EL Tiltmeter

Standard & SC Versions
56802199 56802099

This equipment should be installed, maintained, and operated by technically qualified personnel. Any errors or omissions in data, or the interpretation of data, are not the responsibility of Slope Indicator Company. The information herein is subject to change without notification.

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Introduction

Tiltmeter Applications

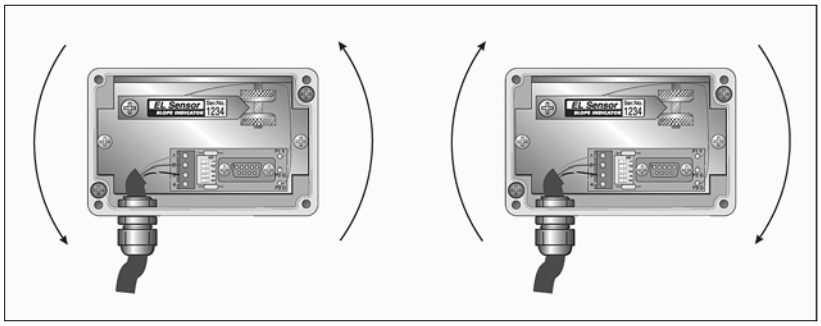
The EL tiltmeter is a narrow angle, high resolution device for monitoring changes in the inclination of a structure. Applications for the tiltmeter include:

- Monitoring the rotation of retaining walls, piers, and piles.
- Monitoring the behavior of structures under load.

Operation

The tiltmeter consists of an electrolytic tilt sensor housed in a compact, weatherproof enclosure. The tilt sensor is a precision bubble-level that is sensed electrically as a resistance bridge. The bridge circuit outputs a voltage proportional to the tilt of the sensor.

After the housing is fixed to the structure, the sensor is adjusted to its zero point, and then the initial reading (near zero) is recorded. Changes in inclination are found by comparing the current reading to the initial reading.

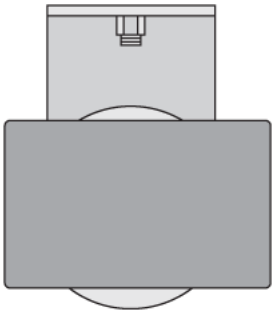


A positive change in tilt indicates counter clockwise rotation.

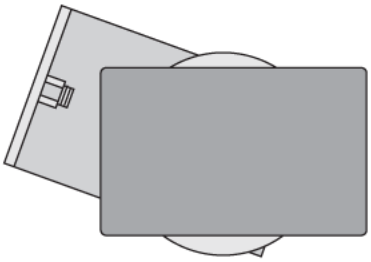
A negative change in tilt indicates clockwise rotation.

Mounting the Tiltmeter

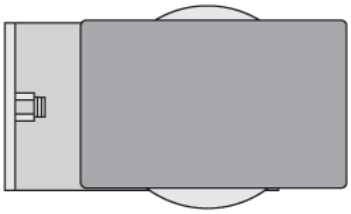
The tiltmeter can be mounted on various surfaces.



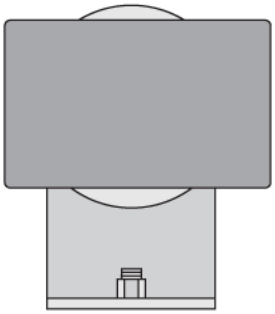
Swivel bracket fixed to a ceiling with one anchor



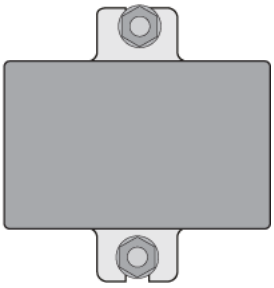
Swivel bracket fixed to a non-vertical surface with one anchor.



Swivel bracket fixed to a wall or pillar with one anchor.



Swivel bracket fixed to a floor with one anchor.



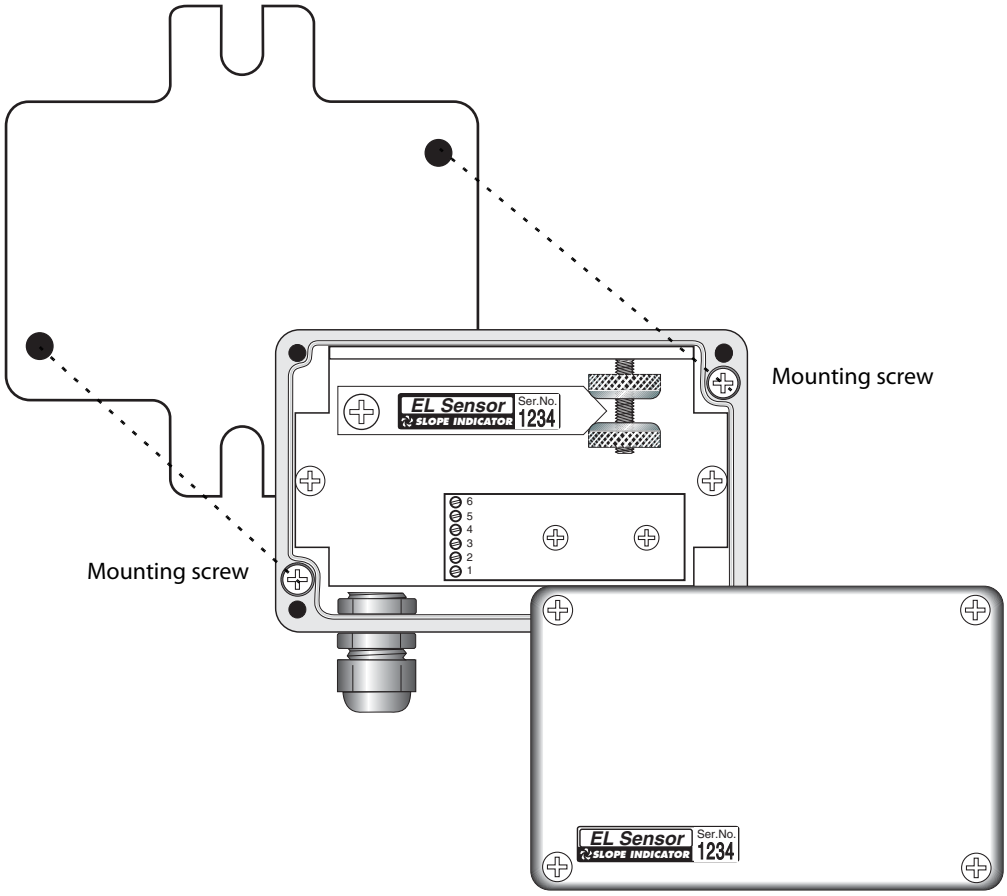
Flat bracket fixed to a wall or pillar with two anchors.

Installing Anchors

1. Mark locations for anchors. The swivel bracket requires one anchor. The flat bracket requires two anchors.
2. Drill anchor holes in structure deep enough to embed about 50mm of anchor. Remove debris.
3. Mix epoxy grout as directed by manufacturer. Fill holes with grout, then insert anchors.

Attaching the Tiltmeter

- Swivel bracket: Place the swivel bracket onto the anchor. Check that sides of the tiltmeter are vertical. If necessary, bend the bracket.
- Flat bracket: Remove the flat bracket from the tiltmeter, if necessary. Place the bracket onto the anchors. Check that the sides of the bracket are as vertical as possible. Then screw the tiltmeter back onto the bracket.
- With either bracket, tighten the tiltmeter against the bracket. The drawing below shows the flat bracket, but the same screws are used with either bracket.



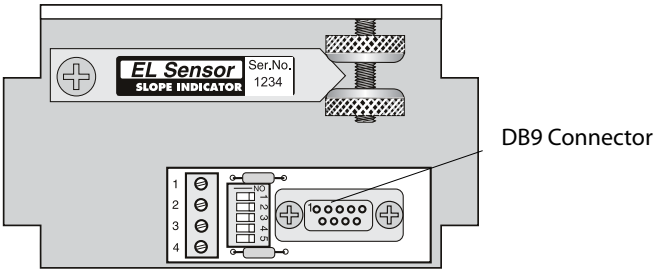
Zero-Adjusting Standard Sensors

Introduction

The EL tilt sensor has a very narrow range, so it must be adjusted so that its initial output is as close as possible to null. This makes the full tilt range of the sensor available.

The standard terminal board has a DB9 connector for connecting a zeroing device. .

EL tilt sensor with standard terminal board



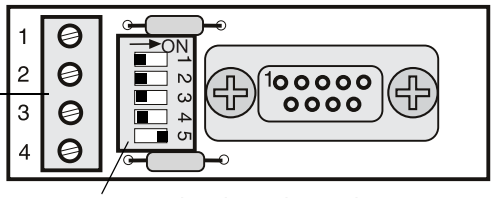
Overview of Zeroing

1. Connecting signal cable to the sensor. The sensor is very sensitive to even small movements, so it is best to connect signal cable to it before you attempt to zero the sensor. Otherwise, you may have to zero the sensor again after the signal cable is connected.
2. Zero the sensor using the EL Zeroing Device, the DataMate MP, or the EL-35 (a retired zeroing device).

Connecting Signal Cable

1. Remove cover of sensor housing.
2. While you connect signal cable, set switches 1 through 4 to the OFF position.

There are four screw terminals for connecting signal cable. Typically, only three are used.



Set switch 1 through 4 to the Off position - away from the DB9 connector.

3. Connect signal cable as shown in the table below:

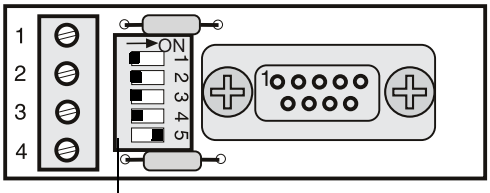
Standard Terminal	Cable 50612804	Function
1	White	AC Excitation
2	not used	
3	Green	AC Output
4	Red	Analog Ground
	Drain	Not connected to sensor

After connecting the signal cable, secure it to the wall or floor so that it will not cause the sensor to move. Note that any testing of the signal cable should be performed with switches 1 through 4 in the "Off" position. This prevents cable-test operations from damaging the sensor.

Zeroing the Sensor

Use the EL Zeroing Device or a DataMate MP to zero the sensor. Instructions appear on following

1. Remove cover and set switches on terminal board. Switches 1 through 4 should be OFF. Switch 5 should be ON.

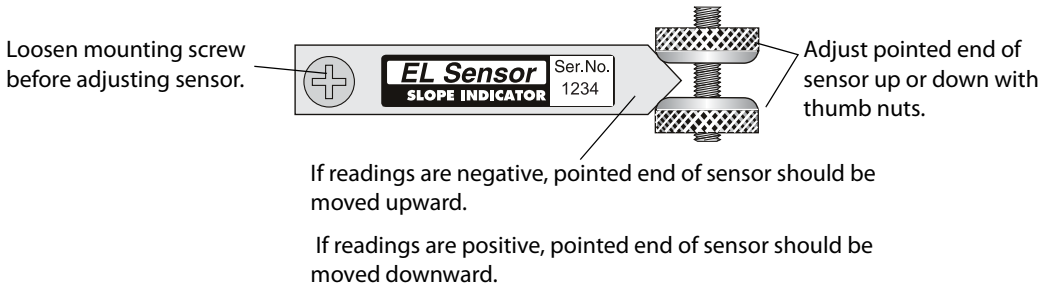


Set switch 1 through 4 to the Off position.
Set switch 5 to the On position.

2. Connect the EL zeroing device or DataMate MP to the DB9 socket on sensor board and switch on.

   If you are using a DataMate MP, use adapter #57710958 to connect to the DB9 socket. Then choose EL 35 RO from the manual mode sensor list. If you do not have the DB9 adapter, you can connect using the bare wire adapter, but you must set the switches differently. See note below.

3. Adjust sensor to zero tilt: Loosen sensor mounting screw and the two thumb nuts to allow adjustment of tilt sensor. Use the thumb nuts to adjust the sensor up or down. With the zeroing device, the object is to light the middle LED. With a DataMate MP, the object is to get the reading as close to zero as possible.



4. Turn thumb nuts until both are in contact with the sensor, then gently tighten the mounting screw. Finger tight is good enough. Over-tightening can cause the reading to change and stress the sensor.

5. Check that the sensor is still zeroed, then switch off and gently disconnect the zeroing device. Make a note of sensor location and serial number.

6. Apply thread-locking compound to prevent screw and nuts from turning. Note that you may need to adjust sensor again later, so do not use a permanent compound.

7. Finally, carefully reset the switches so that switches 1, 3, and 4 are ON and switches 2 and 5 are OFF.

Note: Using the DataMate MP Bare-Wire Adapter for Zeroing

1. Set all switches to the ON position.

2. Connect the bare wire adapter as follows:

Bare Wire Adapter	SC Terminal Board
5	1
2	2
1	3
6	4

Reading Standard Sensors

Data Logging

EL tilt sensors with the standard terminal board are calibrated with the CR10X data logger and factors on the calibration sheet apply only to CR10X readings. For this reason, the instructions below are for use of the CR10X.

CR10X Instructions

Use the P78 and P5 instructions for single ended channels.

P78 (Resolution)

- High Resolution

P5 (AC Half Bridge)

- 2500 mV Fast Range
- 2500 mV Excitation
- Multiplier (10)

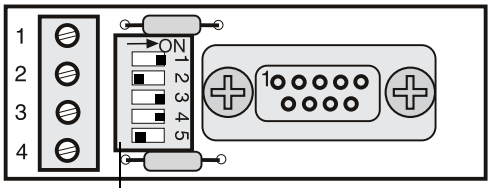
Wiring for CR10X

The exact wiring for the CR10X depends on your program and whether you use multiplexers or not. A generic connection is shown in the table below. You can download a sample monitoring program from www.slopeindicator.com. Go to Support - Technotes- Data Loggers. Then find a link for sample programs.

CR10 Terminals	Wire Color 50612804	Sensor Terminal	Function
E	White	1	AC Excitation
		2	Not Used
H or L	Green	3	AC output
AG	Red	4	Analog Ground
G	Drain	Drain wire not connected to sensor	

Setting Switches for CR10X

1. Set the switches as shown below.

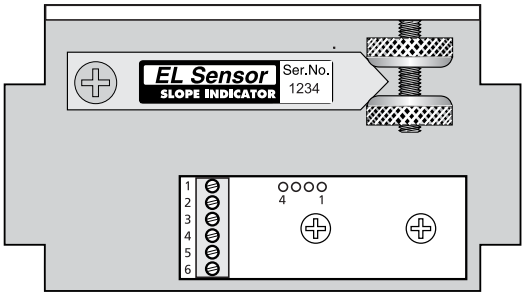


Switches 1, 3, and 4 are ON.
Switches 2 and 5 are OFF

Zero Adjusting SC Sensors

Introduction

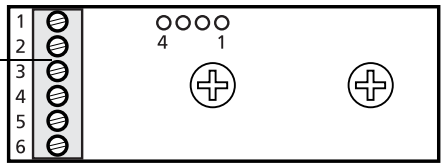
Because the EL tilt sensor has a very narrow range, it must be adjusted so that its initial output is as close as possible to null. This makes the full range of the sensor available. Connect signal cable to the tiltmeter before zeroing it.



EL tilt sensor with the SC terminal board.

Connecting Signal Cable

The drawing shows the SC terminal board. Connect signal cables as shown in the table below. After connecting the signal cable, secure it to the wall or floor so that it will not cause the sensor to move



There are six screw terminals for connecting signal cable.

SC Terminal Board	Cable 50613527	Function
1	Green	+ Power
2	Black	- Power
3	Orange	Tilt
4	Yellow	Signal Common
5	Red	Temperature
6	Violet	Sense

Connecting an EL Data Recorder

1. Connect signal cable to the readout as shown in the table below.
2. Switch on. Choose uniaxial sensor. Tilt is displayed in volts. Temperature is displayed in degrees C.

Data Recorder Terminal	Signal Cable Wire	SC Terminal Board
1 Tilt A	Orange	3
2		
3 Temp	Red	5
4 Sig Common	Yellow	4
5 Sense	Violet	6
6 Power +	Green	1
7 Power -	Black	2
8 Shield	Drain Wire	

Connecting a DataMate MP

DataMate MP must have firmware version 05/01/02 AA or later.

1. Connect signal cable to the bare wire adapter, as shown in table below.
2. Switch on. Choose Manual mode. Choose EL SC RO. "A-axis" tilt is displayed in volts. Ignore "B-axis" value. Temperature is displayed in degrees C.

Bare Wire Adapter	7-Wire Cable	SC Board	Function
1	Orange	3	Tilt
2	Yellow	4	Signal Common
5	Red	5	Temperature
6	Black	2	Power -
	Violet	6	Sense
7	(Yellow)	4	Signal Common
8	Green	1	Power +
Use a jumper wire to connect terminals 2 and 7 of the bare-wire adapter. Black and violet wires are both connected to terminal 6.			

Connecting a Voltmeter

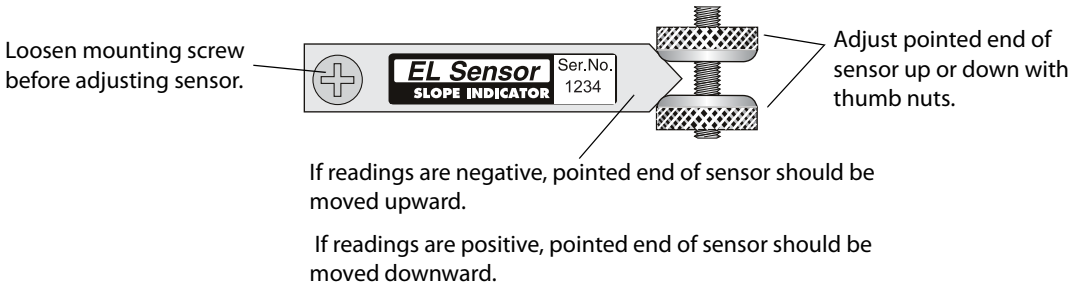
In addition to a voltmeter, you must have a power source, such as a 9-volt battery to supply between 7.5 and 14 Vdc to the sensor. Clips colors may vary.

Sensor Board	Cable 50613527	Battery & Voltmeter	Function
1	Green	+ (Batt)	+ Power
2	Black	- (Batt)	- Power
6	Violet		
3	Orange	+ DC (VM)	Tilt
4	Yellow	Common (VM)	Signal Common

1. Set the voltmeter to DC and set it for about 5 volts. Adjust the sensor until the voltmeter shows zero.
2. Then switch to the 1 volt range for fine-tuning, and adjust the sensor more until it again shows zero.

Adjusting Zero

1. Connect a readout to the signal cable. You can use the EL Data Recorder, the DataMate MP, or as a last resort, a voltmeter. Instructions appear below.
2. Adjust sensor to zero tilt: Loosen sensor mounting screw and thumbscrews to allow adjustment of tilt sensor. Use thumb nuts to adjust sensor up or down according to the sign (+ or -) of the reading. The object is to get the reading as close to zero as possible.



3. Turn thumb nuts until both are in contact with the sensor, then gently tighten the mounting screw. Finger tight is good enough, since you will use thread-locking compound.
4. Check that reading is still zeroed, then disconnect the readout. Make a note of sensor location and serial number and replace the cover.
5. Apply thread-locking compound to prevent screw and nuts from turning.

Reading SC Sensors

Introduction

You can read an EL SC sensor with an EL Data Recorder, a DataMate MP, a precision voltmeter, or a data logger.

Manual Readings EL Data Recorder

1. Connect the readout to the sensor as described in the previous chapter.
2. Obtain the reading and write it down or record it.
3. Later, apply calibration factors to convert the reading in volts to engineering units, as described in the chapter on Data Reduction.

   Additional information about the EL Data Recorder or DataMate MP can be found on Slope Indicator's website. Go to www.slopeindicator.com. Click on Support, then click on Technotes. Find the Readout section and click on the link for EL Data Recorder or DataMate MP.

Voltmeter

Reading with a voltmeter requires a power source, such as a 9-volt battery, to supply between 7.5 and 14 Vdc to the sensor. The table below shows possible clip colors.

Sensor Board	Cable 50613527	Batt & Voltmeter	Function
1	Green	+ (Batt)	+ Power
2	Black	- (Batt)	- Power
6	Violet		
3	Orange	+ DC (VM)	Tilt
4	Yellow	Common (VM)	Signal Common

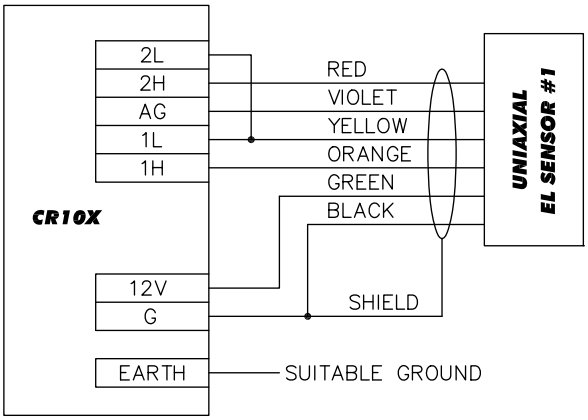
1. Set the voltmeter to DC to measure at a narrow range, for example, the 1 volt range. The right-most digit might be unstable, but other digits should be stable.

Data Logging

Below are wiring diagrams for connecting SC sensors to a Campbell Scientific CR10X data logger. You can download a sample monitoring program from Slope Indicator's website. Go to www.slopeindicator.com - support - tech notes. Look at the data logger technotes to find a link for sample programs that you can download.

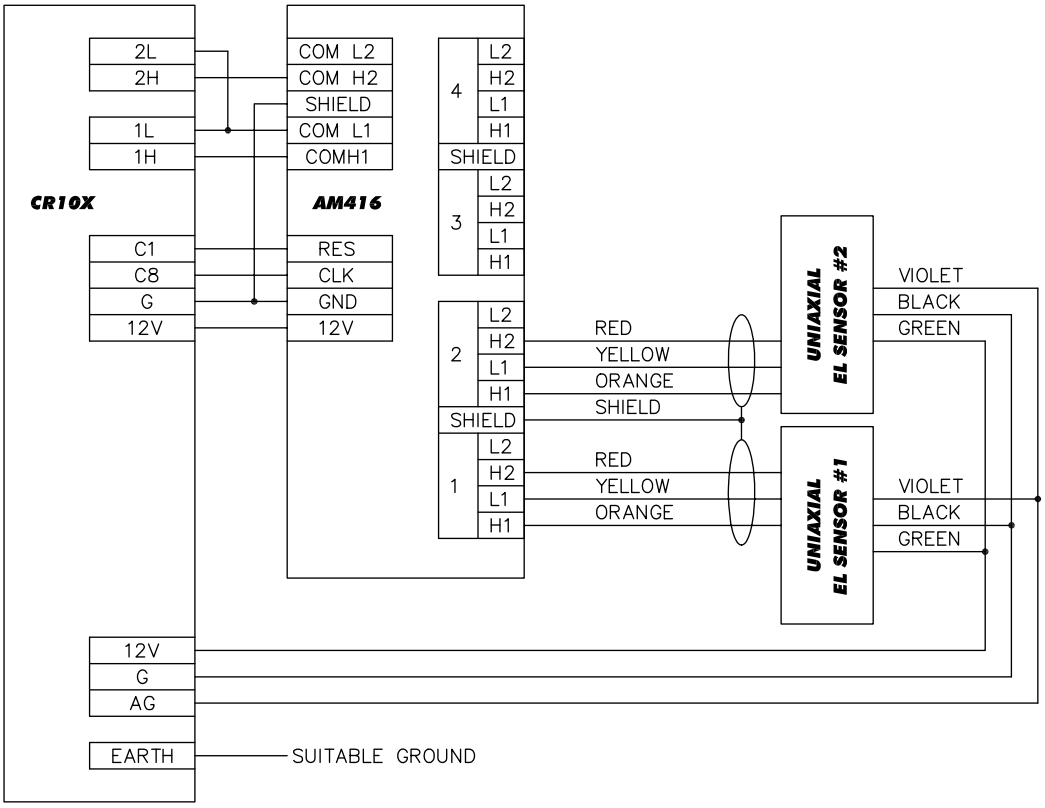
Wiring Diagram 1

Connecting a uniaxial sensor directly to the CR10X



Wiring Diagram 2

Connecting a uniaxial sensor to an AM416 multiplexer



Data Reduction

Overview

1. The EL tilt sensor produces a voltage value that is recorded by the readout or data logger.
2. Each EL tilt sensor has a serial number and a calibration sheet with unique factors.
3. To obtain tilt in degrees, apply these factors to the voltage reading.

Data Reduction Example

Suppose you obtain a reading of 1.1061 volts from a sensor.

Calibration Sheets

Find the calibration sheet for that sensor. In this case, we show factors for sensor 36204. The factors on your calibration sheets will be different.

These factors are coefficients for a 5th order polynomial expression.

C5	1.74849351E-2
C4	-2.91482607E-3
C3	-4.38752771E-2
C2	6.06793437E-3
C1	2.28093126E-1
C0	-2.4647589E-4

Convert voltage reading to tilt in degrees

Process the voltage reading with the polynomial equation shown below.

tilt in degrees = C5 • EL^5 + C4 • EL^4 + C3 • EL^3 + C2 • EL^2 + C1 • EL + C0

	C Factor	Reading Raised to Appropriate Power	Value
C5	1.74849351E-2	1.1061^5	0.0289491613
C4	-2.91482607E-3	1.1061^4	-0.0043630502
C3	-4.38752771E-2	1.1061^3	-0.0593749216
C2	6.06793437E-3	1.1061^2	0.0074238581
C1	2.28093126E-1	1.1061	0.2522938067
C0	-2.4647589E-4	1	-0.0002464759
		tilt in degrees =	0.2246823783

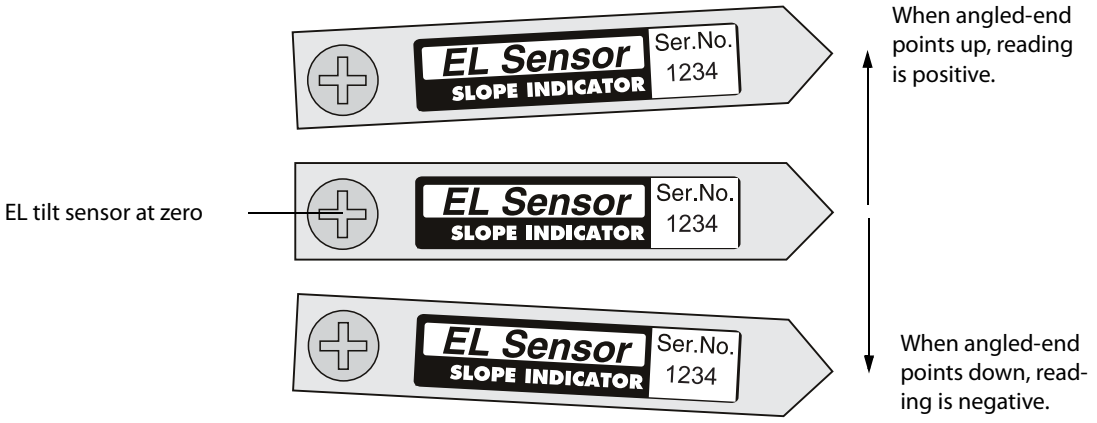
Calculate Change in Tilt

To calculate displacement, subtract the initial reading from the current reading.

change in tilt = current tilt - initial tilt

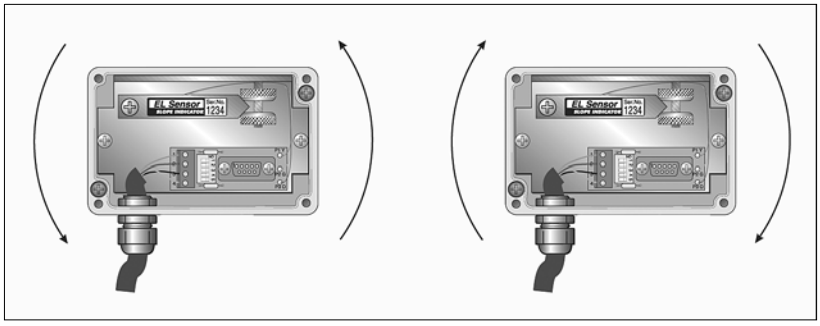
Direction of Tilt

The drawing below shows the orientation of the sensor when reading is positive or negative.



Change in Tilt

Change in tilt is found by subtracting the initial tilt value from the current tilt value. The sign (+ or -) of the resulting value indicates rotation as shown in the drawing below.



A positive change in tilt indicates counter clockwise rotation.

A negative change in tilt indicates clockwise rotation.

Converting the thermistor reading to degrees C.

SC terminal boards are equipped with a thermistor. If you have obtained a thermistor reading in volts, use the equation below to convert volts to degrees C. ET is the thermistor reading in volts.

$$DegC = 58.6752 \cdot ET^5 - 278.839 \cdot ET^4 + 509.188 \cdot ET^3 - 449.099 \cdot ET^2 + 233.754 \cdot ET - 48.4917$$