reset, press and hold the *Setup* button. While holding the *Setup* button, press and release the *Reset* button. The green status LED and orange network LED will begin to flash fast. Continue to hold the *Setup* button down for 10 seconds. After 10 seconds, the LEDs will stop flashing at which point the *Setup* button can be released. All settings will be changed back to the factory state and the device will restart. Any firmware updates made to the device will be preserved.

> **Warning** Returning the device to factory defaults will remove all network settings, rendering remote updates impossible.

Passwords The Senquip QUAD is shipped, pre-loaded, with a random password that prevent unauthorised connection to the Wi-Fi hotspot and prevent access to the built in webserver. The default passwords are printed on a label that can be found under the cover.

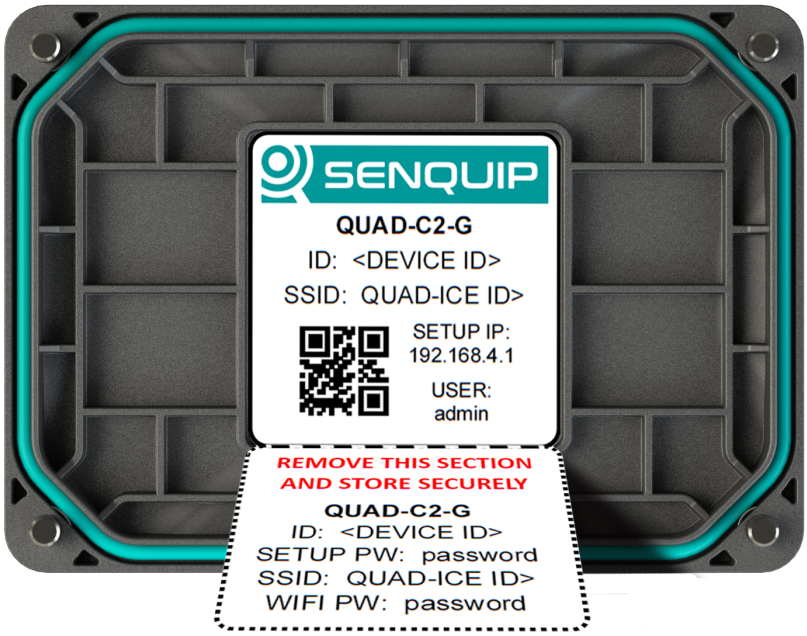

Figure 2.18. The default passwords can be found under the lid

The label contains two sections:

- General information about the Senquip QUAD such as the part number, identification number, Wi-Fi SSID and the IP address of the webserver
- A removable section that contains the part number, identification number, webserver password (setup password), Wi-Fi SSID and Wi-Fi password. This section should be removed and stored securely. It is recommended that the passwords be changed as soon as possible using the webserver or the Senquip portal.

Figure 2.19. Label with general information and passwords

A label with the device ID is placed on the Senquip QUAD base to prevent bases and lids being misplaced.

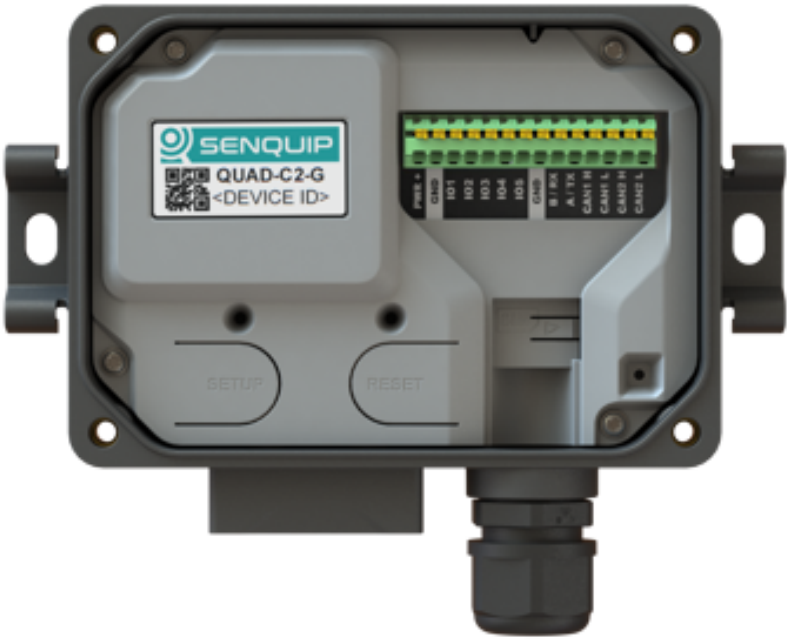

Figure 2.20. Matching device ID label

Take note of the Wi-Fi and setup passwords as you will need them to continue with the setup. In the example above, the Senquip QUAD identifier is *DE9032030*, the Wi-Fi password is *hjg3iplg* and the setup password is *QvjSF3jk*.

Setup Mode Setup Mode allows initial customer configuration via the integrated web-server. This mode is enabled when the *Setup* button is pressed for more than 2 seconds.

In setup mode, an integrated Wi-Fi Access Point (AP) is enabled through which the installer can access the built in web-server. The web-server allows for initial setup using a web based interface, similar to setting up a home router. In this mode, a user can connect to the device using any computer, tablet or mobile phone that has Wi-Fi and is loaded with a browser. After the device is connected to a network, changes can be made remotely using the Senquip Portal.

Note The Senquip QUAD Wi-Fi Access Point is 2.4GHz only

If connected to external power, the device will remain in setup mode as long as the lid is open. If no external power is available, the device will enter sleep mode after 10 minutes of no activity. To re-enable setup mode, press the *Setup* button again for 2 seconds. Setup mode will be exited once the lid has been closed for more than 10 seconds.

Note A shadow over the light sensor can make the device exit setup mode. It is easier to configure the device from the Senquip Portal once a network connection has been established.

To connect to the Senquip QUAD, search for available Wi-Fi networks on your Wi-Fi enabled device. The device will advertise itself as *QUAD-xxxxx*, where xxxxx represents the last 5 digits of the device identifier. The device identifier as well as password and other information can be found on a sticker under the lid. In the example below, using an Android phone, the Senquip QUAD can be seen to be advertising itself as *QUAD-32030*, where *32030* are the last five digits of the device identifier.

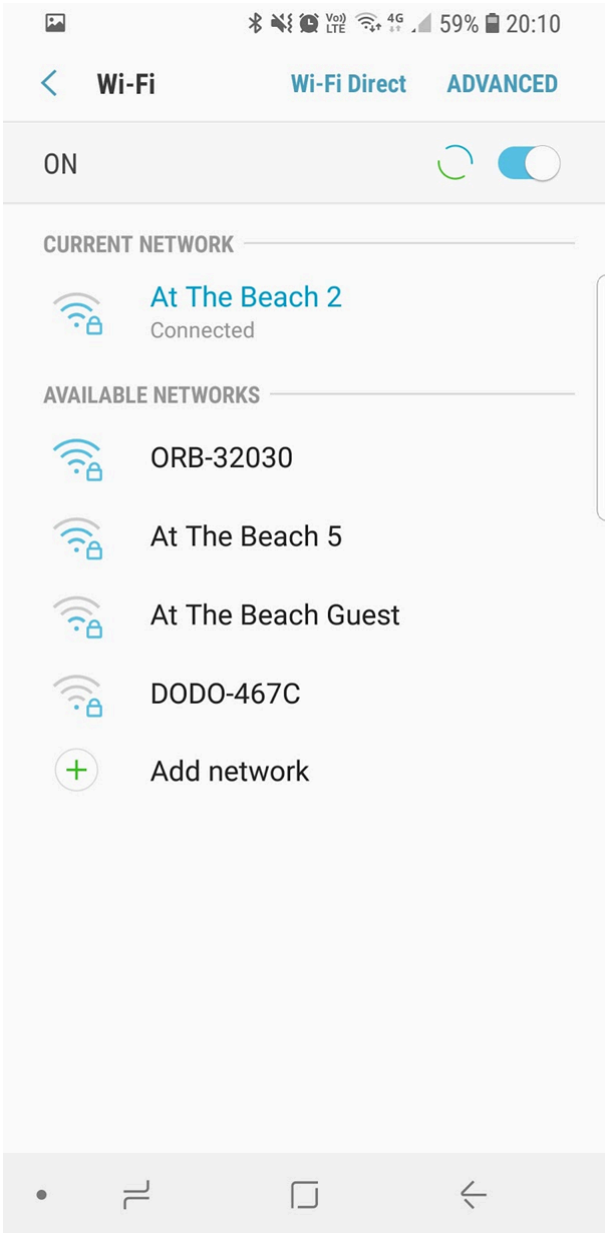

Figure 2.21. Search for Wi-Fi networks

Select the Senquip QUAD's advertised Wi-Fi network name, *QUAD-32030* in this example, and enter the Wi-Fi password found under the lid, *hjg3iplg* in this example. When you press connect, your Wi-Fi enabled device will connect to the device Wi-Fi hotspot. Being connected to the Wi-Fi hotspot does not allow you to view or change any data yet. To view and change data, you need to login to the device webserver.

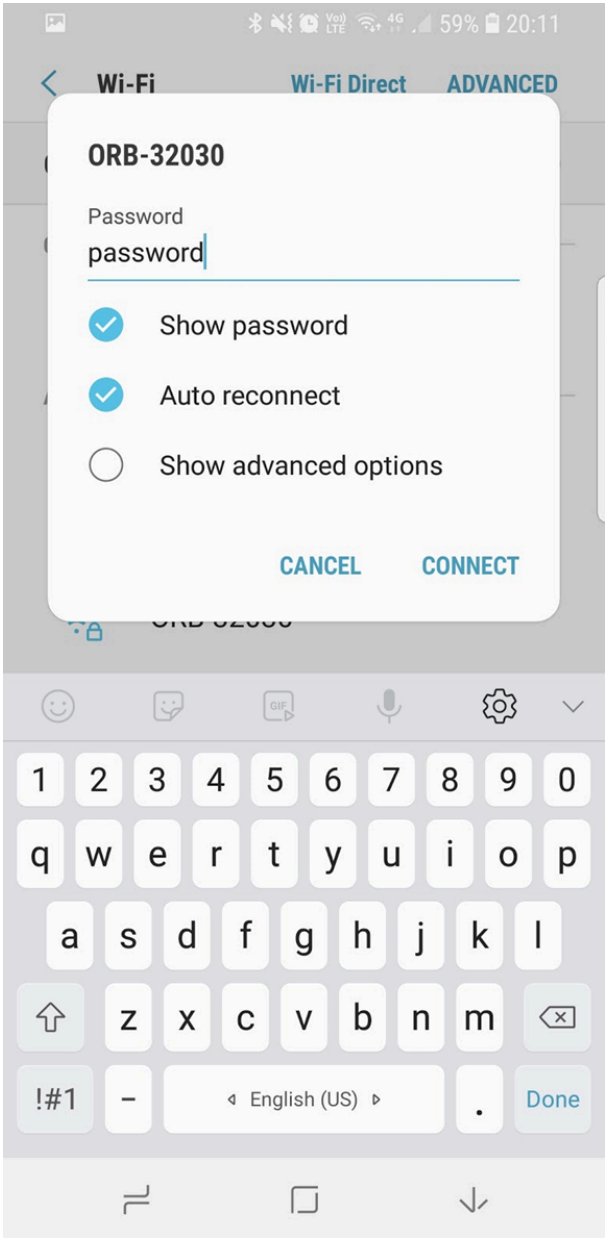

Figure 2.22. Enter the Wi-Fi password

Once you are connected to the Wi-Fi hotspot, to access the web-server, open your preferred web-browser (Senquip recommends Chrome) and in the address bar, type *192.168.4.1* and press enter. Your browser will open the web-server password entry page. For username, type in *admin*; the setup password can be found on the sticker under the lid of the device. In the example above, the password is *QvjSF3jk*. Remember to change this password as soon as possible using the *Admin* tab in the web-server.

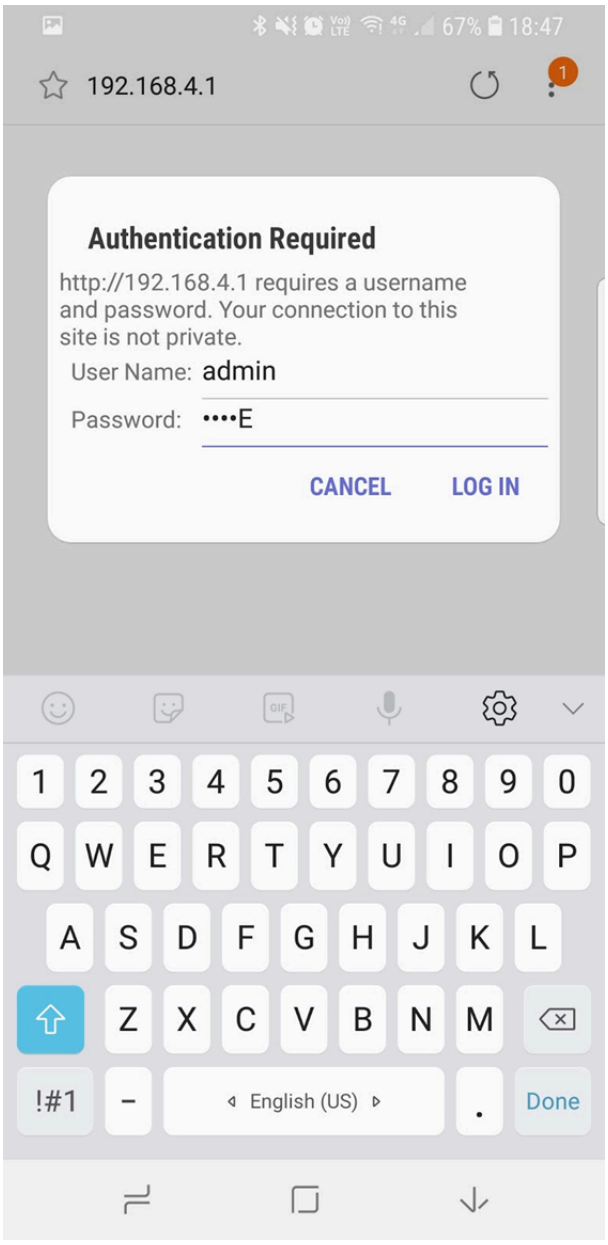

Figure 2.23. Accessing the web-server

Note Performing a factory reset will reset the passwords to their defaults as found under the lid.

If you have entered the username and password correctly, you will now have access to the device web-server. From the web-server, you will be able to view current data, make configuration changes and perform software updates.

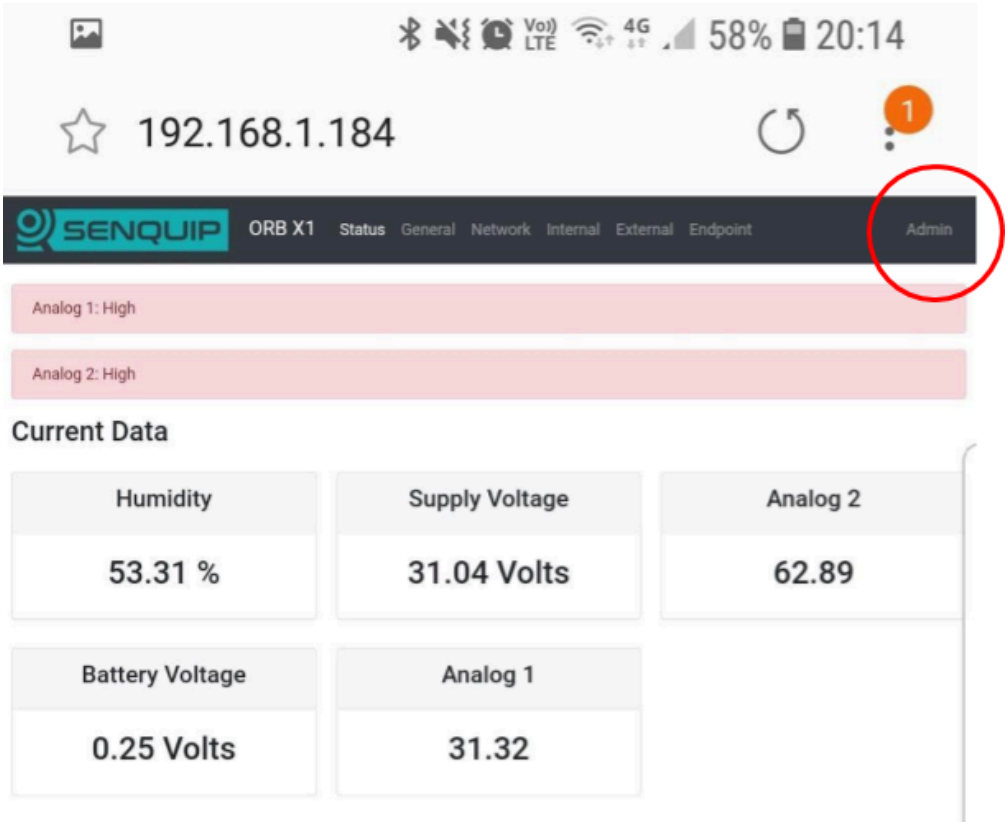

Figure 2.24. Browsing the web-server

The following pages are available on the web-server:

Page Name	Function
Status	View the current status of all enabled modules
General	Configure general, timing and power options
Network	Settings to attach the Senquip QUAD to a Wi-Fi or 4G LTE network
Internal	Configure all sensors that are internal to the Senquip QUAD
External	Configure sensors that are connected to the external interface
Endpoint	Configure the Senquip QUAD to send data to a remote server such as the Senquip Cloud
Events	Set email and SMS notifications when alerts occur
Update	Update firmware on the Senquip QUAD
API	Configure the Senquip API to communicate with third party servers
Admin	Save device settings to a file to enable easy cloning of devices

Warning Remember to change the web-server password as soon as possible using the Admin tab found on the top right, as circled in red in the above image.

Power Supply

The Senquip QUAD has been designed to offer maximum flexibility in terms of power supply requirements and is able to run off permanent power and solar.

3.1 Permanent power

A wide input range of 10-75V operation allows for use in automotive, industrial and telecoms applications. System power is backed up with an internal lithium polymer rechargeable battery in the event of power outages. Supply voltage is monitored to a resolution of 100mV and can be reported on a periodic basis if enabled.

The supply voltage input is reverse polarity protected and is resistant to damage from static and surge.

The Senquip QUAD can be used with a solar panel as a source of power. When used with solar, an internal LiPo backs the device up overnight and during cloudy weather. When running on solar, the panel needs to be able to collect enough energy during sunlight hours to power the device through the night and on cloudy days. Keep in mind that solar panels will tend to get dusty and so should be over-rated to avoid regular maintenance. A typical 12V solar panel used to power the Senquip QUAD along with it's specifications is shown below:

Figure 3.1. Typical Senquip QUAD solar panel

Parameter	Specification
Maximum power	10W
Voltage at maximum power	17V
Current at maximum power	0.56A
Open-circuit voltage	21.6V
Short-circuit current	0.68A

Width	357mm
Height	302mm

The above solar panel was tested with a Senquip QUAD measuring and reporting 2 input voltages, ambient temperature, ambient pressure and thermocouple temperature at an interval of 5 minutes. To conserve energy in what was a fixed location test, GPS location was measured every 20 base intervals or 100 minutes. The results were transmitted over 4G LTE or Wi-Fi at 5 minute intervals. The solar panel was sufficient to power the Senquip QUAD.

3.2 Internal rechargeable battery

An Internal 3.7V, 1800mAh rechargeable Lithium Ion Polymer (LiPo) battery is charged from system power, making the device ideal in applications where power is intermittent such as solar. The LiPo battery can be fully recharged within 4 hours of system power being connected.

If the internal LiPo has been allowed to completely discharge; when power is first applied to a Senquip QUAD, the battery will go into a pre-charge mode where the battery is charged to a minimum level before the device starts operating. Pre-charge mode is identified by a slow flash on the green LED with the orange LED off.

An internal protection circuits prevent damage to the LiPo battery in the event of a short circuit or due to excessive discharge. A temperature monitoring circuit terminates LiPo battery charging at temperatures below 0 °C and above 45°C. It is recommended that the LiPo battery be replaced after three years of use or more regularly if the device routinely operates in extended temperatures. The LiPo battery should only be replaced by a Senquip replacement part and should only be installed by a suitably trained technician.

System voltage which is closely related to the LiPo battery voltage is monitored to a resolution of 100mV and is reported at the base interval.

State	AA Batteries	External Power	Comment
LiPo charge threshold	3.7V	4.108	The voltage below which a charge cycle is initiated
LiPo precharge voltage threshold	3.6V	3.6V	Slow flash on green LED, device not operational below this value
LiPo charging voltage	4.208V	4.208V	
LiPo charging current	150mA	300mA	
LiPo charge current termination	128mA	128mA	Charge terminates when charge current below 128mA and battery voltage is above the charge threshold
System shutdown	3.6V	3.6V	Device enters freight mode
Minimum input voltage for charging	4.1V	10V	
Maximum current from charge source	150mA	500mA	Not suitable for Lithium-thionyl Chloride batteries
Safety timer	8 hours	8 hours	Time after which charging will cease
Charge temperature range	0 to 45°C	0 to 45°C	Charging will terminate outside of this range
Operating temperature range	-20 to 80°C	-20 to 80°C	Charging will terminate outside of this range

3.3 Power consumption

The Senquip QUAD has been designed to be suitable for use in applications where permanent power is not available and solar and other sources of intermittent power are the only source of energy. Factors affecting power consumption include the rate at which sensor measurements are made, the number of transmissions of measured data and which internal and external sensors that are connected.

Broadly, the state of the Senquip QUAD can be divided into three modes: sleep, measurement and transmission. Sleep mode is by far the lowest power state where most internal sensors are turned off and the device is waiting for the next measurement period. During a measurement period, the sensors are turned on and power consumption increases dramatically. The actual power consumed during a measurement phase depends on the power requirements of connected sensors and the duration for which they are turned on. For instance, a 4-20mA pressure sensor will, by default, draw between 4mA and 20mA of current when turned on. The sensor will clearly use less energy when measuring 4mA than when measuring 20mA. Transmission is the most energy intense operation performed by the Senquip QUAD. During transmission, the Wi-Fi and or 4G LTE radios are turned on and data is transmitted. Limiting the length of radio transmissions has a significant impact on energy consumed.

The following strategies can be used to limit power consumption:

- Limit the rate at which measurements are taken - if the parameter being measured changes slowly, then measuring it regularly will consume additional energy without a benefit.
- Turn off sensors that are not required - the Senquip QUAD contains a rich set of internal sensors. If for example, the GNSS is not required, turn it off.
- Choose external sensors carefully - a 4-20mA sensor may use more energy than a voltage output sensor.
- Limit the number of daily transmissions - consider only transmitting data when warning and alarm conditions are breached.
- Ensure that the device is placed in a position where 4G LTE, Wi-Fi, and GNSS reception is optimal. Far more current is consumed when transmitting and receiving in a poor signal environment.

Measured sleep, measurement, and transmission current is given in the table below. The measurements in the table represent current flowing from the internal LiPo battery at 3.5V, with external power to the device removed. Except where stated, the GNSS is assumed off. Actual values will depend on the power source, selected measurements, battery charge state, distance from Wi-Fi or 4G LTE source and temperature.

Mode	Current	Time
Sleep	65uA	Up to 24 hours
Measurement (no external sensors, GPS off)	40mA	0.5s
Measurement (no external sensors, GPS cold start)	70mA	54s
Transmit (WiFi from sleep)	97mA	8s
Transmit (4G LTE from sleep)	120mA	20s

3.4 Freight mode

When shipping a Senquip QUAD, it is important that the device is placed in freight mode. In freight mode, the device is put into sleep mode to reduce battery drain to the minimum, and all transmitting devices are turned off. The Senquip QUAD will exit freight mode when it detects that power has been

re-connected.

To enter freight mode access the device webserver by pressing the setup button or directly from a browser if the webserver is always on. From the webserver, chose the admin link and perform the steps below:

1. Disconnect all wires including the power input.
2. Press the 'Enter Freight Mode' button below.
3. Wait 5 seconds, then check the Status and Network lights remain off.
4. Confirm freight mode has been entered by pressing the *Reset* button; there should be no response from the device.

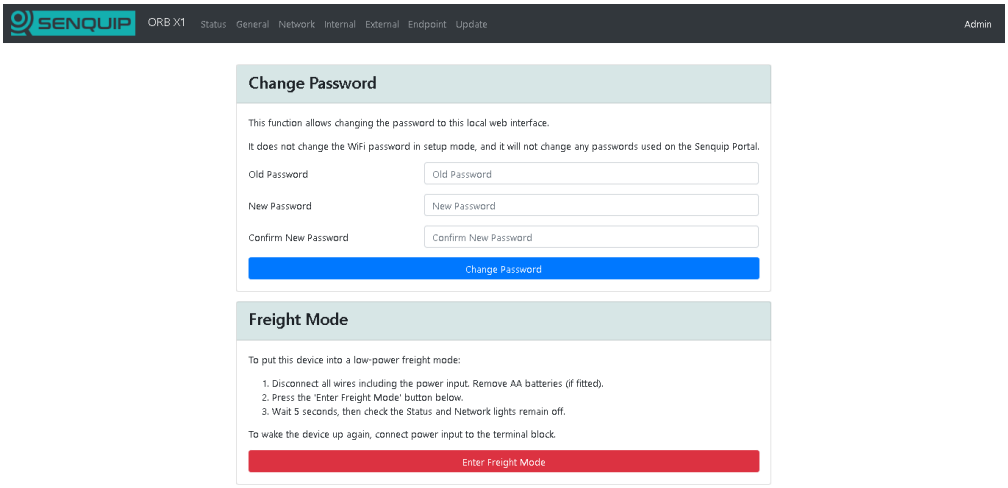

Figure 3.2. Entering freight mode

Note A shortcut is provided where pressing the *Setup* button three times, when in setup mode, will cause the Senquip QUAD to enter freight mode. Confirm freight mode has been entered by pressing the *Reset* button.

General Setup

4.1 Measurement and transmit intervals

The Senquip QUAD can be configured to take periodic measurements and then to transmit those measurements at various intervals or on exception. When not measuring or transmitting, the Senquip QUAD will remain in a very low power state, referred to as sleep. For example, a device can be configured to measure temperature at 1 minute intervals, but only to transmit the temperature once an hour or if a warning or alarm level is exceeded (an exception occurs). By allowing a more regular measurement interval and a less frequent transmit interval, the device is able to reduce power consumption by remaining asleep, thereby maximising battery life. In the event of an exception, a more regular transmit rate can be selected.

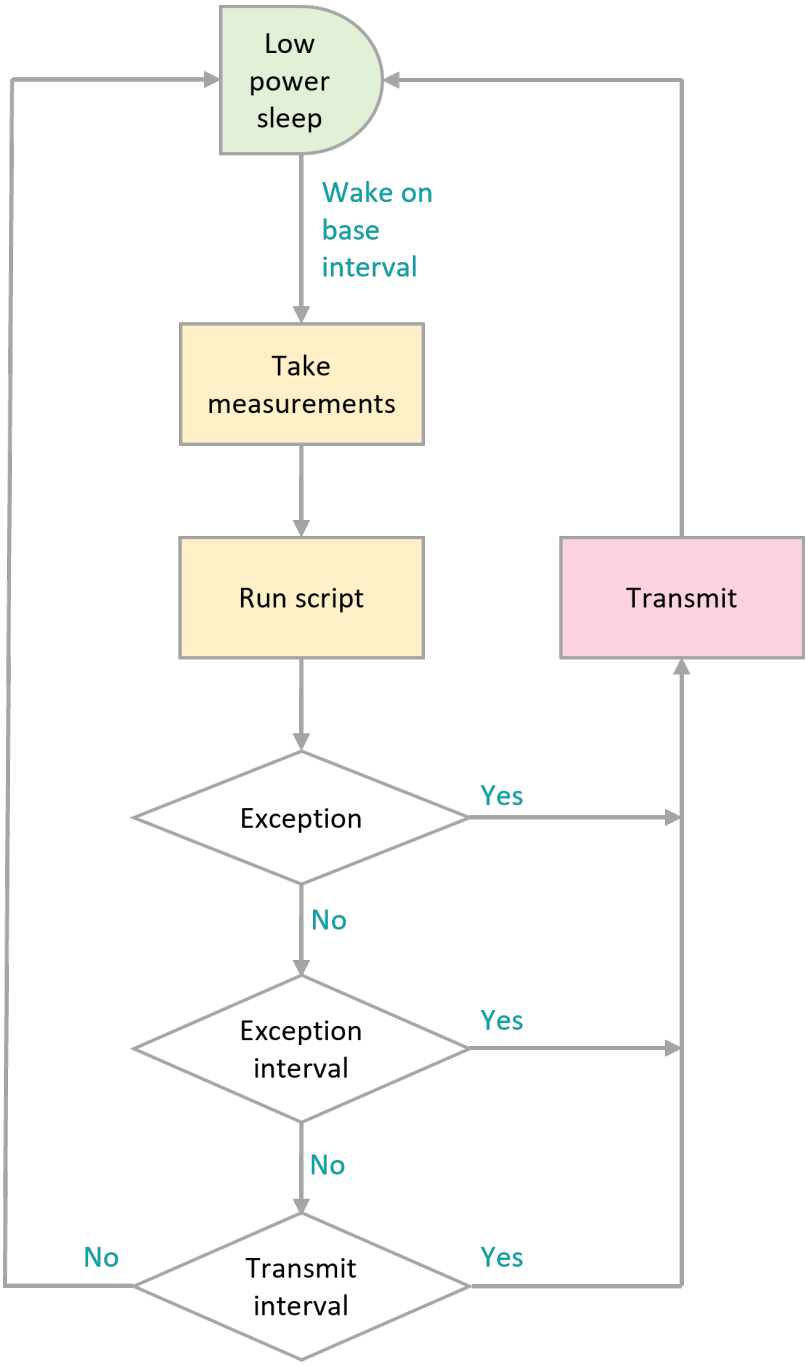

Figure 4.1. Timing flowchart

- Green: Lowest power state; aim to configure the Senquip QUAD to spend maximum time in this state.
- Orange: Moderate power usage; try to reduce the number of times that the Senquip QUAD wakes to measure sensors.
- Pink: Highest power consumption; only transmit data when required.

To allow flexible measurement and transmit intervals, whilst ensuring the lowest possible power consumption, the Senquip QUAD has three global and one per-peripheral measurement interval settings.

Base-Interval The base-interval is the period of time after which the Senquip QUAD will wake from sleep in order to check if there are any measurements to perform or if it is time to transmit the latest measured data. In a system where measurements are required often, the base-interval can be as low as 5 seconds. In systems that are slow to respond, the base interval can be as high as 24 hours. It makes sense to set the base interval as long as possible to enable the device to spend as much time as possible in a low-power sleep state.

Each peripheral, whether internal to the device, or attached to the external interface, can be set to only be measured after a number of base-intervals. If a particular peripheral has the interval setting set to 1, then it will be measured at each base-interval. If the interval is set to 0, then that particular peripheral will be turned off. Each time a measurement is taken, the results will be compared with alert, warning and alarm conditions and if an alert or exception occurs, the results will immediately be transmitted.

Note if a base-interval of less than 10 seconds is specified when the Senquip QUAD is communicating via Wi-Fi or 120 seconds over 4G LTE, the device will remain awake at all times.

Note if the enabled measurements take longer to complete than interval at which they are scheduled, the device will not return to sleep and measurements will be sent as fast as possible. This is most likely where the GPS and serial devices are enabled.

Transmit-Interval The transmit-interval is the time between message transmissions. It is a multiple of the base interval and is set as a number of base-intervals. All enabled measurements will be transmitted at the transmit-interval. For example, if the base-interval is 1 minute and the transmit-interval setting is sixty, then all the latest measurements will be transmitted every 60 minutes.

In cases where the Senquip QUAD is configured to measure more often than to transmit, measured data can be saved and transmitted in batches. It is more efficient to batch messages and transmit less regularly than to send individual measurements. Use this option where power use needs to be minimised but all measured data needs to be retrieved.

Note if during a measurement interval, an exception occurs, the device will immediately transmit the measured data and will switch to the exception interval.

Note if measurement and transmission intervals coincide, measurements will be taken before transmission to ensure the latest values are transmitted.

Exception-Interval If a warning or alarm occurs, the transmit-interval can be shortened in order that measurements are transmitted more often. The exception-interval is a multiple of the base interval and sets the time between message transmissions when an exception is current (warning or alarm). For example, if the base-interval is 1 minute and the transmit-interval setting is sixty, under normal circumstances, measurements will be transmitted every 60 minutes. If the exception-interval setting is 5, then when a warning or alarm condition is current, measurements will be transmitted at 5 minute intervals instead of 60 minute intervals.

Note Only exceptions, which are warnings and alarms will trigger the exception-interval; alert conditions such as exit from a geo-fence will not.

If, on any base interval, a new exception or alert is detected, an immediate transmission will be made regardless of the transmit-interval.

4.2 Power supply

An alert can be generated when the external power source is lost, or the internal LiPo battery is running low. If enabled, the external power loss alert will be triggered as the voltage drops below

9.5V. In order to conserve energy, the Senquip QUAD can be configured to enter hibernate when external power is lost. In this mode, the device will wake on it's usual base interval, but if power is still lost, it will go back to sleep. A number of base intervals that occur before the device enters hibernate can be set. This allows the device to continue operating for a period of time after power is lost. The Senquip QUAD can be set to wake from hibernate if motion is detected by the internal accelerometer or if power is restored. In hibernate mode, a transmission is made once every 6 hours to allow the user to verify that the device is still functional. In the case of the internal LiPo battery being low, this may indicate a faulty, under-rated or dirty solar panel or permanent loss of external power. If the power loss alert is enabled where solar panels are installed, an alert should be expected as clouds move over or the sun sets.

Note If *Device Always On* and *Sleep on Power Loss* are both selected then the Senquip QUAD will remain awake as long as it is powered; the device will sleep when power is removed.

4.3 Settings

A full list of general settings is given in the table below.

Webserver Name	Webserver Item	Function	Default Value	Internal Reference
Device ID	Read only text box	Unique ID associated with the ORB during manufacture.		device.id
Device Model	Read only text box	Model number, in this case X1 followed by either W for the Wifi or G for the GSM model.		device.model
Firmware Version	Read only text box	The verion number of the firmware currently loaded in the ORB.		device.fw
Hardware Revision	Read only text box	The revision of hardware present in the ORB		
Device Name	Text entry box	A name for the ORB that is meaningful to the user.	ORB X1	device.name
Timing				
Base Interval	Text entry box	The time after which the ORB will wakeup to check which measurements need to be taken and if a transmission is scheduled.	Default: 30 sec	device.base_interval
			Min: 5 sec	
			Max: 86400 sec	
Transmit Interval	Text entry box	The number of base intervals after which a transmission is made.	Default: 1	device.transmit_interval
			Min: 1	
			Max: 999999	
Exception Interval	Text entry box	If an exception is current this interval replaces the transmit interval to allow faster updates if required.	Default: 1	device.exception_interval
			Min: 1	
			Max: 999999	

Device Always On	Tick box	If enabled the device will not sleep between Base Intervals and will remain awake. Not recommended for battery powered applications.	Enabled	device.always_on
Batch Transmit	Tick box	Tick this box if messages are to be batched and transmitted together.		
WebServer Always On	Tick box	Keeps the webserver enabled at all times to allow remote connection.		device.web_always_on
Power Input				
Power Loss Alert	Tick box	Enable if an alert is to be sent when the power input drops below a specified limit.	Disabled	device.power.alert.enable
Hibernate on Power Loss	Tick box	If this option is selected, then the ORB will enter hibernate mode when power is lost and will only transmit every 6 hours.	Disabled	device.power.sleep
Hibernate Delay Intervals	Text entry box	Enter the number of base intervals after power has been lost before the ORB enters hibernate	5	
Count Hours	Tick box	Counts the number of hours that the ORB is powered. Typically used as an hour meter.	Disabled	
AA Battery				
AA Battery Low Alert	Tick box	Enable if an alert is to be sent when the AA battery level drops below a specified limit.	Disabled	device.batt.alert.enable
Threshold	Text entry box	The voltage at which an alert is raised.	Default: 4.8V	device.batt.alert.threshold
			Min: 0V	
			Max: 100V	
Lipo Battery				
Lipo Battery Low Alert	Tick box	Enable if an alert is to be sent when the Lipo battery level drops below a specified limit.	Disabled	device.lipo.alert.enable
Threshold	Text entry box	The voltage at which an alert is	Default: 3.4	device.lipo.alert.threshold

Internal Sensors

5.1 Light sensor

The Senquip QUAD is equipped with an internal light sensor that is used to activate the setup functions when the lid is opened and to detect tamper attempts. The light sensor is sampled on a regular basis and does not have an associated measurement interval.

An alert can be generated when the lid is opened and the device detects light.

Note A tamper alert, if enabled will be triggered by a tamper attempt or an authorised entry to change settings.

A full list of light sensor settings is given in the table at the end of the chapter.

5.2 Accelerometer

The Senquip QUAD has an integrated 3-axis accelerometer. The accelerometer allows for angle measurement, movement detection, harsh-usage monitoring and utilisation calculation. To provide more accurate measurement for pitch, roll and angle measurement, each time the accelerometer is measured, 10 samples will be taken at 1 msec intervals and the average will be returned as the measured value. Pitch, roll and angle will be calculated from the average acceleration.

Raw accelerometer data in the X (through the lid), Y (horizontally through the device) and Z (vertically through the device) are available and are delivered in G's. These values can be useful, for instance where an incident is being re-created from force data.

Note Incident recreation using force data requires high speed sampling. Please contact Senquip to discuss your application.

When looking at the front cover, positive pitch is described as the top of the Senquip QUAD tilting towards the observer. In the same scenario, negative pitch is described as the top of the cover moving away from the observer.

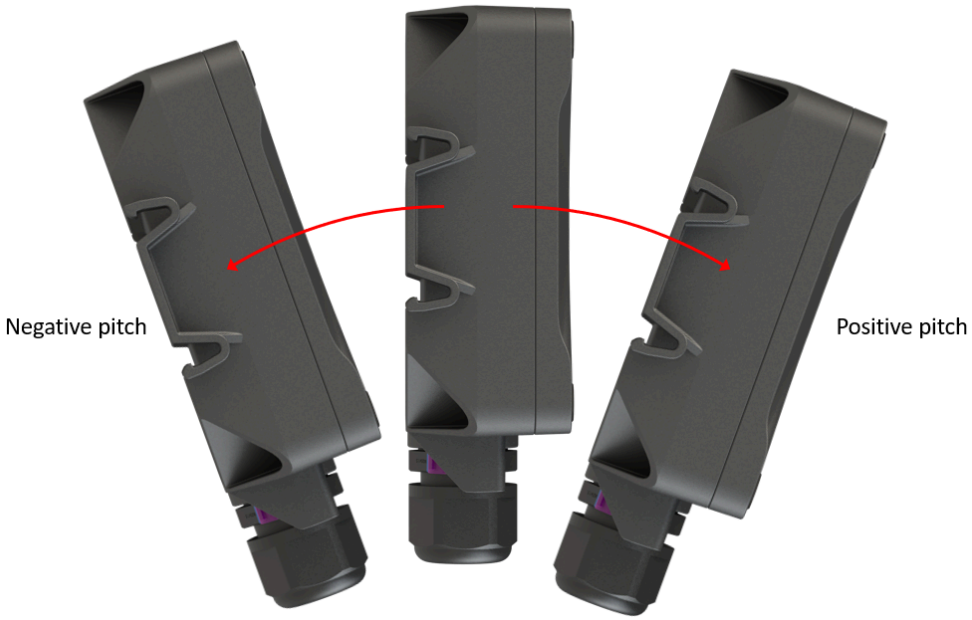

Figure 5.1. Definition of pitch

When looking at the front cover, positive roll is described as the top of the Senquip QUAD rotating towards the right. In the same scenario, negative roll is described as the top of the cover rotating towards the left.

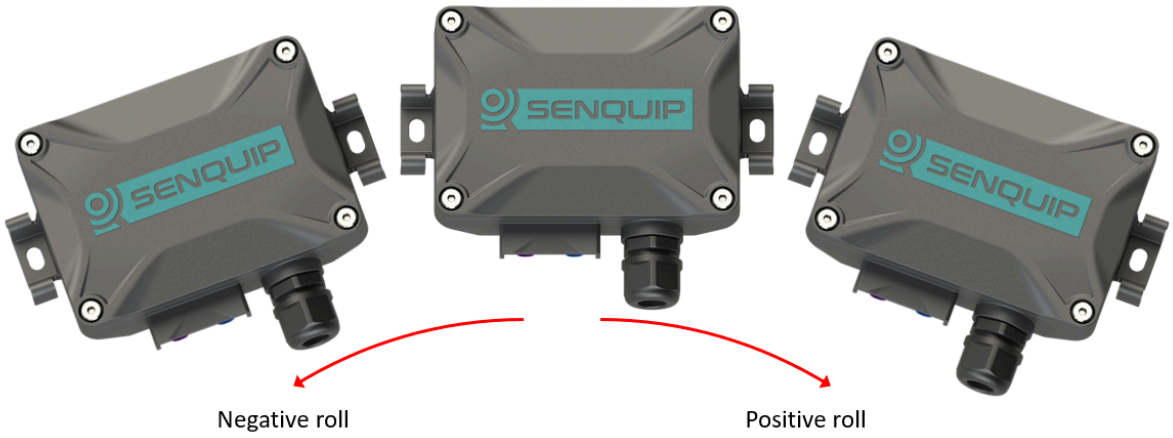

Figure 5.2. Definition of roll

Pitch and roll are useful in applications where objects to which the Senquip QUAD is attached have a definite front, back, left and right; for instance a vehicle. For objects like a pole, the user may be more interested in the angle of the pole to vertical. In these applications, the tilt may be more useful than pitch or roll.

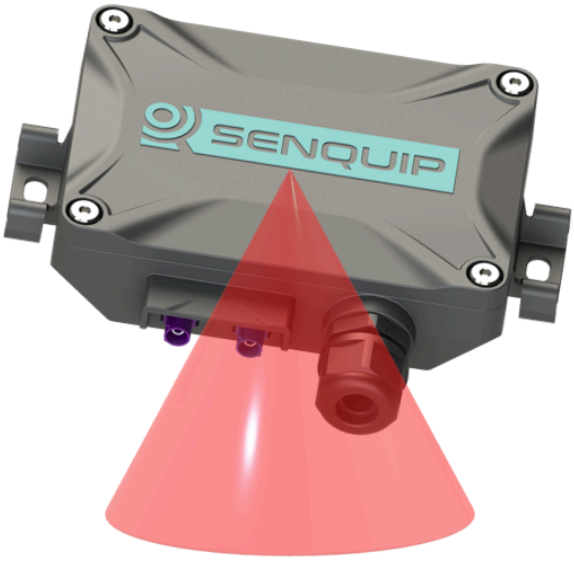

Figure 5.3. Definition of tilt

5.2.1 Specification

Parameter	Specification
G-force range	+- 16G
Resolution	1mG
Sensitivity change vs temperature	0.1% per°C
Typical zero-g level offset accuracy	+- 40mG
Tilt resolution	0.1 deg
Tilt accuracy (0-45 deg)	1.0 deg
Tilt accuracy (45-90 deg)	2.0 deg

5.2.2 Settings

Accelerometer measurements can be scheduled as a multiple of the base-interval. The fastest possible measurement rate is achieved by setting the *interval* to 1 in which case measurements will occur on every base interval. To reduce power consumption, the measurement rate can be turned down by increasing the *interval*.

Warning and *alarm* thresholds for pitch, roll and angle can be enabled. Once enabled, each time a measurement is completed, the returned value will be compared with minimum and maximum *warning* and *alarm* thresholds. If a *warning* or *alarm* level is breached, a message will immediately be transmitted. As long as the warning or alarm condition persists, messages will be transmitted at the exception-interval rather than the transmit-interval. *Hysteresis* can be specified in 1 degree increments, to prevent multiple alarms in the presence of vibration.

The accelerometer is able to detect *motion* and *shocks* due to harsh usage even during sleep. If *motion* or *shock* monitoring is enabled and either of those events occurs, a flag will be set. Event flags are checked at each base-interval and if one exists, an alert message can be scheduled to be sent at that time. The *threshold* as well as *time* for which an activity must be present can be set for both *motion* and *shock* monitoring.

Note Pitch and roll warning and alarm levels can be positive or negative. Angle warning and alarms can only be positive.

Vibration can be used as a trigger to count hours. This may be useful where the number of hours that an engine is running needs to be calculated.

A full list of accelerometer settings is given in the table at the end of the chapter.

5.3 Pressure sensor

The Senquip QUAD contains provision for a built-in pressure sensor for measuring atmospheric pressure and short term height change. Although the enclosure is rated to IPX7, an integrated moisture resistant gore-vent allows internal and external pressure to equalise, meaning accurate atmospheric pressure can be measured.

Note The pressure sensor is not fitted by default, contact Senquip for ordering options.

5.3.1 Specification

Parameter	Specification
Pressure range	300 - 1100 hPa
Temperature range	-40 to 85°C
Absolute accuracy (0 to 65 deg C)	+-1hPa
Relative accuracy (25 to 40 deg C)	+-0.12hPa, equivalent to +-1m altitude
Absolute maximum pressure	20,000hPa

5.3.2 Settings

Measurements can be scheduled as a multiple of the base-interval. The fastest possible measurement rate is achieved by setting the *interval* to 1 in which case measurements will occur on every base interval. To reduce power consumption, the measurement rate can be turned down by increasing the *interval*.

Warning and *alarm* thresholds for pressure can be enabled. Once enabled, each time a measurement is completed, the returned value will be compared with minimum and maximum *warning* and *alarm* thresholds. If a warning or alarm level is breached, a message will immediately be transmitted. As long as the warning or alarm condition persists, messages will be transmitted at the exception-interval rather than the transmit-interval. *Hysteresis* can be specified in 1 kPa increments, to prevent multiple alarms in the presence of fluctuating pressure, for instance due to wind.

A full list of pressure sensor settings is given in the table at the end of the chapter.

5.4 Magnetic switch

The Senquip QUAD contains a built-in hall-effect sensor that acts as a magnetic switch. When the switch detects a magnet, the Senquip QUAD can be made to enter setup mode, wakeup, or trigger a function in a script.

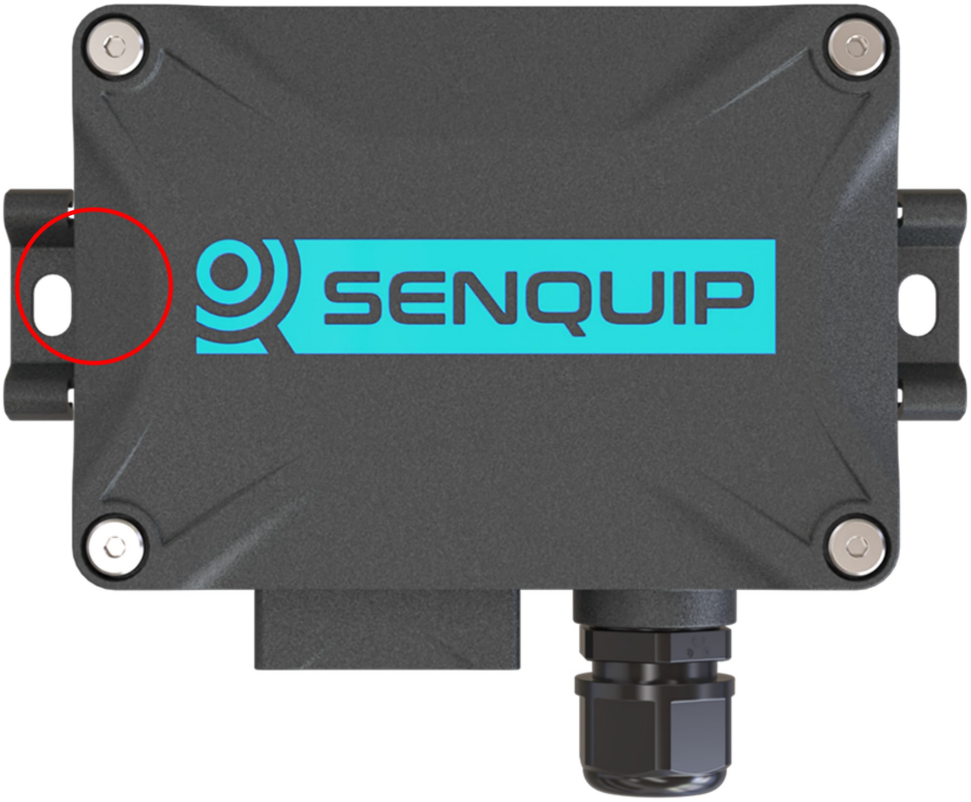

Figure 5.4. Location of magnetic switch

5.4.1 Settings

Three actions are available when the magnetic switch is activated.

- *Setup*: Put the device into setup mode. Identical to pressing the Setup button. If the device is asleep, it will wake and enter Setup Mode.
- *Wake*: Wake the device up and perform a measurement cycle. There is no action if device is already awake.
- *Trigger*: Wake the device if asleep. Trigger TP0 before first measurement cycle. TP0 should be handled in a script.
- *All*: All actions above. Wake device if asleep. Enter setup mode. Trigger TP0 before first measurement cycle.

5.5 Temperature sensor

An integrated temperature sensor allows for measurement of ambient temperature. Please be aware that the temperature sensor will measure the temperature inside the Senquip QUAD enclosure; this temperature can be subject to fluctuations, for example when the internal lithium ion battery is charging and so the environment within the device heats up. For accurate external temperature measurement or to measure a wider range of temperatures, use an external temperature sensor.

5.5.1 Specification

Parameter	Specification
Measurement range	-40 - 85°C
Resolution	0.01 deg°C
Absolute accuracy (25°C)	+-0.5 deg°C
Absolute accuracy (0 - 65°C)	+-1 deg°C

5.5.2 Settings

Measurements can be scheduled as a multiple of the base-interval. The fastest possible measurement rate is achieved by setting the *interval* to 1 in which case measurements will occur on every base interval. To reduce power consumption, the measurement rate can be turned down by increasing the *interval*.

Warning and *alarm* thresholds for ambient temperature can be enabled. Once enabled, each time a measurement is completed, the returned value will be compared with minimum and maximum *warning* and *alarm* thresholds. If a *warning* or *alarm* level is breached, a message will immediately be transmitted. As long as the warning or alarm condition persists, messages will be transmitted at the exception-interval rather than the transmit-interval. *Hysteresis* can be specified in 1°C increments, to prevent multiple alarms in the presence of fluctuating temperature.

A full list of temperature sensor settings is given in the table at the end of the chapter.

5.6 GPS

Models of the Senquip QUAD that have 4G LTE connectivity also have an integrated Global Navigation Satellite System (GNSS). The GNSS receiver, allows for position and speed based reporting. The internal GNSS received uses GPS, GLONASS, BeiDou and Galileo satellites to ensure high accuracy measurement and fast time to first fix. Data available from the GPS includes:

- Latitude, longitude and altitude
- Speed (km/h) and bearing
- Date and time
- Number satellites being tracked

In order to utilise GNSS, the antenna needs to be mounted with clear visibility of the sky. Plastic and fibreglass roof sheeting will have a minimal effect on GNSS performance whereas reinforced concrete and metal roofs will render the GNSS inoperable. Good GNSS signal quality will result in quicker time to position acquisition and lower power use.

5.6.1 Specification

Parameter	Specification
Time to first fix from power up	Typically 60 seconds
Position update rate	Maximum 1Hz
Horizontal position accuracy	Typically +-5m (<2.5m CEP-50)
Vertical position accuracy	Typically +-20m
Horizontal speed accuracy	1km/h

5.6.2 Settings

Measurements can be scheduled as a multiple of the base-interval. The fastest possible measurement rate is achieved by setting the *interval* to 1 in which case measurements will occur on every base interval. To reduce power consumption, the measurement rate can be turned down by increasing the *interval*. The GNSS is a high power peripheral and so use should be limited when running on battery power.

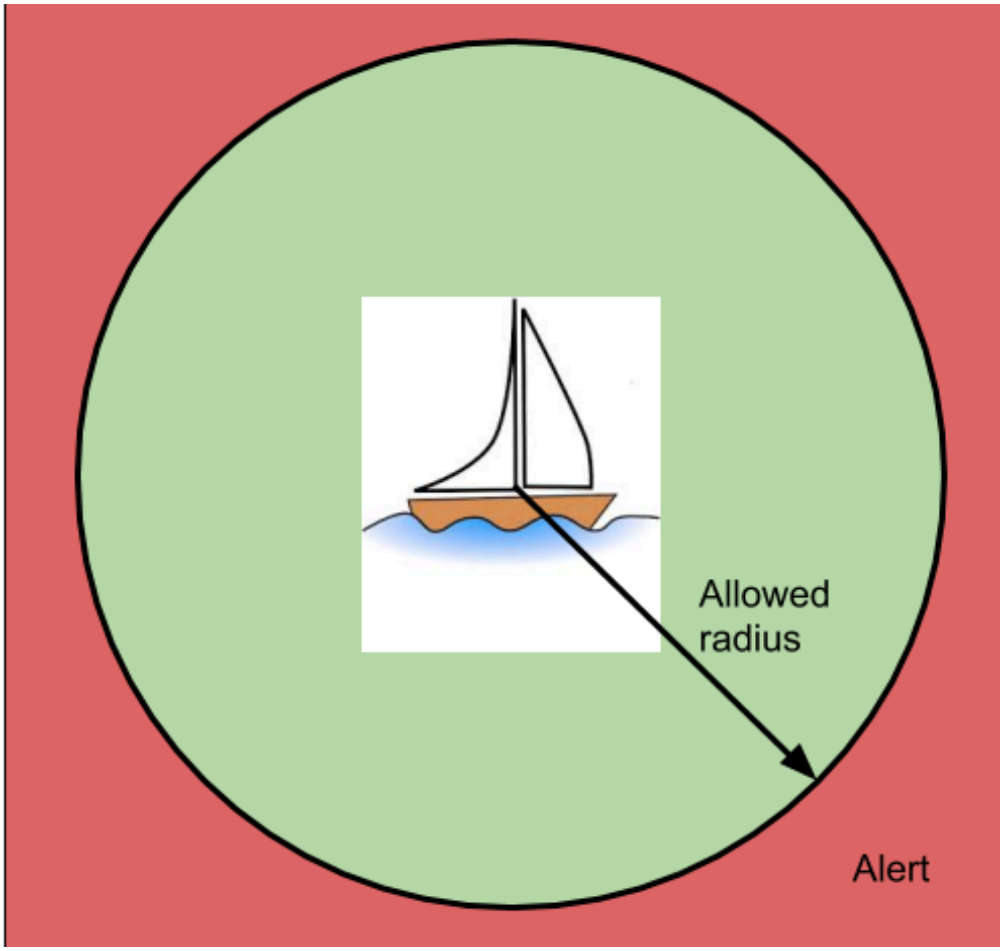

Figure 5.5. GPS alert parameters

The GNSS can create an *alert* based on position and speed. A known position (*expected latitude* and *expected longitude*) can be specified and if the device moves a particular *radius* from that point, an alert can be raised. *Hysteresis* can be specified in 1 meter increments to prevent multiple alerts, for instance as a boat swings on a mooring near the edge of the allowed radius. Likewise, a maximum *speed* can be specified and if the device exceeds that speed, an alert will also be raised. Speed *hysteresis* can be specified in 1km/h increments, to prevent multiple alerts as the speed fluctuates at the alert point. The time that GNSS speed exceeds 2km/h can be counted and used to calculate machine utilisation.

Note In the example above, the Senquip QUAD could also report bilge water level, solar battery voltage and a host of other parameters associated with the yacht.

A full list of GNSS settings is given in the table at the end of the chapter.

5.7 Bluetooth interface

The Senquip QUAD has a Bluetooth peripheral that can transmit and receive Bluetooth Low Energy (BLE) advertising packets. BLE beacons typically use the advertising packets to communicate measured data such as temperatures, voltages, movement, and battery voltage. BLE tags are a special type of beacon that typically only contain identification information and are used to locate items. BLE beacons send advertising messages at different rates. Some report every second and some may be every minute or more. Battery operated BLE devices tend to send at lower rates to save power. Some BLE device are smart and will slow their send rate if they are not being used. A tire pressure monitoring device may stop sending if the tire is not rotating. Typical protocols used in advertising packets include Eddystone and iBeacon. The Senquip QUAD supports both.

The BLE beacons from ELA shown below enable identification, and measurement of temperature, humidity, voltage, switch position, and more.

Figure 5.6. Example BLE beacons from ELA

The Senquip QUAD will report the beacon address, data, and the strength of the received signal.

- The address (or identifier) is unique and allows individual tags to be recognised.
- The data may contain battery voltage, temperature, humidity, or any other data being conveyed by the beacon.
- The receive signal strength (RSSI) gives an indication of how strong the signal from the beacon is.

For details on using the Senquip QUAD as a BLE beacon to transmit custom advertising packets, please refer to the Senquip Scripting Guide.

Note The BLE module and Wi-Fi module share a common radio. BLE operation will work best when

the Senquip QUAD is operated using a cellular network rather than Wi-Fi.

5.7.1 Specification

Parameter	Specification
Bluetooth version	4.2

5.7.2 Settings

Measurements can be scheduled as a multiple of the base-interval. The fastest possible measurement rate is achieved by setting the *interval* to 1 in which case the Bluetooth peripheral will be sampled on every base interval. To reduce power consumption, the measurement rate can be turned down by increasing the *interval*.

When active, the Bluetooth peripheral will scan for all advertising packets. In a typical environment, phones, computers, and other devices are all advertising. The Senquip QUAD Bluetooth peripheral could easily report a dozen Bluetooth devices even when the one you are searching for is off. A filter allows only the required Bluetooth devices to be reported by filling in the *Address Capture List*. Required addresses should be entered in hexadecimal and should be separated by commas. When the Senquip QUAD wakes for the next measurement interval, the Bluetooth peripheral will be sampled until all the messages listed have been found or the *Capture Time* has been reached. If multiple messages with the same identifier are required in a single measurement interval, place a * followed by the number of messages of that identifier to be returned after the identifier in the list. For example: 98588A10375E*4, 98588a103777, 98588a103888*10 will return 98588A10375E four times, 98588a103777 once and 98588a103888 ten times. Leave the *ID Capture List* blank to receive all messages.

The *Capture Time* setting can be used to set a timeout after which the Bluetooth peripheral will stop listening, allowing the device to transmit received messages and return to sleep. *Capture-time* can be used as a mechanism to allow the Senquip QUAD to sample the environment for devices for a defined time-period.

A full list of Bluetooth settings is given in the table at the end of this chapter.

5.8 Internal sensor settings

A full list of settings for internal sensors is given in the table below.

Name	Item	Function	Range	Unit	Internal Reference
Light Sensor					
Name	text	A name for the light sensor that is meaningful to the user.	25 chars		tamper.name
Tamper Alert	boolean	This parameter determines if an alert is generated when the light sensor detects light or not.			tamper.enable
Ambient Temperature					
Name	text	A name for the input that is meaningful to the user.	25 chars		ambient.name
Interval	integer	The number of base intervals after which the temperature is sampled. A value of 1 means that the input is collected every base interval. Set to 0 to disable.	0 to 10000		ambient.interval

Hysteresis	decimal	The amount by which the measured value has to drop below the threshold to re-enable the alert after an event.	0 to 100	°C	ambient.hysteresis
Warning	text	Warning thresholds. Refer to user guide.	-40 to 100	°C	ambient.warning
Alarm	text	Alarm thresholds. Refer to user guide.	-40 to 100	°C	ambient.alarm
Accelerometer					
Name	text	A name for the input that is meaningful to the user.	25 chars		accel.name
Interval	integer	The number of base intervals after which the accelerometer is sampled. A value of 1 means that the input is collected every base interval. Set to 0 to disable.	0 to 10000		accel.interval
Output XYZ Vectors	boolean	Send X,Y,Z gravity vectors in data output.			accel.outputxyz
Hysteresis	decimal	The amount by which the pitch, roll or angle has to exceed a threshold before triggering alarms or warnings.	0 to 20	Degrees	accel.hysteresis
Pitch Warning	text	Warning thresholds. Refer to user guide.	-90 to 90	Degrees	accel.pitch.warning
Pitch Alarm	text	Alarm thresholds. Refer to user guide.	-90 to 90	Degrees	accel.pitch.alarm
Roll Warning	text	Warning thresholds. Refer to user guide.	-90 to 90	Degrees	accel.roll.warning
Roll Alarm	text	Alarm thresholds. Refer to user guide.	-90 to 90	Degrees	accel.roll.alarm
Angle Warning	text	Warning thresholds. Refer to user guide.	0 to 90	Degrees	accel.angle.warning
Angle Alarm	text	Alarm thresholds. Refer to user guide.	0 to 90	Degrees	accel.angle.alarm
Motion Warning	text	Warning thresholds. Refer to user guide.	0 to 5000	milli-g	accel.motion.warning
Motion Alarm	text	Alarm thresholds. Refer to user guide.	0 to 5000	milli-g	accel.motion.alarm
Wake from Hibernate	boolean	The high warning motion threshold is used to wake the device when hibernating.			accel.motion.wake_from_hiber
Motion Wake Threshold	decimal	The motion threshold above which the device will wake from hibernation.	1 to 2000	milli-g	accel.motion.wake_threshold
Count Motion Hours	boolean	Counts the number of hours the device exceeds the Motion Wake Threshold. Typically used as an machinery work vs idle hour meter.			accel.motion.count_hours
GPS					
Name	text	A name for the GPS signal that is meaningful to the user.	25 chars		gps.name
Interval	integer	The number of base intervals after which the gps is sampled. A value of 1 means that the input is collected every base interval. Set to 0 to disable.	0 to 10000		gps.interval

Max Time	integer	Maximum time the device will wait for a valid GPS fix.	0 to 3600	Seconds	gps.maxtime
Position					
Position Alert	boolean	Sets whether a change in position generates an alert.			gps.position.alert.enable
Radius	integer	An alert will be raised if the device moves further than this value from the expected position.	1 to 10000	Meters	gps.position.alert.radius
Hysteresis	integer	Once the alert is active or inactive, the radius must change by this value to change the alert state.	1 to 10000	Meters	gps.position.alert.hysteresis
Expected Latitude	decimal	Latitude at which the device is expected to be.	-90 to 90	Degrees	gps.position.alert.lat
Expected Longitude	decimal	Longitude at which the device is expected to be.	-180 to 180	Degrees	gps.position.alert.lon
Speed					
Count Movement Hours	boolean	Counts the number of hours the device is moving according to the GPS speed.			gps.speed.count_hours
Speed Alert	boolean	Sets whether a change in speed generates an alert.			gps.speed.alert.enable
Threshold	integer	An alert will be raised if the device's speed goes above this threshold.	1 to 1000	km/h	gps.speed.alert.threshold
Hysteresis	integer	Once the alert is active or inactive, the speed must change by this value to change the alert state.	1 to 1000	km/h	gps.speed.alert.hysteresis
Bluetooth					
Name	text	A name that is meaningful to the user.	25 chars		ble.name
Interval	integer	The number of base intervals after which the Bluetooth module is turned on. Set to 0 to disable.	0 to 10000		ble.interval
Scan Time	integer	The device will capture matching messages for this length of time.		Seconds	ble.capture_time
Address Capture List	text	List of adresses to be captured in HEX format, separated by a comma. Leave blank to capture all.	200 chars		ble.id_list
Send Raw Data	boolean	If ticked, all captured messages will be added to the data message.			

External Sensors

6.1 Inputs and Outputs

The Senquip QUAD has 5 multifunction Input/Outputs that can be individually configured.

Pin	Channel
3	IO 1
4	IO 2
5	IO 3
6	IO 4
7	IO 5

Each of the 5 IO can measure:

- analog voltages,
- currents into and out of the terminals,
- frequencies,
- pulses,
- duty cycle,
- digital ON or OFF state.

Each measurement can be calibrated and alerts of type info, alert, warning, and alarm can be set.

The IO can also be used as outputs and can be switched to:

- OFF - high impedance,
- Vin - connected via a switch to Vin,
- GND - connected via a switch to GND,
- Vset - connected to an internal configurable voltage source,
- PULLUP - an internal pullup resistor is enabled.

Vset is an internal voltage source that can be configured in *General IO* settings to be between 5V and 25V. Vset is typically used to power external sensors. Vset is backed up by the internal LiPo battery and so will continue to operate if power to the device is intermittent, for instance if powered by solar. The setting for Vset voltage is used to control the feedback loop of a boost converter acording according to a set of characterisation data. The voltage that appears on the output may vary by approximately 100mV.

A short dead-time is inserted when switching between IO states to prevent high current flows during

the transition from Vin and Vset to ground and ground to Vin and Vset states.

The input and output functionality are independant and can be enabled simultaneously. You can for instance switch an output to Vin, measure the voltage on the output to confirm and measure the current flowing into the output.

Each IO pin can supply up to 100mA from either Vin or Vset and can sink 250mA to ground. The IO are able to switch inductive loads such as relays; it is recommended that flyback diodes always be used with inductive loads. The inputs are protected against over-voltage events to 85V and against static discharge.

Note Vset can provide a maximum of 100mA across all IO pins.

All parameters are measured at the same time, so for instance an input can report measuring 15V with a 20mA current flowing. Settings are available to limit which of the measured parameters are transmitted at the end of each measurement cycle. Limit the data sent at the end of a measurement cycle by only selecting the measurement types that you require.

A simplified internal architecture of the IO module is shown below.

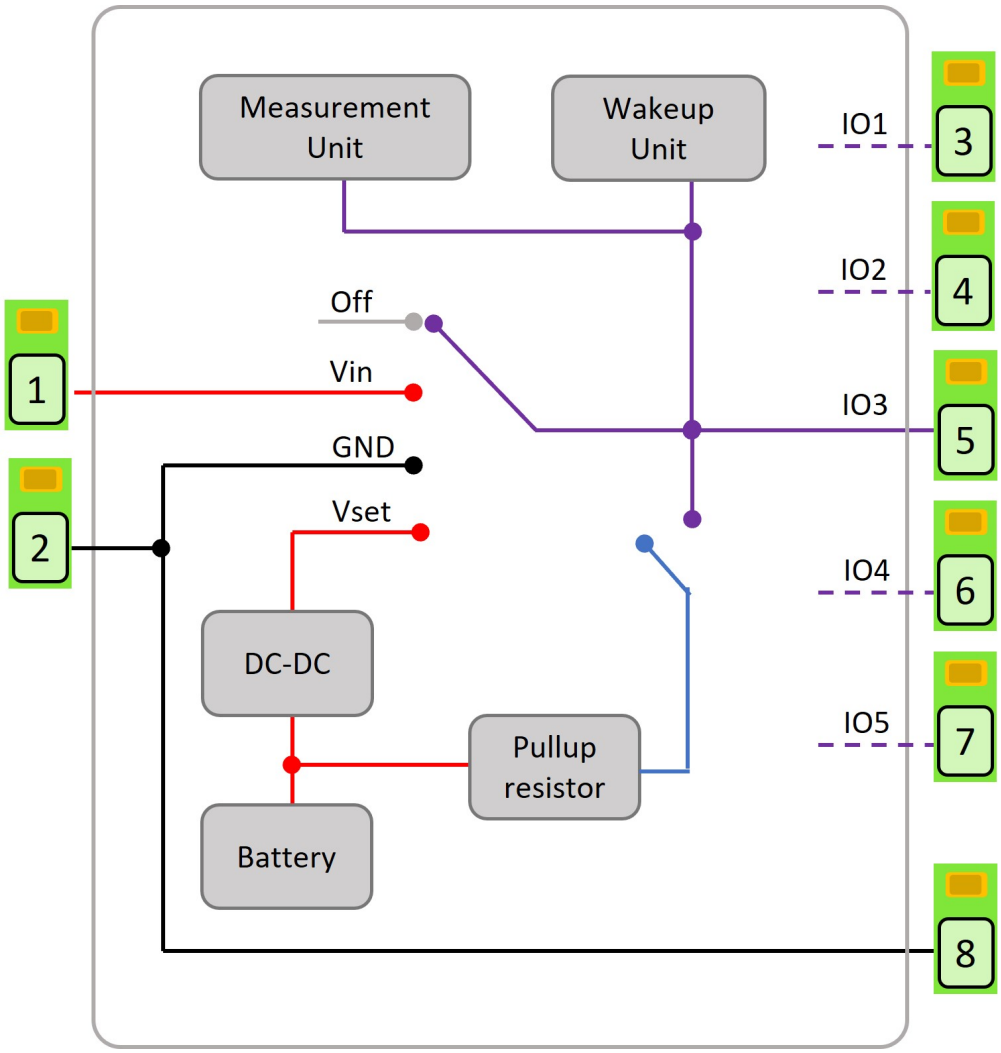

Figure 6.1. Simplified internal IO architecture

Each IO can be configured to cause the device to enter hibernate mode on a high to low voltage level change on the associated pin. Likewise, the device can be made to wake from hibernate on a low to high transition on the associated pin. If these functions are selected, the pullup associated with that