AIO Series Suspended Solids Sensors Installation Guidelines

V1.4 6 July 2026

Contents

Intended Use
Responsibility for use of the Quadbeam Technologies sensors with regards to suitability for application, intended use, resistance of the sensor components against degradation in the environment used is solely with the operator of the sensor.

The manufacturer is not liable for any damages resulting from the use of the sensor beyond the cost of the sensor.

The intended use of the Quadbeam Technologies Suspended Solids Sensors and Turbidity sensors is the continuous monitoring of Suspended Solids concentration in *an industrial, dairy process, storm water, raw water or wastewater installation.*

Product Warranty
The Suspended Solids and Turbidity Sensors have a warranty against defects in materials and workmanship for one year from the date of shipment. During this period Quadbeam Technologies will, at its own discretion, either repair or replace products that prove to be defective.

Limitation of Warranty
No warranty of fitness for a particular purpose is offered. The user assumes the entire risk of using the product. Warranty does not cover damage caused by accidental misuse, abuse, neglect, misapplication or modification. Any liability of Quadbeam Technologies Ltd is limited exclusively to the replacement of defective materials or workmanship.

Disclaimer
Quadbeam Technologies Ltd reserves the right to make changes to this guide or the instrument without notice, as part of our policy of continued developments and improvements.
All care has been taken to ensure the accuracy of the information contained in this manual. However, we cannot accept responsibility for any errors or damages resulting from errors or inaccuracies of information herein.

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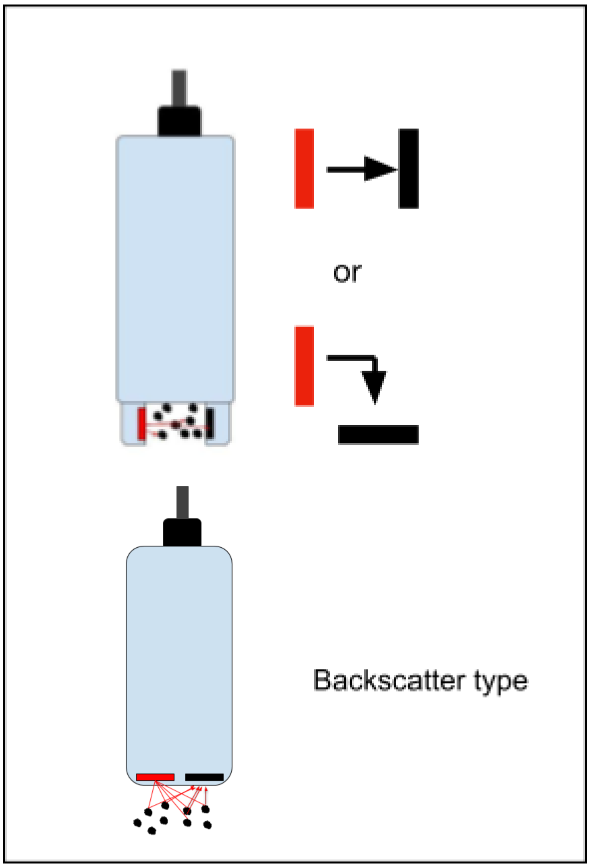
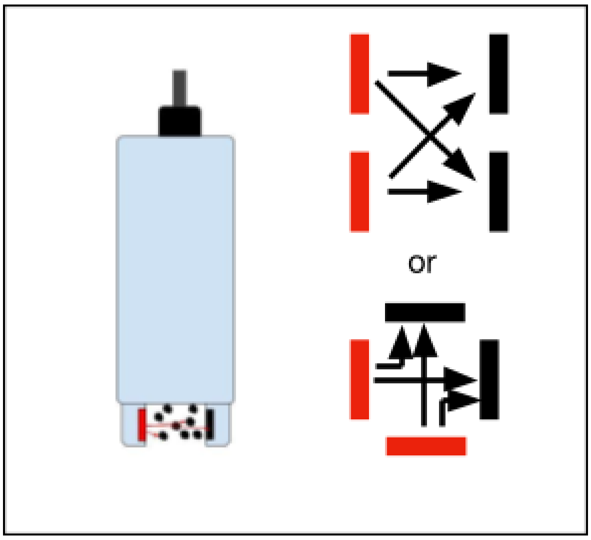
Technologies commonly used in Suspended Solids and Turbidity Sensors

Quadbeam uses the four beam alternating light ratio-metric system of measurement for its sensors.

Suspended Solids Sensors and Turbidity Sensors measure the change in light intensity to produce a relative measure of the solids or turbidity concentration in the liquid being monitored. Most commonly sold suspended solids sensors and turbidity meters use only a single beam of light. When a single beam of light is used the intensity of the light can be influenced by not only the solids particles suspended in the liquid, but also any solids/contamination that are stuck to the surface of the sensor and variability of the light source and photo diode as they age. Therefore it is critical to keep single beam sensors very clean to get accurate readings.

Multi-beam sensors like the Quadbeam, measure across multiple light paths. This allows them to use mathematical algorithms where the change in ratio of intensity of light is measured. This system automatically compensates for contamination stuck to the surface of the sensor and variation of the light components in the sensor. For this reason it is common for multi beam sensors to be used in Process Control installations where a repeatable output is very important.





Multi-Beam Configurations. Algorithm compensates for contamination and ageing giving very repeatable signal.

Common Single Beam Configurations. Signal drifts as sensor ages or gets contaminated

SENSOR TYPES

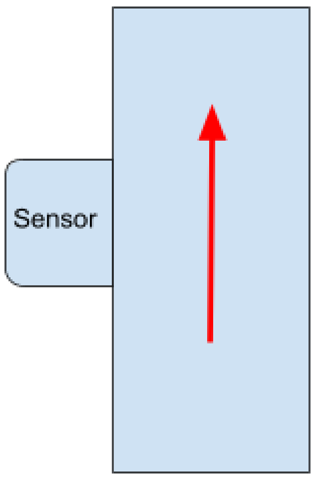
S20-3HY -AIO		Single piece polymer front section 3” Tri-clamp fitting 0 to 20% milk fat Operating temp 0 to 85°C
S40-3HY -AIO		Single piece polymer front section 3” Tri-clamp fitting 0 to 1.5% milk fat Operating temp 0 to 85°C

PIPE INSTALLATION

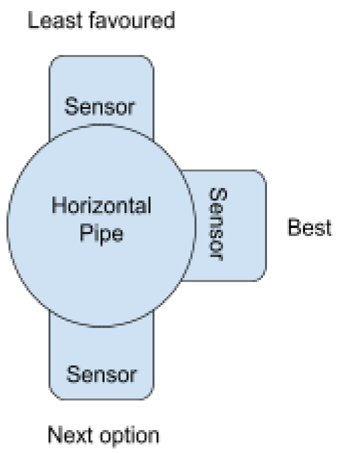
1. The minimum pipe diameter for S20-3HY-AIO and S40-3HY-AIO is 75mm (3”).

2. Where possible the sensor should be mounted in a straight pipe where there are 10 pipe diameters upstream and 5 pipe diameters downstream that are free from valves and bends.

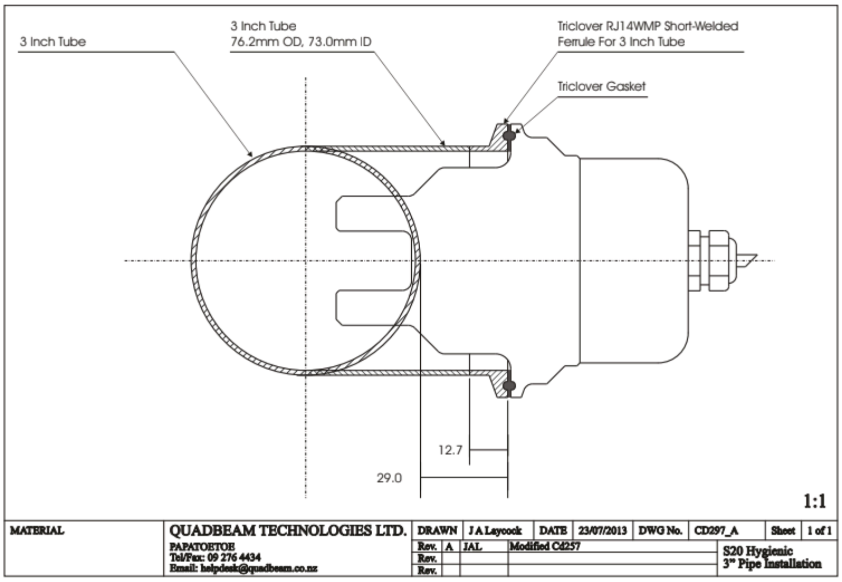
3. It is preferable that the sensor is installed at a vertical pipe where the flow is upwards. This ensures that the pipe is always full. A downwards flow is not recommended as the fluid could have some turbulence which could result in an unstable reading.
   If there is a bend within 10 pipe diameters, place the sensor on the side of the pipe closest to the inside of the bend.



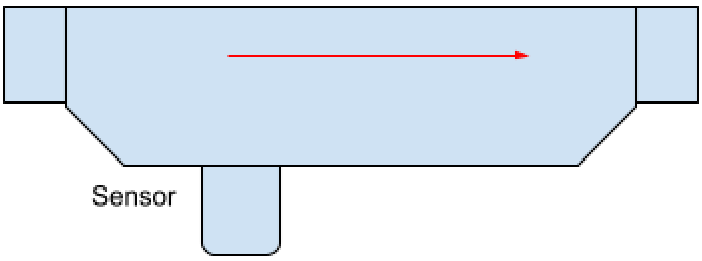
4. If only a horizontal pipe is available the sensor should be installed in the horizontal plane ± 45°. Avoid placing the sensor at the top of the pipe as the pipe may not always be full or there could be an accumulation of bubbles. The bottom is avoided as it could have a higher than normal concentration of solids.



For sensor installation drawings, as below, contact your Quadbeam Technologies Distributor.



5. In installations where there is a very high chance of entrained air, for example CIP monitoring and control applications, the best position is in fact at the bottom of a horizontal pipe. For added protection against the chance of entrained air, expand the pipe eccentrically keeping the top of the pipe inline and the eccentric expansion at the lower section of the pipe.
Increasing the pipe diameter effectively slows the flow encouraging the bubbles to the top of the pipe.



Possible CIP monitoring option when a large amount of entrained air is present.

MANIFOLD INSTALLATION

In Dairy Loss Monitoring installations where there are multiple points of measure, for example Conductivity, pH and Temperature as well as Suspended Solids or Turbidity it can be advantageous to run the monitored fluid through an instrument manifold.

Wiring

Power Connection

The SWW series has two power options: either

1. 3.2 -5.5V (intended for LiPo battery).
2. 9-32V.

Wiring

Determine first which power option is to be used.

	Core colour	Function
	Blue	Gnd ⏚
	Black or Grey	3.2 - 5.5V LiPo
	Brown	9 - 32V
	White	4-20mA out
	Green	RS485 - A
	Yellow	RS485 + B
	Red	Digital Input
	Orange or Pink	Unused
	Silver	Gnd ⏚

Supply power is either Black or Brown - NOT both

! IMPORTANT !
DO NOT CONNECT BLACK WIRE TO 9-32V

Note 1: To activate CIP Mode when enabled in the App or Modbus commands, connect the Red Digital Input wire to Gnd.

Note 2: The LiPo input does have reverse-polarity protection. However please guard against the natural tendency to connect Black to Gnd.

Note 3: The 4-20mA output is powered from the Brown and does not work when the sensor is powered from the Black. For more information on the 4-20mA output please refer to Appendix B.

Note 4: Upon the application of power, there are delays for supply voltage and clock oscillator stabilisation, followed by a power-on self-test and initialisation. This takes about 1.65 seconds. The sensor is now ready to respond to communications. The sensor starts taking measurements at a rate of about 2.2 per second, and (depending on how noisy the readings are) produces a reliable reading after 5 to 8 readings can be averaged; that is to say, after a further 3 to 4 seconds.

CALIBRATION

Relative measurement
Because of the use of the four beam ratio-metric principle Quadbeam sensors have a very repeatable output. With this self compensating technology, quite simply, the more care taken in setting the sensors up the more accurate the output will be.

In the Linearisation process, the raw data PS (probe signal) value is related to concentrations of suspended solids in the solution being used for calibration.

Relative Measurement - Probe Signal (PS)

Probe Signals is the raw output from the sensor's four beam alternating light algorithm. This signal is very repeatable as the four beam algorithm compensates for contamination on the sensor surface and ageing of the electronics.

The calibration and setup process ties the PS to real world or "engineering units" for example % concentration, mg/l, NTU, g/l or ppm.

The calibration and setup process also establishes the sensor output parameters.

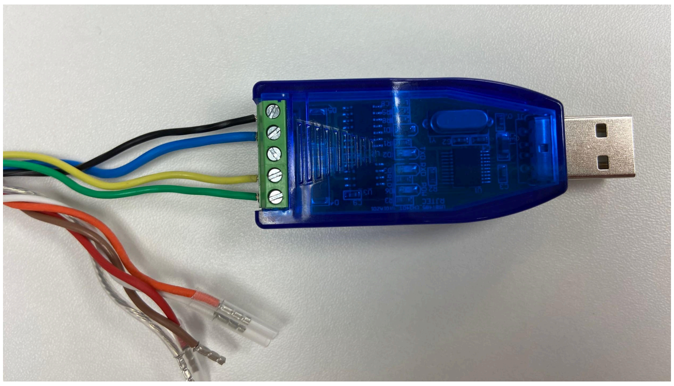
Comms

The Quadbeam AIO sensor has Modbus RS485, 4-20mA output and a solid state relay.

Configuration of the sensor is done using Modbus RS 485. This can be done by connecting the sensor to a PC with the supplied USB dongle and using the Quadbeam AIO configurator app or by using another Modbus RS485 device.

Quadbeam AIO Configurator App

Connect the sensor to the USB dongle.

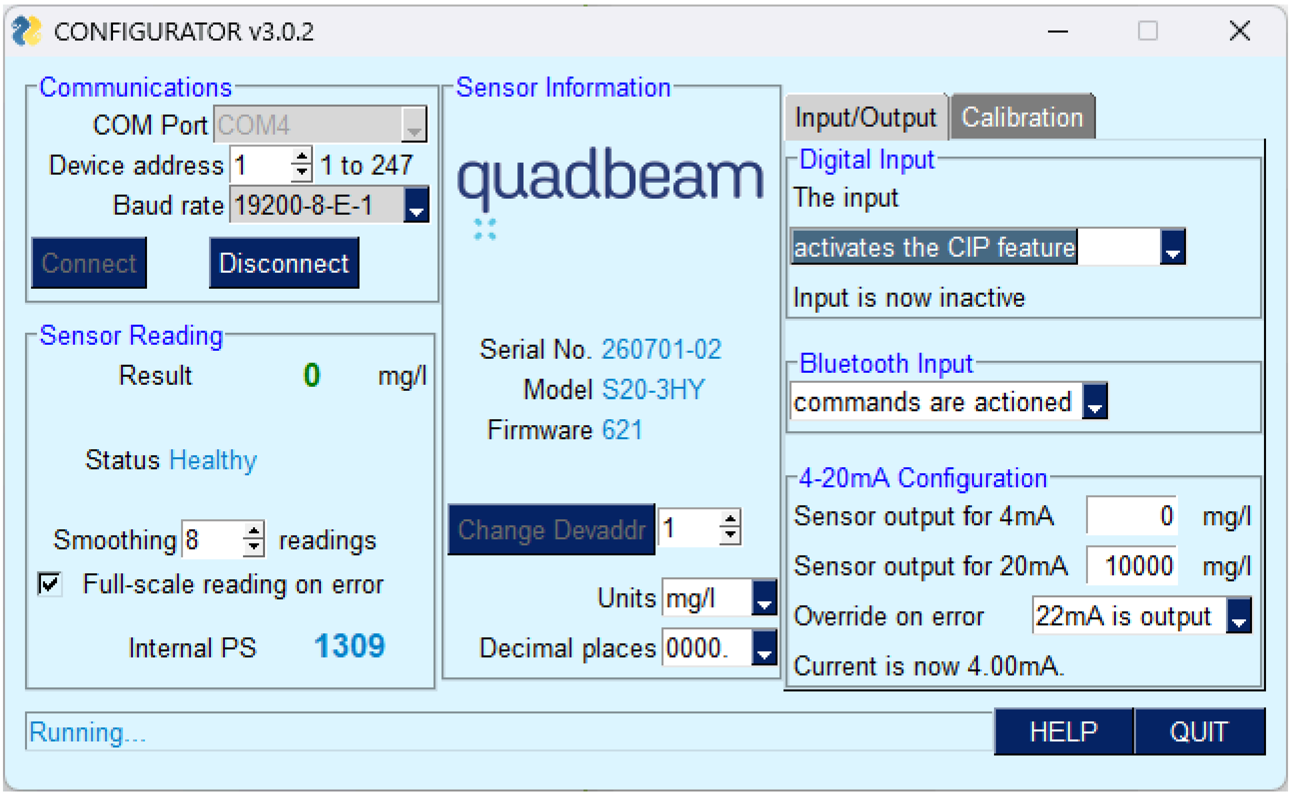


Connect the dongle to your PC

Download and install the App.

Select the com port from the drop down COM Port menu
Set Device address to 1 unless it has been changed to allow more than one sensor to be connected to the bus at the same time.

Output control Screen



Communications

- Set the sensor to the communications port.
- Set Device address to 1
- Choose baud rate "19200-E-8-1"
- Click the Connect button

Sensor Reading

- **Result** is the calculated output reading as a result of the configuration and calibration setup.
- **Status** shows the current state of the communication with the sensor and error messages
- **Smoothing** is the number of readings which is averaged to give the result. There are 2.2 Readings per second
- **Full scale reading on error** checkbox, check this to drive the sensor to full scale on error.
- **Internal PS**. This is the raw data Probe Signal number.

Sensor Information

- **Change Devaddr**. Each device on the same bus must have a unique address.
- **Units** - set “engineering” units, %, mg/l, g/l, NTU, ppm or None (blank)
- **Decimal places** - select decimal places

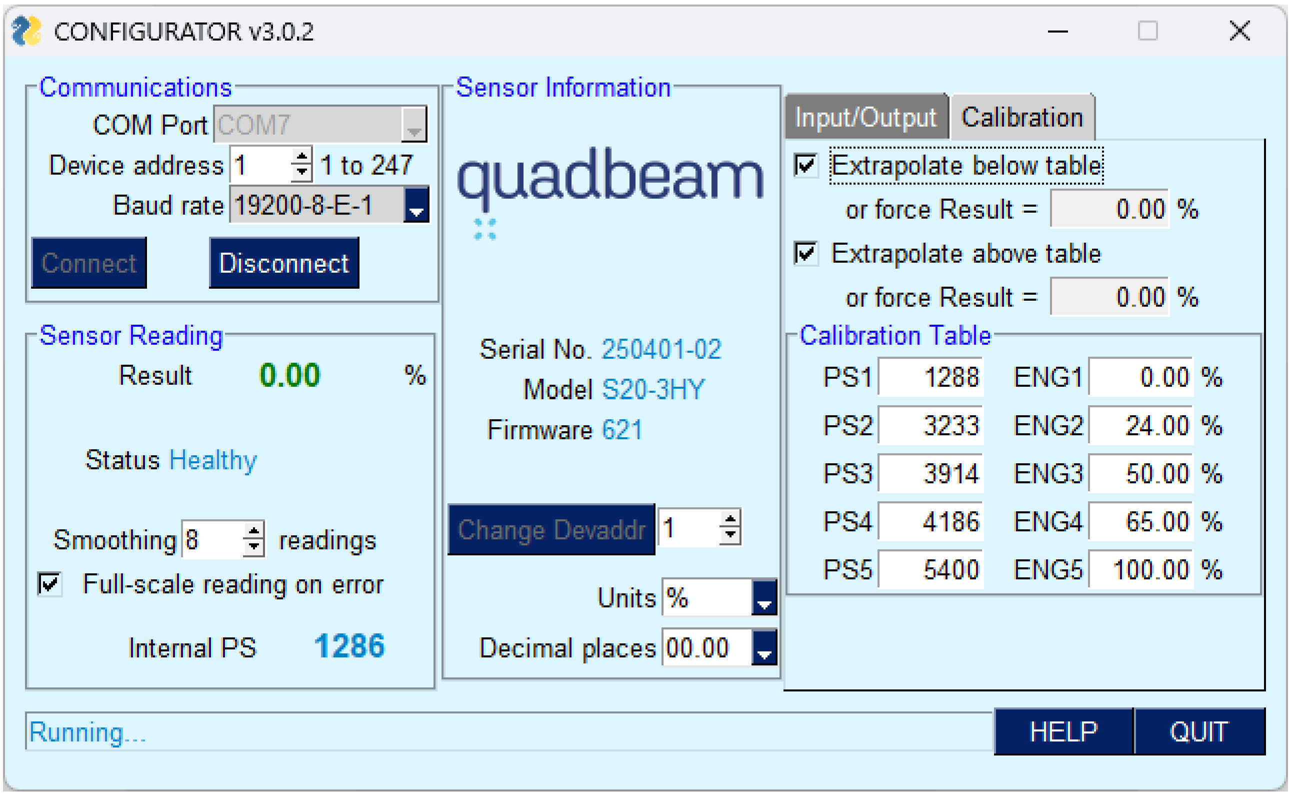
Digital Input Configuration- CIP Mode

Activate CIP mode option if required.
This allows the sensor to be protected during the hot phases of CIP. When the input is active the sensor head will be deactivated and freeze the output.

Bluetooth Input

If the sensor has Bluetooth comms enable this to use the iPhone and Android Apps.

Calibration Screen



Check Extrapolate below table to get readings below the lowest input on the Calibration Table
Check Extrapolate above table to get readings above the highest input on the Calibration Table

Calibration table

In this table you relate the raw data PS values to the corresponding "engineering units" concentration.
This relationship can be determined 2 ways;

1. Using calibration standards or samples
2. Using inline sampling

Once you have the data of PS value against Engineering unit concentration input it into the calibration table.

Note;
If only using 2 calibration points and you need the Sensor Reading to extrapolate below the table use PS1 and PS2. If wanting to extrapolate above the table use PS4 and PS5 The table needs the bottom two points if using extrapolation below the table.
If using 3 calibration points with extrapolation, set PS1 to the lowest point, PS2 PS3 and PS4 to the middle point, and PS5 to the highest point.

Calibration Standards.
The sensors measure the intensity of NIR light emitted across the sensor light paths. Different materials absorb or scatter NIR light in different ways. For best results, where possible, use the actual process fluid and solids being measured as standards to set up the linearisation of the sensors.

It is not uncommon for pre-prepared solutions to be used, for example NTU solutions or varying concentrations of SiO_2 in water. These work very well as repeatable standards, but the questions need to be asked - are they directly relevant to what is being measured and are they understood by operators?

It is possible to have up to 5 points in a calibration curve. Some materials have a linear response to 880 NIR for example NTU Solutions and SiO_2. Some materials have a non-linear response, for example Milk Fat. In applications like milk fat we recommend at least 5 points on the curve.

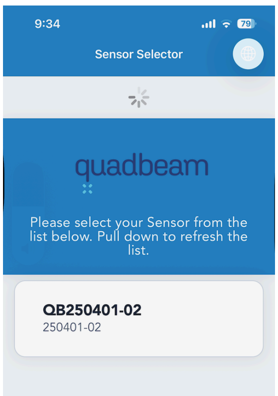
Once the standards are prepared, place them into opaque non-reflective containers.
Please the sensor in the lowest concentration, note the Internal PS number and the concentration of the standard.
Work through each standard/sample ensuring the sensor is cleaned between samples and that the sensor is placed in exactly the same position in the container each time and there is at least 20mm clearance from the bottom of the vessel and the sensor..

As above once you have all the data of PS against solids concentration input into the calibration table.

Inline Sampling
Install the sensor into the line. With the process running, note down the Internal PS value, take a sample from the line.
Vary the process to artificially change the solids concentration, again note down the Internal PS value and take a sample.
When up to 5 concentration changes have been made, send the sample to the site lab to determine the concentration of the solids.
With the PS values and the lab concentration information load the data into the calibration table.

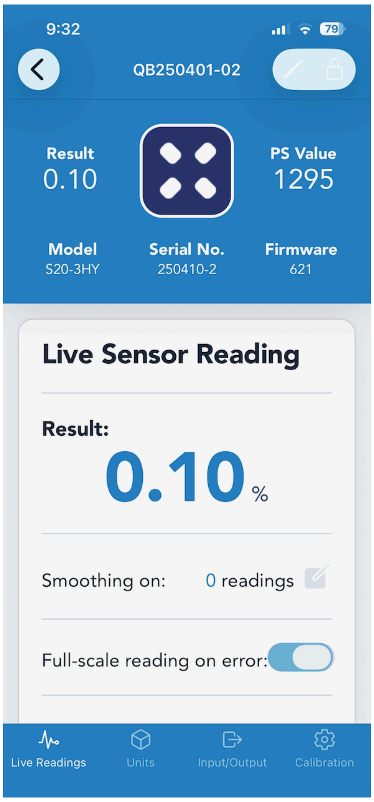
It is always important to ensure that the lab equipment has been recently calibrated.

Setting up with Bluetooth App
Sensor must be powered.
Open App and identify sensor by Serial Number. Open the sensor by clicking on it.



Apple

Android



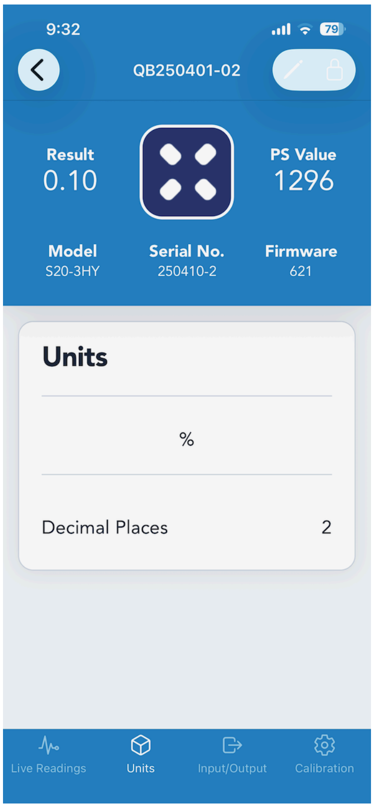
Result shows Calibrated output
PS Value is the raw data output

Open editing by opening lock at the top of the screen

Smoothing - averages the result over the number of readings.

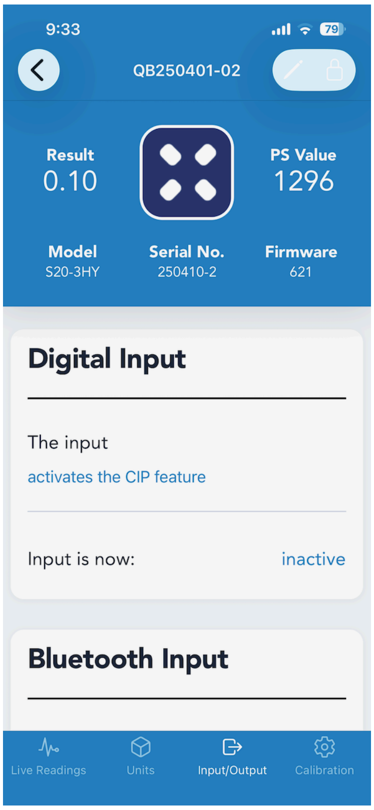
Full Scale on error - useful for 4-20 comms to alert to sensor errors.

Status - current status of sensor will highlight sensor errors



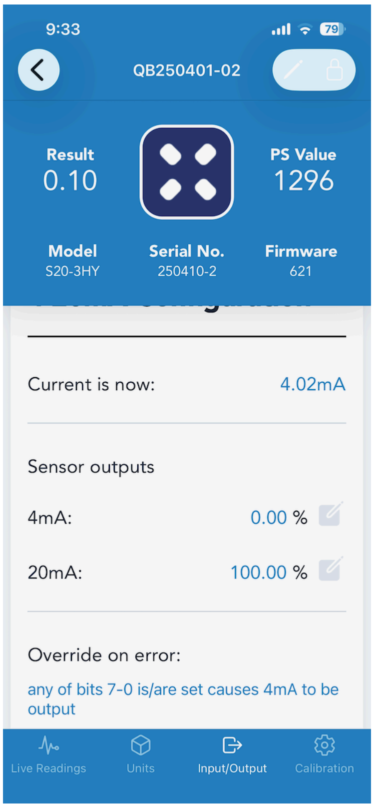
To edit **Units** and **Decimal Places** open lock at top of the screen.
Scroll to the required Unit. mg/l, g/l, ppm, %, NTU, FNU available.

Scroll to the required **Decimal Places**



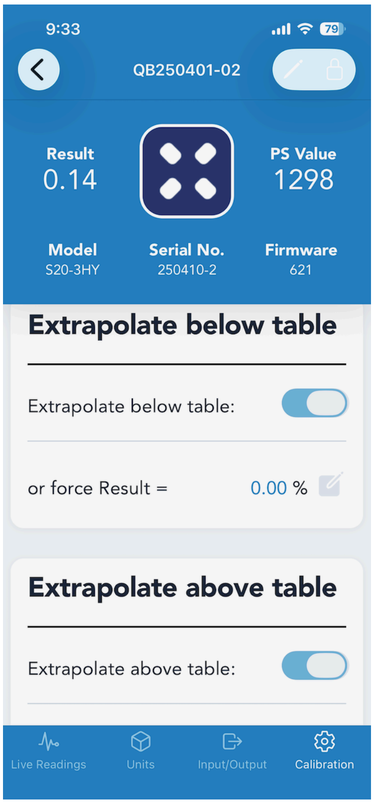
Digital Input - when activated this will give the option of activating CIP mode via a digital input using the red wire of the sensor.
When in CIP the optics of the sensor are switched off and output frozen.

Scroll down for other options



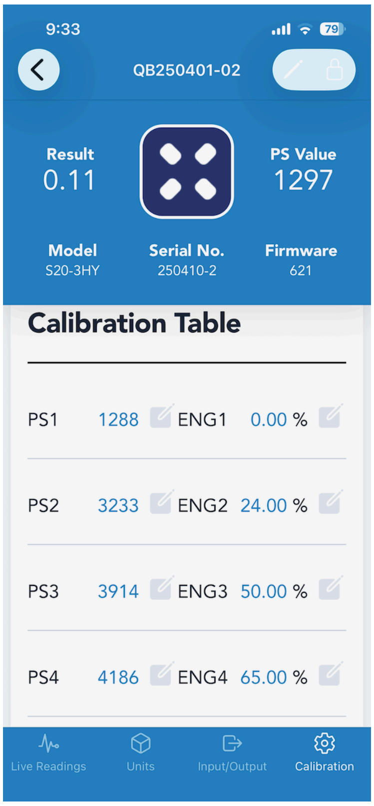
4-20mA Configuration - Span the 4-20mA across the required range

Override on error - open the edit lock to see the options available.



Extrapolate below table - allows for the calibration curve to go beyond the table

Extrapolate above table - allows for the calibration curve to go beyond the table



Complete the Calibration table using data the same as with the PC App.

For example;
Prepare a range of samples of a known concentration value ("Engineering Value"). Place the sensor into each sample. Record the PS value for each different concentration.

Input PS value and "Engineering Value" to complete the calibration of the sensor.

The **Result** will show the output from the Calibration table

Calibrating sensor using Modbus Registers

Register numbers and addresses can be related directly to the different actions taken when using the App.
See a list of registers below in Appendix A.

Appendix A - Table of Modbus Holding Registers

The most used registers are highlighted.

Register number	Reg. address	Name	RO	WP	NV	Brief Description	Even simpler description/Notes
40001	0	MANUFACTURER		X	X	0x5142 ("QB" in ASCII)	Identifier this is a Quadbeam Sensor
40002	1	MODEL_NUMBER		X	X	0x0015 (21_D) = S20-3HY-AIO	Model number
40003	2	SOFTWARE_VER	X		X	Build number	Firmware version
40004	3	PS_VALUE	X			Sensor reading	Raw data number 'Probe Signal Value'
40005	4	FLAGS_VALUE	X			Sensor status flags (error messages)	Error messages
40006	5	PS_FOR_4MA			X	Output value for analogue zero output	Sensor output for 4mA
40007	6	PS_FOR_20MA			X	Output value for analogue full-scale output	Sensor output for 20mA
40008	7	RANGE_&_UNITS				0='mg/l', 1='g/l', 2='ppm', 3='%', 4='NTU', 5='FNU', >5=<blank> [NUBS]	'Engineering units'
40009	8	ACTION_FLAGS			X	Output signal control (see table below)	Action flags, what happens to outputs in various situations
40010	9	RELAY_ON_ABOVE			X	Relay output "ON" above this output value	Relay energised above
40011	10	RELAY_ON_BELOW			X	Relay output "ON" below this output value	Relay energised below
40012	11	FORCE_CURRENT		X		Force a known 4-22mA output. Cleared on powerup. Overrides output when within the 4000-22000 range.	
40013	12	DAC_FOR_4MA		X	X	Adjust accuracy of 4mA output	Factory use only
40014	13	DAC_FOR_20MA		X	X	Adjust accuracy of 20mA output	Factory use only
40015	14	DAC_NOW	X			Value being converted to current now	Factory use only
40016	15	COMMS_ERROR_COUNT	X			Running total of comms errors since last power-up	Comms status
40017	16	MODBUS_DEVADDR		X	X	Modbus device address, 1 - 247	Device address - see pg 10 and appendix A

40018	17	DATA_MAPVERSION	X		X	Version number of this table	Factory use only
40019	18	SENSOR_SERNUMLO	X	X	X	Serial number part 2 [NUBS]	Factory use only
40020	19	SENSOR_SERNUMHI	X	X	X	Serial number part 1 [NUBS]	Factory use only

RO (read only) means that writing these locations has no effect.
WP (write protected) means that the *Debug* flag must be set to allow changes.
NV (non-volatile) means that the setting survives power-cycling.
[NUBS] means this value is not used by the sensor

Sensor software 612 added a “linearisation” lookup table feature, which is implemented as follows.

Register number	Reg. address	Name	RO	WP	NV	Brief Description
40037	36	INTERPOL_KEY			X	Flags indicating options, see below
40038	37	INTERPOL_PS1			X	PS value in sample 1
40039	38	INTERPOL_ENG1			X	Eng value in sample 1
40040	39	INTERPOL_PS2			X	PS value in sample 2
40041	40	INTERPOL_ENG2			X	Eng value in sample 2
40042	41	INTERPOL_PS3			X	PS value in sample 3
40043	42	INTERPOL_ENG3			X	Eng value in sample 3
40044	43	INTERPOL_PS4			X	PS value in sample 4
40045	44	INTERPOL_ENG4			X	Eng value in sample 4
40046	45	INTERPOL_PS5			X	PS value in sample 5
40047	46	INTERPOL_ENG5			X	PS value in sample 5
40048	47	INTERPOL_ENGLO			X	Result when below table, and not extrapolating
40049	48	INTERPOL_ENGHI			X	Result when above table, and not extrapolating
40050	49	INTERPOL_RESULT	X			

Table of FLAGS_VALUE: sensor status bits, measurement errors

	Over range	Custom	Not used	Partial Impedance	Gain error	Full depletion	Partial depletion	Signal overload	No signal
Bit 9	Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0

Table of ACTION_FLAGS: what happens to outputs in various situations

Reserved for factory use	Debug	Res-erved	LIMP	Relay output	4-20mA output
Bits 15-10	Bit 9	Bit 8	Bit 7	Bits 6-4	Bits 3-0

To allow the Modbus address to be changed, Bit 9 must be set.

Bit 7 can be set to disable the normal behaviour that PS=full-scale if an error is present. This defeats the measurement validity checks, and allows potentially invalid output results to be calculated and output. If you set this bit, you should always check status (FLAGS_VALUE) to confirm confidence in the PS value.

Bits 6-4: relay output control
The SSR Form A (see datasheet for International Rectifier PVT412 “Connection A” for more details) connects the Red and Orange cable cores together when energised.
0 = de-energised
1 = energised if any of sensor flag bits 7-0 is/are set
2 = energised if sensor flag bit 8 is set
3 = energised if any of sensor flag bits 8-0 is/are set
4 = reserved
5 = energised
6,7 = controlled by values of PS, RELAY_ON_ABOVE and RELAY_ON_BELOW as follows.
If RELAY_ON_ABOVE is lower than RELAY_ON_BELOW, then the relay is energised when the PS value is between the two, and de-energised otherwise. If RELAY_ON_BELOW is lower than RELAY_ON_ABOVE, then the relay is de-energised when the PS value is between the two, and energised otherwise. If RELAY_ON_BELOW and RELAY_ON_ABOVE are the same, the relay is de-energised.

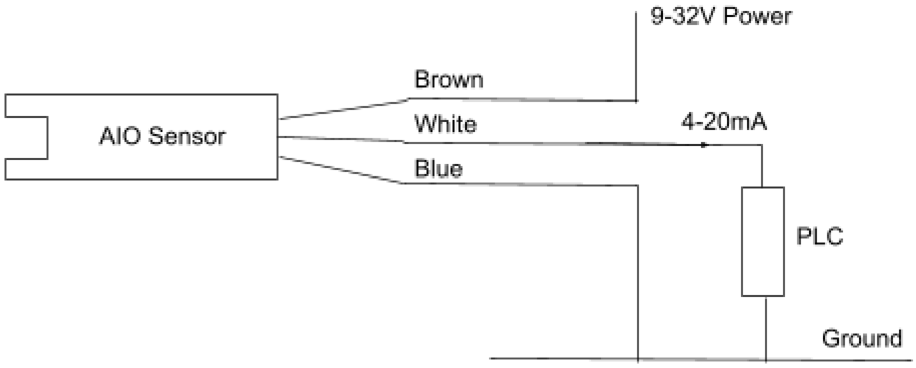
Bits 3-0 (bottom nybble): 4-20mA output control
In normal operation, the output signal is a linear interpolation of the PS value, in the range specified by the contents of registers 5 and 6. Optionally, this can be overridden and forced to a special value in the event of an error by setting these bits.
0 = any of FLAGS_VALUE bits 7-0 is/are set causes 22mA to be output
1 = any of bits 7-0 is/are set causes 20mA to be output
2 = any of bits 7-0 is/are set causes 4mA to be output
3 = any of bits 7-0 is/are set causes the output to freeze (i.e. hold its last “good” value)
4..15 = output signal is not affected by error conditions.
Note that some sensor errors can cause the PS calculation to produce a zero or full-scale value (16000 for S Series) and this “erroneous” PS value will be converted to mA.
If the *Debug* flag is set, the output signal can be forced to any arbitrary value by setting the “FORCE_CURRENT” register to a value from 4000-22000. This register is cleared to 0 at power-up.

Appendix C - Wiring and Programming

The sensor can be powered from 2.7-5.5V (intended for a LiPo battery) or alternatively from 9-32V (intended for plant 12V or 24V supply).

The cable wiring colours are shown on page 7 of this manual.

When powered from 9-32V, there is a 4-20mA analogue output available. There is no supply voltage booster, so if the supply is only 9V then the analogue output will be unable to drive the full 20mA into a 500 ohm burden (which would need at least 10V output). A lower value of burden resistor must be chosen in this situation.



There is a solid-state relay output as well, with a maximum current when on of 100mA, and a maximum voltage when off of 400V.

The sensor uses a total power consumption of about 95mW plus whatever is required to drive 3V comms into 120R terminators if connected, plus the power necessary to drive 4-20mA into its burden, if connected.

All settings are changed by serial data, using RS485 multidrop hardware using the Modbus RTU protocol, following Modicon document PI-MBUS-300 Rev.J (June 1996). The sensor implements the minimum requirements of Modbus RTU. The comms parameters are 19200,8,E,1[1]. It only responds to functions 03, 06 and 16, read and write holding registers. Ex-factory the device address is set to 1. There are no single-bit "coils" or "inputs" that can be set or read. There are only "holding registers" which hold 16-bit unsigned numbers.

[1] This can be changed by people with prior knowledge. See Modbus register 52 (page 16).

HOW TO USE THE "CIP" FUNCTION

To reduce ageing of the optical diodes, the sensor measurement cycle can be suspended by a Modbus command. This is particularly effective when it is known that the sensor will experience a temperature excursion outside its rated range, and readings are not required during this time. The most common example of this is when the hot stages of a clean-in-place operation are performed. The sensor can be reactivated (i.e. CIP mode turned off) for the cooler final rinse stage, when it can be used to detect the end of the rinse.

Please see the following Modbus register definition, as shown in the Manual:
Table of ACTION_FLAGS (Reg 8):

Unpublished	Debug	Res-erved	LIMP	Relay output	4-20mA output
Bits 15-10	Bit 9	Bit 8	Bit 7	Bits 6-4	Bits 3-0

In order to activate the CIP function, Bit 8 is set to 1. To achieve this without changing the other settings controlled by the same register, you have to read the value in register 8, set bit 8 to 1, and then write it back to the sensor. Similarly, to deactivate the CIP function, read register 8, clear bit 8 to 0, and write it back to the sensor. If you have a recent sensor (see below), the setting will be promptly overridden by the digital input if bit 4 is set.

- The power-up state of the CIP mode is inactive.
- The Windows™ configurator software does not affect the CIP setting.

Sensors with firmware version 600 and above have a digital input instead of a digital output.
Table of ACTION_FLAGS (Reg 8):

Unpublished	Debug	Res-erved	LIMP	Digital input	4-20mA output
Bits 15-10	Bit 9	Bit 8	Bit 7	Bits 6-4	Bits 3-0

Bits 6-4 are set as follows:
If Bit 4 is set, then the CIP function follows the digital input (default).
If Bit 5 is set, then the reception of commands via Bluetooth is enabled (default).

Product Code ID Numbers Look-up Table

The distinct Quadbeam All-In-One (AIO) sensor models are identified by specific Product Code IDs, which are detailed in the table below.

These Product Code ID numbers are also designated as **MODEL_NUMBER (reg 2)** within the configurator and production test software.

Model	Product Code ID Number
S10-3HY	0x0B (11d)
S10-2HY	0x0C (12d)
S20-3HY	0x15 (21d)
S40-3HY	0x29 (41d)
T30-3HY	0x1F (31d)

Document revision notes
Rev 15: Jan 2024: The CIP feature is now documented.
Rev 16: July 2025: Sensors now have a digital input.
Rev 17: Jan 2026: Added Product Code ID Numbers lookup based of the QB_Configurator_V302