In Place Inclinometer Installation Manual

SDI-12I / RS485 Digital Network Devices

Vertical Sensor Chain Operations Only

KEYNES CONTROLS

Note: This document supports all versions of the sensor shipped since its introduction.

Any sensors shipped after April 2018 use new waterproof connectors which are factory installed. Sensors shipped after this date must be returned to Keynes Controls Ltd for any cable changes. Keynes Controls only use standard signal cabling and standard colour code that has never changed since the sensor's introduction.

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1.0 Introduction

The following manual details the instruction to follow to assemble the Keynes Controls In-place-inclinometers to form a vertical measurement chain.

This manual is meant as a guide only and some prior knowledge on the use of In-place-inclinometers is expected.

Where possible Keynes Controls have endeavoured to make sure the parts only fit together in a single way in order to avoid any confusion in any measurement operation.

All of the inclinometers described in this manual use a digital network for data communications. All of the sensors are intelligent and undertake any measurement operation internally within the device,

1.1 Recommended Calibration Period

For best results Keynes Controls recommends that the sensors are re-calibrated on an annual basis.

1.2 Mounting Bolts

All metal parts making up the In-place-inclinometer are constructed from stainless steel. The mounting bolts are M6 and also of stainless steel.

1.3 Successful Measurements

For a successful measurement system to be created the in-place-inclinometers should not be subject to mechanical shock during installation. They shall be located away from any sources of local vibration and use the correctly rated power supply.

Figure 1 - KEVNES CONTROLS In-place-inclinometer

1	Sensor Bottom t
2	Top Plug - Secure a spacer bar here
3	Fit wheel assembly here
4	Sensor Top

HOW TO CONTACT US

Technical Support
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Berkshire, RG7 1PQ

Tel: (0044) 118 327 6067
Email: **sales@keynes-controls.com**

Important Note:

This product contains sensitive electronics and can be damaged by physical shock.

Under no circumstances allow the In-place-Inclinometer to be dropped.

Standard Sensor Dimensions

Figure 3 - Sensor Dimensions

1	**Sensor Tube Length = 165 mm**
2	**Complete Standard Wheel Assembly**
3	**100 mm - Standard Wheel Assembly**
4	**60 mm - Standard Wheel Assembly**
5	**Top Plug Diameter = 17 mm**
6	**Sensor Tube Diameter = 32 mm**
7	**Top Plug Length = 28 mm**

2.0 WARRANTY PROVISIONS

Keynes Controls Ltd. warrants the Inclinometer 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 ou

The information in this document is subject to change without notice. Keynes Controls Ltd. has made a reasonable effort to be sure that the information contained herein is current and accurate as of the date of publication.

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The customer is responsible for all courier charges and local fees unless agreed by Keynes Controls in advance. In case any parts are to be returned Contact Keynes Controls for a RMA number before shipment. Keynes Controls cannot

2.1 FIRMWARE & SOFTWARE UPGRADES

The Inclinometers have a firmware upgrade facility, this enables the device operations to be customised. Contact Keynes Controls Ltd. For details.

2.2 Deployment

The sensors can be deployed into any measurement location on a sensor chain. No special sensor model is required to be installed at the top, or bottom of a sensor chain.

Only the bottom sensor is physically different from any other sensor model in that only one connector is installed on the device. The bottom of the sensor is sealed.

If you suspect that an In-place-inclinometer is malfunctioning, or requires re-calibration and repair is required then contact us.

2.3 SU Unit Conversion - mm/m to Deg

The sensors are factory set to give output values in SI units of mm/m.

To convert the sensor output tilt values from mm/m to Deg, then the sensor scale and offset values have to be adjusted.

The sensor calibration factors can only be adjusted by a direct connection to the sensor. This action can be done via a direct connection to the device over the digital network.

The simplest way to undertake the conversion is to use the ‘Terminal Port’ feature in the Keynes Controls Q-LOG software via a media converter. Once the commands are completed correctly then the results can be seen directly on the screen in SI units of Deg.

A 3rd party device suitable for communication across the specified sensor digital network can also be used.

Industry Standard Commands for Units Conversion

Dual Axis Sensor	Description
XCA1,-14,47!	Y-Axis SI Units to Deg
XCA3,14.47!	X-Axis SI Units to Deg
XCA0,0.329!	Y-Axis Offset conversion from mm/m to Deg
XCA2,0.329!	X-Axis Offset conversion from mm/m to Deg

Example: Change a Dual-axis sensor with ID=3 from SI units mm/m to Deg then use commands:

3XCA1,-14,47!	*Y-Axis Scale*
3XCA3,14.47!	*X-Axis Scale*
3XCA0,0.329!	*Y-Axis Offset*
3XCA2,0.329!	*X-Axis Offset*

2.4 Table of Standard Degree to mm/m Conversions

Deg		mm / m
0		0
1		17.45
2.5		43.63
5		87.26
7.5		130.89
10		174.53
12		209.43
15		261.79

2.5 On Delivery Testing

Upon receipt of the sensors Keynes Controls recommends that the individual sensors are tested for communications prior to installation.

To simplify the testing Keynes Controls offer free applications software to display test data, and a series of media converters to enable the inclinometers to be attached and operated from a Microsoft Windows Operating System PC.

2.6 Measurement Data Values

A **dual** axis sensor returns A + X-axis + Y-axis + Temp where A = ID Number

A single axis sensor returns A + X-axis + Temp Temperature is is Deg C.

3.0 Pre-installation Communications Test

On receipt of the sensors Keynes Controls recommends that the individual sensors are tested for communications prior to installation. This test is to ensure that the sensors have not been damaged in transit.

To simplify the testing, Keynes offers a free software applications package named Q-LOG and a series of USB media converters that can be used to connect a sensor directly to a Windows PC. The application software can be used to configure a sensor, make test measurements and display results..

3.1 Free Applications Software Download

The Q-LOG software can be downloaded at:
http://keynes-controls.com/Download/QLogSetup50_21may2020.zip

The Q-Log software enables the data to be observed directly in engineering units and to calibrate sensors.

3.2 Media Converters

The Keynes Control range of media converters offer sensor excitation, opto isolation, and automatically installed Microsoft accredited device drivers. The device drivers automatically install upon the detection of a media converter installation onto a Windows PC.

The automatic driver installation only operates when an internet link is available.

Figure 4 USB Media Converter Installation

Simply install the media converter for the desired sensor type into a USB port on a PC.

Connect the in-Place-Inclinometer to the interface using the pin-out shown on the media converter and read the tilt data back into the applications software in a Windows friendly operating environment,

No programming experience is required to configure a Keynes Controls inclinometer sensor.

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See the youtube Video demonstrates the use of 2 X Dual Axis SDI-12 Inclinometers, a USB media converter and the Q-LOG applications software making and displaying test measurements.

Youtube Demo Videos

https://youtu.be/UBUmWnMTZbg

Wire Spaced Sensors

When deploying multiple sensors using steel wire sling then a double wheel assembly is placed above the sensor connecting to the wire. This is used to align the sensor into the casing correctly.

Figure 5 Double Wheel Assembly

Q-LOG Quick User Guide

1. Ensure that the Q-LOG software has been downloaded and saved to the hard drive. Only download the software from the Keynes Controls Site. Q-LOG only runs under the Microsoft Windows operating systems.

2. Install the Software as '**Admin**'. This prevents any operating system warning messages appearing on the screen

3. Install a suitable media converter to enable a sensor to talk to the PC. See Figure 4.
   For the RS485 network instruments use the media converter with Part Number **USB-485-Pro**, and for the SDI12 version sensors use a media converter with Part Number **USB-SDI12-Pro**.

   Any 3rd party media converter can be used so long as it supports the correct network protocols for the sensors.

4. Start The Q-LOG Software, the Window shown in Figure 40 will appear. From the QLOG tab select '**Configure**' and a Window shown in Figure 6 will appear.

   Enter the COM Port number used by the operating system to identify the media converter.
   The Com Port number can be identified in Ports on the Device Manager Operating System Window.

5. From the '**Network'** menu Option - Set the network type for the sensor.

   The Q-LOg software only supports SDI-12 and RS485 versions of instruments.

   The Modbus version instruments have to be used with SCADA or similar software packages.

6. Select from the **'Sample Rate**' options.how fast the measurements from a sensor are to be made. For a single sensor operation then '**1** sec' is fine. When multiple sensors are in operation then a **5** or **10** second sample rate should be set.

7. Plug the sensor into the media converter. It is presumed in this document that the media converter will be a Keynes Controls model. All of the Keynes Controls model media converters contain status indicators to show the network operation. Upon installation into a USB port on a PC should make the LED indicator lights illuminate. The quick flash of the LED indicators shows that the device drivers have been installed.

8. The software is now configured for operation and ready to start measurements.Select '**OK**' button.

   Scanning for Sensors

9. Select the '**Q-LOG**' tab from the main menu and Select the **' Scan Network**' option. Any instruments on the network will appear under the device list. **Tab A** on Figure 40 shows where the sensors that have been identified will appear in the software.

10. The software will now start scanning the network to see if there are any sensors attached. The media converter status lights will illuminate to show that network data operations are underway. A Youtube video showing a Keynes Controls media converter in operation can be found on Page 10..

    Should the media converter status lights not flash then this generally means that the media converter has not been assigned correctly. Repeat step 3.

    Identifying Sensors

11. The Q-LOG software will display any sensor it has discovered on the Device list. The 'Device list' is shown on the main Q-LOG Window. Leave the software to complete the network scanning.

12. It is important that each sensor that is used on a network has a unique ID (Identifier Number).

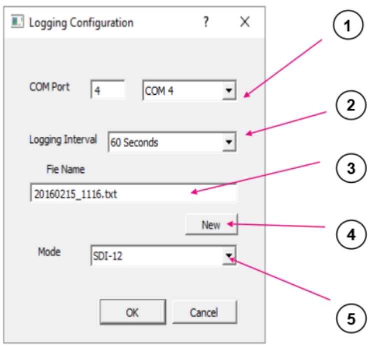
    Press the '**Config**' button that appears adjacent to each sensor that has been identified on the 'Device List'.
    A sensor configuration Window will appear. From the pull-down list select the sensor type from the available options.
    The User will be able to select from single or dual axis devices.

    Figure 41 on Page 31 shows the Q-LOG Device Configuration Window.

13. All of the Keynes Controls range of inclinometers are configured and operated in the Q-LOG software in the same way.

14. Repeat 14 for all identified devices. The software will assign a cell name for the results. Ignore this information until all the sensors have been assigned.

15. Select the '**Auto-assign**' option from the Q-LOG menu list. The results from the sensors will be correctly identified and displayed by the software.



1 = Serial Port Number
2 = Sample Rate 1, 5, 10, 30 seconds
3 = Results File Name
4 = Automatically Assign new Results File
5 = Network Type Selection

RS485 or SDI12 only

Figure 6 Q-LOG Configuration Window

Starting the Measurements and Observing the Results

16. Once the software is all set up and the auto assign button has been activated then everything is ready to start gathering measurements.

17. Select '**Start Acquisition**' option from the main Q-LOG menu. The status indicators on the Keynes Controls media converts should be flashing on and off. This indicates that instructions are being sent, and data is being received from a senso

18. Select the '**Variable**' tab from the Q-LOG main Window, The screen will change and a results table will be displayed.

19. The output units for the sensor have to be manually assigned. Details on how this is done can be seen in the demonstration **Youtube video**. The link for the video is shown below.

Youtube Demo Video

1. In Place Inclinometer Operations in the Q-LOG Software

2. **USB Media Converter in Operation**

3. Q-LOG Media Converter Configuration

4.0 Part Numbers

All of the sensors shown support the full and identical range of accessories.

Part Number		Description
IPI-bar-1m		1m gauge bar for any In Place Inclinometer sensor
IPI-bar-2m		2m gauge bar for any In Place Inclinometer sensor
IPI-bar-3m		3m gauge bar for anyIn Place Inclinometer sensor
IPI-case-cap		Top Cap for Inclinometer Sensor Casing
SDI-12 Network		
IPI-D-15-SDI12		Dual Axis Sensor - +/- 15 deg – SDI-12 Communications
IPI-D-75-SDI12		Dual Axis Sensor - +/- 7.5 deg – SDI-12 Communications
IPI-D-50-SDI12		Dual Axis Sensor - +/- 5 deg - SDI-12 Communications
IPI-S-15-SDI12		Single Axis Sensor - +/- 15 deg – SDI-12 Communications
IPI-S-75-SDI12		Single Axis Sensor - +/- 7.5 deg – SDI-12 Communications
IPI-S-50-SDI12		Single Axis Sensor - +/- 5 deg - SDI-12 Communications
RS-485 Network		
IPI-D-15-RS485		Dual Axis Sensor - +/- 15 deg - RS-485 Communications
IPI-D-75-RS485		Dual Axis Sensor - +/- 7.5 deg - RS-485 Communications
IPI-D-50-RS485		Dual Axis Sensor - +/- 5 deg - RS-485 Communications
IPI-S-15-RS485		Single Axis Sensor - +/- 15 deg - RS-485 Communications
IPI-S-75-RS485		Single Axis Sensor - +/- 7.5 deg - RS-485 Communications
IPI-S-50-RS485		Single Axis Sensor - +/- 5 deg - RS-485 Communications

4.1 Definitions

The following definitions are used in this document

Reach :   The length of the steel wire sling from the top fastening to the mounting point on the double wheel assembly.

Standard Sensor Length : This is the total length of the sensor body with attached wheel assembly. See Figure 3.

Casing :   This is the tube that supports the sensor when deployed for measurements. It can be circular or rectangular. See Figure 25.

Sensor: Any of the Keynes Controls Single or Dual axis In Place Inclinometer sensors.

Spacer Bar Length : Is defined as the total length of the sensor system with the sensor body, wheel assembly and bar plug attached.

Example : 1m spacer bar forms a complete sensor assembly including the spacer bar, wheel assembly and sensor body that is 1 m in length from the top of the wheel assembly to measurement point.

Top Sensor Depth when deployed from a Steel Wire Sling

This is defined as the total length of the suspension system from the top of the securing point on the top cap to the measurement position on the first sensor under the sling.

The total distance consists of a spacer bar under the top cap including the bar plug and universal joint, The length of the steel sling, the length of the double wheel assembly and the sensor mechanism attached to the bottom of the double wheel assembly. See the image on Page 42.

5.0 Mechanical Assembly Operations for the Vertical Sensor Chain

The creation of a sensor chain is a simple operation. Connect the spacer bars and wheel assemblies together to make a measurement chain of the desired length.

The sensor length is assigned by the overall inclinometer length with a spacer bar to give the desired spacing between the measurement points. The standard measurement points are spaced 0.5, 1, 2 or 3 metres apart. Other distances can be created on request.

5.1 Spacer Bars

The sensor bars are supplied with all mounting bolts and with a factory pre-set rod end bearing attached.
Apart from bolting the spacer bar to the In-place-inclinometer, no other mechanical assembly will be required.

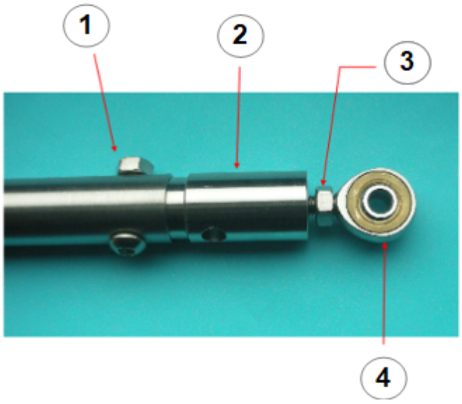


Figure 6 - Spacer Bar Fastenings

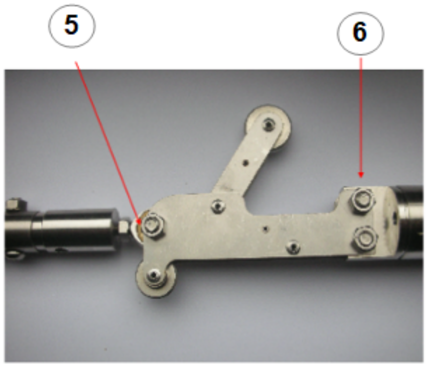
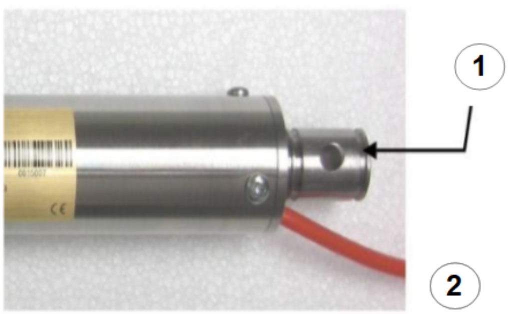


Figure 7 - Wheel Assembly

	Spacer Bar Fastening Dimensions
1	Bar plug securing bolt - M6 x 25 mm
2	Bar Plug
3	Universal Joint Locking Nut
4	Rod End Bearing Universal Joint

	Wheel Fastening Dimensions
5	M6 x 25 mm Stainless Steel Bolts
6	M6 x 18 mm Stainless Steel Bolts



1	Secure Spacer Mounting Point
2	Sensor Network Cable

Figure 8 Spacer Bar top piece mounting position

5.2 Attaching the Wheel Assembly onto a Spacer Bar

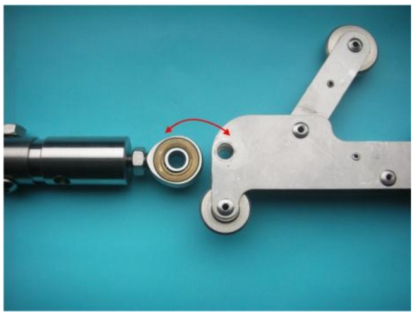


Figure 9 Fastening the spacer rod to the Wheel Assembly

Fig 9 above shows how the wheel assembly connects to the spacer bar.

Line up the rod end bearing to the wheel assembly as shown.
Slide the red end bearing into the wheel assembly
Secure the wheel assembly to rod end bearing using the supplied **M6 X 25mm** stainless steel bolt.

Figure 10 below shows how the wheel assembly is secured onto the sensor body and to a spacer bar . The wheel assembly has to be attached to the sensor prior to the inclinometer being installed on to the sensor chain.

Figure 10 - Connection of a Spacer Bar to the Wheel Assembly

The eyelet is pushed into the wheel assembly secured using a bolt passing through the eyelet.

The process is repeated for each In-place-inclinometer on the string.

Figure 11 Complete Sensor Assembly

Fig 11 shows how the In-place-inclinometer with the wheel assembly attached. The wheel assembly fits on to all models of the sensor in exactly the same manner.

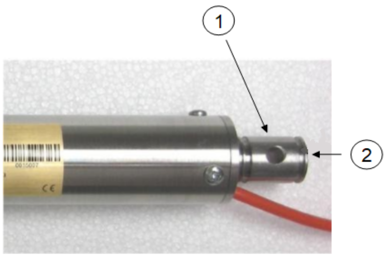
Figure 12 -Another batch of sensors being prepared for shipment.

5.3 Fastening the spacer bar to the top of the In-place-inclinometer

The spacer bar only fits onto the sensor top in one position and is used to align the bar to the next adjacent sensor.

Slide the spacer bar onto the sensor top mounting piece and secure into place with the M6 x 25 mm stainless steel bolt. Make sure the securing nut is tightly fastened.

All the spacer bars are secured into place regardless of length in exactly the same alignment for each device..



1	M6 Spacer bar securing point
2	Spacer bar mounting point

Figure 13 Securing the spacer bar to the top of the sensor

5.4 Minor adjustments to the Spacer Bar Alignment

The spacer bars are supplied with a factor aligned rod end bearing. Once the spacer bar is attached to the sensor it will correctly align the axis of measurement.In some cases it may be desirable to make minor adjustments in the alignment of the bar to correct for any local mechanical irregularities in the sensor casing tubes.

5.5 Rod End Bearing

The rock end bearing is screwed into the bar plug and secured into place with a locking nut.

1. Slacken the locking nut. See the image below.
2. Adjust the rod end bearing orientation and length to the new desired position.
3. Secure the rod end bearing into place by tightening the locking nut.

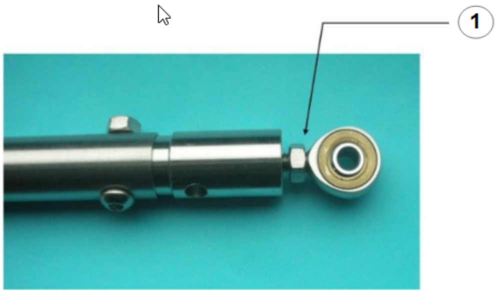


Figure 14 - Spacer bar locking nut

1. Bearing Locking Nut - M6 Stainless Steel

5.5 Joining Standard Sensors together up on a Spacer Bar

For most applications the complete sensor assembly consists of

1. Universal Joint Locking Nut
2. Wheel Assembly
3. Bar Blug
4. Universal Joint.
5. Munting Eyelet.

Figure 15 Spacer Bar Fixtures

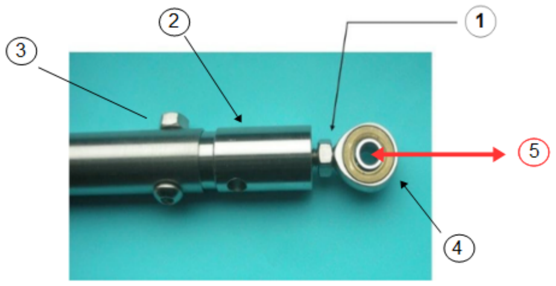


Figure 15 opposite shows the end of a spacer bar with the bar plug and universal joint attached.

The spacer bar is machined to accept the bar plug and is secured into place with an M6 bolt. Make sure the locking nut is secure.

The Universal Joint screws into the bar plug.

The eyelet screws into the bar plug and is secured into the wheel assembly. The completed assembly is ready to be fastened together in order to form the sensor chain.

The individual sensor assemblies are secured to each other using the mounting point in the wheel assembly

Push the eyelet of the universal joint into the wheel assembly and secure using an M6 bolt. Figure 16 below shows the Universal Joint secured into a wheel assembly.

Ensure the wheel assembly is bolted to the sensor body. Use M6 bolts and locking nuts. The wheel assembly and sensor body must be firmly attached with no mechanical movement.

Item 5 shown in Figures 16 and 17 demonstrates the eyelet of the universal joint and its mounting point on a wheel assembly.

The alignment of the Spacer Bar can be adjusted manually by slackening off the universal joint, adjusting the position and locking down again by securing the locking nut.

Item **1** in Figure 15 shows the locking nut.

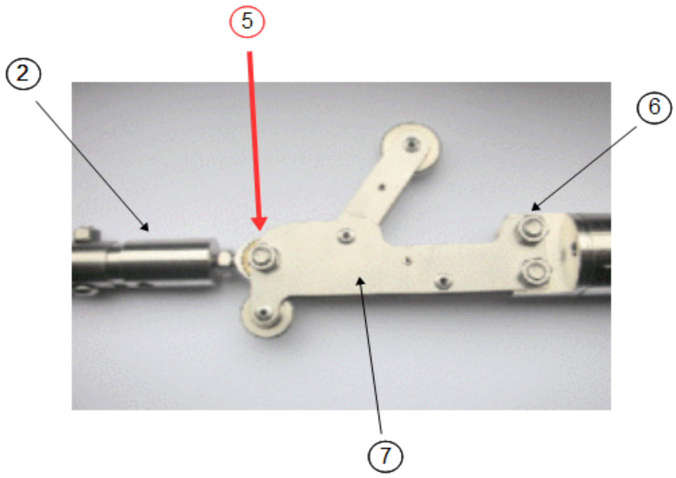


Figure 16 Spacer Bar attachment to a Wheel Assembly.

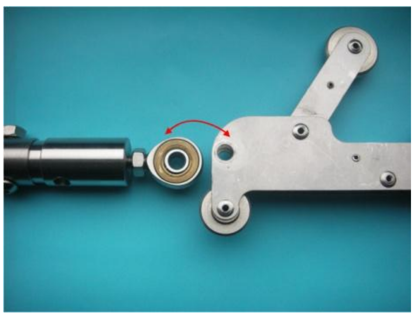


Figure 17 Universal Joint Eyelet Mounting Position

Repeat the above operation for each sensor to be installed on the chain.

6.0 Digital Network Connection

The standard sensor used on a sensor chain is supplied with two network connectors, one at each end of the sensor and used to daisy chain the digital network between devices. Each sensor connects to the adjacent device along the network by simply linking the connectors together. All of the sensors can be used in any position on the network without restriction. The sensor at the bottom of the chain only requires a single connector as it only connects to the device above. See Figures 22 and 23 on page 19.

The Keynes Controls I-P-I sensors use a self aligning bayonet fitting plug and sockets to connect the sensors together. The watertight seal is only formed once the connectors are screwed together. Care has to be taken to make sure the connectors are screwed together tightly prior to deployment on the chain in order to stop the ingress of water to the signal cable cores.

To ensure long term operations Keynes recommends that a water tight seal be bonded over the device connectors. See details on Page 18.

6.1 Network Types

The Keynes Controls I-P-I sensors support SDI-12, RS-485 and Modbus over 485 digital network communications.

Contact Keynes Controls for details of the Mobus devices.

SDI-12 Network Length

Any In-place-inclinometer chain, connecting to an SDI-12 type data logger, must not exceed a maximum length of 100 m from the bottom of the I-P-I chain to the data logger. Figure 11 below shows sensors connected together on a daisy chained network. The SDI-12 network cable is to be good of quality and any connections to logger units to be clean and secure.

RS-485 Network Length

Any In-place-inclinometer sensor chain deployed using the RS-485/ Modbus must not exceed a maximum length of 1000 m from the bottom of the sensor chain to the data logger or PC.

The RS485 version sensors can be connected to a RS485 to WiFi converter when long distance cable free operations.

6.2 Waterproof Connector

Figure 18 below shows the standard connector used on all of the Keynes Controls Inclinometer range of sensors.

The standard sensor is rated for up to 20m of water depth and is suitable for operations to that depth and all land based applications.

Long Term and Submerged Operations

For applications requiring long term deployment, or submergence then keynes Controls advise that a water tight seal is placed over the connector and secured into place.

The heat shrink seals are 140 mm in length and contain an adhesive inner cover.
Only this type of seal is to be used to secure the connectors on the Keynes Controls sensors.

Figure 18 The Standard Sensor Connector

Figure 19 Sealed Connector with Heat Shrink Cover

6.3 Securing and Sealing the Connector

The standard connector fitted to the sensor uses self aligning bayonet fitting to ensure the pins between the connectors are correctly aligned.

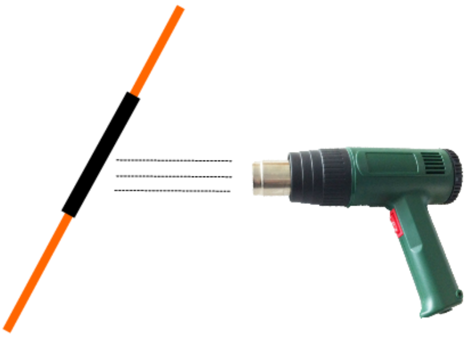


Figure 20 Heat Shrink Seal

1. Use the heat shrink cover supplied and insert it onto the sensor signal cable to one side of the connector that is to sealed

2. Join the two sensors together so they are daisy chained together. Secure the locking nut and ensure it is tight. The connector is now water tight.

3. Slide the seal cover over the connector so that the middle of the seal is exactly over the joined connectors.

4. Starting at the centre of the seal, use a heat gun and melt the heat shrink seal into place. Take care not to break the seal during the heating process.

5. The final result of a correctly installed seal is shown in Figure 19. A small amount of bonding glue should appear around the edge of the seal.

6.4 Sensor Standard Connector

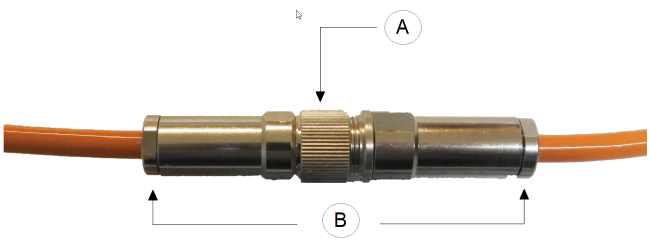


Figure 21 Locked Male / Female Connector Pair

A = Connector Locking Nut.

Secures the two halves of the connector pair together.

B = Connector Securing Nut

This nut secures the connector to the cable and forms part of the seal. Make sure this is fastened tightly before any sensor deployment.

7.0 Sensor Types

There are only 2 mechanical variations of the Keynes Control range of In-Place-Inclinometer sensors, See Figures 22 and 23 below.

The **bottom** sensor has only a single network connection coming out of the top of the sensor body. All other sensors have **'Dual'** network connection enabling the sensor to be daisy chained together.

The sensors are simply connected, one after the other until the desired number in the string is completed. Care should be taken to check that the O-ring seal, which forms the waterproofing is not damaged as the two halves of the connectors are secured together.

Bottom Type Sensor - Single Entry

Figure 22 Bottom Sensor

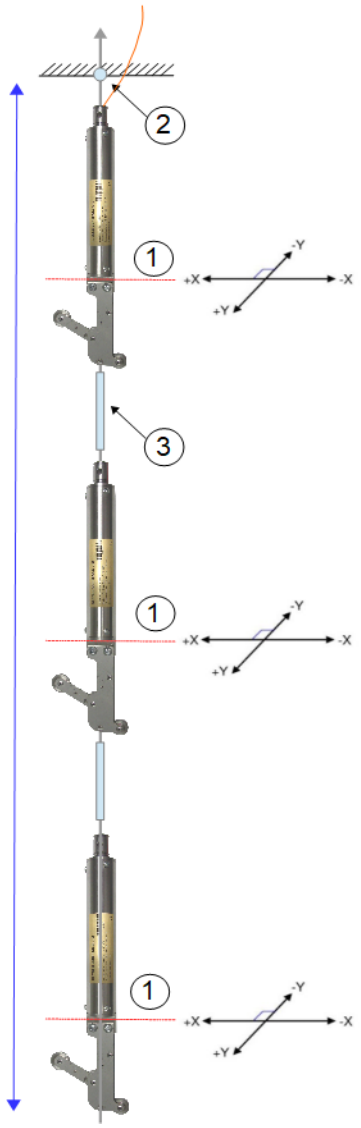
Network Type Sensor - Dual Entry

Figure 23 Standard Sensor

8.0 Axis alignment

In order to undertake a successful measurement all of the sensors have to be aligned in the same axis.The image below demonstrates how the sensors are deployed to ensure the measurement axis are all in the correct orientation.

All of the sensors have to be aligned on the same axis for the interpretation of the results to be correct.



1	Sensor Measurement Point
2	Fixed Datum Point
3	Spacer Bar

The sensor has a label defining the axis of operation.

Make sure that each sensor on the chain when assembled has all the sensors in the same alignment.

Failure to do so will cause a misunderstanding in the results

Figure 24 Sensor Chain showing a common sensor orientation for all instruments

8.1 Axis of Movement

Figure 25 below shows the most common types of casing used with the sensors. The wheel assembly grips the circular casing using the slots which prevent the sensor from turning. The wheel assembly sits into opposite corners of the rectangular casing.

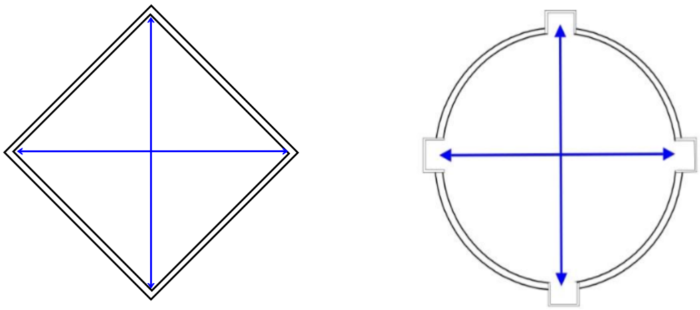


Figure 25 Common Casing Types

The orientation of the X-Y axis of movement for the sensor is purely defined by the way the device is fitted into the casing. Figure 26 shows the label fitted to the sensor case and shows the orientation of the axis inside the sensor. When reading data from the sensor it is the orientation shown on the label that defines axis operation.

Important Note - All sensors have to be deployed in the same axis in order for the measurements to be correctly understood.

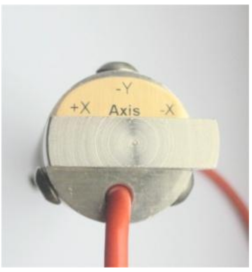


Figure 26 Sensor Orientation Label

.

Important Note: Take care to record the orientation of the sensors once they are mounted inside the casing. This information will be required to understand the movement of the sensors.

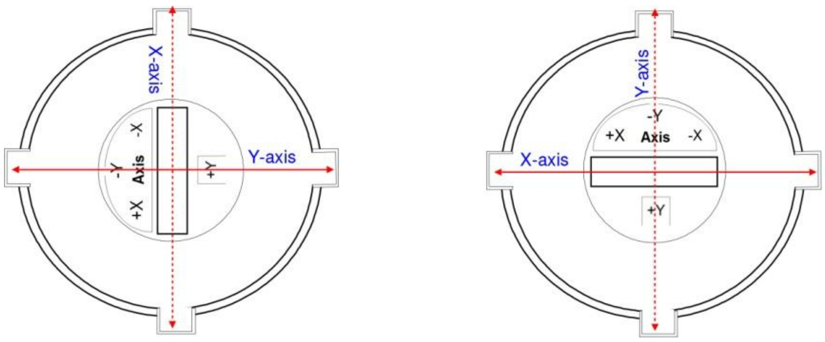


Figure 27 Sensor casing showing the different sensor orientation in a circular options

8.2 Securing the In Place Inclinometer Chain to the Casing

The sensor chain is secured to the casing using the Top Cap as shown in Figure 28. The sensor chain is suspended into place once the cap is placed on top of the casing. The weight of the sensor chain helps to secure the sensor into place. Unless specified, Keynes Controls assumes that the sensor chain is deployed on a steel wire sling directly from a spacer bar secured through the top cap.

1. Slide the mounting cap over the spacer bar until it is passed the hole for the securing bolts.

2. Fix into place the securing bolt and tighten.

The securing bolts are M6 x 70 mm.

3. Lower the top mounting cap into place on top of the casing tube.

Figure 28 Top Cap securing bolt

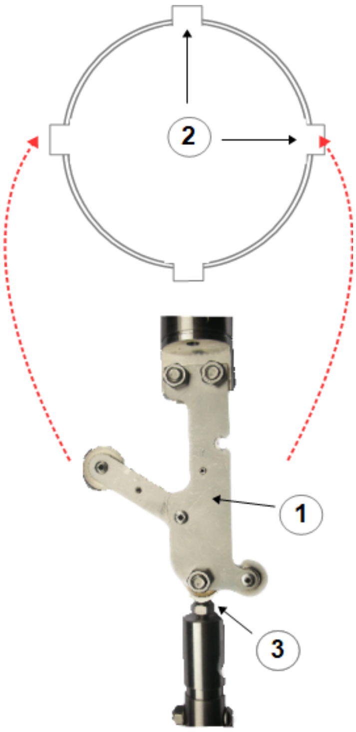


Figure 28A opposite demonstrates how the wheel assembly fits into a circular sensor casing.

The wheel assembly slides into the wheel guides, and the spring mechanism expands to grip the casing and secure the sensor into a stable position.

The wheel assembly just about to go into the wheel guide of a casing can be seen in the photo on Figure 46 on Page 34..

1	Wheel Assembly
2	Casing Wheel Guide
3	Universal Joint

Figure 28A Wheel Assembly alignment into a Circular Casing

8.3 Lowering the Inclinometer Sensor Chain into the Casing

Once the sensor chain is assembled and tested it can be lowered into the casing one sensor at a time. Make sure all the sensors on a chain have identical alignments.

Line up the wheel assembly with the groves in the casing and slowly lower the sensor chain into the casing. As each sensor is lowered into the casing fit the safety bar to hold the chain at the top cap. Make test measurements when possible to ensure all the sensors are operational before connecting to any remote data logging and reporting equipment.

Seal each connector with protective heat shrink sleeving to give added environmental protection to the connectors.

Use the Keynes Q-LOG software and media converter to test the completely assembled sensor chain before deploying on site.The sensors should all respond to the measurement commands issued across the network.

Take care when fitting the sensors into the casing that the chain is not dropped. Should the sensor chain be dropped to the bottom of the casing then it is likely to become damaged due to mechanical shock.

The Top Cap secures the spacer bar for the top sensor to the top of the casing.

Datum Position

Once the sensor chain is deployed then take a measurement from all of the sensors on the chain. The initial position will become the datum position, from where future measurements will be made.

The sensors should be left for a few hours to acclimatize to the environmental conditions and to settle mechanically.

9.0 Sensor Connectors

The sensors can be daisy chained together to form a network of sensors, or connected using a suitable media converter directly to a PC. The network is bi-directional and so either end of the sensor can be used.

Make sure the locking nut on each connector is secured tightly before adding additional sensors to a chain.

Connect to sensor  **Connect to Sensor**

Figure 29 Mated Sensor Connection

The daisy chain of sensors can be created using both the SDI-12 and RS-485 network devices.

Keynes Controls recommends that the RS-485 version devices be used for continuous submerged operations, and SDI-12 for stand-alone structural monitoring solutions.

For long term unattended submerged operations Keynes recommends that each sensor is wired individually to the surface.

9.1 Connector Pin-out

Figure 29 above shows the standard waterproof connectors are used on sensors shipped after June 2018.

Figure 30 Male Connector

Figure 31 Female Connector

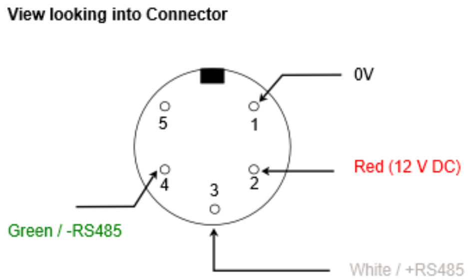


Figure 32 Tajimi Connector Pin-out

RS-485 Sensor Pin-out

1		0V / Gnd	**Core = Black**
2		+12 V DC	Core = Red
3		+RS485	Core = Green
4		-RS485	Core = white
5		N/A	

SDI-12 Sensor Pin-out

1		0V / Gnd	**Core = Black**
2		+12 V DC	Core = Red
3		SDI-12	**Core = Green**
4		N/A	
5		N/A	

10.0 Advice for Successful Measurement Operations

Once the sensor chain is deployed and before data acquisition operations are undertaken take care to:

1. Allow the sensors to settle to the standard operating temperature.
2. Wait for the sensor string to stop moving and to settle after lowering into the casing. Even small movements will be detected by the sensors.
3. Take an initial measurement from each sensor and use this point as the starting position for any future measurements.

All future measurements should be referenced from the starting datum position.

10.1 Advice for selecting the Sensor Chain Location

The main criteria for locating an inclinometer sensor, be that a sensor chain, or stand-alone sensors mounted on fixed brackets is that they are placed into a position away from sources of local vibration and have a fixed anchor position. Any local vibration will be detected by the sensors and can cause errors in any measurements.

Ensure that there is no movement at the datum position. This movement can be structural i.e. badly fitted or sited brackets, or due to local surface ground movements.

10.2 Power Supply Rating

For reliable long term operation Keynes Controls recommends that a power supply should have a minimum of 3 X over capacity for the number of sensors in operation.

1 X Sensor in scan mode = 12 mA   Therefore use 40 mA 12V DC Supply

so

6 X sensors on a chain = (6 X 12) X 3 = 300mA 12V DC supply

10.3 Wall Fastening

Figure 33 Wall Mounting Bracket and Concrete Wedge Bolts

Where possible use the concrete wedge bolts to secure the wall mounting bracket to a masonry structure. The bolts open into the mounting holes when they are being secured. The concrete bolts are readily available from many sources.

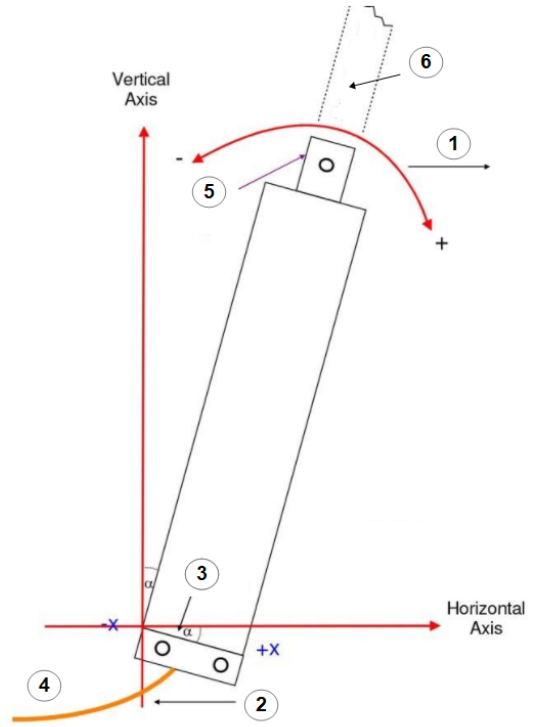
10.4 Sensor Deployment

Make sure the complete sensor assembly is mounted as solid as possible. Use locktite on the securing bolts to ensure they remain locked, this is especially important when the sensor is mounted on dynamic structures such as bridges and railway tunnels. The sensor is designed to detect static movement only.

11.0 Interpreting the Results

The following images demonstrate how the sensor tilt angles are interpreted depending upon how the sensor is mounted to the supporting brackets of gauge rods.

Vertical Sensor



1	+Ve displacement from the bottom.
2	-Ve displacement from the bottom
3	Angle of Movement
4	Sensor Network Cable
5	Sensor Top
6	Spacer Bar

Figure-27

α = Angular movement from the horizontal.

Total Horizontal Displacement

= C(m) . sin(α)

in SI Units mm/m

where C(m) = Total sensor length including spacer bar

Figure 35 Angle Polarity from Top Cap Vertical Sensor

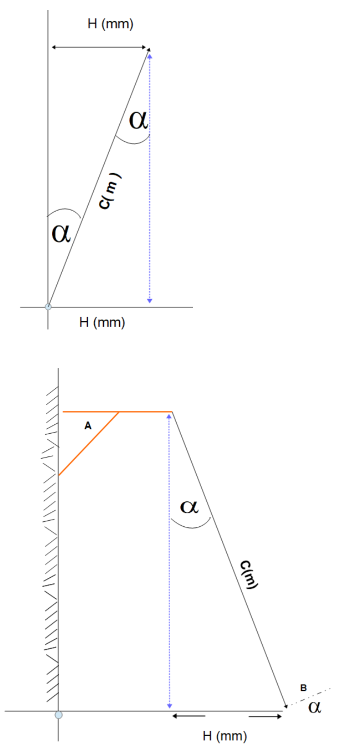


Figure 36 Total Horizontal Displacement

Sensor Displacement

When a sensor is deployed from a fixed position on a structure and is on the end of a spacer bar then

Total Horizontal Displacement (mm)

All calculations are in Radians**.**

where C(m) = Total sensor length (m)

The total horizontal movement

H(mm) = C(m) . sin(α)

The output from the sensor is in mm / m and is a very small angle then only the output value from the sensor is used.

H (mm) = C(m) . Sensor Reading

Example. A fixed sensor attached to an abutment wall extended to 2 m length using a spacer bar.

Displacement (mm) = 2 . Sensor Output

A = Wall Mounting
B = Sensor Measurement Point

The space bar is only used to enhance the sensor displ

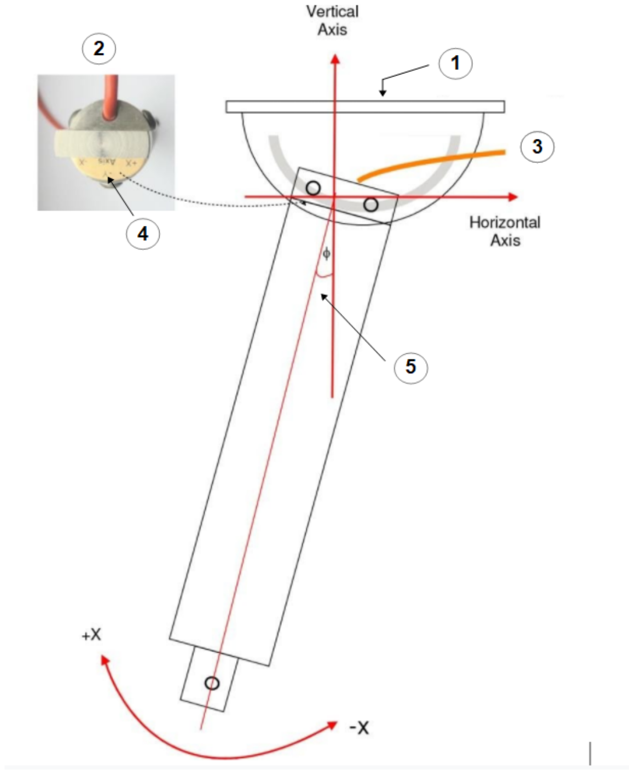


Figure 37 Ceiling Mounted Sensor

1	Ceiling Horizontal Support.
2	View looking at sensor mounting point..
3	Sensor Network Cable.
4	Sensor Label.
5	Angle of Movement.

Figure-28

Φ = Angular movement from the vertical.

USB Media Converter Part No

USB-SDI12-Pro SDI-12 network interface
USB-RS485-Pro RS485 network interface

Model USB-RS485-Pro

Device Driver Installation

All of the Keynes Controls USB media converters use the Microsoft accredited device driver which loads automatically into a Microsoft Windows operating system PC. The drivers install automatically so long as a suitable Internet connection is available.

Some versions of the operating system have this driver built in.

Figure 39 Media Converter Installation into a Windows PC.

12.0 Single Sensors or Interfaces Connection

Keynes Controls recommends the use of the circuit below to connect a single sensor or interface to the media converter. Keynes Controls manufactures and supplies 2 types of media interface. The USB-SDI-12-pro is used with SDI-12 type sensors. Model USB-RS485-Pro is used with RS-485 version type sensors.

Both the USB-485-pro and USB-SDI12-Pro devices isolate the sensors from the PC USB port and can directly power the sensors without any external power supply requirements. The ability to power sensors directly from the media converter depends upon how well the chosen port on the PC meets the USB operating specification. Some low cost devices do not power the USB port to the correct rated levels, and as such they may not supply enough power to the port. If there are problems powering a sensor from the media converter then try it again on another device.

The Keynes Controls media converters opto isolate the network from the PC USB port. Should a sensor fail, or cabling becomes damaged then the opto isolation will protect the USB port from damage. An automatic resetting fuse further protects the media converter in case of overload.

In practice the Keynes Controls media converters can power a number of sensors directly. Should the number of sensors required exceed the power limitations from the media converter directly, then an external power supply can be fitted to the external power port on the device. A self resetting fuse inside the media converter will prevent damage to the device in case of overload.

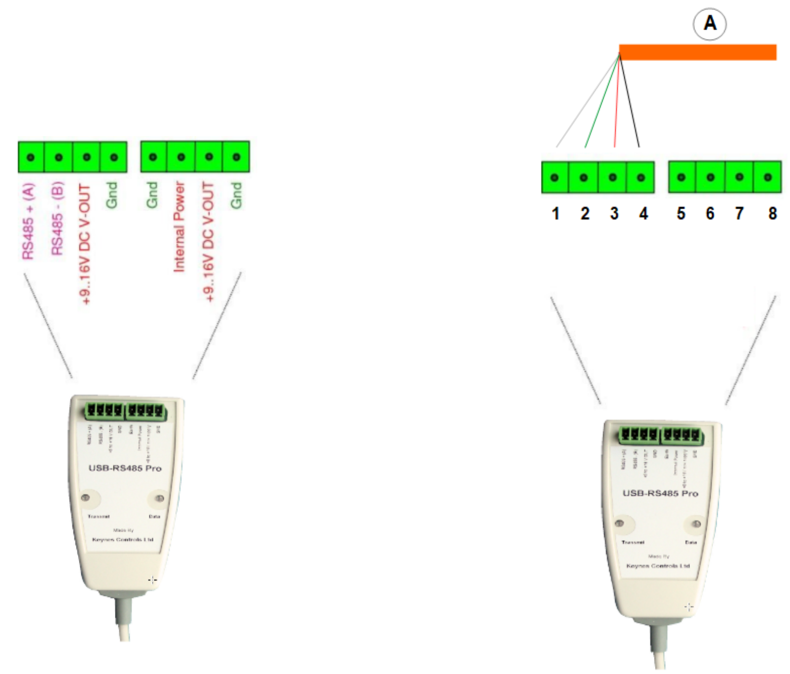
Network Cable Colour Code

All of the Keynes Controls intelligent sensors follow the same colour code.

RS-485 Version Sensor Cable Colour Code

Core		Media Converter Pin
Black	0V / Gnd	4
Red	+12 V DC	3
White	- RS485	2
Green	+ RS485	1

Figure 32 - USB-RS485-Pro Media Converter Connection



A = Sensor Network Cable.

SDI-12 Version Sensor Cable Colour Code

Keynes Controls use the following industry standard cable colour code for SDI-12 type sensors.

The SDI-12 network consists of only 3 wires. It is relatively slow in operation but is simple to install and operate.

Sensor cable Core		Media Converter Pin
Black	0V / Gnd	4
Red	+12 V DC	3
Green	SDI-12 Data	1
White	Not Used	

All of the media converter models use the same pin number representation.

13.0 Q-LOG Data Display Application

The SDI-12 and RS-485 type sensors are fully integrated into the free Q-LOG Data Acquisition and Display Software.

Install the Q-LOG Software and a suitable media converter onto a Windows PC. Use the '**Administrator**' mode when carrying out the software installation operation. All the examples in this document where a media converter is shown is based upon using the Keynes Controls devices. The Keynes media converters support 3rd party devices and are not limited to our product ranges.

Typical Q-Log Panel Meter Screen

Figure 42 below shows a typical panel meter display for showing sensor measurements. The Q-LOG software enables test measurements to be made before sensors are deployed onto 3rd party data loggers and acquisition systems. A terminal feature built into Q-LOG enables the User to observe the SDI12 or RS845 instructions operating across the network.

QLOG Application Software - A free Data Display and Configuration Software package for the Keynes Controls ranges intelligent SDI-12 and RS485 network sensors.

The Q-LOG software can be used to make test measurements, configuration changes and display results and is free to download.

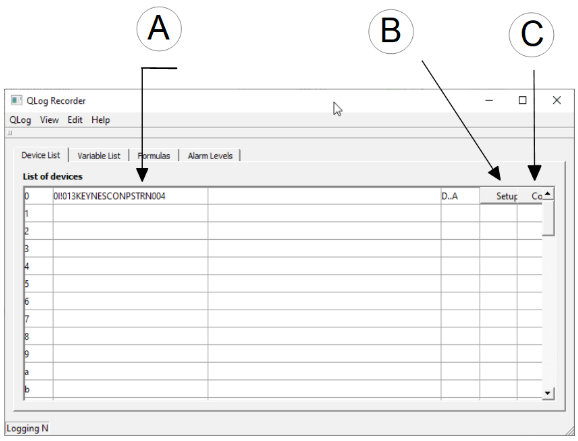


Figure 40 Q-LOG Main Window

A = Identifier String
B = Setup Button
C = Configure Button

Q-LOG is the free issue applications software supplied with this product. The software is used to Configure, make test measurements and display data.

1. Ensure the card is connected to a suitable media converter.
2. Set the COMM port used by the media converter into Q-LOG. Use the 'Config' Window.
3. Scan the network and identify the card.

Select the 'Device **Setup**' tab to select the card type. The Window shown in Figure 15 will appear.

Select the '**Config Tab**' and the Sensor Configuration Window shown in Figure 16 will appear

The '**Device Setup**' Window is used to

1. Assign the start location for the measurements in the results file. Figure 41 shows Cell D as the first location for the storage of values in the text results file.

2. The '**Configuration**' list gives the operations supported by the sensor. Currently this is limited to '**Single-axis**' or '**Dual-axis**'.

The Q-LOG software can be downloaded at:
http://keynes-controls.com/Download/QLogSetup50_21may2020.zip

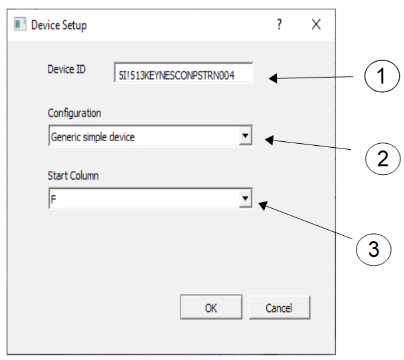


Figure 41 Q-LOG Device Configuration Window

1 - Device ID String
2 - Sensor Type Selection (Single, or Dual Axis)
3 - Cell start location for sensor results.

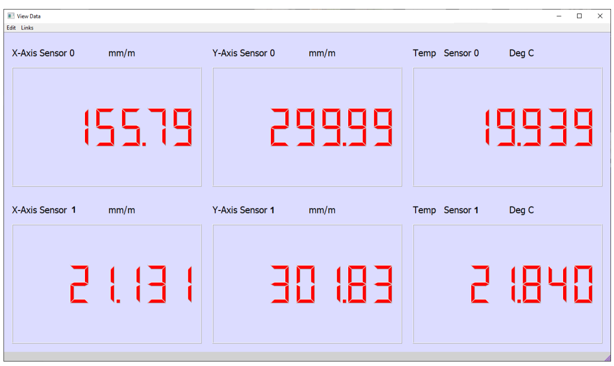


Figure 42 Typical Real-time Inclinometer Sensor Results Display

13.1 Real-time Display

The Q-LOG software provides a real-time display for the sensors. The values can be presented as a series of panel meters, or charts for individual parameters.

13.0 Cable Routing

Figure 43 below shows the cable routing for daisy chained sensors inside a vertical casing. The network cable passes through the gap in the Top Cap. The daisy chain network of the sensors is clearly shown.

Excess cabling is cable tied to the spacer bars. See Figures 45 and 46 for details.

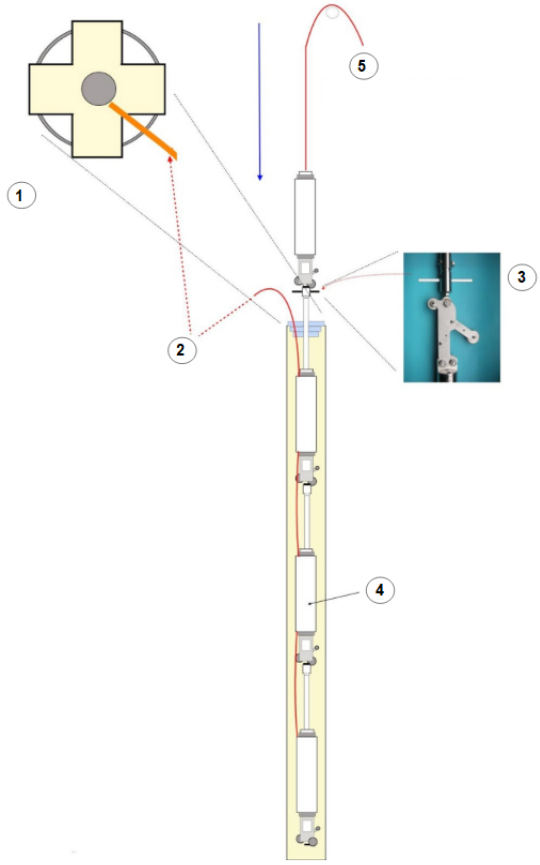


Figure 43 Cable Routing Guide & Safety bar installation

1	Casing Top Hat - Used to secure the sensor chain to the top of the casing..
2	Sensor Network Cable - SDI12 or RS485.
3	Safety bar. Used to prevent the sensor string from slipping into the casing - See Figure 27. when being fitted or under test.
4	In Place Inclinometer Sensor
5	Safety Wire - used to suspend the sensors from the Top cap

The photograph below shows the sensor cable coming out of the casing adjacent to the space in the top cap and the network cable is connected to a remote data logger.

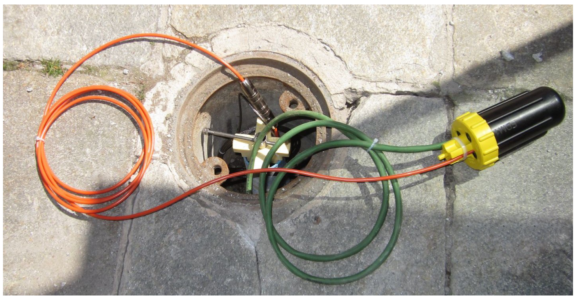


Figure 44 Sensor Wiring exiting the Casing

14.1 Securing the Network Cable.

For the applications where the sensors are deployed into a casing, be that vertical as shown in Figure 45 below, or any other layout where spacer bars are used to assign the distance between the instruments then it is important to secure the network cables originating from the sensors to the spacer bars. The securing of the cabling will prevent damage to the network in case the sensors are removed for maintenance, or the chain is modified to suit a new application.

1. **Excess Network Cable**

Secure the excess signal cable from the sensor to the closest spacer bar. Carefully wrap the excess cable around the bar and secure with a cable tie if possible,

Make sure that there is sufficient cable so the connector line-up between adjacent sensors.

2. **Secure the Connector**

Secure the connector halves together for adjacent sensors.

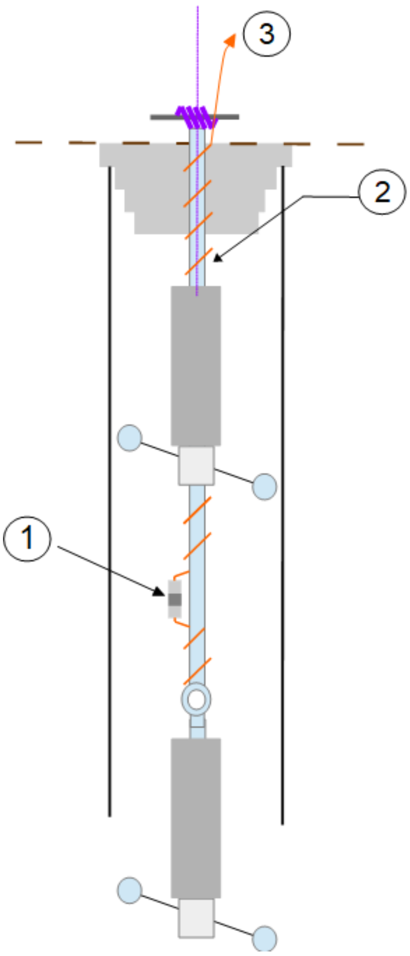
Make sure the securing nut is tightly fitted.

See Page 16 for further details. Cable-tie the excess cabling as necessary.

3. **Network Test**

Test the sensors as they are being deployed onto the chain and make any corrections as necessary. The Keynes Controls Q-LOG software can be used to make test measurements and display the results.

Testing is easily carried out using a USB media converter and a Windows laptop.



1. **Sensor Connector.**
2. **Spacer Bar**
3. **Network Cable**

Figure 45 Securing the Excess Wiring

Figure 46 above shows how the network cable is secured to a spacer bar as the network chain is lowered into the casing. The wheel assembly slides into the sensor alignment guide built into the casing.

14.2 Lowering the sensors into a Vertical Casing with a Wire Rope

Technical Note:

1. Layout the complete sensor string and connect all the sensors together.
2. Acquire measurements across the network and make sure all sensors are operational.
3. Check the connectors, both top and bottom, are clean and undamaged. Any damage should be reported to Keynes Controls immediately.
4. Make sure the sensor string location and addresses are noted before the devices are fitted into place.

Make sure the casing top cap is installed. See Figure 47 below..

Figure 47 Top Cap and Securing Bolt

Lower the sensors into the casing one sensor at a time.

Make sure the safety bar is in place as each individual sensor assembly is lowered into the casing, as this will prevent the sensor chain from dropping into the casing. There are holes in the spacer bars and bar-plugs to take the safety bar as the string is lowered into place.

The safety bar is useful when the chain is long and heavy to hold and It makes holding the chain while work is in progress easier than holding just the spacer bars.

Lower the sensor chain slowly into the casing. The wheel assembly fitted to the bottom of the sensor should grip the casing as the sensor is installed.

At any time that the deployment has to stop, slide the safety bar into the hole into the spacer bar..

Rest the entire mechanical assembly onto the top plug. This action will prevent the sensors from sliding into the casing.

Easy Assembly and Deployment

The Keynes Controls sensors can be shipped pre-assembled, Pre-configure, complete with wheel assembly and spacer bars fitted. Contact Us for further information

In-Place Sensor Testing

Once the sensor chain has been lowered into place carefully test that each sensor is operating correctly.

The easiest way to test the chain is to use the optional USB-media converter to connect the sensor chain to a Windows laptop. The Keynes Controls free Q-LOG software can be used to scan the network nas show sensor data.

As a rule of thumb. The temperature values returned from the sensors should be similar but will not be exactly the same. This is the case when all of the sensors are in air, or when submerged. When the sensors are deployed underground and there are few degrees difference between the top and bottom sensors then this is a good indication that there is water inside the casing.

Leave the sensor chain for a few hours to settle for a fews hours in operation before using the results in a measurement system.

14.3 Sensors Deployed Using Steel Wire Sling

Figure 48 below demonstrates how to deploy a sensor below the Top Cap into a vertical casing. The steel wire sling is used when the first sensor in a chain is to be deployed greater than 4 m below the casing Top Cap.

Follow the detailed installation instructions on page 31.

The wire rope should be terminated to a bar plug. The bar plug is secured through the centre of the Top Cap used to align the instruments into the casing. The Top Wheel assembly is connected to the spacer rod to the top sensor, this ensures the Inclinometer chain is correctly aligned into the casing. The bar plug can be seen on Figure 15..

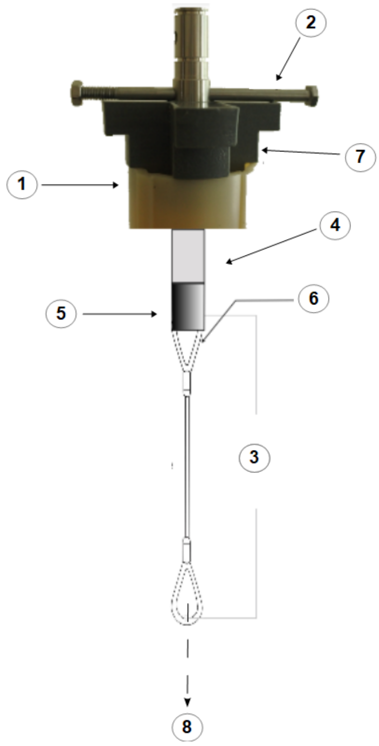


Figure 48

14.4 Top Cap and Steel Rope Sling

1		Sensor Casing.
2		M6 X 76 mm safety bolt.
3		Steel Wire Reach -
4		Spacer Bar.
5		M 6 mounting point.
6		2.5 mm Stainless Steel Sling.
7		Top Cap.
8		Suspended sensor chain.

Important Note

The 2.5 mm wire rope has a breaking strength in excess of ½ metric tonne, and is easily capable of supporting the maximum number of sensors allowed on a single network.

The sensors are daisy chained together during the installation. The bottom sensor has a single connection only and is used to terminate the network.

A double wheel assembly is used to connect sensors to the steel wire sling and secure them into the correct location inside a casing.

Double Wheel Assembly

Part No: IPI-DB-WHEEL-ASM

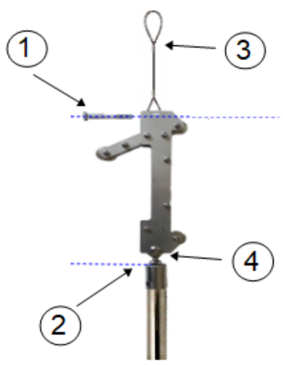


Figure 49 Sensor Connection to a Steel Wire Sling

14.2 Fastening a Sensor to Steel Rope Sling

Figure 49 opposite shows the parts used to suspend a sensor from the bottom of the stainless steel sling.

1		M6 x 25 mm securing bolt
2		Bar Plug and Universal Joint
3		Stainless Steel Wire Sling
4		Spacer Bar Mounting Point

14.4 Steel Sling Sensor Deployment directly from the Casing Top Cap

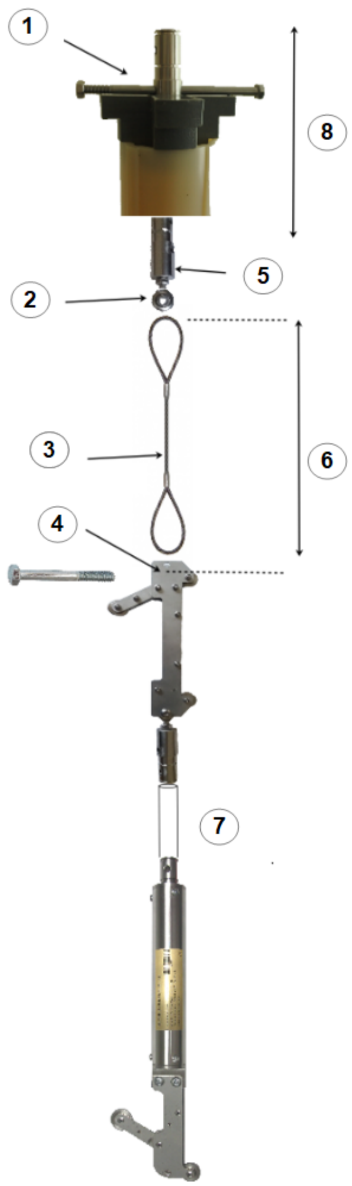


Figure 50 Stainless Steel Sling Sensor Deployment

Description

Figure 50 demonstrates the mechanical sensor chain configuration for deploying sensors from a stainless steel sling suspended directly from the casing Top Cap.

This configuration enables the sensor chain to be accurately lowered to a pre-set depth which can be of length greater than the standard steel spacer bars. The measurement depth can be a considerable way down a casing.

1		Securing Bolt
2		Securing Islet
3		2.5 mm Steel Wire sling
4		Securing Point
5		Bar Plug
6		Wire Sling distance in cm
7		Spacer Bar
8		Spacer Bar distance from the Top Cap in cm..

1. Assemble the sensor chain that is to be deployed
 - make sure the sensors are correctly aligned.

2. Fit the bar plug and Universal joint to the bottom of the spacer bar (5). A closeup photograph of the bar plug and universal joint can be seen in Figure 14 on Page 15.

3. Secure the stainless steel sling (3) to the eyelet of the universal joint.

4. Secure the other end of the stainless steel sling to the double wheel assembly, see item 4 in image opposite. The steel sling is secured with a M6 bolt and locking nut. Use loctite to secure the nut if required

5. The top section of the Inclinometer chain is now assembled and is ready for deployment.

Securing the Sensor to the bottom of Double Wheel Assembly

Make sure that the sensor chain that is to be attached below the steel wire sling has been assembled, tested and installed into the casing. The top sensor in the chain should be secured into place with the spacer safety bar attached.

6. Mechanically secure the spacer bar connected to the first sensor in the chain into the bottom of the double wheel assembly. This should be undertaken by sliding the universal joint attached to the spacer bar into wheel assembly, as shown in Figure 43 above.

7. Lower the sensor chain into the casing. Make sure the safety bar is inserted into the top spacer bar to prevent the sensor chain from being dropped into the casing. A 6mm hole at the midpoint of the bar is fitted for this operation. Connect each sensor to the network and secure the excess cable to the spacer bar. Cable ties are ideal for this.

8. Cover each sensor connection with the heat shrink cover and seal with a heat gun. Make sure that some of the bonding glue is observed at the edge of the seal after heating. See Figure 19.

9. Secure the double wheel assembly to the eyelet of the universal joint fastened into the top sensor spacer bar on the chain.

10. Lower the completed assembly into place and secure to the Top Cap.
11.

15.0 Physical Dimensions

1. Rod End Bearing
2. Spacing = 23 mm

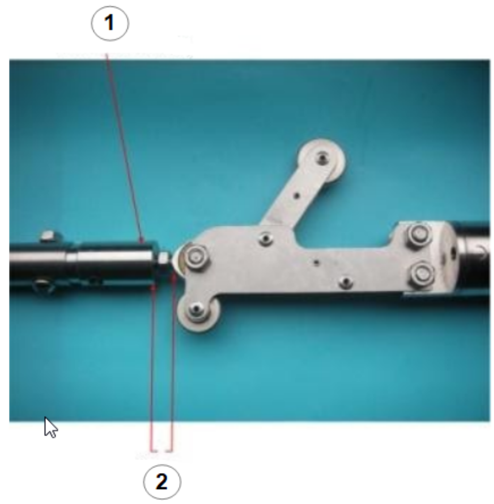


Figure 51 Rod end Bearing Spacing

Rod end bearing gap to the wheel assembly is set to 23 mm

Measure the distance using a ruler and lock the distance with the nut.

15.1 Spacer Bars

The sensor bars are supplied with all mounting bolts and with a factory pre-set rod end bearing attached. Apart from bolting the spacer bar to the In-place-inclinometer, no other mechanical assembly will be required. The standard spacer bar lengths are 0.5, 1 and 2 m.

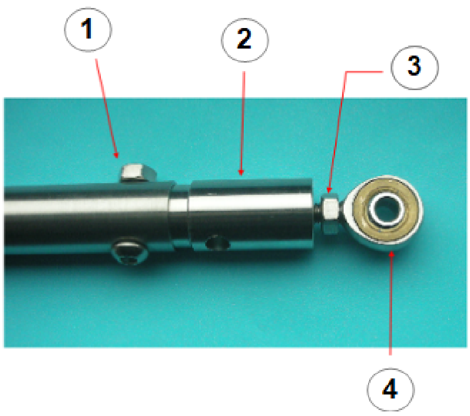


Figure 52 Spacer Bar Components

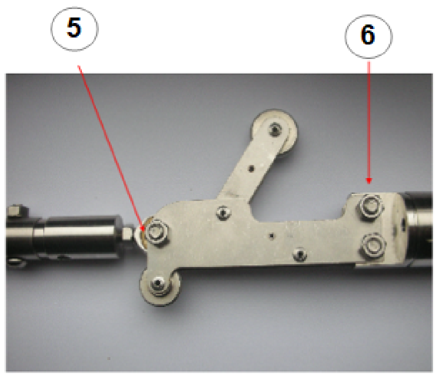


Figure 53 Wheel Assembly Fastenings

	Spacer Bar Fastening Dimensions
1	Bar plug securing bolt - M6 x 25 mm
2	Bar Plug
3	Universal Joint Locking Nut
4	Rod End Bearing Universal Joint

	Wheel Fastening Dimensions
5	M6 x 25 mm Stainless Steel Bolts
6	M6 x 18 mm Stainless Steel Bolts

15.2 Dimensions for 3 m Vertical Inclinometer Sensor String

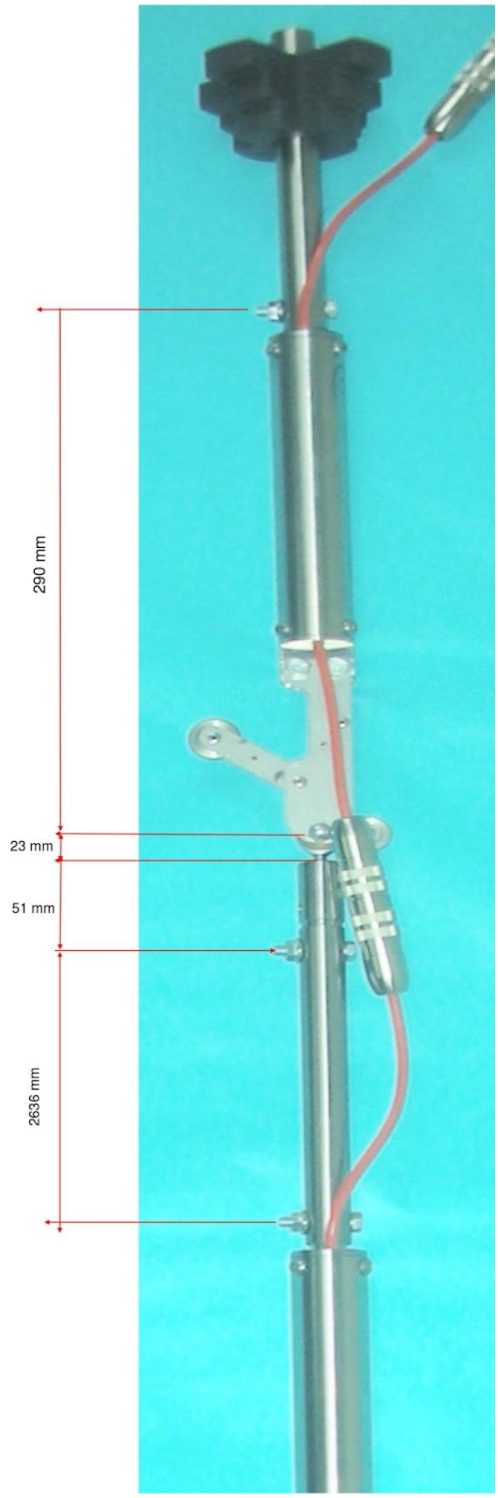
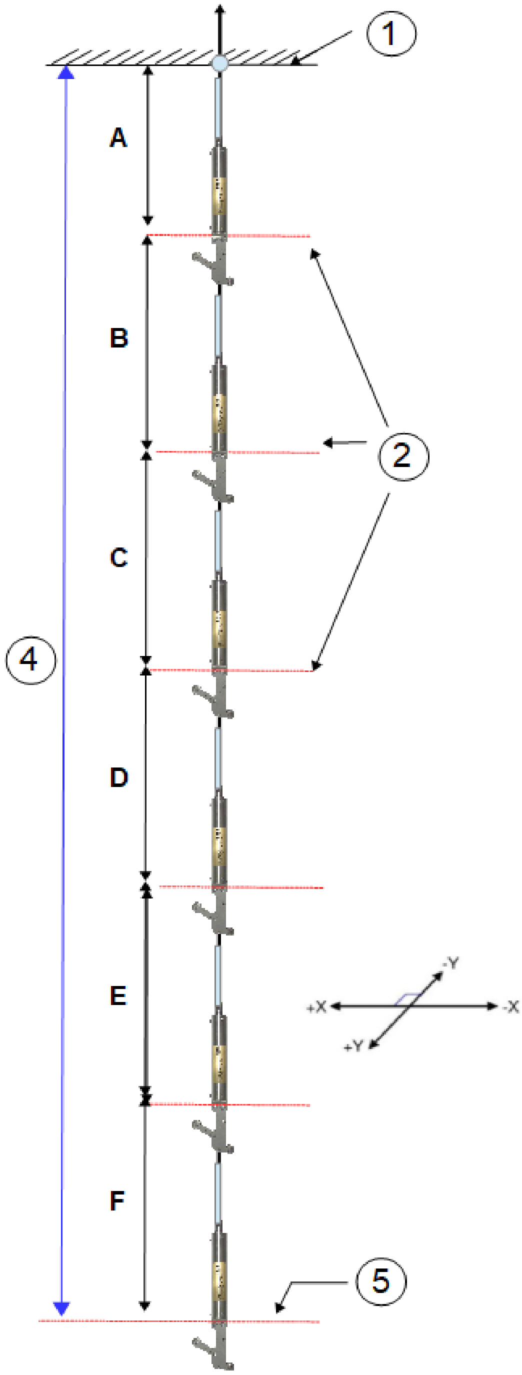


Figure 54 Sample Dimensions for 3 m Vertical Sensor Chain

Vertical Inclinometer Build Record Form - 1 to 10 sensors



1 = **Fixed Datum Point.**
2 = **Sensor Measurement Point.**
4 = **Total Sensor String length.**
5 = **Bottom sensor Measurement.**

Job Details

Job No:	
Client:	
PO Number / Quote	
Issue Date	
Sheet __ of __	1 of
Sensor Type / Part No :	
Network Type :	
Wheel Assembly Size (mm)	
No of Sensors	
Casing Diameter	
Total String Length (m)	

Fill in all items on the list:

Sensor Details:

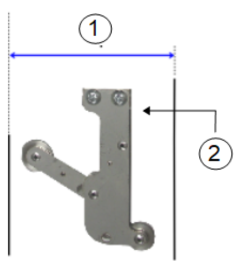
Top Cap: YES/ No :

Sensor	**Spacing**	**Wheel Joint Type**	**Cable Length(m)**
1	A (m) =		
2	B (m) =		
3	C (m) =		
4	D (m) =		
5	E (m) =		
6	F (m) =		
7	G (m) =		
8	H (m) =		
9	I (m) =		
10	J (m) =		

Distances are between measurement points as shown on the plan.
Wheel Assembly Joint - Options for **Fixed** or **Universal.**

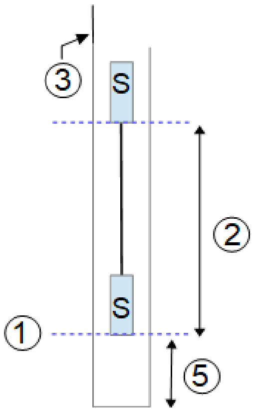
Wheel Assembly Size

Select the wheel assembly size to match the internal diameter of the casing.



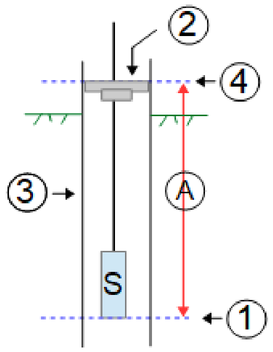
1. Sensor Casing Diameter
2. Standard Wheel Assembly options - 62 - 80 mm

Bottom Sensor Section



Make sure there is a gap below the final sensor and casing.The in chain is to be mechanically suspended from the top cap.

Top Sensor Section



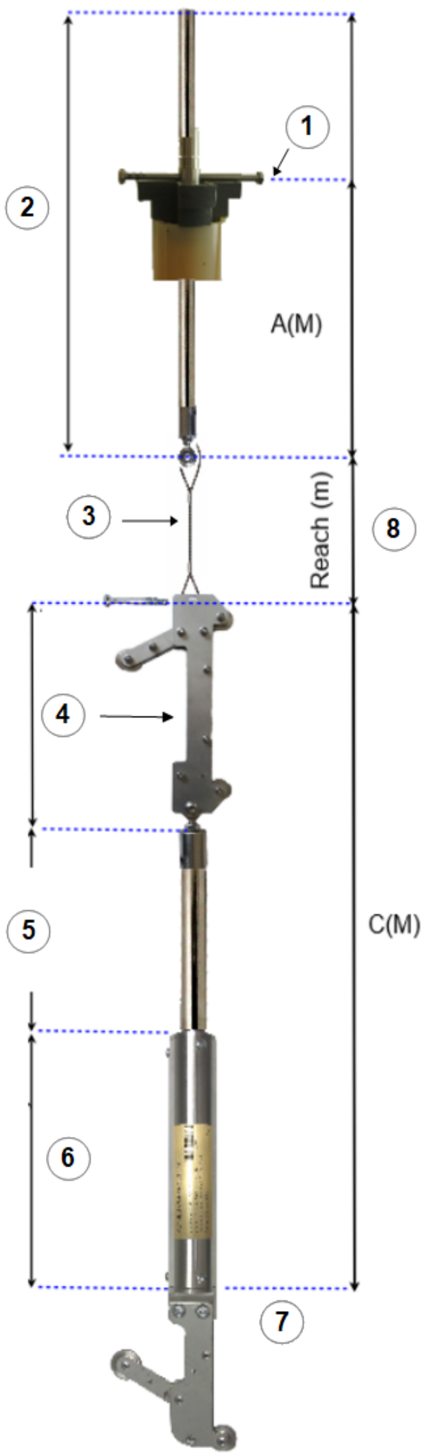
The outcrop of the spacer bar above the top cap is typically 30 cm. Fit the securing bolt through the top section bar.

S	Sensor	1	Sensor Measurement Point	2	Casing Top Cap
3	Casing	4	Datum Reference Point	5	Space below bottom sensor

Setup Instructions
Sensor Labelling Instruction

Top Sensor Suspended from a Steel Wire

Vertical Inclinometer Chain Build Record Form - Top Sensor suspended from a Steel Wire



Job Details

Job No:	
Client:	
PO Number / Quote	
Issue Date	
Sheet __ of __	1 of
Sensor Type / Part No :	
Network Type :	
Wheel Assembly Size (mm)	52 - 72 mm
Depth first sensor below the Top cap.	cm
Casing Diameter	
Total String Length (m)	
Spacer bar length above the Top cap.	cm
Spacer bar length A(M)	cm

Definition

Unless specified, Keyes Controls assumes that the sensor chain is deployed on a steel wire directly from a spacer bar secured through the top cap.

Physical length

Basic Sensor Length = Wheel Assembly + Body + Top Plug
= 29.3 cm: .

Typically this is the total distance between the connection point on the wheel assembly to the measuring point on the sensor body..

1	Top Datum level
2	Total Top Spacer bar Length - cm / mm
3	Steel suspension wire
4	Double Wheel Assembly - 20 cm / 200 mm
5	Spacer bar 1 / 2 /3 m (Standard)
6	Sensor Body = 16.5 cm / 165 mm
7	Sensor Measurement Position
8	Length of the steel suspension wire - Reach

The parameter **C(m)** shown in the image opposite shows what is meant as the total sensor length when the first sensor in the chain is deployed using a steel sling

Top Spacer Bar length = Spacer Bar + Bar Plug + Eyelet
Height above cap = 0.30 m (Standard)

Top Sensor Depth

The total length of the spacing for the top sensor, from the datum point at the top cap to the measurement point on the sensor is made up of dimensions:

Top Sensor Depth (m) = A(cm) + Reach (cm) + C(cm)

= cm

When ordering this give the total distance from the Top Cap to the measurement point on the Inclinometer Sensor Chain..

Additional Instructions
Labelling Instructions

Contact Details:

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