



AquaDAT Analogue Input Expansion Unit

Updated: December 2015

Suitable for SDI-12 & RS-485 Networks

Installation & User Guide

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A quick user guide can be found in [Appendix A on Page 29](#)

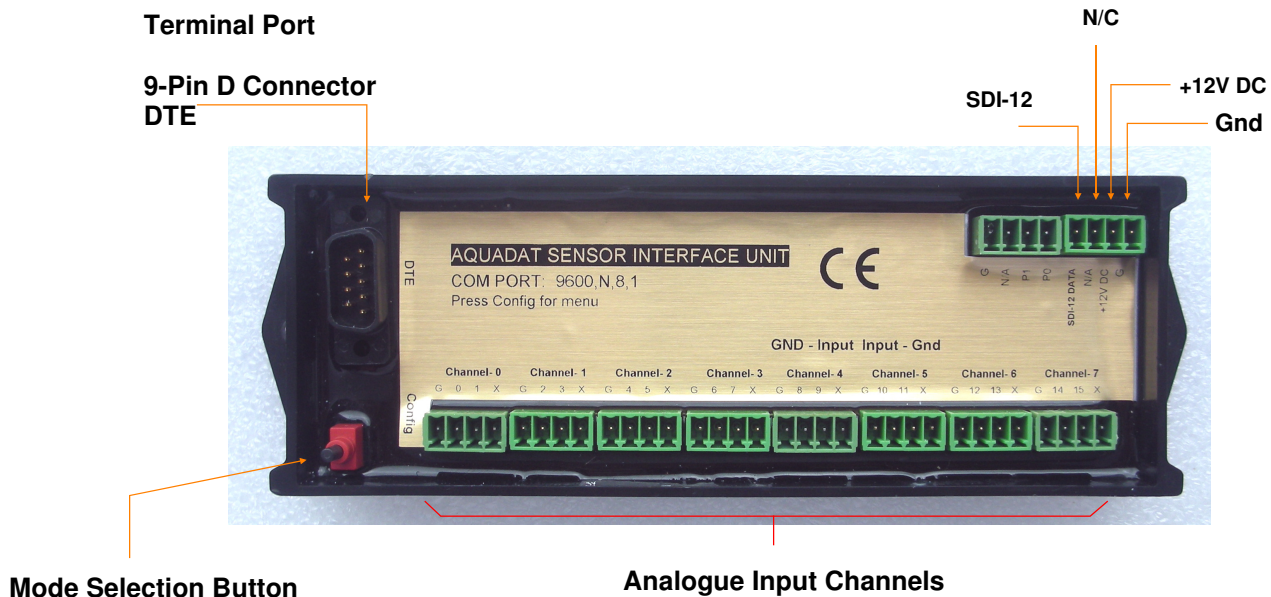
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AquaDAT Analogue Input Expansion Module

For the SDI-12 Network



The AquaDAT is an SDI-12 network and RS-232 data-acquisition unit for science, industry and research applications. Housed in a splash-proof enclosure, the AquaDAT reads the output of a range of sensors and then digitises, processes and stores the results prior to transmission across a network. Data can be sent to any data-logger or PC using the SDI-12 digital network.

The AquaDAT is a rugged, versatile, lightning-protected device that offers an easy expansion for any data-logger requiring precision measurements. Use with any third-party device to expand measurement capability at a fraction of the price of large channel loggers. The AquaDAT can be used in the harshest of environments as it is provided in an immersion-proof enclosure as standard.

Sensors the AquaDAT can use:

- Cup, propellor, and sonic anemometers
- Tipping bucket rain gauges
- Wind vanes
- Strain gauges / Load Cells
- Pyranometers
- Ultrasonic ranging sensor
- Thermistors, RTDs, and thermocouples
- Barometric pressure sensors
- RH sensors
- Cooled mirror
- Hygrometers
- Soil Moisture

Features

16 Single-ended or 8 Full Differential inputs
Lightning-protected Inputs - Gas Discharge Tube
Immersion-proof Enclosure
SDI-12 & RS232 Com Ports
Engineer Unit Conversion - In-built programmable formula translations.

Applications

The measurement precision, flexibility, long-term reliability, environmental protection and economical price of the AquaDAT make the unit ideal for scientific, commercial, remote-field industrial applications.

Meteorology
Structural Monitoring
Agriculture and Agricultural Research
Water Services
Building Services
Soil Moisture
Air Quality
Geotechnical Applications
Vehicle testing

The AquaDAT has been designed from the outset to offer low-cost precision measurements in any industrial application and is environmentally protected as standard. The AquaDAT will still operate even when immersed in water.

Specifications

DATA ACCESS RATE

The AquaDAT returns 8 values in 2 seconds depending upon the analogue channel configuration in use. Should ensemble averaging be assigned, then this sample rate will be increased.

ANALOGUE INPUTS

8 Differential (full) or 16 single-ended individually configured. Channel expansion by additional **AquaDAT** modules.

COMMON MODE RANGE

±5 V

DC COMMON MODE REJECTION

>100 dB

NORMAL MODE REJECTION:

70 dB @ 50 Hz when using 50 Hz rejection

SUSTAINED INPUT VOLTAGE W/O DAMAGE:

±15 V_{dc} max.

INPUT RESISTANCE

20 G Ohms typical ±0.8 °C, -55 ° to 85 °C.

ANALOGUE INPUT AUTO-RANGE

The analogue inputs are auto-ranging and the User needs not have set the gain levels in order to make a reading. The AquaDAT makes a series of readings and adjusts the gain to optimise the results. The device operates just like a DV

RANGES and RESOLUTION

Basic resolution (Basic Res) is the A/D resolution of a single conversion. Resolution of DF measurements with input reversal is half the Basic Res.

Input DF Basic Range (mV)	Resolution
± 5000	2.44 mV
± 2500	1.22 mV
± 250	120 uV
± 25	2 uV
± 10	2.44 uV
± 1	0.24 uV

ACCURACY

Typical accuracies are:

±(0.06% of reading + offset), 0 ° to 40 °C
±(0.11% of reading + offset), -25 ° to 50 °C
±(0.14% of reading + offset), -55 ° to 85 °C

The programmable DAQ output enables switched level readings to remove thermal offset and common mode errors.

INPUT NOISE VOLTAGE

The AquaDAT unit uses a high speed ADC and makes multiple measurements that are ensemble-averaged automatically before being returned as a value. The User can assign the time period over which the input data is averaged in order to reduce the effects of noise.

Common averaging periods are shown below:

1/60 Hz Analogue Integration: ~60 ms
1/50 Hz Analogue Integration: ~20 ms

RESISTANCE MEASUREMENTS

Measurement Types: the AquaDAT provides ratio-metric measurement operations for 4- and 6-wire full bridges, also 2-,3-, and 4-wire half -bridges. Precise dual-polarity excitation using the DAC output switched excitation eliminates any DC errors. Supports 120,300, 500, 1K Ohm sensor.

RATIO ACCURACY

Assuming excitation voltage greater than 1000 mV, not including bridge resistor error:

±(0.04% of voltage reading + offset) / V_x

The sensor and measurement noise are not included and the offsets are the following:

Offset for DF w/ input reversal = 1.5 · Basic Res + 1.1 µV
Offset for DF w/o input reversal = 3.0 · Basic Res + 2.0 µV
Offset for SE = 3.0 · Basic Res + 3.0 µV

PULSE COUNTERS

Two 24-bit inputs selectable for switch closure, high- frequency pulse, or low-level AC.

MAXIMUM COUNTS PER SCAN

18 x10⁶

SWITCH CLOSURE MODE:

Minimum Switch Closed Time: 5 ms
Minimum Switch Open Time: 6 ms
Maximum. Bounce Time: 1 ms open w/o being counted

HIGH-FREQUENCY PULSE MODE

Maximum Input Frequency: 100 kHz
Maximum Input Voltage: ±15 V
Voltage Thresholds: Count upon transition from below 0.85 V to above 2.2 V after input filter with 1.3 µs time constant.
Meets TTL level specification for level detection.

LOW - LEVEL AC MODE

Low-level AC signals can be directly connected to the pulse counter input. As long as the signal exceeds the trigger levels for TTL states then it will be counted.

AC offsets up to ±0.5 V.
Input Hysteresis: 18 mV @ 1 Hz
Maximum ac Input Voltage: ±15 V
Minimum ac Input Voltage: ± 2.2V

ANALOGUE OUTPUTS

A programmable DAQ output is available to provide sensor excitation for differential input pair, or for 8 channels of single-ended inputs.

RANGE AND RESOLUTION

Voltage outputs programmable between ±5 V with 0.15 mV resolution.

MAXIMUM FREQUENCY

5 KHz

EXCITATION

A/C Excitation: 0 to ± 5V over 0 - 100 Hz User Configured
D/C Excitation: 0 to ± 5V @ 40 mA

Introduction

This manual covers the operation of the AquaDAT analogue expansion module and is shown connected to other Keynes Controls products such as a data logger and to a PC using a media converter.

We recommend that this manual is read in conjunction with the AquaLOG manual; some information in this manual and that of the AquaLOG is duplicated for clarity where necessary.

AquaDAT is an analogue expansion board for science, industry and research applications. Housed in an immersion-proof enclosure, the AquaDAT excites and reads the output of a range of sensors and can be used to digitise and process results prior to transmission to a data logger or via a media converter directly to a PC.

The AquaDAT is fully integrated into the free Q-LOG application software which enables a PC to act as a data recorder and display unit.

The AquaDAT is a rugged, versatile, lightning protected device that offers easy expansion for any data-logger requiring precision measurements. It can be used with any third-party device to expand measurement capability at a fraction of the price of large channel loggers. The AquaDAT can be used in the harshest of environments as it is provided in an immersion-proof enclosure as standard.

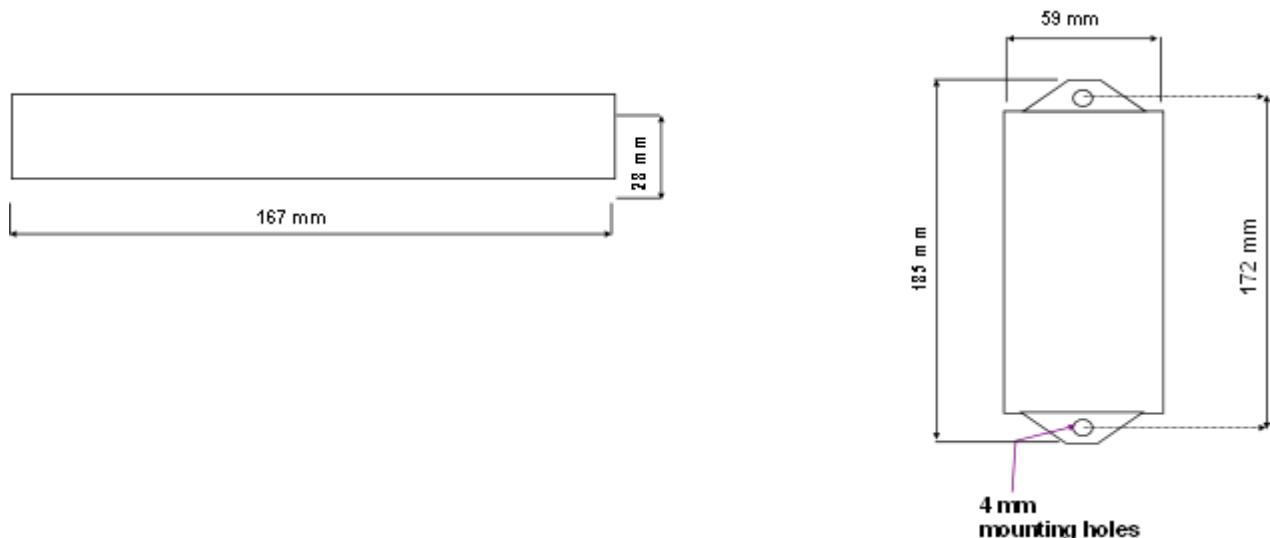
The AquaDAT can accept 16 single-ended or 8 differential inputs.

The AquaDAT has an internal 52 column table into which data input is temporarily stored until the scan of attached sensors is complete, and then the resultant data is transmitted digitally to the AquaLOG unit via the SDI-12 bus. Processing of input data contained within a column can be accomplished by allocating a formula to that column, or spare columns may be allocated to perform calculations referenced to a column containing data values to return data in engineering units. The

User may specify which data columns are returned to the AquaLOG unit.

Physical Dimensions

The AquaLOG enclosure has 2 mounting tabs spaced 173.0 mm apart for 4 mm mounting bolts. Secure the AquaLOG to a suitable mounting plate. The enclosure cannot be earthed as it is made of plastic.



Power Consumption

The AquaDAT uses **40 mA** when operating and is switched off between scans. The time of the scan is user-defined and is equal to the sum of the scan times for each channel being used.

Example: 12 single-ended channels set to scan for 2 seconds each will mean that the AquaDAT is powered on for 24 seconds using 12V DC at 40 mA.

The AquaDAT is an SDI-12 network device and is only activated when data is required and is powered off between scans.
Power Consumption = **40 mA** when powered on
0 mA when switched off

Installation

Power Supply

The AquaDAT is powered from the SDI-12 bus from the data-logger and is only powered on during a scan of instruments.

The unit may also be powered directly from a 12 V battery supply via the 12 V and Gnd pins. This can be used when setting up and programming the AquaDAT with direct communication to a laptop computer

ESD Protection (Electrostatic Discharge)

Electrostatic discharge can originate from a number of sources, the most common, and destructive, being primary and secondary lightning strikes. Primary lightning strikes hit the data-logger or sensors directly. Secondary strikes induce a voltage in power lines or sensor wires.

The SDI-12 network port is protected against ESD using a gas-discharge tube (GDT). All sensor inputs and outputs on the AquaDAT are protected with transorbs or transient voltage suppression diodes. GDTs fire at 150 V to allow any subsequent transient to be diverted to the Earth ground. To be effective, the AquaDAT must be connected to a good Earth.

Terminal Port Pin-outs

The terminal port on the AquaDAT requires a Null Modem cable to communicate to a PC.

Note. A Null modem cable can be identified as they have 9-pin female D-connectors at both ends

The Comm port is a 9-pin male connector configured for DCE operations

Ground Potential Differences

A single-ended measurement is referenced to local ground; any difference in ground potential between the sensor and the AquaDAT will result in a measurement error. Differential signals must be used when the input ground is known to be at a different ground potential from AquaDAT ground.

Ground potential differences are a common problem in applications measuring full-bridge sensors (strain gauges, pressure transducers, etc), and thermocouples when used to measure soil temperature. Care must be taken when a sensor is in direct connection to a large metal structure and there is a considerable distance between the sensor and the AquaDAT. Try to use a single Earth reference point.

The AquaDAT is most often deployed and powered by an SDI-12 network. Connect sensor inputs to the local ground (0V) on each channel.

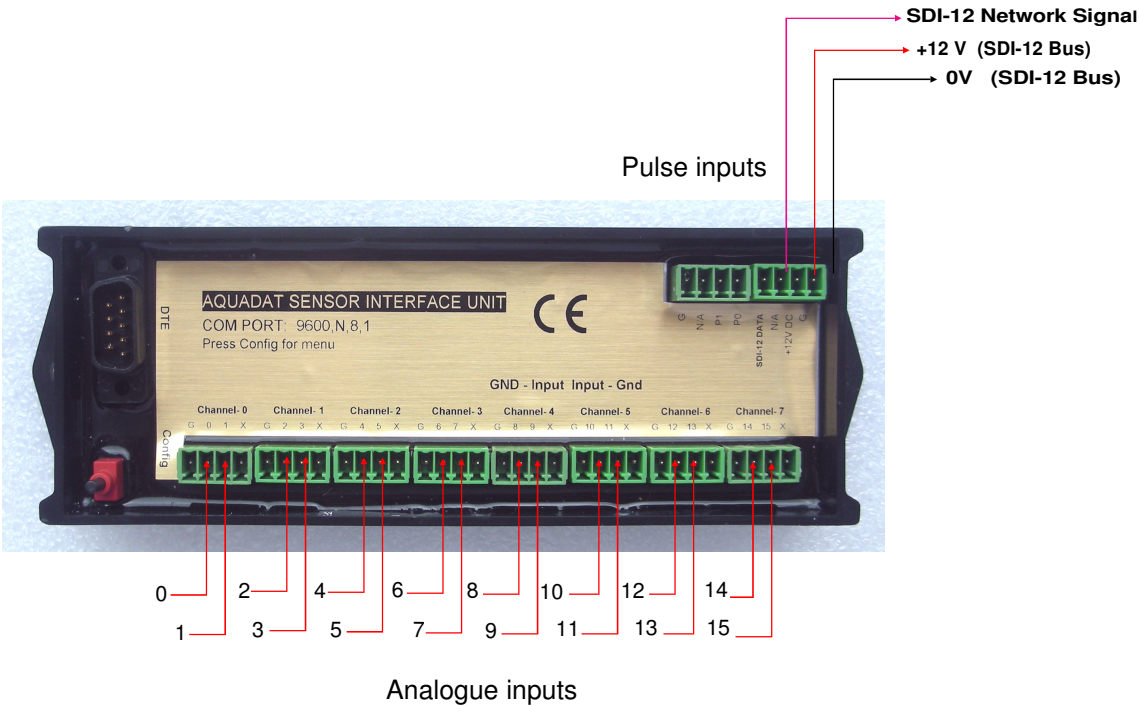
Deployment

The AquaDAT is supplied with a immersion-proof enclosure as standard. As a rule an instrumentation enclosure is used to combine the AquaDAT into a complete solution and enables cable terminations to be easily carried out. The AquaDAT is not rated for operation submerged but will survive short term immersion. A simple cleaning will enable the device to operate again reliably.

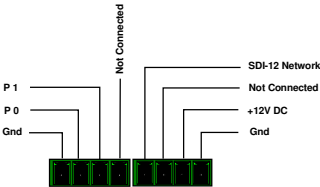
The AquaDAT enclosure has 2 x mounting tabs and these are spaced 173 mm apart and use 5-mm mounting bolts. Secure the AquaDAT to a suitable mounting plate. The enclosure cannot be earthed as it is made of plastic.

If a local earth is needed simply connect this to a Gnd point adjacent to the 12V DC power inlet,

AquaDAT Connections



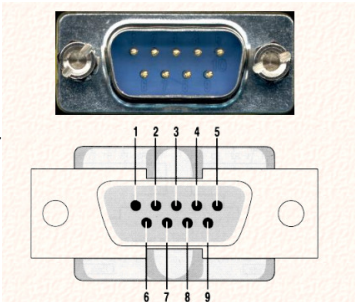
Pulse and SDI-12/power connections



Terminal Port Pin-outs

The terminal port on the AquaDAT requires a Null Modem cable to communicate to a PC.

The Comm port is a 9-pin male connector configured for DCE operations.



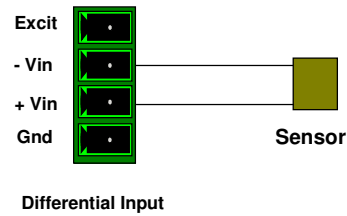
- | | | |
|---|---------------------|-----|
| 1 | Data carrier detect | |
| 2 | Receive Data | Rx |
| 3 | Transmit Data | Tx |
| 4 | Data Terminal Ready | DTR |
| 5 | Signal Ground | |
| 6 | Data Set Ready | DSR |
| 7 | Request to send | RTS |
| 8 | Clear to send | CTS |
| 9 | Ring Indicator | |

Terminal Port Settings

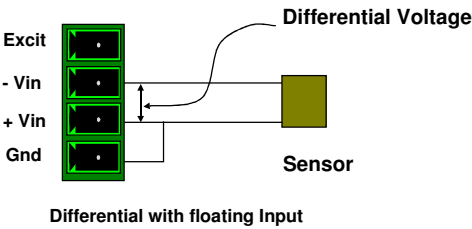
The terminal port uses the following default settings for communication operation to a PC / Laptop serial port:

9600 baud, 8 bits, 1 stop bit, N parity

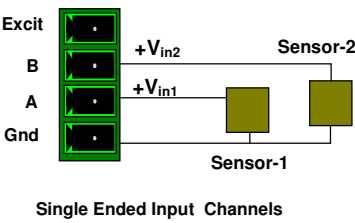
VoltDE



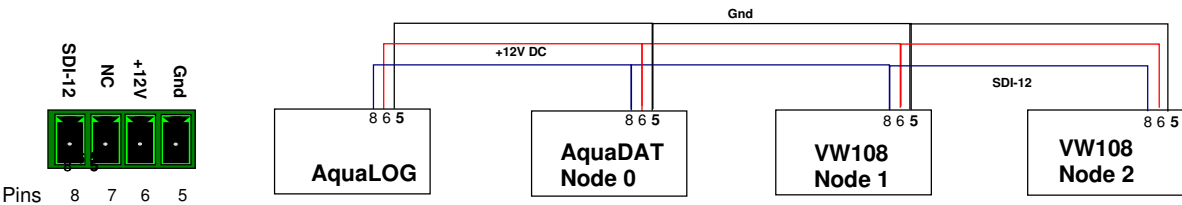
VoltDE



VoltSE



Typical System



AquaDAT Overview

The AquaDAT is an 8 differential channel / 16 channel single-ended analogue module that communicates with a host logger via SDI-12 protocol.

We recommend that when this module is used with the AquaLOG unit, the AquaLOG manual is read in conjunction with this manual.

Analogue instruments are connected to the AquaDAT, and these inputs can be configured via Instruction sets so that the unit recognises the channel configurations.

Each AquaDAT comprises one node (one address) on the SDI-12 network, and with conventional SDI-12 data-loggers, 10 nodes or addresses can be used (nodes 0 - 9). With the AquaLOG, up to 52 nodes may be attached to the SDI-12 network subject to power constraints.

The AquaDAT has an internal **52-column table** into which data is temporarily stored until the scan of attached sensors is completed, and then the resultant data is transmitted digitally to the AquaLOG unit via the SDI-12 bus. Processing of input data contained within a column can be accomplished by allocating a formula to that column, or spare columns may be allocated to perform calculations referenced to a column containing data values, to return data in engineering units. The User may specify which data columns that are returned to the data logger or PC based data acquisition system.

During the setup of the AquaDAT unit, input is assigned to these data columns (A to AZ), and additionally, formulae may be assigned to the input column or further columns may be assigned to process and calculate values contained in other cells.

Thus, the AquaLOG instructs the AquaDAT to take measurements on the internal addresses specified. The AquaDAT energises the sensors and takes readings of the attached sensors in accordance with the requirements of the Instruction Sets, places the data in the columns specified and carries out the processing of formulae within the columns. The data assigned in columns to that internal address is then returned to the AquaLOG as a data string.

Setting Up an AquaDAT

We recommend that master spreadsheets are used to ensure that programming of all units attached to an SDI-12 network are constructed correctly (see this manual and that of the AquaLOG for further details).

- Ensure Hyperterminal or Token 2 are installed on a host computer so that the AquaDAT can communicate with the computer.
- Apply power and attach serial connection.
- From **Device Setup**, set communication mode and baud rate.
- From **Device Setup**, assign node addresses to the AquaDAT(s) either by connection via the AquaLOG, or directly. By default, AquaDATs are assigned a node address of 0 unless otherwise indicated.
- From **Analogue Measurements**, enter channel **Set Up Options** (Instruction Sets) assigning internal columns to data, similarly for Pulse inputs in **Pulse counter Inputs**.
- From **formulae**, assign formulae to columns.
- From **Device Setup**, assign the measurement and read command specifying which column data is associated with an internal address

Data Handling Operations

The AquaDAT uses an internal 52-value table to store the values read from the inputs and results calculated from the formulae prior to data transmission across a network. The table has cell references just like a spreadsheet to make understanding and using it simple to understand.

The input cells represent a single value for each possible analogue and digital pulse input.

The Data Table is referenced via cells starting at 'A' and finishing at 'AZ' - see the table below. Any new value read from a sensor is stored into the table from where additional formulae can be applied, or data can be sent to a logger for storage.

Data Table Layout

Cell	A	B	C	D	E	G	H	I	J
Parameter	23.09	105.09	1200.65	0.0056	3.345				
Data Values									
Cell	AR	AS	AT	AU	AV	AW	AX	AY	AZ
Parameter									

Master Spreadsheet for an AquaDAT System

14	AquaDAT node 5, location pier 6	A	B	C	D	E	F	G	H	I	J	K	L
15	AquaDAT Cell reference	POT	POT	POT	POT	differential	differential	strain	strain	strain	strain	strain	strain
16	Instrument type	P123	P168	P194	P232	D22	D24	RSG2	RSG2	RSG8	RSG9	RSG2	RSG8
17	Instrument serial number	Abutment 1	Abutment 2	Abutment 3	Abutment 4	Abutment 1	Abutment 2	Deck 4	Deck 5	Deck 6	Deck 6	Deck 4	Deck 5
18	Instrument location	ratio	ratio	ratio	ratio	volts	volts	mv/v	mv/v	strain	strain	strain	strain
19	parameter	ratio	ratio	ratio	ratio	volts	volts	mv/v	mv/v	microstrain	microstrain	microstrain	microstrain
20	data units	BrHalf	BrHalf	BrHalf	BrHalf	VoltDE	VoltDE	BrFull	BrFull	BrFull	BrFull	BrFull	BrFull
21	measurement type	1000	1000	1000	1000	5000	5000	5000	5000	5000	5000	5000	5000
22	excitation value(mV)	0	0	0	0	0	0	0	0	0	0	0	0
23	excitation frequency(Hz)	0	1	2	3	4	6	8	10	12	14	14	14
24	primary measurement channel	0	0	0	0	0	0	0	0	0	0	0	0
25	secondary measurement channel	0	0	0	0	0	0	0	0	0	0	0	0
26	delay before measurement (ms)	100	100	100	100	100	100	100	100	100	100	100	100
27	averaging period(ms)												
28	formula												
29	AquaLOG Cell reference	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE
30	AquaDAT internal address	0	0	0	0	0	1	1	1	1	1	2	2
31													

The menu set up system of the AquaDAT allows the allocation of data columns (any column selection to a maximum of 5) to an internal address.

Within the set up menu of the AquaDAT, the address containing the column data is used to assign the device to return the data to the Data Logger or Q-LOG software, and into the specified start cell. The number of values returned is also used by Q-LOG. The start cell locations are used to identify data in the aD0! .. aD3! commands.

We can allocate an internal AquaDAT address of 0 to AquaDAT columns of D Y J K L and specify that internal address to return data to the AquaLOG starting in column T. Thus the AquaLOG columns T U V W X will then contain AquaDAT column data from D Y J K L.

For example, left,

AquaDAT internal address 0 is assigned to 5 sensors at input storage locations A B C D E, which in turn are to be allocated to AquaLOG storage columns starting at T.

Data returned to the column locations are in raw format with the exception, in this example, of column J where the input into column J is processed by a calibration factor so that data in engineering units is stored in J.

Further in this example, Columns H and I are in raw data, and subsequently processed to return engineering units in K and L.

NOTE:

Data in this example is for demonstration only.

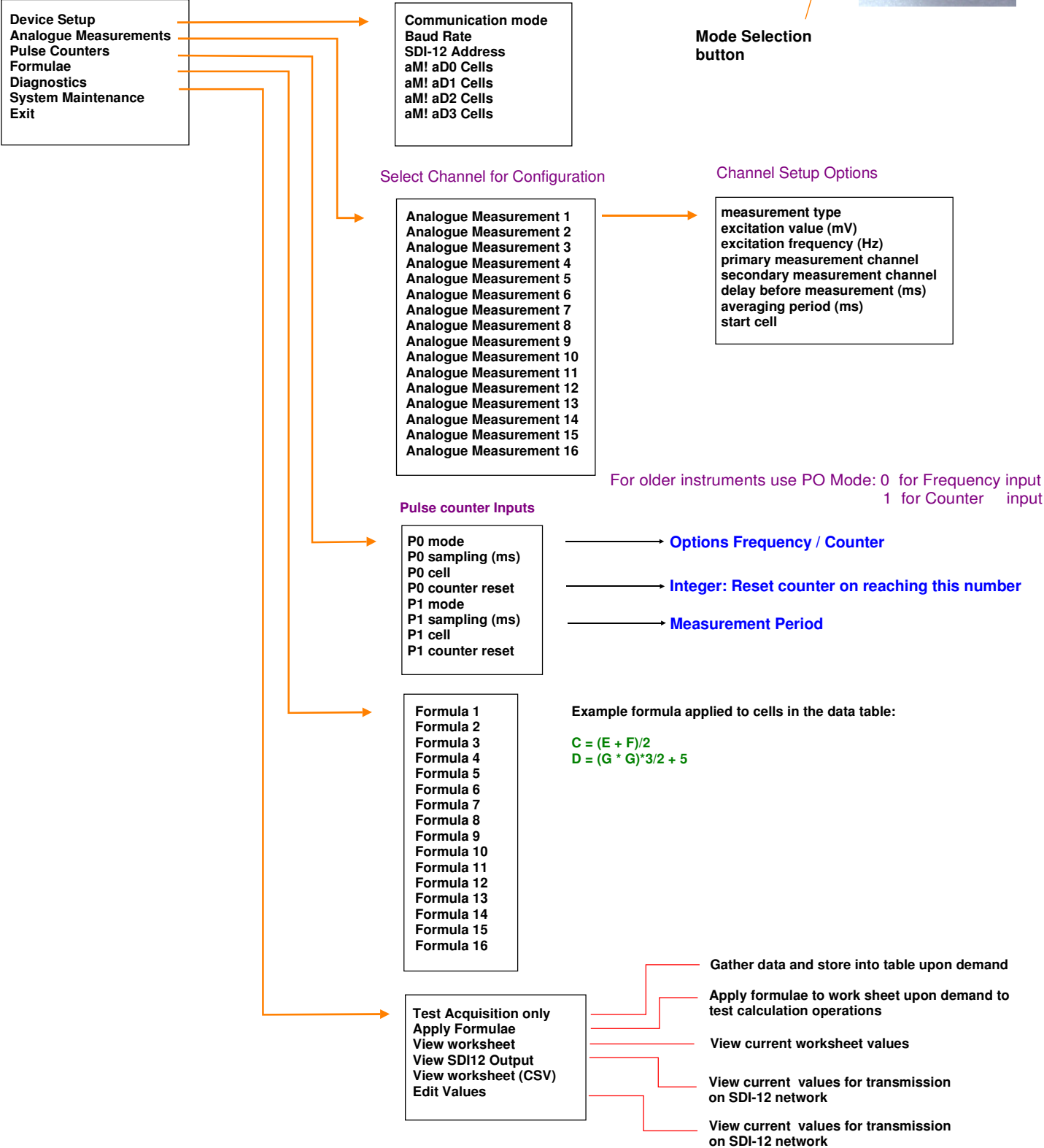
For specific details of excitation value, delays and formulae applicable to various analogue sensors please refer to the supplier information of the sensors and examples within the AquaDAT manual.

AquaDAT Menu Layout

Main Menu

1. Press mode selection button to “active” to activate the menu system
The main menu will appear on the terminal screen

Main menu



AquaDAT Menu Commands

The AquaDAT communicates with a data-logger or PC via the SDI-12 network. The AquaDAT connects to a PC using a media converter or to the data logger via the SDI-12 port. The AquaLOG supports a 'Transparent' mode enabling commands to be sent to intelligent sensors across the digital network.

Page 11 shows how the AquaDAT is connected to a PC or data logger.

However node setup and other set ups are to be done with the AquaDAT, it is necessary to have a direct connection between the host computer and the AquaDAT. This is normally performed before the AquaDAT is deployed in the field.

To operate the AquaDAT using the in-built menu system then a suitable terminal emulator software has to be used on the host PC. Two of the most common but freely available Windows based terminal emulators are Hyper-terminal or Token 2.

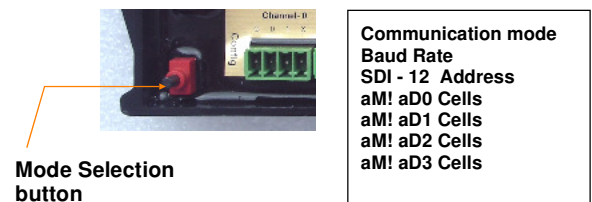
See the AquaLOG manual for installation instructions.

Operating the Menu System with Terminal Emulator Software - VT100 Compatible

Connect the host computer to the AquaDAT via a null modem cable. Start Hyper-terminal and then apply power to the AquaDAT via the 12 V and ground pins.

Press the Mode selection button

The menu system will then appear on the host computer



Select Device Setup.

Option Communication Mode

The AquaDAT supports 2 modes of operation: RS-232 and SDI-12.

For local operations and data read directly into a PC use the RS-232 option.

For SDI-12 network operations: **Press the button to Select SDI-12 mode.**

Baud Rate.

Once the SDI-12 mode has been selected, the baud rate will default to 1200 baud.

SDI-12 Address

On an SDI-12 network, each device attached to the network has a unique address. Conventional networks allow a maximum of 10 addresses (nodes) 0 to 9. The AquaLOG unit has an expanded capability of up to 52 addresses with addresses 0 to 9, a to z and A to Z. AquaDAT units are supplied with a default address of 0 (unless otherwise indicated) and this address may need to be changed.

To change the address, enter address required.

Command aM! aD0!Cells

This command sets device **a** to commence measurement and return data from internal address **0** defined as **cells** when instructed by the logger.

We can assign **any** columns in the data table to an internal address. This data will be sent to the logger when the logger issues a corresponding command to measure and return the node and internal address (See AquaLOG manual)

For example with an **AquaDAT** with address 9:

aM! aD0! **enter** A C D E
aM! aD1! **enter** P Q S T
aM! aD2! **enter** X Y AB AF

Corresponding **AquaLOG** Device command Instruction:

[G] 9M! 9D0!
[Q] 9M! 9D1!
[Z] 9M! 9D2!

Alternatively the AquaLOG commands can be combined:

[G] 9M! 9D0! [Q] 9M! 9D1! [Z] 9M! 9D2!

For example in the first command, the AquaDAT command defines **aM! aD0! A C D E** as AquaDAT address **9** with internal address **0** which contains data held in columns **A C D E** and so forth for the commands. The AquaLOG corresponding command starts measurement on device **9** and returns data from internal address **0** (data A C D E) and places that data in the AquaLOG table starting at column **G**. So AquaLOG columns **G H I J** will contain data from AquaDAT columns **A C D E** respectively.

NOTE: The AquaLOG supports up to 5 cells per command; other SDI-12 loggers support only 4 cells.

AquaDAT Menu Commands

Analogue Measurements

Analogue Measurements sets up the input channels to suit the sensor inputs. It is important that the User is familiar with the instruments to be connected to ensure that the correct excitation values and configurations are applied.

Each measurement type (see page 15) sets up the channels correctly, but care must be taken to ensure that the correct values are entered. See examples.

Start cell defines the cell within the AquaDAT data table where the input will be sent to.

Pulse Counter Inputs

Select Channel for Configuration

Analogue Measurement 1
Analogue Measurement 2
Analogue Measurement 3
Analogue Measurement 4
Analogue Measurement 5
Analogue Measurement 6
Analogue Measurement 7
Analogue Measurement 8
Analogue Measurement 9
Analogue Measurement 10
Analogue Measurement 11
Analogue Measurement 12
Analogue Measurement 13
Analogue Measurement 14
Analogue Measurement 15
Analogue Measurement 16

Channel Setup Options

measurement type
excitation value (mV)
excitation frequency (Hz)
primary measurement channel
secondary measurement channel
delay before measurement (ms)
averaging period (ms)
start cell

Pulse counter Inputs

P0 mode
P0 sampling (ms)
P0 cell"
P0 counter reset
P1 mode
P1 sampling (ms)
P1 cell"
P1 counter reset

Options Frequency / Counter

Integer: Reset counter on reaching this number

Measurement Period

The mode command specifies whether frequency or counts are to be returned.

Sampling (ms): defines the period over which counts are to be undertaken.

Cell: defines the column in the AquaDAT table where the result is to be stored.

Counter reset: this resets the counter after a specified number of counts.

Formulae

Formulae may act on input cells directly, or may be placed in additional cells referencing the input cell.

Formulae currently supported are:-

+ , - , / , * , ()

$A = A \times A = A^2$ (Term squared)

$A = B + 2$

$A = B / 7$

$A = B * D$

Example. Quadratic coefficients:

Cell B = $(D * D * D) / 5 + (D + 1) / 7$
 $= D^3 / 5 + (D + 1) / 7$

Formula 1
Formula 2
Formula 3
Formula 4
Formula 5
Formula 6
Formula 7
Formula 8
Formula 9
Formula 10
Formula 11
Formula 12
Formula 13
Formula 14
Formula 15
Formula 16

It is possible to self-reference a cell . New values are only updated after the formula operation is complete
 Values are updated prior to new recordings being made and data transmitted across a network.

Typical Examples

Formula 0 $B = B * 180$

(self-referencing input cell)

Formula 1 $J = (5.625 * E) - 1.25$

(uses input E and places result in J)

Formula 2 $E = (D - 0.134) * (D - 0.134) * (D - 0.134) / 7$
 for quadratic equation

(uses input D and places result in E)

Analogue Measurement Instruction Sets

The table below details the analogue channel processing options available within the AquaDAT. Additional options are becoming available or can be added upon request.

Channel Setup Options

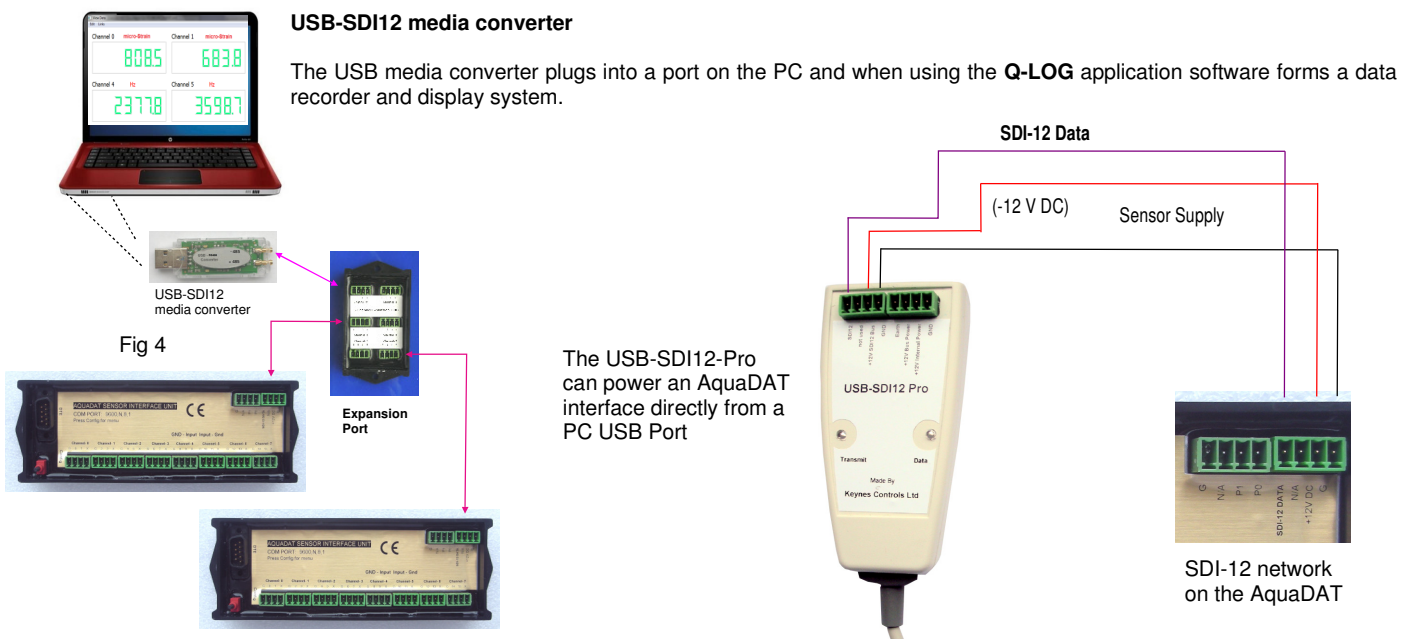
measurement type
excitation value (mV)
excitation frequency (Hz)
primary measurement channel
secondary measurement channel
delay before measurement (ms)
averaging period (ms)
start cell

Analogue Channel Type Description	Instruction Set	Description	Instruction Set
Voltage Single-ended	VoltSE	Resistance	Resistance
Voltage Differential	VoltDE	Thermocouple Type J Single-ended input	TC-JSE
Half Bridge	BrHalf	Thermocouple Type K Single-ended input	TC-JSE
Half Bridge 3-wire	BrHalf3W	Thermocouple Type T Single-ended input	TC-TSE
Half Bridge 4-wire	BrHalf4W	Thermocouple Type J Differential input	TC-JDE
Full Bridge	BeFull	Thermocouple Type K Differential input	TC-KDE
Full Bridge 6-wire	BrFull6W	Thermocouple Type T Differential input	TC-TDE
Resistance	Resistance	Thermistor temperature sensor	Thermistor

Configuring the AquaDAT with Q-LOG.

Connect the AquaDAT to the PC using the USB media converter. See the simple diagram below showing how the USB is installed and power is applied to the AquaDAT. The AquaDAT is fully integrated into the Q-LOG applications software. Q-LOG enables all the features of the device to be configured using a pull-down menu system without the User having to understand any programming operations.

Once the AquaDAT is connected to the PC as shown below and the Q-LOG software is installed. To simplify the configuration operation use a single AquaDAT on the network at any one time. Scan the network and the AquaDAT will be identified by the software. The Pull-down menu options for this device will then be available to the User.



Analogue Measurement Instruction Sets

Analogue Measurement 0:

Analogue channel 0 single-ended input averaged over 1 second period representing Anemometer direction signal with range between 0 and 2V DC. Excitation DC = 2V (2000 mV). 0 = North and 2V represents 360-degree movement. Output from wiper on anemometer potentiometer. Results stored to cell B.

measurement type	VoltSE
excitation value (mV)	2000
excitation frequency (Hz)	0
primary measurement channel	0
secondary measurement channel	
delay before measurement (ms)	0
averaging period (ms)	1000
start cell	B

Analogue Measurement 1:

Analogue channel 2 thermocouple type K single-ended input averaged over a 2 second period (2000 mS) and the results stored to cell C in the data table within the AquaDAT.

measurement type	TC-KSE
excitation value (mV)	0
excitation frequency (Hz)	0
primary measurement channel	2
secondary measurement channel	
delay before measurement (ms)	0
averaging period (ms)	2000
start cell	C

Analogue Measurement 2:

Analogue channel 3 thermocouple type T single-ended input averaged over a 3 second period and the results stored to Cell D. Signal is averaged over 3 seconds.

measurement type	TC-TSE
excitation value (mV)	0
excitation frequency (Hz)	0
primary measurement channel	3
secondary measurement channel	
delay before measurement (ms)	0
averaging period (ms)	3000
start cell	D

Analogue Measurement 3:

A differential pressure sensor is connected to channels 4 and 5. The sensor has range 1 - 10 bar. A delay of 1 second is required before a measurement is started. The measurement is made over a 4 second period to remove transient effects. Results are stored into Cell E in the data table.

measurement type	VoltDE
excitation value (mV)	0
excitation frequency (Hz)	0
primary measurement channel	4
secondary measurement channel	
delay before measurement (ms)	1000
averaging period (ms)	5000
start cell	E

The AquaDAT automatically assigns channel 5 as the matching differential input,

Analogue Measurement 4:

Battery voltage is measured through a potential divider circuit to keep the range below 5 V DC. The instantaneous value is stored into Cell F.

measurement type	VoltSE
excitation value (mV)	0
excitation frequency (Hz)	0
primary measurement channel	6
secondary measurement channel	
delay before measurement (ms)	0
averaging period (ms)	0
start cell	F

The output is scaled by a factor of 3.0

Analogue Measurement 5:

A wave height signal representing a range 1 - 10 m is averaged over a period of 10 seconds to remove spray effects. The results are stored into Cell G.

measurement type	VoltSE
excitation value (mV)	0
excitation frequency (Hz)	0
primary measurement channel	7
secondary measurement channel	
delay before measurement (ms)	0
averaging period (ms)	6000
start cell	G

Analogue Measurement 6:

Electro-level sensor with 50 Hz excitation frequency averaged over 2 seconds with a start-up delay of 50 mS is connected into channel 8. The output is stored into Cell H. Amplitude of the excitation voltage = 1 V.

measurement type	BrHalf
excitation value (mV)	1000
excitation frequency (Hz)	50
primary measurement channel	8
secondary measurement channel	
delay before measurement (ms)	50
averaging period (ms)	2000
start cell	H

Thermistor setting

measurement type:	Thermistor
excitation value (mV)	5000
excitation frequency (Hz)	0
primary measurement channel	14
secondary measurement channel	
Input Range (mV)	5000
delay before measurement (ms)	10
averaging period (ms)	20
start cell	I
Cal Factor 0	0.3333
Cal Factor 1	-2.2253E-07
Cal Factor 2	-2.8085E-01
Cal Factor 3	1.8512E+03
Cal Factor 4	Steinhart-Hart 'D'

Analogue Measurement 7:

Thermistor temperature sensor connected to channel 14. Input range = 5 V (5000 mV), delay before measurement is 10 mS. Measurement period = 20 mS

The output is stored into Cell I the AquaDAT data table.
Amplitude of the excitation voltage = 5 V.

The sensor calibration parameters are taken directly from a sample Vibrating Wire strainsensor calibration data sheet shown on page 32.

Pulse Counter Inputs:

Digital input P0 is configured as a frequency input for the wind speed anemometer output signal. Result stored to Cell A in the data table. Measurement period is 1 second.

P0 mode	Frequency
P0 sampling (ms)	1000
P0 cell"	A
P0 counter reset	
P1 mode	
P1 sampling (ms)	
P1 cell"	
P1 counter reset	

Technical Information

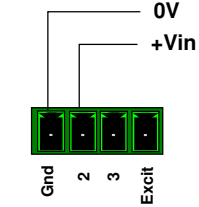
Analogue Input Channels

The AquaDAT supports 8 full differential or 16 single-ended inputs only.

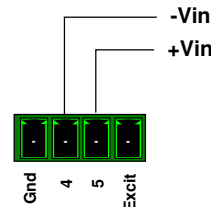
Any combination of inputs can be set according to the menu system below. For example the AquaDAT can be used with 2 differential inputs and 12 single-ended inputs depending upon the application.

Differential inputs are always adjacent pairs of channels see table below:

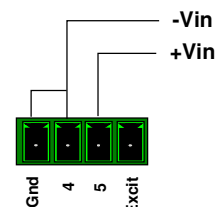
Inputs Channel	DE Inputs
0 & 1	0
2 & 3	1
4 & 5	2
6 & 7	3
8 & 9	4
10 & 11	5
12 & 13	6
14 & 15	7



Single ended input



Differential inputs



Differential inputs

Connect -Vin to gnd
to reduce common mode effects

A/C Power Line Rejection

The AquaDAT undertakes analogue integration on voltages to be measured by any analogue channel. The magnitude of the frequency response of an analogue integrator is a Sinc(X) shape, which has notches (transmission zeroes) occurring at $1 / (\text{integer multiples})$ of the integration duration. It is the notches that enable the mains interference to be removed from an input signal.

This means that noise at $1 / (n \times \text{Mains Filter Averaging Period})$ of the recording duration is effectively rejected by the analogue integration process.

Integration periods that are commonly used to remove grid / mains-borne interference from the analogue input signals. are:

Mains Filter Averaging Period

Integration Time mS (Averaging Periods)	
60 mS	Filters 60 Hz noise
20 mS	Filters 50 Hz noise

So long as the averaging period remains a multiple of the above time periods shown above, then the mains rejection feature of the integration period will be maintained.

Low-level AC Signals

Magnetic pickup sensors commonly generate AC output signals ranging from millivolts at low rotational speeds to several volts at high speeds. The analogue inputs auto range and can easily accept and identify signals in the low 0 to 1 mV range.

Common Mode / Input Range

For the AquaDAT to make a differential measurement, the voltage inputs must be within the common mode range of ± 5 V.

The common mode range is the voltage range, that is relative to AquaDAT ground, for which both inputs of a differential measurement must lie.

For example, if the high side of a differential input is at 4.7 V and the low side is at 2.2 V relative to AquaDAT ground, there is no problem. A measurement made on the ± 5000 mV range will return 2500 mV.

However, if the high input is at 8.8 V and the low input is at 4.2 V, the measurement can not be made because the high input is outside of the ± 5 V common mode range.

Technical Information

Sensors Requiring AC Excitation:

Some resistive sensors require AC excitation for operation, for example, electrolytic tilt and water conductivity sensors. A DC excitation may result in polarisation of the sensor and serious errors in the measurements.

Other sensors, e.g., LVDTs (Linear Variable Differential Transformer), use an AC excitation because they rely on inductive coupling to provide an output signal. DC excitation will provide no output whatsoever.

The AquaDAT provides User programmable AC excitation to remove polarisation effects.

Note. Sensors requiring AC excitation to minimise or eliminate ground loops:
See Section 19.1, page 10 for further details.

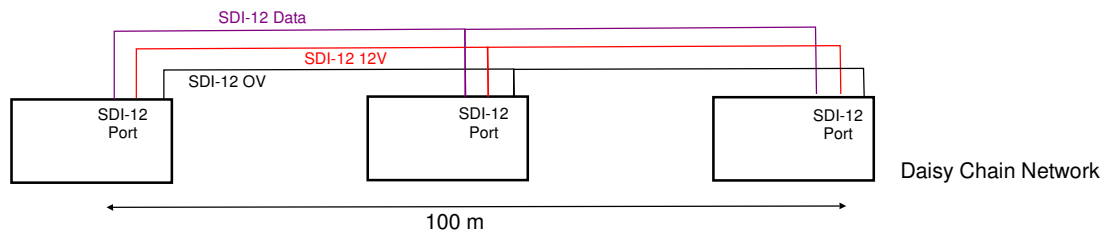
Averaging Periods:

The analogue input signals can be averaged over set time periods in 1 ms increments. Therefore, a signal with averaging period = 2000 mS will take 2000 readings over a 2 second time period. The result supplied will then be the average value of the total number of samples over the time period defined.

SDI-12 Network Operations

The AquaDAT is connected onto an SDI-12 network using the SDI-12 port. Each node on the network is daisy-chained to the next as shown below until the final device is terminated to a logger or media converter.

The same operation is repeated for both the +12V DC and Gnd lines. All 12V power is connected together and all Gnd (0V) lines are connected together.



SDI-12 Network Version

The AquaDAT supports version 1.3 firmware.

The SDI-12 digital network is a communications protocol developed to transmit digital data from smart sensors to data-acquisition units. It is a simple protocol, requiring only a single communication wire. The range of the network is 100 metres and supports up to 10 modes.

Voltage Measurements

The AquaDAT measures both single-ended (**VoltSE**) and / or differential (**VoltDE**) voltage inputs. Single-ended measurements use the instruction **VoltSE**, which returns the voltage difference between a single input (y.y mV) and ground (0 mV).

Differential measurements use the analogue input type **VoltDiff**, which returns the voltage difference (x.x - y.y) between a high input (A.A mV) and a low input (B.B mV).

Associated with differential measurements is common-mode voltage, defined as the average DC voltage common to both the high and low inputs $[(V_{Hi} + V_{Lo}) / 2]$ associated with a differential measurement. The AquaDAT incorporates a differential instrumentation amplifier on its measurement front end. This amplifier processes the difference between the voltage inputs, while rejecting common-mode signals, as long as the common-mode signals are within the ± 5000 mV common-mode input range of the amplifier.

Analogue Input Auto-ranging

The AquaDAT uses an intelligent auto-ranging data-acquisition system to optimise the analogue signal measurements. No User commands are necessary to set the input range for any type of measurement.

Technical Information

Differential or Single-ended Inputs - which should I use?

Deciding whether a differential or single-ended measurement is appropriate for a particular sensor is often decided by the sensor manufacturer. The difference between the two types of inputs requires sorting through trade-offs of accuracy and precision, available measurement hardware, and fiscal constraints.

In broad terms, analogue voltages are best measured differentially because this technique includes noise reduction features, listed below, and not shown included in single-ended measurements.

- Passive Noise Rejection:
 - No voltage reference offset
 - Common-mode noise rejection
- Rejects capacitive coupled noise
- Active Noise Rejection
 - Input reversal

Reasons for using single-ended measurements, however, include:

- Sensor is not designed for differential measurement.
- Sensor number exceeds available differential channels, large channel counts sensors with a high signal-to-noise ratios.

Note. When long distances between a sensor and logging device are involved then it is best to use differential inputs where possible.

Settling Time

When the AquaDAT switches an analogue input channel or activates excitation for a bridge measurement, a settling time is required for the excitation voltage to settle to its true value before a measurement is to be made. The rate at which the signal settles is determined by the input settling time constant which is a function of both the source resistance and input capacitance.

On bridge measurements:

Allow	2 mS	settling for low resistance loads
	10 mS	settling for high impedance loads

The settling time quoted is meant as a guide and the User can adjust the settling time to suit an application in 1 mS intervals.

Minimising Settling Times

When long lead lengths are used the following general practices should be followed to minimise errors:

1. **DO NOT USE WIRE WITH PVC-INSULATED CONDUCTORS.** PVC has a high dielectric and this extends input settling time.
2. Ensure excitation and signal leads use separate shields to minimize transients.
3. When measurement time is not a prime consideration, additional time can be used to ensure settling time for a sensor has occurred satisfactorily before a measurement is made.

Technical Information

5.3 PC Data Acquisition System

Fig 4



USB-SDI12 media converter

The USB media converter plugs into a port on the PC and when using the **Q-LOG** application software forms a data recorder and display system.



USB-SDI12 media converter

Model: USB-SDI12-Pro



Isolated USB Media Converters

Model: USB-485-Pro



Expansion Port



Download a copy of Q-Log

Further information at:

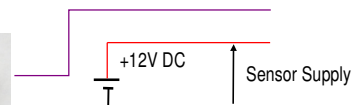
<http://www.aquabat.net/QLOGFree/qlogv2.html>

The image below shows how the power supply is connected to the media converter in order to drive the AquaDAT sensor interface.

Part Number: **USBS12v1**

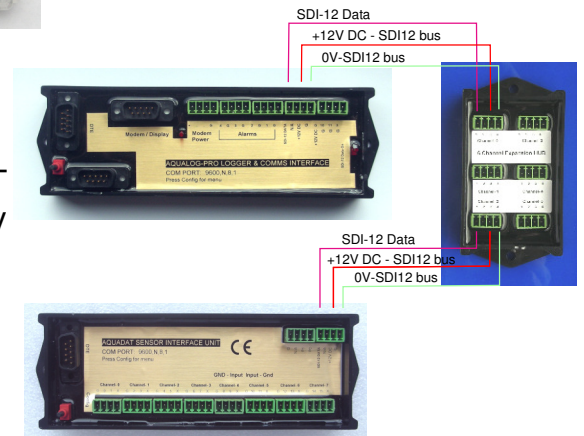


SDI-12 Data



AquaLOG Data Recorder with AquaDAT Expansion

The image opposite shows how to connect the AquaDAT expansion unit to a data logger. The AquaDAT is only powered on to take a measurement and is powered off



Total Scan Time:

The total amount of time that the AquaDAT stays active for a measurement operation is the sum of all of the measurement times for all defined operations.

Measurement time = Delay before measurement + Averaging Period

Bridge Resistance Measurements:

Many sensors detect phenomena by way of change in a resistive circuit, for example, thermistors, strain gauges, and displacement potentiometers. Bridge measurements are undertaken by supplying a precise, known voltage to a resistive circuit, then measuring the returning voltage from where the resistance can be calculated.

The AquaDAT is supplied with 5 bridge measurement commands as shown in Table 3. In the diagrams

R_s = Sensor resistance and
 R_f = Precision bridge resistor

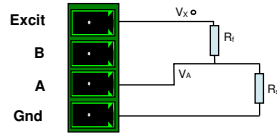
All bridge measurements have the ability of taking a reading with the excitation polarity reversed. The bridge calculation automatically takes into consideration the reverse excitation in any calculation. The offset error in the two measurements due to thermal EMFs can then be accounted for in the processing of the measurement reading.

The excitation level can be adjusted in amplitude and frequency under User control. When more than one measurement per sensor is necessary (four-wire half-bridge, three-wire half-bridge, six-wire full bridge), excitation is applied separately for each measurement. For example, in the four-wire half-bridge, when using AC excitation, the differential measurement across the sensor is made with the excitation at both polarities. The sensor excitation is applied and then reversed for the measurement of the voltage drop across the fixed resistors.

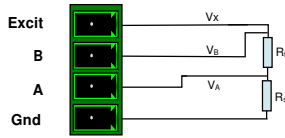
Sensor Inputs

18.3 Sensor Input Circuits

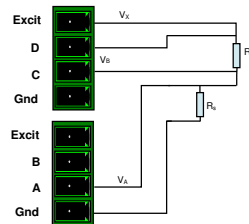
BrHalf



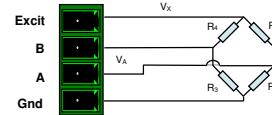
BrHalf3W



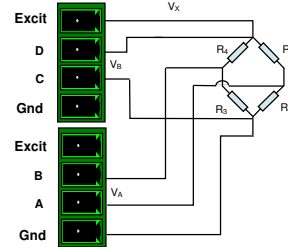
BrHalf4W



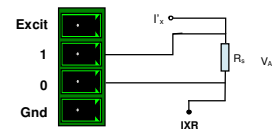
BrFull



BrFull6W



Resistance



Strain Calculations

The AquaDAT supports strain gauge measurements using the different bridge circuits shown above.

Installing A Strain Gauge

To undertake strain measurements connect the gauges into the bridge circuits as shown in section 18.3. The output of the different bridge circuits is in mV/V

The output from the strain gauge bridge is in units mV/V. To convert to engineering units use:

$$\mu\epsilon = \text{micro Strain} = \text{Bridge Output} \times \text{GF}$$

where GF is obtained from manufacturer's data sheet.

Note. Bridge measurements can be dual polarity to remove thermal offset effects by simply setting an A/C excitation frequency. The AquaDAT automatically takes the excitation voltage into consideration in all calculations.

Strain Gauge Equations

Quarter Bridge strain gauge

$$\mu\epsilon = \frac{-4 \cdot 10^6 \cdot V_r}{\text{GF}(1 + 2V_r)}$$

Half-bridge strain gauge, one gauge parallel to strain, the sensor at 90° to the strain

$$\mu\epsilon = \frac{-4 \cdot 10^6 \cdot V_r}{\text{GF} \cdot [(1 + \nu) - 2 \cdot V_r(\nu - 1_r)]}$$

Where:

- ν = Poisson Ratio (o if not N/A)
- GF = Gauge Factor
- V_r = 0.001 .(source - zero) (output in mV)

where "source" = output of the Wheatstone Bridge
"Zero" = gauge offset used to establish the arbitrary zero position.

Half-bridge strain gauge, one gauge parallel to strain ϵ and the other strain gauge parallel to $-\epsilon$

$$\mu\epsilon = \frac{-2 \cdot 10^6 \cdot V_r}{\text{GF}}$$

Full-bridge strain gauge with 2 gauges parallel to ϵ and 2 sensors parallel to $-\epsilon$.

$$\mu\epsilon = \frac{-10^6 \cdot V_r}{\text{GF}}$$

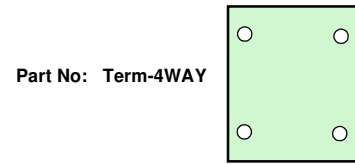
Full-bridge strain gauge, half the bridge has 2 gauges parallel to $+\epsilon$ and $-\epsilon$

$$\mu\epsilon = \frac{-2 \cdot 10^6 \cdot V_r}{\text{GF}}$$

Connecting the Sense Resistors & Strain Gauges

The images shown below demonstrate how the sense resistors are fitted to the AquaLOG using the 4-way terminal block.

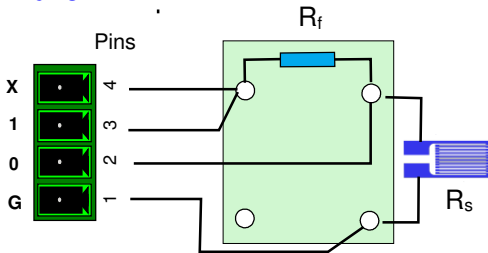
The terminal block contains of 4 isolated screw posts which are set into a waterproof / corrosion-proof enclosure. This device has been designed solely for the fitting of the strain gauge sensor resistors.



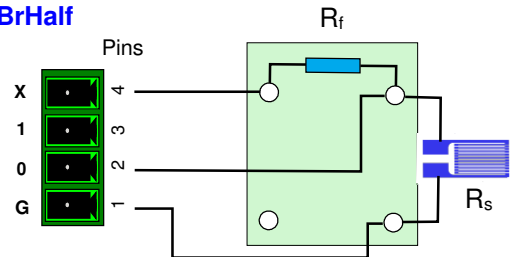
The AquaLOG supports any strain gauge type 120 - 1 K Ohm.

The sensor resistors used should be precision devices with the same resistance of the gauge being used. For example, if a 120 Ohm gauge is to be used in a bridge then 120 Ohm precision resistors should be used to form the bridge.

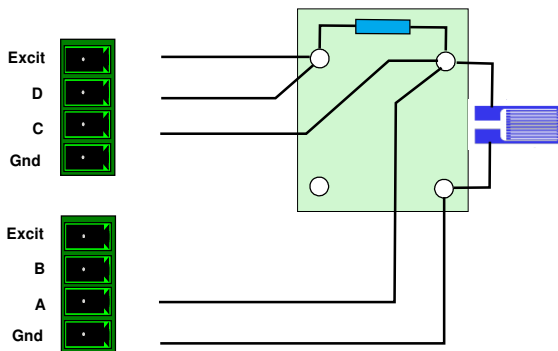
BrHalf3W



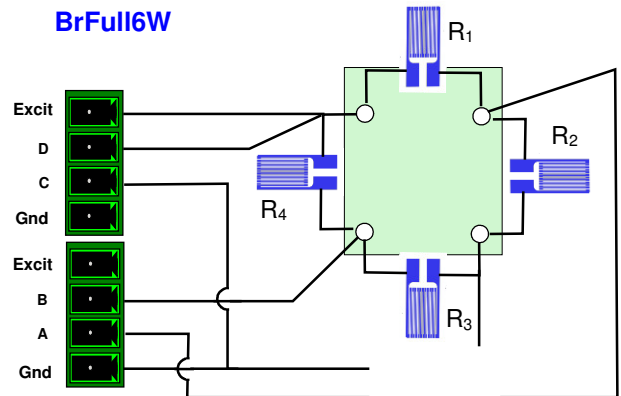
BrHalf



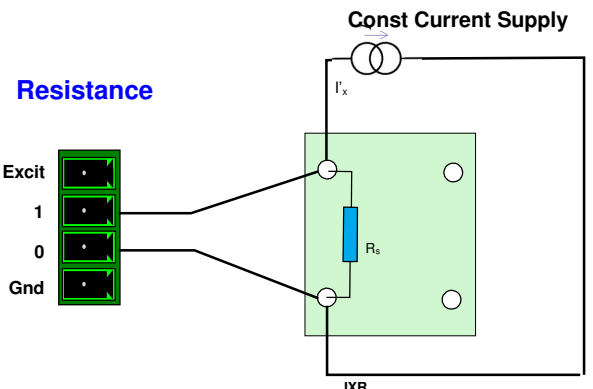
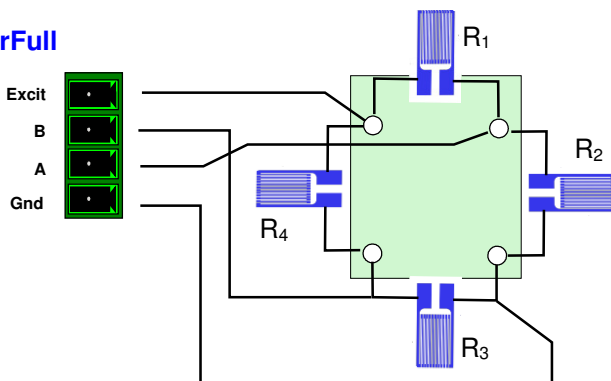
BrHalf4W



BrFull6W



BrFull



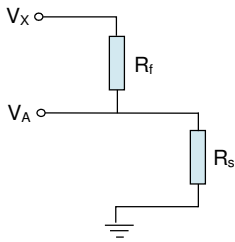
Choosing the Sense Resistors

The sense resistors are chosen to balance the bridge as close to 0V output at normal operating temperature. The output from the bridge is taken to a differential input on the AquaDAT. Care has to be taken to ensure that the sense resistors do not change resistance with temperature so choose devices with 0.05 % tolerance or better with a low temperature change coefficient.

The sense resistors are chosen to have the same resistance as the gauge in operation. For example when using 1 K Ohm gauges use 1 K ohm sense resistors.

Bridge Circuit Equations

BrHalf



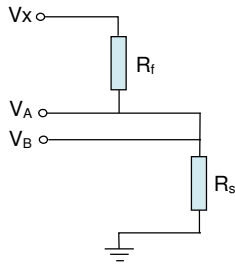
$X = \text{Result}$ scale=1 Offset = 0

$V_x = \text{Excitation Voltage} = \text{nominally } 1\text{V DC}$

$$R_S = R_F \frac{X}{1 - X}$$

$$X = \frac{V_A}{V_X} = \frac{R_S}{R_S + R_F}$$

BrHalf3W



$X = \text{Result}$ scale=1 Offset = 0

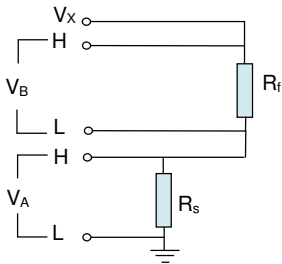
$V_x = \text{Excitation Voltage} = \text{nominally } 1\text{V DC}$

$$R_S = R_F \cdot X$$

$$R_F = R_S / X$$

$$X = \frac{2V_B - V_A}{V_X - V_A} = \frac{R_S}{R_F}$$

BrHalf4W



$X = \text{Result}$ with scale = 1 Offset = 0

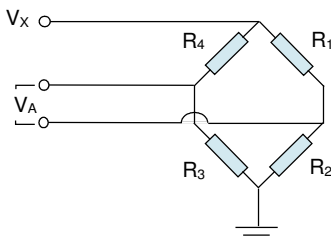
$V_x = \text{Excitation Voltage} = \text{nominally } 1\text{V DC}$

$$R_S = R_F \cdot X$$

$$R_F = R_S / X$$

$$X = \frac{V_B}{V_A} = \frac{R_S}{R_F}$$

BrFull



$X = \text{Result}$ with scale = 1 Offset = 0

$V_x = \text{Excitation Voltage} = \text{nominally } 1\text{V DC}$

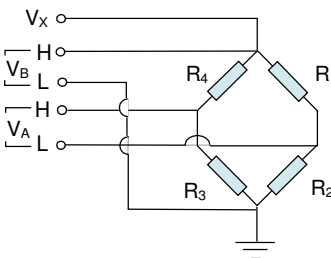
$$X_1 = -\frac{X}{1000} + \frac{R_3}{[R_3 + R_4]}$$

$$R_1 = \frac{R_2 (1 - X_1)}{X_1}$$

$$R_2 = \frac{(R_1 \cdot X_1)}{1 - X_1}$$

$$X = 1000 \cdot \frac{V_A}{V_X} = 1000 \cdot \left[\frac{R_3}{R_3 + R_4} - \frac{R_2}{R_1 + R_2} \right]$$

BrFull6W



$X = \text{Result}$ with scale = 1 Offset = 0

$V_x = \text{Excitation Voltage} = \text{nominally } 1\text{V DC}$

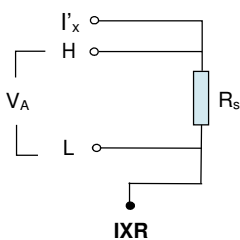
$$X_1 = -\frac{X}{1000} + \frac{R_2}{[R_1 + R_2]}$$

$$R_3 = \frac{(R_4 \cdot X_2)}{1 - X_2}$$

$$R_4 = \frac{R_3 (1 - X_2)}{X_2}$$

$$X = 1000 \cdot \frac{V_A}{V_B} = 1000 \cdot \left[\frac{R_3}{R_3 + R_4} - \frac{R_2}{R_1 + R_2} \right]$$

Resistance



$X = \text{Result}$ with scale = 1 Offset = 0

$I'_x = \text{Constant Current Excitation}$

$$X = \frac{V}{I_x} = R_S$$

Connect **strain gauge** or **RTD sensors** to the bridge circuits as shown. The type of sensor will indicate the bridge circuit to use. Use the manufacturer's data sheet to obtain the formula for converting the bridge output to engineering units.

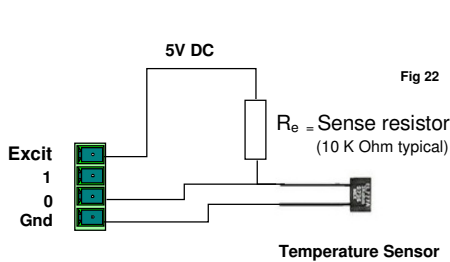
Bridge output is in mV/V.

Sensor Input Examples

Thermistor Measurements

The AquaDAT supports temperature measurements from thermistor temperature sensors. The most common type of thermistor used by the AquaDAT are those used to support of temperature measurements used with vibrating wire sensors.

An example of a thermistor temperature sensor calibration parameters is shown on page 32 of this manual, and are used below in the configuration example.



Thermistor setting

measurement type: **Thermistor**
excitation value (mV) 5000
excitation frequency (Hz) 0
primary measurement channel **14**
secondary measurement channel
Input Range (mV) 5000
delay before measurement (ms) 10
averaging period (ms) 10
start cell **1**
Cal Factor 0 **0.3333**
Cal Factor 1 **-2.2253E-07**
Cal Factor 2 **-2.8085E-01**
Cal Factor 3 **1.8512E+03**
Cal Factor 4 Steinhart-Hart 'D'

Where sense resistor $R_E = 10\text{ K Ohm}$

$R_{T0} = 3.3\text{ K Ohm}$ @ $t_0 = 25\text{ Deg C}$ (typical)

Therefore ratio of $R_{T0}/R_E = 3300.0 / 10000 = 0.3333$

Cal Factor 0 ratio of R_{T0}/R_E
Cal Factor 1 Steinhart-Hart 'A'
Cal Factor 2 Steinhart-Hart 'B'
Cal Factor 3 Steinhart-Hart 'C'
Cal Factor 4 Steinhart-Hart 'D'

For most applications use $R_E = 1\text{ K Ohm}$

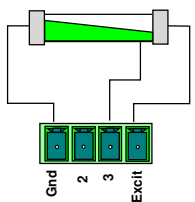
A/C Sensor Excitation

The AquaDAT supports both A/C and D/C User-configured sensor excitation over the range +/- 5V to a maximum frequency of 100 Hz. For D/C operation set the "excitation frequency (Hz)" parameter = 0.

The A/C excitation operation is best shown by an example and is shown below with an electro-level sensor:

Dual-polarity RTD measurements remove thermal offset errors.

Electro-level Tilt Sensor Connection



Analogue Excitation Frequency = 5 - 100 Hz Typical

Analogue input type = Differential

Dual polarity measurements

Measurement type: **BrHalf**

Example

excitation value (mV) **1000** (1V)
excitation frequency (Hz) **50**
primary measurement channel **2**
secondary measurement channel
delay before measurement (ms) **10**
averaging period (ms) **2000**
start cell **D**

Fig 24

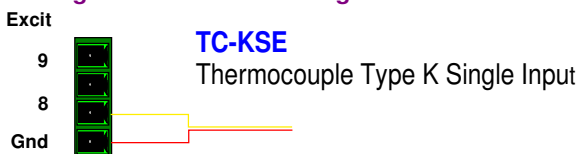
A single electro-level sensor is connected to differential Channel 1 (inputs 2 & 3) with a 1V AC excitation signal operating at 50 Hz. The readings will be averaged over a 2-second period to remove any vibration effects. The result is stored into cell D of the data table prior to transmission to a data recorder.

Thermocouple Measurements Types TC-J, TC-K, TC-T

The AquaDAT supports both single-ended and differential thermocouple inputs. The type of input will depend only on the sensor type fitted. The examples below demonstrate how the sensor types are configured. The AquaDAT contains a CJC and the temperature results automatically take the cold junction values in consideration when storing results.

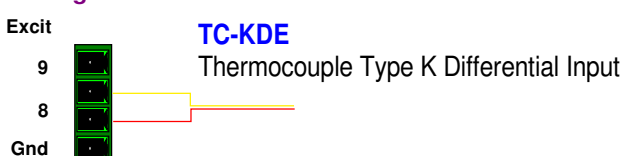
The following analogue channel configuration examples are for the thermocouples shown below:

Analogue Measurement - Single-ended



measurement type **TC-KDE**
excitation value (mV) **0**
excitation frequency (Hz) **0**
primary measurement channel **8**
Secondary measurement channel
delay before measurement (ms) **0**
averaging period (ms) **0**
start cell **G**

Analogue Measurement - Differential



measurement type **TC-KDE**
excitation value (mV) **0**
excitation frequency (Hz) **0**
primary measurement channel **8**
Secondary measurement channel
delay before measurement (ms) **0**
averaging period (ms) **100**
start cell **G**

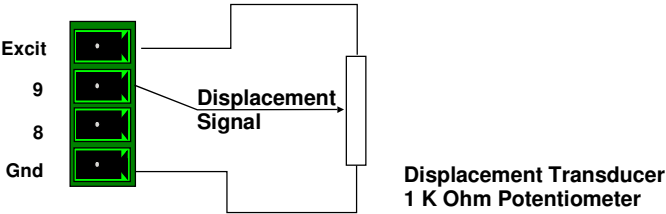
Secondary measurement channel is not used in this option and is not required to be configured.

Sensor Input Examples

Single-ended Inputs VoltSE

Single-ended signals are the easiest type of analogue signal that can be connected to the AquaDAT. Up to 16 individual inputs can be used. All analogue sensors are lightning-protected so no additional protection need be fitted for field applications.

Example: Channel 9 has a linear potentiometer displacement sensor installed. The sensor is to be energised 2 seconds before a reading is made and will be averaged over 5 seconds to remove any local vibration effects. The results will be stored into Cell B of the data table.

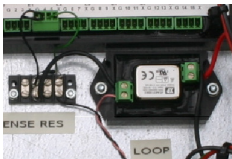
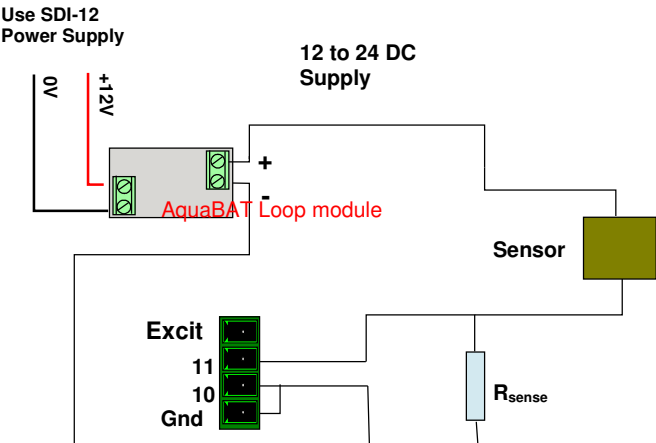


Analogue Measurement 9

measurement type	VoltSE
excitation value (mV)	1000
excitation frequency (Hz)	2
primary measurement channel	9
Secondary measurement channel	
delay before measurement (ms)	2000
averaging period (ms)	5000
start cell	B

4-20 mA Current Loop Operation VoltDE

Current loops require an external 12- 24 V DC power supply and a **100 Ohm** external sense resistor for operations. Schematic shows how to connect a 4-20 mA loop powered sensor to the AquaDAT using an AquaBAT loop module. The input is typically of floating differential type .



Analogue Measurement 4

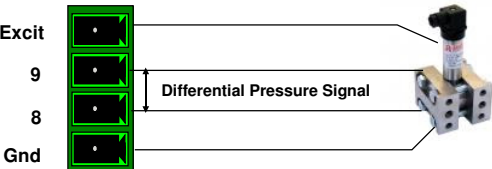
measurement type	VoltDE
excitation value (mV)	0
excitation frequency (Hz)	0
primary measurement channel	10
Secondary measurement channel	
delay before measurement (ms)	2000
averaging period (ms)	4000
start cell	B

A current loop is connected to differential channel 5 made up of analogue inputs 10 & 11. The results are stored into data table Cell B. There is a delay of 2 seconds while the sensor energizes and the measurements are averaged over a 4-second period.

Differential Inputs VoltDE

Single-ended signals are the easiest type of analogue signal that can be connected to the AquaDAT. Up to 16 individual inputs can be used. All analogue sensors are lightning-protected so no additional protection need be fitted for field applications.

Example, A differential pressure sensor is being used to monitor the pressure for a chemical plant application. The sensor has an excitation of 2 V. A dual-polarity measurement is to be made to remove offset errors. As the pressure being measured is the output from a pump and the removal of any transients is important, the signal will be averaged over a 6 -second period. The input signal is applied to differential channel 6, i.e. between channels 12 and 13. and the result will be stored to cell G of the data table.



Data Table

Analogue Measurement 9

measurement type	VoltDE
excitation value (mV)	2000
excitation frequency (Hz)	5
primary measurement channel	12
Secondary measurement channel	
delay before measurement (ms)	0
averaging period (ms)	6000
start cell	G

Sensor Input Examples

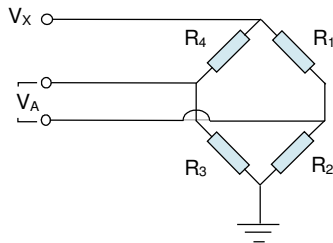
Strain Gauge Bridge

BrFull

The easiest way to understand the operation of the AquaDAT is by example:

A full strain gauge bridge is installed on differential channel 3, that is between channels 0 and 1 on the AquaDAT, see Table 1 above. The output of the bridge is to be stored into Cell D of the data table. The bridge excitation will be 1 volt, and will be applied 50 mS before a reading is taken to remove self-heating effects. The measurement will be made over a period of 2 seconds and will be dual-polarity to remove any offset errors. Gauge factor =5

Full-bridge circuit



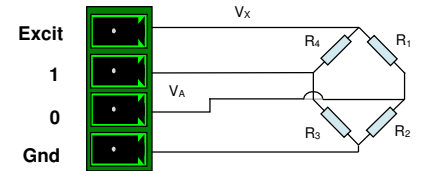
$X = \text{Result with scale} = 1 \text{ Offset} = 0$

$V_x = \text{Excitation Voltage} = \text{nominally } 1\text{V DC}$

$$X = 1000 \cdot \frac{V_A}{V_x} = 1000 \cdot \left[\frac{R_3}{R_3 + R_4} - \frac{R_2}{R_1 + R_2} \right]$$

Analogue Measurements → Analogue Measurement 6 →

measurement type
excitation value (mV)
excitation frequency (Hz)
primary measurement channel
secondary measurement channel
delay before measurement (ms)
averaging period (ms)
start cell



BrFull
1000
2
0
(channels 0 or 1 could be used)

Note: to convert the value in the data table into engineering units of micro-strain, then formula $D = D \cdot GF$ (Gauge Factor) = 5 . **D** is embedded in cell D

Cell	A	B	C	D	E	G	H	I	J
Parameter				X					
				↑					
				Value in table					

Differential Input Operation

A differential input is made of 2 channels A and B. For example, differential input 1, above, is made up of input channels 0 and 1.

When setting the primary measurement channel, the AquaDAT automatically identifies between the channel pairs in use.

The Primary measurement channel can be set with either of the input channels forming the differential pair.

Pulse Counter / Digital Input

The AquaDAT supports 2 x digital frequency / counter inputs P0 and P1.

The **Frequency** input takes its calculation over a defined gating period and writes the result to data table.

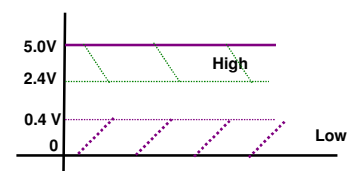
The Counter writes a cumulative count to the data table at a set time with a maximum count value to 1.6×10^{24}

Input Signal conforms to TTL signal. Low < 0.4V High > 2.4 V

Options are:

P0 mode
P0 sampling (ms)
P0 cell"

Frequency or Counter
1000 (Measurement period)
Data Table location

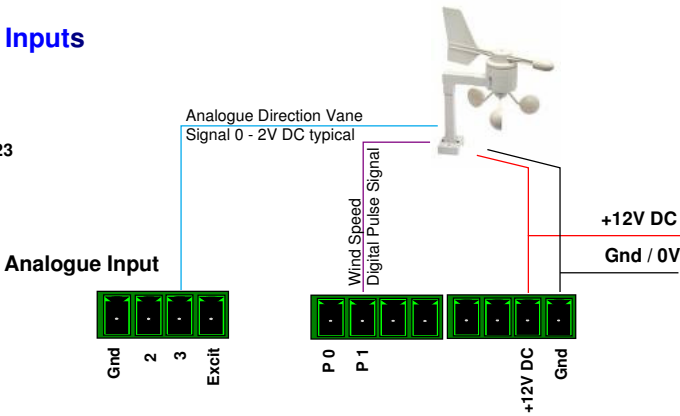


Digital Signal Level - Standard TTL

Sensor Input Examples

Pulse Inputs

Fig 23



The output from Pulse input P1 is stored into Cell A of the data table.

It is in the data table that the results are processed into engineering units.

Pulse counter inputs

P0 mode	
P0 sampling (ms)	
P0 cell"	
P0 counter reset	
P1 mode	Frequency
P1 sampling (ms)	1000
P1 cell"	A
P1 counter reset	

Example Application

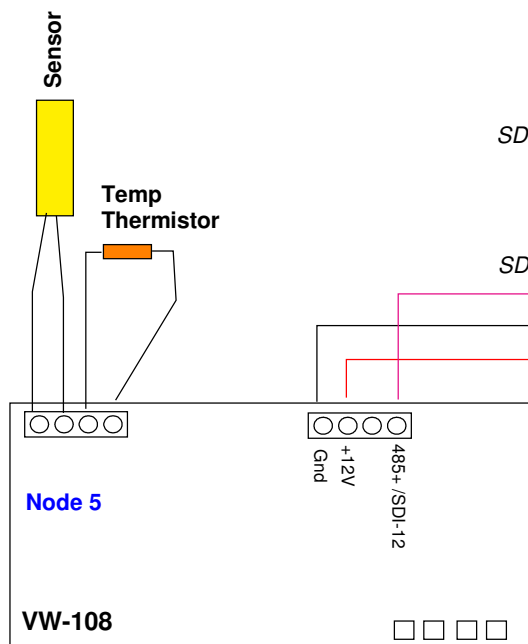
System Overview

The system shown opposite is typical of an application for which the AquaLOG is used.

The AquaLOG acts as the data-logger and communications interface to control a modem or mesh network interface. Information can be transmitted using a radio modem or stored to a flash memory stick using the USB interface.

SDI12 Setup AquaLOG

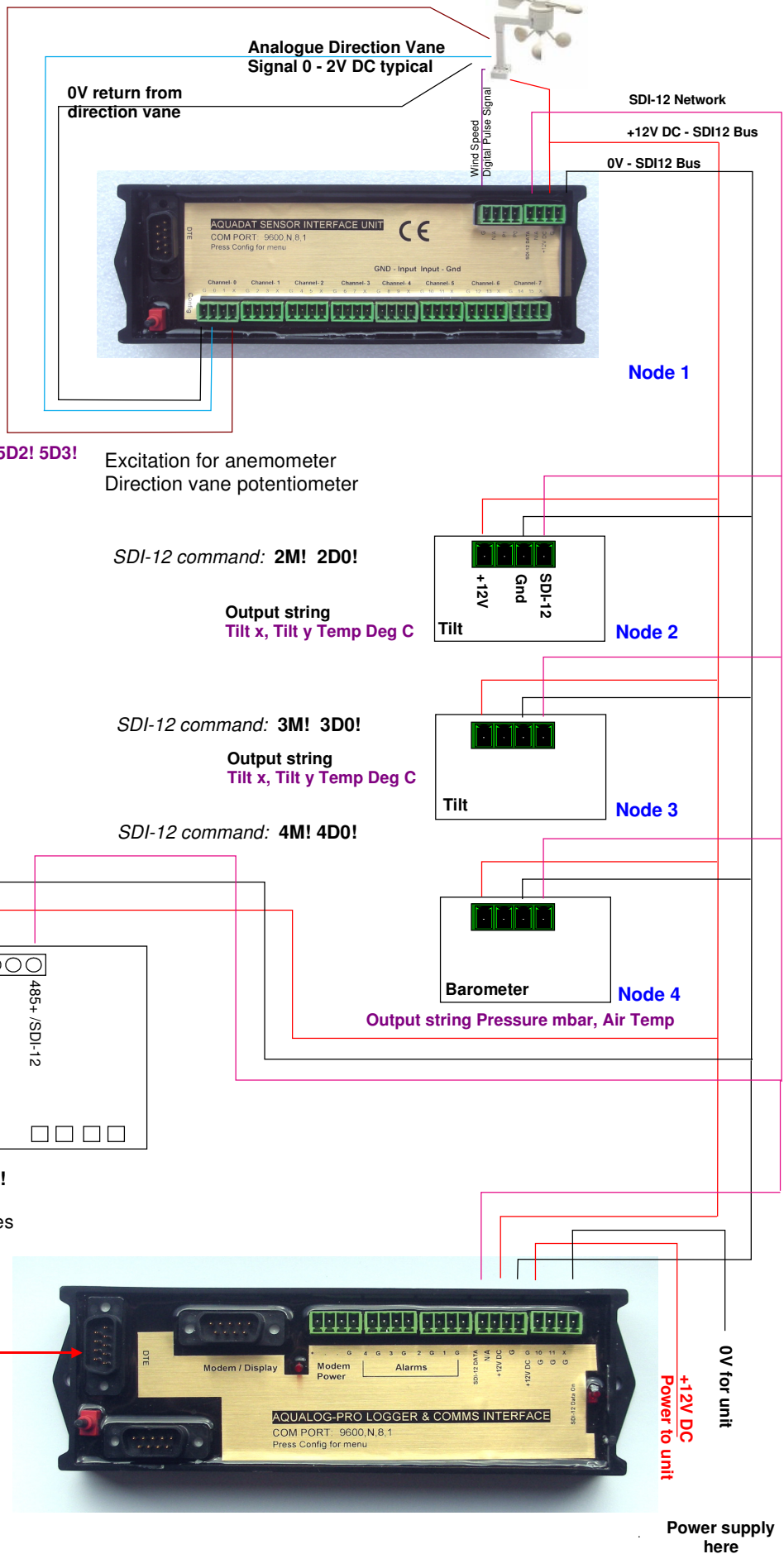
1 Powerup delay (ms)	100
2 Powerdown delay (ms)	0
3 Device 1 Command	[C] 1M! 1D0!
4 Device 2 Command	[E] 2M! 2D0!
5 Device 3 Command	[H] 3M! 3D0!
6 Device 4 Command	[K] 4M! 4D0!
7 Device 5 Command	[M] 5M! 5D0! 5D1! 5D2! 5D3!
8 Device 6 Command	
9 Device 7 Command	
A Device 8 Command	
B Device 9 Command	
C Device 10 Command	
U Up. T Top	



SDI-12 command: 5M! 5D0 5D1 5D2! 5D3!

returns all frequency and temperature values

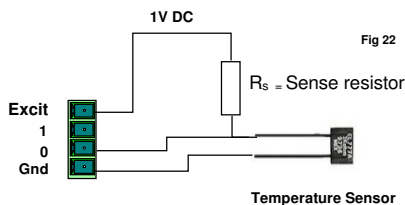
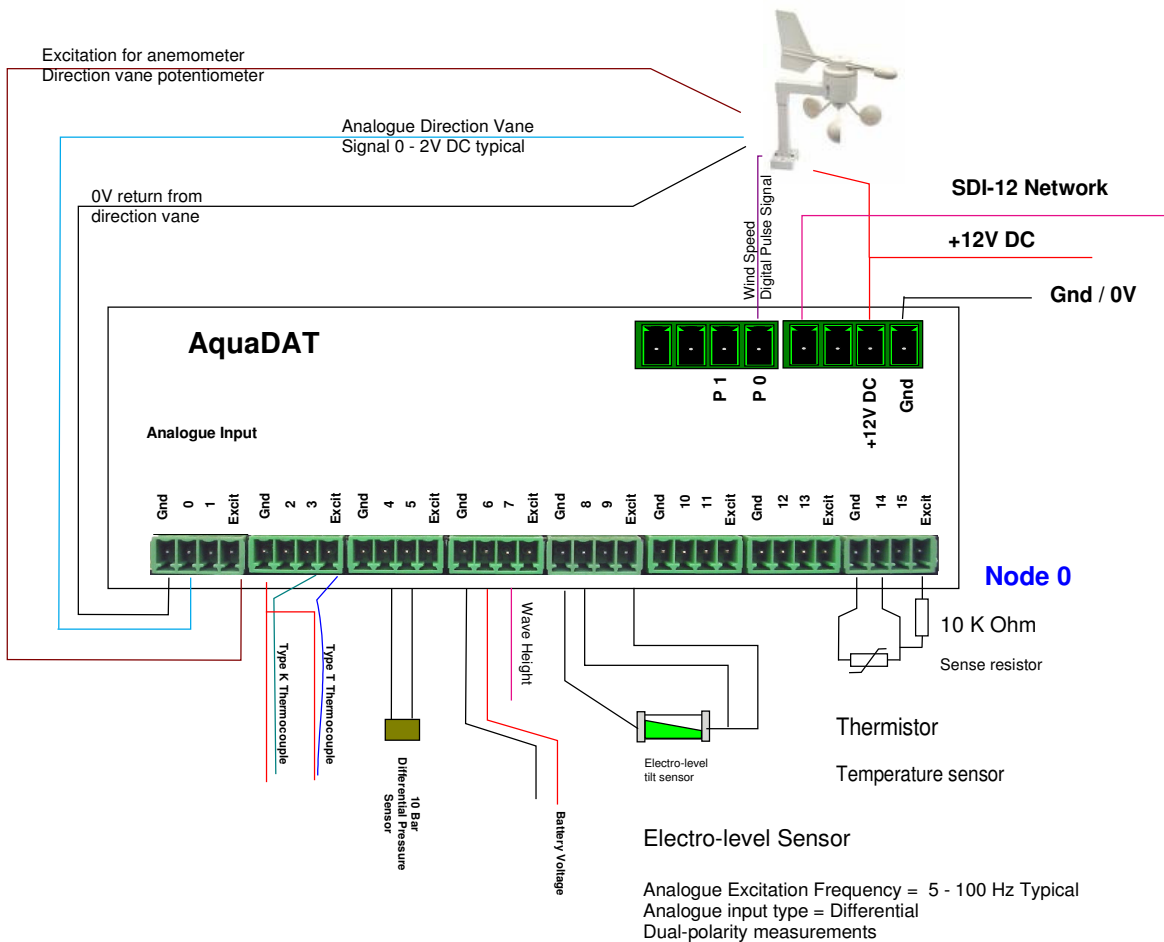
Anemometer Connections



Example Application

The details for configuring the input channels for the sensors shown connected to AquaDAT in the image below is shown on page 14.

Anemometer Connections

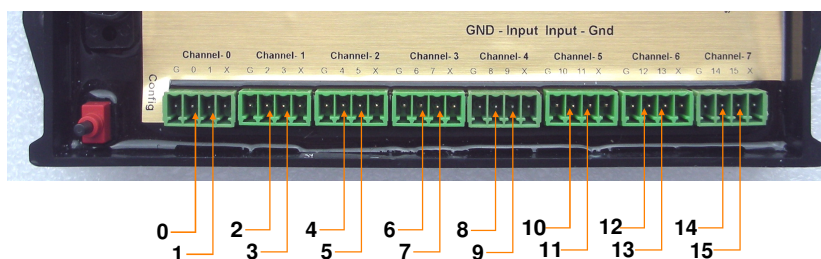


Data Table

Cell	A	B	C	D	E	F	G	H	I	J
Parameter	4.40	220	79.5	28.76	6.521	10.58	4.24	0.00451	22.6	7.213
	Wind Speed	Wind Direction	Type K Temp	Type T Temp	Pressure Bar	Battery Voltage	Wave Height	Tilt Angle	Temperature	

Calculated
from formulae

Analogue Channel Inputs



Carlson Type Strain Meter

Introduction

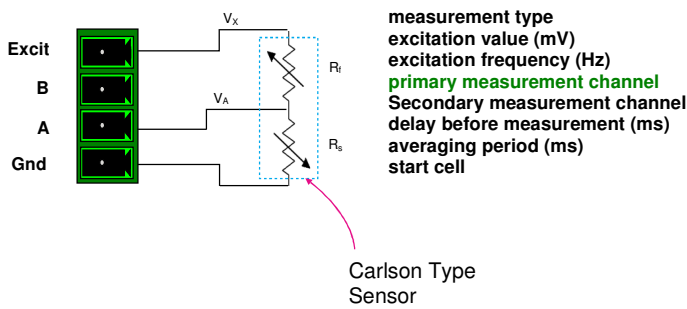
Any of the Carlson type sensors can be integrated to the AquaDAT sensor interface. The AquaDAT supports upto 8 sensors.

The Carlson type strain meter contains 2 coils of highly elastic steel wire, one which increases in length and electrical resistance as the gage is extended, the other which decreases in length and electrical resistance as the gage is extended. The resistance ratio of one wire to the other is used to determine the change in strain, pressure or deformation.

The total resistance remains constant with changes in length because as one wire increases in resistance the other decreases by an equal amount. The wire resistance does change with temperature so the overall resistance can be used for temperature measurement.

The innards of the instrument are typically filled with oil which protects the instrument from corrosion and water ingress.

BrHalf



AquaDAT Sensor Interface

BrHalf
5000
0
2

where 0 (Hz) = DC

50
1000
G

Delay to let the sensor settle before taking a measurement,

Data averaging period over a complete measurement operation. 1 Sec.

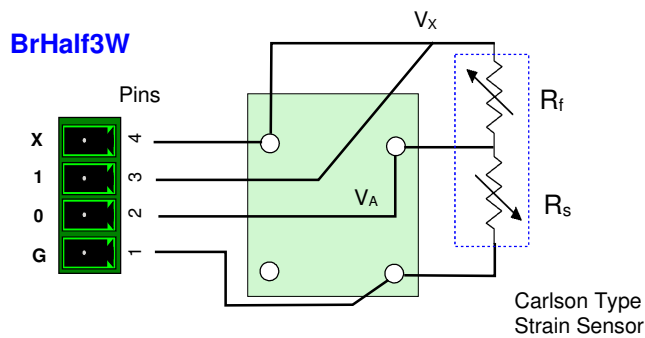
Store data into cell 'G' in the data table within the interface.

Carlson Type Concrete strain sensor

The half bridge type connection offers the easiest installation

The output value = Ratio of $V_A / V_x = 0 \dots 1$

BrHalf3W



For sensors shipped after 12/03/2015 then the **BrHalf3W** measurement can be used.

This measurement option compensates for the sensor cable length.

The output value = Ratio of $V_A / V_x = 0 \dots 1$

Analogue Measurement

BrHalf3W
5000
0
2

where 0 (Hz) = DC

50
1000
H

Warranty

What We Provide

Warranty Provisions

Keynes Controls Ltd. warrants the AquaDAT for one year from date of purchase by the end user against defects in materials and workmanship under normal operating conditions.

To exercise this warranty contact Technical Support at the phone or e-mail address listed below for a return material authorization (RMA) and instructions. Complete warranty provisions are posted on our website at <http://www.aquabat.net>

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Appendix !

Quick User Guide

The following is a simple example setup designed as a quick hands on tutorial guide to get you started. For a full description of this product and its capabilities please refer to the full manual 'AquaDAT Installation & User Manual version 1.7'

User access can be obtained both through the DTE connection and through the SDI12 interface.
The DTE connection can be seen in the photograph found on page 26.

Note: If the SDI12 interface is being used then the unit can obtain its supply power from the USB interface on any PC or Laptop computer. If the SDI12 interface is NOT being used then a separate 12V DC power source will be required.

For setting up purposes only, the unit may be powered up as a stand-alone device while each channel is defined. This can also be done with the unit installed .

Connect a power supply (or the SDI12 interface cable) to the top right connector. Full details of the connector pin-outs are shown on page 7.

Connect a PC or Laptop computer via a 'null-modem' cable to the DTE 'D' connection on the far left of the unit.

Using a 'VT100' terminal emulation such as '**Hyperterminal**' or '**Token 2**', set the following on your PC:

Com port (identified from START\Control Panel\System (within the Microsoft Operating Systems)

Select 'Device Manager' and Com Ports.)

- ☐ Speed: 9600 Bd
- ☐ Data bits: 8
- ☐ Parity: None
- ☐ Stop Bits: 1
- ☐ Flow Control: None

Now press the 'Config' button next to the DTE connector on the AquaDAT. The following menu will appear on the VT100 screen:

1. Device Setup
2. Analogue Measurements
3. Pulse Counters
4. Formulae
5. Diagnostics
6. System Maintenance
7. Exit

Select No. 2 for Analogue Measurements. This will display the following list:

1. Analogue Measurement 1
2. Analogue Measurement 2
3. Analogue Measurement 3
4. Analogue Measurement 4
5. Analogue Measurement 5
6. Analogue Measurement 6
7. Analogue Measurement 7
8. Analogue Measurement 8
9. Analogue Measurement 9
- A. Analogue Measurement 10
- B. Analogue Measurement 11
- C. Analogue Measurement 12
- D. Analogue Measurement 13
- E. Analogue Measurement 14
- F. Analogue Measurement 15
- G. Analogue Measurement 16

Each one of these menu items is a dedicated setup for a single measurement definition. Using the following menu's each one can be setup with a number of parameters which are dependant on the measurement type, and can be assigned to any of the channels. As an example a simple voltage measurement will use the following:

Select any number or letter displayed to the left of the menu above i.e. 1-9 or A-G. This will produce the following:

1. Measurement Type
2. Excitation value (mV)
3. Excitation frequency (Hz)
4. Primary measurement channel
5. Secondary measurement channel (Note. This function is not currently used)
6. Delay before measurement (ms)
7. Averaging period (ms)
8. Start cell

Measurement type can be any of;

- | | |
|------------|------------------------------|
| VoltSE | – voltage single ended input |
| VoltDE | – voltage differential input |
| BrHalf | – Half Bridge |
| BrHalf3W | – Half Bridge 3 Wire |
| BrHalf4W | – Half Bridge 4 wire |
| BrFull | – Full Bridge |
| BrFull6W | – Full Bridge 6 wire |
| Resistance | |

See the full User Manual for a complete description of each type.

To set the VoltSE (Voltage Single-ended), Select '1' for measurement type 'voltse'. The selection is not case sensitive.

Next select option '4' to set the primary measurement channel. This can be any number between 1 and 16 and references the inputs.

Next select 8 to set the start cell. The start cell is the first location in the internal data table used to store results.

The Start Cell can be any letter between A and P .

Finally, enter a value in option '7' (Averaging period) to obtain a measurement over a defined averaging period . For test purposes set this to around 1000 ms.

If a voltage is now applied to the relevant channel (between the gnd pin 1 and pin 2 or 3 on the relevant connector), the output can be observed on the terminal display by selecting option '5' (diagnostics) from the main menu followed by option '1' (Test acquisition only).

After a few seconds the screen will display all output cells. You can now verify the voltage applied to your selected input channel at the defined output cell.



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TEST CERTIFICATE

DWT Traceable to standard no. : J082301 T8F 281 TC

Customer :
 P.O. No. :
 Instrument : V W Piezometer Date : 02.02.2012
 Serial number : xxxxx Temperature : 19°C
 Capacity : 350 kPa Atm. Pressure : 100 kPa

Input pressure (kPa)	Up1 (Digit)	Observed value Down (Digit)	Up2 (Digit)	Average (Digit)	End Point Fit (kPa)	Poly Fit (kPa)
0.0	6555.9	6556.9	6556.9	6556.4	0.0	0.3
70.0	6312.4	6312.6	6312.4	6312.4	69.3	69.5
140.0	6064.0	6064.3	6063.1	6063.5	139.9	140.1
210.0	5817.1	5818.4	5816.2	5816.7	210.0	210.1
280.0	5569.8	5570.7	5568.0	5568.9	280.3	280.3
350.0	5323.3	5323.3	5323.7	5323.5	350.0	349.8

Digit : $f^2/1000$
 Linear gage factor (G) : 2.8388E-01 kPa/digit
 (Use gage factor with minus sign with our read out unit Model : EDI-51V)
 Thermal factor(K) : -0.087 kPa/°C
 Polynomial constants :
 A= -2.2253E-07 B= -2.8085E-01 C= 1.8512E+03

Pressure "P" is calculated with the following equation:

Linear : $P(\text{kPa}) = G(R_0 - R_1) + K(T_1 - T_0) - (S_1 - S_0)$ Polynomial : $P(\text{kPa}) = A(R_1)^2 + B(R_1) + C + K(T_1 - T_0) - (S_1 - S_0)$

R1 = current reading & R0 is initial reading in digit.

S1 and T1 = current atmospheric pressure(kPa) and temperature (°C)

Readings at the time of shipment

Date
 f : Hz
 f² : Digit
 Temperature : °C
 Thermistor : Ohm
 Atm. pressure : kPa
 Coil resistance : Ohm

The terms $K(T_1 - T_0)$ are the temperature compensation terms for this sensor.

Temperature compensated readings only work if the thermistor operation is defined.

(Zero conditions in the field must be established by recording the reading R0 (digit) along with temperature T0 (°C) and atmospheric pressure S0 (kPa) at the time of installation. If polynomial constants are used, determine value of 'C' as per § 6.2 of user's manual.)