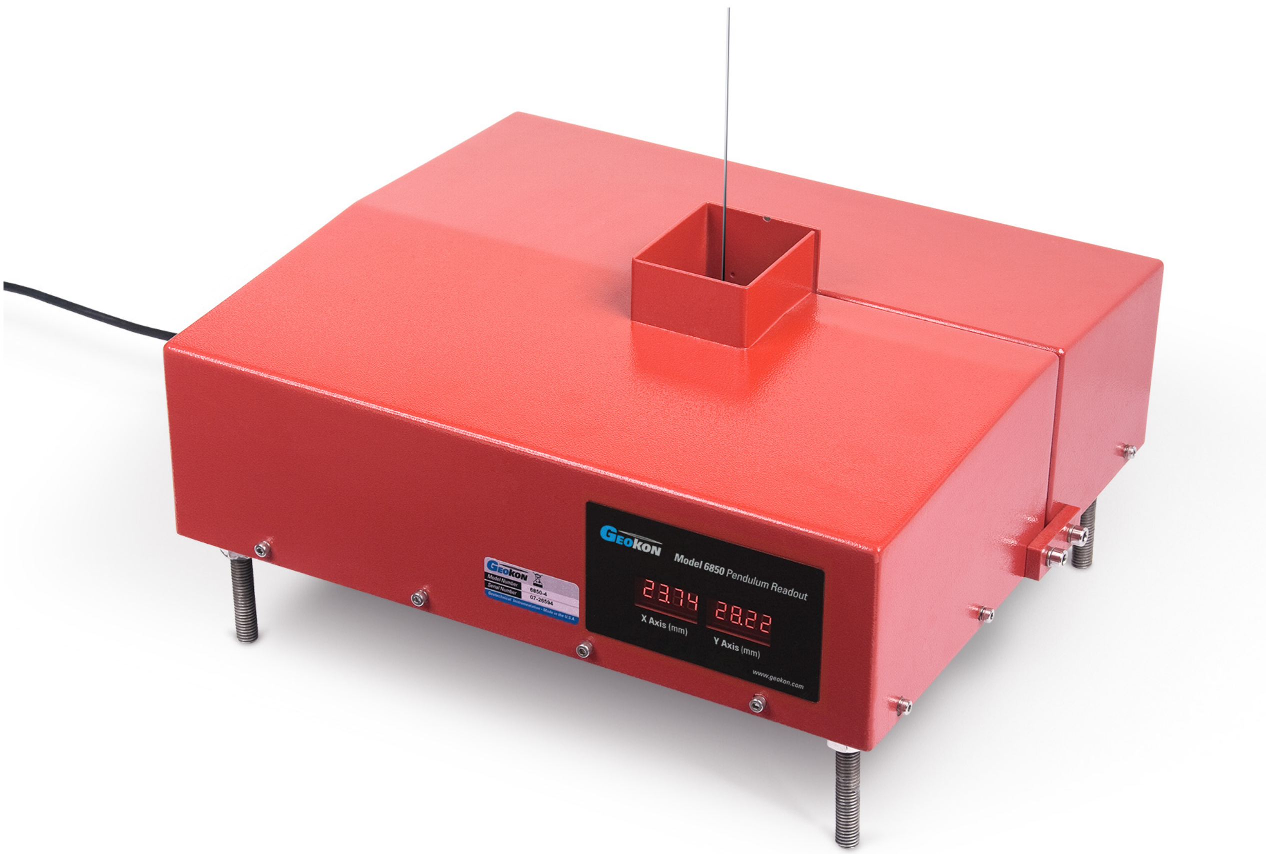
Model 6850

Pendulum System

Instruction Manual



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GEOKON warrants its products to be free of defects in materials and workmanship, under normal use and service for a period of 13 months from date of purchase. If the unit should malfunction, it must be returned to the factory for evaluation, freight prepaid. Upon examination by GEOKON, if the unit is found to be defective, it will be repaired or replaced at no charge. However, the WARRANTY IS VOID if the unit shows evidence of having been tampered with or shows evidence of being damaged as a result of excessive corrosion or current, heat, moisture or vibration, improper specification, misapplication, misuse or other operating conditions outside of GEOKON's control. Components that wear or are damaged by misuse are not warranted. This includes fuses and batteries.

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1. INTRODUCTION

The GEOKON Model 6850 Pendulum System can be used with direct or inverted pendulums. Both 2D and 3D readouts are available. The readout automatically measures horizontal deflections in two directions. The 3D system also measures changes in the vertical distance between the top suspension point of the wire and the readout location. These systems are designed to measure the tilting of large structures such as dams, high-rise buildings, bridges, etc.

GEOKON pendulum readouts utilize two high-resolution linear array Charge Coupled Devices (CCDs). Two collimated light sources, positioned at 90 degrees from each other, shine on the photosensitive CCD screens. When the shadow of the pendulum wire falls on the CCD sensors, an automatically generated scan of the CCD pixels maps, records, and digitally stores the coordinates of the shadow.

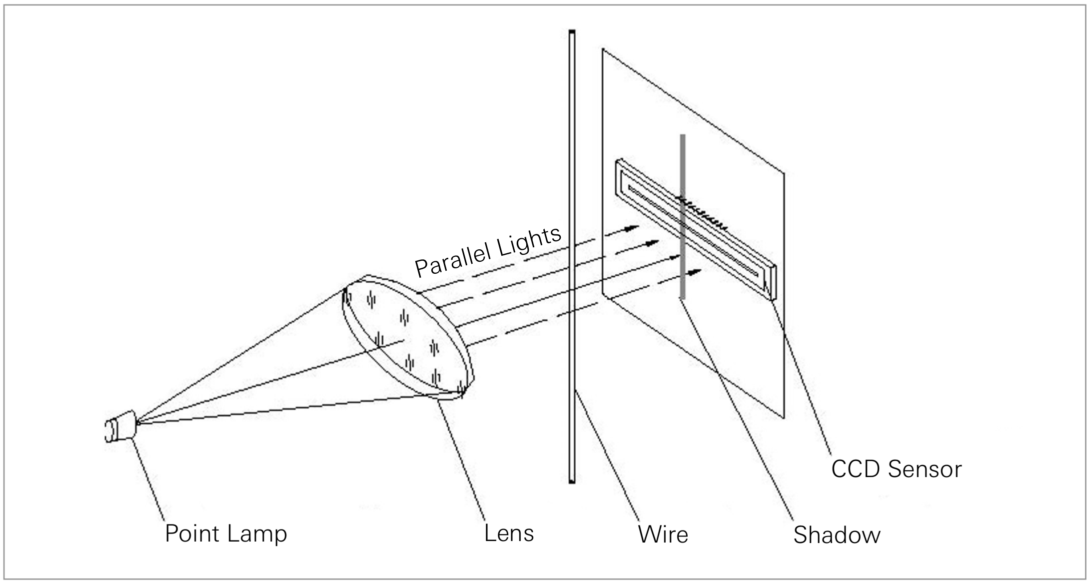


FIGURE 1: *System of CCD Imaging*

The information obtained by the CCD sensors is converted to an analog signal and displayed on the LED panels mounted in the console. This signal can also be transmitted via 4-20mA output or RS-485 output to a remote readout site.

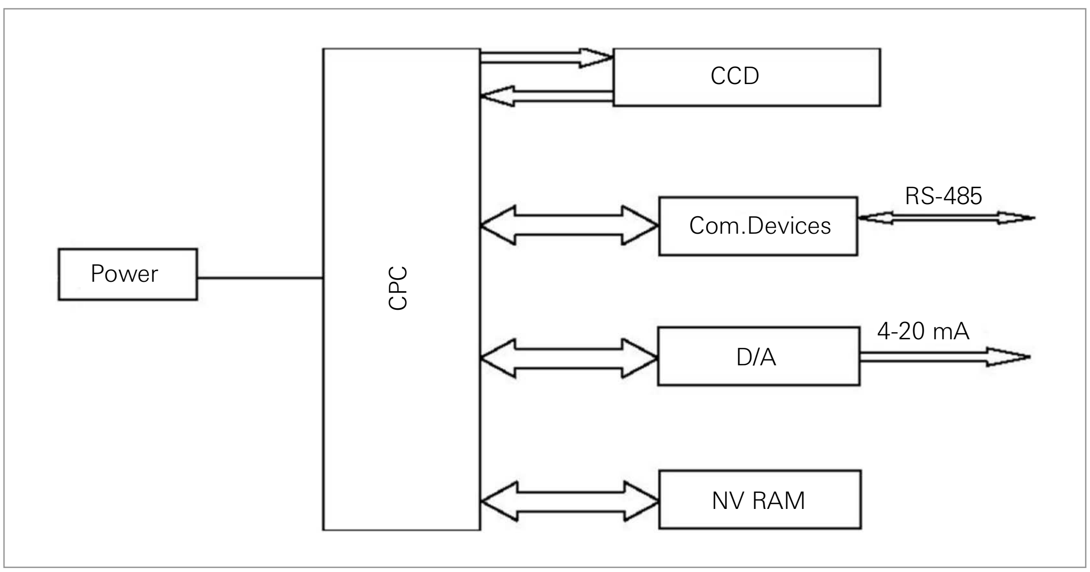


FIGURE 2: *Electrical Schematic*

1.1 TECHNICAL FEATURES

- Non-contact measurement using CCD photoelectric imaging:
  - **2D Readouts:** Two-dimensional measurement with a range of 50 x 50 mm (2 x 2”) or 50 x 100 mm (2 x 4”) and a resolution of 0.01 mm (0.0004”).
  - **3D Readouts:** Three-dimensional with a horizontal measurement range of 50 x 100 mm (2 x 4”), a vertical measurement range of 50 mm (2”), and a resolution of 0.01 mm (0.0004”).
- High Precision, no electrical drift, good long-term stability.
- Strong ambient light resistance.
- Built-in four digit LED visual display panels facilitate installation, debugging, and manual observation of the dual-axis (2D) or three-axis (3D) pendulum wire coordinates.
- Selectable sampling rate intervals ranging from every 10 seconds to once per day.
- RS-485 output coupled with an addressable network function makes it possible for several pendulum readouts to be interconnected, as well as remotely and separately addressed.
- 4-20mA output enables the pendulum system to be compatible with all standard data acquisition and SCADA systems.
- Up to 2,000 (2D) or 1,200 (3D) sets of measurement data can be stored.
- Power Off protection with nonvolatile storage ensures no data loss in the event of a power failure.
- Sealed modular construction, moisture proof circuitry, and a compact, sturdy, weatherproof cabinet ensure reliable performance in high humidity environments.
- A slot in the cabinet enables it to be placed around the pendulum wire without dismantling the pendulum system.
- The built in power supply works worldwide and is compatible with voltages ranging from 85 V to 265 V.
- Self-diagnosis feature displays error codes by which a fault can be traced and corrected.
- An optional drip shield may be purchased, which clamps to the pendulum wire and prevents ambient light and water droplets from entering the CCD chamber of the readout.
- Direct pendulum systems can be ordered with a measurement table for mounting the readout. Custom brackets can be made to order to facilitate the mounting of the cabinet onto a vertical wall behind the pendulum wire.
- Inverted pendulum systems can be ordered with a measurement table that allows the cabinet to be mounted directly below the float tank. Custom tables and float chambers can be made to order.

2. SYSTEM COMPONENTS

The components of the Model 6850 Pendulum Readout consists of the cabinet with built in slot for pendulum wire, LED display panel, output connector, power input, and CCD chamber.

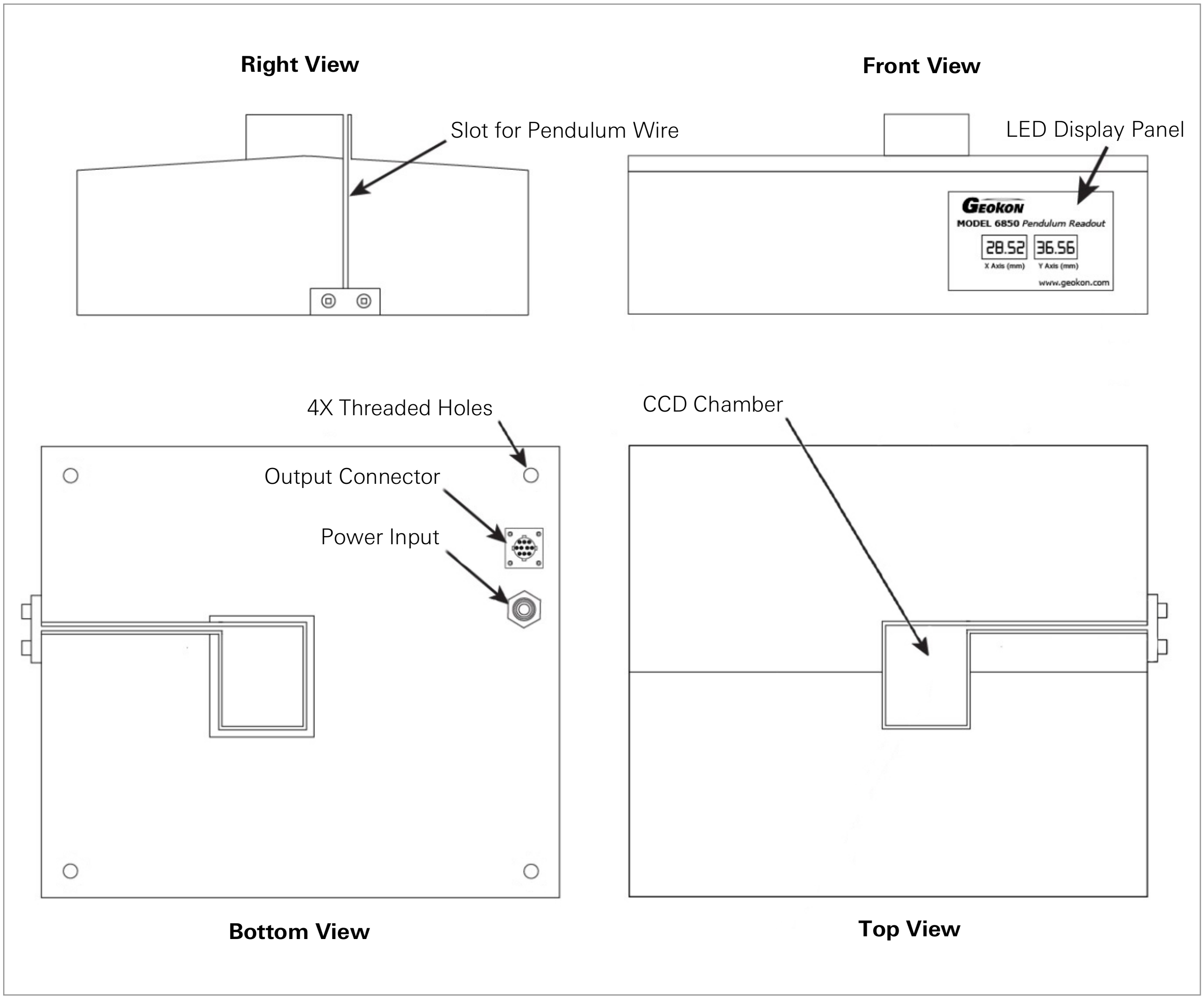


FIGURE 3: *2D Pendulum Readout*

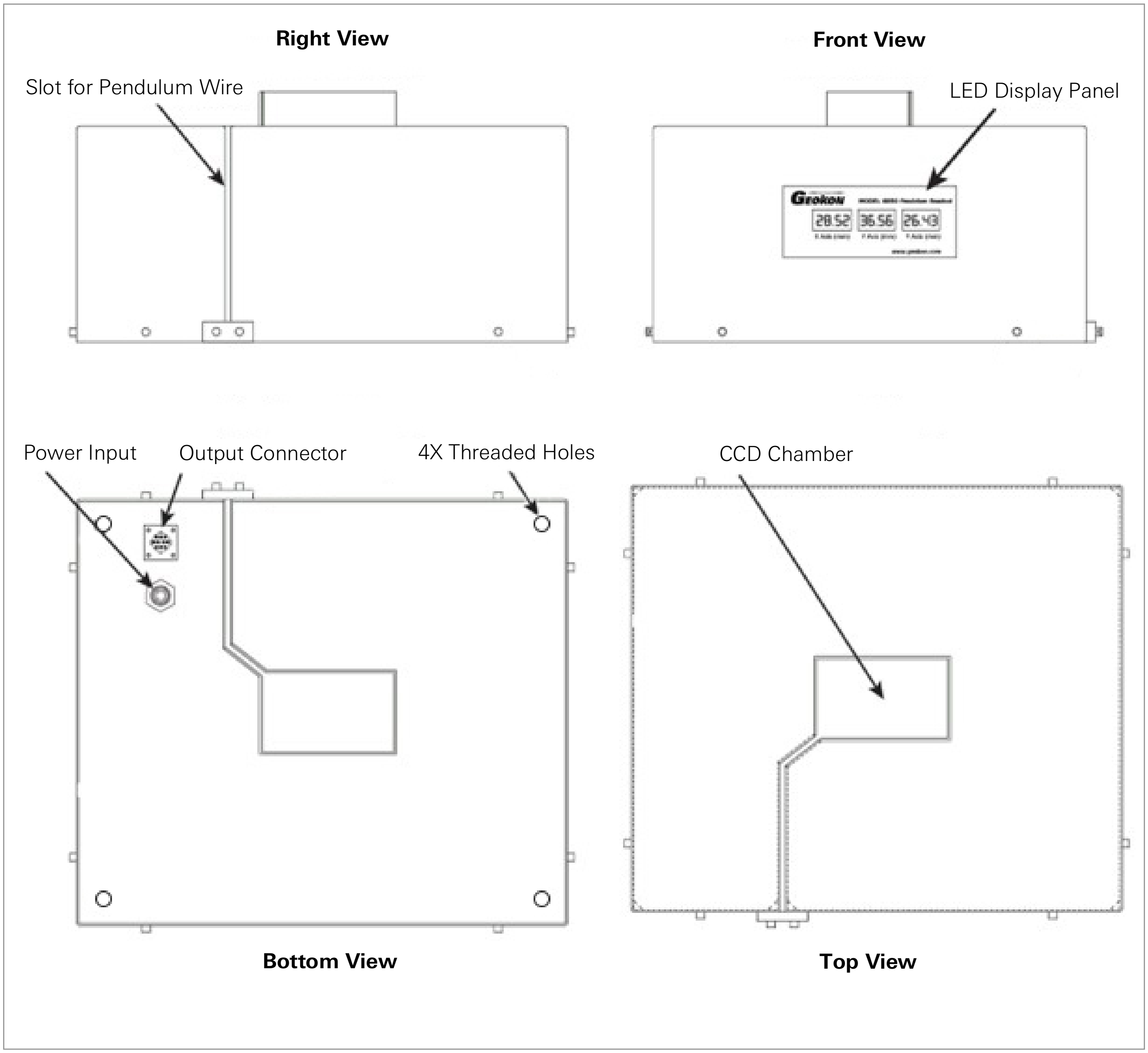


FIGURE 4: *3D Pendulum Readout*

Each pendulum system also comes with the following accessories: An upper and lower light shield, CCDTest software, power cord, readout cable, RS-232 to RS-485 converter, two 400 x 38 x 6 mm (15.7 x 1.5 x 0.24") metal mounting strips, and a roll of hook-and-loop fastener. 3D Systems additionally come with a Z-block.

An optional drip shield may be purchased, which clamps to the pendulum wire and prevents ambient light and water droplets from entering the CCD chamber of the readout.

Normal Pendulum Systems (Models 6850-1-1, 6850-2-1, and 6850-3-1) contain the pendulum readout and its accessories plus a pendulum weight, hanger, damping tank and measurement table.

Inverted Pendulum Systems (Models 6850-1-2, 6850-2-2, and 6850-3-2) contain the pendulum readout and its accessories plus a pendulum anchor, float tank, float, and measurement table.

3. INSTALLATION CONSIDERATIONS

3.1 ORIENTATION AND PLACEMENT

Figure 5 and 6 show the dimensions of the pendulum readout models, as well as the orientation and direction of positive changes in the displacement of the X and Y axes when looking down at the top of the cabinet. For dams, the usual convention is to orient the cabinet so that the positive direction of the Y-axis points downstream, and the positive direction of the X-axis points towards the right bank, the right bank being the bank on the right when facing downstream.

Note that with this orientation, for direct pendulums, a downstream movement of the dam wall (produced by an increase in the height of water behind the dam) will produce a positive increase in the Y-axis direction. Whereas, for a reverse pendulum the same movement would produce a negative change in the Y-axis direction. To avoid confusion, it is best to check the orientations by examination once the installation has been made.

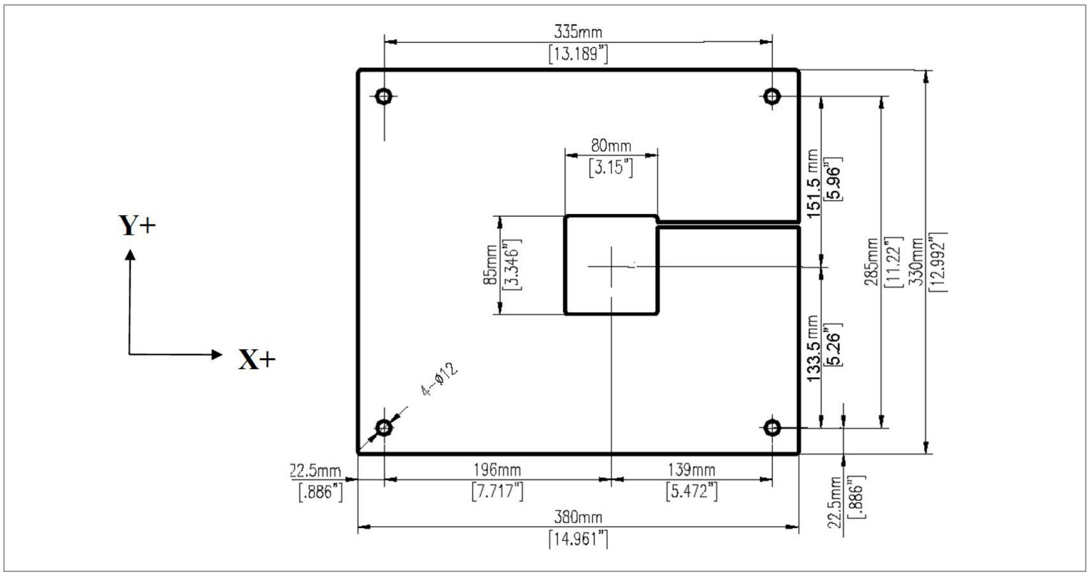


FIGURE 5: *Model 6850-4 (2D, 50 x 50 mm) Dimensions and Orientation*

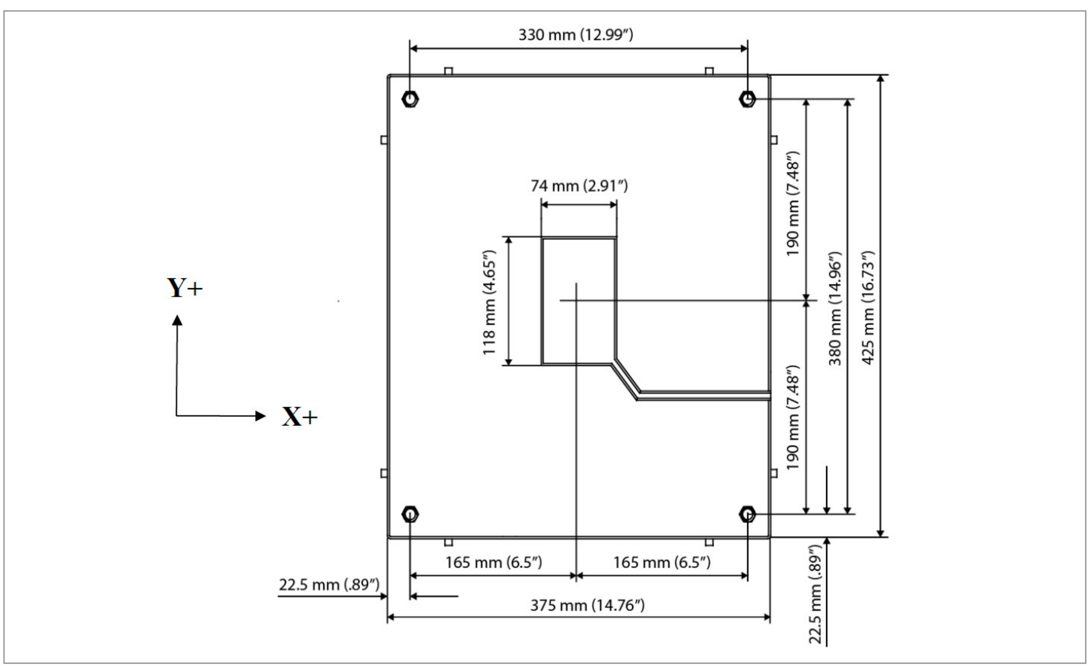


FIGURE 6: *Model 6850-5 (3D, 50 x 100 x 50 mm) and 6850-6 (2D, 50 x 100 mm) Dimensions and Orientation*

4. INSTALLATION

4.1 PRELIMINARY TESTS

Before installation, check the pendulum system for proper functioning.

1. Connect the pendulum to a power supply.
2. Cover the top and bottom of the square hole leading to the CCD chamber so that no light can enter. The readout display should read ‘Err 4’ indicating that the shadow of the pendulum wire is absent.
3. Insert a needle or a piece of wire approximately 1.6 mm (0.63”) in diameter into the CCD chamber in order to simulate the pendulum wire. A reading should register on the X and Y LED displays.
4. When the needle or wire is centered the displays should read:
   - 6850-4 (2D, 50 x 50 mm) Readouts: Both displays should read 25.00 mm. (A 4-20 mA reading should be approximately 12 mA.) Moving the needle back and forth should change the readings from 0 to 50.00 mm.
   - 6850-5 (3D, 50 x 100 x 50 mm) and 6850-6 (2D, 50 x 100 mm) Readouts: The X-axis should read 25.00 mm, and the Y-axis should read 50.00 mm. (A 4-20 mA reading should be approximately 12 mA.) Moving the needle back and forth should change the readings from 0 to 50 mm for the X-axis and 0 to 100 mm for the Y-axis.
5. **For 3D Readouts Only:** Check the Z-axis by clamping the supplied conical Z-block to the wire with the flat face uppermost, and move the Z-block up and down. The Z-axis readings should change from 0 to 50 mm as the block is moved.

4.2 PREPARE THE READOUT

1. Attach the supplied metal mounting strips to the underside of the readout with the supplied metric screws. The mounting strip with additional holes is oriented over the protruding screws on the readout (Figure 7).

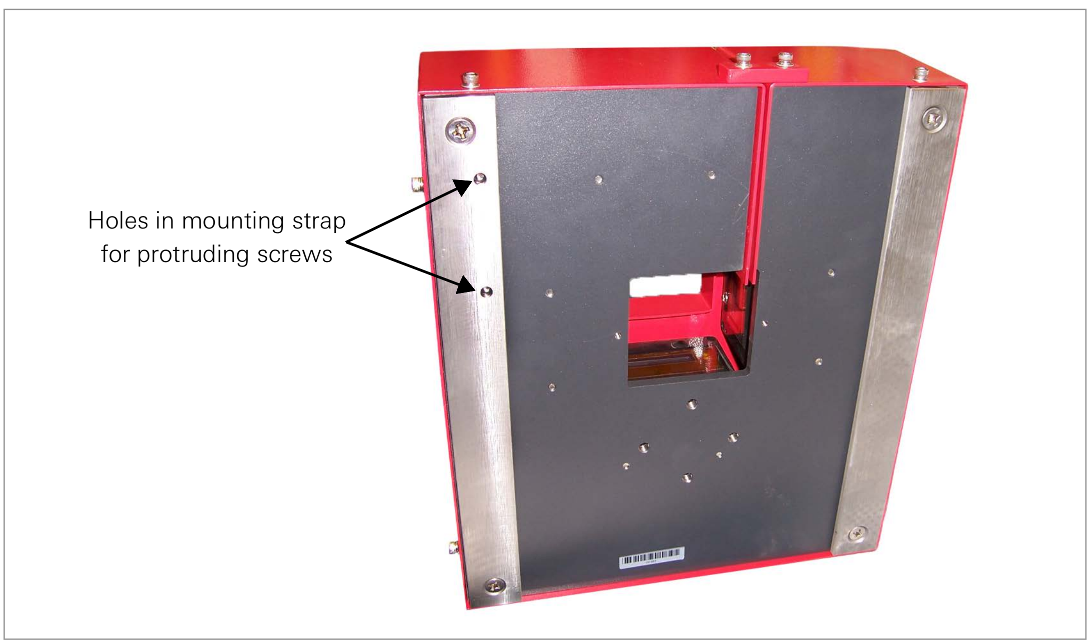


FIGURE 7: *Metal Strips Secured to the Readout*

2. Place two strips of the hook-and-loop fastener on the bottom of the readout along the entire length of the installed metal mounting strips. This will later be used to secure the readout to the pendulum table.

3. Proceed to the installation section for direct (Section 4.3) or inverted (Section 4.4) systems.

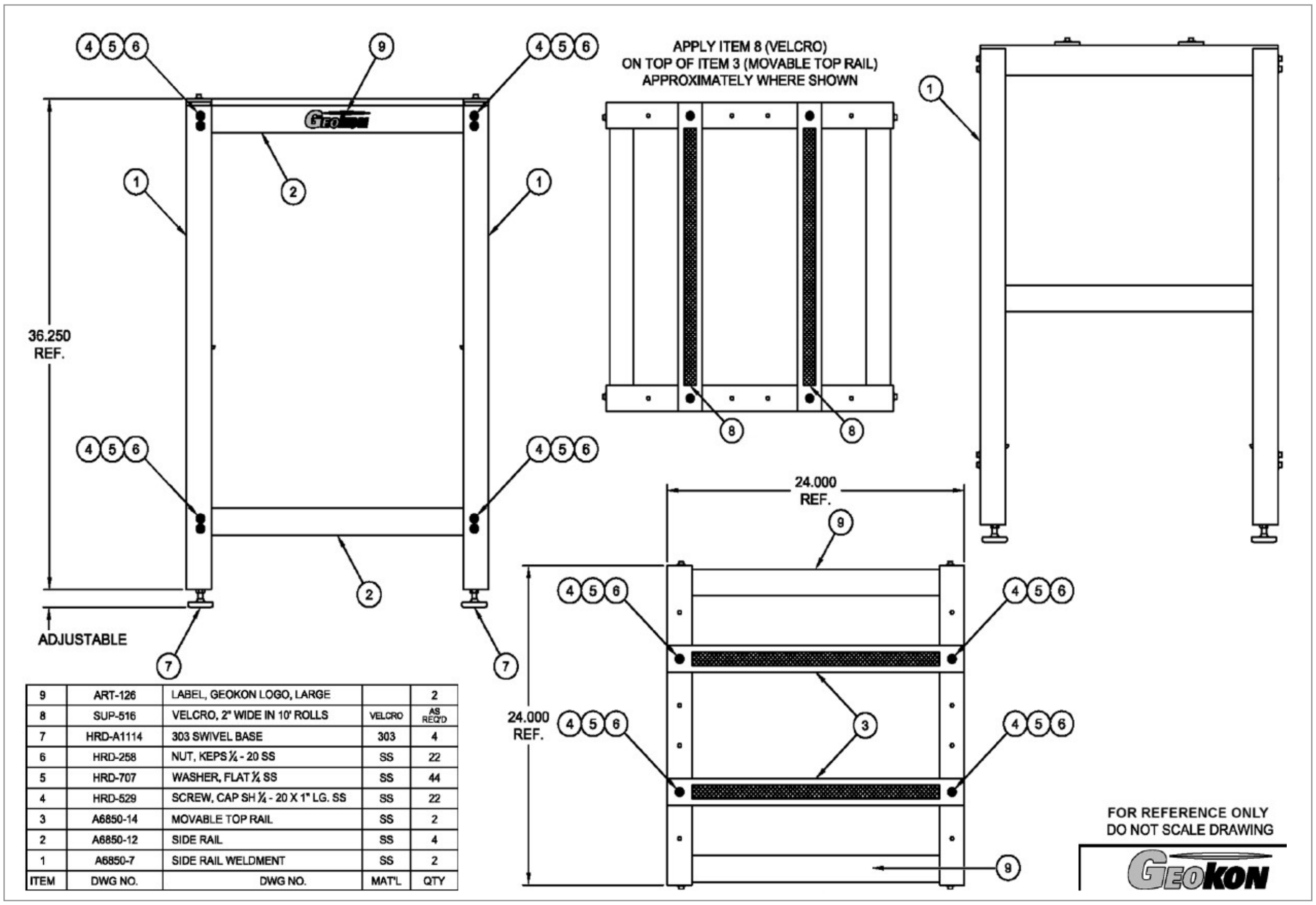
4.3 DIRECT PENDULUM INSTALLATION

Direct pendulums and intermediate stations require that the cabinet be mounted either on a measurement table or on a mounting bracket bolted to a vertical wall. Wall mounting brackets can be made locally, or by GEOKON if the necessary dimensions and orientation are provided. See Appendix E for vertical wall mounting bracket instructions.

4.3.1 PENDULUM TABLE

If the pendulum system was purchased with a measurement table, assemble it per the print shown in Figure 8. The pictures shown in Figure 9 can be used as a general assembly guide.

Note: If the hanging pendulum wire is already in place, assemble the table around the wire.



ITEM	DWG NO.	DWG NO.	MAT'L	QTY
9	ART-126	LABEL, GEOKON LOGO, LARGE		2
8	SUP-516	VELCRO, 2" WIDE IN 10' ROLLS	VELCRO	AS REQ'D
7	HRD-A1114	303 SWIVEL BASE	303	4
6	HRD-258	NUT, KEPS ¼ - 20 SS	SS	22
5	HRD-707	WASHER, FLAT ¼ SS	SS	44
4	HRD-529	SCREW, CAP SH ¼ - 20 X 1" LG. SS	SS	22
3	A6850-14	MOVABLE TOP RAIL	SS	2
2	A6850-12	SIDE RAIL	SS	4
1	A6850-7	SIDE RAIL WELDMENT	SS	2

FIGURE 8: *Direct Pendulum Measurement Table Assembly Drawing*

FIGURE 9: *Measurement Table for Direct Pendulum General Assembly Guide*

4.3.2 SYSTEM ASSEMBLY

1. The wire for the direct pendulum system is normally anchored at the top of a borehole or in the roof of the gallery directly above the drill hole. If the wire is to be anchored to the floor at the top of the drill hole, two angle brackets are required (as shown in Figure 10); if it will be anchored to the ceiling over the hole, just the bracket with the wire guide is used. Mount the angle bracket(s) as follows:
   a. Mark the location of the three mounting holes in the bracket.
   b. Using a hammer drill, drill a 12 mm (0.5”) hole, approximately 37 mm (1.5”) deep at each of the markings.
   c. Clean the holes thoroughly, blow them out with compressed air if possible.
   d. Insert the drop-in anchors, threaded side up, into the holes. Insert the provided setting tool into the anchors and strike with a hammer until the lip of the anchor touches the lip of the setting tool.
   e. Place a washer over each of the cap screws.
   f. Attach the bracket to the ceiling by tightening the cap screws into the anchors using the supplied Allen wrench.
2. Uncoil the pendulum wire in a straight line off the spool to prevent kinks or bending of the wire. The wire can be held down with weights on both ends to avoid kinks, bends, and twisting.
3. Attach the pendulum wire to the bracket by feeding it through the wire guide and then through the eye bolt. Wind the wire around itself to secure (Figure 10).

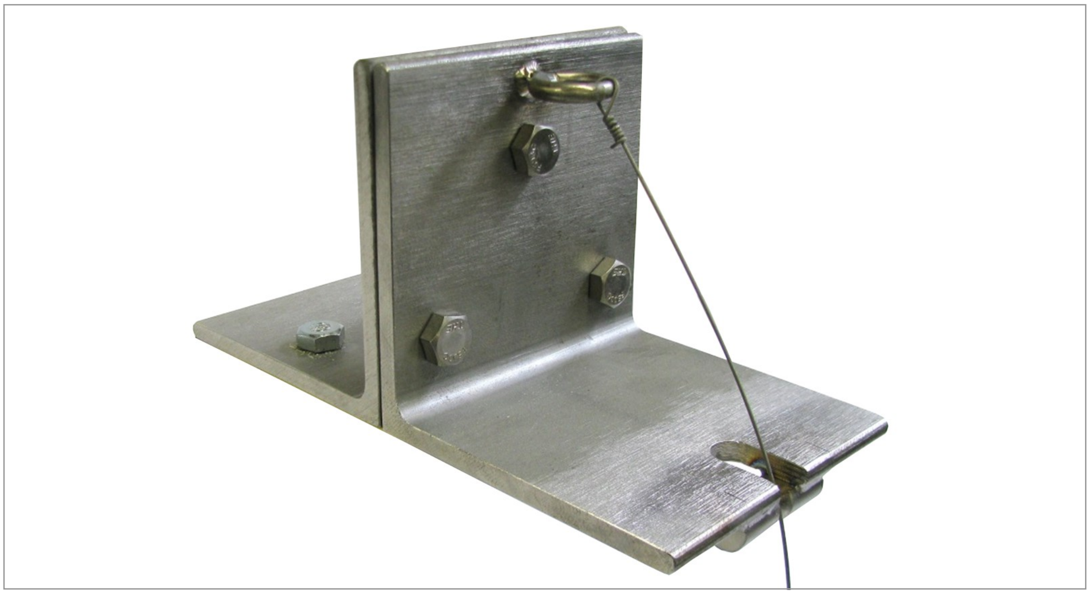


FIGURE 10: *Mounting Brackets With Twisted Wire*

4. Cut the pendulum wire so that when the weight is attached it will be suspended about 50 mm (2”) above the floor. The wire will stretch approximately 25 mm (1”) for every 30 m (99’) of length.
5. Position the measurement table so that the pendulum wire hangs in its center. Orient the table so that the two plates (with installed hook-and-loop fastener) that the pendulum readout will sit on are facing in the upstream/downstream direction.
6. With the aid of a spirit level, level the table using the adjustment screws on the feet.
7. Push the pendulum wire into the wire grip at the top of the weight until it stops.
8. Tighten the set screw against the wire with the wrench provided. Do not use excessive force (18 in/lbs.); experiment with a short piece of wire first.

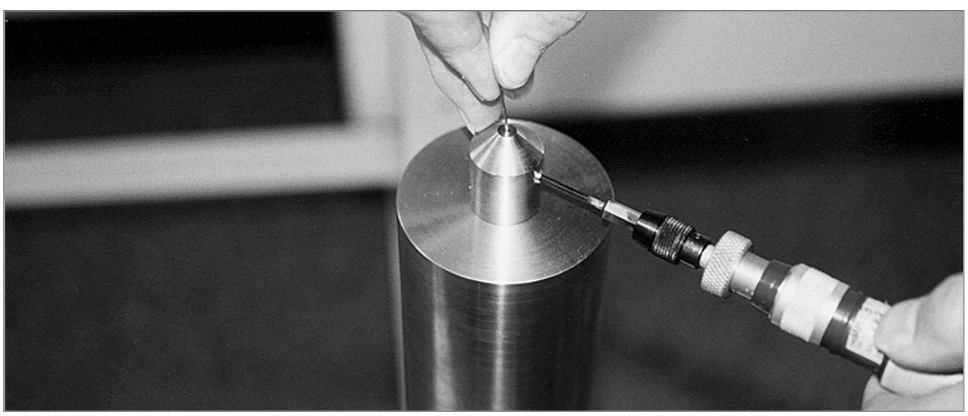


FIGURE 11: *Tighten the Set Screw to the Wire*

9. Place the tank underneath the measurement table.
10. Allow the weight to hang inside the tank.
11. Make any adjustments needed to position the weight correctly inside the tank and then fill the tank with water (or antifreeze solution).
12. Guide the wire through the readout, the procedure is different depending on the readout type:
    - **2D Readouts:** Slide the wire through the slot in the readout unit. Avoid scratching the photosensitive screens inside the CCD chamber.

- **3D Readouts:** Position the Z-block on the pendulum wire at a height of approximately 100 mm (4") above the pendulum table. Using a Phillips head screwdriver, tighten the two screws in the Z-block so that it clamps onto the pendulum wire. Figure 12 shows the positioning of the Z-block. With the readout above the Z-block, slide the wire through the slot in the readout.

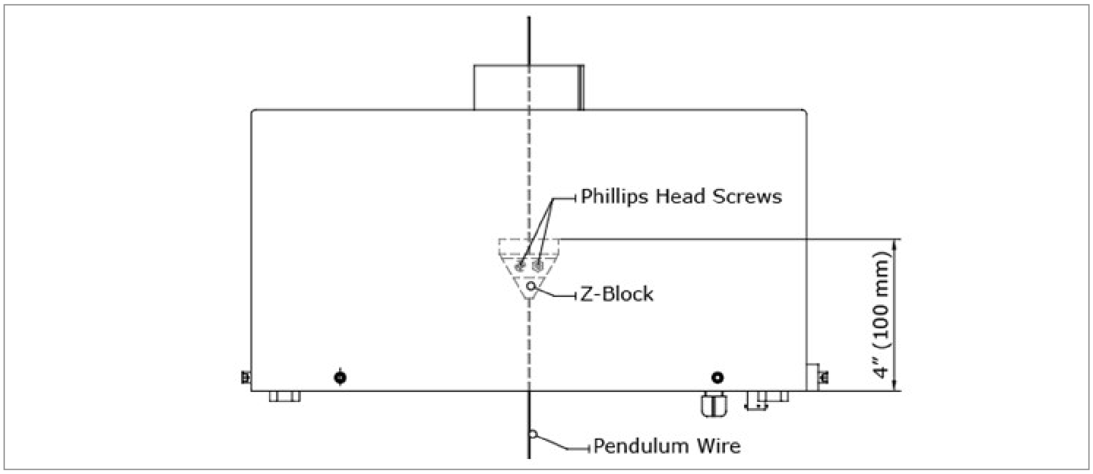


FIGURE 12: *3D Readout, Positioning of the Z-Block*

13. Orient the Y-axis of the cabinet so that it points in an upstream/downstream direction; orient the X-axis so that the positive direction points towards the right bank. The cabinet can be positioned so that the wire is centered in the CDC chamber, or offset to accommodate the maximum movements anticipated.
14. Lower the readout onto the table so that hook-and-loop fastener strips on the bottom of the cabinet contact the ones on the mounting surface. Figure 13 shows the assembly thus far.

Caution! With 3D readouts, avoid scratching the photosensitive screens inside the CCD chamber with the Z-block.

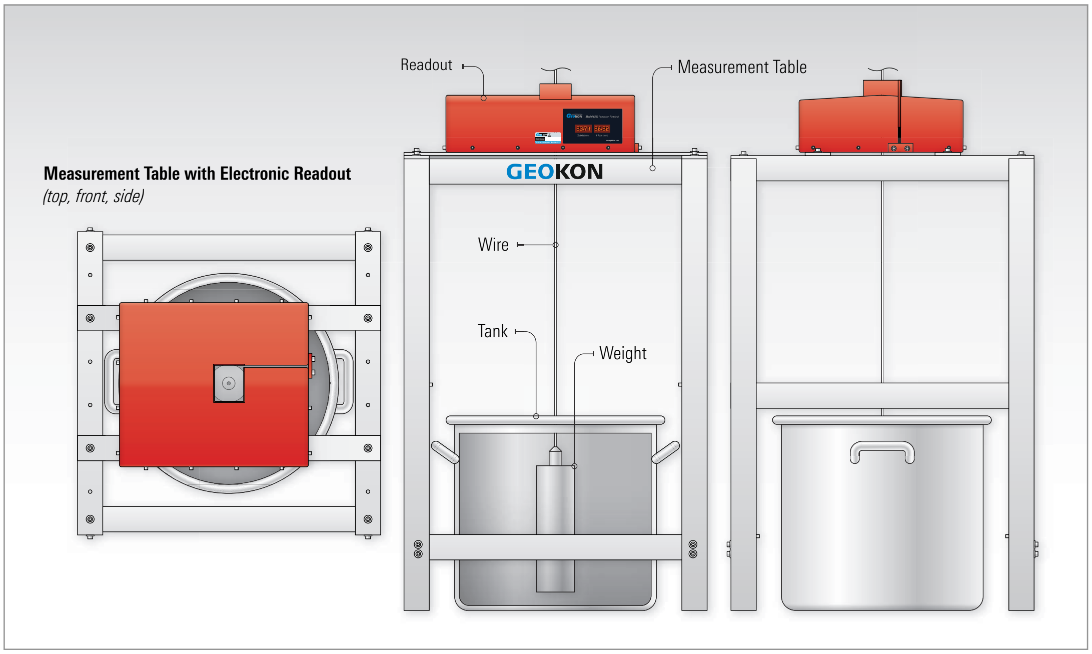


FIGURE 13: *Direct Pendulum System with Measurement Table*

15. Attach the upper and lower light shields to the cabinet as shown in Figure 14 with the supplied screws.

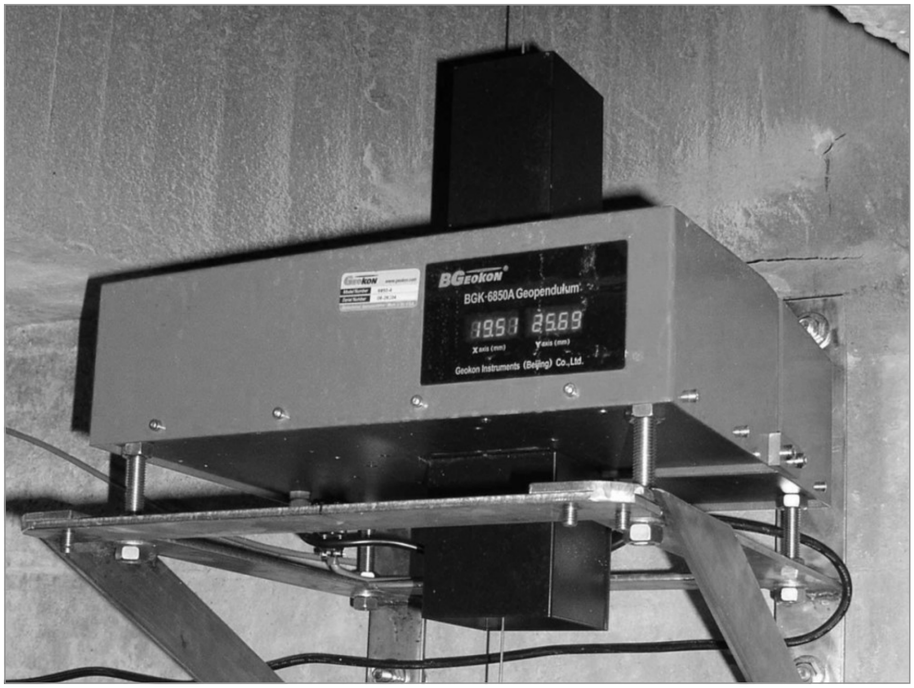


FIGURE 14: Light Shields Installed, Image for Reference Use Only

16. If a conical drip shield was purchased, use the wrench provided to tighten the nylon set screws onto the pendulum wire. Spacing will be different depending on if a light shield is installed:
    - **If not light shield is installed:** Leave about a one-centimeter gap between the conical drip shield and the readout (Figure 15).
    - **If a light shield is installed:** Leave the bottom of the conical drip shield approximately 1 cm (0.4”) above the top of the light shield.

FIGURE 15: Conical Drip Shield Installed, with No Light Shield. Image for Reference Use Only

17. Take initial readings for the axes. See Section 5 for data processing.

4.4 INVERTED PENDULUM INSTALLATION

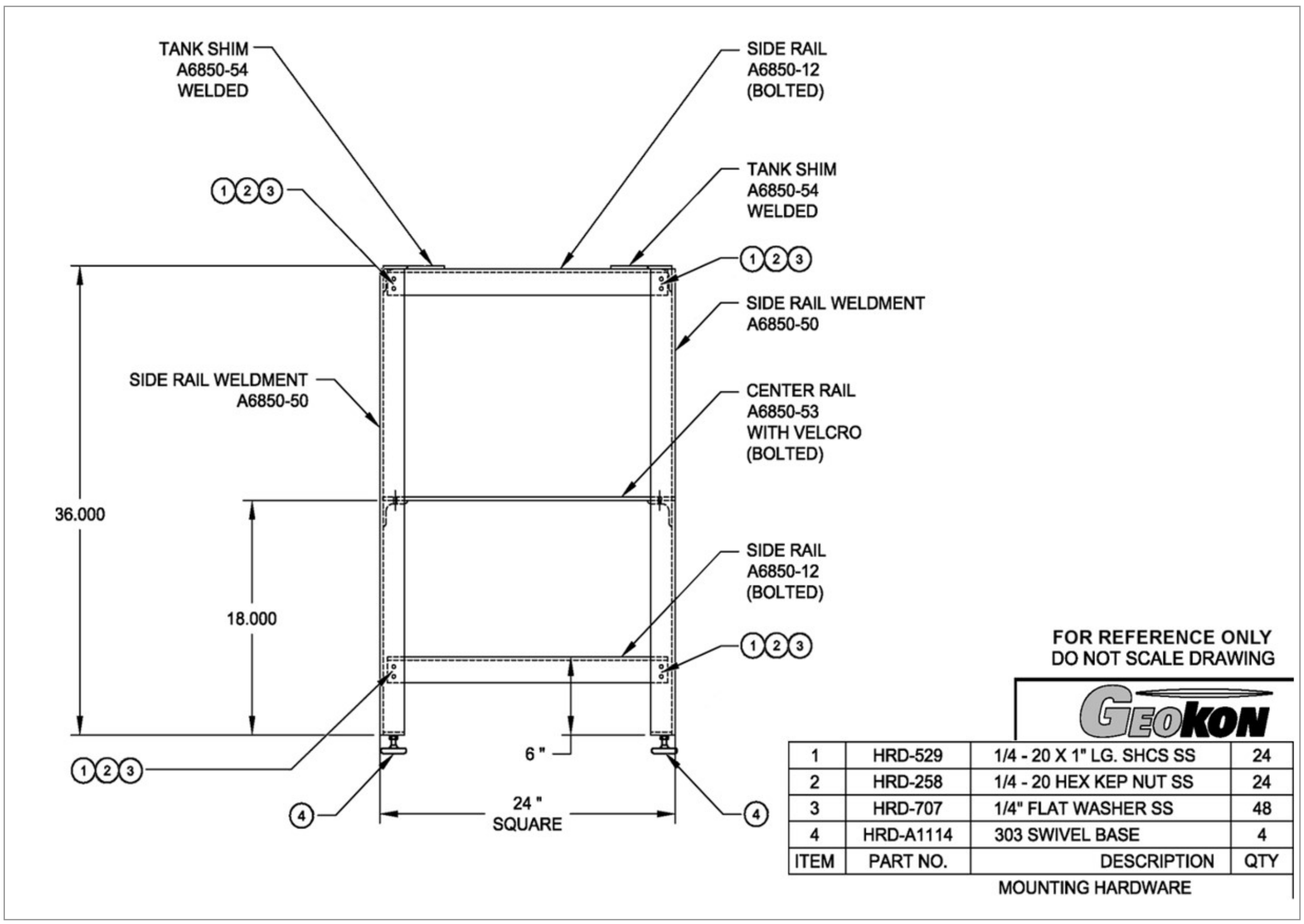
Inverted pendulum systems are designed for use in vertical holes to measure displacement relative to a fixed anchor point below the readout system. The grout anchor is installed inside a vertical hole drilled or erected inside the embankment. This vertical hole must be of sufficient diameter so that the stainless steel wire, which is attached to the anchor, will never contact the sides of the hole.

The pendulum wire is kept vertical and taut by means of a float attached to the upper end of the wire. The float is installed inside a donut shaped tank, which is partially filled with water, causing the center of the float to always be vertically aligned with the anchor point. Any lateral displacement of the upper part of the assembly relative to the lower part – by either sliding or tilting – causes the float and the wire to move relative to the donut shaped tank, as well as to the table support on which the tank and electronic readout sit.

4.4.1 INVERTED PENDULUM TABLE ASSEMBLY

If the pendulum system was purchased with a measurement table, assemble it per the print shown in Figure 16. The pictures shown in Figure 17 can be used as a general assembly guide.

Note: If the hanging pendulum wire is already in place, assemble the table around the wire.



ITEM	PART NO.	DESCRIPTION	QTY
1	HRD-529	1/4 - 20 X 1" LG. SHCS SS	24
2	HRD-258	1/4 - 20 HEX KEP NUT SS	24
3	HRD-707	1/4" FLAT WASHER SS	48
4	HRD-A1114	303 SWIVEL BASE	4

FIGURE 16: *Inverted Pendulum Measurement Table Assembly Drawing*

FIGURE 17: *Measurement Table for Inverted Pendulum General Assembly Guide*

4.4.2 SYSTEM ASSEMBLY

1. Assemble the two halves of the grout anchor by threading them together.

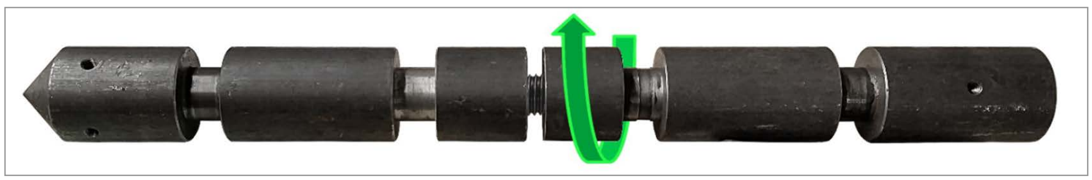


FIGURE 18: *Assemble the Two Large Anchor Pieces*

2. Loosen or remove the Phillips head screws from the wire clamp. Slide the stainless steel wire through the back of the anchor nut, then through the flat side of the wire clamp (i.e., not the side with the conical indentation).

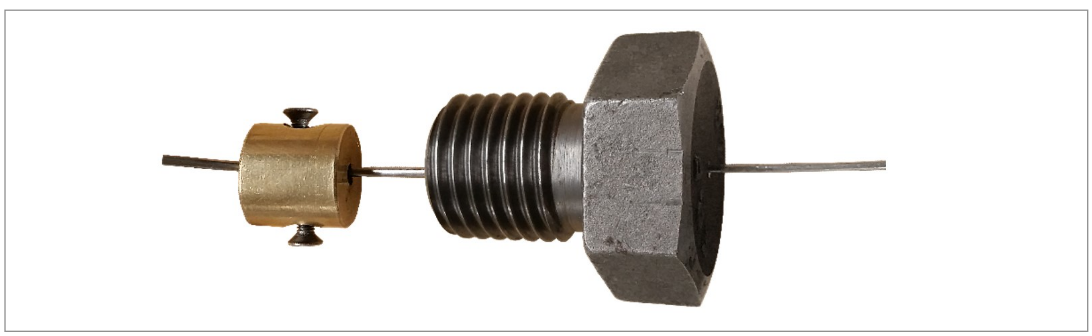


FIGURE 19: *Wire Inserted Through Anchor Nut and Wire Clamp*

3. Loop the end of the stainless steel wire around the groove in the end block then slide it back through the wire clamp until it emerges on the other side. Push the wire clamp and the end block as close together as possible then tighten the two Phillips head screws to secure the wire in place. Figure 20 shows the completed end block and wire clamp assembly.

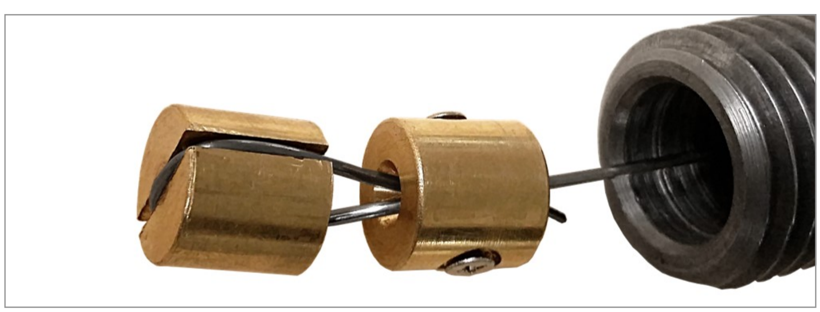


FIGURE 20: *End Block and Wire Clamp Assembly*

4. Slide the end block and wire clamp into the anchor nut.

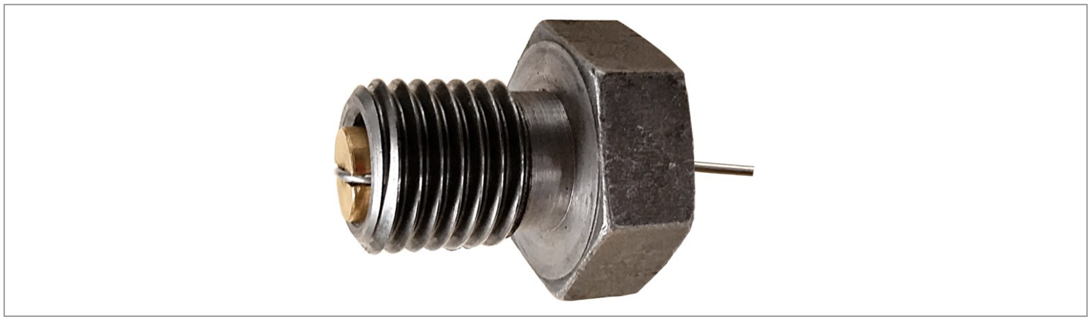


FIGURE 21: *Wire Clamp and End Block Seated Inside Anchor Nut*

5. Thread the anchor mating end into the anchor nut (Figure 22). The completed anchor and wire assembly is shown in Figure 23.

Important! Do not twist the wire during this process, rotate the anchor to tighten.

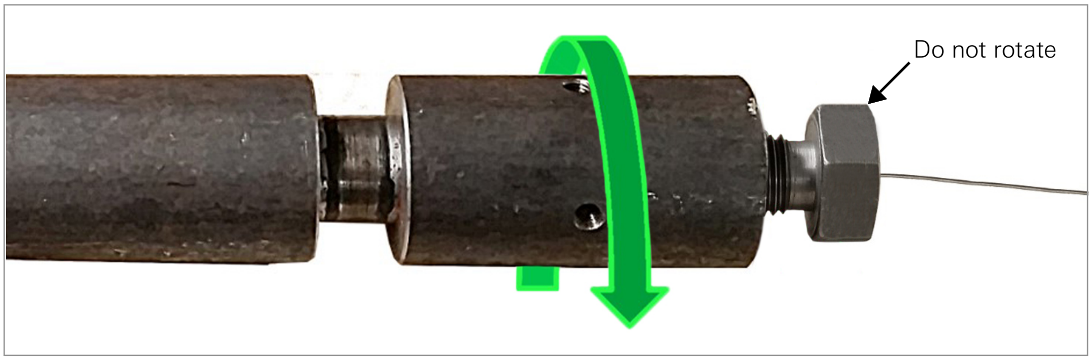


FIGURE 22: *Anchor Nut Attachment*

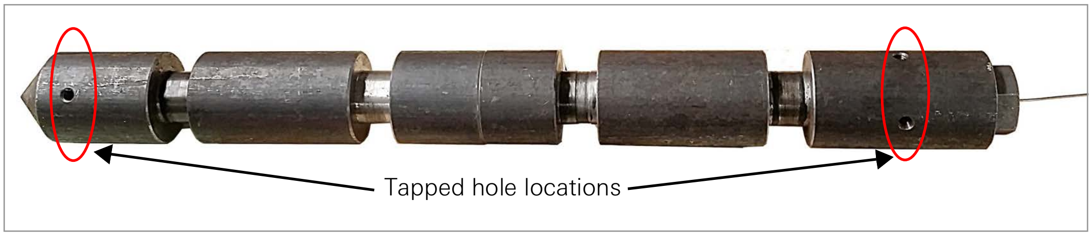


FIGURE 23: *Completed Anchor Assembly*

6. Install four customer supplied M10 bolts of sufficient length (based on the borehole diameter) into the tapped holes at the top and bottom of the anchor (locations shown in Figure 23) to help centralize the anchor in the drilled borehole.
7. Lower the anchor into the borehole and let it rest at the bottom of the hole, keeping the wire centralized.
8. Tremie cement grout (mixed to a creamy consistency, similar to pancake batter) into the borehole until it almost encases the anchor, but does not cover the top of the anchor. Allow the grout to fully cure before proceeding.
9. Position the measurement table so that it is centered over the top of the borehole. Orient the table so that the two plates the pendulum readout will sit on are facing in the upstream/ downstream direction.
10. With the aid of a spirit level, level the table using the adjustment screws on the feet.
11. Place the tank on top of the table.
12. Pass the wire up through the table and through the central hole in the tank.

13. Secure the clamp rod to the top of the float using the two large, knurled nuts.
14. Pass the wire up through the clamp rod and out the top.
15. Lower the float into the tank.
16. Push the end of the stainless steel wire through the hole in the upper wire clamp and out the hole in the side. Push the upper wire clamp along the wire until it is approximately 50 mm (2") away from the top of the clamp rod.
17. Tighten the upper wire clamp onto the wire. Cut off any excess wire.
18. After the grout in the borehole has set up sufficiently, pour water (or antifreeze solution) into the tank to raise the float and exert tension in the stainless steel wire. Continue to add water until the upper clamp can be seated inside the top of the clamp rod.
19. Make sure the float is centralized within the tank (move the table if necessary).
20. Add more water until the tension on the stainless steel wire is around 60 kilograms (132 lbs). The sides of the float should be submerged approximately 200 mm (8").
21. Tighten the pin vise to the stainless steel wire.
22. Guide the wire through the readout, this procedure is different depending on the readout type:
    - **2D Readouts:** Slide the wire through the slot in the readout unit. Avoid scratching the photosensitive screens inside the CCD chamber.
    - **3D Readouts:** Position the Z-block on the pendulum wire at a height of approximately 100 mm (4") above the pendulum table. Using a Phillips head screwdriver, tighten the two screws in the Z-block so that it clamps onto the pendulum wire. Figure 25 shows the positioning of the Z-block. With the readout above the Z-block, slide the wire through the slot in the readout.

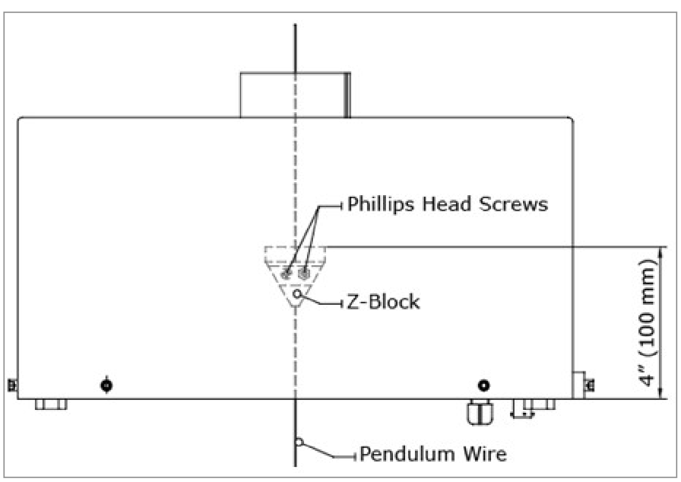


FIGURE 25: *3D Readout, Positioning of the Z-Block*

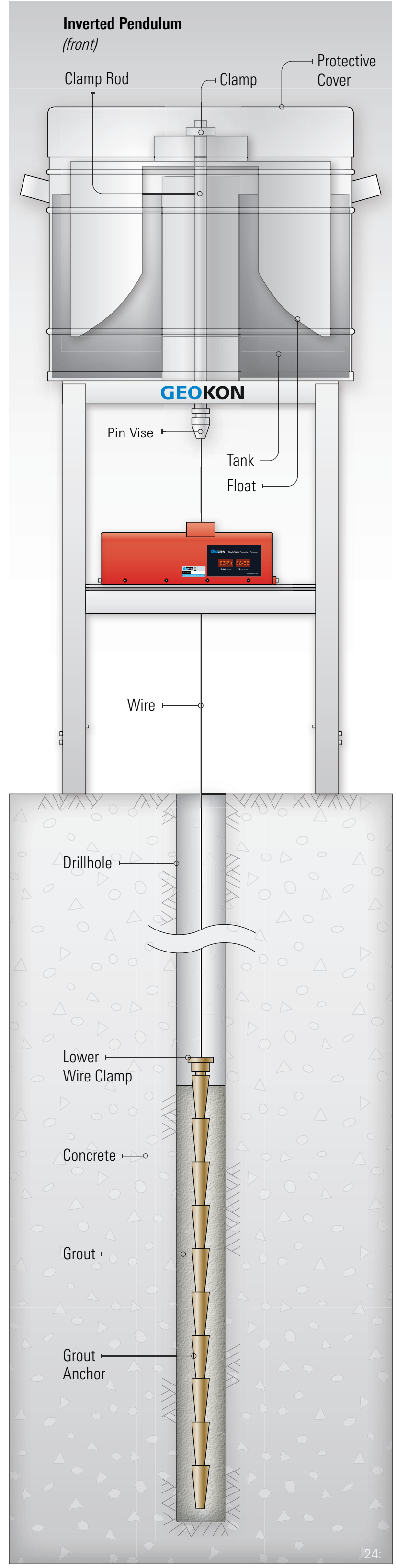


FIGURE 24: *Inverted Pendulum System*

23. Orient the Y-axis of the cabinet so that it points in an upstream/downstream direction; orient the X-axis so that the positive direction points towards the right bank. The cabinet can be positioned so that the wire is centered in the CDC chamber, or offset to accommodate the maximum movements anticipated.
24. Lower the readout onto the table so that Velcro strips on the bottom of the cabinet contact the ones on the mounting surface. Figure 24 depicts the assembly thus far.

Caution! With 3D readouts, avoid scratching the photosensitive screens inside the CCD chamber with the Z-block.

25. Attach the upper and lower light shields to the cabinet as shown in Figure 26 with the supplied screws.

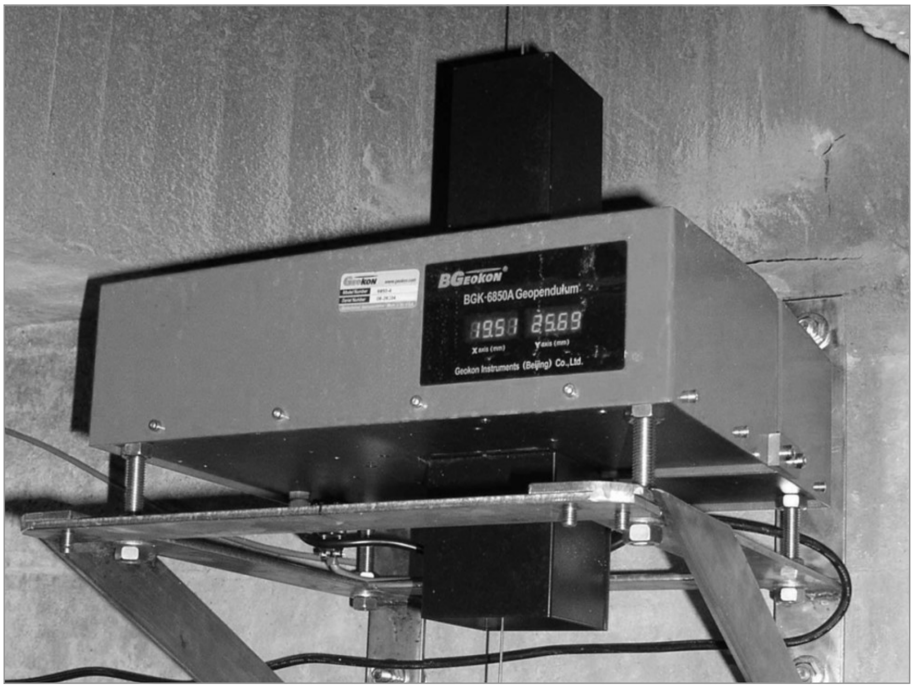


FIGURE 26: *Light Shields Installed, Image for Reference Use Only*

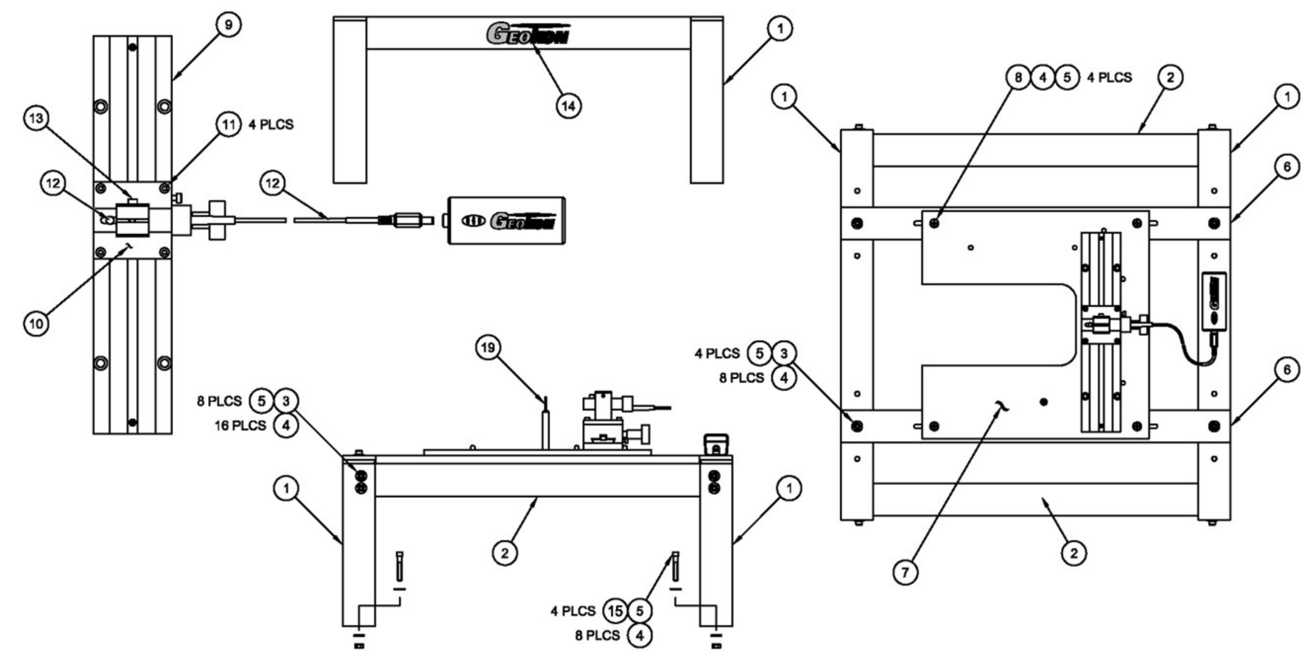
26. Take initial readings for the axes. See Section 5 for data processing.

4.5 OPTICAL MANUAL READOUT WITH LED LIGHT BEAM

The GEOKON Model 6850-10 Optical Manual Readout is designed to be used **only with 2D readout systems** where automated systems are not necessary, or where a manual reading backup is required.

Assemble the table and optical readout per the print shown in Figure 27. The optical readout may also be purchased with wall mounting brackets (Model 6850-9). Contact GEOKON for more information.

Note: If the hanging pendulum wire is already in place, assemble the table around the wire.



∗ INCLUDES SPARES

ITEM	DWG NO.	DESCRIPTION	MAT'L	QTY
9	ELC-257	STAGE & TRACK COMBINATION 250MM	ALUM.	1
8	HRD-766	SCREW, ¼ - 20 X 1" LG. FHP 316SS	SS	8 ∗
7	B6850-22	MANUAL READING TABLE	ALUM.	1
6	B6850-18	MANUAL READING TABLE FRAME TOP RAIL	SS	2
5	HRD-258	NUT, KEPS ¼ - 20 SS	SS	30 ∗
4	HRD-707	WASHER, FLAT ¼ SS	SS	70 ∗
3	HRD-529	SCREW, CAP SH ¼ - 20 X 1" LG. SS	SS	17 ∗
2	B6850-25	MANUAL READING TABLE SIDE RAIL	SS	2
1	B6850-28	MANUAL READING TABLE FRAME WELDMENT	SS	2

FOR REFERENCE ONLY
DO NOT SCALE DRAWING

ITEM	DWG NO.	DESCRIPTION	MAT'L	QTY
19	B6850-27	MANUAL READING TABLE CALIBRATION POINTER		1
18	TLS-227	ALLEN WRENCH, 3MM (FOR ITEM 11)		1
17	TLS-205	ALLEN WRENCH, 3/16" (FOR ITEM 3 & 15)		1
16	TLS-108	ALLEN WRENCH, 9/64" (FOR ITEM 13)		1
15	HRD-538	SCREW, CAP SH ¼ - 20 X 1-½" LG. SS		8 ∗
14	ART-126	LABEL, GEOKON LOGO, LARGE		1
13	HRD-421	SCREW, CAP SH 8 - 32 X ¾ ALLOY, BLACK	ALLOY	1
12	S-A6850-29	LED POINTER AND POWER SUPPLY ASSEMBLY		1
11	HRD-776	SCREW, SH M4 X .7 X 10 MM LG. BLACK OXIDE	ALLOY	4
10	B6850-23	MANUAL READING TABLE LED POINTER HOLDER	ALUM.	1

FIGURE 27: *Drawing of the Optical Manual Readout with LED Light Beam*

4.5.1 SYSTEM ASSEMBLY

1. Mount the assembled optical readout and table to the top of the measurement table using the four cap screws and lock washers provided (Figure 28). Make sure that the holes in the top rails of the upper table line up with the matching holes in the lower table.

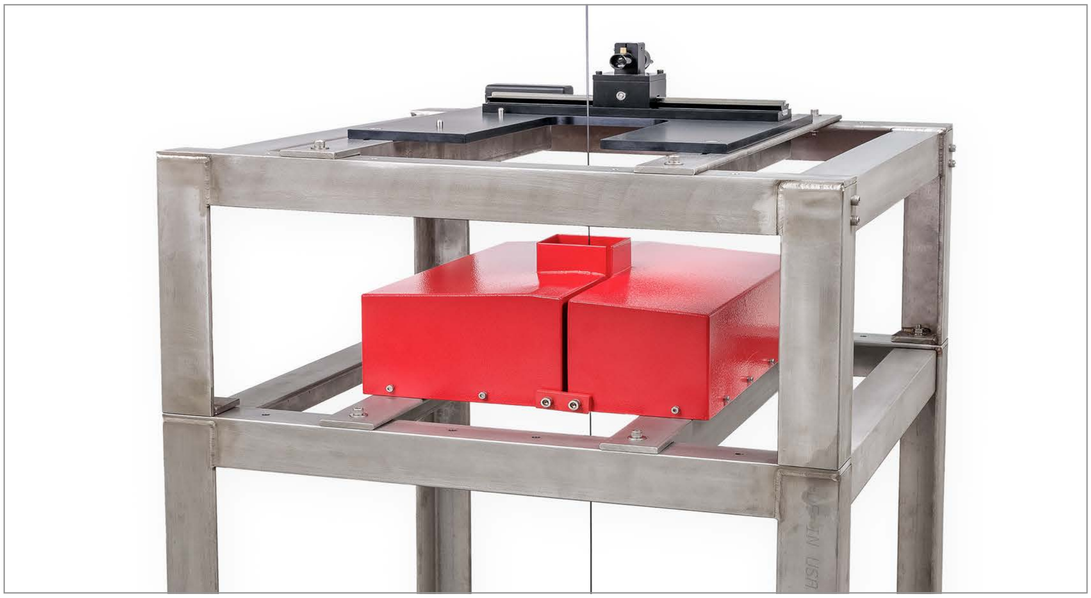


FIGURE 28: *Optical Readout and Table Mounted to Measurement Table*

2. Place the LED collimator on top of the U-shaped mounting plate so that the side with the vernier scale rests against two pegs and the left end rests against a third peg.

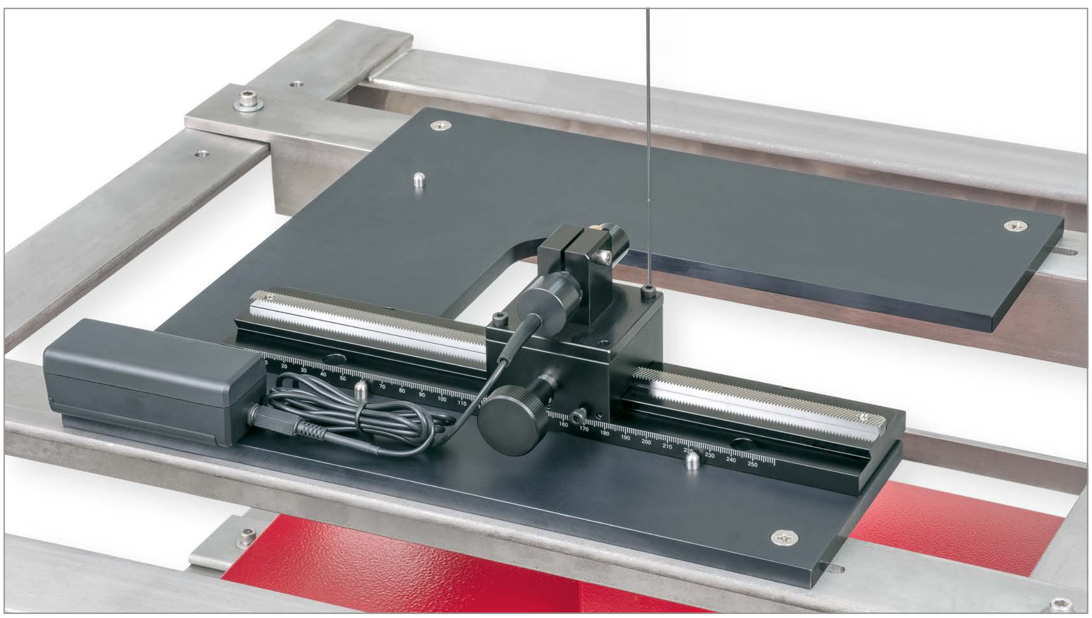


FIGURE 29: *Manual Readout in Position One*

3. Power the unit by plugging the LED into the battery pack.
4. Take a reading for the current axis by turning the vernier screw until the LED light shines on the center of the pendulum wire. Record the position of the collimator relative to the vernier scale.
5. Place the LED collimator on top of the U-shaped mounting plate at a 90-degree angle from the first position. Once again, position it so that the vernier scale side rests against two pegs, this time placing the right end against the third peg, as shown in Figure 30.

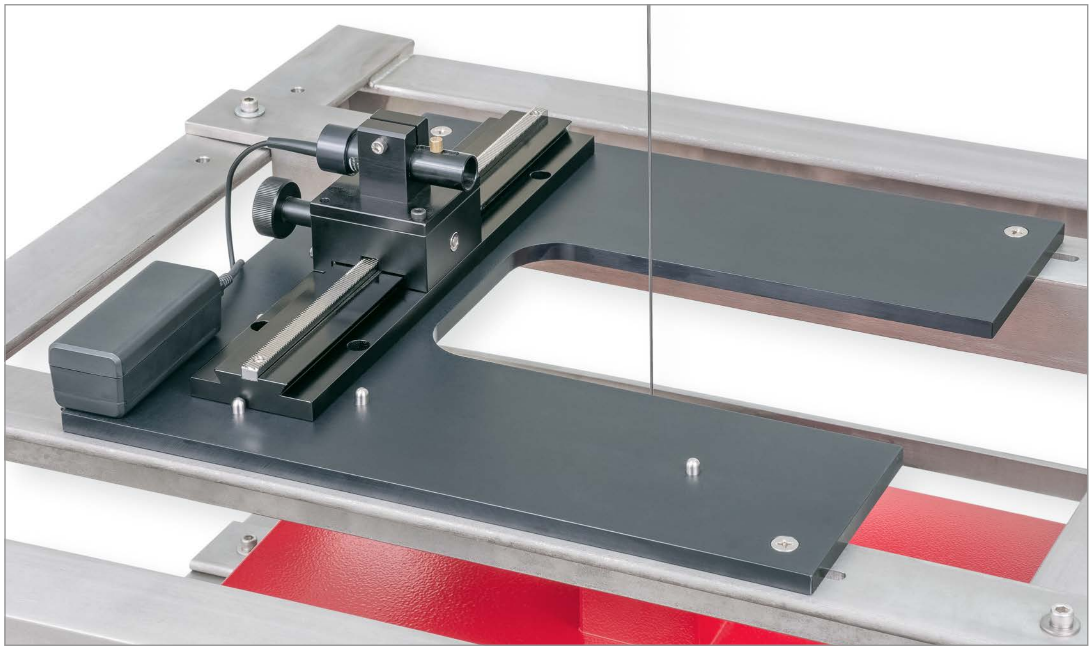


FIGURE 30: *Manual Readout in Position Two*

6. Take a reading for the current axis. Subsequent readings are taken in the same manner. For information on data processing, see Section 5.

4.5.2 CALIBRATION POINTER

The Model 6850-10 Optical Manual Readout is shipped with a calibration pointer, which is a fixed target that can be used to confirm that the manual readout is working properly. To use the calibration pointer complete the following:

1. Screw the calibration pointer into the threaded hole in the mounting plate.

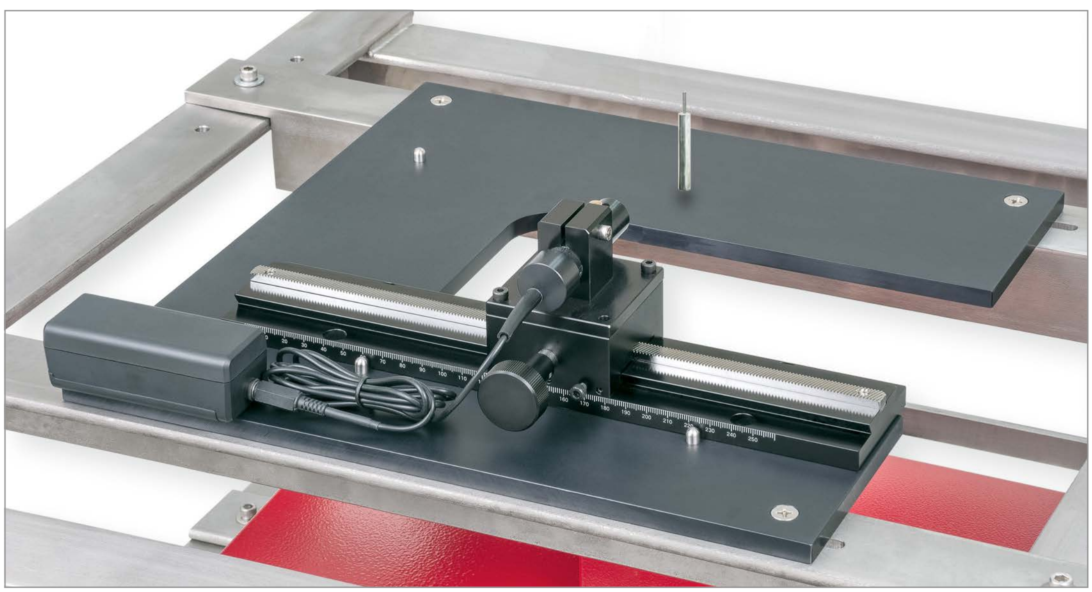


FIGURE 31: *Calibration Pointer Attached to the Mounting Plate*

2. Attach the LED to the battery and adjust the vernier screw, turning it until the LED light shines on the center of the roll pin attached to the top of the pointer. Record the reading. The reading taken with the calibration pointer should not change over time. If it does, correct the pendulum wire reading by adding the change in the calibration position.

5. DATA ACQUISITION AND REMOTE MONITORING

5.1 DATA CALCULATION

Initial values of the axes should be obtained during installation. For 2D readout systems, calculate the X and Y axes. For 3D readout systems, calculate for X, Y, and Z axes.

Movements of the pendulum wire (ΔX, ΔY, and ΔZ) as displayed on the readout cabinet in mm are derived from the equations:

$$\Delta X = X_1 - X_0$$

EQUATION 1: *Movement of the Pendulum Along the X-Axis*

$$\Delta Y = Y_1 - Y_0$$

EQUATION 2: *Movement of the Pendulum Along the Y-Axis*

$$\Delta Z = Z_1 - Z_0$$

EQUATION 3: *Movement of the Pendulum Along the Z-Axis*

Where:
X_0 = The initial reading of the X-axis.
Y_0 = The initial reading of the Y-axis.
Z_0 = The initial reading of the Z-axis.
X_1 = The current reading of the X-axis.
Y_1 = The current reading of the Y-axis.
Z_1 = The current reading of the Z-axis.

When using the 4-20 mA output the actual displacements of the wire in mm is obtained by multiplying each of the measured ΔX and ΔZ by the calibration factor 3.125 mm/mA and the measured ΔY by 6.25 mm/mA

5.2 RS-485 COMMUNICATIONS

In addition to providing on site monitoring, the readout also has an RS-485 digital interface. Each 6850 pendulum readout has a unique network address. Up to 32 pendulum readouts can be connected together through the RS-485 interface, as shown in Figure 32.

Caution! To prevent damage to the communications port, the RS-485 connection must be three wire. In addition, all devices on the network must be connected to a common ground!

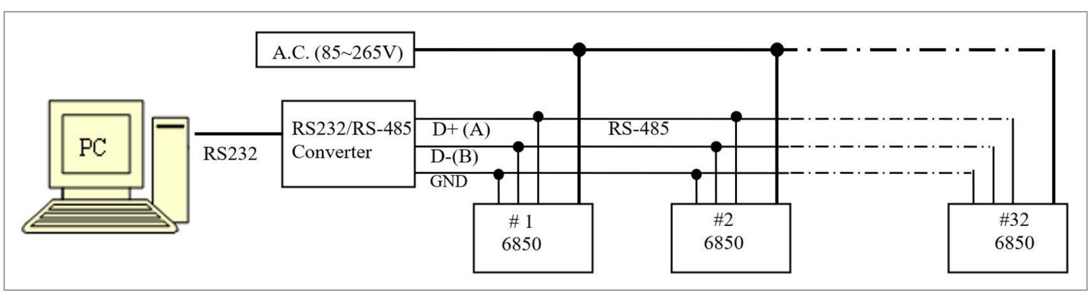


FIGURE 32: *The RS-485 Addressable Network*

When using the RS-485 network the distance to the farthest pendulum should not exceed 1200 m (3937’). In order to decrease signal reflectance, a 120-ohm resistance must be connected at the most remote pendulum, through a parallel connection to the RS-485 connector. If the transmission distance exceeds 1200 m (3937’), a fiber optic cable can be used.

Note: With fiber optic cables, there is no limit on the transmission distance and up to 99 pendulums can be connected into the network.

5.3 4-20 MA ANALOGUE OUTPUT

In addition to providing onsite monitoring, the 6850 pendulum readout also has a 4-20 mA analogue output. The pendulum readout's 4-20 mA output can be measured using a high precision (0.1%) digital ammeter, e.g., the 20 mA level of a 4.5-bit digital multimeter, or any standard datalogger. If ammeters are used, one is required per each axis on each readout unit (2 for a single 2D readout, 3 for a single 3D readout).

5.4 WIRING DIAGRAMS

The Power connector located on the base of the cabinet is wired as follows:

Power Cord Three Conductor	Label	Function
Red	L	Line
Blue	N	Neutral
Yellow	GND	Ground

TABLE 1: *Power Cord Connections*

Every Pendulum System ships with an RS-485/4-20 mA cable equipped with a 10-pin bulkhead connector. These cables are wired as shown in Table 2.

10-Pin Bendix Connector RS-485 and 4-20mA	Function	Cable Wire Color
A	X-axis 4-20 mA output	Red
B	X-axis ground	Red's Black
C	Y-axis 4-20 mA output	White
D	Y-axis ground	White's Black
E	None	Shield
F	RS-485 T/R -	Green
G	RS-485 T/R +	Green's Black
H	None	N/C
K	Z-axis 4-20 mA output (3D Readouts Only)	Yellow
J	Z-axis ground (3D Readouts Only)	Yellow's Black

TABLE 2: *RS-485 and 4-20 mA Connector*

6. CCDTEST SOFTWARE

Note: These Instructions were written for the 2-axis (2D) readout but can be extrapolated to the 3-axis (3D) readout.

The Pendulum System comes with a copy of CCDTest software, used for setting the pendulum parameters and checking the operation of the unit. Use the supplied installer to install the software. (For details on how to use the Pendulum System with MultiLogger software, see Appendix B.)

6.1 INITIAL SETUP

Upon opening, the program will default to the main screen.

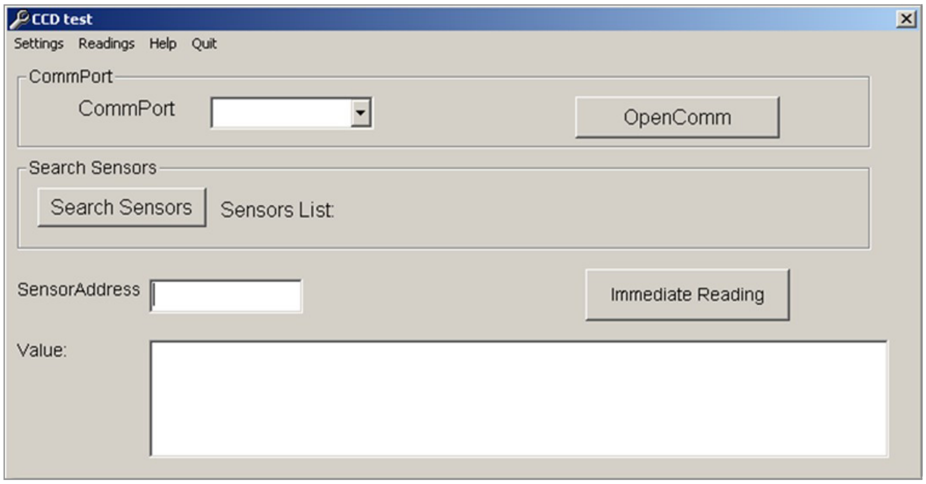


FIGURE 33: *CCDTest User Interface*

1. In the CommPort section of the screen:

   - select the CommPort that has the RS-485 adaptor attached, then select **OpenComm**.

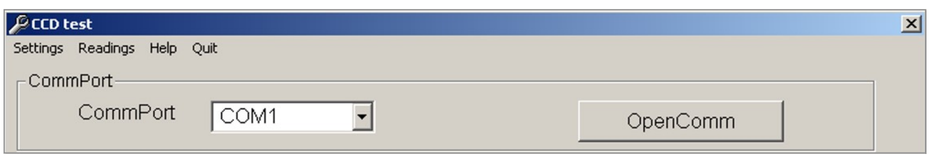


FIGURE 34: *Select CommPort*

   - If unsure of the address, select **Search Sensors**. This will cause the software to attempt to locate the correct CommPort.

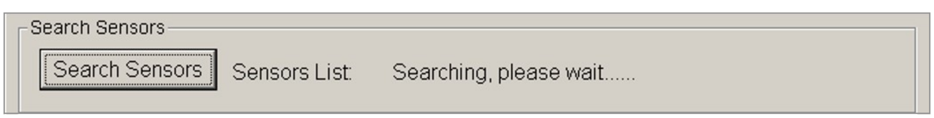


FIGURE 35: *Search Sensors*

2. Sensors found will be shown in the Sensors List. Enter the Sensor Address of the pendulum the software will communicate with in the SensorAddress field. In Figure 36, sensor address 15 was found and subsequently entered into the SensorAddress field.

FIGURE 36: *Sensor Address*

3. Select **Immediate Reading**. The program will take measurements from the attached pendulum every 10 seconds. These measurements will be displayed in the Value: section of the screen. From left to right the readings are displayed as follows: Time Stamp, X-axis Value, Y-axis value. Note any errors shown and troubleshoot if necessary. See Section 7 for troubleshooting tips and an explanation of the error codes. To clear the readings displayed in the Value field select the **Stop** button then restart the Immediate Readings.

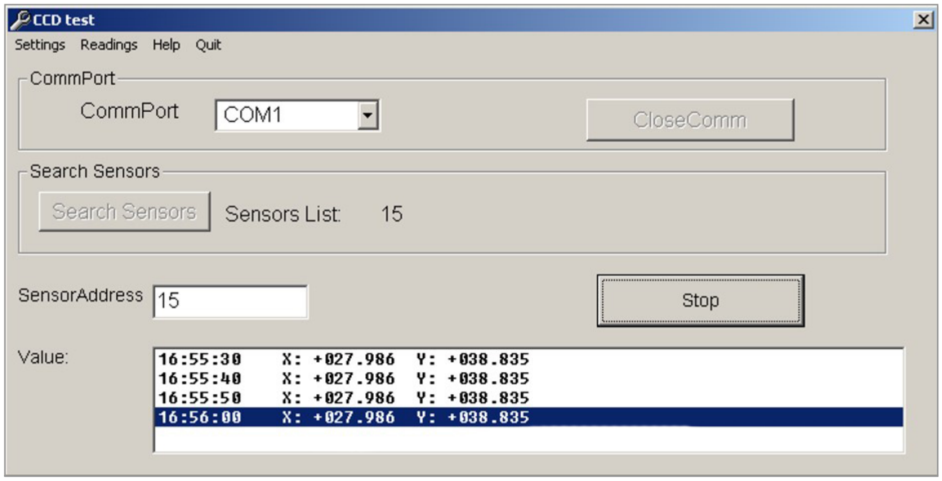


FIGURE 37: *Time Stamped X and Y Readings*

6.2 SETTINGS

The CCDTest software provides several functions related to the configuration of the pendulum. These options are made available by selecting **Settings** in the upper left portion of the screen. The function of each available setting is described in the subsections below.

FIGURE 38: *Settings Drop down*

6.2.1 CHANGE A SENSOR'S ADDRESS

Selecting **Change Sensor's Address** from the **Settings** drop-down list will cause the Set Sensor's Address form to display.

1. Enter the Original Address followed by the New Address, then select **OK**. In Figure 39, the sensor address is being updated from 15 to 1.

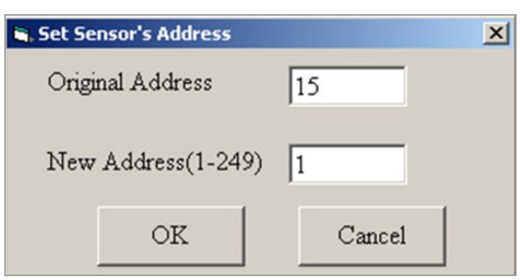


FIGURE 39: *Set a Sensor's Address Form*

2. The software will attempt to change the sensor address and then show a message stating if the address change was successful.
   - If successful, select **OK** to return to the Set Sensor's Address form.

FIGURE 40: *Address Set Successfully*

   - If the change fails, try again with a new address.
3. Once all desired address changes have been made, select **Cancel** to return to the main screen. A CommError will be displayed until the new sensor address has been entered.

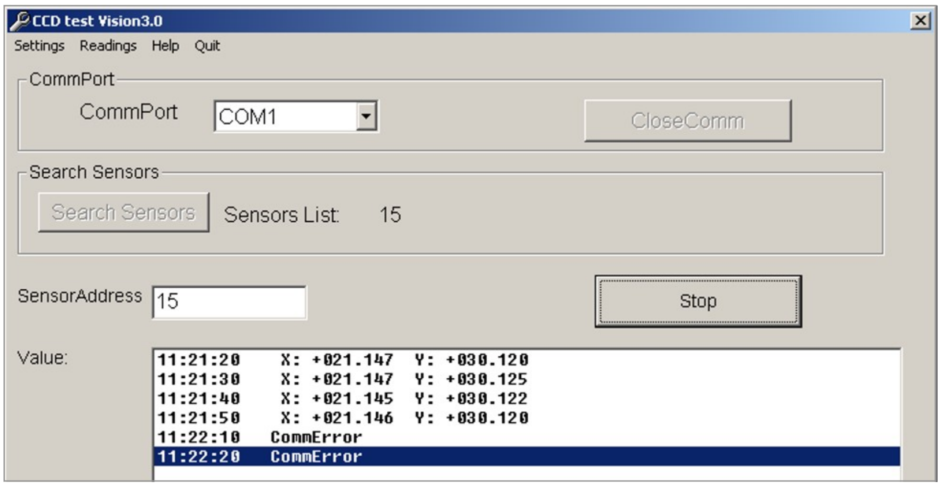


FIGURE 41: *CommError Caused by Incorrect Sensor Address*

4. To fix this error, the sensor address must be updated in the SensorAddress field on the main screen. In Figure 42 the sensor address has been updated from the original address of 15 to the new address of 1, causing the readings to display properly.

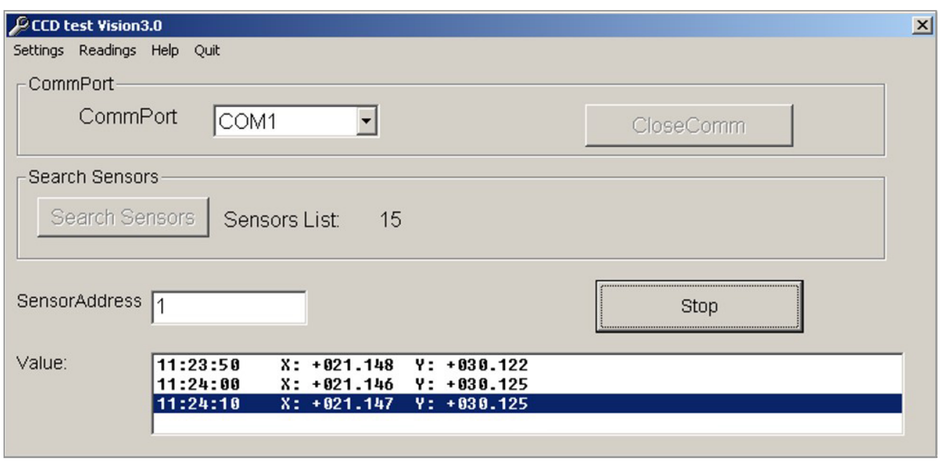


FIGURE 42: *Updated Sensor Address*

6.2.2 PARAMETER SETTING

Select **Parameter Setting** from the **Settings** drop-down list to configure the wire diameter and the permitted error for each Pendulum (Figure 43).

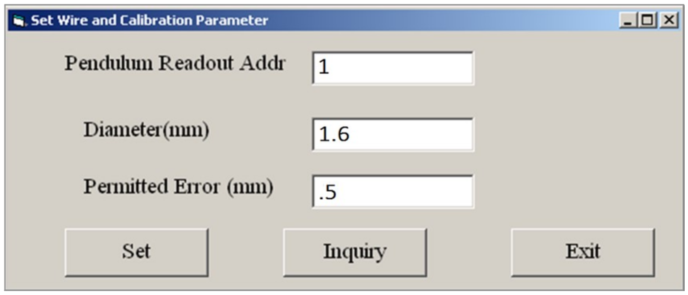


***FIGURE 43:** Parameter Settings Window*

1. Enter the Sensor address the calibration parameters will be set for in the Pendulum Readout Addr field.
2. Enter the wire diameter in millimeters in the Diameter(mm) field.
3. Enter the desired permitted error in millimeters in the Permitted Error (mm) field. (The recommended Permitted Error is 0.5 mm.)
4. Select **Set** to adjust the internal pendulum settings. The **Inquiry** button will populate the fields with the current pendulum settings. Select **Exit** when finished to return to the main screen.

6.2.3 INITIALIZATION

Note: The pendulum address must be entered into the Sensor Address field on the main screen for these options to work correctly!

Selecting **Initialization** from the **Settings** drop-down list will cause the Swap window to display. The swap window allows the X and Y axes of the pendulum to be interchanged. (This includes reversing the digital display and the 4-20 mA outputs of the unit.) The default is False, meaning no change will take place. If it is preferred that the X and Y axes be swapped, follow the procedure below:

1. Select True from the drop-down list, then select **Set**. Selecting **Query** will display the pendulum’s current setting. Select **Next**.

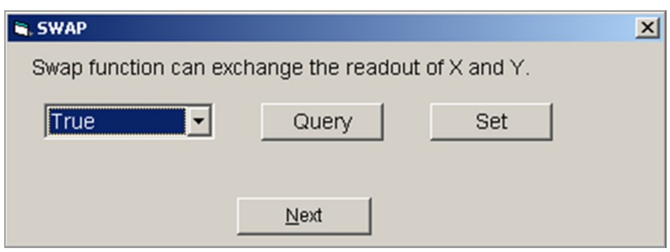


***FIGURE 44:** Swap Readout of X and Y*

2. The Invert window will open (Figure 45) which allows the direction of movement for the X or Y-axis to be reversed. This feature is useful where the installed orientation of the unit must match the direction of anticipated movement. If the direction of movement of an axis needs to be changed:
    a. change the value of the X Direction or Y Direction drop-down list to True. For example, if the X-axis is currently reading 35.78 mm out of the 50 mm range, and the field under X-Direction is changed to true, it will now read 14.22 mm.
    b. Select **Set** to update the pendulum with the chosen settings. Select **Query** to view the current settings.

Note: The Invert options will configure the axis as it is currently displayed. In other words, if the Swap function has been set to True (Figure 44) then setting the X Direction to True in the invert screen will invert what was originally the Y-axis.

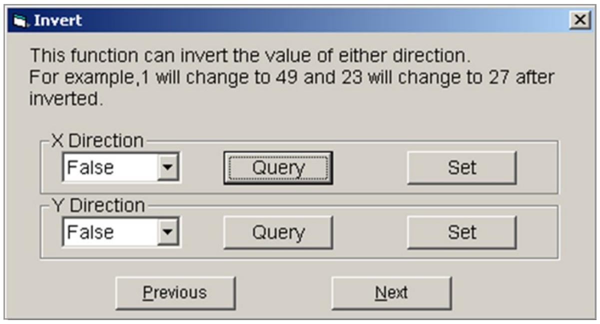


FIGURE 45: *Invert Window, Used to Reverse the Direction of an Axis*

3. Select **Next** (advances the program to the Reference Setting window detailed in Section 6.2.4), or select **Previous** (returns to the Swap form).

6.2.4 REFERENCE SETTING

Note: For these options to work correctly, the following must be done:

1. Enter the Sensor Address the settings will be applied to on the main screen.
2. Enter only whole numbers, i.e., 38.00, not 38.
3. Ensure that the PC is set to use a period as a separator, not a comma.

The Reference Setting feature (Figure 46) allows the output of the unit to be adjusted for a given value. This feature is often used to maintain contiguous data when replacing units in service or when moving units for regular cleaning or other maintenance. If the Reference feature is not used, the values must be adjusted during post-processing to account for differences in the measurements after moving or replacing a unit.

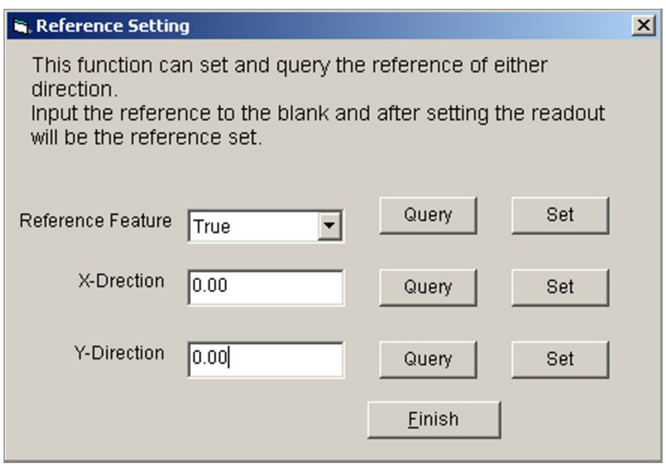


FIGURE 46: *Reference Setting Window*

1. Enter the desired value for the X-axis reference in the X-Direction field then select the **Set** option adjacent to the value. Pressing the **Query** button will display the current setting. The reference for the Y-axis can be entered into Y-Direction field in the same manner.
2. **After** the X-Direction and Y-Direction references have been set, the Reference Feature field may be set. Choose True to turn the reference feature on, False to turn it off. Select the **Set** option adjacent to Reference Feature. Pressing the **Query** button will display the current setting.

   If the Reference Feature has been set to True, the program will configure the unit to use the new X and Y-direction values as the starting values for the pendulum readings, as well as for the 4-20mA output. A dialog box will appear showing the internal offset (the current absolute measurement) that will be used to adjust the output in order to achieve the desired Reference output (Figure 43).

3. Select **OK** to continue.

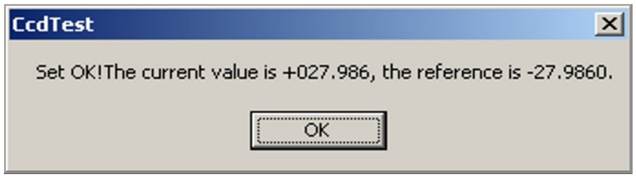


FIGURE 47: *Reference Setting Message*

4. Once the Reference values have been set, the pendulum display will update to account for the new Reference values. Select the **X** in the upper right corner to close the window.
5. The program will return to the Reference Setting window (Figure 46). Select **Finish** to return to the main screen.

The X and Y values will be updated according to the values entered (Figure 48).

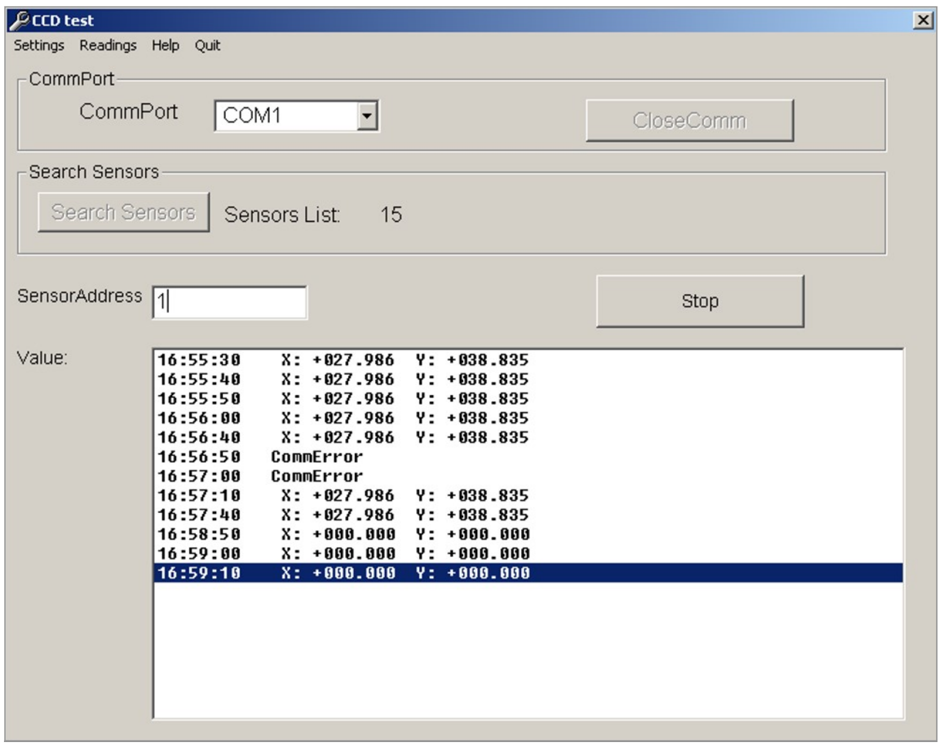


FIGURE 48: *Updated X and Y Values Coinciding with Reference Changes*

The following sequence is an example of how the References feature can maintain contiguous data:

1. The values from the currently installed pendulum are 27.986 and 38.835 millimeters for X and Y respectively. The References feature is NOT being used, so these are absolute values.
2. The unit is removed, cleaned, and reinstalled. The new readings are 25.456 and 31.894 for X and Y respectively.
3. Using the Reference Setting form, the X and Y-direction References are entered as 27.986 and 38.835 respectively. The Reference Feature is then set to True. The display will update to show the measurements last recorded prior to removing the unit. This provides for contiguous data without the need to apply post-processing offset corrections.

Note: To show changes in movement after installation, configure the fields as shown in Figure 46.

6.2.5 CLOCK SETTING

The Clock Setting function is useful when the pendulum is logging readings in its internal memory. Select **Clock Setting** from the Settings drop-down list to display the Set Time form.

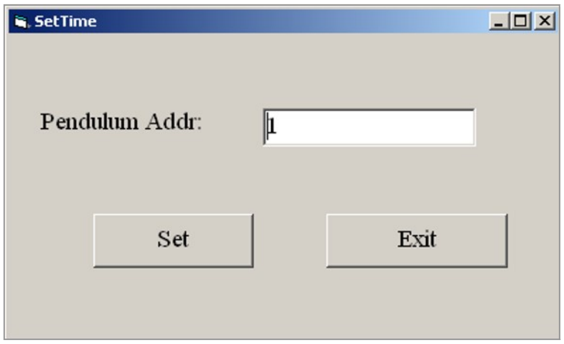


FIGURE 49: *Set Pendulum Time to Match PC Clock*

To match the internal pendulum clock to the PC clock, enter the desired pendulum address and select **Set**. Select **Exit** to return to the main form.

6.3 QUITTING THE PROGRAM

Before closing the program, stop the immediate readings by selecting **Stop** and then close communications to the Comm port by selecting **CloseComm**.

To exit the CCDTest software, select **Quit** in the upper portion of the screen.

7. TROUBLESHOOTING

The Model 6850 Pendulum System requires no regular maintenance other than periodic checks to see that the optics are clean. Using a computer and the software supplied with the system it is possible to initiate a “grayscale scan” that looks at all the pixels of the CCD output and determines if the optics require cleaning.

If it is determined that cleaning is necessary then it can be done with a clean, soft cloth, slightly moistened with water if necessary. **Do not use any chemical organic solutions in the cleaning process.**

The pendulum readout is equipped with a self-diagnosis feature; when a fault occurs, the display will show the corresponding error code. Use the table below to trace and correct the fault. If the fault still exists after performing the suggested remedy, return the readout to the manufacturer.

Note: These codes have equivalent values when automating the systems using MultiLogger (see Appendix B on how to configure MultiLogger Software).

Err2, Err4, and Err6 may alternate on the display if the ambient light is too bright.

Displayed Error Code or fault symptom	MultiLogger Code (If Applicable)	Problem	Solution
Err2	-99992	The ambient light is too bright	Enhance the light shielding methods or use an additional light shield
Err3	-99993	The light is too weak	Return to manufacturer for repairs
Err4	-99994	There is no shadow indicating that the pendulum wire has moved out of range	Readjust the position of the readout
Err5	-99995	A fault has occurred in the CCD image sensor	Return to the manufacturer for repair
Err6	-99996	There are too many shadows; there may be some debris or water drops blocking the optical paths	Clean any debris or water found in the CCD chamber or on the wire
Displays are blank	-99999	Power supply has failed	Restore Power. Check the communication cable if applicable
Displays work but communications have failed	N/A	The readout address may be incorrect, or there is a fault in the communication line	Reset the address, or check the communication cable
No analog output	N/A	A fault has occurred in the readout box analogue circuit	Return to the manufacturer for repair

TABLE 3: *Error Codes and Troubleshooting Information*

APPENDIX A. SPECIFICATIONS

A.1 MODEL 6850 2D SPECIFICATIONS

Model	**6850-4 (Pendulum Readout Only, 2D)**	**6850-5 (Pendulum Readout Only, 3D)**	**6850-6 (Pendulum Readout Only, 2D)**	**6850-11 (Optical Manual Readout Only)**
Range	(X axis) 0 to 50 mm (Y axis) 0 to 50 mm	(X axis) 0 to 50 mm (Y axis) 0 to 100 mm (Z axis) 0 to 50 mm	(X axis) 0 to 50 mm (Y axis) 0 to 100 mm	(X axis) 0 to 50 mm (Y axis) 0 to 50 mm
Resolution	0.01 mm			
Electrical Drift	Zero			
Accuracy	Better than 0.1 mm			0.2 mm
Communication Method	4-30 mA, EIA RS-485			N/A
Sensor	CCD			N/A
Power Supply	85-265 VAC, 50-60 Hz			N/A
Sample Frequency	Once/10 seconds to Once/day, programmable			N/A
Operating Temperature	-15 to +60 °C			N/A
Operating Humidity	100% relative humidity			N/A
Display	4-digit LED			N/A
Data Storage	2000 data sets on nonvolatile RAM. Each reading has values of X, Y, date and time.	1200 data sets on nonvolatile RAM. Each reading has values of X, Y, Z, date and time.	2000 data sets on nonvolatile RAM. Each reading has values of X, Y, date and time.	N/A
Dimensions (L x W x D)	380 x 330 x 145 mm	425 x 375 x 190 mm	425 x 375 x 190 mm	356 x 356 x 100 mm
Wire Diameter	1.0 mm to 9.9 mm			N/A
Enclosure Material	Weatherproof, painted steel (Red)			N/A

TABLE 4: *Model 6850 2D Pendulum System Specifications*

APPENDIX B. MULTILOGGER SOFTWARE CONFIGURATION

Note: These Instructions were written for the 2-axis (2D) readout but can be extrapolated to the 3-axis (3D) readout.

The Model 6850 Pendulum includes an RS-485 (half-duplex) interface as well as dual 4-20mA outputs. The pendulum may be integrated to the Campbell MCU using the 4-20mA output or RS-485. RS-485 is recommended as it eliminates any analog measurement error from the readings.

B.1 OVERVIEW

Using Sensor Application Note #16 will provide information to help integrate the GEOKON Model 6850 Pendulum into a Campbell CR6, CR800, or CR1000 based monitoring system when configured using MultiLogger. It will include wiring details as well as programming details to deploy this equipment.

B.2 WIRING

The table below shows the pinout for the output connector found on the base of the cabinet.

Pin	Description	Color (Pre-Assembled)
A	X-axis 4-20 mA Output	Red
B	Ground	Red’s Black
C	Y-axis 4-20 mA Output	White
D	Ground	White’s Black
E	No Connection	N/C
F	RS-485 -	Green
G	RS-485 +	Green’s Black
H, J, K	No Connection	N/C
J	Z-axis 4-20 mA output (3D Readouts Only)	Yellow
K	Ground (3D Readouts Only)	Yellow’s Black

TABLE 5: *Output Connector Pinout*

B.3 4-20 MA CONFIGURATION

Direct Connect Channels are used for configuring the pendulum measurements. Each channel corresponds to an X or Y-axis measurement; this provides for including the math to convert the output from mA to millimeters or to other engineering units. See the figure below for a diagram of the 4-20 mA connection.

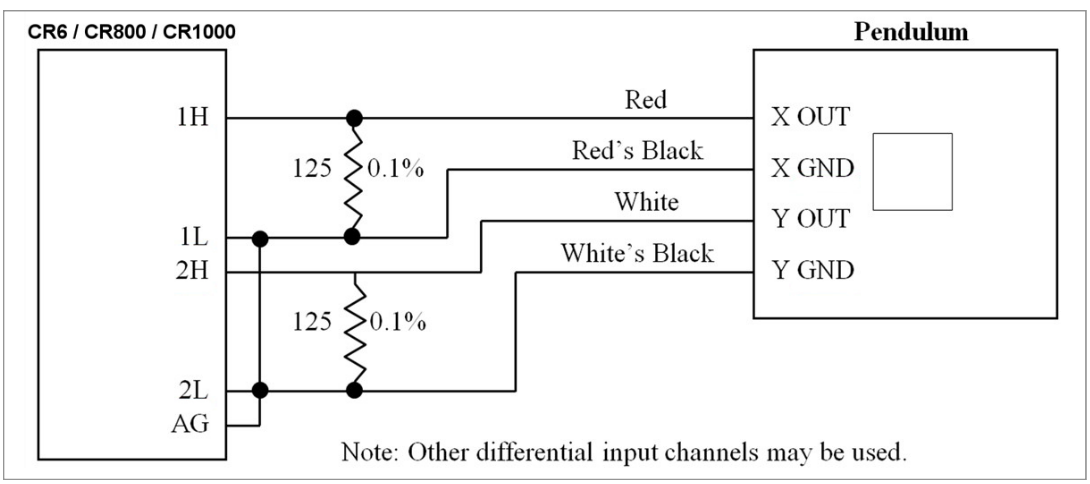


FIGURE 50: *4-20 mA Connection Diagram*

Figure 51 shows the Linear Coefficients used to convert from current to millimeters. Configure both the X-axis (Channel 1) and Y-axis (Channel 2) in this manner.

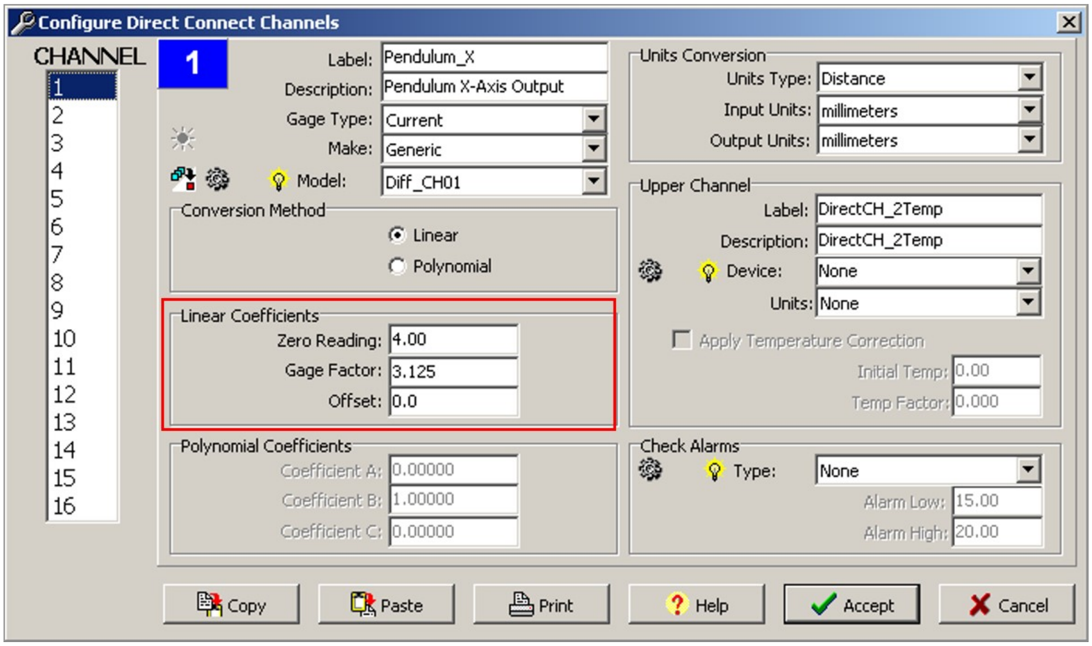


FIGURE 51: Linear Coefficients

B.4 RS-485 CONFIGURATION

Pendulum RS-485 support is only provided for the CR6, CR800, and CR1000 control modules. The gage types referenced in the following section are found in MultiLogger V4.2 or higher. Contact Canary Systems directly to obtain the current version of MultiLogger software.

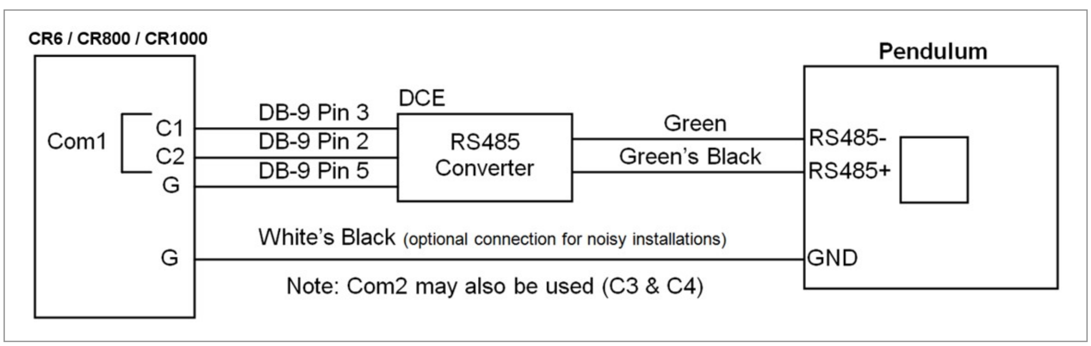


FIGURE 52: RS-485 Connection Diagram

Generally, the Direct Connect Channels are used for configuring the pendulum measurements. There are two methods of configuring them, dependent upon whether the resultant values must be converted to other units, or if alarms must be configured on each measurement. The output units of the pendulum are millimeters.

Figure 53 shows a typical channel configuration to read the X and Y-axis outputs of a pendulum connected to Com1 on the control module (Control Ports C1 & C2 used for communications) at address 01. Addresses 1-16 are supported – contact Canary Systems if the intended application has more than 16 pendulums per network.

Note: The availability of gage types for COM1 (Control Ports C1 & C2) and COM2 (Control Ports C3 & C4). The CR800 has two COM ports, the CR1000 has four. Contact Canary Systems if the intended application requires the use of COM3 (Control Ports C5 & C6) or COM4 (Control Ports C7 & C8) on the CR1000.

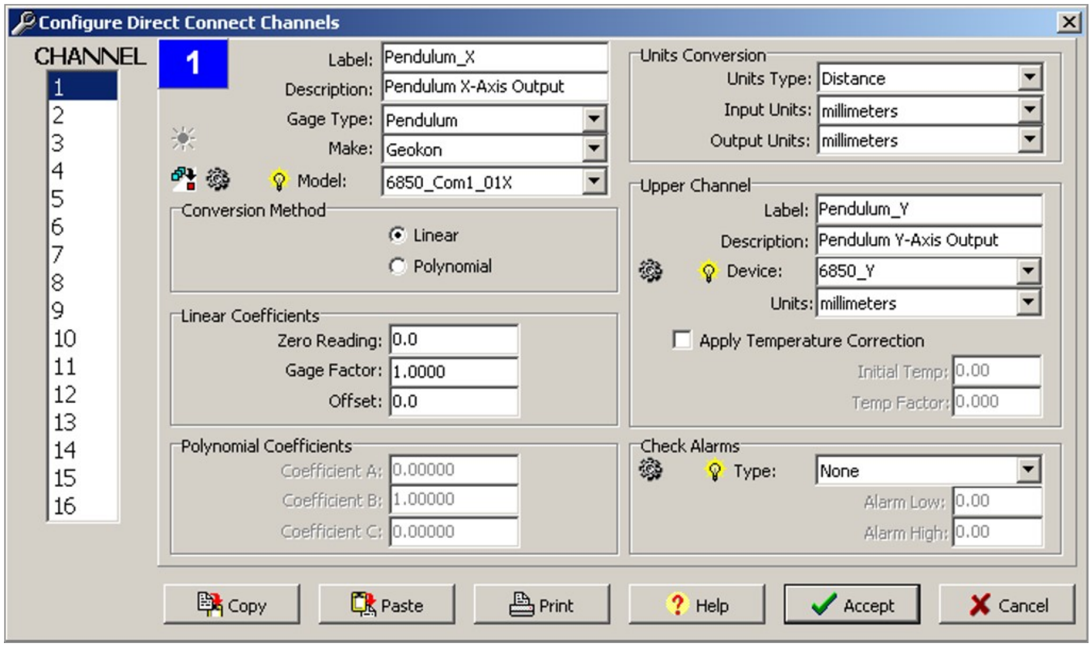


FIGURE 53: *Typical RS-485 Channel Configuration*

The configuration shown in Figure 53 allows converting the X-axis values using the Conversion Method and/or the Units Conversion, as well as configuration of alarms using the Check Alarms options. Note that when using a single channel configuration, the type of adjustments listed above, including Check Alarms, will not be available for the Y-axis value. If the application of the pendulum requires conversions and/or Check Alarms settings for the Y-axis, then the Y-axis will need to be configured as a separate Channel. Configuring the Y-axis as a separate channel limits the number of pendulums that can be configured to eight. Channel 1 would be used for the X-axis, and would be configured as shown in Figure 54.

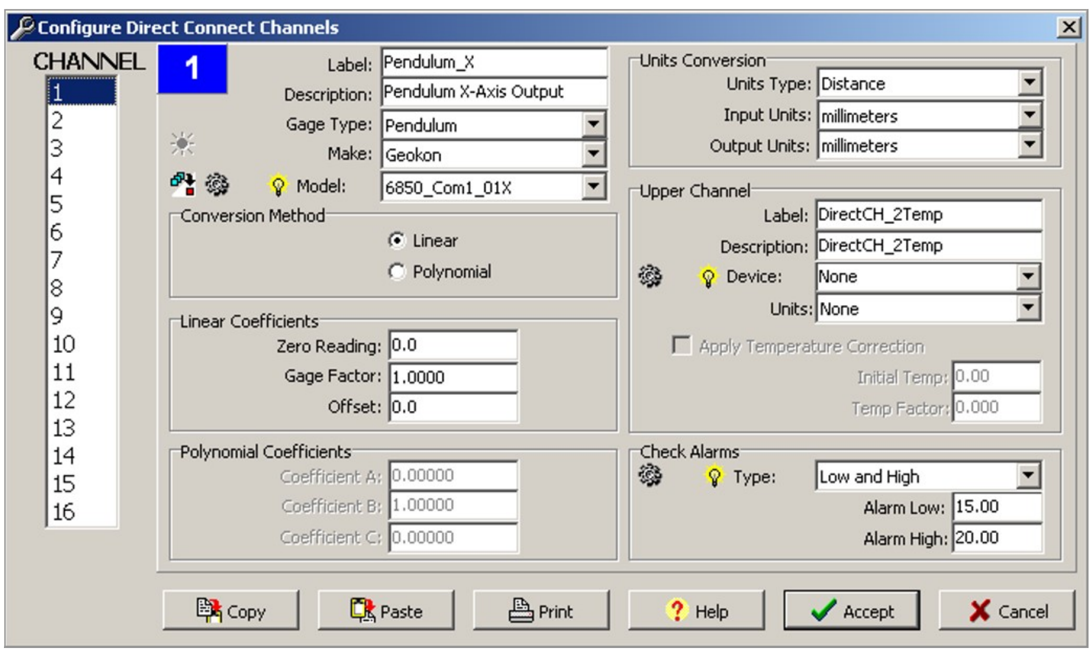


FIGURE 54: *Channel 1, X-axis Configuration*

Channel 2 would then be used to support the Y-axis measurement, and would be configured as shown in Figure 55.

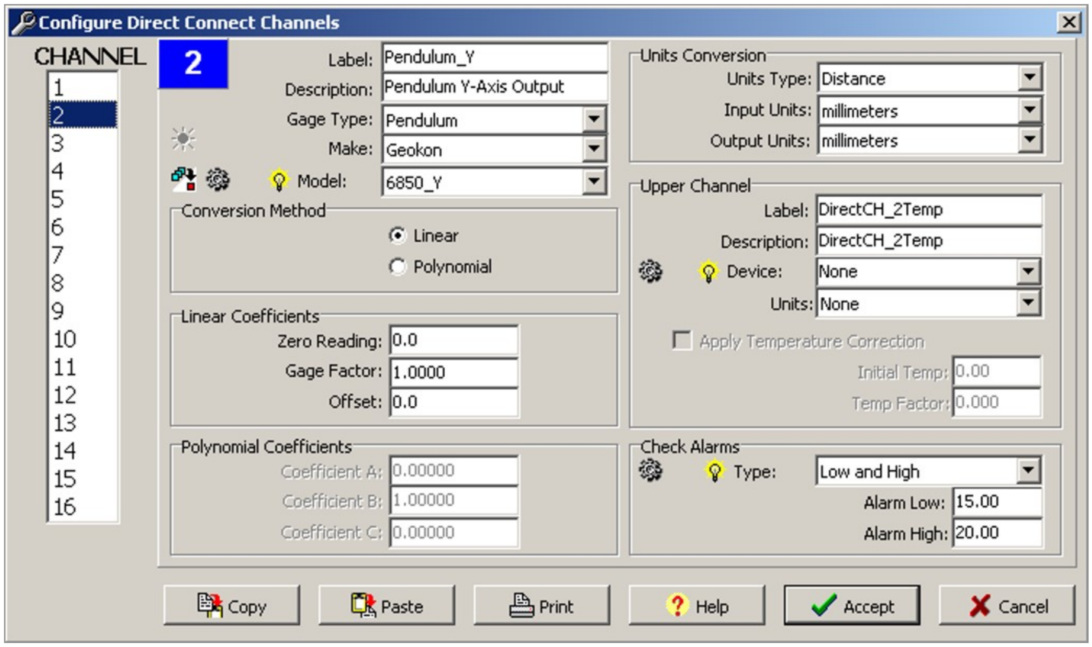


FIGURE 55: *Channel 2, Y-axis Configuration*

APPENDIX C. PENDULUM COMMANDS

Note: These Instructions were written for the 2-axis (2D) readout but can be extrapolated to the 3-axis (3D) readout.

Terminal emulation programs may be programmed with the pendulum commands to help with troubleshooting and configuration of the units. The table below shows typical commands and responses. Communication parameters are **9600 bps, 8 data bits, 1 stop bit, no parity bit**. The baud rate of the pendulum is fixed at 9600 bps.

All commands are prefaced with a colon, followed by the address of the unit in hexadecimal notation, and then by the command and any corresponding parameters. The command is terminated with "FF" <CR> <LF>. Responses include a two-byte signature ("gg").

Command	Command	Response
Set Address, where; aa = Current Address (01-FF) bb = New Address (01-FF)	**:aa02bbFF**	:aa02bbFB
Get X & Y-axis readings, where; aa = Address s = Sign (+/-) xxx.xxx = X-axis yyy.yyy = Y-axis gg = Signature	**:aa2101FF**	:aa2101sxxx. xxxsyyy.yyygg
Set X-axis Parameters, where; aa = Address ww = Wire diameter in mm (2 digits no decimal, e.g. 1.0 mm = 10) ee = Error in mm (2 digits no decimal, e.g. 0.5 mm = 05)	**:aa67wwee010000FF**	:aa67wwee010000gg
Set Y-axis Parameters (Same as X-axis.)	**:aa69wwee010000FF**	:aa69wwee010000gg
Query Reference Setting, where; aa = Address	**:aa76FF**	:aa76rrgg
Set Reference False	**:aa7500FF**	:aa7500gg
Set Reference True	**:aa7501FF**	:aa7501gg
Set X-Axis Reference, where; aa = Address s = Sign (+/-) xxx.xxx = X-axis reference value (Entered as an offset.)	**:aa71Sxxx.xxxFF**	:aa71Sxxx.xxxgg
Set Y-Axis Reference, where; aa = Address s = Sign (+/-) yyy.yyy = Y-axis reference value (Entered as an offset.)	**:aa73Syyy.yyyFF**	:aa73Syyy.yyygg
Read/Set Clock, where; aa = Address yy = Year mm = Month dd = Day hh = Hour mm = Minute ss = Second	**:aa04FF** **:aa03yymmddhhmmssFF**	:aa04yymmddhhmmssgg :aa03yymmddhhmmssgg

TABLE 6: *Commands for Terminal Emulation Programs*

APPENDIX D. CRBASIC PROGRAMMING

D.1 SAMPLE CR6 PROGRAM

```
'CR6 Program
'Read the X, Y and Z output of a Geokon Geopendulum connected to COM1 (C1 & C2) at Address 01
Public I                        'Counter
Public sInStr As String * 30    'String used to record incoming data from pendulum
Public Var(6)                   'Temporary variables, used in error code calculation
Public Result(3)                'Data points stored in the Data Table X, Y, Z, axis
```

'Define Data Tables

```
DataTable(Test,True,1000)
  'Store X Y and Z axis results
  Sample (3,Result(),IEEE4)
EndTable
```

'Main Program

```
BeginProg
    Alias Result(1) = X_Axis
    Alias Result(2) = Y_Axis
    Alias Result(3) = Z_Axis

    'Open our port
    SerialOpen (ComC1,9600,0,1000,255)

    Scan (5,Sec,0,0)

        'Clear the buffer
        SerialFlush (ComC1)

        'Send Reading command of first set of data characters
        SerialOut (ComC1,":012101FF" + CHR(13) + CHR(10),"",0,0)

        'Listen to communication line for half a second to give time to receive message.
        SerialIn (sInStr,ComC1,50,"",30)

        If Len (sInStr) >= 23 Then
            'Remove E from string to properly split the string as it is registered as an
            'exponential.
            sInStr = Replace (sInStr,"E","+")
            'Split the string to three parts
            SplitStr (Var(1),sInStr,"",3,0)

            'Check for error codes for Var(2) and Var(3)
            For I = 2 To 3
                'Check result against error codes
                If Var(I) = 2000000 Then
                    'Error code for Ambient light is too bright
                    Var(I) = -99992
                ElseIf Var(I) = 3000000 Then
                    'Error code for Projected light is too weak
                    Var(I) = -99993
                ElseIf Var(I) = 4000000 Then
                    'Error code for Wire is out of range
                    Var(I) = -99994
                ElseIf Var(I) = 5000000 Then
                    'Error code for Fault has occurred in CCD element
                    Var(I) = -99995
                ElseIf Var(I) = 6000000 Then
                    'Error code for Shadows interfering with measurement
                    Var(I) = -99996
                EndIf
            Next

        Else
            'When a returned string is incomplete, communication breakdown error
            Var(2) = -99999
            Var(3) = -99999
        EndIf

        'Store recorded variable into X axis
        X_Axis = Var(2)

        'Store recorded variable into Y axis
        Y_Axis = Var(3)
```

```
        'Delay a short time between readings
        Delay (0,250,mSec)

        '------------------------------------------------------------------------------------------
        'Include this code if Z axis is required
        '------------------------------------------------------------------------------------------
        'Clear the buffer
        SerialFlush (ComC1)

        'Send Reading command on second set of data characters
        SerialOut (ComC1,":012102FF" + CHR(13) + CHR(10),"",0,0)

        'Listen to communication line for half a second to give time to receive message.
        SerialIn (sInStr,ComC1,50,"",30)

        If Len (sInStr) >= 23 Then
            'Remove E from string to properly split the string as it is registered as an
            'exponential when split by numeric values.
            sInStr = Replace (sInStr,"E","+")

            'Split the string to three parts
            SplitStr (Var(4),sInStr,"",3,0)

            'Check result against error codes
            If Var(5) = 2000000 Then
                'Error code for Ambient light is too bright
                Var(5) = -99992
            ElseIf Var(5) = 3000000 Then
                'Error code for Projected light is too weak
                Var(5) = -99993
            ElseIf Var(5) = 4000000 Then
                'Error code for Wire is out of range
                Var(5) = -99994
            ElseIf Var(5) = 5000000 Then
                'Error code for Fault has occurred in CCD element
                Var(5) = -99995
            ElseIf Var(5) = 6000000 Then
                'Error code for Shadows interfering with measurement
                Var(5) = -99996
            EndIf

        Else
            'When a returned string is incomplete, communication breakdown error
            Var(5) = -99999
        EndIf

        'Store recorded variable into Z axis
        Z_Axis = Var(5)
        '------------------------------------------------------------------------------------------
        'End of Z axis code
        '------------------------------------------------------------------------------------------

        'Call Output Table(s)
        CallTable Test
    NextScan
EndProg
```

D.2 SAMPLE CR800 / CR1000 PROGRAM

(gt_6850_com1_01x.cr1 instruction file)

```
'Read the X and Y output of a Geokon Geopendulum connected to COM1 (C1 & C2) at Address 01
'Open our port
SerialOpen (Com1,9600,0,1000,255)

'Clear our counter
ScratchLoc(1) = 0

'Loop 5 times to get measurement
Do
	'Make sure buffer is clear
	SerialFlush(Com1)

	'Send Reading command
	SerialOut (Com1,":012101FF"+CHR(13)+CHR(10),"",0,0)

	'Receive response with .25 second timeout
	SerialIn(sInBuf,Com1,25," ",30)

	'Check for enough characters
	if Len(sInBuf) >= 23 then
		'Split out response values
		Splitstr(ScratchLoc(2),sInBuf,"",3,0)

		'Check for error codes
		if ScratchLoc(3) = 2000000 or ScratchLoc(4) = 2000000 then
			ScratchLoc(3) = -99992
			ScratchLoc(4) = -99992
		endif
		'Check for error code
		if ScratchLoc(3) = 3000000 or ScratchLoc(4) = 3000000 then
			ScratchLoc(3) = -99993
			ScratchLoc(4) = -99993
		endif
		'Check for error code
		if ScratchLoc(3) = 4000000 or ScratchLoc(4) = 4000000 then
			ScratchLoc(3) = -99994
			ScratchLoc(4) = -99994
		endif
		'Check for error code
		if ScratchLoc(3) = 5000000 or ScratchLoc(4) = 5000000 then
			ScratchLoc(3) = -99995
			ScratchLoc(4) = -99995
		endif
		'Check for error code
		if ScratchLoc(3) = 6000000 or ScratchLoc(4) = 6000000 then
			ScratchLoc(3) = -99996
			ScratchLoc(4) = -99996
		endif
	'No valid response
	Else
		ScratchLoc(3) = -99999
		ScratchLoc(4) = -99999
	EndIf

	'Short delay before trying again or exiting
	Delay(0,250,mSec)

	'Increment our counter
	ScratchLoc(1) = ScratchLoc(1) + 1
Loop Until (ScratchLoc(1) >= 5) OR (ScratchLoc(3) > -99990)

'Copy our reading whatever it is (ScratchLoc(4) holds Y-Axis value)
mlReading = ScratchLoc(3)

'Close our serial port
SerialClose (Com1)
```

APPENDIX E. MOUNTING BRACKET (OPTIONAL ACCESSORY)

Mounting brackets can be made locally, or by GEOKON (if the necessary dimensions and orientation are provided). The following information is to be used as a general guide for assembly only, as custom mounting brackets may require a different procedure. Generally, GEOKON provided mounting brackets consist of two triangular pieces made from 45 x 45 mm (1.8 x 1.8”) angle iron, which are connected together by one strut at the wall and a U shaped top plate.

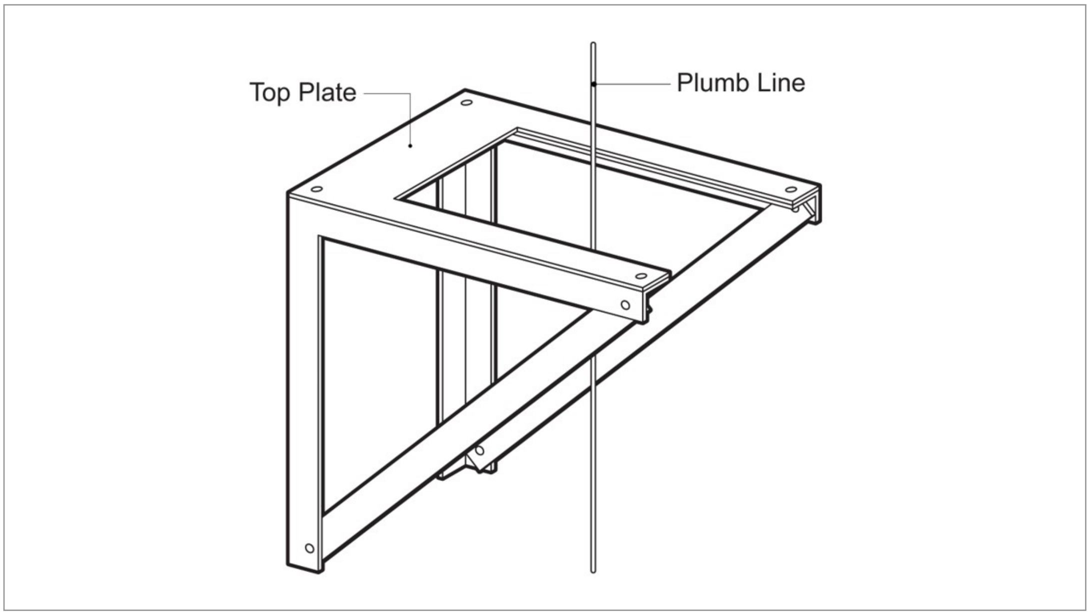


FIGURE 56: *Mounting Bracket*

E.1 MOUNTING BRACKET INSTALLATION

The clearance between the wall and the pendulum wire needs to be at least 230 mm (9”), large enough so that there is space enough for the readout cabinet, bearing in mind the orientation convention found in Section n.

1. Drill four, 12 mm (0.468”) diameter holes in the wall, matching them to the four slots in the bracket uprights. The positioning of the holes must be done very carefully to ensure that the pendulum wire will fall near the centerline of the space in the top plate.
2. Tighten the provided expansion bolts into the drilled holes.
3. Slide the bracket assembly behind the pendulum wire.
4. Position the slots in the two bracket uprights around the anchor bolts.
5. Bolt the plate to the brackets using the flat head screws provided.
6. Use a spirit level to level the plate.
7. Tighten the nuts onto the anchor bolts.
8. Attach hook-and-loop fastener strips to the top plate so that they will contact the strips attached to the readout unit when the readout is put into position.

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