IO channel will be enabled.

6.1.1 Powering external devices

IO on the Senquip QUAD can be used to power and provide signals to external sensors, relays, lights, buzzers, and other devices. To permanently power an external device by supplying it with a voltage, set the IO *Default State* to *VIN* or *VSET* in which case the connected device will be permanently powered. To power a device by connecting it to ground, select *GND* as the *Default State*. The default state will continue to be applied between measurement cycles.

Alternatively, the IO can made to switch power on only at a measurement cycle, and for a defined period. To enable switched power, set the default for the IO to *OFF* and enable the *Measurement State* as *VIN* or *VSET*. Set the *Measurement Time* as the time for which the externally connected sensor must be powered before being measured. This time is typically the boot time for a sensor. In this case, Vin or Vset will only be made available on the IO during a measurement interval and for the time specified. This is the preferred method for installs that are solar powered or have intermittent power. Measurement of CAN, RS232, and RS485 are delayed by the longest of all specified measurement times to allow for the case where an IO is being used to power a serially connected device.

The figure below shows an RS232 sensor that is powered by IO5 and measured on the RS232 port and a relay that is energised by setting an IO to ground.

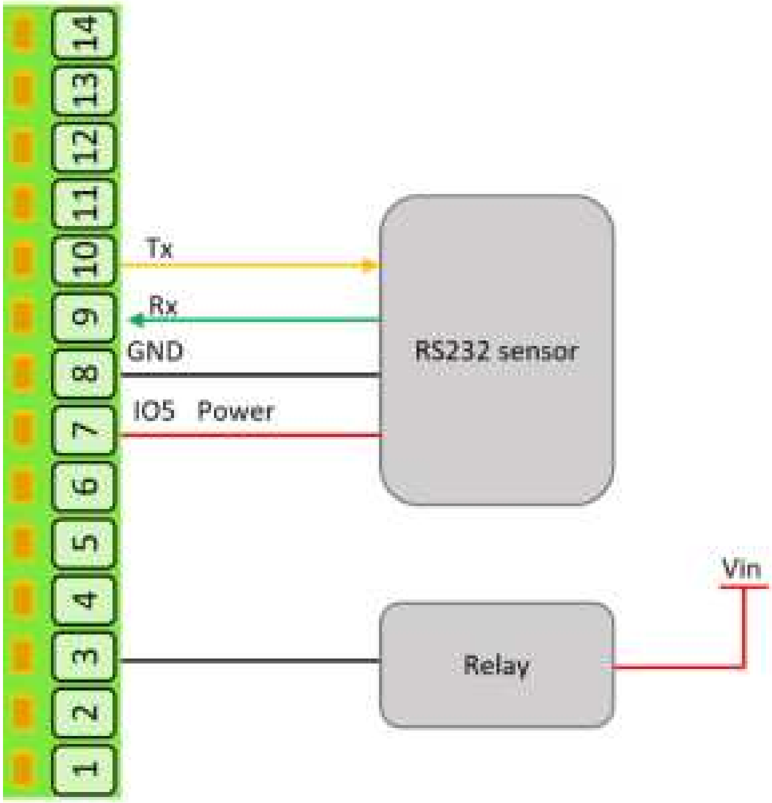


Figure 6.2. Powering external devices on an IO

Note Where switched power is used to power a sensor that is read by another input, the *Measurement Time* specified for the IO and the input must be the same to ensure that the sensor is powered when measured.

For advanced users, the state of an IO can be switched from within a script. This allows for the control of complex sensors and systems and precise timing. If changes to the IO are made from within a script, the default will only be re-applied the next time the device boots. Output states are held when the Senquip QUAD enters sleep.

6.1.2 Current Measurement

Loop powered (2-wire) and externally powered (3-wire) 4-20mA devices can be used with the Senquip QUAD.

For 2-wire devices, Vin or Vset power can be supplied by an IO and the current drawn measured by that same IO. A typical 2-wire install is shown in the figure below.

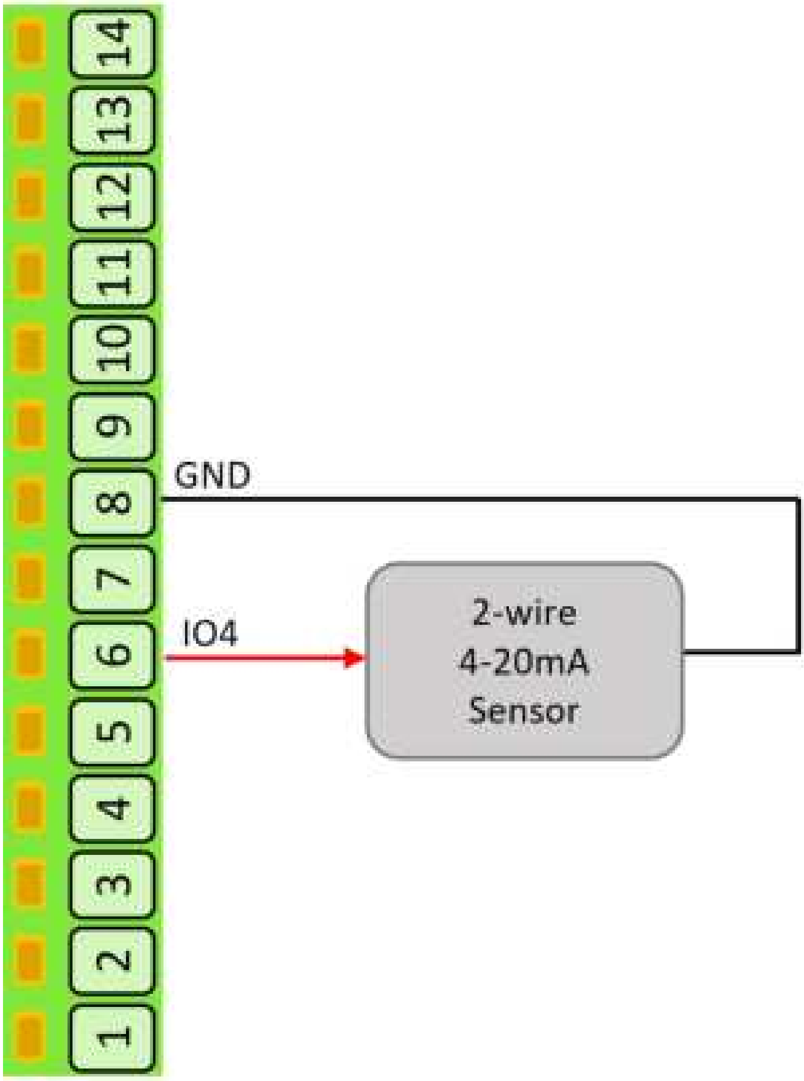


Figure 6.3. 2-wire 4-20mA device install

3-wire devices are externally powered as they typically draw more than 4mA at a minimum and so are not suitable for loop powering. The Senquip QUAD can power a 3-wire device with Vin or Vset from one IO and measure the output current on a second IO. A typical 3-wire install in shown in the figure below.

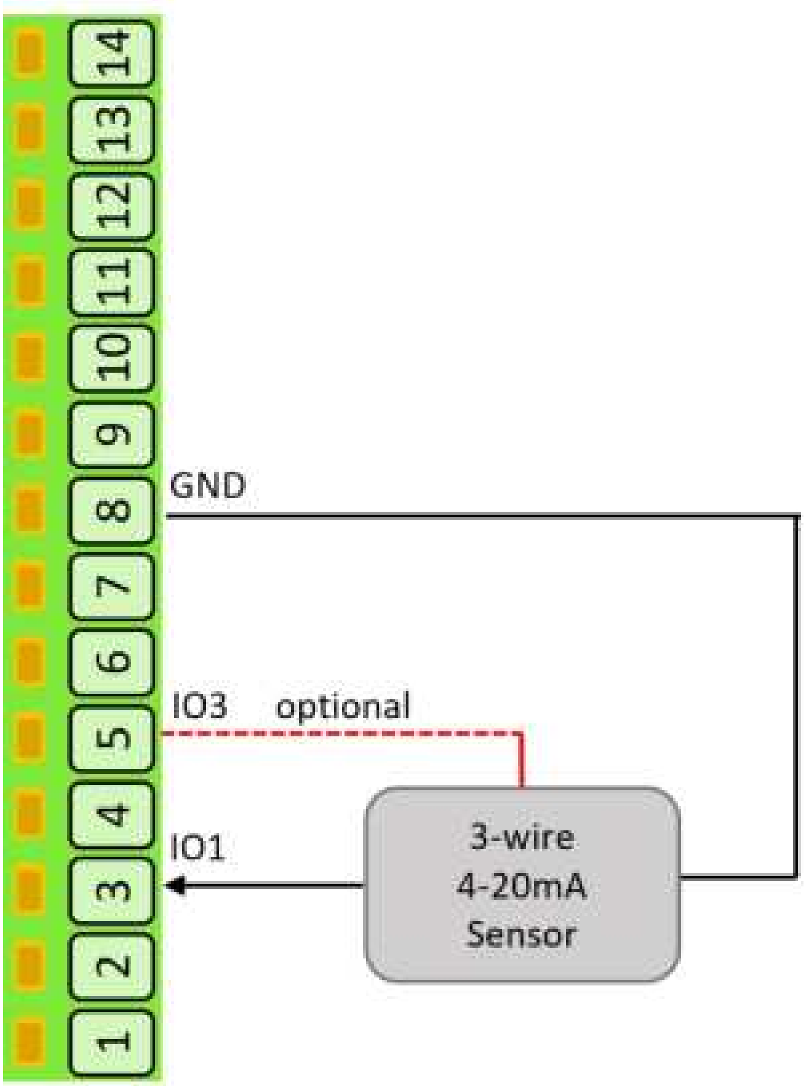


Figure 6.4. 3-wire 4-20mA device install

Current out of the IO terminal is defined as positive (2-wire) and current into the terminal (3-wire) is defined as negative. Although optimised for 4-20mA, the IO can measure currents in the range -100mA to 100mA.

6.1.3 Pulse Count Measurement

The Senquip QUAD can count pulses from devices like water-meters, rain guages, and speed-sensors. The inputs can be from voltage free contacts like reed switches, hall effect sensors, or pulse trains from powered devices. When connecting to voltage free switches, am optional pullup (wetting) resistor can be enabled in the settings. The Senquip QUAD can count pulses while awake and between cycles when sleeping. Although all IO can count in a very low power mode, IO1 and IO2 have additional circuitry that allows ultra low power pulse counting. Along with a total pulse count, frequency and duty cycle are also measured at the measurement interval.

The figure shows how to wire a voltage free contact and powered pulse train to the Senquip QUAD IO.

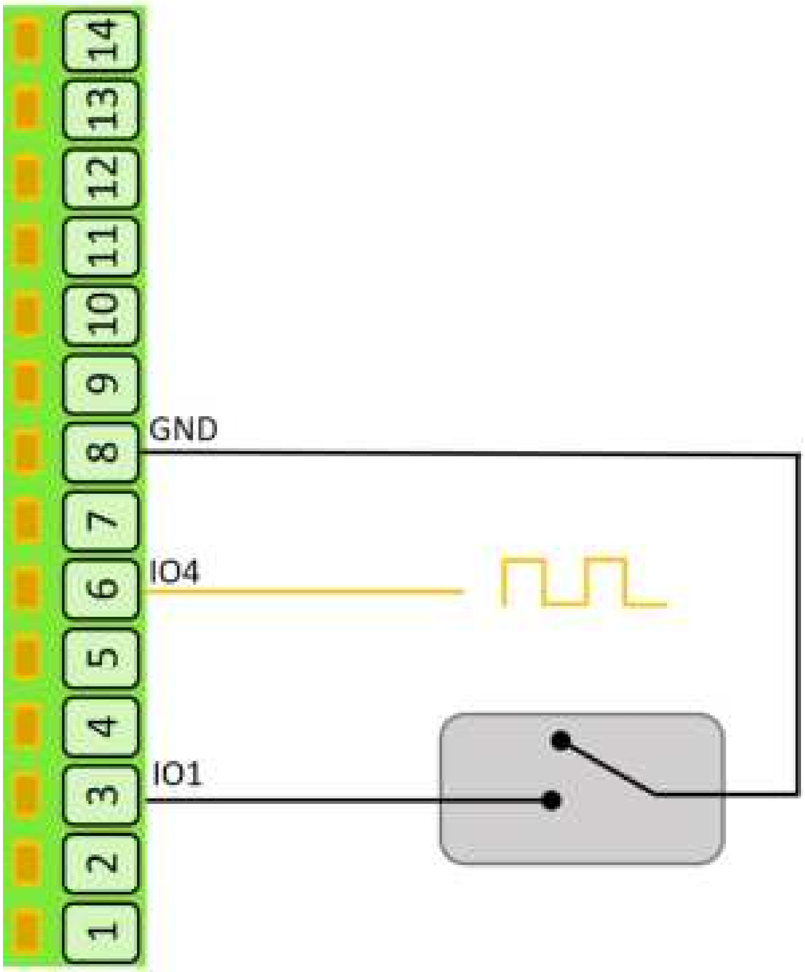


Figure 6.5. Pulse counting

Calibration

Calibration can be applied to each measurement so that the value returned by the Senquip QUAD is in units that are meaningful in the end application. For instance, a fuel level sensor that outputs a voltage between 0 and 5V may represent a level between 0 and 100 litres of diesel. The voltage measurement can be calibrated to convert from Volts to the more meaningful unit of litres.

In any system, the measurement instrument (the Senquip QUAD), the sensor and possibly the measured value will be subject to errors that may accumulate to reduce accuracy. In a system that measures fluid volume in a 100 litre tank using a 4-20mA sensor, offset errors may result in a non-zero or negative reading when the tank is empty. Sensor gain may also not be perfectly linear and so a 1 litre change may be measured differently when the tank is empty versus when it is full. The sensor may report in inches of liquid height where a more meaningful unit may be litres. To achieve an accurate and meaningful measurement, a calibration can be performed.

In this example, the tank could be calibrated by adding a small amount of liquid, say 10 litres at which point the current measured may be 4.1mA. Now add more liquid to take the level to say 80l. The sensor now reads 16.2mA. The calibration would then be filled into the IO setting as shown below:

Low In	4.1	This is the value in mA measured by the Senquip QUAD
Low Out	10	This is the actual value that we would like to report
High In	16.2	This is the value in mA measured by the Senquip QUAD
Low Out	80	This is the actual value that we would like to report

Unit	l	The unit to be reported is litres

Warnings and Alarms

For each measurement type, high and low warning and alarm levels can be set. Once enabled, each time a measurement is completed, the returned value will be compared with low and high *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*.

Note If calibration has been applied, then the warning and enable thresholds should be set in the calibrated units.

To set a high level warning or alarm level only, set the low level to a value that is impossible to achieve. For instance to set a high only warning at 50V, set the low warning to -1V which is an unachievable value.

Hysteresis can be specified in increments of the specified unit, to prevent multiple alarms in the presence of electrical noise.

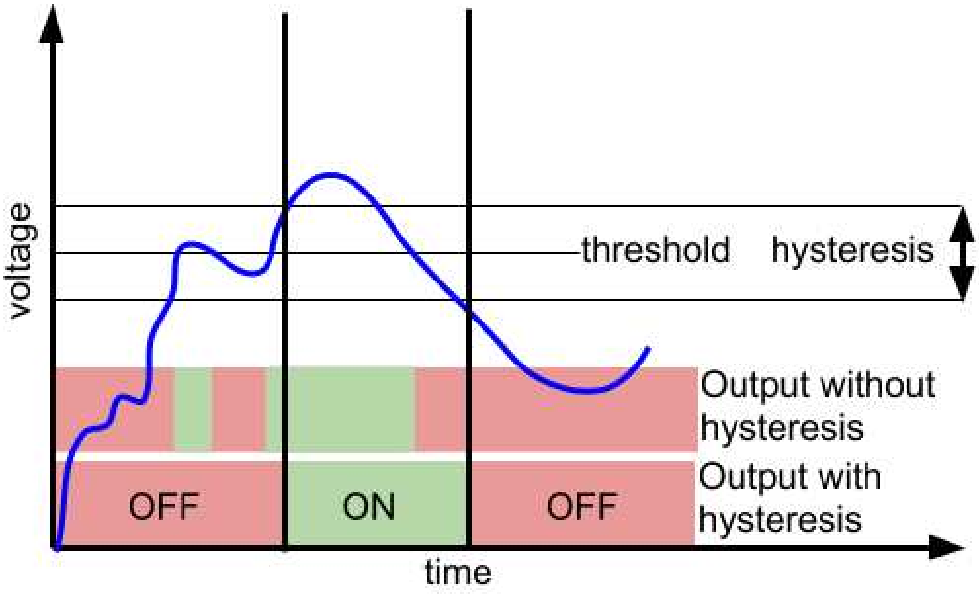


Figure 6.6. Hysteresis

6.1.4 Specification

Parameter	Specification
Output	
Maximum Vin source current	100mA per pin
Maximum Vset source current	100mA per pin, 100mA total from Vset
Maximum GND sink current	250mA per pin
Pullup resistor	33k to 3.3V
Input	
Voltage ADC Type	5 x 16 bit sigma delta
Voltage range	0-75VDC
Voltage measurement precision	3.125mV
Voltage measurement accuracy (0-5V, as measured)	+-0.005V

Voltage measurement accuracy (0-75V, as measured)	+-0.1V
Current ADC Type	5 x 16 bit sigma delta
Current maximum positive (out)	100mA
Current maximum negative (in)	+-100mA
Maxiumum measurable positive current	80mA
Maxiumum measurable negative current	-80mA
Current precision	2.5uA (15 bits across 80mA)
Accuracy (4-20mA, as measured)	+-0.05mA
Accuracy (-100-100mA, as measured)	+-0.1mA
Pulse counting voltage threshold	TBC
Pulse counting maximum frequency	TBC
Pulse counting maximum frequency in ulta low power mode	TBC
Pulse minimum width	TBC
Pulse debounce	TBC
Frequency measurement range	TBC
Frequency measurement precision	TBC
Duty cycle measurement range	TBC
Duty cycle precision	TBC
IO terminal input impedance	>250k ohms
Threshold to wake from hibernate	>2.3V
Threshold to enter hibernate	<1.0V

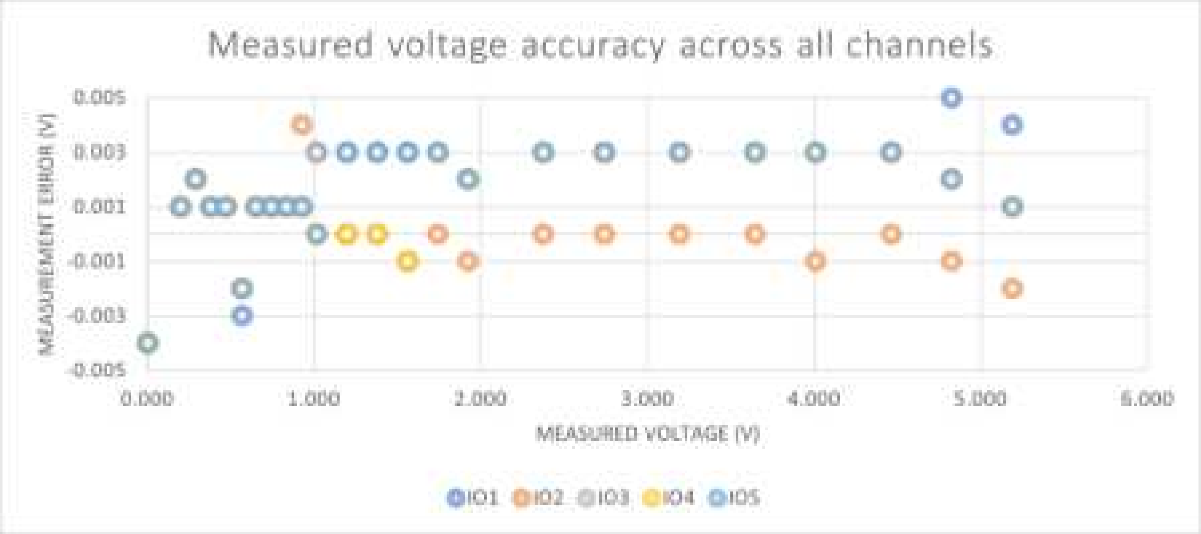


Figure 6.7. Voltage accuracy across all IO channels

6.1.5 Settings

Each IO block has an identical set of 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*. To turn an IO block off, set the *Interval* to 0.

If the *Wake on Low to High* option is selected, the device will wake from hibernate on a low to high voltage transition. If the *Hibernate on High to Low* option is selected, the device will entern hibernate mode after *Hibernate Delay Intervals* number of base intervals.

The *Default State* can be selected as *OFF*, *GND*, *VIN*, *VSET*, and *PULLUP*.

The *Measurement State* can selected as *NO CHANGE*, *GND*, *VIN*, and *VSET*. Where a measurement state is specified, a *Measurement Time* must be selected.

Each voltage, current, frequency, duty-cycle, pulse and digital measurement can be individually *Enabled* has an associated calibartion and alert settings.

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

6.2 Serial interface

The serial port can be used to capture data that is sent from an external system or to interface to a MODBUS sensor.

The serial port occupies pins 6 and 7 on the interface header. The pins have functions that depend on the chosen interface as shown in the table below. When RS485 mode is chosen, an optional 120Ω termination resistor can be selected.

Interface type	Pin 6 function	Pin 7 function
RS232	Receive (Rx)	Transmit (Tx)
RS485	RS485-B	RS485-A

Note RS485-B is sometimes referred to as D+ or TX+/RX+ and RS485-A as D- or TX-/RX-.

The RS485 receiver supports up to 256 nodes per bus, and features full failsafe operation for floating, shorted or terminated inputs. Interface pins are protected against electrostatic discharge up to 26kV, whether the QUAD is powered or unpowered.

6.2.1 Specification

Parameter	Specification
RS232 transmitter output low voltage (typical)	-5.5V
RS232 transmitter output high voltage (typical)	+5.9V
RS232 Input threshold voltage	+1.5V
RS485 differential output voltage (minimum with load resistance 120Ω)	+2V
RS485 differential input signal threshold	+-220mV
Maximum nodes in RS485 mode	256
RS485 termination resistor	120Ω

6.2.2 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*.

In *serial capture* mode the measurement interval can be used to reduce the number of readings being provided by a connected sensor or system that may be permanently powered. If for instance, a connected system is sending a message every second but it is only required to be read and transmitted every minute, the measurement interval can be set to 1 minute in which case the device will wake on the minute interval, receive a message and return to sleep thereby missing the other 59 messages sent by the attached system. Since serial packets cannot be interrogated by the Senquip QUAD without a customised script, it makes sense to set the measurement interval to the same as the transmit interval in most cases.

The serial port on the Senquip QUAD can be configured as an RS232 or RS485 hardware interface using the *type* option.

If RS485 mode is selected, an optional 120Ω termination resistor can be selected by selecting the *Termination resistor* option. The purpose of the termination resistor is to match the impedance of a transmission line to the hardware impedance of the interface to which it is connected. Termination is generally not required in lower speed networks (9600 baud or less) and networks shorter than 500m in length. No more than 2 termination resistors should be used, one at each end of the RS485 transmission line.

A *baud rate* of 4800, 9600, 19200, 38400, 56800 or 115200 needs to be selected using the *baud rate* option. Other settings, including the number of bits, odd or even parity and 1 or 2 stop bits are added in the *settings* field. The most common setup is 8 bits, no parity and 1 stop bit or "8N1".

The serial interface can be configured in serial capture mode or MODBUS mode using the *mode* option. Capture mode is typically used where an external sensor sends serial data and a portion of that serial data is to be captured. MODBUS mode is used to connect to external sensors that are compatible with the MODBUS standard.

In *serial capture mode* The device listens for periodic data and when received, transmits this data at the next send interval. The maximum length of a message that can be captured is 512 characters. Once 512 characters have been received, the Senquip QUAD will terminate the capture and will transmit it on the next transmit interval.

In capture mode, the *max-time* setting can be used to set a timeout after which the serial port will return to sleep. *Max-time* can be used as a way to end serial measurement in the event that no serial data is received, or as a mechanism to allow the device to sample the serial port for a defined time-period.

Note If the serial port needs to be kept on all the time, set the *max-time* to longer than the measurement interval. The contents of the serial buffer is retained as long as the device does not return to sleep.

The operation of the *max chars* option is similar to the *max time* setting except that the serial port stops sampling after a certain number of characters has been received. In most cases where the *max-chars* setting is used to terminate serial capture, the *max-time* setting is also used to end the serial measurement in the event that data does not arrive.

In *Serial capture mode*, in systems where many messages are sent and only a few are of interest, a *start string* of up to 10 characters can be enabled. For instance, in a typical GPS serial NMEA feed, the following are a subset of available messages:

- DTM - Datum being used.
- GGA - Fix information
- GLL - Lat/Lon data
- GSA - Overall Satellite data
- GSV - Detailed Satellite data
- RMC - Recommended minimum data for GPS
- RTE - Route message
- VTG - Vector track an Speed over the Ground

If in the application, the user is only interested in receiving the GGA message, then a *start string* can be set to GGA. In that way, any messages starting with DTM, GLL, GSA or other unwanted messages will be discarded.

Note If a start string is enabled, the device will stay awake until the string is received or until the *max-time* is reached.

In firmware revisions less than 2, serial *start strings* are specified as text, with special characters such as carriage return and line feed being specified by their respective escape sequences. A list of allowable escape sequences is given below:

- \f Form-feed
- \n Newline (Line Feed)
- \r Carriage Return
- \t Horizontal Tab
- \v Vertical Tab
- \\ Backslash

Note Because escape sequences start with a backslash (\), if a capture string contains a backslash, it needs to be escaped and so is represented as a double backslash (\\).

In firmware release 2 and above, serial *start strings* are specified as text, with special characters such as carriage return and line feed being specified by their respective ASCII codes in hexadecimal. A list of example hexadecimal sequences is given below:

- \x0C Form-feed
- \x0A Newline (Line Feed)
- \x0D Carriage Return
- \x09 Horizontal Tab
- \x0B Vertical Tab
- \x08 Backslash

The change to the method used to represent special characters has been made to allow for all ASCII characters to be used, and to allow for hexadecimal data to be captured.

Note In firmware revisions 2 and lower, special characters are specified as escape characters. In revisions 2 and above, special characters are represented by their ASCII representations in hexadecimal.

In some serial protocols, the start of a packet is specified by a preceding period of inactivity on the serial bus. The *Idle Time Before Start* parameter can be used to specify an idle time, which is exceeded will trigger the serial port to start capturing serial data.

Note If the serial port is capturing data and a subsequent idle time occurs, the capture process will restart and captured data will be discarded.

A serial capture *stop string* of up to 10 characters can also be provided. Again using the NMEA example, all NMEA messages end with a carriage return and line feed and so the serial capture *stop strings* in each case will be the same and will be "\r\n" or \x0D\x0A in revision 2 and above firmware. In most instances, the serial *stop strings* will be the same for all messages.

Note If a *start string* is specified without a *stop string*, or the *stop string* is never encountered, the serial port will capture characters until the *max-time* or *max-chars* is reached, the next measurement interval occurs or 256 characters are received.

An optional serial *request string* can be sent, on each measurement interval, to an external device. The purpose of the *request sting* is to request data from an external sensor or system. The *request string* can be a maximum of 10 characters and can be entered as text. Special characters like carriage return and line feed can be inserted using escape sequences or their ASCII representations as described earlier in the chapter.

The Senquip QUAD implements the *MODBUS* communications protocol standard as a master, which enables communication with many slave devices connected to the network. The Senquip QUAD can be configured to periodically request specific data from slave *MODBUS* devices on the network and transmit that data at specified intervals.

Up to fifty MODBUS data requests can be configured; these data requests can either be from twenty individual slave devices or multiple requests from the same device. For each of the fifty data reads, the *slave address*, *function* and *register address* need to be specified. The *slave address* will be specified by the manufacturer of the device that is attached to the Senquip QUAD; in some cases, slave devices allow their addresses to be configured. The *function* specifies the type of data to be read from the slave device. The Senquip QUAD supports the following types of data reads:

- Disabled - the particular MODBUS channel is not used
- Read Coil - a 1 bit data value
- Read Discrete - a 1 bit data value
- Read Holding - a single 16 bit holding register
- Read Input - a 16 bit input register
- Read Holding (32 bits, Little Endian register order) - a 32 bit holding register
- Read Holding (32 bits, Big Endian register order) - a 32 bit holding register
- Read Input (32 bits, Little Endian register order) - a 32 bit input register
- Read Input (32 bits, Little Endian register order) - a 32 bit input register

Endianness is the order or sequence of bytes of digital data in computer storage and will be specified by the sensor that is being connected to the QUAD.

A single MODBUS device may have multiple data values that can be read. The *register address* specifies which data the slave device needs to deliver.

In *MODBUS mode*, calibration can be applied so that the registers read by the Senquip QUAD can be scaled to be in the units of what is being measured. For instance, a register that returns 0 to 255 may represent 0% humidity to 100% humidity. The Senquip QUAD can be calibrated to take a number and to convert it to humidity in % and return that as the measured value.

In any system, the sensor and possibly the measured value will be subject to errors that may accumulate to reduce accuracy. In a system that uses the Senquip QUAD to measure fluid volume in a 100 litre tank using a MODBUS sensor, the sensor may have offset errors such that with zero liquid in the tank, the Senquip QUAD is showing a small volume. The Senquip QUAD and sensor may also not be perfectly linear in that they may not measure 1 litre in exactly the same way when the tank is empty versus when it is full. The tank itself may also not be perfectly manufactured and may, for instance have walls that are not perfectly straight. All of these errors could add together such that the final system is less accurate than expected. To achieve a more accurate system, a calibration can be performed. In this example, the tank could be calibrated by adding a small amount of liquid, say 10 litres (low Y) and noting the value reported by the Senquip QUAD (low X). Now fill the tank by adding another 99 litres (high y) and note the value being reported by the Senquip QUAD (high X). By filling the high and low X and Y values into the calibration constants associated with *analog mode*, offset and non-linearity errors can be eradicated, resulting in a much more accurate system.

In *MODBUS mode*, *warning* and *alarm* thresholds for can be set for each MODBUS channel. 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.

Note If calibration has been applied, then the warning and enable thresholds are in the calibrated units.

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

6.3 CAN Bus interface

The Senquip QUAD-C1 has a CAN bus interface that can be used to read data from all kinds of vehicles and sensors that use CAN as their communications medium. Hundreds of sensors can be connected to a single CAN network.

In many cases, the protocol that is being used on the CAN bus is known, and so large volumes of understandable data can be extracted from all kinds of vehicles. Common CAN protocols include:

- J1939, the dominating CAN-based protocol for trucks and busses.
- ISO 11783, a J1939 flavor for agricultural tractors.
- ISO 11992, an interface between trucks and trailers.
- NMEA 2000, a protocol based on J1939 for marine use.
- CANopen, provides a standard for industrial machinery commonly used in industrial automation.

The Senquip QUAD is compatible with the latest CAN Flexible-Data-rate (FD) specification.

Pins 11 and 12 on the Senquip QUAD header provide the interface to a CAN network with pin 11 being CAN High (dominant high) and pin 12 being CAN Low (dominant low).

In CAN networks, 120Ω terminating resistors are found at each end of the network. In most systems, the terminating resistors will already be in place and will not be needed. In cases where a sensor network is being formed between an Senquip QUAD and external sensor, a 120Ω resistor should be placed between the pins 11 and 12 on the Senquip QUAD.

> **Warning** In CAN bus systems, the ground supplied to the Senquip QUAD must be the same ground as used by the CAN network. High differential voltages between the CAN lines and ground can damage the CAN interface.

6.3.1 Specification

Parameter	Specification
CAN High driver voltage (typical)	2.9V
CAN Low driver voltage (typical)	0.9V
Common mode voltage for reception (maximum)	+-25V
Absolute maximum voltage on CAN High and CAN Low	+-60V
Termination resistor	120Ω

6.3.2 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 the CAN network will be sampled on every base interval. To reduce power consumption, the measurement rate can be turned down by increasing the *interval*.

The Senquip QUAD CAN bus supports can bit rates of 125, 250, 500 and 1000 bits per second as specified in the *Nominal Baud Rate* field.

To ensure minimum intrusion on CAN systems, the Senquip QUAD can be set to listen only. In this mode the Senquip QUAD will only receive messages that are acknowledged on the bus by a listening node. Where required, the Senquip QUAD can be made to acknowledge messages by selecting the *TX Enable* option.

A typical automotive CAN network will contain hundreds of messages, all with their own identifiers.

The Senquip QUAD can filter only the required messages by filling in the *ID Capture List*. Required identifiers should be entered in hexadecimal and should be separated by commas. When the Senquip QUAD wakes for the next measurement interval, the CAN network 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: 18FF20F2*4, 18FF36F0, 18FF1BF2*10 will return 18FF20F2 four times, 18FF36F0 once and 18FF1BF2 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 CAN bus will stop listening, allowing the Senquip QUAD to transmit received messages and return to sleep. *Capture-time* can be used as a mechanism to allow the Senquip QUAD to sample the CAN bus for a defined time-period.

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

6.4 External Sensor Settings

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

Name	Item	Function	Range	Unit	Internal Reference
Input 1					
Name	text	A name for the input that is meaningful to the user.	25 chars		input1.name
Interval	integer	The number of base intervals after which the input is sampled. A value of 1 means that the input is collected every base interval. Set to 0 to disable.	0 to 10000		input1.interval
Mode	preset	Specifies the function of the IN1 terminal. The calibration, warnings and alarms are applied to this mode.			input1.mode
Digital 1					
Digital Threshold	decimal	A threshold against which the input is compared to determine if the input state is ON or OFF.	0 to 30	Volts	input1.digital.threshold
Digital Hysteresis	decimal	Once the input is in a certain state, hysteresis is the amount by which the input has to change before moving to the other state.	0 to 20	Volts	input1.digital.hysteresis
Count Hours	boolean	Counts the number of hours the digtial input is ON (above threshold).			input1.digital.count_hours
Digital Change Alert	boolean	Sets whether a change in digital state generates an alert.			input1.digital.alert.enable
Analog 1 Calibration	text	Calibration parameters for Analog 1. Refer to user guide.	30 chars		input1.cal
Unit	text	The unit of measure associated with the calibration. Examples: Litres/min, RPM, Volts			input1.unit
Warning	text	Warning thresholds. Refer to user guide.			input1.warning
Alarm	text	Alarm thresholds. Refer to user guide.			input1.alarm

Alarm/Warning Hysteresis	decimal	Once the input is in a certain state, hysteresis is the amount by which the input has to change before moving to the other state.			input1.hysteresis
Pulse Input					
Pulse Counting	boolean	Enables counting of pulses in addition to frequency measurement.			input1.pulse.enable
Reset Value	integer	The value at which the number of pulses counted on the input is reset to zero.	1 to 2000000000	Counts	input1.pulse.reset_value
Pulse Scaling	decimal	Multiplier to convert the pulse count to a useful unit.			input1.pulse.scaling
Pulse Unit	text	The unit of measure associated with the scaled pulse count. Eg: Litres			input1.pulse.unit
Pulse Warning	text	Warning thresholds. Refer to user guide.			input1.pulse.warning
Pulse Alarm	text	Alarm thresholds. Refer to user guide.			input1.pulse.alarm
Input 2					
Name	text	A name for the input that is meaningful to the user.	25 chars		input2.name
Interval	integer	The number of base intervals after which the input is sampled. A value of 1 means that the input is collected every base interval. Set to 0 to disable.	0 to 10000		input2.interval
Mode	preset	Specifies the function of the IN2 terminal. The calibration, warnings and alarms are applied to this mode.			input2.mode
Digital 2					
Digital Threshold	decimal	A threshold against which the input is compared to determine if the input state is ON or OFF.	0 to 30	Volts	input2.digital.threshold
Digital Hysteresis	decimal	Once the input is in a certain state, hysteresis is the amount by which the input has to change before moving to the other state.	0 to 20	Volts	input2.digital.hysteresis
Count Hours	boolean	Counts the number of hours the digtial input is ON (above threshold).			input2.digital.count_hours
Digital Change Alert	boolean	Sets whether a change in digital state generates an alert.			input2.digital.alert.enable
Analog 2 Calibration	text	Calibration parameters for Analog 2. Refer to user guide.	30 chars		input2.cal
Unit	text	The unit of measure associated with the calibration. Examples: Litres/min, RPM, Volts			input2.unit
Warning	text	Warning thresholds. Refer to user guide.			input2.warning
Alarm	text	Alarm thresholds. Refer to user guide.			input2.alarm
Alarm/Warning Hysteresis	decimal	Once the input is in a certain state, hysteresis is the amount by which the input has to change before moving to the other state.			input2.hysteresis

Output 1					
Name	text	A name for the input that is meaningful to the user.	25 chars		output1.name
Interval	integer	Does not affect output mode. The number of base intervals at which the input is sampled. Set to 0 to disable. Set to 1 for every base interval.	0 to 10000		output1.interval
Mode	preset	Specifies the function of the OUT1 terminal.			output1.mode
Warnings	boolean	Determines if the output is turned on when a warning is active.			output1.warnings
Alarms	boolean	Determines if the output is turned on when an alarm is active.			output1.alarms
Alerts	boolean	Determines if the output is turned on when an alert is active.			output1.alerts
Hold Time	integer	Sets the time in seconds for which the output is held on after it is triggered. If set to zero, the output remains on while any exceptions are active.		Seconds	output1.hold_time
Digital Change Alert	boolean	If enabled, a change in digital state will generate an alert.			output1.digital.alert.enable
Analog 3 Calibration	text	Calibration parameters for Analog 3. Refer to user guide.	30 chars		output1.cal
Unit	text	The unit of measure associated with the calibration. Examples: Litres/min, RPM, Volts			output1.unit
Warning	text	Warning thresholds. Refer to user guide.			output1.warning
Alarm	text	Alarm thresholds. Refer to user guide.			output1.alarm
Alarm/Warning Hysteresis	decimal	Once the input is in a certain state, hysteresis is the amount by which the input has to change before moving to the other state.			output1.hysteresis
Thermocouple 1					
Name	text	A name for the input that is meaningful to the user.	25 chars		tc1.name
Interval	integer	The number of base intervals after which the thermocouple is measured and events are checked. A value of 1 means that the input is collected every base interval. Set to 0 to disable.	0 to 10000		tc1.interval
Hysteresis	decimal	The amount by which the measured value has to drop below the threshold to re-enable the event.	-1000 to 1000	&deg;C	tc1.hysteresis
Type	text	Determines the type of thermocouple connected. Valid values are: K, J, T, N, S, E, B and R	1 chars		tc1.type
Warning	text	Warning thresholds. Refer to user guide.	-1000 to 1000	&deg;C	tc1.warning

Alarm	text	Alarm thresholds. Refer to user guide.	-1000 to 1000	&deg;C	tc1.alarm
CAN 1					
Name	text	A name that is meaningful to the user.	25 chars		can1.name
Interval	integer	The number of base intervals after which the CAN module is turned on. Set to 0 to disable.	0 to 10000		can1.interval
Nominal Baud Rate	integer	Baud rate for CAN communication. Supported values are: 125, 250, 500, 1000		kbit/s	can1.nominal_baud
Capture Time	integer	The device will capture matching messages for this length of time.		Seconds	can1.capture_time
TX Enable	boolean	Allows the device to transmit and acknowledge messages on the CAN bus.			can1.tx_enable
ID Capture List	text	List of IDs to be captured in HEX format, separated by a comma eg: 18FEE60A. Leave blank to capture all.	200 chars		can1.id_list
Send Raw Data	boolean	If ticked, all captured messages will be added to the data message.			
CAN 2			25 chars		can2.name
Name	text	A name that is meaningful to the user.	0 to 10000		can2.interval
Interval	integer	The number of base intervals after which the CAN module is turned on. Set to 0 to disable.		kbit/s	can2.nominal_baud
Nominal Baud Rate	integer	Baud rate for CAN communication. Supported values are: 125, 250, 500, 1000		Seconds	can2.capture_time
Capture Time	integer	The device will capture matching messages for this length of time.			can2.tx_enable
TX Enable	boolean	Allows the device to transmit and acknowledge messages on the CAN bus.	200 chars		can2.id_list
ID Capture List	text	List of IDs to be captured in HEX format, separated by a comma eg: 18FEE60A. Leave blank to capture all.			
Send Raw Data	boolean	If ticked, all captured messages will be added to the data message.			
Current Loop 1			25 chars		current1.name
Name	text	A name for the input that is meaningful to the user.	0 to 10000		current1.interval
Interval	integer	The number of base intervals after which the input is sampled. A value of 1 means that the input is collected every base interval. Set to 0 to disable.			current1.mode
Mode	preset	Specifies the function of the SRC1 terminal.			current1.always_on
Always On	boolean	Determines if Switched Power is to be enabled permanently.	0 to 3600	Seconds	current1.start_time

Start Time	decimal	Time in seconds that the output is turned on before measurements are taken. Allows an external device to stabilise.			current1.digital.alert.enable
Digital Change Alert	boolean	Sets whether a change in digital state generates an alert. (Digital Mode Only)	30 chars		current1.cal
Current 1 Calibration	text	Calibration parameters for Current 1. Refer to user guide.			current1.unit
Unit	text	The unit of measure associated with the calibration. Examples: Percent, Pascals, Meters			current1.warning
Warning	text	Warning thresholds. Refer to user guide.			current1.alarm
Alarm	text	Alarm thresholds. Refer to user guide.			current1.hysteresis
Alarm/Warning Hysteresis	decimal	The amount by which the calibrated current value has to drop below the threshold to re-enable the event.			
Current Loop 2			25 chars		current2.name
Name	text	A name for the input that is meaningful to the user.	0 to 10000		current2.interval
Interval	integer	The number of base intervals after which the input is sampled. A value of 1 means that the input is collected every base interval. Set to 0 to disable.			current2.mode
Mode	preset	Specifies the function of the SRC2 terminal.			current2.always_on
Always On	boolean	Determines if Switched Power is to be enabled permanently.	0 to 3600	Seconds	current2.start_time
Start Time	decimal	Time in seconds that the output is turned on before measurements are taken. Allows an external device to stabilise.			current2.digital.alert.enable
Digital Change Alert	boolean	Sets whether a change in digital state generates an alert. (Digital Mode Only)	30 chars		current2.cal
Current 2 Calibration	text	Calibration parameters for Current 2. Refer to user guide.			current2.unit
Unit	text	The unit of measure associated with the calibration. Examples: Percent, Pascals, Meters			current2.warning
Warning	text	Warning thresholds. Refer to user guide.			current2.alarm
Alarm	text	Alarm thresholds. Refer to user guide.			current2.hysteresis
Alarm/Warning Hysteresis	decimal	The amount by which the calibrated current value has to drop below the threshold to re-enable the event.			
Serial 1			25 chars		serial1.name
Name	text	A name for the input that is meaningful to the user.	0 to 10000		serial1.interval

Interval	integer	The number of base intervals after which the serial port is turned on. Set to 0 to disable.			serial1.type
Type	preset	The electrical interface type.			serial1.termination
Termination Resistor	boolean	This parameter enables the integrated termination resistor.			serial1.mode
Mode	preset	Describes how the serial port is to be handled. CAPTURE: serial data is captured between start and end characters. MODBUS: serial data is treated according to MODBUS RTU standard			serial1.baud
Baud Rate	integer	Baud rate for serial communication. Common values are: 4800, 9600, 19200, 38400, 57600, 115200			serial1.settings
Settings	text	A string describing the number of bytes: 7,8,9. Parity type: N(none), E(even), O(odd). Number of stop bits: 1 or 2. Typically: 8N1			
Capture			32 chars		serial1.capture.start
Start String	text	The serial port starts reading data when it detects these characters. Example: $GPGGA, serial data will be ignored until $GPGGA is received after which data will be captured. If nothing is specified, the serial port will capture all data until the timeout period is reached.	0 to 60000	Milliseconds	serial1.capture.start_idle_time
Idle Time Before Start	integer	For a valid start condition, there must be this amount of idle time before receiving serial data. Additionally, the captured data will restarted if the serial port is idle for this time. Set to 0 to disable.	32 chars		serial1.capture.end
End String	text	Once capturing, if these characters are received, the serial port will stop capturing and will return to sleep. For binary data or escape sequences refer to the User Guide.	32 chars		serial1.capture.request
Request String	text	This string will be sent when the serial port is first turned on. Use this function to request data from a remote module.		Seconds	serial1.capture.maxtime
Max Time	integer	The device will wait this length of time for a valid capture.			serial1.capture.maxchars
Max Chars	integer	Maximum number of characters to be captured before the serial port goes back to sleep.			serial1.capture.alert
Alert on Capture	boolean	If checked an alert will be raised on any successful serial capture.			
MODBUS RTU			0 to 10	Seconds	serial1.modbus.timeout
Slave Timeout	decimal	How long to wait for a response from each slave device.			

MODBUS 1			25 chars		mod1.name
Modbus 1 Name	text	A meaningful name for Modbus Channel 1.	18 chars		mod1.settings
Modbus 1 Settings	text	Settings for Modbus Channel 1. Refer to user guide.	30 chars		mod1.cal
Modbus 1 Calibration	text	Calibration paramters for Modbus Channel 1. Refer to user guide.			mod1.unit
Modbus 1 Unit	text	The unit of measure associated with the calibration. Examples: Percent, L/hr, Meters			mod1.warning
Warning	text	Warning thresholds. Refer to user guide.			mod1.alarm
Alarm	text	Alarm thresholds. Refer to user guide.			
MODBUS 2			25 chars		mod2.name
Modbus 2 Name	text	A meaningful name for Modbus Channel 2.	18 chars		mod2.settings
Modbus 2 Settings	text	Settings for Modbus Channel 2. Refer to user guide.	30 chars		mod2.cal
Modbus 2 Calibration	text	Calibration paramters for Modbus Channel 2. Refer to user guide.			mod2.unit
Modbus 2 Unit	text	The unit of measure associated with the calibration. Examples: Percent, L/hr, Meters			mod2.warning
Warning	text	Warning thresholds. Refer to user guide.			mod2.alarm
Alarm	text	Alarm thresholds. Refer to user guide.			
MODBUS 3			25 chars		mod3.name
Modbus 3 Name	text	A meaningful name for Modbus Channel 3.	18 chars		mod3.settings
Modbus 3 Settings	text	Settings for Modbus Channel 3. Refer to user guide.	30 chars		mod3.cal
Modbus 3 Calibration	text	Calibration paramters for Modbus Channel 3. Refer to user guide.			mod3.unit
Modbus 3 Unit	text	The unit of measure associated with the calibration. Examples: Percent, L/hr, Meters			mod3.warning
Warning	text	Warning thresholds. Refer to user guide.			mod3.alarm
Alarm	text	Alarm thresholds. Refer to user guide.			
MODBUS 4			25 chars		mod4.name
Modbus 4 Name	text	A meaningful name for Modbus Channel 4.	18 chars		mod4.settings
Modbus 4 Settings	text	Settings for Modbus Channel 4. Refer to user guide.	30 chars		mod4.cal
Modbus 4 Calibration	text	Calibration paramters for Modbus Channel 4. Refer to user guide.			mod4.unit
Modbus 4 Unit	text	The unit of measure associated with the calibration. Examples: Percent, L/hr, Meters			mod4.warning

Warning	text	Warning thresholds. Refer to user guide.			mod4.alarm
Alarm	text	Alarm thresholds. Refer to user guide.			
MODBUS 5			25 chars		mod5.name
Modbus 5 Name	text	A meaningful name for Modbus Channel 5.	18 chars		mod5.settings
Modbus 5 Settings	text	Settings for Modbus Channel 5. Refer to user guide.	30 chars		mod5.cal
Modbus 5 Calibration	text	Calibration paramters for Modbus Channel 5. Refer to user guide.			mod5.unit
Modbus 5 Unit	text	The unit of measure associated with the calibration. Examples: Percent, L/hr, Meters			mod5.warning
Warning	text	Warning thresholds. Refer to user guide.			mod5.alarm
Alarm	text	Alarm thresholds. Refer to user guide.			
MODBUS 6			18 chars		mod6.settings
Modbus 6 Settings	text	Settings for Modbus Channel 6. Refer to user guide.	30 chars		mod6.cal
Modbus 6 Calibration	text	Calibration paramters for Modbus Channel 6. Refer to user guide.			
MODBUS 7			18 chars		mod7.settings
Modbus 7 Settings	text	Settings for Modbus Channel 7. Refer to user guide.	30 chars		mod7.cal
Modbus 7 Calibration	text	Calibration paramters for Modbus Channel 7. Refer to user guide.			
MODBUS 8			18 chars		mod8.settings
Modbus 8 Settings	text	Settings for Modbus Channel 8. Refer to user guide.	30 chars		mod8.cal
Modbus 8 Calibration	text	Calibration paramters for Modbus Channel 8. Refer to user guide.			
MODBUS 9			18 chars		mod9.settings
Modbus 9 Settings	text	Settings for Modbus Channel 9. Refer to user guide.	30 chars		mod9.cal
Modbus 9 Calibration	text	Calibration paramters for Modbus Channel 9. Refer to user guide.			
MODBUS 10			18 chars		mod10.settings
Modbus 10 Settings	text	Settings for Modbus Channel 10. Refer to user guide.	30 chars		mod10.cal
Modbus 10 Calibration	text	Calibration paramters for Modbus Channel 10. Refer to user guide.			

Chapter 7

Scripting

Senquip devices have the ability to run user written scripts, allowing extra flexibility. The scripting language is called mJS and is essentially a restricted JavaScript engine. Typical uses include:

Scripting on Senquip devices allows:

- Decoding and parsing of messages from serial and CAN-bus devices
- Mathematical manipulation of measured data
- Controlling connected devices
- Creating complex alerts that may be dependent on more than one variable
- Customisation of data payloads to be compatible with third party dashboards

Scripts can be executed in response to a measurement cycle completing, a trigger button being pressed, or based on a recurring timer function.

For more information about writing JavaScript for a Senquip device, please see the Senquip Scripting Guide.

7.1 Risks

> **Warning** The scripting environment is a powerful tool. If incorrectly used the scripting functions may cause the device to malfunction, or even permanently brick the device.

- The mJS scripting environment provides low level access to the device's memory and CPU. Running a script on the device is not without risk, some of which include:
- Permanent filesystem damage rendering the device unable to boot.
- Malfunction of other functions, such as regular reporting of data to the portal.
- Memory corruption, causing incorrect reporting of data.
- Memory leaks, which may present intermittently or after a period of time.
- Loss of remote control over the device, if your Portal account is compromised.

A good understanding of the environment, language and best practices will help avoid or mitigate these risks.

7.2 Access

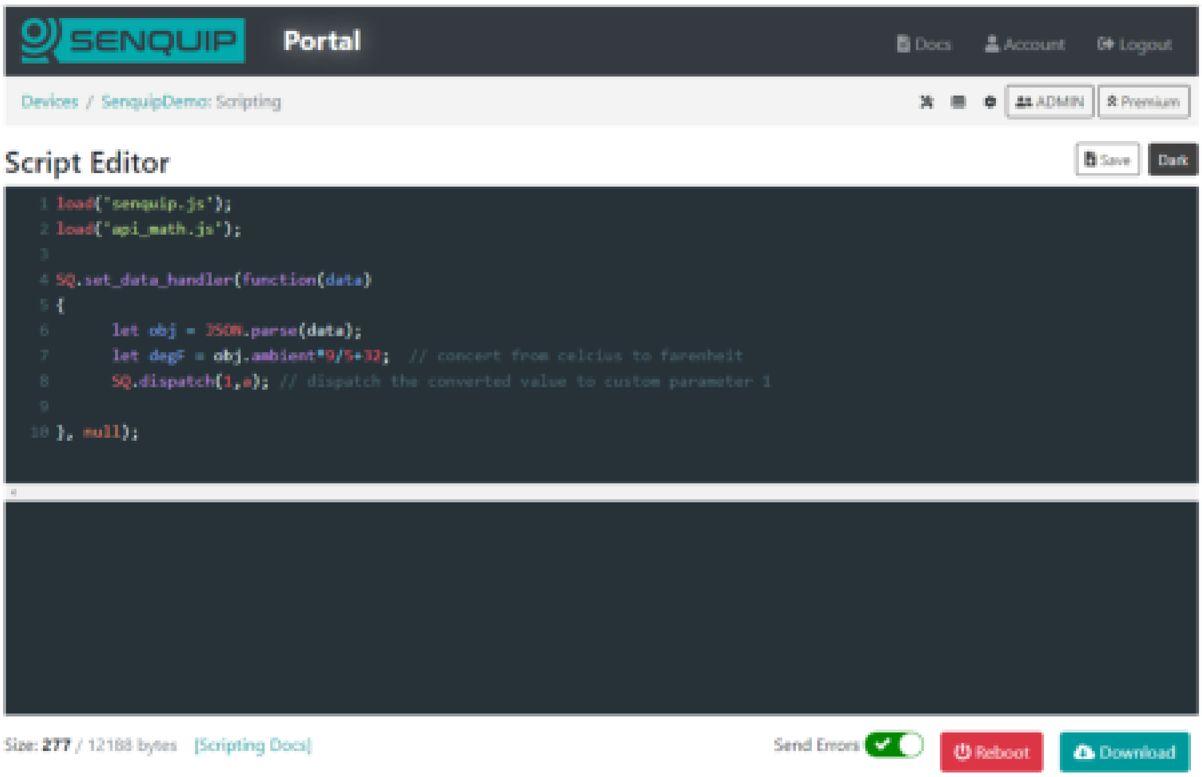
Scripts can be written and securely downloaded to the device from the Senquip Portal. There are several requirements for access scripting on your device:

- You must have ADMIN status on the Portal for the device.
- Your Portal account must be granted SCRIPTING permissions. This can be granted by making a request to support@senquip.com

Once the requirements are met, you can access the scripting page at: https://portal.senquip.com/script/DEVICEID or by pressing the scripting icon on the device dashboard.

7.3 Writing and deploying a script

The scripting page on the Senquip Portal allows scripts to be written and downloaded, and custom variables, custom settings, and triggers to be created.



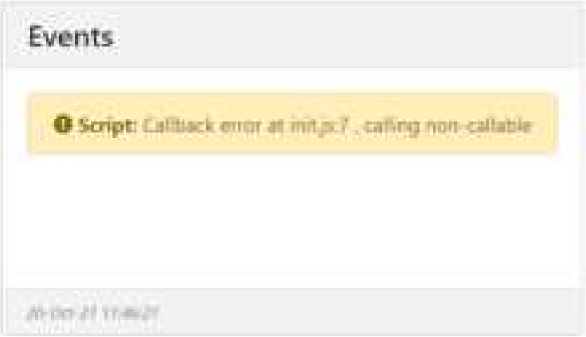
```
load('senquip.js');
load('api_math.js');

SQ.set_data_handler(function(data)
{
        let obj = JSON.parse(data);
        let degF = obj.ambient*9/5+32;  // concert from celcius to farenheit
        SQ.dispatch(1,a); // dispatch the converted value to custom parameter 1

}, null);
```

Figure 7.1. Senquip scripting page

Once written, the user can deploy the script to a remote device by pressing the download button and then the reboot button. To enable error reporting, enable the *Send Errors* option. If the script terminates unexpectedly, a message will be sent with a description of the reason that the script failed to complete execution.



Events

Script: Callback error at init.js:7 , calling non-callable

20-Oct-21 11:46:21

Figure 7.2. Feedback on unsuccessful script

Scripts can be saved to a file using the *Save* button on the scripting page. It is recommended that all scripts are backed up to a secondary storage medium.

Note Remember to backup your scripts.

Chapter 8

Network Connection

The Senquip QUAD can communicate with the Senquip Portal or a remote server via Wi-Fi or 4G LTE. Where both Wi-Fi and 4G LTE networks are selected, the Senquip QUAD will first attempt to connect via Wi-Fi and if that is unsuccessful, the device will then attempt to connect via 4G LTE. In the event that neither Wi-Fi or 4G LTE networks can be found, the device can be set to log data to internal memory and then upload it when a network becomes available (see *Endpoint* settings).

8.1 Wi-Fi specification

Wi-Fi on the Senquip QUAD is used to transmit data, to allow settings to be remotely updated, to allow in-field software updates and also to enable setup via an integrated web-server that can be accessed in setup mode via a mobile phone or other Wi-Fi device.

The Wi-Fi implementation supports Wi-Fi 802.11 b/g/n. The Wi-Fi antenna is integrated into the Senquip QUAD. In typical applications, the range achievable with Wi-Fi is 500m.

8.2 4G LTE specification

4G LTE on the Senquip QUAD is used to transmit data, to allow settings to be remotely updated and to allow in-field software updates.

The 4G LTE implementation is designed for global use and supports Cat-M1 and NB-IoT in the following bands:

Device	LTE Category	Bands
QUAD-xx-G	CAT-M1 EGPRS	B1/B2/B3/B4/B5/B8/B12/B13/B18/B19/B20/B26/B28/B39 850/900/1800/1900MHz
QUAD-xx-H	CAT-1 GSM / EDGE	B1/B3/B7/B8/B20/B28 B3/B8

A FAKRA-D (Violet) socket is provided on the bottom of the Senquip QUAD for connection of a 4G LTE antenna.

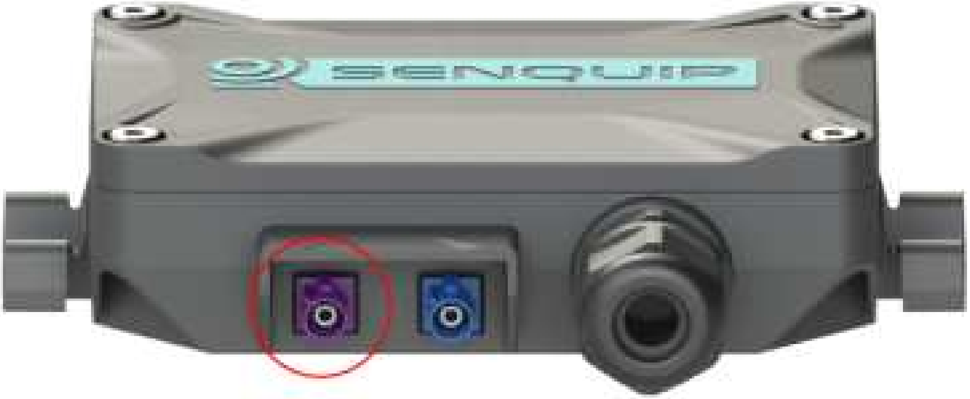
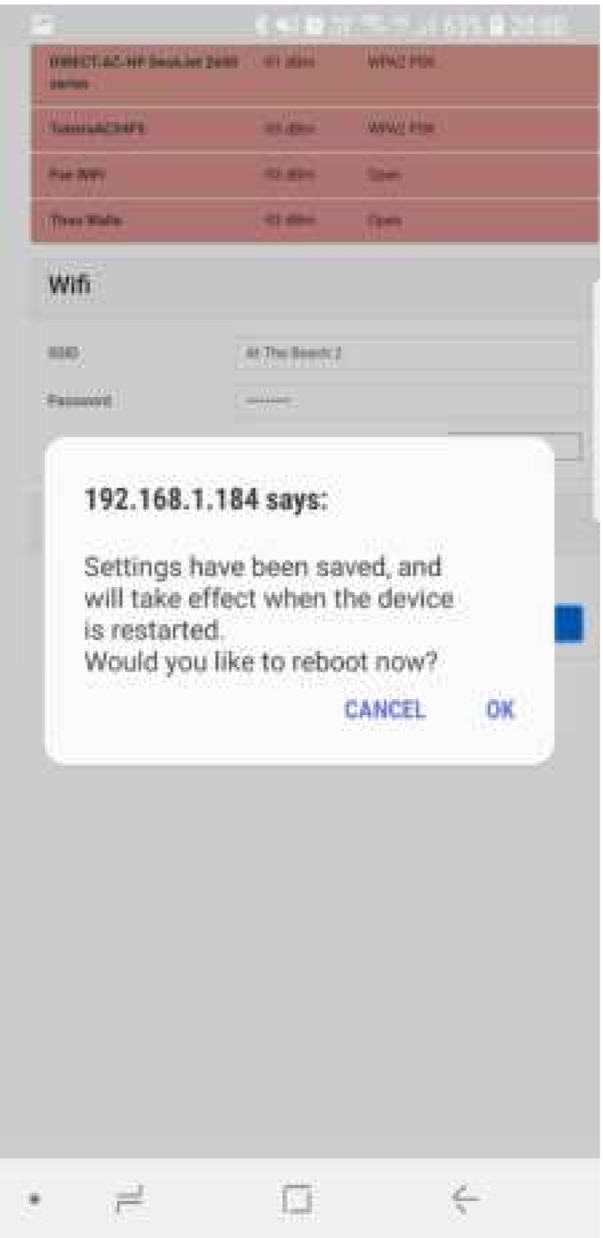


Figure 8.1. FAKRA-D 4G LTE antenna connector

8.3 Connecting to a Wi-Fi network

Once in setup mode, use the Network page to connect the Senquip QUAD to a Wi-Fi network.

On the Network page, press the Scan for Wi-Fi Networks button. After a few seconds, a list of SSIDs for visible Wi-Fi networks will be shown. Select the Wi-Fi network to which you would like to connect by selecting the SSID from the list. The SSID will automatically be copied to the Wi-Fi SSID field and you will be prompted for the network password. After entering the password, press Save Settings. You will be prompted to restart the device; settings will only be applied after a restart. To continue with setup, press *CANCEL* or to restart and apply your settings, press *OK*.



SSID At The Beach 2

Password

192.168.1.184 says:

Settings have been saved, and will take effect when the device is restarted.
Would you like to reboot now?

Figure 8.2. Save changes and reboot

After a reboot, the Senquip QUAD will attempt to connect to the specified Wi-Fi network. You can check if the Senquip QUAD has successfully connected to the chosen network by placing the device in setup mode and returning to the Network page. At the top of the page, the current network status will be shown. Note the IP address that your Wi-Fi modem has allocated to the Senquip QUAD; you can use this address to access the device directly on your WiFI network.

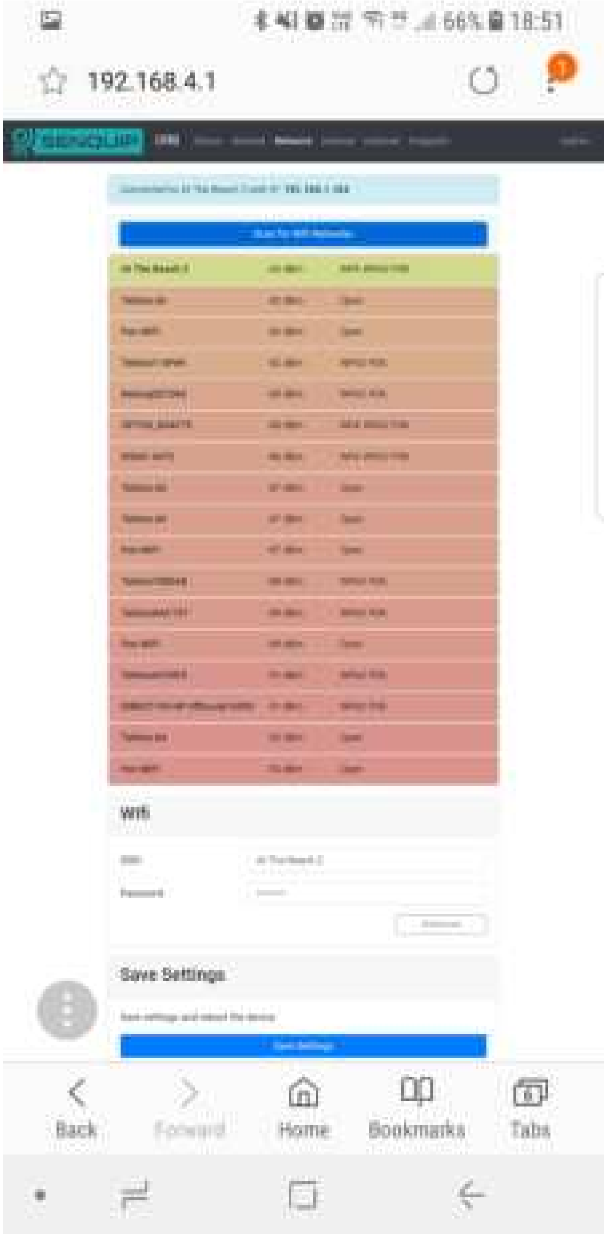
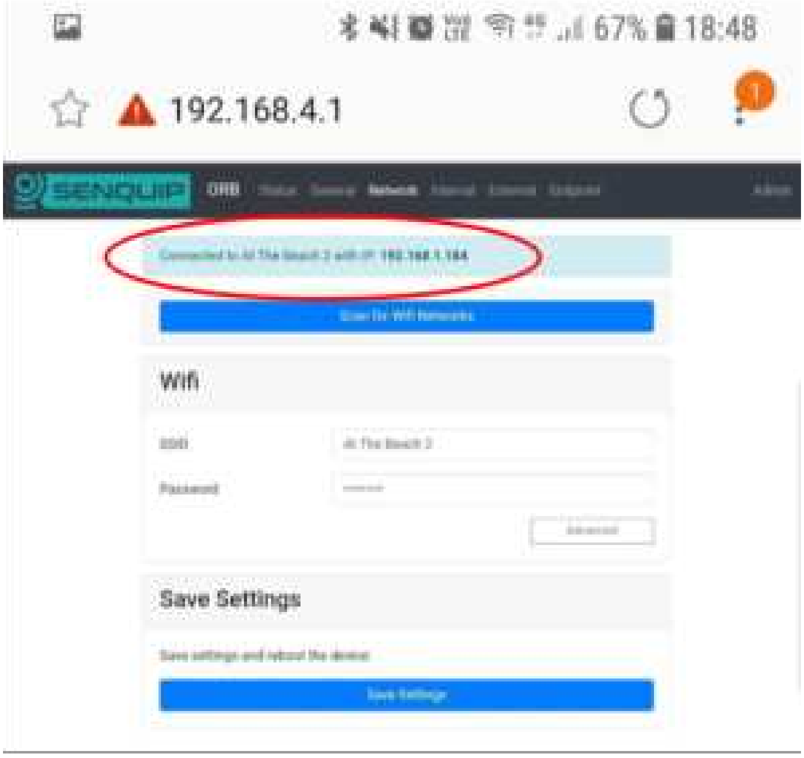


Figure 8.3. Note the IP address on your network

Further Wi-Fi settings are available by selecting the *Advanced* option. Once selected, a static IP address, netmask, gateway and DNS server can be specified.

The integrated web-server is normally only active in setup mode; it can however be made to be always on by setting the web setting to ON. This may be an advantage in systems where permanent power is available and the user wants to be able to make remote changes directly on the Senquip QUAD without having to access the Senquip Portal. Keeping the web-server active will require that the device remain awake at all times but does mean that the user can make instant changes to settings and see the latest measured data.



Connected to At The Beach 2 with IP: 192.168.1.184

Wifi

SSID: At The Beach 2

Password: ••••••••

Save Settings

Save settings and reboot the device

Figure 8.4. Access via local IP

When connected to a Wi-Fi network, the Senquip QUAD may need to be able to make outgoing connections to remote services. To allow the device to make connections, some ports need to be enabled for outgoing connections on your Wi-Fi network.

Function	Port Number	Description
NTP Time	123	To be able to correctly timestamp measured data and for certain encryption functions the Senquip QUAD needs to know time accurately. Time is accessed by connecting to an NTP server on this port.
MQTT to Senquip Portal	8883	Secure communications with the Senquip Portal are established on this port.
OTA update	80, 443	Over the Air (OTA) is a method by which the Senquip QUAD software can be remotely updated. To enable remote software upgrades, outgoing connections need to be enabled on this port.

8.3.1 Wi-Fi settings

A full list of Wi-Fi settings is given in the table at the end of the chapter.

8.4 Connecting to a mobile network

Once in setup mode, use the Network page to connect the Senquip QUAD to a mobile network.

In most cases only an APN will be required to establish a 4G LTE connection. Some service providers will require a username and password and some SIM cards will require a pin. If these are not needed, leave them blank.

For CAT-1 devices, an additional *Connection Mode* setting is available. This setting allows the selection of 4G or 2G, 3G, 4G mobile technology. 4G offers higher bandwidth and is recommended unless there are initial connection issues.

A *Roaming* option is available for SIM cards that offer connection to networks other that SIM card home network.

RSSI	Signal Strength	Meaning
0	-113dBm or less	Signal strength poor
1	-111dBm	Signal strength poor
2…30	-109… -53dBm	Medium signal strength
31	-51dBm or greater	Signal strength excellent

8.4.1 4G LTE settings

A full list of 4G LTE settings is given in the table at the end of the chapter.

8.5 Network settings

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

Name	Item	Function	Internal Reference
Wi-Fi			
Wifi	boolean	Connect to existing Wifi connection specified below.	wifi.sta.enable
SSID	text	Wifi SSID to connect to.	wifi.sta.ssid
Password	password	Wifi password to use for connection.	wifi.sta.pass
Static IP Address	text	Leave blank if assigned by DHCP.	wifi.sta.ip
Static Netmask	text	Leave blank if assigned by DHCP.	wifi.sta.netmask
Static Gateway	text	Leave blank if assigned by DHCP.	wifi.sta.gw
DNS Server	text	Leave blank if assigned by DHCP.	wifi.sta.nameserver
GSM			
GSM	boolean	Enable the GSM connection.	gsm.enable
APN	text	Access Point Name of mobile operator	gsm.apn
Username	text	Username for data connection. Leave blank if not specified	gsm.user
Password	text	Password for data connection. Leave blank if not specified	gsm.pass
Connection Mode	preset	Select mobile technology (CAT-1 devices only)	gsm.scan_mode
Roaming	boolean	Enable network roaming	gsm.roaming

Chapter 9

Endpoint Setup

When connected via Wi-Fi or 4G LTE, data measured by a Senquip QUAD can be sent to the Senquip Portal or a remote server or SCADA system, using UDP, HTTP, HTTPS, MQTT and MQTTS. The endpoint settings allow for configuration of the end server detail and the protocol used to communicate with that server.

9.1 Data security

Devices that connect to company networks and the internet need to be properly secured to mitigate risks and protect organisations from malicious cyber-attacks. Senquip takes the challenge of cyber-security seriously and utilises public-key-infrastructure as a part of their security solution to create a unique, trusted and protected identity for every Senquip QUAD.

Public Key Infrastructure certificates are an important part of developing a complete security solution. By authenticating devices, encrypting confidential data, and maintaining data and system integrity, certificates establish online trust and reliable security.

Authentication: Certificates for devices validate identities to make sure only authorized users, messages, or other types of servers have access to the device.

Encryption: A certificate creates an encrypted link and allows information to be transmitted privately.

Integrity: Certificates make sure that any messages or data transferred to and from Senquip devices are not altered.

To ensure the highest levels of each of the three levels of trust, Senquip uses a NIST validated, ultra-secure hardware crypto-element for key and certificate storage and cryptographic processing. The crypto-element is pre-loaded with certificates for Amazon Web Services (AWS), allowing for immediate, out-of-the box, secure communication with the Senquip Portal. Users can load additional certificates to allow secure communications with other servers, using the Senquip Portal.

Note For volume applications, Senquip can supply the Senquip QUAD pre-loaded with additional certificates.

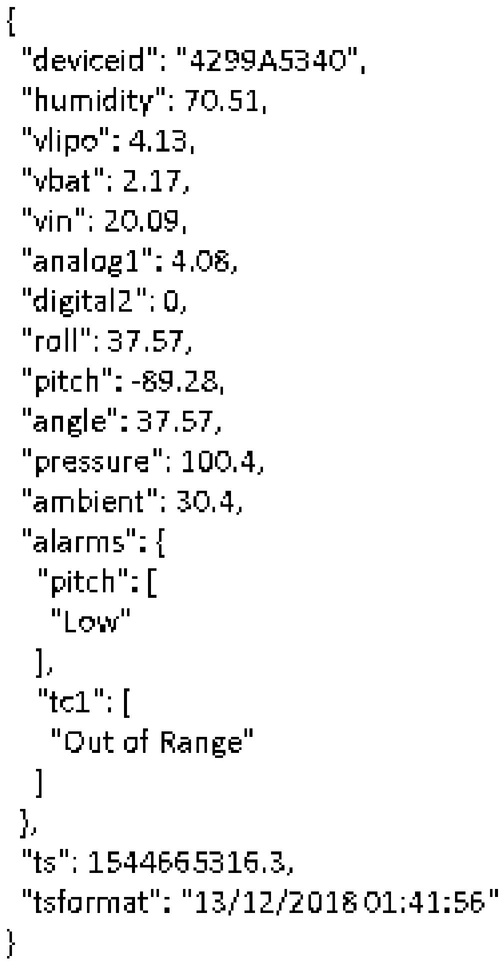
9.2 Data format

Data that is transmitted by the Senquip QUAD to a remote server is formatted in JSON format. JSON (JavaScript Object Notation) is a lightweight data-interchange format. It is easy for humans to read and write and it is easy for machines to parse and generate. It is based on a subset of the JavaScript Programming Language, Standard ECMA-262 3rd Edition - December 1999. JSON is a text format that is completely language independent but uses conventions that are familiar to programmers of the C-family of languages, including C, C++, C#, Java, JavaScript, Perl, Python, and many others. These properties make JSON an ideal data-interchange language.

JSON is built on two structures:

- A collection of name/value pairs. In various languages, this is realized as an object, record, struct, dictionary, hash table, keyed list, or associative array.
- An ordered list of values. In most languages, this is realized as an array, vector, list, or sequence.

An example data JSON packet as sent by a Senquip QUAD is shown below:



```
{
 "deviceid": "4299A5340",
 "humidity": 70.51,
 "vlipo": 4.13,
 "vbat": 2.17,
 "vin": 20.09,
 "analog1": 4.08,
 "digital2": 0,
 "roll": 37.57,
 "pitch": -89.28,
 "angle": 37.57,
 "pressure": 100.4,
 "ambient": 30.4,
 "alarms": {
  "pitch": [
   "Low"
  ],
  "tc1": [
   "Out of Range"
  ]
 },
 "ts": 1544665316.3,
 "tsformat": "13/12/2018 01:41:56"
}
```

Figure 9.1. Example JSON data packet

Users of the Senquip Portal do not need to understand the data format; data can be viewed on the Senquip Portal numerically or graphically or can be downloaded in spreadsheet format.

For users who are sending data to third party servers that require data in a format other that JSON, arbitrary data formats can be scripted on the Senquip device. Application notes are provided that detail the scripting of custom data packet formats for connection to common third party platforms. Further information on scripting for Senquip devices can be found in the Senquip Scripting Guide.

9.3 Data buffer

Where neither Wi-Fi or 4G LTE networks can be found, the Senquip QUAD can store up to 10 MB of messages to internal memory for later transmission when a network becomes available. When the internal memory is full, the device stop logging. Once network connectivity is established, the most recently stored data will be transmitted first.

9.4 UDP

Data can be sent via raw UDP to a fixed IP address and port. This method is only suitable for a local network Wi-Fi connection as the data is not encrypted and there is no authentication. Raw UDP also provides no acknowledgment that data was received.

9.5 HTTP

An HTTP session is a sequence of network request-response transactions. The Senquip QUAD initiates a request by establishing a HTTP connection on a particular port on a client server (typically port 80, occasionally port 8080).

9.6 HTTPS

HTTPS is the secure version of HTTP and is sometimes referred to HTTP over TLS. The 'S' at the end of HTTPS stands for 'Secure'. It means all communications between your browser and the website are encrypted. Wherever possible, HTTPS should be used as an alternative to HTTP.

HTTPS requires that the certificate-authority (CA) certificate of the destination be loaded onto the Senquip QUAD.

Note for volume applications, devices can be pre-configured with CA certificates to allow secure communications with a customer server.

9.7 MQTT

MQTT is a secure machine-to-machine (M2M) Internet of Things connectivity protocol specifically designed for low data-rate applications and is perfect for implementation on Senquip devices. MQTT is the protocol used when the Senquip QUAD communicates with the Senquip Portal and is also supported by many open source IoT platforms such as Thingsboard.

Note Senquip devices can maintain concurrent MQTT connections to the Senquip portal and a customer server or SCADA system.

Consideration must be given to data security on open networks. In applications where data security is critical, the use of MQTTS with encryption and authentication should be considered.

9.8 MQTT over TLS

MQTT over TLS (MQTTS) adds enhanced security as all data is encrypted and secured with SSL certificates. Most business grade IoT platforms such as AWS (Amazon Web Services) offer MQTTS.

MQTTS is recommended by Senquip as the preferred protocol for use with the Senquip QUAD as it offers a low power, reliable, secure connection. The Senquip QUAD is pre-loaded with certificates allowing secure communication with the Senquip Portal.

Note For volume applications, devices can be pre-configured with additional certificates to allow secure communications with a customer server or SCADA system.

9.9 Settings

UDP, *TCP* and *HTTP* connections require an IP address of the host server and a port on which the host server is listening. Secure protocols like *MQTTS* and *HTTPS* require certificates to be loaded on the device. The Senquip QUAD is pre-loaded with certificates that allow connection to the Senquip Portal that is hosted on Amazon Web Services. Certificates for customer servers can be uploaded using the Senquip Portal.

All messages are time-stamped using the UNIX time standard. Unix time (also known as POSIX time or UNIX Epoch time) is a system for describing a point in time, defined as the number of seconds that have elapsed since 00:00:00, Thursday, 1 January 1970. Every day is treated as if it contains exactly 86400 seconds, so leap seconds are not applied. UNIX time is used to timestamp messages as it is used widely in Unix-like and many other operating systems and file formats.

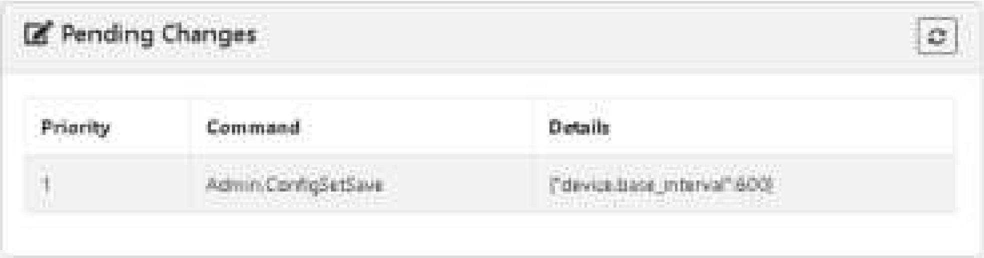
The Senquip QUAD automatically updates time by accessing a Network Time Protocol (NTP) server. By default the device will get the time via NTP from pool.ntp.org, on whatever network connection is available (Wi-Fi or 4G LTE). It does this if the time is not valid, for instance, after a reset, and then every 12 hours thereafter. Between updates, time is kept with a high precision real-time clock that is powered by the internal LiPo battery.

Although UNIX time is easy for computer systems to use, it is not easily human readable. If a human readable time-stamp is required, set the *timestamp* setting to ON, in which case, the device will insert an additional time and date field, formatted in human readable format, as below:

DD/MM/YYYY, hh:mm:ss for example: 27/06/2018, 17:30:15

Time is UTC (coordinated universal time); no offsets are applied for local time-zones. The Senquip Portal will apply local time offsets as specified by the settings on your computer.

The Senquip Portal can be used to update settings on the Senquip QUAD remotely. Each time the device makes contact with the Senquip Portal (for example to transmit measurements), the device will check for any settings changes. If there are changes to settings, these will be downloaded and applied. Pending configuration changes are listed on the settings pages on the Senquip Portal.



Pending Changes

Priority	Command	Details
1	Admin.ConfigSetSave	{"device.base_interval":600}

Figure 9.2. Pending change where the base interval has been changed to 600 seconds

If the Senquip QUAD is configured to send data to a 3rd party server, the device will by default contact the Senquip Portal to check for settings updates once a day. Set the *Configuration via Senquip Portal* to OFF to prevent the device from contacting the Senquip Portal to check for settings. This setting may be used where power consumption is critical such as when AA batteries are being used an a very long battery life is required.

Warning Disabling *Configuration via Senquip Portal* will mean that no settings or firmware updates will be able to be performed remotely using the Senquip Portal.

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

Name	Item	Function	Internal Reference
Data Endpoints			
Configuration via Senquip Portal	boolean	Enables connection to Senquip Portal for remote configuration.	endpoint.config_to_portal
Send Data to Senquip Portal	boolean	Enables data from the device to be sent to the Senquip Portal.	endpoint.data_to_portal
Offline Buffer	boolean	Save data if device is offline, and send when network is available.	endpoint.buffer_enable
Add Formatted Time	boolean	This option adds a human readable time/date format to the data output.	endpoint.addtimedate
Report Network Info	boolean	Add network details and signal strength to data output.	endpoint.network_report
UDP			
UDP	boolean	Enables sending data over UDP to specified address below.	endpoint.udp.enable
UDP Address	text	Address and port to send data to.	endpoint.udp.address
HTTP			
HTTP POST	boolean	Enables sending data via a HTTP POST request to address below.	endpoint.http.enable
HTTP Address	text	Destination address and port for HTTP POST request.	endpoint.http.address
MQTT			
MQTT	boolean	Enables sending data to a MQTT broker.	endpoint.mqtt.enable
Broker Address	text	MQTT Broker Address and Port.	endpoint.mqtt.server
Client ID	text	Client ID to send to the broker. Defaults to device.id if left blank.	endpoint.mqtt.client_id
Username	text	Username for MQTT authentication with username/password. (Optional)	endpoint.mqtt.user
Password	text	Password for MQTT authentication with username/password. (Optional)	endpoint.mqtt.pass

Chapter 10

Senquip Portal

The Senquip Portal is Senquip's secure cloud solution that is powered by Amazon Web Services (AWS). The portal allows for:

- numerical and graphical viewing of current data,
- long term data storage,
- remote modification of settings,
- remote updates to firmware,
- event forwarding,
- user account management.

By default, access to the Senquip Portal is enabled; it is highly recommended that users retain this setting. If disabled, device settings may not be able to be changed remotely and important firmware changes will not be able to be performed. Two instances where access to the portal may disabled are in very power battery operated applications and where the device is connected to an alternate server.

> **Warning** Disabling communication with the Senquip Portal will mean that no settings or firmware updates will be able to be performed remotely using the Senquip Portal.

Connection with the Senquip Portal is achieved using an MQTT connection. To ensure the highest levels data security, Senquip uses a NIST validated, ultra-secure hardware crypto-element for key and certificate storage and cryptographic processing. The crypto-element is pre-loaded with certificates for AWS, allowing for immediate, out-of-the box, secure communication with the Senquip Portal.

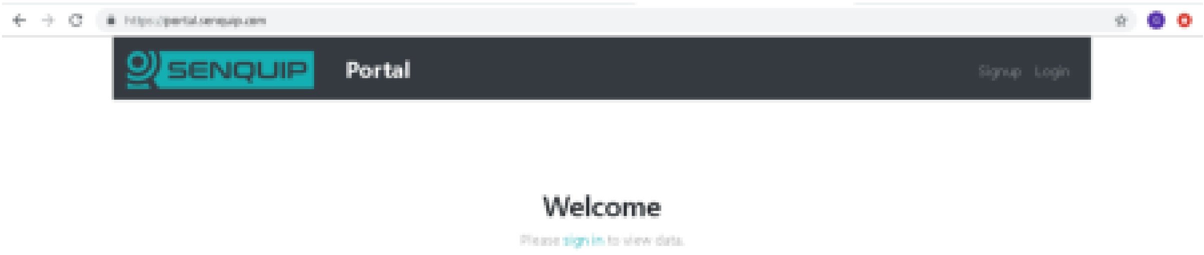
10.1 Using the Senquip Portal

This section describes the various features of the Senquip Portal and how to use them.

10.1.1 Login to the Senquip Portal

The Senquip Portal can be accessed at: https://portal.senquip.com/. At the welcome page, you will need to *Login* or *Sign Up* to access the portal. If you choose sign-up, you will be asked for your email address, name and a password.

Note Password must be at least 8 characters and contain uppercase letters, lowercase letters and numbers.



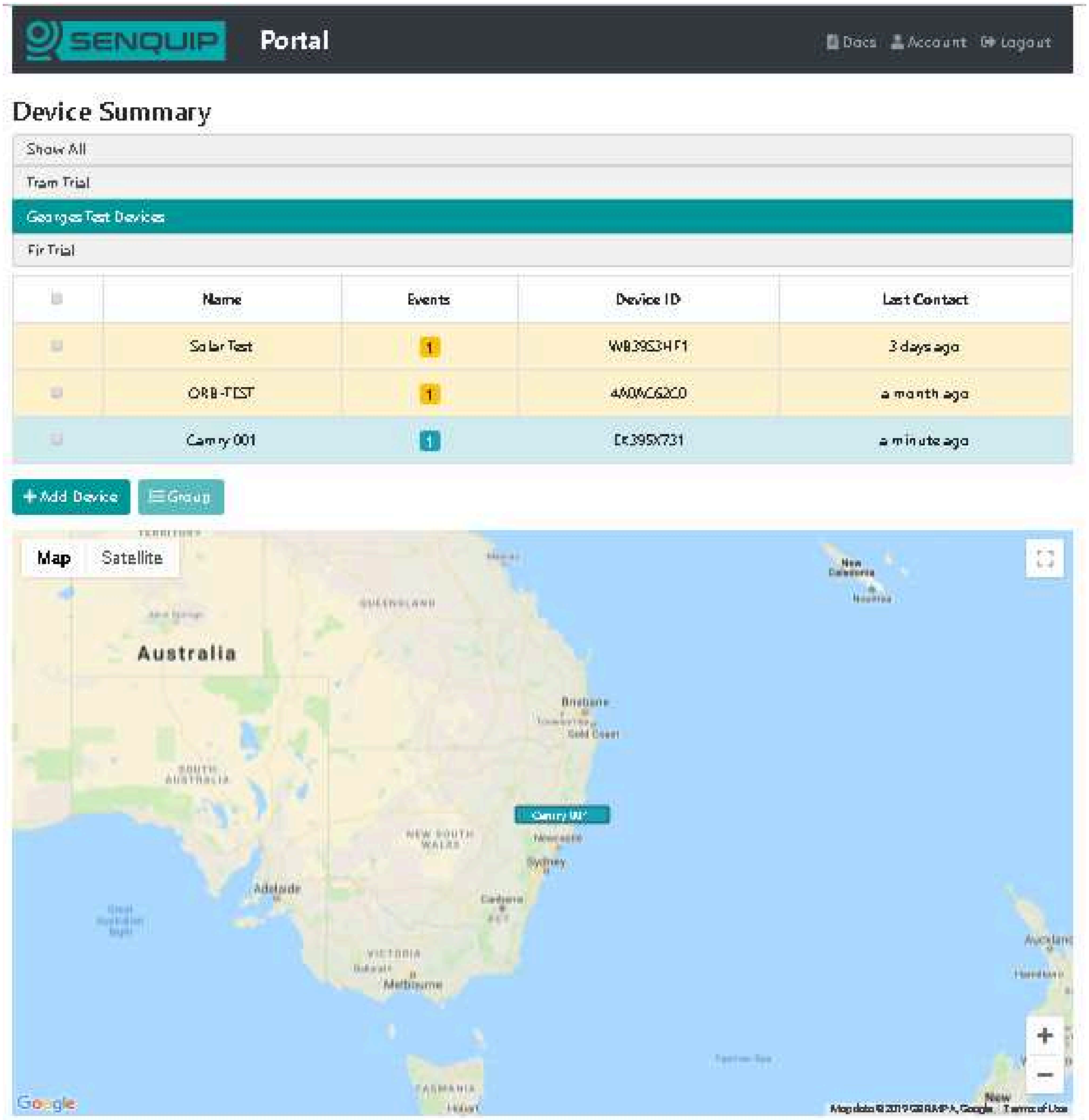
Welcome

Please sign in to view data.

Figure 10.1. Welcome to the Senquip Portal

10.1.2 Device Summary

Once logged-in, on the summary page, a list of all devices associated with your account is shown. From the summary page, new devices can be added to your account, and can be grouped into logical categories. Where GNSS on a device is enabled, that device will be shown on a map below the list of devices. Note that where exceptions are present, they will be shown in the *Events* column; to see detail on the exceptions, select the device. In the *Contact* column, the time since last successful contact is shown; use this column to check that all devices are communicating as expected.



Device Summary

Show All

Tram Trial

Georges Test Devices

Fir Trial

□	Name	Events	Device ID	Last Contact
□	Solar Test	1	WB39S3HF1	3 days ago
□	ORB-TEST	1	4A0AC62C0	a month ago
□	Camry 001	1	EK395X731	a minute ago

Figure 10.2. View or add Senquip devices

To add a device, click on the *+Add Device* button. You will be asked for the ID and password associated with the Senquip device. Enter the details and press *Submit*. The device will be added to the list of devices available on your user.

Note The Device ID should look something like 7DA540190.

10.1.3 View Device Data

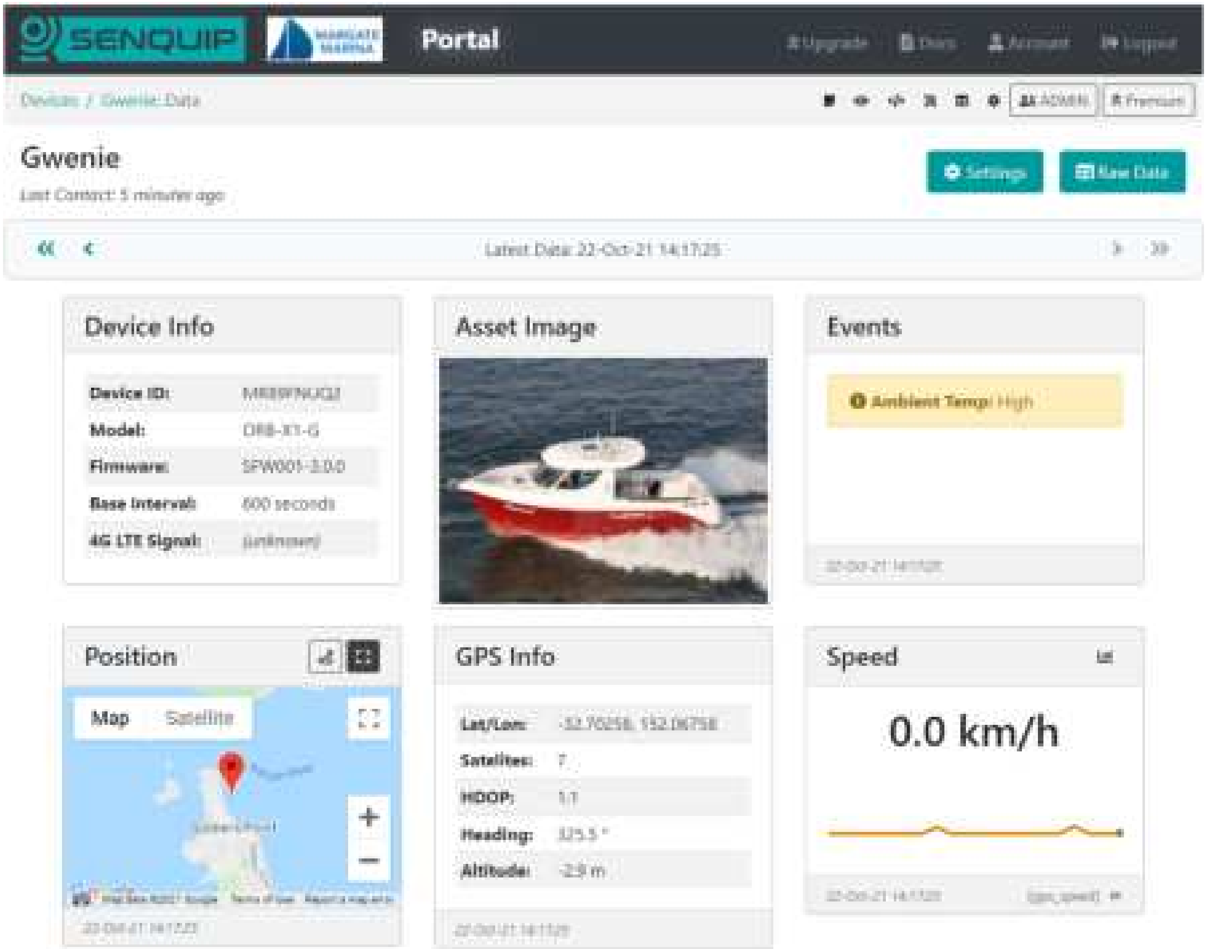
View the data associated with a Senquip device by clicking on the device *Name* or *Device-ID*. After a few seconds, a dashboard associated with the selected device will appear. The dashboard is user customisable in the following ways:

- Widgets can be turned off so that they do not show on the dashboard.
- Widgets can be re-ordered to change the order in which they are displayed.

- An image associated with the machine or system being monitored can be added.
- A company logo can be added.

Only sensor interfaces that are enabled and have transmitted data recently will be displayed on widgets. Any exceptions currently being experienced will be shown in the *Events* widget. Information associated with the selected device such as the model number and firmware version will be shown in the *Device Info* widget.

Note Any alerts, warnings or alarms currently present on the selected device will be shown in the Events widget on the dashboard.



Devices / Gwenie: Data

Gwenie

Last Contact: 5 minutes ago

Latest Data: 22-Oct-21 14:17:25

Device ID:	MR89FNUQ2
Model:	ORB-X1-G
Firmware:	SFW001-3.0.0
Base Interval:	600 seconds
4G LTE Signal:	(unknown)

Ambient Temp: High

22-Oct-21 14:17:25

22-Oct-21 14:17:23

Lat/Lon:	-32.70256, 152.06758
Satellites:	7
HDOP:	1.1
Heading:	325.5 °
Altitude:	-2.9 m

22-Oct-21 14:17:25

0.0 km/h

22-Oct-21 14:17:25

Figure 10.3. Senquip device dashboard

Click on the icon at the top right of each widget to show the data on a graph. Data on the graph can be selected for time periods of an hour, day, week, or custom. Click on a point on the chart to show values at that point.

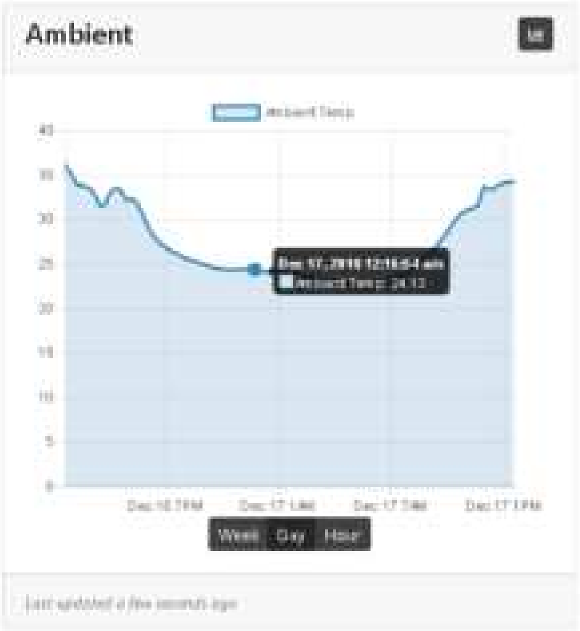


Figure 10.4. Example chart showing the days temperature

Data measured by Senquip devices can be visualised in various formats. To change the format in which data is visualised, press the eye icon on the bottom right of the tile. Formats available are:

- Hidden - Hide the data if it is not relevant to the application
- Trendline - The default graph that facilitates recognition of change. Allows the user to view longer term trends between date ranges.
- Gauge - Useful when representing measurements that must exist within a range. Can be scaled so that the pointer is vertical under normal conditions. Warning and alarm levels can be set.
- Digital - A simple ON or OFF display that shows the status of a measurement. The threshold at which the display switches from ON to OFF can be set.

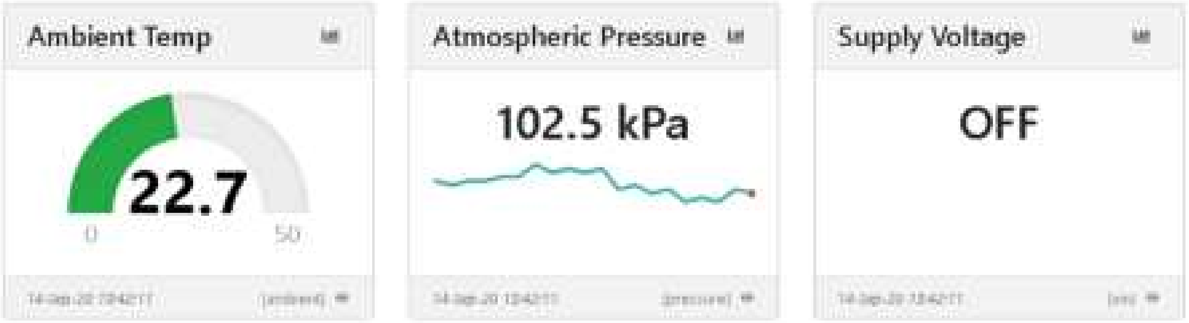


Figure 10.5. Data visualisation in different formats

Buttons can be added to a dashboard that allow user to trigger events on remote devices. When the buttons are pressed, next time the remote device makes contact with the Portal, a user script is triggered to run on the remote device.

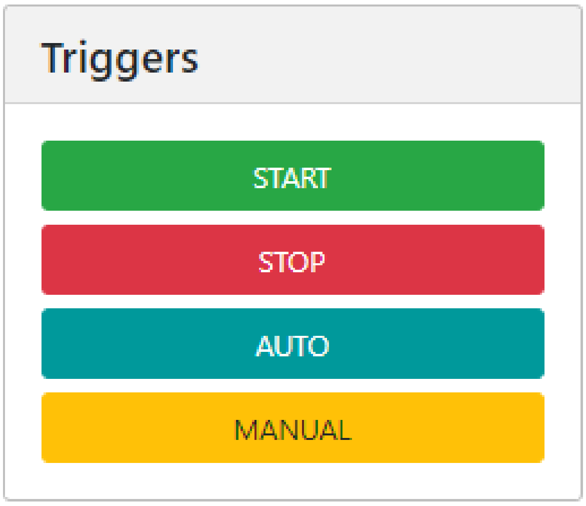


Figure 10.6. Buttons to trigger remote operations

From the device dashboard, the user can navigate to the settings, raw data, display settings and other pages.

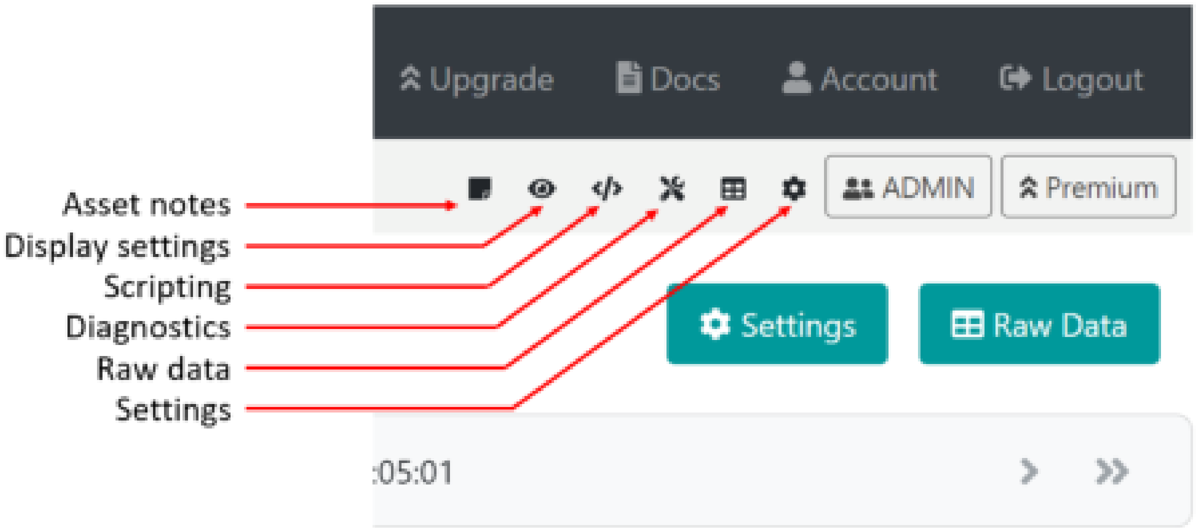


Figure 10.7. Navigate to device configuration pages

Asset notes allows the user to add an image of the system being monitored, add install images, other notes, and a company logo. Display settings allows the user to turn widgets on and off and re-order the widgets. The scripting icon passes the user to the JavaScript editor to enable scripts to be written for Senquip devices. Raw data allows the user to display and then download historic data in csv format. The settings icon takes the user to the device settings pages. Not all of the icons will be available to all users. For instance, the scripting icon will not show up for users who do not have access to scripting.

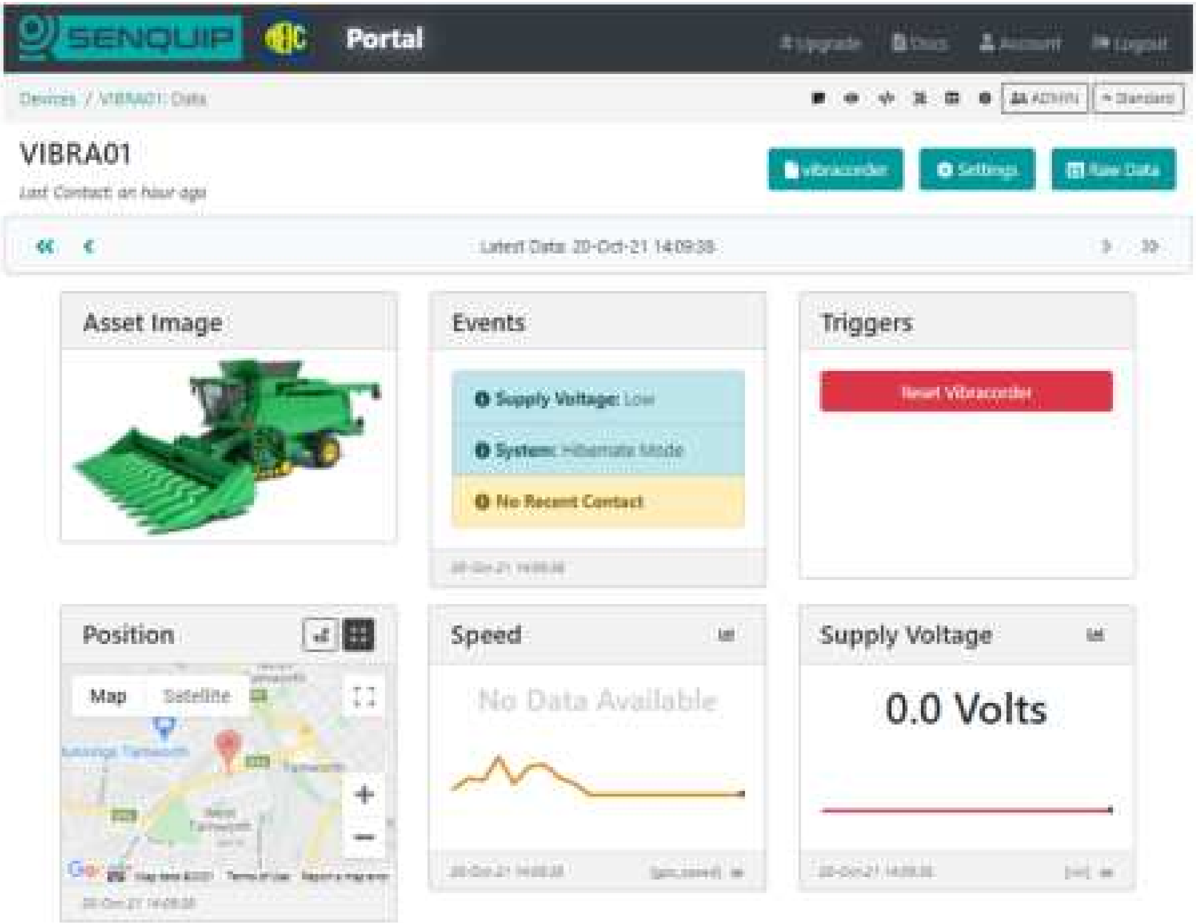
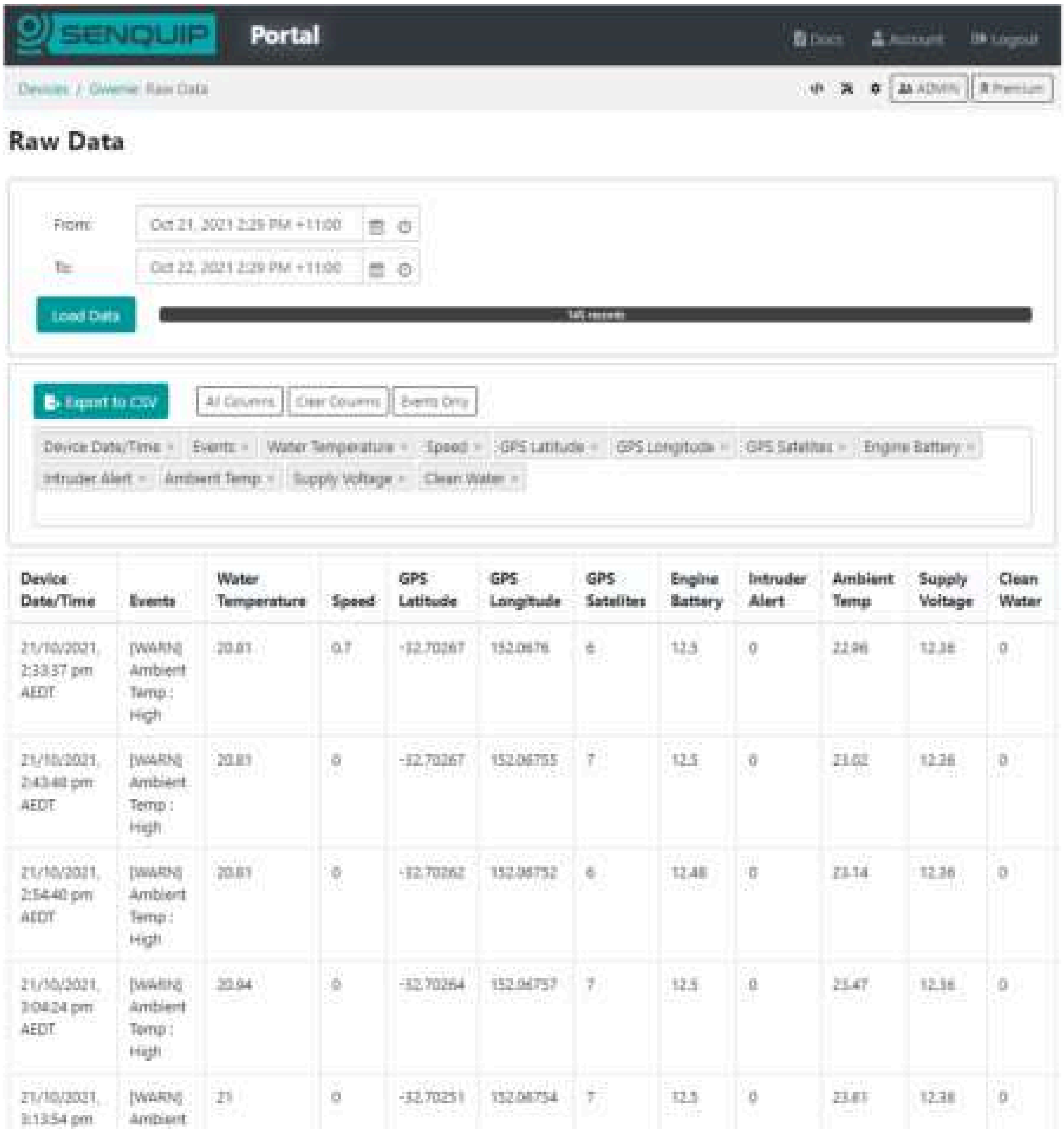


Figure 10.8. Dashboard with an image showing the system being monitored

10.1.4 Historical Data

To view or download historical data, press the *Raw Data* button on the top right of the dashboard. A table showing all the data associated with the selected device will be shown. To download the data, press the *Export to CSV* button. The data will be saved to your downloads folder. The downloaded file can be opened and manipulated with any spreadsheet tool.



Raw Data

From: Oct 21, 2021 2:29 PM +11:00

To: Oct 22, 2021 2:29 PM +11:00

Device Date/Time × Events × Water Temperature × Speed × GPS Latitude × GPS Longitude × GPS Satellites × Engine Battery × Intruder Alert × Ambient Temp × Supply Voltage × Clean Water ×

Device Date/Time	Events	Water Temperature	Speed	GPS Latitude	GPS Longitude	GPS Satellites	Engine Battery	Intruder Alert	Ambient Temp	Supply Voltage	Clean Water
21/10/2021, 2:33:37 pm AEDT	[WARN] Ambient Temp : High	20.81	0.7	-32.70267	152.0676	6	12.5	0	22.96	12.38	0
21/10/2021, 2:43:48 pm AEDT	[WARN] Ambient Temp : High	20.81	0	-32.70267	152.06755	7	12.5	0	23.02	12.38	0
21/10/2021, 2:54:40 pm AEDT	[WARN] Ambient Temp : High	20.81	0	-32.70262	152.06752	6	12.48	0	23.14	12.38	0
21/10/2021, 3:04:24 pm AEDT	[WARN] Ambient Temp : High	20.94	0	-32.70264	152.06757	7	12.5	0	23.47	12.36	0
21/10/2021, 3:13:54 pm	[WARN] Ambient	21	0	-32.70251	152.06754	7	12.5	0	23.61	12.38	0

Figure 10.9. Data associated with the selected device shown in a table

Note The timestamp in the *timestamp* column is in Unix Time; if you would like a GMT date and time field, enable the timestamp setting in endpoint settings.

10.1.5 User Administration

Use the *Admin* button to manage the users of each Senquip device. When a device is added to an account using the device ID and password, the user that added the device automatically becomes an admin for that device. Admin users can manage other user rights and have full permissions for the device. The different user types are detailed in the table below:

Allowed Permission	Admin	User	Operator	View
View data	Yes	Yes	Yes	Yes

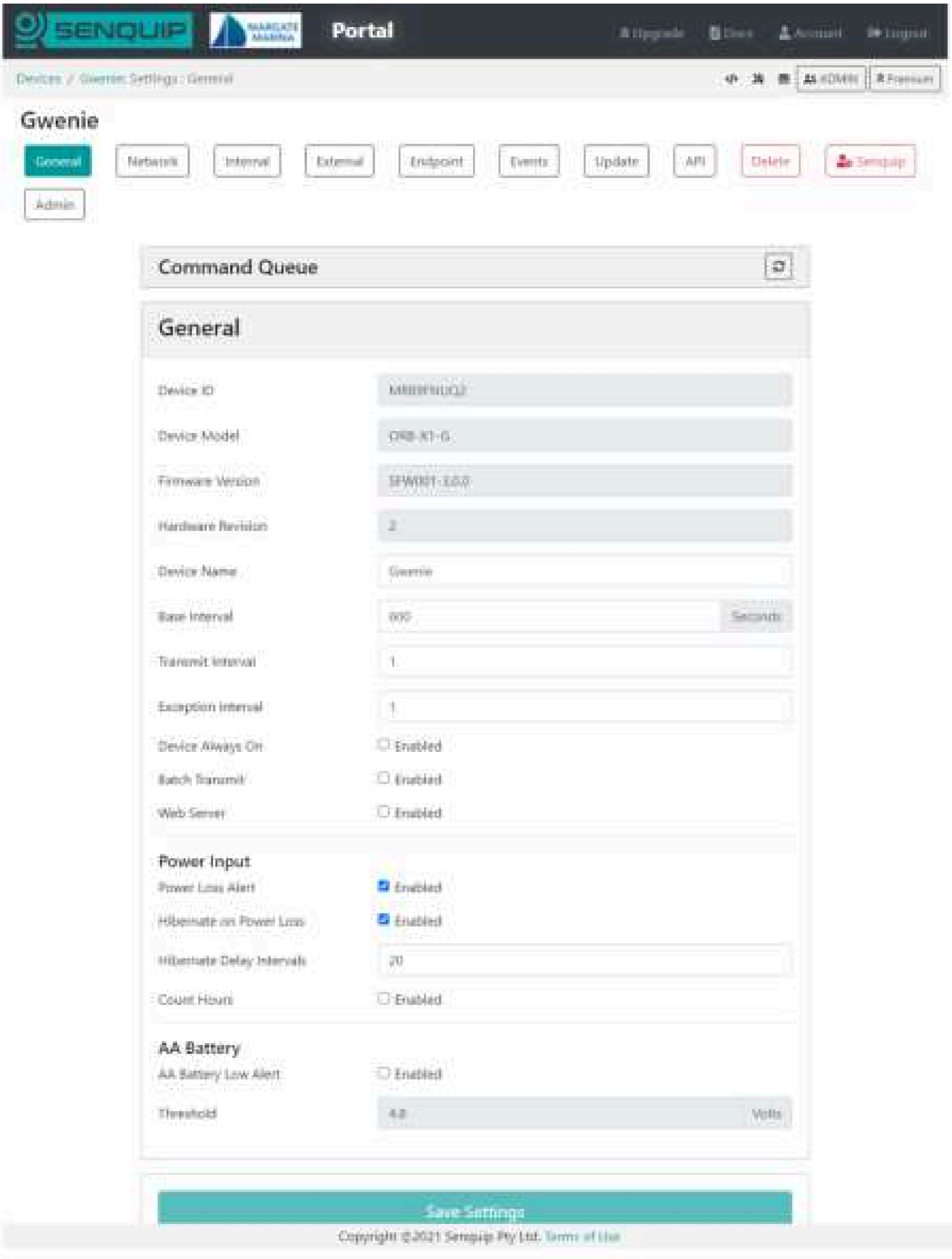
Trigger device actions	Yes	Yes	Yes	
View users	Yes	Yes		
Change device settings	Yes	Yes		
Add/remove users	Yes			

Warning Anyone who has the device ID and setup password can add the device to their account with Admin permissions.

10.1.6 Configuration via Senquip Portal

Settings associated with a Senquip device can be updated remotely via the Senquip Portal. To change the settings for a selected device, press the *Settings* button on the top right of the dashboard. The selected device settings will be shown and can be changed by clicking in the relevant fields. Once a setting has been changed, press the *Save Settings* button at the bottom of the page.

Senquip devices check for settings changes each time they make a connection to the Senquip Portal. If a device is set to transmit data once an hour, then the settings will be changed up to an hour after the changes have been made on the portal. If quicker changes are required, the device will need to be visited and the changes made via the integrated webserver in setup mode.



Gwenie

Command Queue

General

Device ID	M889FNUQ2
Device Model	ORB-X1-G
Firmware Version	SFW001-3.0.0
Hardware Revision	2
Device Name	Gwenie
Base Interval	600 Seconds
Transmit Interval	1
Exception Interval	1
Device Always On	☐ Enabled
Batch Transmit	☐ Enabled
Web Server	☐ Enabled

Power Input

Power Loss Alert	☑ Enabled
Hibernate on Power Loss	☑ Enabled
Hibernate Delay Intervals	20
Count Hours	☐ Enabled

AA Battery

AA Battery Low Alert	☐ Enabled
Threshold	4.0 Volts

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Figure 10.10. Remote update of device settings via the Senquip Portal

Note In applications where power is available, a quicker transmit interval will mean that settings changes can be made more quickly.

10.1.7 Remote Firmware Updates

Senquip will routinely make firmware updates to enable new features, enhance security and fix bugs.

Device firmware can be updated via the Senquip Portal. To update the firmware, press the *Update* button on the settings page. You will be directed to a page asking for the firmware number. This number can be found in the Device Firmware Changelist on the Senquip website or through your preferred distributor.

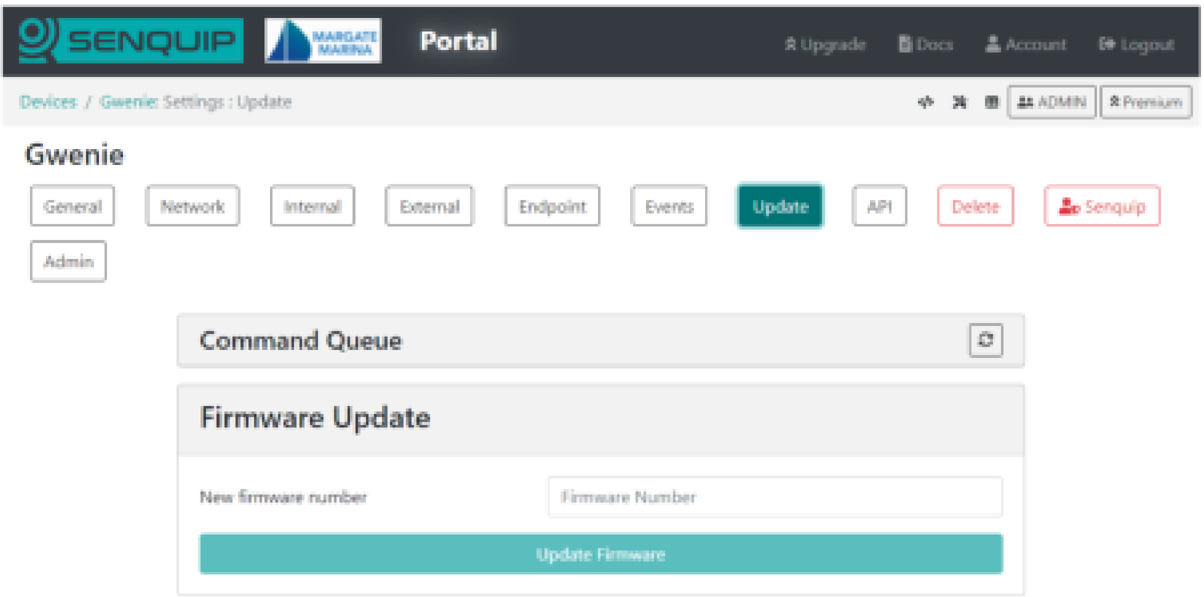


Figure 10.11. Remote firmware updates via the Senquip Portal

A Firmware Update typically takes about 5 minutes on Wi-Fi and 20 minutes on 4G LTE. During the update the green light will be off and the orange light will flash fast. Once the device has received the firmware update and is processing it, the lights may appear to freeze. This is normal behaviour. Please allow plenty of time for the device to finish the update and return to normal operation.

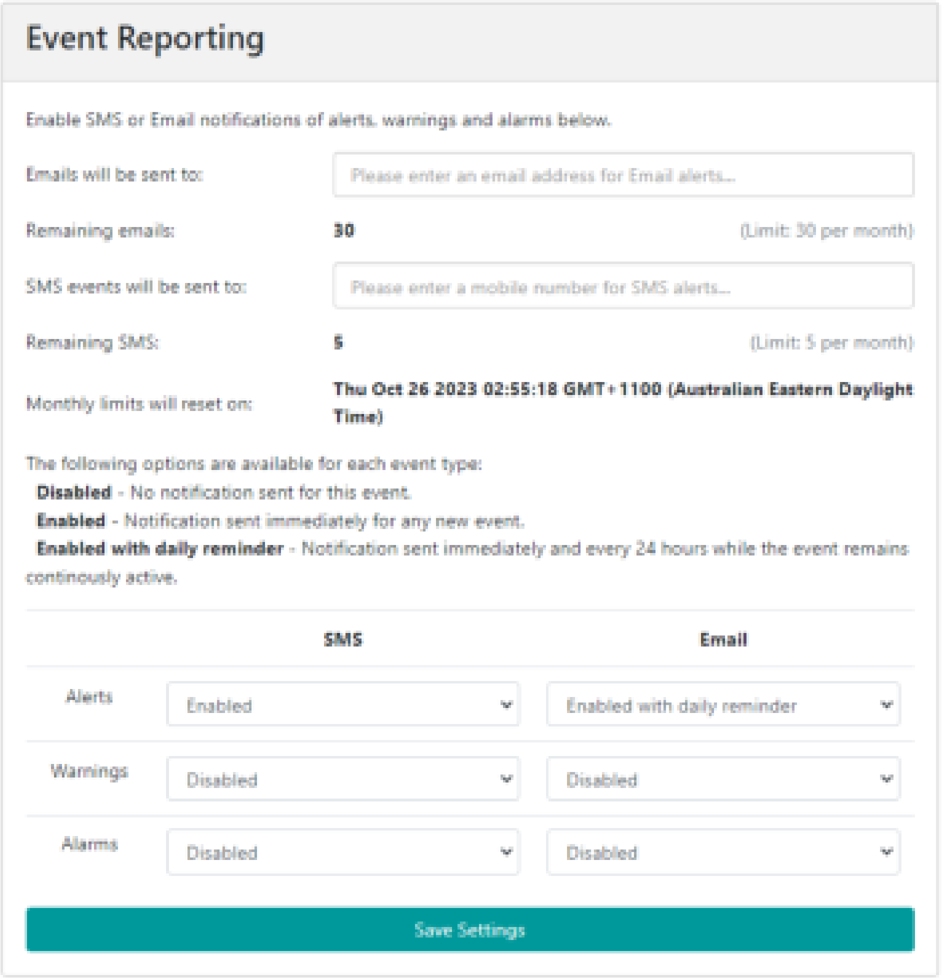
Note There is always a risk that something may go wrong during a firmware update; it is not recommended that firmware be updated unless it is suggested by Senquip or a specific new feature is required.

Note Under some circumstances, output states may change during firmware updates.

10.1.8 Event Reporting

The Senquip Portal allows forwarding of alert, warning, and alarm events generated on a device to email or SMS endpoints. A Hosted plan is required for this feature. Use the *Events* page on the Senquip Portal to configure event reporting. Events can be configured to be sent once as they occur, or with a daily reminder.

Warning Make sure to add *no-reply@senquip.com* to your safe senders list on you email client to prevent email events from going into spam or junk folders.



Event Reporting

Enable SMS or Email notifications of alerts, warnings and alarms below.

Emails will be sent to:	Please enter an email address for Email alerts...	
Remaining emails:	**30**	(Limit: 30 per month)
SMS events will be sent to:	Please enter a mobile number for SMS alerts...	
Remaining SMS:	**5**	(Limit: 5 per month)
Monthly limits will reset on:	**Thu Oct 26 2023 02:55:18 GMT+1100 (Australian Eastern Daylight Time)**	

The following options are available for each event type:
Disabled - No notification sent for this event.
Enabled - Notification sent immediately for any new event.
Enabled with daily reminder - Notification sent immediately and every 24 hours while the event remains continously active.

	SMS	Email
Alerts	Enabled	Enabled with daily reminder
Warnings	Disabled	Disabled
Alarms	Disabled	Disabled

Figure 10.12. Configure event forwarding

If an event is current, and the event escalates, for example a warning turns into an alarm, the more severe event will be forwarded. If an event is current and it de-escalates, for an example, an alarm turns into a warning, the event will not be forwarded. If a type of event is current, and a new type of event occurs, the new event will be forwarded. For instance, if a high current warning is active and has been forwarded to email or SMS, and a high temperature warning becomes active, the high temperature warning will also be forwarded.

10.2 Management and Hosting on the Senquip Portal

The Senquip Portal offers hosting of data, a data visualisation dashboard, firmware upgrades, and device management including remote configuration and scripting. Every Senquip device purchased comes with a *managed* plan for the life of the product (10 years). *Managed* plans allow remote configuration and scripting on the Senquip Portal. Users have the option of purchasing a *hosted* plan to enable data hosting and data visualisation on the Senquip Portal. Hosted plans are available on a monthly, yearly, or lifetime basis (10 years), and can be purchased directly off the Senquip Portal or through distributors.

10.2.1 Basic

Managed plans are most suitable for users who are hosting their data on their own server and have their own dashboards. Features of the management plan include:

- Configure devices from the Senquip Portal
- Connection to a private server
- View current data
- 5 Minute updates to the Senquip Portal
- 1 Day of data storage
- Device Scripting
- Access for 3 users
- Firmware updates

10.2.2 Hosted

Hosted plans are for users who will use the Senquip Portal to store and visualise their data. Features of the hosted plan include:

- Configure devices from the Senquip Portal
- Connection to a private server
- View current and historical data
- 5 second data update limit
- 2 years of data storage
- Device scripting
- Senquip Portal access for 20 users
- Firmware updates
- Export raw data
- Trigger remote actions
- 300 email alerts per month
- 100 SMS alerts per month
- Senquip Cloud API access
- AEMP API access

Note Every device includes 90 days of hosted access from the date of activation.

For the most up to date feature list and to purchase a hosted plan, please visit the Senquip Portal or contact your preferred distributor.

Chapter 11

Mechanical Specification

11.1 Mechanical drawings

Critical dimensions for the Senquip QUAD are given below. Full three dimensional models are available on request.

Note All dimensions are in mm.

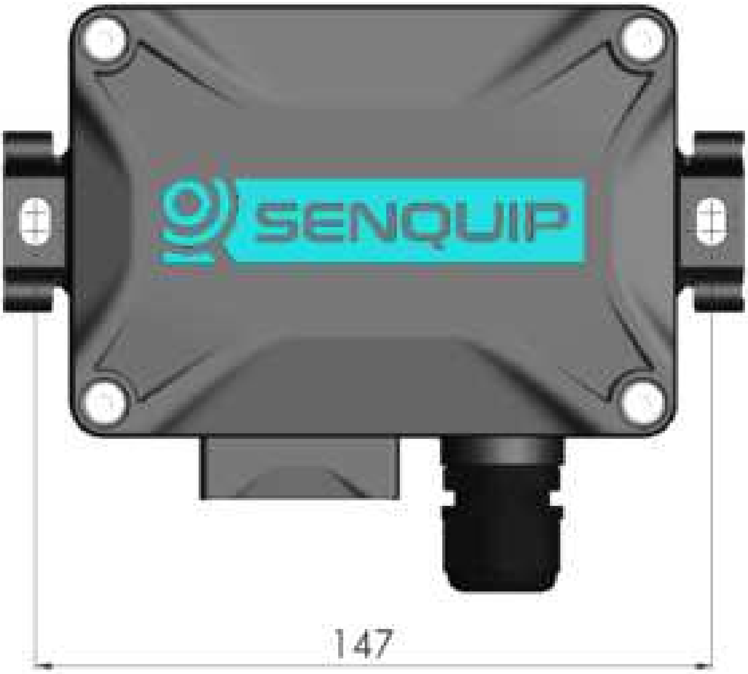


Figure 11.1. Dimensioned front view

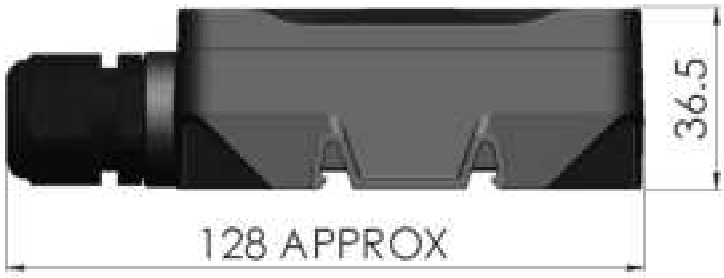


Figure 11.2. Dimensioned side view

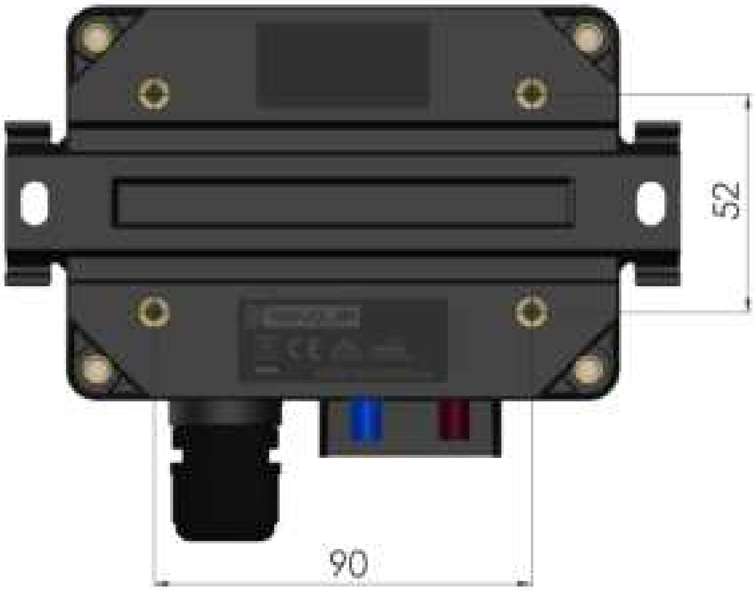


Figure 11.3. Dimensioned rear view

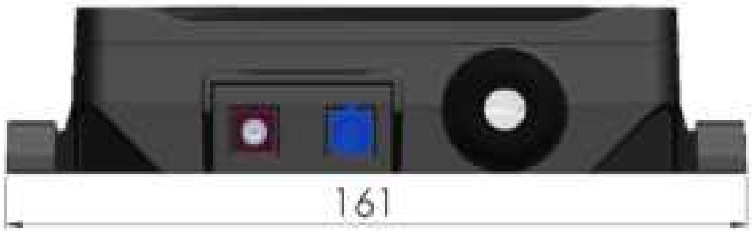


Figure 11.4. Dimensioned bottom view

11.2 Mechanical Fittings

The following screws and seals are used on the Senquip QUAD. Spare parts, if required are available from Senquip.

Location	Size	Length	Max depth	Fastening method
Screws				
Lid attachment	M5	To avoid hinge damage, only captive screws provided by Senquip are to be used.		3mm Allen key
Mounting	M5	8mm	9.5mm	3mm Allen key
PCB mounting	M3	10mm	10mm	T10 Torx key
Gland nut	AF24			
Seals				
O-ring		To maintaing the IP rating of the enclosure, only use o-rings that have been provided by Senquip.		
Gland	M20 x 1.5	To maintaing the IP rating of the enclosure, only use glands that have been provided by Senquip.		

11.3 Environmental

The Senquip QUAD is designed for use in harsh outdoor environments and is suitable for use in industrial, mining, fleet and agricultural applications.

The enclosure is rated to IPX7, meaning that it is dust tight, with no ingress of dust permitted and watertight against the effects of immersion of up to 1m for 30 minutes.

The chart below describes IP ratings and how to interpret them.

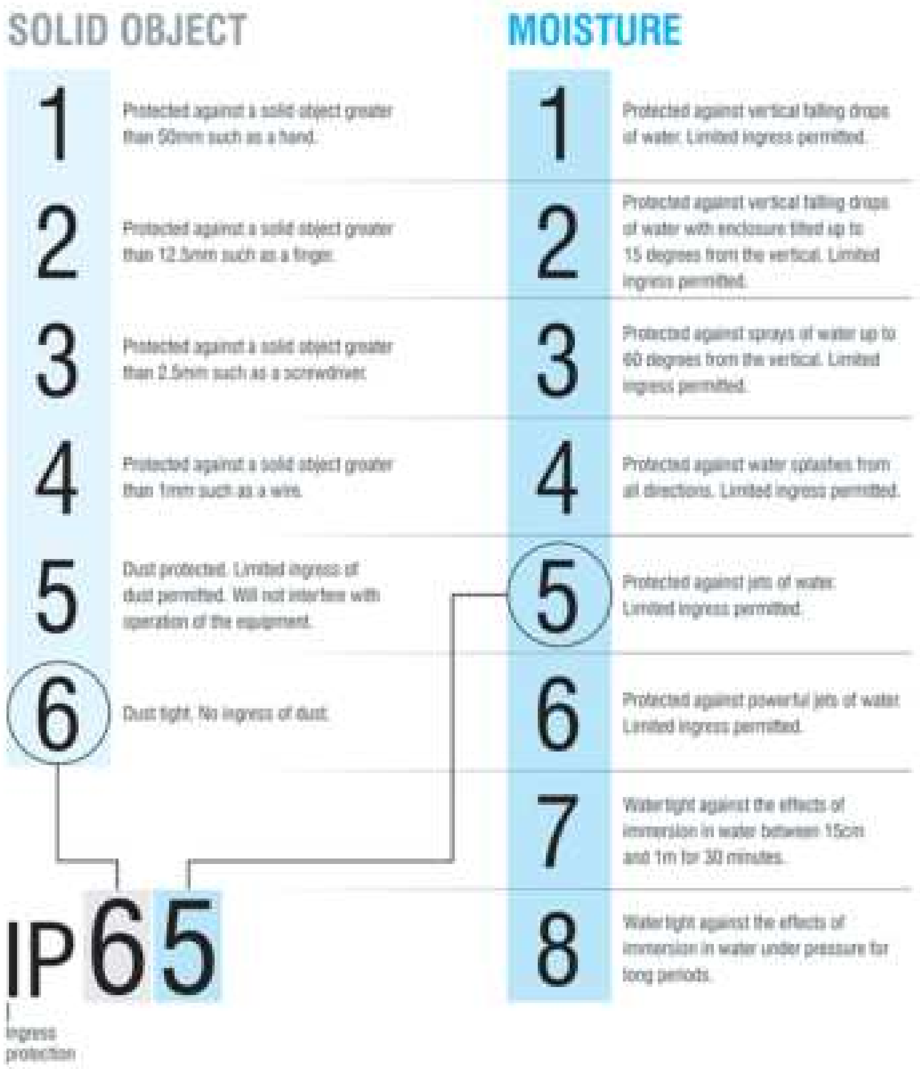

SOLID OBJECT
MOISTURE
1
Protected against a solid object greater than 50mm such as a hand.
2
Protected against a solid object greater than 12.5mm such as a finger.
3
Protected against a solid object greater than 2.5mm such as a screwdriver.
4
Protected against a solid object greater than 1mm such as a wire.
5
Dust protected. Limited ingress of dust permitted. Will not interfere with operation of the equipment.
6
Dust tight. No ingress of dust.
1
Protected against vertical falling drops of water. Limited ingress permitted.
2
Protected against vertical falling drops of water with enclosure tilted up to 15 degrees from the vertical. Limited ingress permitted.
3
Protected against sprays of water up to 60 degrees from the vertical. Limited ingress permitted.
4
Protected against water splashes from all directions. Limited ingress permitted.
5
Protected against jets of water. Limited ingress permitted.
6
Protected against powerful jets of water. Limited ingress permitted.
7
Water tight against the effects of immersion in water between 15cm and 1m for 30 minutes.
8
Water tight against the effects of immersion in water under pressure for long periods.
IP65
ingress protection

Figure 11.5. IP number description

The Senquip QUAD can be operated in temperatures between -40°C and 85°C however the internal Lithium-Ion-Polymer battery charging will be throttled at temperatures colder than -10°C and higher than 40°C.

An internal gore vent allows for pressure equalisation between the interior of the enclosure and the environment meaning that the Senquip QUAD can be shipped in non-pressurised environments such as some aircraft.

11.4 Material Specification

The enclosure and all fittings have been chosen to be resistant to salt spray and common industrial chemicals such as petro-carbons. UV stabilised materials have been chosen to allow mounting in direct sunlight.

Component	Material
Enclosure and front cover	Glass filled nylon
Enclosure front cover seal	Nitrile Butadiene Rubber (NBR)

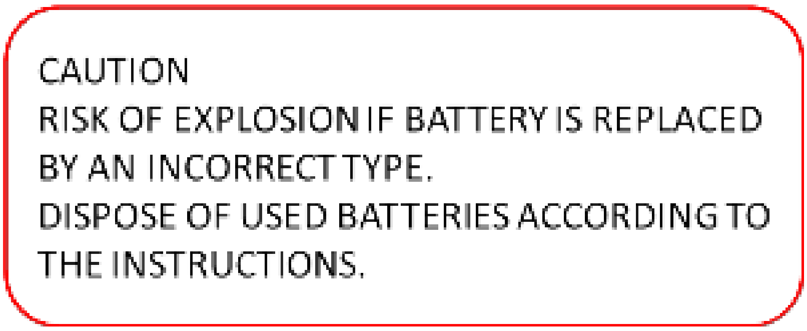
Captive cover screws	Stainless-steel (304)
Cable Gland	Polyamide
Gland insert	Nitrile Butadiene Rubber (NBR)
Antenna	ABS + PC

Chapter 12

Maintenance

The Senquip QUAD has been designed to require a minimum of maintenance. The only serviceable item is the internal LiPo backup battery.

12.1 Replacing the LiPo Battery



CAUTION
RISK OF EXPLOSION IF BATTERY IS REPLACED BY AN INCORRECT TYPE.
DISPOSE OF USED BATTERIES ACCORDING TO THE INSTRUCTIONS.

It is expected that the LiPo battery will have an in service life of 5 years. Factors that will reduce the life are:

- Exposure to temperatures above 55°C or below -10°C.
- Unusually high number of charge / discharge cycles.
- Being left in a discharged state for an extended period of time.

Replacement of the LiPo battery should only be performed by suitability trained service personnel. Only LiPo batteries supplied by Senquip should be used. Senquip LiPo batteries contain temperature sensing and protection circuitry to ensure safe operation of the Senquip QUAD.

Note Use of 3rd party batteries may cause damage to the unit and will void the warranty.

The LiPo battery is located under the user access panel inside the Senquip QUAD. To replace the LiPo battery, the following steps need to be completed:

- Un-fasten the 4 hex-head screws securing the cover using a 4mm hex bit. The screws are captive and will not fall out when loose. Do not attempt to remove the screws from the lid.
- When the lid is opened, an internal light detector will recognise the increase in brightness and will enable the LEDs and configuration switches.

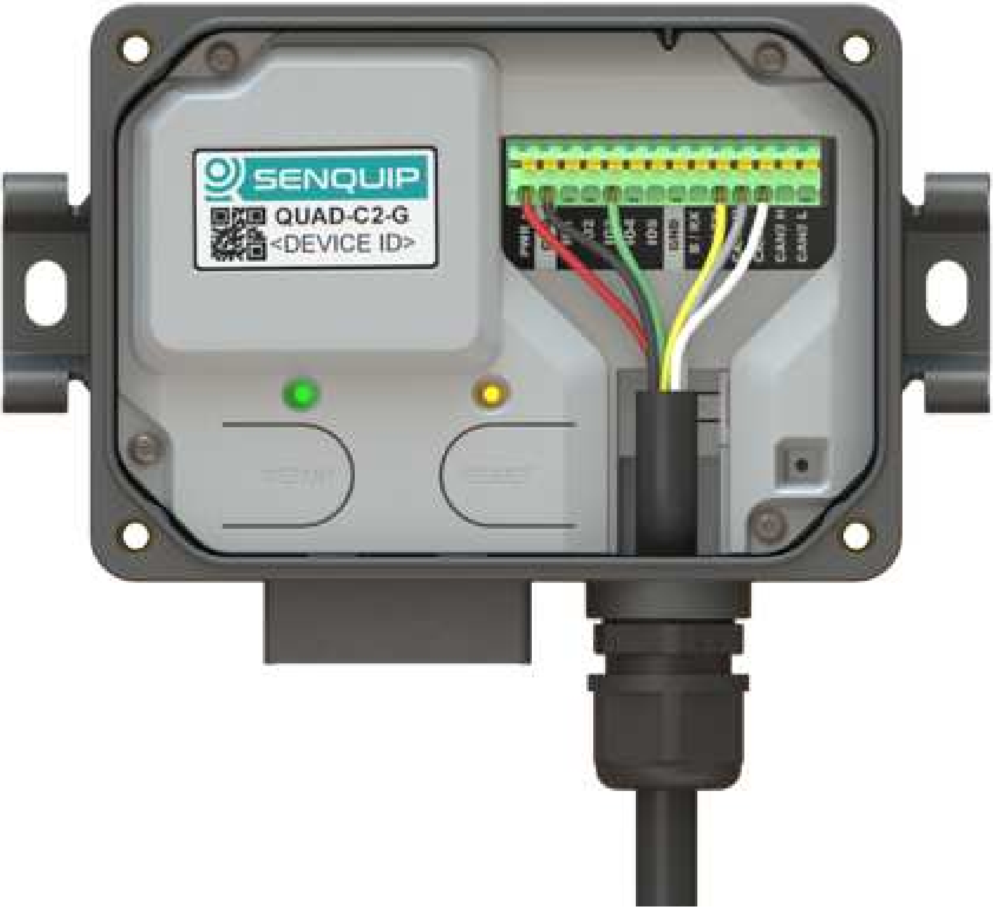


Figure 12.1. LEDs and configuration switches.

- Switch power to the Senquip QUAD off.
- Disconnect all wiring from the header.
- Remove the SIM card.

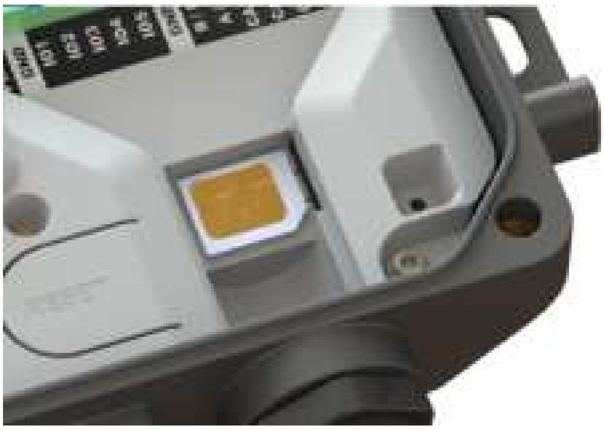


Figure 12.2. Remove the SIM card before opening.

Warning Failure to remove the SIM card before trying to remove the battery cover could cause mechanical damage to the SIM card holder.

- Remove the use access panel by removing the 4 Torx-head screws using aTorx T10 driver. Note that by removing the access panel, sensitive electronics may be exposed.

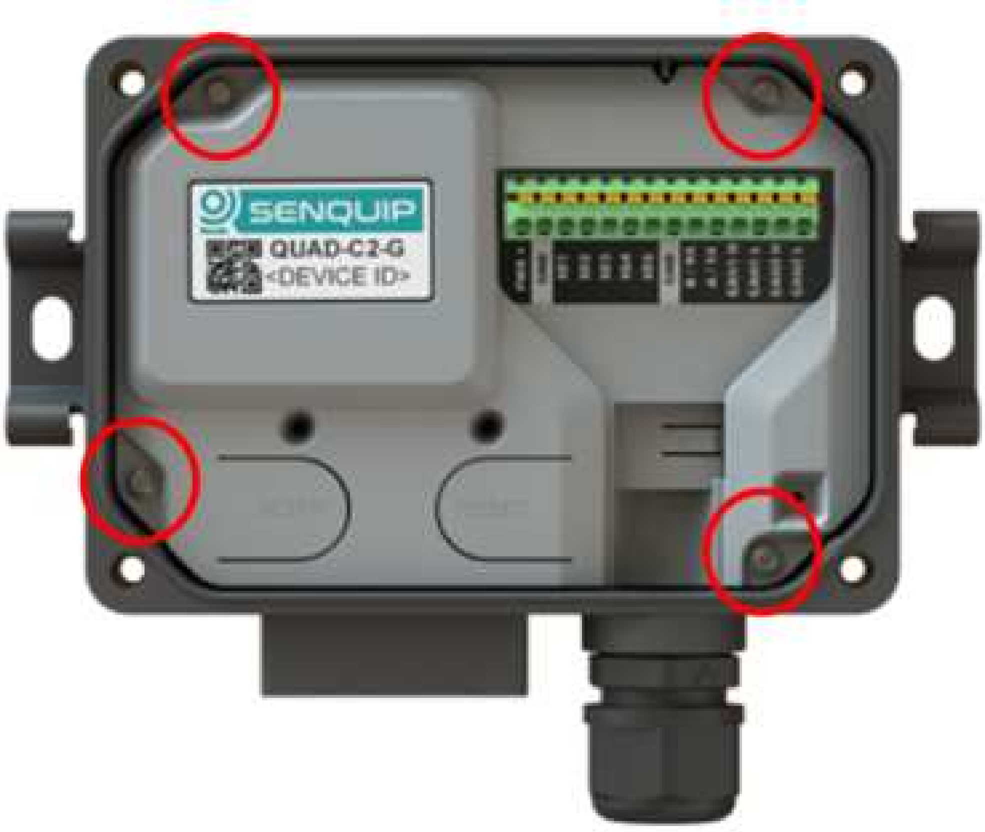


Figure 12.3. Removing the battery cover.

Warning Make sure that you do not expose the circuit board or components to static electricity.

- The LiPo battery is plugged into a polarised 3 pin JST connector. Gently remove the battery plug by pulling on the 3 wires, ensuring that the direction of pull is in-line with the connector.

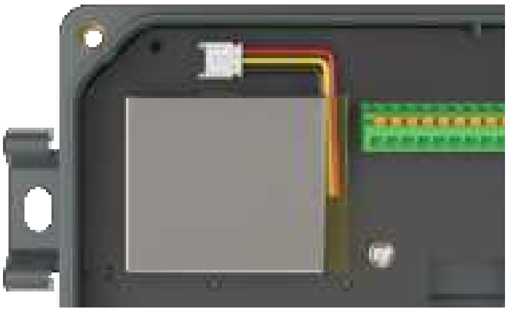


Figure 12.4. Orientation of Lipo Battery.

- Note carefully the polarisation of the 3-way battery plug and be sure to insert the replacement