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Installation Manual

Model 6350

Vibrating Wire Tiltmeter

(Doc Rev Q, 05/01/19)

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TABLE of CONTENTS

FIGURES

TABLES

EQUATIONS

1. INTRODUCTION

1.1 Theory of Operation

The Geokon Model 6350 Vibrating Wire Tiltmeter is designed for permanent long-term monitoring of changes in tilt of structures such as dams, embankments, foundation walls and the like. The basic principle is the utilization of tilt sensors attached to the structure being studied to make accurate measurement of inclination. See Figure 1.

Two brackets are available, one to measure tilt uniaxially, the other biaxially.

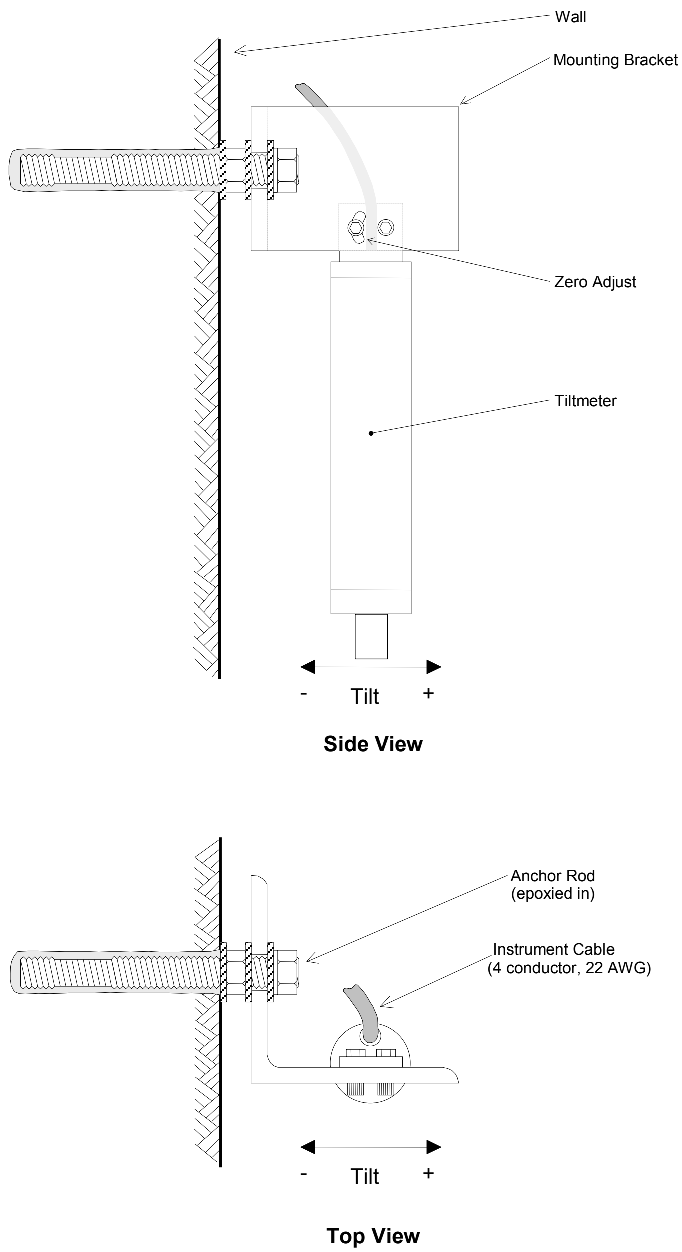

Figure 1 - Model 6350 Uniaxial Tiltmeter Installation

1.2 Tilt Sensor Construction

The sensor is comprised of a pendulous mass, which is supported by a vibrating wire strain gauge and an elastic hinge. See Figure 2. The strain gauge senses the changes in force caused by rotation of the center of gravity of the mass. The mass and sensor are enclosed in a waterproof housing, which includes components for connecting the sensor to the mounting bracket. The housing is constructed using stainless steel tubing to minimize the effects of corrosion. Biaxial systems use a mounting bracket to mount two transducers at 90° to each other. In environments subject to vibrations, a damping fluid can be used, as shown in the figure below.

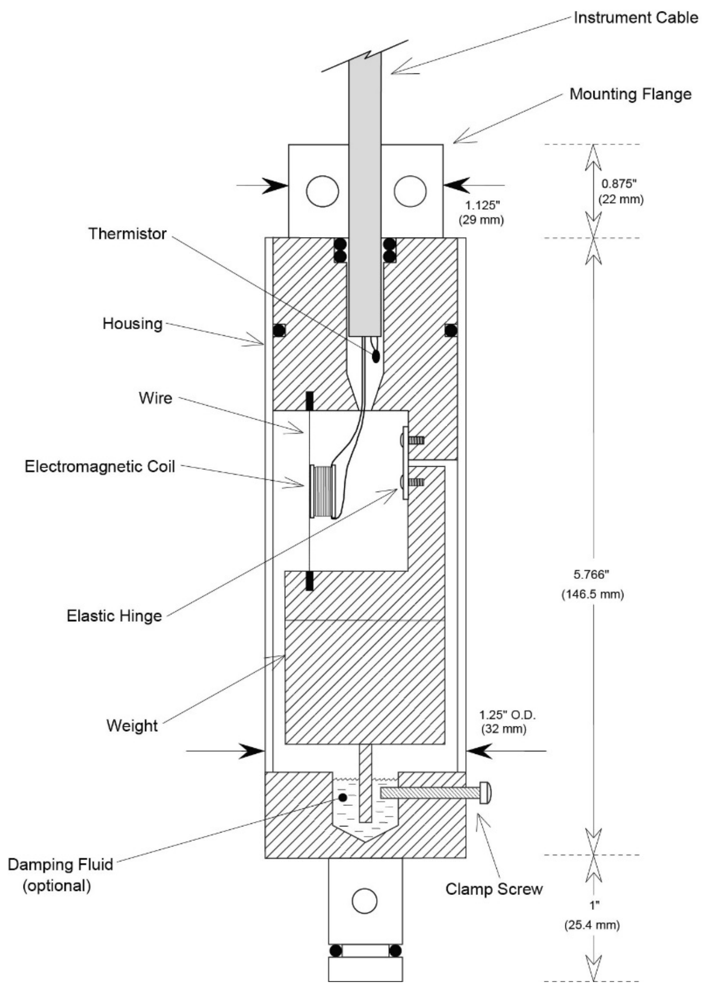

Figure 2 - Model 6350 Tilt Sensor

To prevent damage during shipment the tilt sensors are locked in place by means of a slotted head locking clamp screw. This slotted head locking clamp screw must be removed and replaced by a Phillips head seal screw (provided), to render the tiltmeter operative.

2. INSTALLATION

2.1 Preliminary Tests

Prior to installation, the sensors need to be checked for proper operation. Each tilt sensor is supplied with a calibration report, which shows the relationship between readout digits and inclination. The tilt sensor electrical leads (usually the red and black leads) are connected to a readout box (see Section 3 for readout instructions) and the current reading compared to the calibration readings. After backing off the clamp screw three full turns, carefully hold the sensor in a vertical position and observe the reading. It will take a few seconds to come to equilibrium and the sensor must be held in a steady position. The readings should be in the range of the factory reading but will vary according to inclination. The indicated temperature should be close to ambient.

Note: Vibrating wire tilt sensors are shock sensitive and severe shocks can cause a permanent offset or even break the suspension. (The unit will not survive a two foot (.5 m) drop onto a hard surface.) When transporting the tiltmeter tighten the locking clamp screw.

Checks of electrical continuity can also be made using an ohmmeter. Resistance between the gauge leads should be approximately 180Ω, ±10 ohms. Remember to add cable resistance when checking. Remember to add cable resistance when checking. The resistance of 22 AWG stranded copper leads is approximately 14.7Ω per 1,000 feet (48.5Ω per km), multiply this factor by two to account for both directions.

Resistance between the green and white leads varies by temperature. Using Table 4 in Appendix C, convert the resistance to temperature and compare the result to the ambient temperature.

Resistance between any conductor and the shield should exceed two megohms.

2.2 Installing the Mounting Brackets

Two mounting brackets are available for the Model 6350. One is designed for uniaxial tilt measurements the other for biaxial.

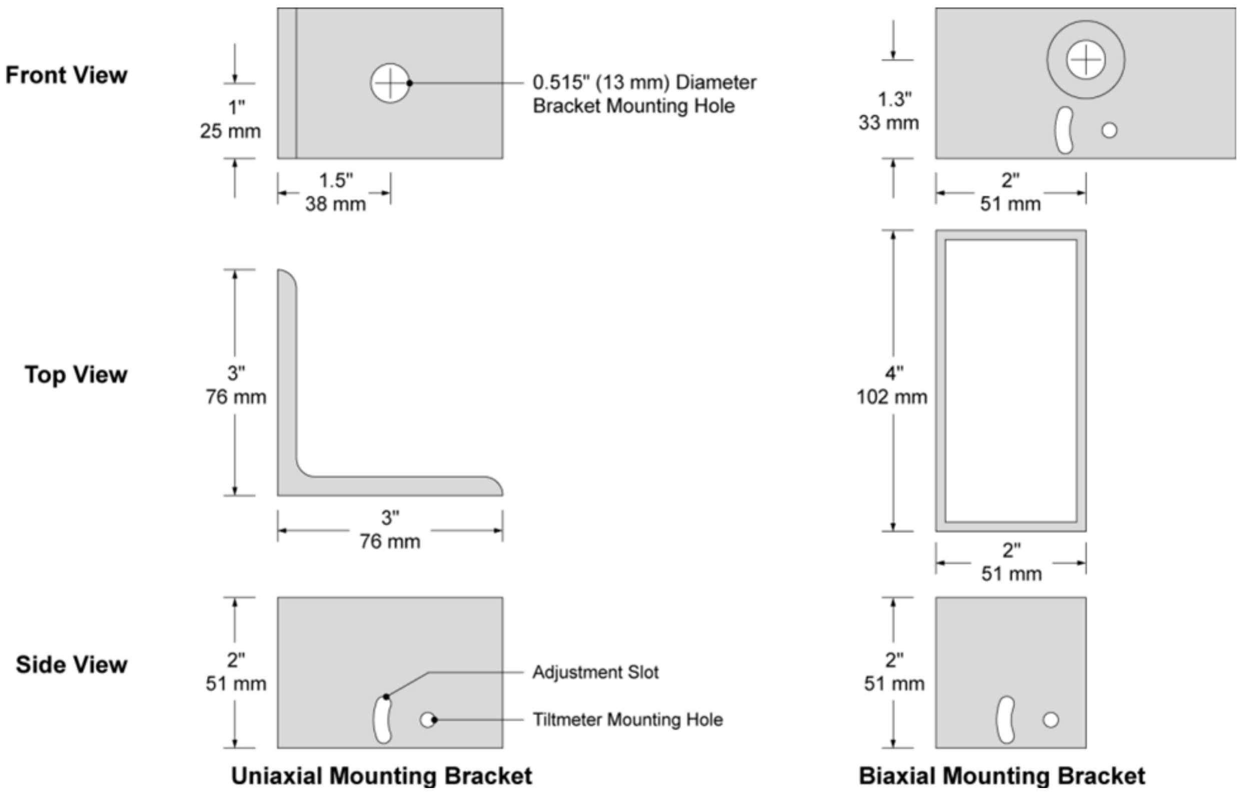

Figure 3 - Tiltmeter Mounting Brackets

Both bracket types may be mounted using a drop-in anchor or an anchor rod that is epoxied or grouted in place. See Section 2.2.1 for instructions using drop-in anchors, and Section 2.2.2 for anchor rods.

2.2.1 Mounting with a Drop-in Anchor

1) Mark the location where the bracket will be installed.

2) Using a hammer drill, drill a half inch (12 mm) hole approximately 1.5" (37 mm) deep. Clean the hole thoroughly, blowing out with compressed air if possible.

3) Insert the 3/8" drop-in anchor with setting pin into the hole. The threaded end should be closest to the opening.

4) Insert the provided setting tool, small end first, into the anchor. Expand the anchor by hitting the large end of the setting tool with several sharp hammer blows.

5) Thread the supplied 3/8-16 anchor rod into the anchor.

6) Attach the mounting bracket to the bolt using the supplied hardware, as illustrated in Figure 4.

7) Use a leveling device to align the bracket vertically to the wall.

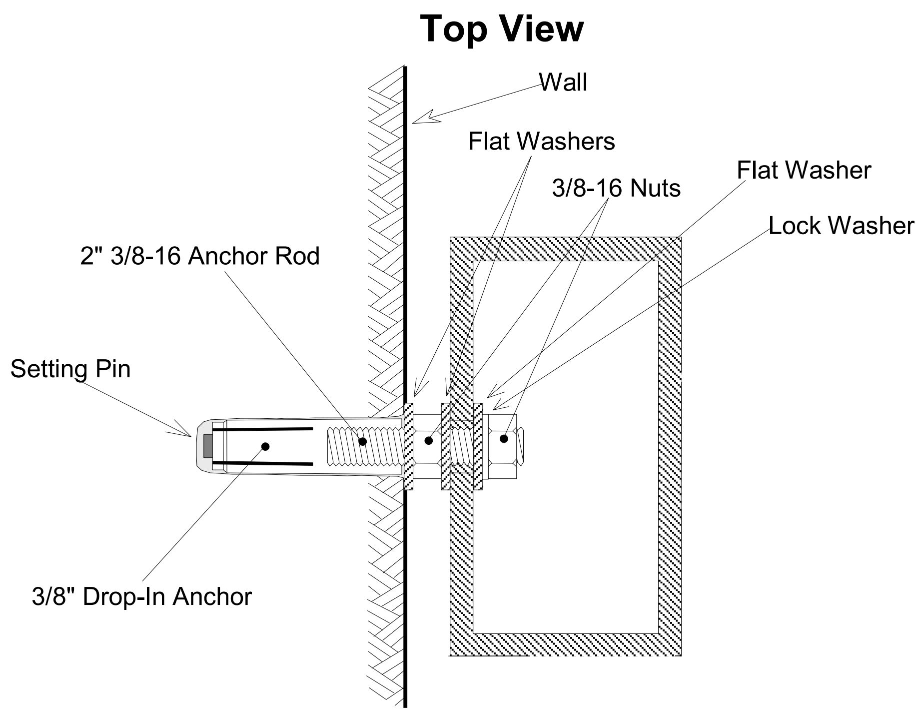

Figure 4 - Drop-in Anchor Installation (Biaxial Mounting Bracket Shown)

2.2.2 Mounting with an Anchor Rod

1) Mark the location where the bracket will be installed.

2) Using a hammer drill, drill a half inch (12 mm) hole approximately four inches (100 mm) deep.

3) Clean the hole thoroughly, blowing out with compressed air if possible.

4) Mix the grout or epoxy and fill the hole.

5) Push the 1/2-13 threaded anchor rod into the hole. (Use a hammer if necessary to get the anchor to reach the bottom.)

6) Let the anchor rod set before continuing the installation.

7) After setting, attach the mounting bracket to the bolt using the supplied hardware as illustrated in Figure 5.

8) Use a bubble level or other leveling device to align the bracket vertically to the wall.

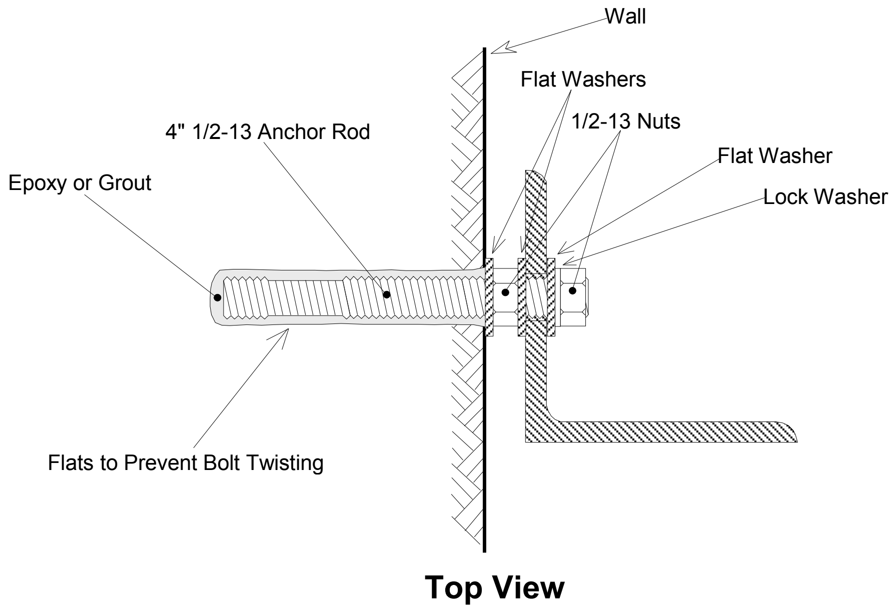

Figure 5 - Anchor Rod (Uniaxial Mounting Bracket Shown)

2.3 Sensor Installation

2.3.1 Installing Uniaxial Tiltmeters

Attach the tiltmeter to the mounting bracket using the supplied 10-32 cap screws, washers, and nuts. **Remove the slotted head locking clamp screw completely and replace with the Phillips head seal screw (provided). This is very important if the sensor is to remain waterproof.** Do not tighten the cap screws yet. Attach a portable readout such as the GK-404 or GK-405 (see Section 3 for readout instructions) and observe the reading. Adjust the sensor in the slot of the mounting bracket while observing the readout until the tiltmeter reads within ±50 digits of the zero reading as shown on the calibration report supplied with the sensor. (See Appendix A for a sample calibration report.) When the desired reading is reached, tighten the cap screws to secure the tiltmeter in place. Check the reading again after tightening to make sure it still reads within ±50 digits of the zero reading. Figure 6 shows the completed installation.

If the tiltmeter is installed in an exposed location in a construction area, and/or if the installation is in direct sunlight, it should be covered with a protective enclosure and/or insulation.

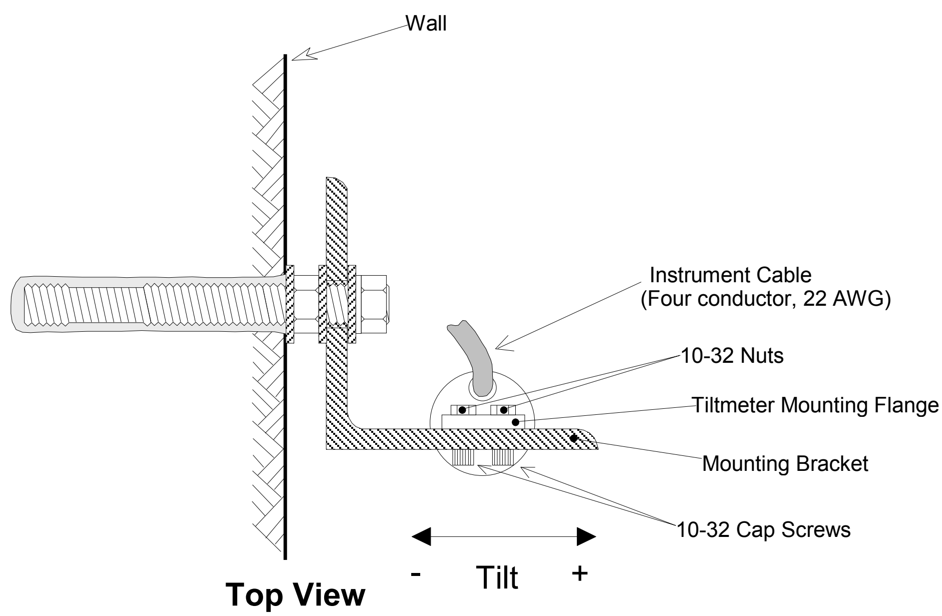

Figure 6 - Uniaxial Installation

2.2.2 Installing Biaxial Tiltmeters

The sensors may now be installed. Attach the tiltmeters to the mounting bracket using the supplied 10-32 cap screws, washers, and nuts. **Remove the slotted head locking clamp screw completely and replace with the Phillips head seal screw provided. This is very important if the sensor is to remain waterproof.** Do not tighten the cap screws yet. Attach a portable readout such as the GK-404 or GK-405 (see Section 3 for readout instructions) and observe the reading. Adjust each sensor in their slots of the mounting bracket while observing the readout until the tiltmeter reads within ±50 digits of the zero reading as shown on the calibration report supplied with each sensor. (See Appendix A for a sample calibration report.) When the desired reading is reached, tighten the cap screws to secure the tiltmeter in place. Check the reading again after tightening to make sure it still reads within ±50 digits of the zero reading. Figure 7 shows the completed installation.

If the tiltmeters are installed in an exposed location in a construction area, and/or if the installation is in direct sunlight, it should be covered with a protective enclosure and/or insulation.

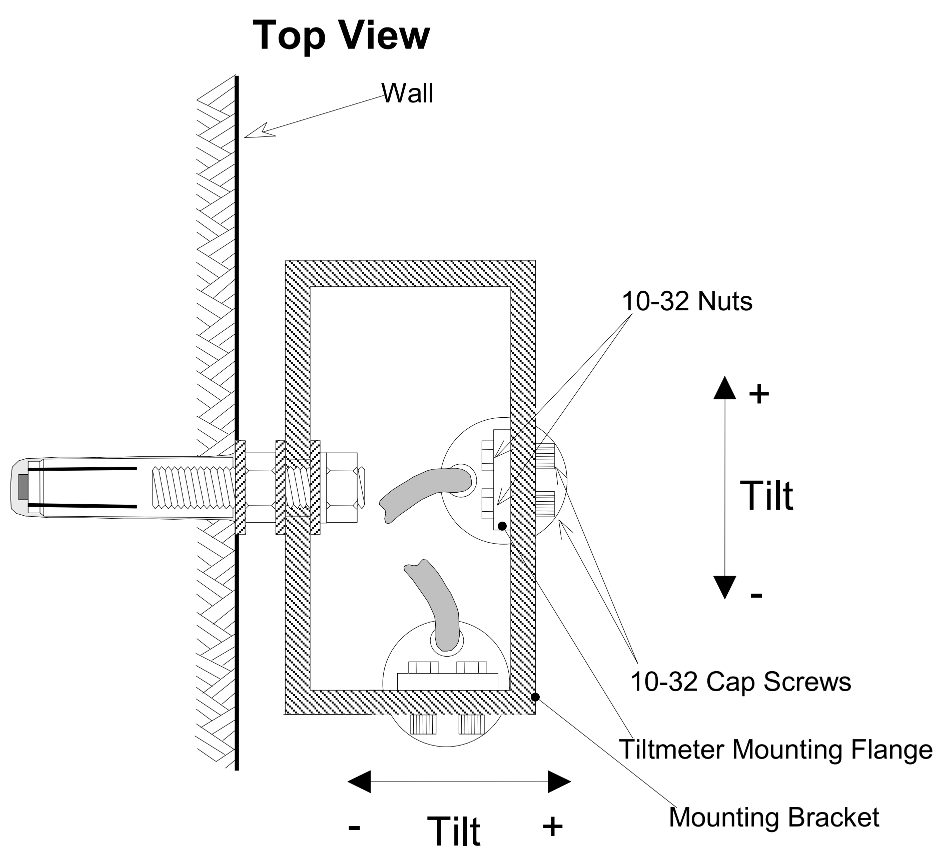

Figure 7 - Biaxial Installation

2.4 Fluid Damping

The vibrating wire tilt sensor acts as a self-damping system when used in vibration free environments. When external ground or structural vibrations exceed a certain threshold, the pendulous mass will continue to "swing" and stable readings may not be possible. In such cases, additional damping can be achieved by adding a viscous damping fluid to a small reservoir contained in the sensor. A thin, wide "paddle" is connected to the mass and when the fluid is added the pendulum is damped by the action of the paddle in the damping fluid (see Figure 2).

Damping fluid kits are available from Geokon (part number 6350-4).

Most in-place tiltmeter installations will not require this fluid. However, if the instrument gives unstable outputs, or it is known that the structure is constantly vibrating, the fluid can be added. The fluid is a very high viscosity silicone oil which must be injected into the sensor with a syringe.

The sensor must be held upright during the injection of the fluid and **at all times** following the injection. This makes it necessary to perform this operation in the field. The following applies for a typical in-place installation.

1) Remove the clamp screw on the bottom side of the sensor (see Figure 2).

2) Using the syringe applied, first pull the piston from the syringe and squeeze the silicone from the tube into the syringe. Replace the piston and start the fluid out of the "needle" end.

3) Inject 2.00 cc of the damping fluid into the hole in the sensor. Immediately following this operation, the seal screw should be replaced in the sensor.

4) The sensor may now be attached to the mounting bracket.

2.5 Splicing and Junction Boxes

Terminal boxes with sealed cable entries are available from Geokon for all types of applications. These allow many gauges to be terminated at one location with complete protection of the lead wires. The interior panel of the terminal box can have built-in jacks or a single connection with a rotary position selector switch. Contact Geokon for specific application information.

Because the vibrating wire output signal is a frequency rather than a current or voltage, variations in cable resistance have little effect on gauge readings; therefore, splicing of cables has no ill effects, and in some cases may in fact be beneficial. The cable used for making splices should be a high-quality twisted pair type, with 100% shielding and an integral shield drain wire. **When splicing, it is very important that the shield drain wires be spliced together.** Always maintain polarity by connecting color to color.

Splice kits recommended by Geokon incorporate casts, which are placed around the splice and are then filled with epoxy to waterproof the connections. When properly made, this type of splice is equal or superior to the cable in strength and electrical properties. Contact Geokon for splicing materials and additional cable splicing instructions.

Cables may be terminated by stripping and tinning the individual conductors and then connecting them to the patch cord of a readout box. Alternatively, a connector may be used which will plug directly into the readout box or to a receptacle on a special patch cord.

2.6 Lightning Protection

The Model 6350 Tiltmeter, unlike numerous other types of instrumentation available from Geokon, does not have any integral lightning protection components, i.e. transzorbs or plasma surge arrestors. Usually this is not a problem. However, if the instrument cable is exposed, it may be advisable to install lightning protection components, as the transient could travel down the cable to the gauge and possibly destroy it.

Note the following suggestions:

- If the tiltmeter is connected to a terminal box or multiplexer, components such as plasma surge arrestors (spark gaps) may be installed in the terminal box/multiplexer to provide a measure of transient protection. Terminal boxes and multiplexers available from Geokon provide locations for installation of these components.
- Lighting arrestor boards and enclosures are available from Geokon that install near the instrument. The enclosure has a removable top to allow the customer to service the components or replace the board if the unit is damaged by a lightning strike. A connection is made between this enclosure and earth ground to facilitate the passing of transients away from the gauge. See Figure 8. Consult the factory for additional information on these or alternate lightning protection schemes.
- Plasma surge arrestors can be epoxy potted into the gauge cable close to the sensor. A ground strap would connect the surge arrestor to earth ground, either a grounding stake or other suitable earth ground.

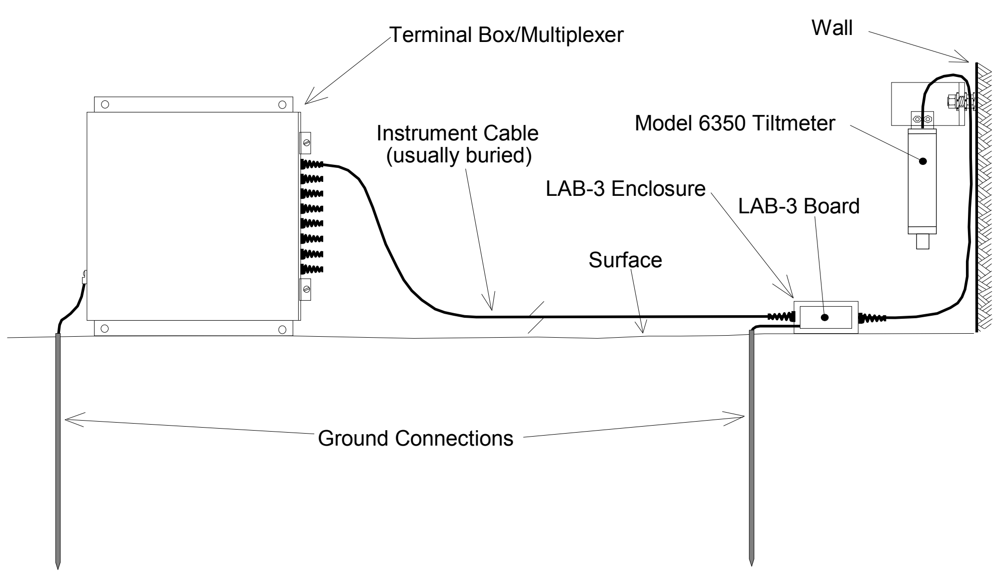

Figure 8 - Lightning Protection Scheme

3. TAKING READINGS

3.1 GK-404 Readout Box

The Model GK-404 Vibrating Wire Readout is a portable, low-power, handheld unit that can run continuously for more than 20 hours on two AA batteries. It is designed for the readout of all Geokon vibrating wire gauges and transducers; and is capable of displaying the reading in either digits, frequency (Hz), period (μs), or microstrain (με). The GK-404 also displays the temperature of the transducer (embedded thermistor) with a resolution of 0.1 °C.

3.1.1 Operating the GK-404

Before use, attach the flying leads to the GK-404 by aligning the red circle on the silver Lemo connector of the flying leads with the red line on the top of the GK-404 (Figure 9). Insert the Lemo connector into the GK-404 until it locks into place.

Figure 9 - Lemo Connector to GK-404

Connect each of the clips on the leads to the matching colors of the sensor conductors, with blue representing the shield (bare).

To turn the GK-404 on, press the "ON/OFF" button on the front panel of the unit. The initial startup screen will display. After approximately one second, the GK-404 will start taking readings and display them based on the settings of the POS and MODE buttons.

The unit display (from left to right) is as follows:

- The current Position: Set by the **POS** button. Displayed as a letter A through F.
- The current Reading: Set by the **MODE** button. Displayed as a numeric value followed by the unit of measure.
- Temperature reading of the attached gauge in degrees Celsius.

Use the **POS** button to select position **B** and the **MODE** button to select **Dg** (digits). (Other functions can be selected as described in the GK-404 Manual.)

The GK-404 will continue to take measurements and display readings until the unit is turned off, either manually, or if enabled, by the Auto-Off timer.

If no reading displays or the reading is unstable, see Section 5 for troubleshooting suggestions. For further information, consult the GK-404 manual.

3.2 GK-405 Readout Box

The GK-405 Vibrating Wire Readout is made up of two components: The Readout Unit, consisting of a Windows Mobile handheld PC running the GK-405 Vibrating Wire Readout Application; and the GK-405 Remote Module, which is housed in a weatherproof enclosure and connects to the vibrating wire gauge to be measured. The two components communicate wirelessly. The Readout Unit can operate from the cradle of the Remote Module, or, if more convenient, can be removed and operated up to 20 meters from the Remote Module.

3.2.1 Connecting Sensors with 10-pin Bulkhead Connectors Attached

Align the grooves on the sensor connector (male), with the appropriate connector on the readout (female connector labeled senor or load cell). Push the connector into place, and then twist the outer ring of the male connector until it locks into place.

3.2.2 Connecting Sensors with Bare Leads

Attach the GK-403-2 flying leads to the bare leads of a Geokon vibrating wire sensor by connecting each of the clips on the leads to the matching colors of the sensor conductors, with blue representing the shield (bare).

3.2.3 Operating the GK-405

Press the button labeled “POWER ON”. A blue light will begin blinking, signifying that the Remote Module is waiting to connect to the handheld unit. Launch the GK-405 VWRA program on the handheld PC by tapping on “Start”, then “Programs”, then the GK-405 VWRA icon. After a few seconds, the blue light on the Remote Module should stop flashing and remain lit, indicating that the remote module has successfully paired with the handheld PC. The Live Readings Window will be displayed on the handheld PC. Figure 10 shows a typical vibrating wire output in digits and thermistor output in degrees Celsius.

If the no reading displays or the reading is unstable, see Section 5 for troubleshooting suggestions. For further information, consult the GK-405 Instruction Manual.

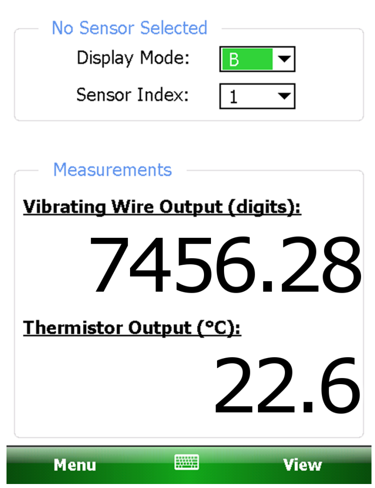

Figure 10 - Live Readings – Raw Readings

3.3 GK-403 Readout Box (Obsolete Model)

The GK-403 can store gauge readings and apply calibration factors to convert readings to engineering units. The following instructions explain taking gauge measurements using Mode "B". Consult the GK-403 Instruction Manual for additional information.

3.3.1 Connecting Sensors with 10-pin Bulkhead Connectors Attached

Align the grooves on the sensor connector (male), with the appropriate connector on the readout (female connector labeled senor or load cell). Push the connector into place, and then twist the outer ring of the male connector until it locks into place.

3.3.2 Connecting Sensors with Bare Leads

Attach the GK-403-2 flying leads to the bare leads of a Geokon vibrating wire sensor by connecting each of the clips on the leads to the matching colors of the sensor conductors, with blue representing the shield (bare).

3.3.3 Operating the GK-403

1) Turn the display selector to position "B".

2) Turn the unit on.

3) The readout will display the vibrating wire output in digits (See Equation 1 in Section 4.1.) The last digit may change one or two digits while reading.

4) The thermistor reading will be displayed above the gauge reading in degrees centigrade.

5) Press the "Store" button to record the value displayed.

If the no reading displays or the reading is unstable, see Section 5 for troubleshooting suggestions.

The unit will automatically turn off after approximately two minutes to conserve power.

3.4 MICRO-10 Datalogger

The following parameters are recommended when using the Model 6350 with the MICRO-10 datalogger or any other CR10 based datalogger:

3.4.1 Excitation

The 2.5V excitation directly off the wiring panel is ideal for these sensors. The five volt supply from the AVW-1 and AVW-4 modules is also usable, but the 12V excitation should be avoided as it tends to overdrive the sensor. The default excitation voltage used in MICRO-10 systems is 5V.

3.4.2 Excitation Frequency

The starting and ending frequencies of the excitation sweep should be kept in a relatively narrow band for these sensors to maximize the stability and resolution of the output. The exact values can be calculated for a given sensor from the supplied calibration report. Ideally, the settings should be calculated by taking an initial reading and then setting the starting frequency to 200 Hz below and the ending frequency 200 Hz above. Alternately, the low-end frequency sweep setting should be set to 14 (1400 Hz), the high end, 35 (3500 Hz).

3.5 Measuring Temperatures

All vibrating wire tiltmeters are equipped with a thermistor, which gives a varying resistance output as the temperature changes. The white and green leads of the instrument cable are normally connected to the internal thermistor.

The GK-403, GK-404, and GK-405 readout boxes will read the thermistor and display the temperature in degrees C.

To read temperatures using an ohmmeter:

1) Connect an ohmmeter to the green and white thermistor leads coming from the tiltmeter. (Since the resistance changes with temperature are large, the effect of cable resistance is usually insignificant. For long cables a correction can be applied, equal to 14.7Ω per 1,000 feet or 48.5Ω per km, multiply this factor by two to account for both directions.

2) Look up the temperature for the measured resistance in Appendix C, Table 4.

4. DATA REDUCTION

4.1 Tilt Calculation

Tilts are measured in digits on Position B of either the GK-404 or GK-405 Readout Box. The relationship between these digits and the change of the angle of inclination (tilt) is given by the equation:

$$\Delta\theta = (R_1 - R_0)\, G \qquad \text{degrees}$$

Equation 1 - Digits Calculation

Where;
R_1 is the current reading in digits.
R_0 is the initial reading in digits.
G is the Calibration Factor in degrees/digit.

The linear equation works very well for tilt angles of less than two degrees. More than this and the linearity errors increase. The error incurred by using the linear equation is shown on the calibration chart.

For better accuracy at larger inclinations, use the polynomial equation:

$$\theta = R^2A + RB + C$$

Equation 2 - Polynomial Equation

Where;
A, B and C are the coefficients supplied on the calibration report. Calculate θ for $R = R_1$ and $R = R_0$ then subtract to find the difference $\Delta\theta$ for $(R_1 - R_0)$.

4.2 Temperature Correction

The Model 6350 Tiltmeter has a very slight temperature sensitivity on the order of – 0.5 digit per °C rise, i.e. the reading falls by 0.5 digits for every 1 °C rise of temperature. The temperature correction is:

$$+K\,(T_1 - T_0) \qquad \text{degrees}$$

Equation 3 - Temperature Correction

Where K = 0.5G.

Normally, corrections are not applied for this small effect because the structure being monitored usually is affected to a much greater degree. An important point to note, also, is that sudden changes in temperature will cause both the structure and the Tiltmeter to undergo transitory physical changes, which will show up in the readings. The gauge temperature should always be recorded for comparison, and efforts should be made to obtain readings when the instrument and structure are at thermal equilibrium. The best time for this tends to be in the late evening or early morning hours.

5. TROUBLESHOOTING

Maintenance and troubleshooting of vibrating wire tiltmeters is confined to periodic checks of cable connections and maintenance of terminals. The transducers themselves are sealed and are not user serviceable. **Gauges should not be opened in the field.**

Should difficulties arise, consult the following list of problems and possible solutions. For additional troubleshooting and support, contact Geokon.

Symptom: Thermistor resistance is too high:

- ✓ Is there an open circuit? Check all connections, terminals, and plugs. If a cut is located in the cable, splice according to instructions in Section 2.4.

Symptom: Thermistor resistance is too low:

- ✓ Is there a short? Check all connections, terminals, and plugs. If a short is located in the cable, splice according to instructions in Section 2.4.

- ✓ Water may have penetrated the interior of the tilt sensor. There is no remedial action.

Symptom: Tiltmeter Readings are Unstable:

- ✓ Is the readout box position set correctly? If using a datalogger to record readings automatically, are the swept frequency excitation settings correct?

- ✓ Is there a source of electrical noise nearby? Most probable sources of electrical noise are motors, generators, and antennas. Make sure the shield drain wire is connected to ground.

- ✓ Does the readout work with another tilt sensor? If not, the readout may have a low battery or be malfunctioning.

Symptom: Tiltmeter Fails to Read:

- ✓ Is the cable cut or crushed? This can be checked with an ohmmeter. Table 1 shows the expected resistance for the various wire combinations; Table 2 is provided for the customer to fill in the actual resistance found. Cable resistance is approximately 14.7Ω per 1000 feet (48.5Ω per km) of 22 AWG wire. Multiply this factor by two to account for both directions. If the resistance reads very high or infinite (megohms), a cut wire must be suspected. If the resistance reads very low (<100Ω), a short in the cable is likely.

- ✓ Does the readout or datalogger work with another tilt sensor? If not, the readout or datalogger may be malfunctioning.

Vibrating Wire Sensor Lead Grid - SAMPLE VALUES					
	Red	Black	White	Green	Shield
Red	N/A	**≅180Ω**	infinite	infinite	infinite
Black	**≅180Ω**	N/A	infinite	infinite	infinite
White	infinite	infinite	N/A	**3000Ω at 25°C**	infinite
Green	infinite	infinite	**3000Ω at 25°C**	N/A	infinite
Shield	infinite	infinite	infinite	infinite	N/A

Table 1 - Sample Resistance

Vibrating Wire Sensor Lead Grid - SENSOR NAME/## :					
	Red	Black	White	Green	Shield
Red					
Black					
White					
Green					
Shield					

Table 2 - Resistance Worksheet

APPENDIX A. SAMPLE CALIBRATION REPORT

GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Vibrating Wire Tilt Sensor Calibration

Model Number: 6350

Calibration Date: September 15, 2014

This calibration has been verified/validated as of 03/23/2015

Serial Number: 1427971

Temperature: 22.4 °C

Calibration Instruction: CI-6300

Technician: [signature]

Inclination (sin)	Inclination (degrees)	*Reading 1st Cycle (digits)	*Reading 2nd Cycle (digits)	*Average Reading (digits)	Linear Error (%FS)	Polynomial Error (%FS)
0.1737	10.001	11544	11544	11544	-0.86	0.02
0.1392	8.002	10738	10739	10739	-0.54	0.00
0.1045	6.000	9926	9928	9927	-0.30	-0.02
0.0698	4.002	9108	9108	9108	-0.14	0.00
0.0349	2.002	8286	8287	8287	-0.02	-0.02
0.0175	1.001	7871	7871	7871	-0.01	0.00
0.0087	0.500	7664	7664	7664	0.00	0.00
0.0000	0.000	7456	7456	7456	0.00	0.00
-0.0087	-0.500	7249	7249	7249	0.01	-0.01
-0.0175	-1.001	7040	7040	7040	0.00	0.00
-0.0349	-2.002	6621	6621	6621	-0.04	0.01
-0.0698	-4.002	5780	5780	5780	-0.15	0.02
-0.1045	-6.000	4934	4935	4935	-0.31	0.02
-0.1392	-8.002	4083	4083	4083	-0.55	0.02
-0.1737	-10.001	3229	3230	3230	-0.81	-0.03

*Readings displayed in GK-401 Position B .

Linear Gage Factor (G): 0.002404 **(degrees/ digit)**

Polynomial Gage Factors: **A:** 9.719E-09 **B:** 0.002261 **C:** -17.395

Calculated Angle (degrees): **Linear,** $q = G(R_1 - R_0) + K(T_1 - T_0)$

Polynomial, $q = AR^2 + BR + C$

Wiring Code: Red and Black: Gage White and Green: Thermistor Bare: Shield

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

Figure 11 - Sample Model 6350 Calibration Report

APPENDIX B. SPECIFICATIONS

B.1 Vibrating Wire Tilt Sensor

Model:	6350
Range:[1]	±10°
Resolution:[2]	±0.5 mm/m (eight arc seconds)
Accuracy:[3]	±0.1% FSR
Linearity:	±0.3% FSR
Thermal Zero Shift:	±4 arc seconds/°C
Operating Temperature:[4]	-20 to +80 °C -4 to 176 °F
Operating Frequency:	1400-3500 Hz
Coil Resistance:	180 Ω
Diameter:	1.250" (32 mm)
Length:	7.375" (187 mm)
Weight:	1.5 lbs. (0.7 kg)
Materials:	304 Stainless Steel
Electrical Cable:	Two twisted pair (four conductor) 22 AWG Foil shield, PVC jacket, nominal OD=6.3 mm (0.250")

Table 3 - Model 6350 Tilt Sensor Specifications

Notes:
[1] Consult the factory for other ranges.
[2] Depends on readout equipment. With averaging techniques, it is possible to achieve one arc second
[3] Derived using second order polynomial.
[4] Versions to -40 °C available on request.

B.2 Thermistor

(Also see Appendix C.)

Range: -80 to +150° C
Accuracy: ±0.5° C

APPENDIX C. THERMISTOR TEMPERATURE DERIVATION

Thermistor Type: YSI 44005, Dale #1C3001-B3, Alpha #13A3001-B3
Resistance to Temperature Equation:

$$T = \frac{1}{A + B(\mathrm{LnR}) + C(\mathrm{LnR})^3} - 273.15\ ^\circ C$$

Equation 4 - Resistance to Temperature

Where;
T = Temperature in °C.
LnR = Natural Log of Thermistor Resistance
$A = 1.4051 \times 10^{-3}$
$B = 2.369 \times 10^{-4}$
$C = 1.019 \times 10^{-7}$
Note: Coefficients calculated over the −50 to +150° C. span.

Ohms	Temp	Ohms	Temp	Ohms	Temp	Ohms	Temp	Ohms	Temp
201.1K	-50	16.60K	-10	2417	+30	525.4	+70	153.2	+110
187.3K	-49	15.72K	-9	2317	31	507.8	71	149.0	111
174.5K	-48	14.90K	-8	2221	32	490.9	72	145.0	112
162.7K	-47	14.12K	-7	2130	33	474.7	73	141.1	113
151.7K	-46	13.39K	-6	2042	34	459.0	74	137.2	114
141.6K	-45	12.70K	-5	1959	35	444.0	75	133.6	115
132.2K	-44	12.05K	-4	1880	36	429.5	76	130.0	116
123.5K	-43	11.44K	-3	1805	37	415.6	77	126.5	117
115.4K	-42	10.86K	-2	1733	38	402.2	78	123.2	118
107.9K	-41	10.31K	-1	1664	39	389.3	79	119.9	119
101.0K	-40	9796	0	1598	40	376.9	80	116.8	120
94.48K	-39	9310	+1	1535	41	364.9	81	113.8	121
88.46K	-38	8851	2	1475	42	353.4	82	110.8	122
82.87K	-37	8417	3	1418	43	342.2	83	107.9	123
77.66K	-36	8006	4	1363	44	331.5	84	105.2	124
72.81K	-35	7618	5	1310	45	321.2	85	102.5	125
68.30K	-34	7252	6	1260	46	311.3	86	99.9	126
64.09K	-33	6905	7	1212	47	301.7	87	97.3	127
60.17K	-32	6576	8	1167	48	292.4	88	94.9	128
56.51K	-31	6265	9	1123	49	283.5	89	92.5	129
53.10K	-30	5971	10	1081	50	274.9	90	90.2	130
49.91K	-29	5692	11	1040	51	266.6	91	87.9	131
46.94K	-28	5427	12	1002	52	258.6	92	85.7	132
44.16K	-27	5177	13	965.0	53	250.9	93	83.6	133
41.56K	-26	4939	14	929.6	54	243.4	94	81.6	134
39.13K	-25	4714	15	895.8	55	236.2	95	79.6	135
36.86K	-24	4500	16	863.3	56	229.3	96	77.6	136
34.73K	-23	4297	17	832.2	57	222.6	97	75.8	137
32.74K	-22	4105	18	802.3	58	216.1	98	73.9	138
30.87K	-21	3922	19	773.7	59	209.8	99	72.2	139
29.13K	-20	3748	20	746.3	60	203.8	100	70.4	140
27.49K	-19	3583	21	719.9	61	197.9	101	68.8	141
25.95K	-18	3426	22	694.7	62	192.2	102	67.1	142
24.51K	-17	3277	23	670.4	63	186.8	103	65.5	143
23.16K	-16	3135	24	647.1	64	181.5	104	64.0	144
21.89K	-15	**3000**	**25**	624.7	65	176.4	105	62.5	145
20.70K	-14	2872	26	603.3	66	171.4	106	61.1	146
19.58K	-13	2750	27	582.6	67	166.7	107	59.6	147
18.52K	-12	2633	28	562.8	68	162.0	108	58.3	148
17.53K	-11	2523	29	543.7	69	157.6	109	56.8	149
								55.6	150

Table 4 - Thermistor Resistance Versus Temperature