In-Place-Inclinometer User Manual

SDI-12/RS485 Digital Network Device

All models of the I-P-I sensors

Advantages

- **The In-place Inclinometer (IPI) is ideally suited for near real-time measurement of lateral displacement of rock, soil and man made structures.**
- **Sensor strings can give a complete profile of vertical or horizontal displacements.**
- **Available in Uni-Axial and Bi-Axial sensor versions.**
- **Low Power SDI-12 or RS-485 digital communications. In-line network connection for fast installation & maintenance.**
- **Programmable averaging period for signal enhancement and noise reduction**
- **Digital data communication to remove noise and simplify installation.**
- **Ideal for monitoring the stability of natural and cut slopes, tunnels, embankments and structural foundations for large structures.**
- **Immersion Proof to 100 m (standard) - other ranges on request**

CE

In-Place-Inclinometer

In-Place Inclinometers are typically used for monitoring subsurface deformations around excavations when rapid monitoring is required or when instrumented locations are difficult to access for continued manual readings.

The sensors are computer driven, gravity-sensing transducers joined in a string by articulated rods, or mounted and they can be installed equidistantly in the casing or concentrated in zones of expected movement.

With the in-place instrument, as many as 36 sensors are mounted in the casing and left semi-permanently in place. The sensors are easy to install and maintain using the in-line digital network for all measurement operations. A single 3 core cable is all that is required to communicate to the sensor chain.

Compared with conventional instruments, the in-place inclinometer hardware is in-expensive and simple to use. A complete sensor chain cab be removed and deployed into a new location in most cases with little or no experience.

Signals from the different In-Place inclinometers can be stored into a data logger and access remotely via the Internet, or in real time directly to a PC for local observation by construction/maintenance staff.

This product is integrated into the Q-LOG free data acquisition and display software package.

Last updated Aug-2015

Purpose of Monitoring

If the different parts of a structure should move uniformly by even large amounts, considerable damage could occur.

Structures affected by construction, or ground effected by a shift in water flow react by exhibiting movement. This movement is the principal cause of construction related damages because the affected structure may be subjected to forces it was not designed for. A building, for example, whose footings are settling on one side while the other side settles less or not at all will suffer tilting of some walls structures. The change in the water table may cause movement of an embankment leading to a slip. The Keynes Controls In-place-inclinometers have been designed to measure and report this type of structural movement.

Q-LOG Application Software

Download free at: http://www.aquabat.net/downloads/QlogSetupv1207.zip

Important Note

Network Type Selection

1. **For applications where a sensor may be immersed in water or when there is a chance the I-P-I chain can become flooded then the RS-485 version sensor is to be used.**

2. **For local applications where the sensors are easy to access, deployed onto structures where there is no chance of flooding, subject to normal outside environmental conditions then the SDI-12 network should be used.**

Contact Keynes Controls for advice on your application if unsure of the model and type of sensor to be used.

Features

Advanced rugged sensor technology utilising power management.

Lightning Protects as standard

In-line coupling for signal cable installation. Simplifies installation and maintenance.

Calibrated range ±15 ±10 ±5 Deg

Programmable Sample Period :- removes unwanted vibration

Waterproof to 200 m.

Sensor strings can provide a complete profile of vertical and horizontal displacements.

Digital data communications to minimise noise

Calibration

All sensors are calibrated at the Keynes Controls facility in the UK. External calibration can be undertaken upon request.

Simple Command Structure

All of the I-P-I models use the same command structure.

aM! – starts a measurement
aC! – starts a concurrent measurement
aD0! – gets data from the sensor

where a = Instrument ID Number

Quick User Guide

The Keynes Controls range of inclinometers are intelligent devices and transmit data directly across the RS-485 or SDI-12 digital network. The guide is not meant as a teaching aid and some prior knowledge of using these two networks is expected.

SDI-12 Sensor

Unless specified at the time of order a single sensor is set to use ID=0. If the sensors are supplied as part of a kit then they will be pre-set to unique network ID numbers.

Connect the sensor to any suitable data logger or PC supporting the SDI-12 network and issue the following commands.

Command: 0An! sets the sensor ID from 0 to ID = n 0A3! new ID=3
0M! start measurement 0D0! Get Data

Data will be returned. If using a Keynes Controls media converter then the status LED's will illuminate.

RS-485 Sensor

Unless specified at the time of order a single sensor is set to use ID=0. If the sensors are supplied as part of a kit then they will be pre-set to unique network ID numbers. This version of the sensor requires a break character to be sent with the instruction. The break character is identified in the manual as the **%** symbol.

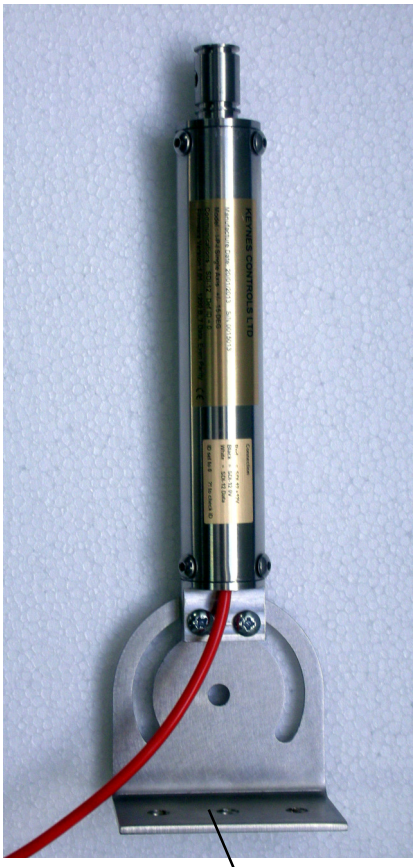
Connect the sensor to any suitable data logger or PC supporting the RS-485 network and issue the following commands.

Command: %0An! sets the sensor ID from 0 to ID = n 0A3! new ID=3
%0M! start measurement 0D0! Get Data

Data will be returned. If using a Keynes Controls media converter then the status LED's will illuminate.

The Q-LOG software automatically inserts the correct break character when identifying the network being used for communications.

Guide Wheel



Mounting Bracket

Sensor Components - Vertical I-P-I Digital Sensors

In-place-inclinometers can be installed as a single sensor or as a chain of sensors making up a string of a set length.

An individual instrument typically consists of a body, wheel assembly and gauge tube.

Sensor Bodies - The I-P-I contains either single axis or bi-axis sensors but physically look identical.

Gauge-tubes - The gauge tubes are available in various dimensions and when fitted to the sensor bodies make inclinometers from 1 through to 3 metres in length.

Default Output Values - The Keynes Controls in-place-inclinometers default data type output is in mm/m.

Sensor Wheels - Are used to link the different sensors together. The sensor wheel attaches to the bottom of the sensor body and uses this wheel as a guide in the casing.

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WHAT WE PROVIDE

WARRANTY PROVISIONS

Keynes Controls Ltd . warrants the I-P-I range of tilt sensors 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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FIRMWARE & SOFTWARE UPGRADES
The In-place-inclinometer is upgrade able. Contact Keynes Controls Ltd. for details.

If you suspect that your In-place-inclinometer is malfunctioning or requires re-calibration and repair is required,

you can help assure efficient servicing by following these guidelines:

Part Number	Description
IPI-bar-1m	1m gauge bar for any IPI sensor
IPI-bar-1m	2m gauge bar for any IPI model
IPI-bar-1m	3m gauge bar for any IPI model
IPI-case-cap	Cap for I-P-I housing
SDI-12 network	
IPI-D-15-SDI12	Dual Axis I-P-I Solid state - +/- 15 deg - SDI-12 Comms - sealed to 50 m
IPI-D-75-SDI12	Dual Axis I-P-I Solid state - +/- 7.5 deg - SDI-12 Comms - sealed to 50 m
IPI-D-25-SDI12	Dual Axis I-P-I Solid state - +/- 2.5 deg - SDI-12 Comms - sealed to 100 m
IPI-S-15-SDI12	Single Axis I-P-I Solid state - +/- 15 deg - SDI-12 Comms - sealed 50 m
IPI-S-75-SDI12	Single Axis I-P-I Solid state - +/- 7.5 deg - SDI-12 Comms - sealed 50 m
IPI-S-25-SDI12	Single Axis I-P-I Solid state - +/- 2.5 deg - SDI-12 Comms - sealed 50 m
RS-485 network	
IPI-D-15-485	Dual Axis I-P-I Solid state - +/- 15 deg - RS-485 Comms - sealed 50 m
IPI-D-75-485	Dual Axis I-P-I Solid state - +/- 7.5 deg - RS-485 Comms - sealed 50 m
IPI-D-25-485	Dual Axis I-P-I Solid state - +/- 2.5 deg - RS-485 Comms - sealed 50 m
IPI-S-15-485	Single Axis I-P-I Solid state - +/- 15 deg - RS-485 Comms - sealed 50 m
IPI-S-75-485	Single Axis I-P-I Solid state - +/- 7.5 deg - RS-485 Comms - sealed 50 m
IPI-S-25-485	Single Axis I-P-I Solid state - +/- 2.5 deg - RS-485 Comms - sealed 50 m

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Please contact Keynes Controls Ltd for the latest details regarding this product
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SENSORS	SPECIFICATIONS
Calibrated Range	± 15 , ± 7, ± 2.5 Deg
Sensor Input	32 bit
Resolution	+/- 2 arc Seconds (+/- 0.01 mm/m)
Sensor Accuracy	±0.05% Full Scale
Repeatability	±0.01% Full Scale (Typical values only)
Operating Temperature	-20 to + 75 ℃
Linearity	0.2% Full Scale
Digital Network Type	SDI-12 - 3 wire RS-485 - 4 wire
Minimum Casing Internal Diameter	56 mm
Maximum Casing Internal Diameter	72 mm
Length	230 mm
Power Supply @ 12V DC (SDI-12)	12 mA Dual Axis - measurement period 0.3 mA Idle
RS-485	16 mA Dual Axis - measurement period 2 mA Idle
Typical values only	
Ingress Protection	IP68 - rated 100 m - other ranges on request
Housing Material	316 stainless steel
Weight	560 g without cable
Signal Output	Digital engineering values - Raw data using configuration commands
Addressing Mode:	All I-P-I models support standard and enhanced ID address modes. 0..9 A..Z
Range: SDI-12	0 .. 100 m standard
RS-485	0 .. 1 km standard Increased can be achieved depending on signal cable quality.
Firmware	This product has a firmware upgrade facility
Supported Commands	
ID string	a13KEYNESCOINPINC001H001F004
	where a = ID number
aM!	start measurement
aMC!	start measurement with CRC
aC!	concurrent measurement
aCC!	concurrent measurement with CRC
aD0! variable list A B C D E	5 parameters returned for each measurement
?! Query address	Find the sensor ID number
aXI n!	Integration Period milli-Seconds where n is in ms
aXCT n!	temperature offset in hundredths of degrees n is integer in hundredths of a degree
Range Settings	
±15 Deg 250 mm/m	
±10 Deg 175 mm/m	
± 5 Deg 87 mm/m	
Electrical Cable SDI-12 RS-485	24 AWG Polyeurethene Covered 2 twisted pair (4 core) + foil shield 3 twisted pair (6 core) + foil seal

Adjusting the Full Scale Range

The inclinometer can have the full scale range adjusted to suit the monitoring application.

Over a small range the sensor is considered to be linear. The range setting is undertaken in units of mm/m

The factors shown below are the default factory settings for 15 deg sensor.

Use command

aXCAn,val Sets cal n to val

n	Field	Default
0	X-axis Offset	0
1	X-axis Range mm/m	250
2	X-axis Scale	1
3	Y-axis Offset	0
4	Y-axis Range mm/m	250
5	Y-axis Scale	1

therefore to change change the X-axis sensor to operate over +/- 10 deg range use the command

aXCA1 175! where 175 is in units mm/m
a = sensor ID number

Example

for a sensor with ID = 8 is to have the X-axis set to operate over 10 deg range (175 mm/m).

Command: 8XCA1 175!

Setting the number of returned data values

The order and number of measured data values from the inclinometer can be assigned:

Command: aXRA=”A B C D E” results variables

A	Tilt-X	Units (mm/m)
B	Tilt Y	Units (mm/m)
C	Tilt-X	(Calibrated)
D	Tilt Y	(Calibrated)
E	Temperature	Deg C

The calibrated results are those assigned using the command in ‘aXCAn’ above.

Example, return tilt angle data items only:

3XRA=”A B C D”!

Example commands

where a = instrument ID number

The following example shows an I-P-I with ID number = 3 set to a measurement with integration period for all axis to 1000 ms (1 second). Any integration period can be used to reduce the effect of unwanted vibration on a measurement operation.

Command: 3XI 1000!

Example, Set the temperature sensor offset to + 0.25 deg above the normal reading for a sensor with ID = 7

Command: 7XCT 250!

Stand-Alone Data Recorder

The image below shows a standard low cost data recording system for stand-lone applications. The I-P-I sensors will operate with any suitable 3rd party logger unit supporting SDI-12 or RS-485 digital communications. For low power applications the SDI-12 based sensors and recorder are the recommended option, and for large scale systems RS-485 network sensors are recommended. When operating with the AquaLOG data recorder shown in the image below, the sensors are powered off between readings and are only activated when required to take a measurement..

Expansion Options

The AquaLOG data recorder shown opposite can be expanded to accept up to a maximum of 36 I-P-I sensors or other intelligent SDI-12 based devices.

Any suitable sensor from 3rd party suppliers can be used so long as it supports the correct digital network.

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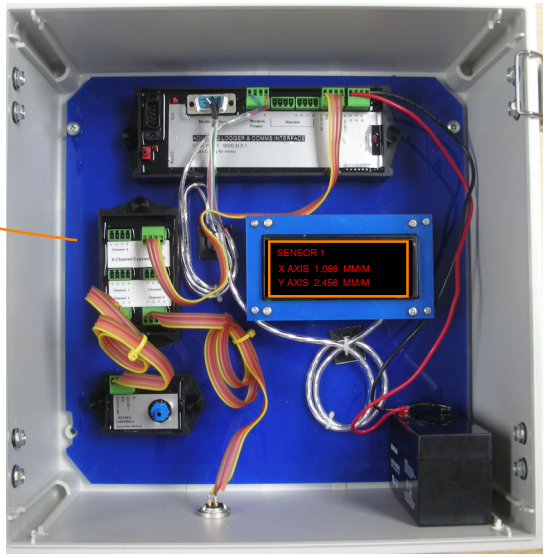
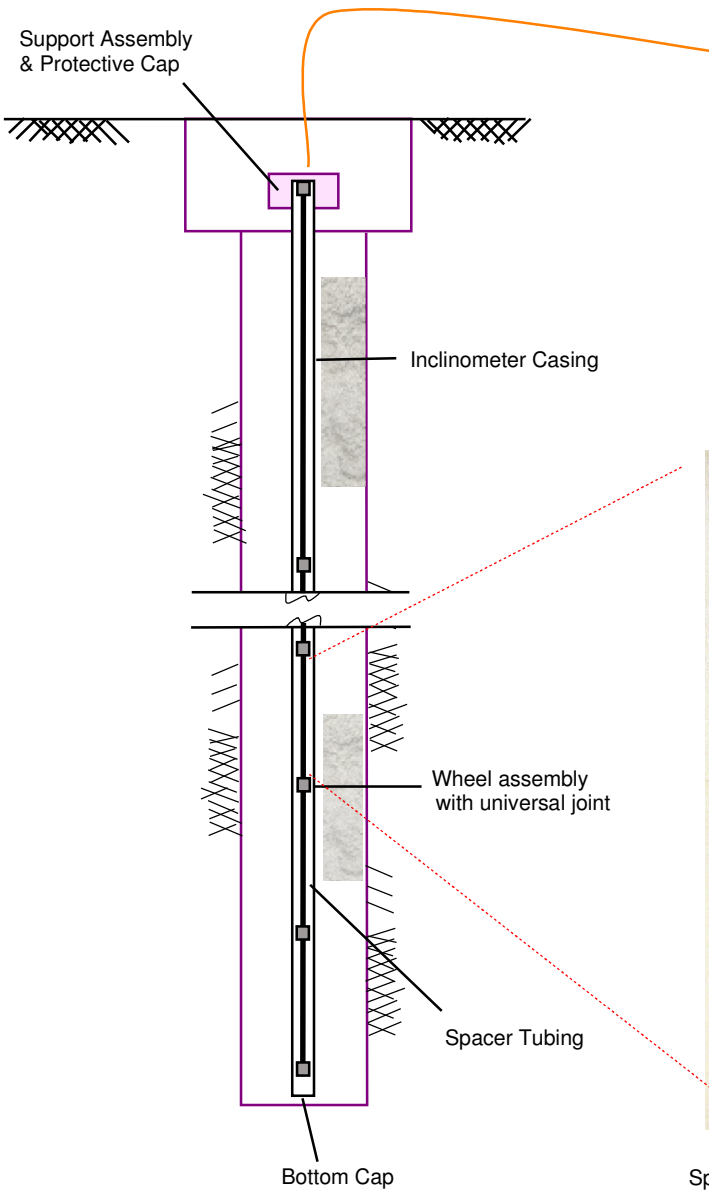
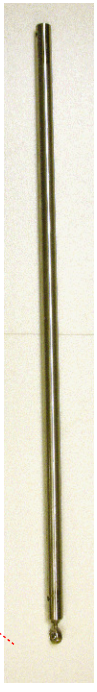
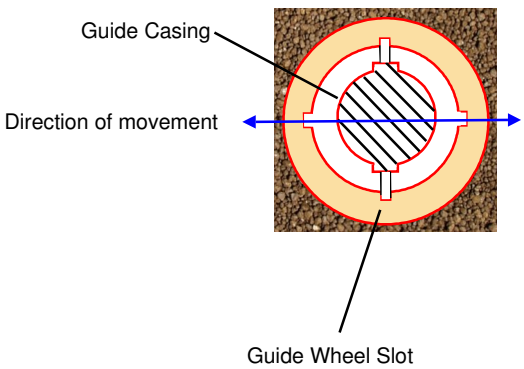






Spacer Tube



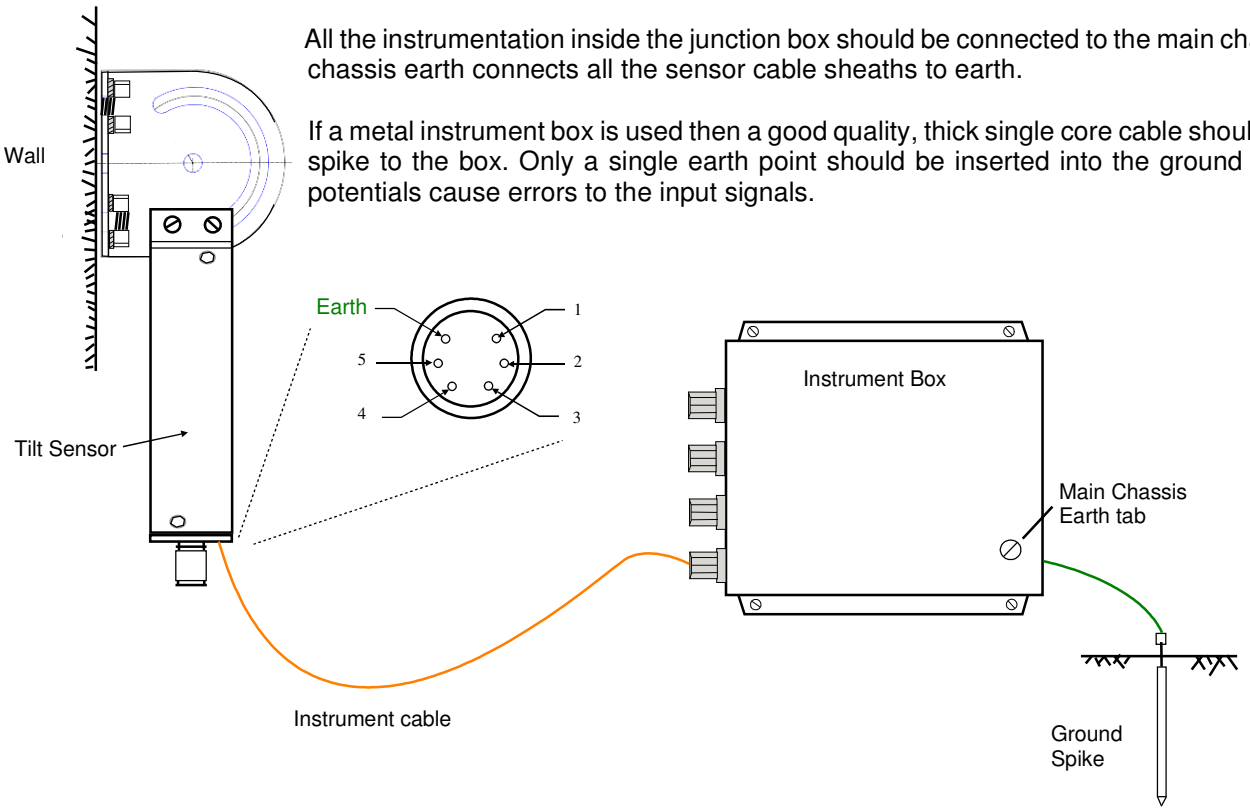
Lightning Protection Scheme

All of the Keynes Controls tilt sensors contain integral lightning protection using a gas discharge protection making them safe from anything but a direct strike.

For the lightning protection to work the sensor earth has to be connected to a good ground connection.

All the instrumentation inside the junction box should be connected to the main chassis earth. The main chassis earth connects all the sensor cable sheaths to earth.

If a metal instrument box is used then a good quality, thick single core cable should connect the ground spike to the box. Only a single earth point should be inserted into the ground to ensure no ground potentials cause errors to the input signals.



Temperature Compensation

Although the temperature effects on the tilt sensor is tiny, and the results are automatically compensated for in the measurement operation. When there is considerable temperature changes on the sensor then the effect can be seen in results and the effect can be miss-interpreted as a physical movement. In this case recording the temperature values as part of the tilt measurement operation is essential in order to detect this possible source of error. It is good practice to record the sensor temperature data values as part of the logging program.

Troubleshooting

Maintenance and troubleshooting is reserved to periodically checking the sensor and cabling for damage.

For sensors deployed outside for long term deployments then the cable entry ports should be examined for corrosion that may cause the signal cable to fail. The sensors are fully sealed units with no User serviceable parts.

Sensor Readings are unstable:

If there is a source of electrical noise nearby the sensor then the reading may be unstable. The source of noise can be motors, generators or antennas. To minimise the noise effects ensure that the **earth** cable is attached to the sensor and terminated to a suitable ground point. The earth cable is attached to pin-6 of the cable port.

Noise Reduction

All of the I-P-I ranges of sensors have a User programmable recording period in steps of 1 ms. This has the effect of removing background vibration and enhancing the correct tilt value. The unwanted noise is averaged out

Understanding the Results

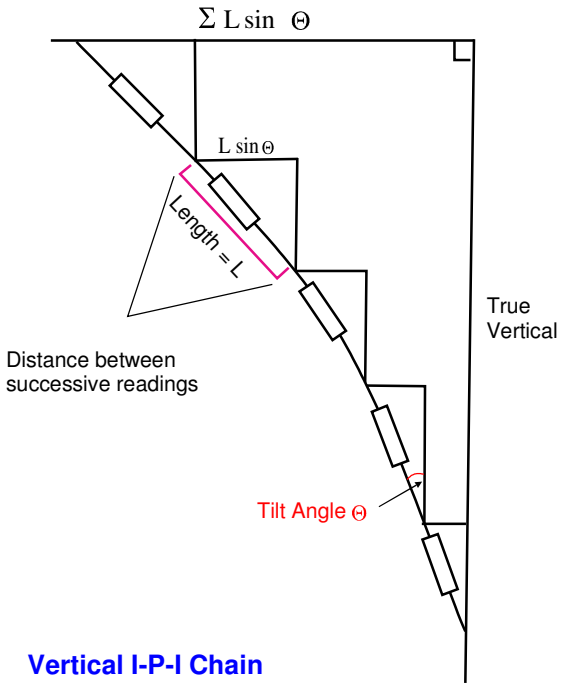
The In-place-inclinometer is intelligent and provides results directly in engineering units. The most common unit used with this sensor is mm/m (milli-meters / metre). The image opposite shows the in-place-inclinometer deployed on a vertical chain and the movement has been exaggerated to make clear the expected movement that can be detected.

The vertical I-P-I chain are typically deployed in a casing as shown in the bottom image on page 6.

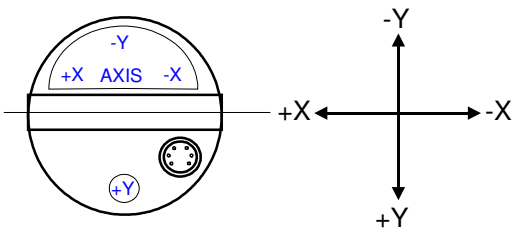
The total movement, from the top to the bottom of the chain and in a specified direction is the sum of the displacements from each sensor in that direction.

All the sensors have to be deployed in the same mechanical orientation for the results to be meaning full. Failure to mechanically align the sensors will cause errors in the total movement calculation.

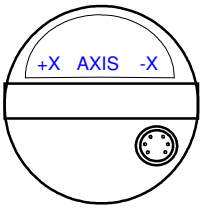
In practice the individual inclinometers are deployed equally spaced along the I-P-I chain. There is a choice of spacer bars that fix the sensors to specified points in the casing depending upon the sensor chain length and the required number of monitoring points.



Vertical I-P-I Chain



Dual-Axis Sensor Polarity



Single-Axis Sensor Polarity

Dual Axis Sensor Polarity

The adjacent Image shows the polarity of the sensor output readings from the dual axis Inclinometer.

Single Axis Sensor Polarity

The adjacent image shows the polarity of the sensor output readings from the dual axis Inclinometer.

Signal Connection

A glass seal is built into the top and bottom of the sensors This seal isolates the signals from the cables to the electronics mounted inside the sensor case. The pins are gold plated and so are protected from corrosion.

The glass seal is rated to 80 m water depth.

Displacement Calculation

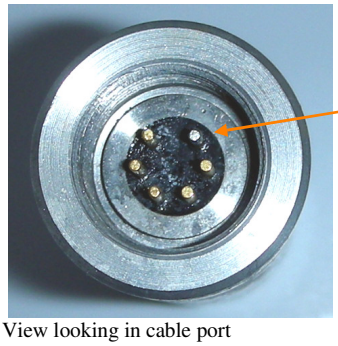
All of the In-place-inclinometer models provide data values in engineering units of mm/m.

To convert the output value to displacement in mm

Displacement (mm) = Sensor Output (mm/m) * Spacer length (m)

Example

A sensor supplying 12.23 mm/m output value is mounted on a 3 m spacer bar then the



View looking in cable port

Full systems detail & prices can be found at

http://www.aquabat.net

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In-Place-Inclinometer Chain Installation

The following instructions should be followed to assemble an I-P-I chain. The instructions are the same for both the SDI-12 and RS-485 version of the sensors.

Overview

1. Layout the sensors in the order of installation.

   When purchased as a complete kit the individual sensors are individually labelled with their network ID number. It is good practice to install the instruments onto the I-P-I chain in order of the ID number, so instrument with ID = 0 goes to the top of the chain and the sensor with the highest ID number is installed at the bottom of the chain.

2. Insert the first sensor into the slots of the gauge casing making sure the wheels are correctly aligned.

   Ensure that the sensor signal cable is secured to the gauge rod using a cable tie or tape and that the cable passes clear of the sensor body as it passes down the tube.

   Clamp the top of the I-P-I sensor to the top of the gauge tube while preparing the next sensor in the chain.

3. Align the next sensor in the chain and connect the signal cables together using the waterproof connectors used as standard on this range of product. The connectors self align so the they cannot be wrongly terminated.

4. Repeat steps 2 and 3 for each sensor in the chain.

5. Connect the top wheel assembly and lower into place and lower the sensors into their final position. Secure the I-P-I string with the end cap.

Note. Make sure there is slack cable around the joins to the cable does not influence or prevent the I-P-I string movement.

Tools

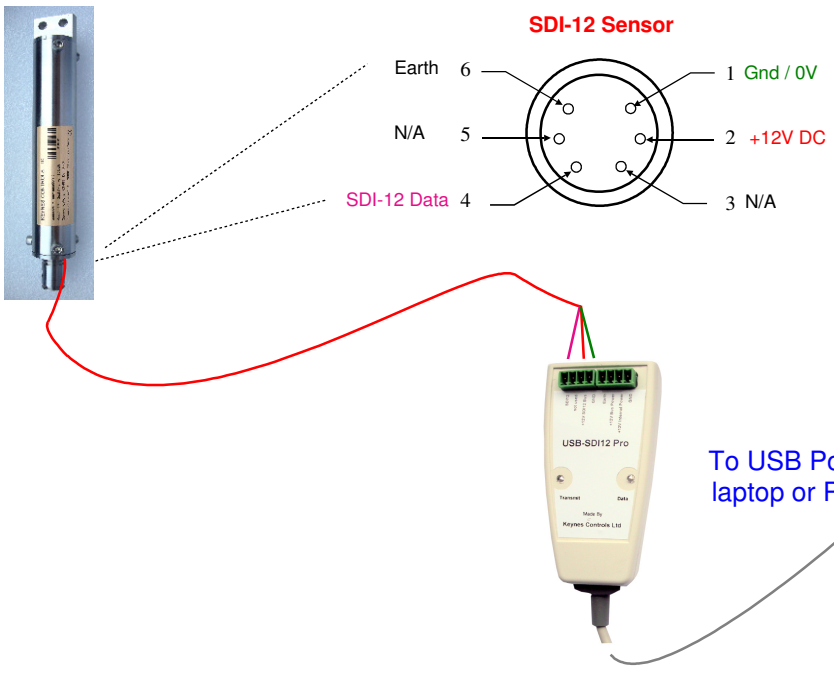
- Vice grips for temporarily securing the I-P-I chain to the gauge casing.
- Allen Hex Key for securing the sensor body to the gauge rod.
- Cable ties for securing the signal cables to the gauge rods.
- Optional safety cable fastened to the bottom sensor to prevent the loss of the I-P-I chain.

Data Averaging

All of the Keynes Control model I-P-I sensors have the ability to define the averaging period ever which time a measurement is made.

If the sensor is being deployed close to a source of local vibration, for example a railway track, then the effect of the unwanted vibration can be minimised and in some cases removed all together by

USB-SDI12-Pro Media Converter Connections

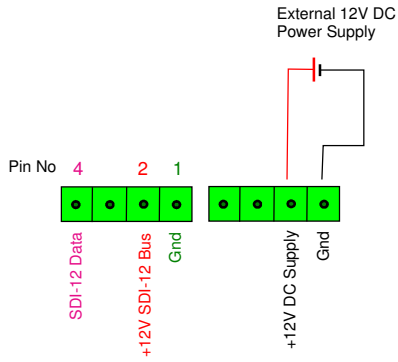


No. 1 - 4 I-P-I Sensor Installation

For 1 to 4 I-P-I sensors simply connect them directly to the USB-SDI12-Pro network bus. The USB-SDI12-Pro device powers the sensors directly from the USB port of the PC without any external power supply.

Multiple I-P-I Sensors & Interface Installation

When there are more than 4 I-P-I sensors or the total current drawn by the sensors attached to the network exceeds 100 mA then an external 12V DC power supply is to be connected as shown to the USB-SDI12-Pro media converter



Connecting the I-P-I to a Data Logger

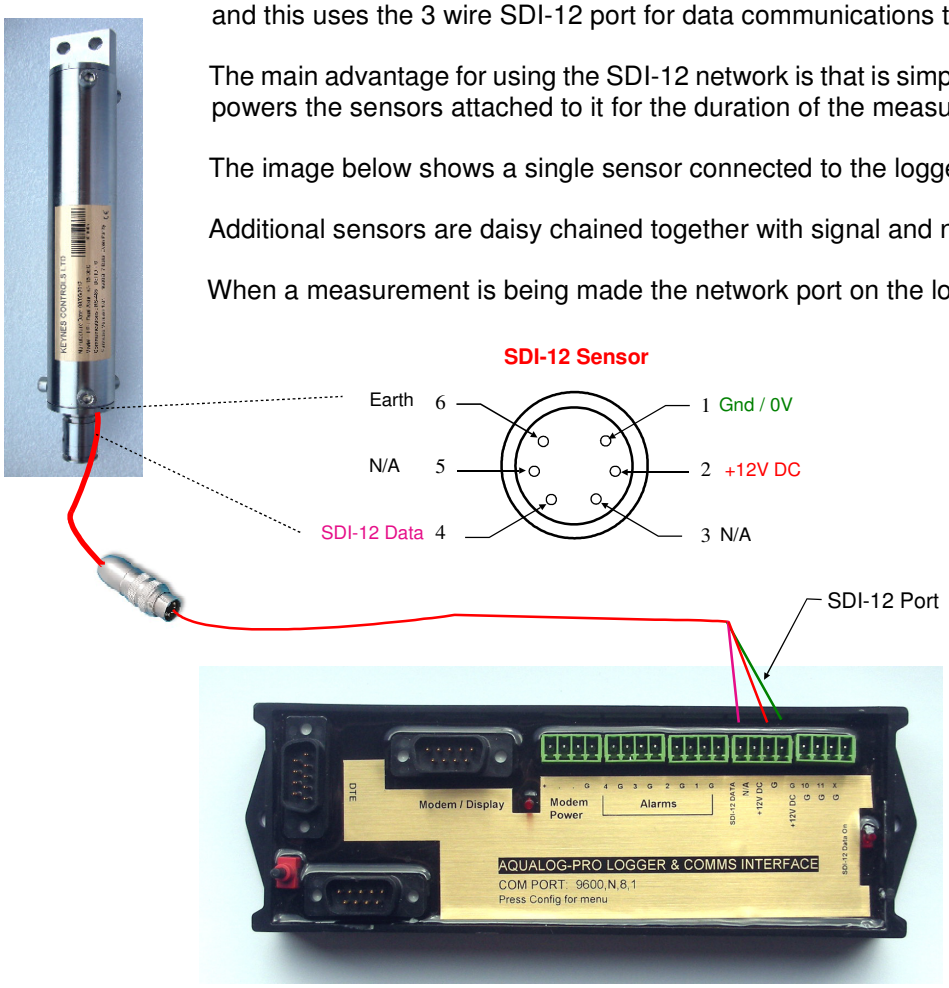
The images below show how to connect the I-P-I to a data logger. The data logger shown is the AquaLOG unit and this uses the 3 wire SDI-12 port for data communications to the sensors.

The main advantage for using the SDI-12 network is that is simple to install and to operate. The SDI-12 network powers the sensors attached to it for the duration of the measurement operation.

The image below shows a single sensor connected to the logger unit.

Additional sensors are daisy chained together with signal and network power supply all in common.

When a measurement is being made the network port on the logger unit will power the sensor.



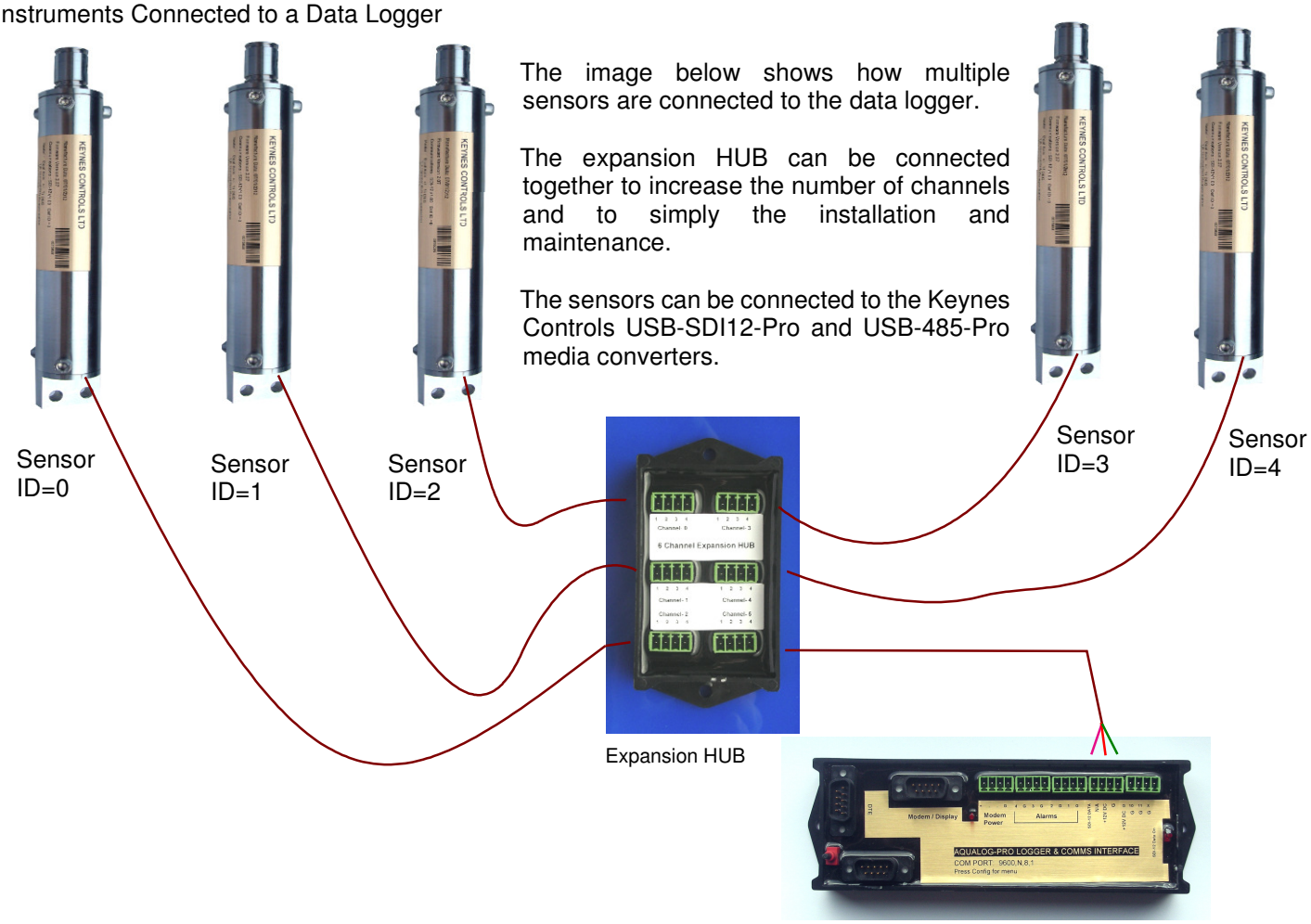
AquaLOG Data Logger

Battery Power Optimisation

To optimise the battery life for a stand-alone logger system keep the number of recording operations to a minimum, and the averaging period over which the measurements are made as low as possible to give satisfactory results.

The longer the sensor is powered on to make a measurement then the faster the battery supply will be used up.

Multiple Instruments Connected to a Data Logger



The image below shows how multiple sensors are connected to the data logger.

The expansion HUB can be connected together to increase the number of channels and to simply the installation and maintenance.

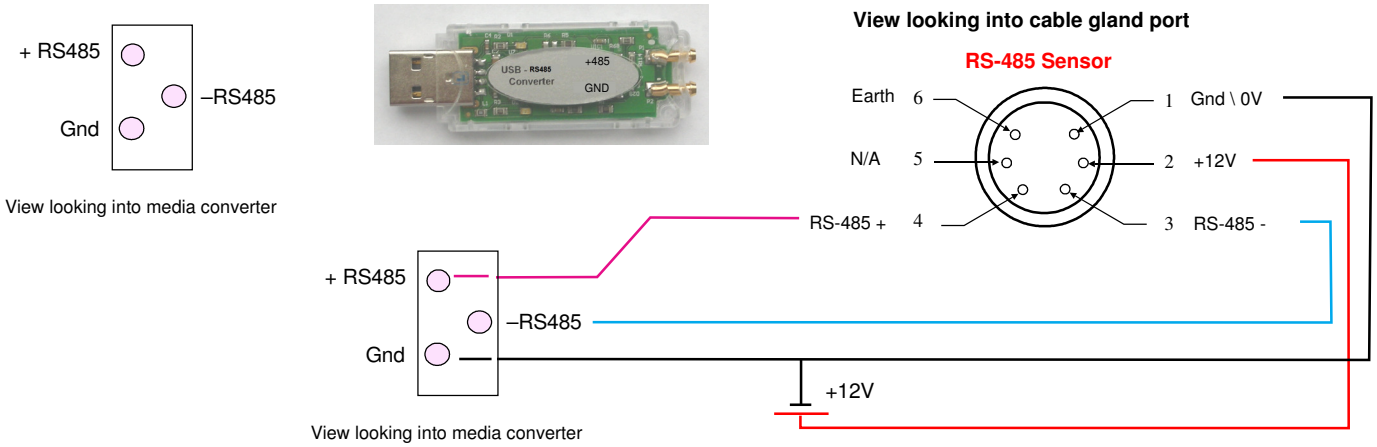
The sensors can be connected to the Keynes Controls USB-SDI12-Pro and USB-485-Pro media converters.

Expansion HUB

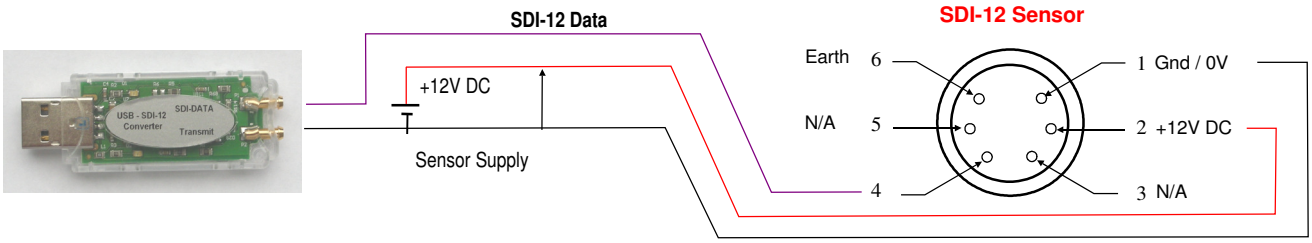
4.2 USB-RS485 Media Converter Wiring Diagram

Fig 2 shows the signal connections required for connecting the PIEZOI-RM sensor to the RS-485 digital network. The USB-485 media converter fits into any USB port on a PC and uses the Q-LOG application software for data recording and configuration operations.

The USB-RS-485 media converter shown below is a 3 pin device and requires a separate power supply to power the sensors. Make sure that the 0V on the media converter and the external power supply are connected together as shown in the diagram.

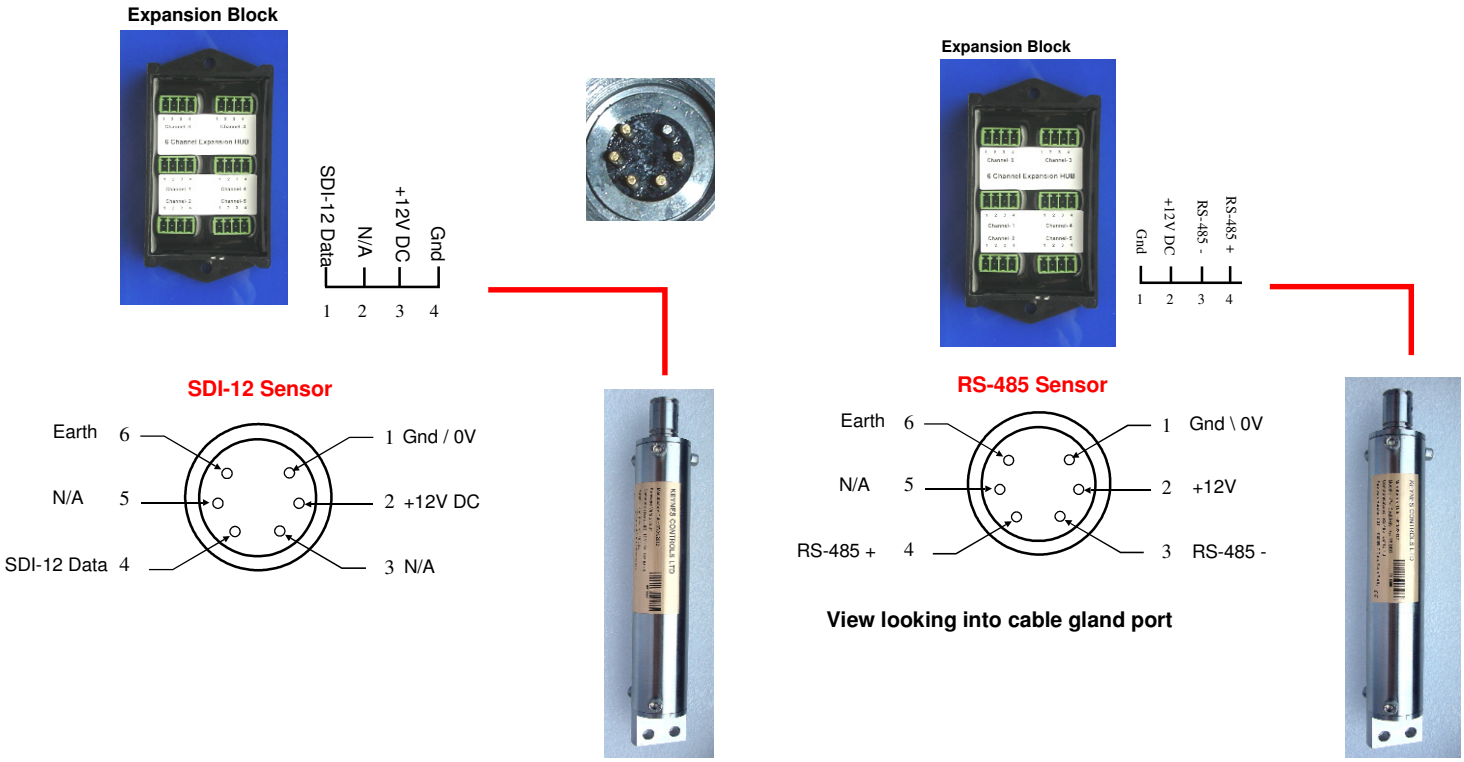


4.1 USB-SDI-12 Media Converter Wiring Diagram



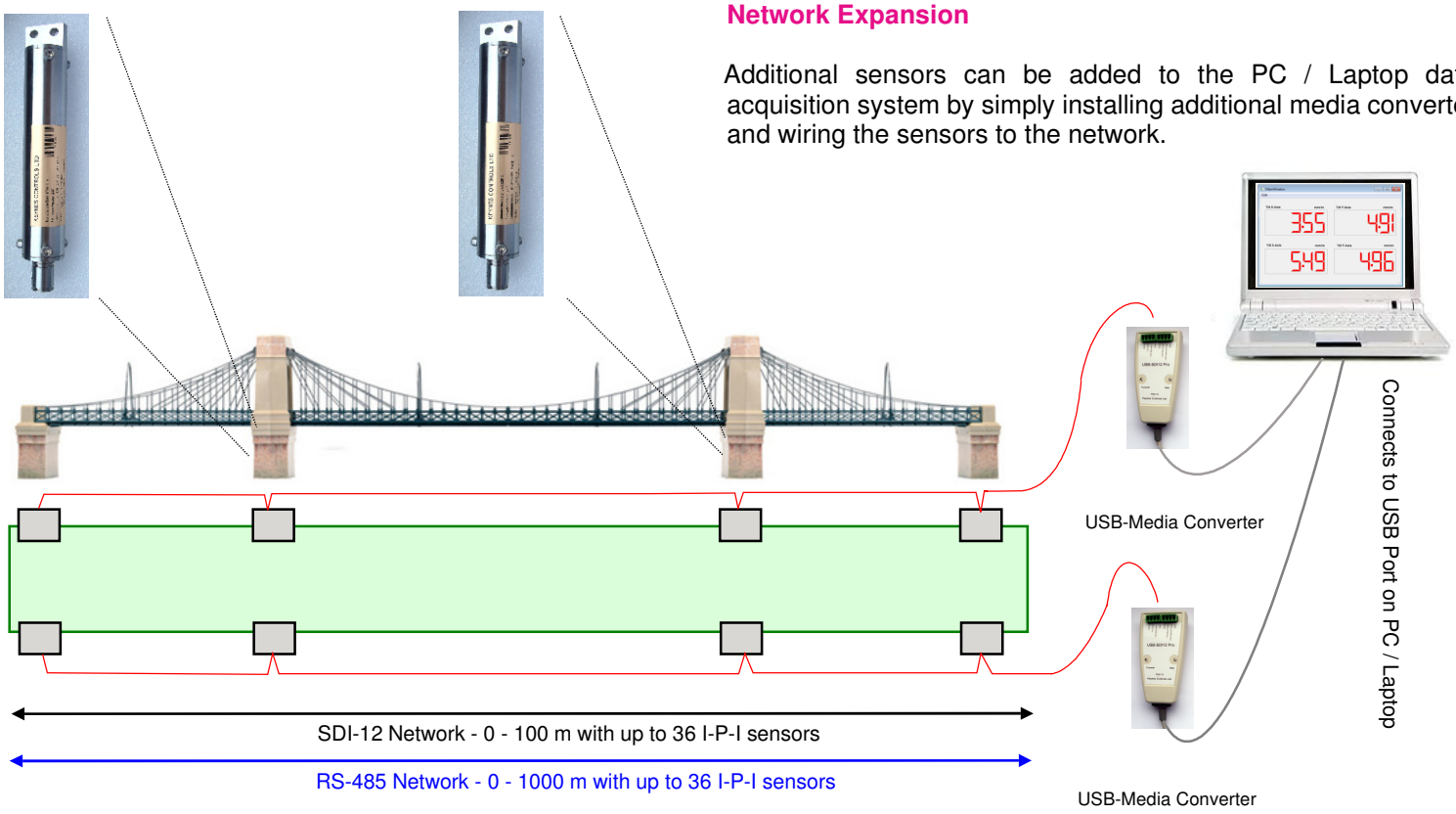
Sensor Connection Diagram

The images below show the sensor connection details for both the SDI-12 and RS-485 model sensors.



Fixture Structure - PC Data Acquisition System

For applications on large structures such as a building or bridges, and where different types of sensor are to be used to create a complete monitoring system then the RS-485 network type instruments are best used. RS-485 version instruments enable sensor installations up to 1 km away for the data recording system to be used. The inclinometers can be mixed with any other suitable sensor along the network string. Up to a maximum of 36 sensors can be deployed



Network Expansion

Additional sensors can be added to the PC / Laptop data acquisition system by simply installing additional media converter and wiring the sensors to the network.

Product Part Numbers

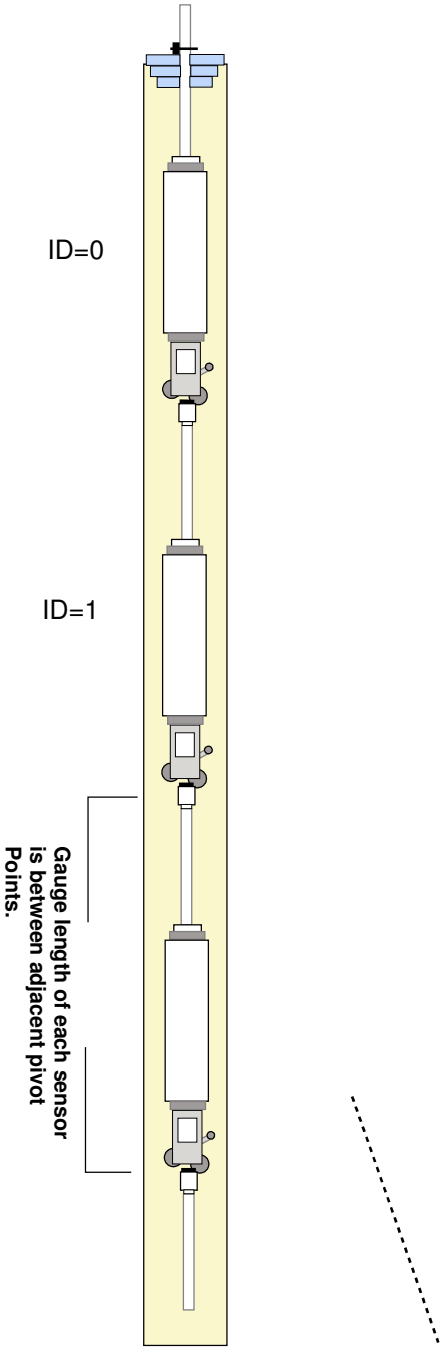
Description	Part Number
SDI-12 USB Dongle	USBS12v1
SDI-12 USBPro Model	USB-SDI12-Pro
Battery Powered Handheld SDI-12 Dongle	SDI12-HB
AquaLOG Data Logger	Aqualog
Digital Barometer	Barom-SDI12
6 Port Expansion Block	HUB-SDI12-6

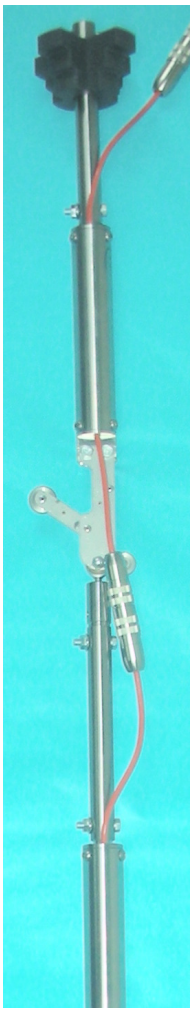
Lightning Protection

All of the I-P-I ranges of sensors have lightning protection fitted on the power and data lines.

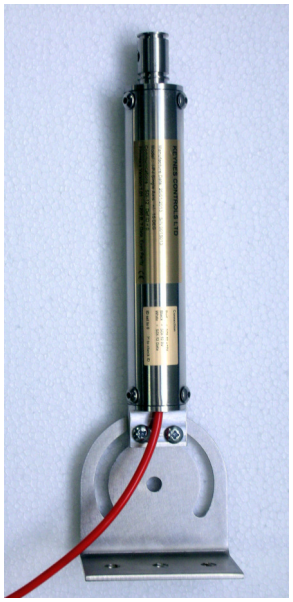
Connecting In-Place-Inclinometer Sensors Together

All of the In-place inclinometers come supplied with IP-68 rated mating interlocking connectors enabling the sensors to be quickly installed. Simply lock adjoining connectors together to increase the I-P-I string length. A multi-core plastic sheathed cable is used for signal transmission with any spare cores acting as the local earth to reduce voltage losses for long network length operations. The signal cables are terminated to the glass-metal seals fitted into the sensor to maintain water integrity.



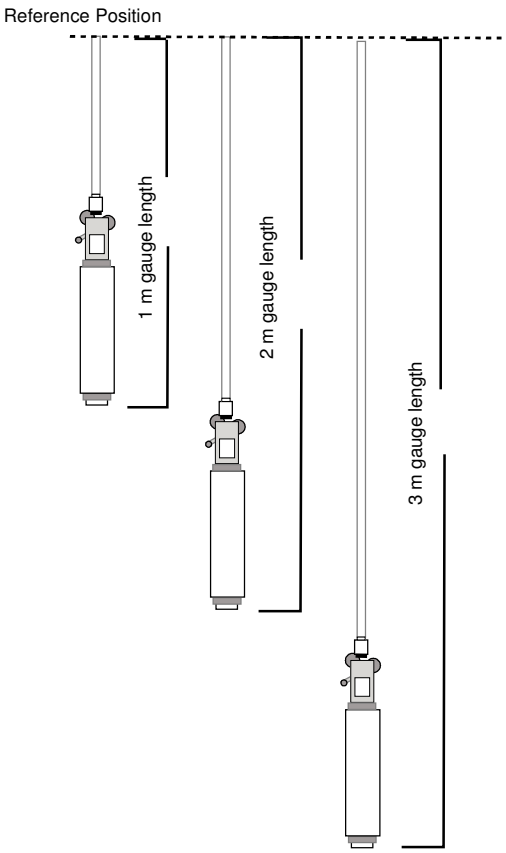


IP-68 rated mating interlocking connectors for fast installation and maintenance operations.

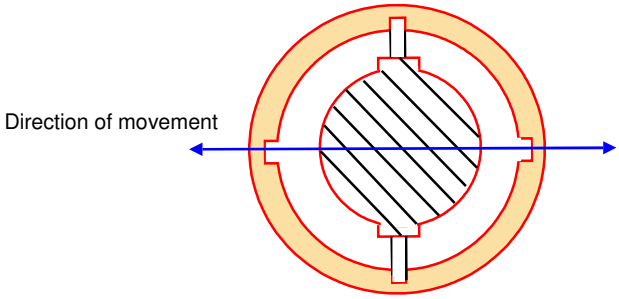


I-P-I sensor fastened to the wall mounting bracket.

I-P-I with gauge tube wheel assembly



The image opposite shows the standard length of the I-P-I sensors and gauge rods that are used for the sensor chain.



For the optimum results the casing should be installed with one set of grooves aligned into the expected direction of motion.

The wheels are used to align the sensor inside the gauge tube.

Vertical In-Place-Inclinometer

The in-place-inclinometer sensor chain consists of a series of inclinometers and a gauge case. Generally the sensors are connected to a data recording device such as a stand-alone logger unit or laptop for storage and display of the inclinometer data The Keynes Controls Q-LOG software is a good companion to the I-P-I sensor chain and gives easy access to the data and sensor configurations.

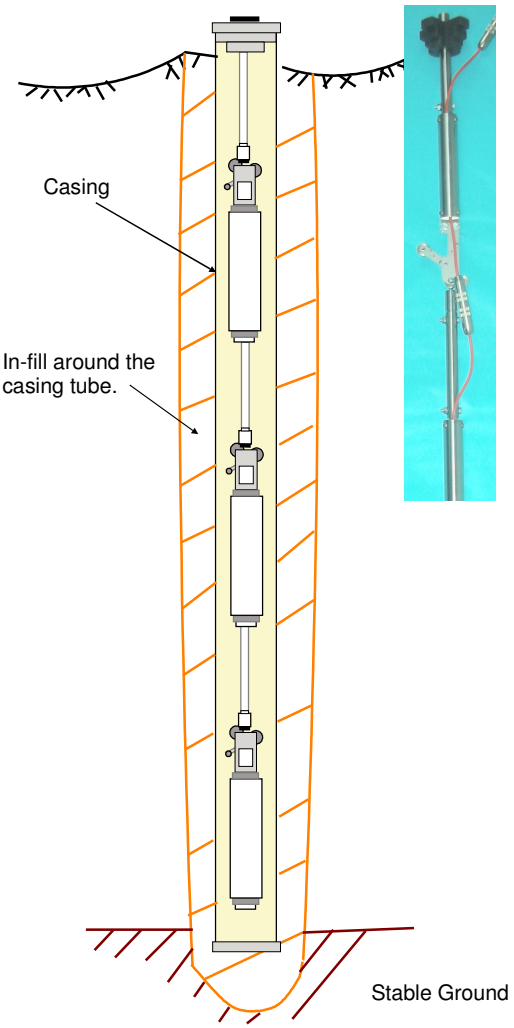
.The inclinometer casing provides easy access to the sub-surface movement, controls the orientation of the sensors, and moves with the surrounding landscape.

In vertical installations the gauge tube is mounted into a bore hole, and this bore-hole passes vertically through the suspected zone of movement into stable ground. The stable end of the I-P-I chain typically acts as the reference point for any future measurement points. One set of groves in the casing is always aligned into the expected direction of movement of the ground.

The sensor casing tube is secured into the bore hole using sand and grout which is tampered to fill in the excess space between the land under investigation and the casing. Any movement of the land is directly transmitted to the gauge casing and so to the sensors contained inside. The casing is secured to make sure there is no movement apart from that induced by the landscape under investigation.

The sensors are intelligent and provide data values directly in engineering units of mm/m by default. The output value can be converted directly into displacement of mm by scaling the output value by the gauge rod length.

Displacement = Output mm/m x Gauge Rod length (m).



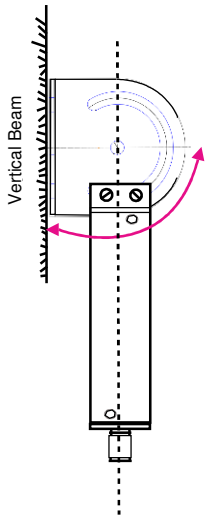
Setting the Initial Zero Position

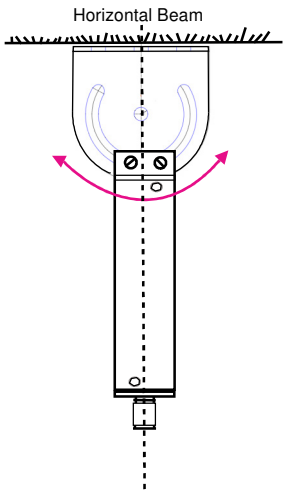
Once the mounting bracket is attached to the structure then the In-place-inclinometer can be secured.

Attach the inclinometer to the mounting bracket and adjust the sensor position until it is in the vertical position, or as close to the vertical as can be judged by the eye. This gives the sensor the maximum possible measurement range.

The images below show the direction of movement to the sensor that should be undertaken to set the initial position.

Once the inclinometer has been moved to its starting position fasten the 2 x 8 mm mounting bolts securely.





Setting the Datum measuring point

Once the tilt sensor is installed and set to the zero position mechanically then it can be electronically set to zero absolutely in software. Setting the sensor to zero position gives the sensor the ability to measure the maximum amount of movement.

The initial position of the sensor at the start of the measurement operation is known as the datum position. Any further movement from the datum position is the actual movement of the structure under investigation. The movement from the datum position is in absolute units making it easy to judge how much a structure under investigation has moved.

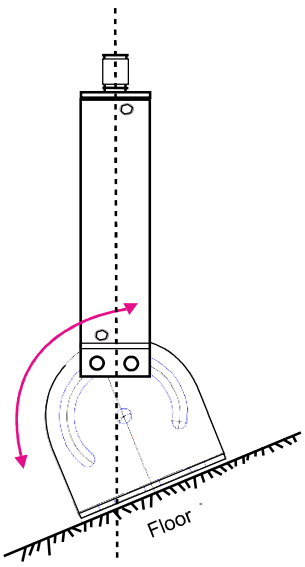
It is best practice to store raw data and to post process any movement.

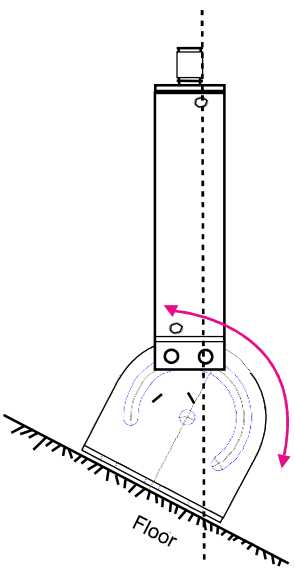
Once the sensor is fixed into place then take a measurement from it manually. Both the AquaLOG data recorder and Q-LOG software have the facility to take and display a single reading.

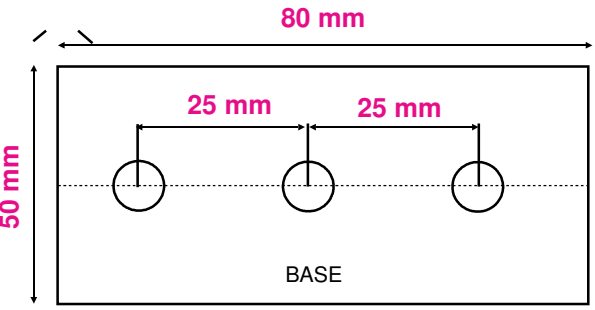
1. Once the I-P-I is fixed into place take the first reading - this is the initial datum position

   Measurement from datum = Current Value - datum This is a simple formula in Q-LOG or in the logger.

Q-LOG and the AquaLOG support this simple formula.





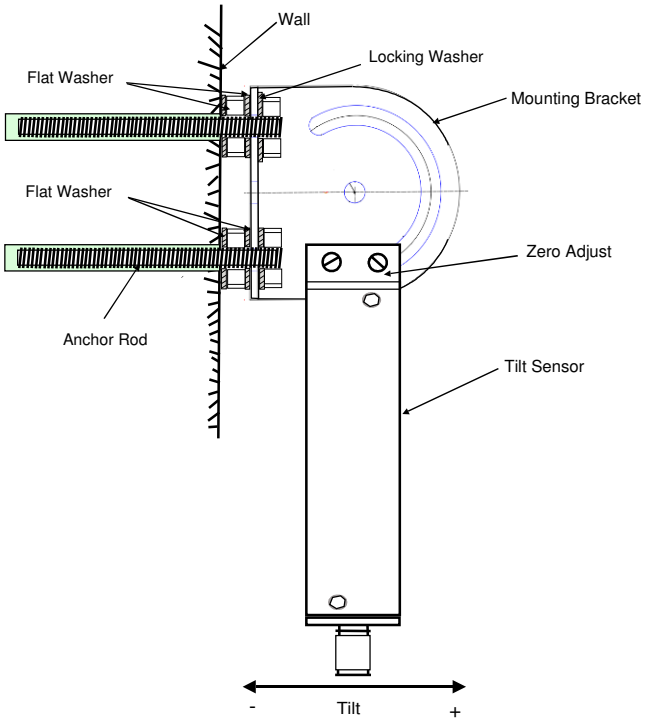


Mounting Bracket Dimensions - Installation

The diagram opposite is not to scale.

For optimum results the bracket has to be firmly attached the the structure under investigation using mounting bolts in all three holes.

If the bracket is difficult to fit then ensure that the 2 outer mounting points are used to secure the base.



Mounting the Tilt Sensor

The aim when fixing the tilt sensor to a structure is to secure it so that only movement from the structure under investigation is measured, and not movement due to environmental effects on sensor.

There are 2 parts to securing the sensor for successful measurement operations. A firm anchor for the mounting bracket to the structure under investigation, and secondly a solid mechanical fastening for the sensor to the bracket.

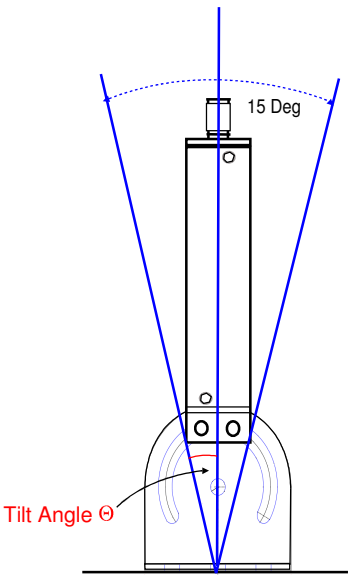
To obtain the optimum measurement range, the tilt sensor is set to its zero point. The sensor zero point can be approximated by eye and can be accurately set using a spirit level.

Starting - Datum Position

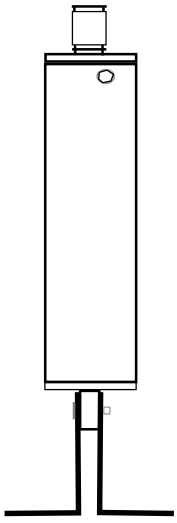
All of the Keynes Controls tilt sensors are intelligent devices and have the ability to store the initial datum position. The datum position can then be used as a reference for the measurement of any future movement.

The datum position is only suitable as reference point so long as the sensor is not mechanically adjusted.

Maximum Measurement Angle
from the centre is +/- 15 Deg



The maximum angle that can be measured in a single axis is +/- 15 Deg.



Securing the sensor to a floor

The inclinometer is a very sensitive instrument and to achieve the optimum results the sensor has to be secured to the based as firmly as possible.

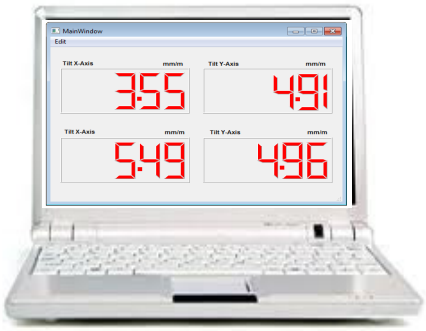
The inclinometer should be secured to a pair of back to back mounting brackets.

Complete In-place-inclinometer PC Based Data Acquisition System

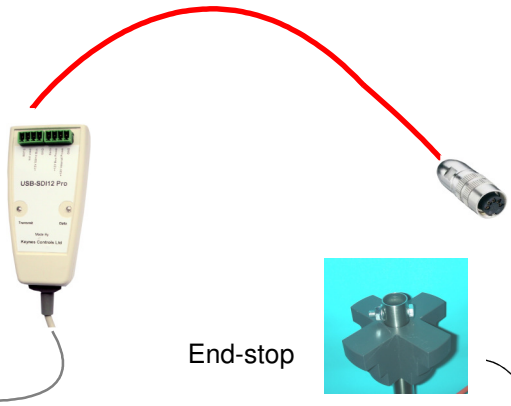
The image below shows a complete In-Place-Inclinometer chain that can be supplied by Keynes Controls Ltd.

The complete kit of parts consists of:

Q-Log applications software
I-P-I sensors and spacer bars
Sensor Casing
End stop and support
USB Media Converter



PC Data Recorder



End-stop

The laptop operates as the data recorder and display unit and offers the simplest way of undertaking a monitoring system. The Q-LOG software is free to download from the web site.

The I-P-I chain can be made to any length to suit most geotechnical applications. Simply set the number of sensors and spacer bars to obtain the desired sensor chain length. All of the sensors are daisy chained together to form a local network. The sensors are all supplied with waterproof self aligning connectors ensuring the sensors cannot be wired incorrectly.

The sensor cables are set at the time of manufacture to match the spacer bar lengths so there is no over hang and to minimise space the cabling takes up in the tube casing. The cabling does not restrict the sensor movement as can be the case in traditional in-place-inclinometer sensor deployments. There is still plenty of space

Sensor Kit length

The In-place-inclinometers are deployed into a casing and separated by spacer bars to create a fixed interval between the measurement points.

First sensor location

The first sensor in the chain is suspended underneath the end stop support. It is recommended that the first spacer bar connecting the upper sensor to the end stop be kept as short as possible in order to detect the surface movement. The smallest spacer bar that is currently manufactured is 0.5 m in length.

Complete I-P-I sensor with wheel assembly

Uniformity of measurement

To simplify the data analysis operations and to visualise the movement then it is recommended that the sensors are equally spaced along the sensor chain. The individual measurement nodes can be set between 0.5 to 3 m along the chain using the standard spacer bars. Additional spacer bars can be manufactured on demand.

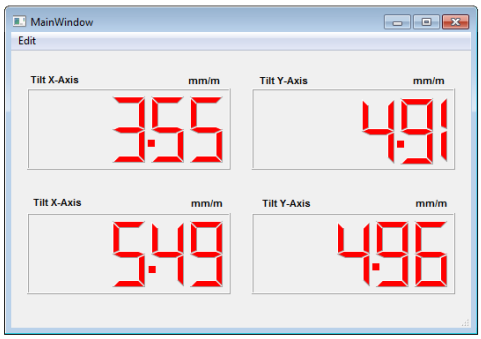
Maximum number of sensors

The maximum number of sensors that can be directly connected to the PC is purely limited to the network type in used the the free USB ports

In-place Inclinometer Data Acquisition System

The image below shows how simple a PC / Laptop computer data acquisition system can be put together using the Keynes Controls media converter unit and I-P-I range of sensors. All of the current inclinometers connect to a network and send values directly in engineering units into data recorders or PC / Lap top data logging systems. Tilt values in units of mm/m and temperature values units of Deg C, or Deg F are transmitted digitally across the network. Digital data transmission minimises noise and errors due to cabling losses and also has the advantage of fast installation and simple maintenance.

Adding new sensors to a network is simplified as no new calibration factors have to added to or changed inside the software.



Q-Log Application

Laptop / PC Computer

USB Data Link

SDI-12 digital network

SDI12-HB Media Converter

I-P-I Tilt Sensor

All of the inclinometer range of sensors are fully integrated into the Q-Log Data Recording and display software. Q-log is available free of charge for up to 10 sensors.

The maximum number of sensors that can be used and distance they can be deployed from the data logger is dependent on the network being used.

Model USB-SDI12-Pro

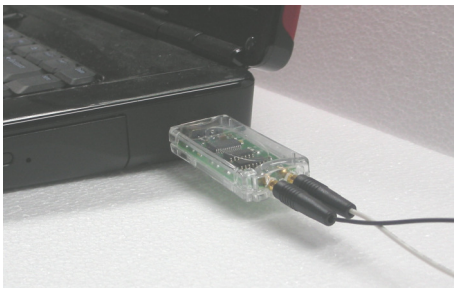
Media Converters

A range of media converters are available from Keynes Controls such as the USB-SDI12-Pro version shown opposite.

The USM-Model-Pro version media converters can power individual sensors or interfaces directly from the PC USB port without any use of an external power supply.

Models

USB-SDI12-Pro
USB-RS485-Pro



SDI-12 Dongle installed in a Laptop.

SDI-12 Network

This product supports SDI-12 1.3 operations

The image above shows the basic type USB media converter installed into a laptop.

An external power supply is required to energise the sensors with this model of converter.

Operation in Q-LOG

All of the I-P-I range of sensors are fully integrated into the Q-LOG application software.

Refer to the Q-LOG user manual for full instructions in using the software.

Once the sensors are installed and the media converter is connected to the PC then the Q-LOG software can be used to acquire data in real-time.

The quick guide for gather data from the I-P-I sensors is:

Media Converter Comm Port Number

1. Make sure the sensors are installed correctly and that the are connected to the digital network media converter in the pins on the device.

2. Install the USB media converter into the PC

   Identify the Comm Port used by the media converter as this number is required by the Q-LOG Configuration.

   In the Microsoft Windows operating system the details can be found using

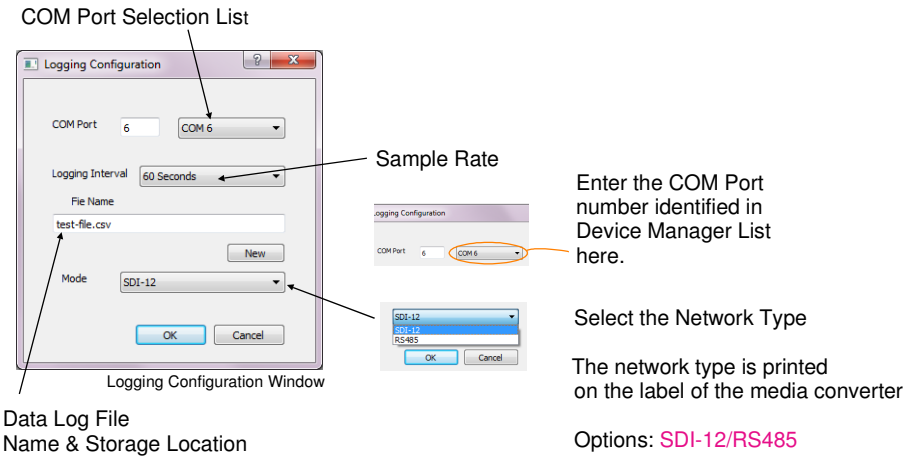
   Control Panel - System Devices - hardware - Com Ports - The options in Control Panel vary slightly between the different versions of the operating system is use.

Q-LOG Software

The In-place-inclinometer is integrated into Q-LOG. This manual expects that Q-LOG has already been downloaded and is operational on the data logger PC.

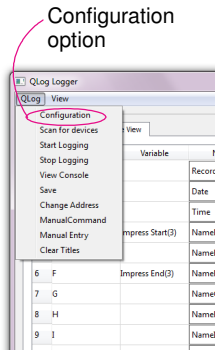
3. Start Q-Log Software

   File - Configuration tab. The 'Logging Configuration' Window will appear. This example shows that the USB media converter is an SDI-12 model and is using Com Port 6 in the operating system.



4. The Q-log software has the facility to scan the chosen network and automatically identify any sensors that are detected.

   Select File - Scan for devices - the software updates the table in the main Window for each sensor that has been detected



Q-LOG Main Window

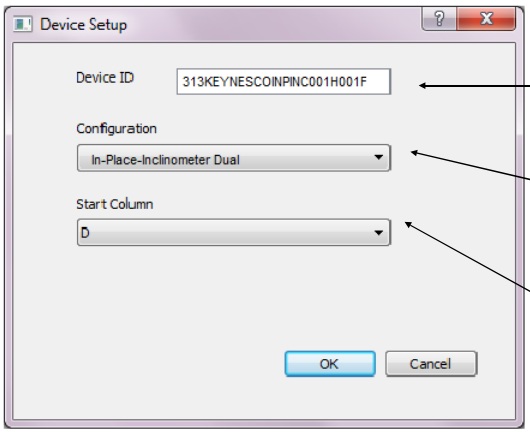
SDI-12 / RS485 Network Selection

Assign the network type used for communication between the sensors and the I-P-I using the options provided. Currently there are only 2 options, SDI-12 or RS-485. The type of network in use depends solely upon the type of media converter installed into the PC. Use only the Keynes Controls media converters when running Q-LOG software.

Selecting the Model Type

There are only 2 models of I-P-I currently available and they are single or dual axis devices. Both sensor models have the ability to return local temperature data values along with the tilt angle.

Select the type of sensor to be used from the 'Configuration' menu options. Q-Log will return the number correct number of parameters from the device.

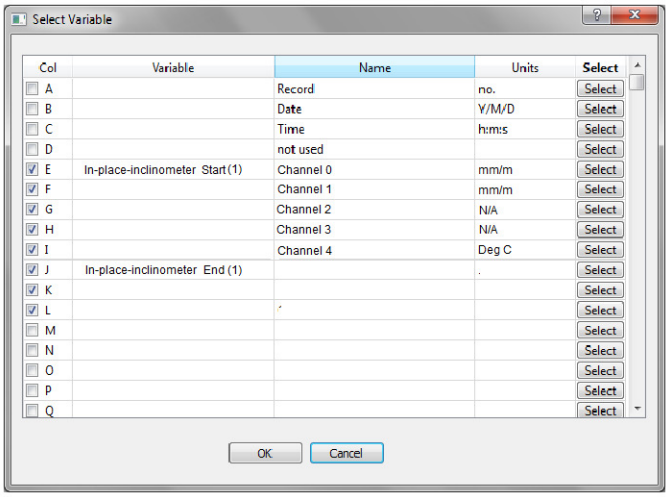


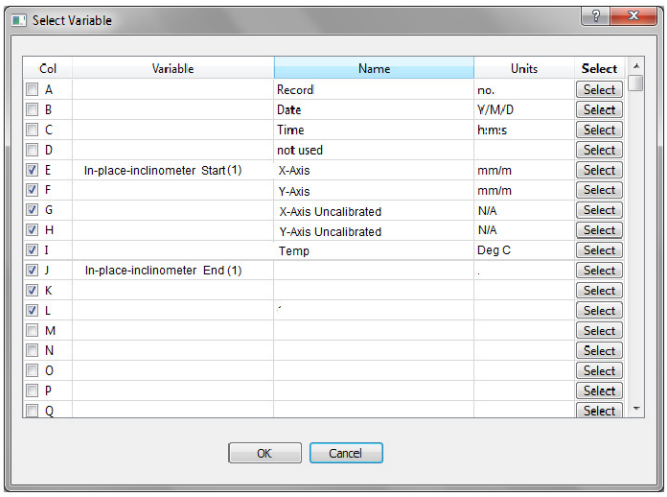
Device Identification String
Preset into the sensor or interface

Sensor Option Selection
Enables different sensor options to be used.

Assigns the start cell of the sensor data into the data table making up the log file.

A .. IU - Excel spreadsheet format.





Displaying Engineering Units

The full details for the use of the Q-LOG software can be found at http://www.aquabat.net/QLOGFree/qlogv2.html

Follow the link and download the manual.

I-P-I Operation in Q-LOG

The in-place-inclinometer is integrated into the Q-LOG software.

The engineering units for the in-place-inclinometer that are displayed on the Q-LOG screens is simply entered into the table opposite as text. The sensors used to acquire the data have to be pre-configured to the correct engineering units before being entered into the units column. The data values from the inclinometer is typically in units of mm/m

The example is going to insert engineering units for use with an AquaDAT with ID = 2 for channel 0.

From the '**Select Variable**' Window

Select the 'Units' cell to be configured.

Cell to be configured

This cell can be edited and values deleted just like a cell in a spreadsheet.

Type the new 'Units' title into the specified cell:

In this example shows a dual channel I-P-I with ID = 1 starting at cell 'E' with units is set to 'mm/m' .

Type 'mm/m' in the 'Units' adjacent to any tilt sensor value.

Repeat the 'Units', 'Titles' update for all the required cells.

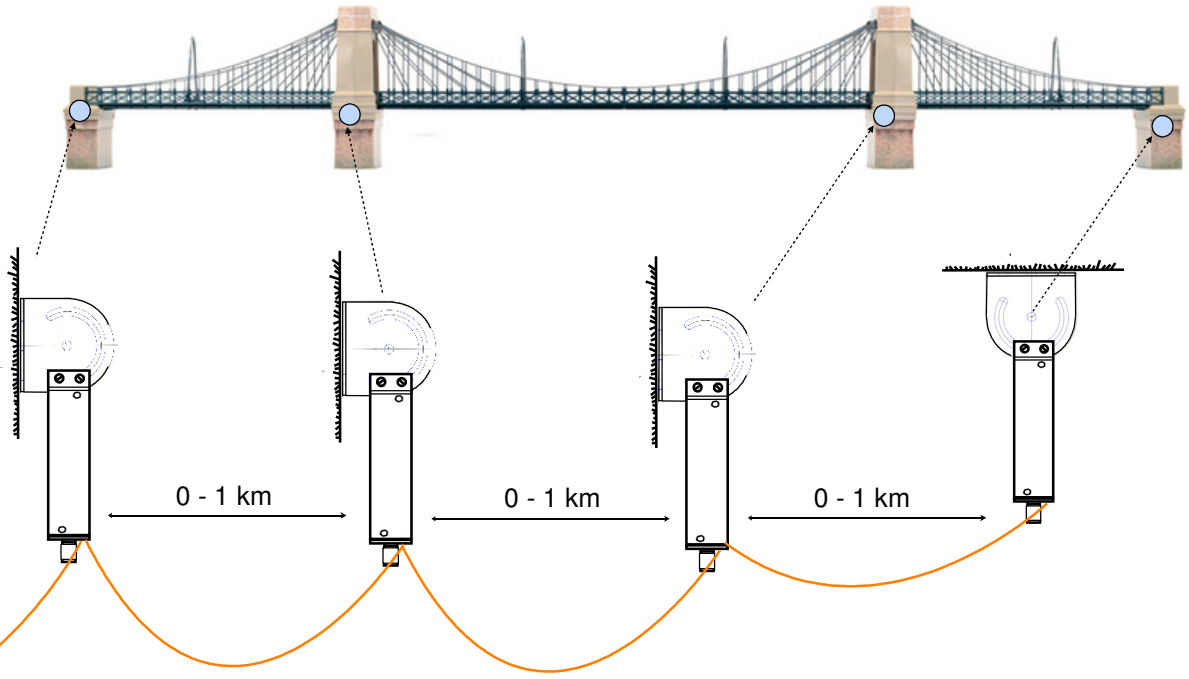
The units that is inserted into the table will appear on the panel meter and chart plots.

Press the 'OK' button to store the new units.

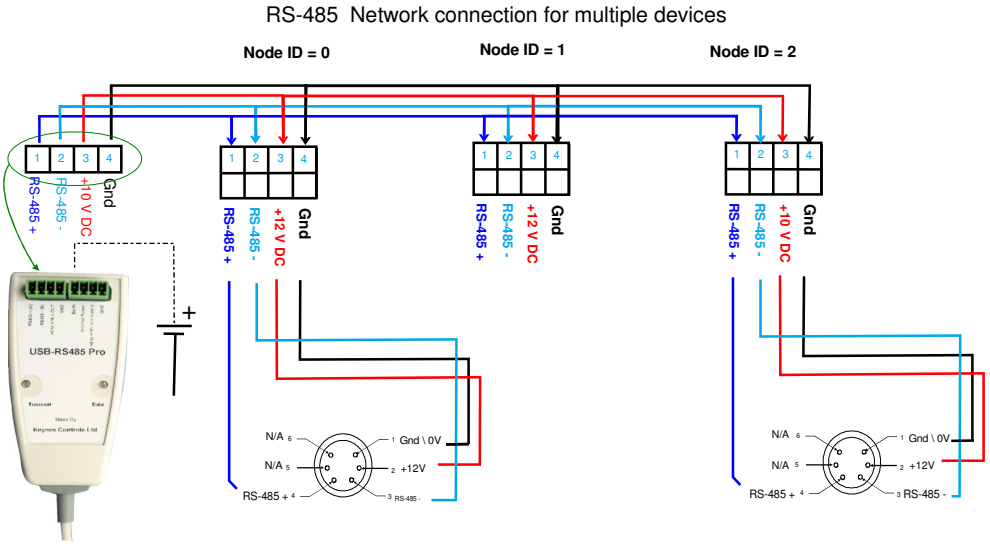
Connection of Multiple RS-485 Sensors on a Network

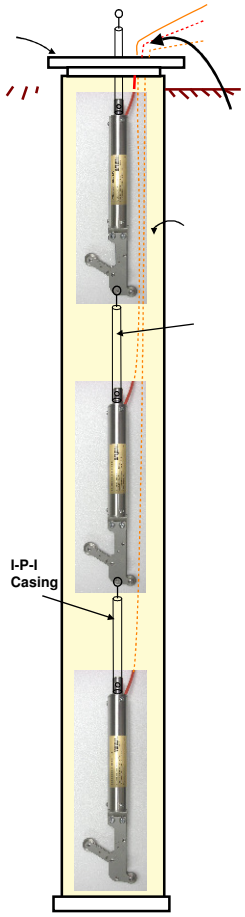
The image below demonstrates how multiple RS-485 sensors are connected together on a network.

Where long distances between sensors are involved, then the NP_Isolator modules can be used. The NP_Isolator modules are used to isolate protect network strings, prevent earth loop noise effects and convert between SDI-12 and 485 operations.



To data logger
or suitable RS-485
data acquisition system





External Power Supply Port

12 - 16 V DC

Connect external power supply if the maximum current for the number of devices on the RS485 network exceeds 85 mA

Connect multiple devices in the same way to the next port

Contents