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Instruction Manual
Model 6850
2D Pendulum Readout



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1. OPERATING PRINCIPLE

Geokon's Model 6850 2D Pendulum Readout can be used with direct or inverted pendulums. The readout automatically measures horizontal deflections in two directions, and is designed to measure the tilting of large structures such as dams, high-rise buildings, bridges, etc. Two models with different ranges of pendulum movement are available. Model 6850-4 has a range of 50 mm x 50 mm; Model 6850-6 has a range of 50 mm x 100 mm.

Geokon's 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. See Figure 1.

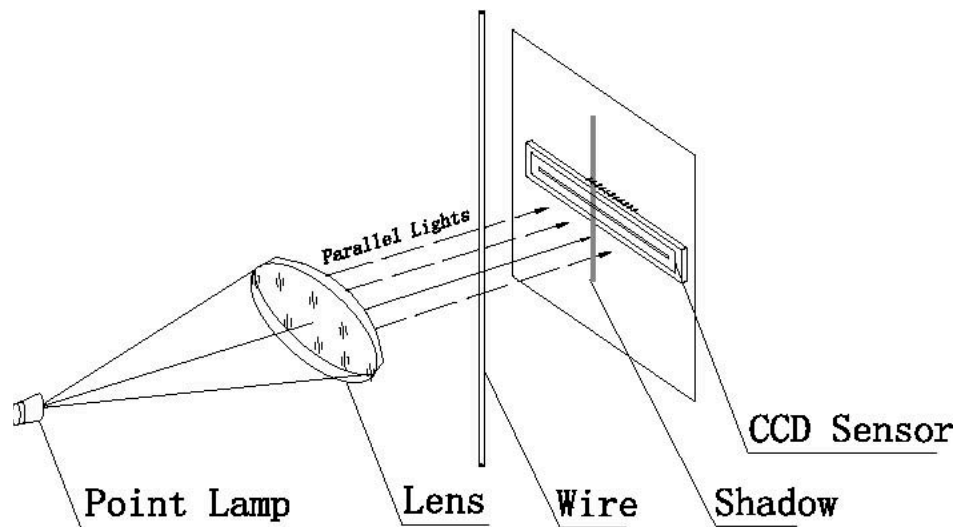


Figure 1 - System of CCD imaging

The information obtained by the CCD sensors is converted to an analog signal and displayed on the two 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, as shown in Figure 2.

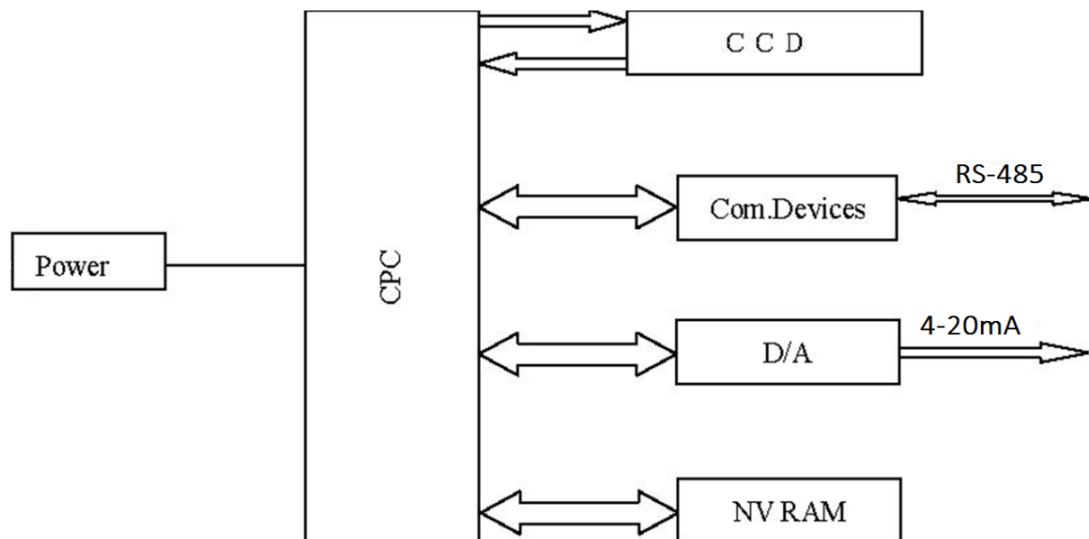


Figure 2 - Electrical Schematic

2. TECHNICAL FEATURES

- Noncontact, two-dimensional measurement using CCD photoelectric imaging with a range 50 mm x 50 mm or 50 mm x 100 mm and a resolution of 0.01 mm.
- High Precision, no electrical drift, good long-term stability.
- Strong ambient light resistance.
- Two built-in four digit LED visual display panels facilitate installation, debugging, and manual observation of the dual-axis 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 6850 Pendulum Readouts to be interconnected, as well as remotely and separately addressed.
- 4-20mA output enables the 6850 Pendulum Readout to be compatible with all standard data acquisition and SCADA systems.
- Up to 2,000 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 100V to 240V.
- 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.

3. SYSTEM COMPONENTS

Figure 3 shows the components of the 6850 Pendulum Readout, consisting of the cabinet with built in slot for pendulum wire, LED display panel, output connector, power input, CCD chamber, and a mounting plate on the side to mate with an optional universal mounting bracket.

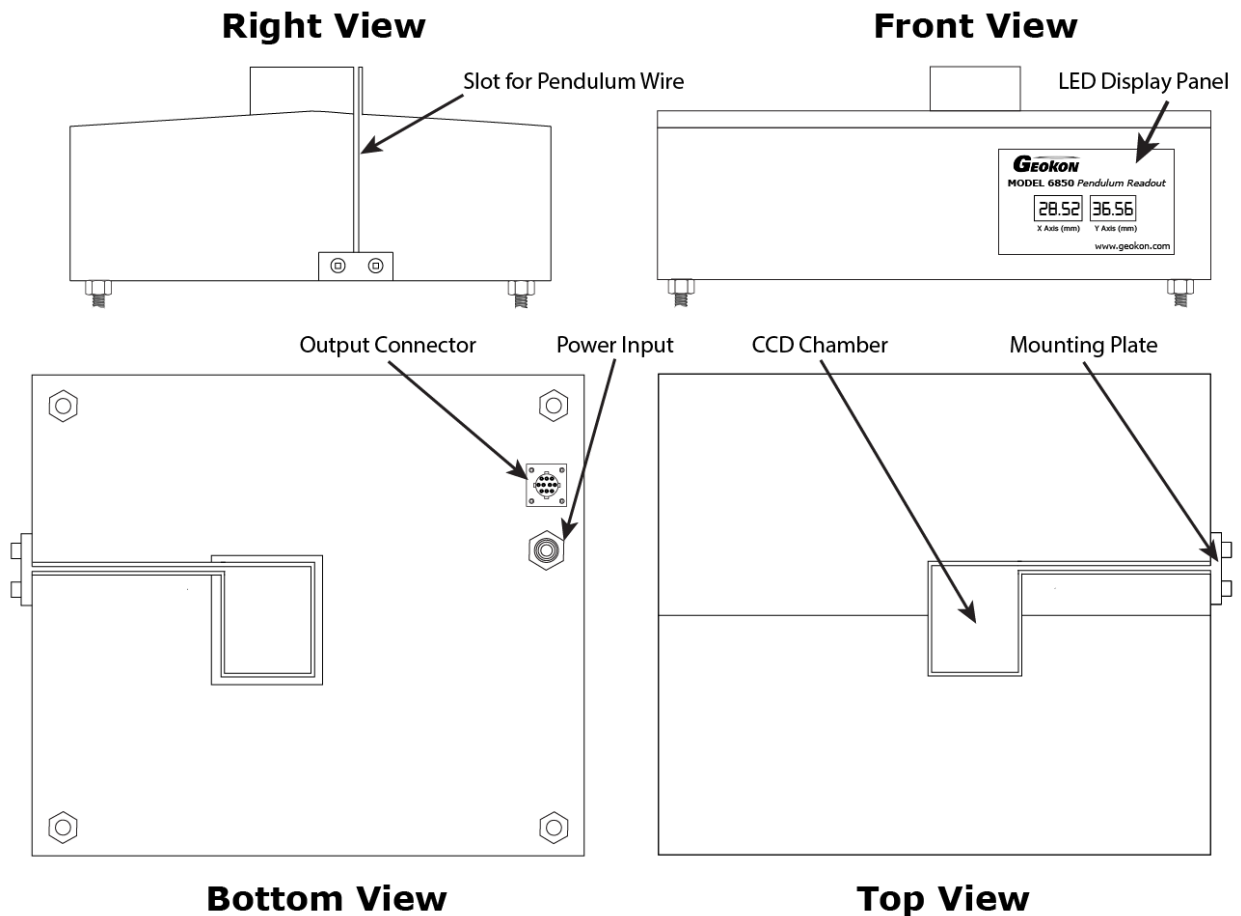


Figure 3 - 2D Pendulum Readout

Each pendulum readout also comes with the following accessories: An upper and lower light shield, CCDTest software, power cord, readout cable, RS-232 to RS-485 converter, and four mounting bolts for solid mounting or raising the electronics.

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 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 and 6850-3-2) contain the pendulum readout and its accessories plus a pendulum anchor, float tank, float, and measurement table.

4. INSTALLATION

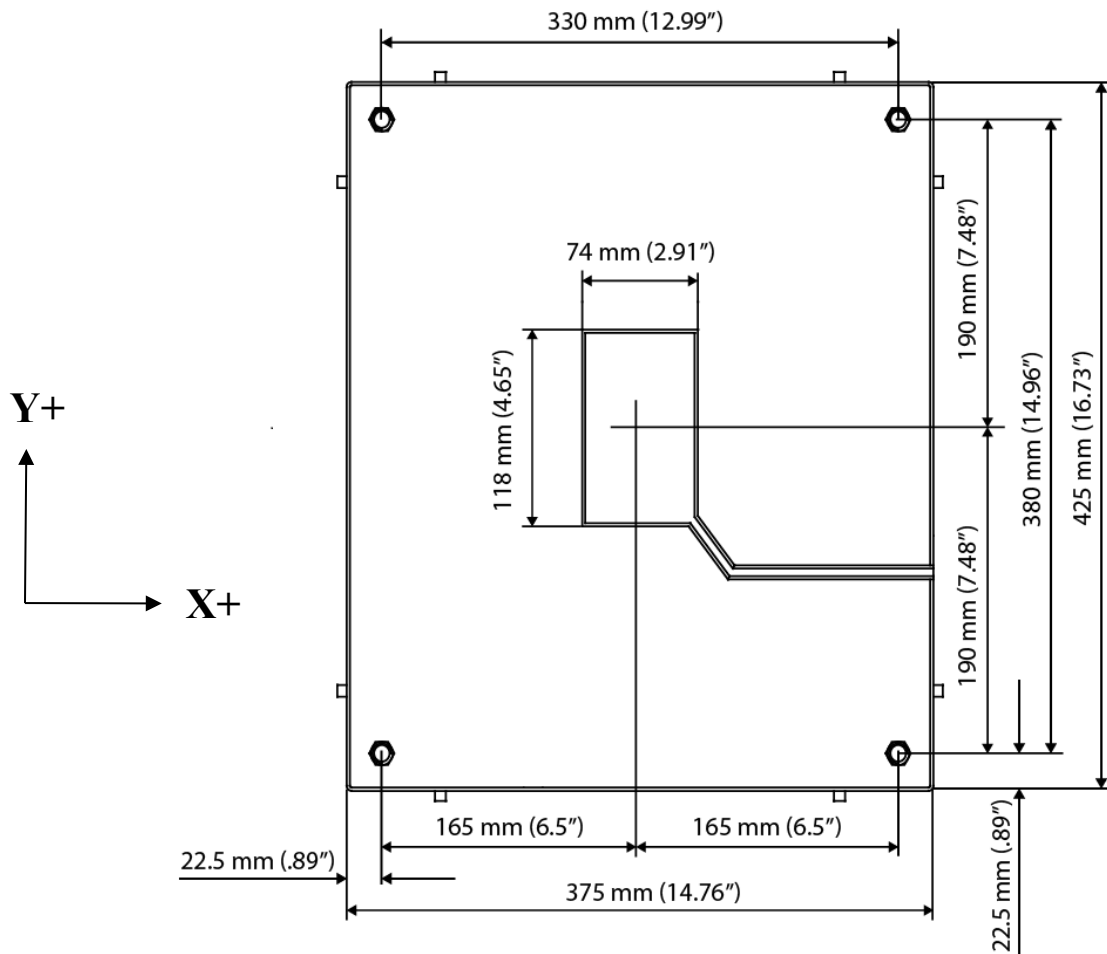
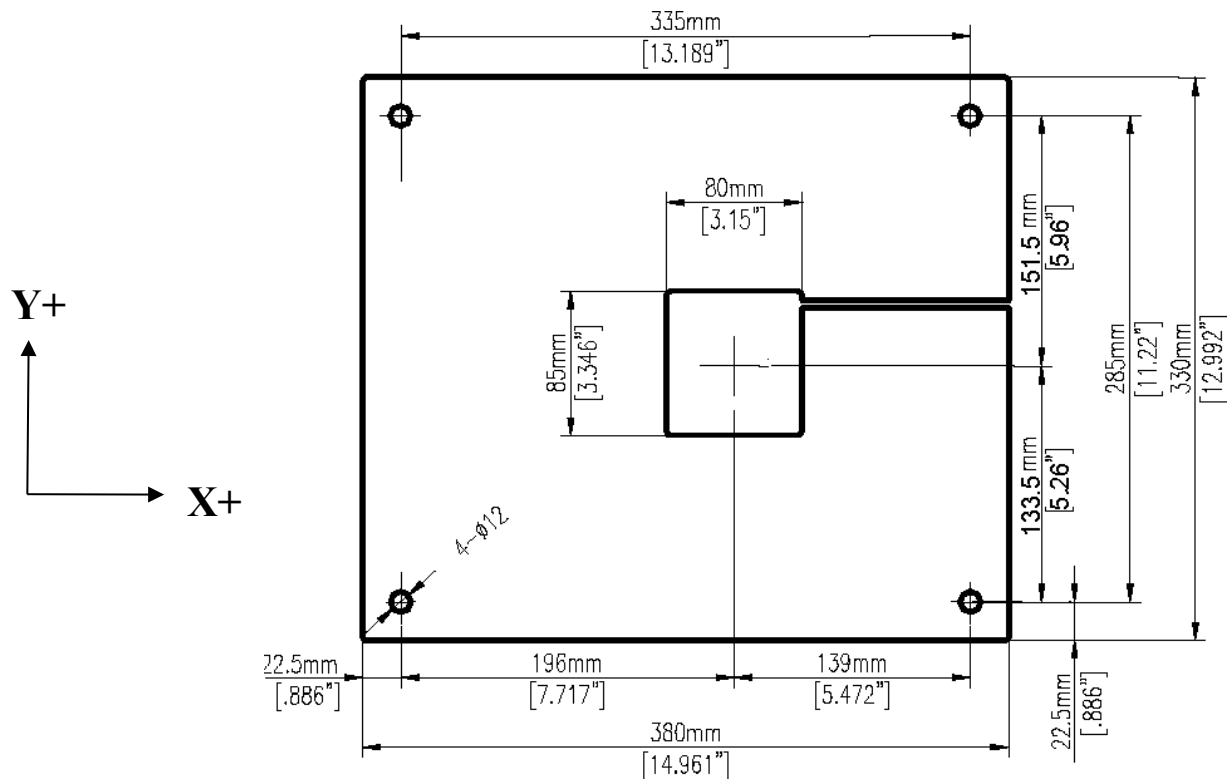
4.1 Initial Checks

- 1) Check the cabinet for signs of external damage. If any damage is found, contact Geokon.
- 2) Connect to the power supply.
- 3) 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.
- 4) Insert a needle or a piece of wire approximately 1.6 mm in diameter into the CCD chamber in order to simulate the pendulum wire. A reading should register on the two LED displays.
- 5) When the needle or wire is centered, both displays should read 25.00 mm. (A 4-20mA reading should be approximately 12mA). Moving the needle back and forth should change the readings from zero to 50.00 mm.

4.2 Orientation and Placement

Figure 4 and Figure 5 on the following page show the dimensions of the two models of the pendulum readout, 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



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 F for mounting bracket instructions.

4.3.1 Pendulum Table

If the pendulum readout was purchased with a measurement table, assemble it per the print shown in Figure 7. The pictures shown in Figure 6 can be used as a general assembly guide.

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



Figure 6 - Measurement Table for Direct Pendulum General Assembly Guide

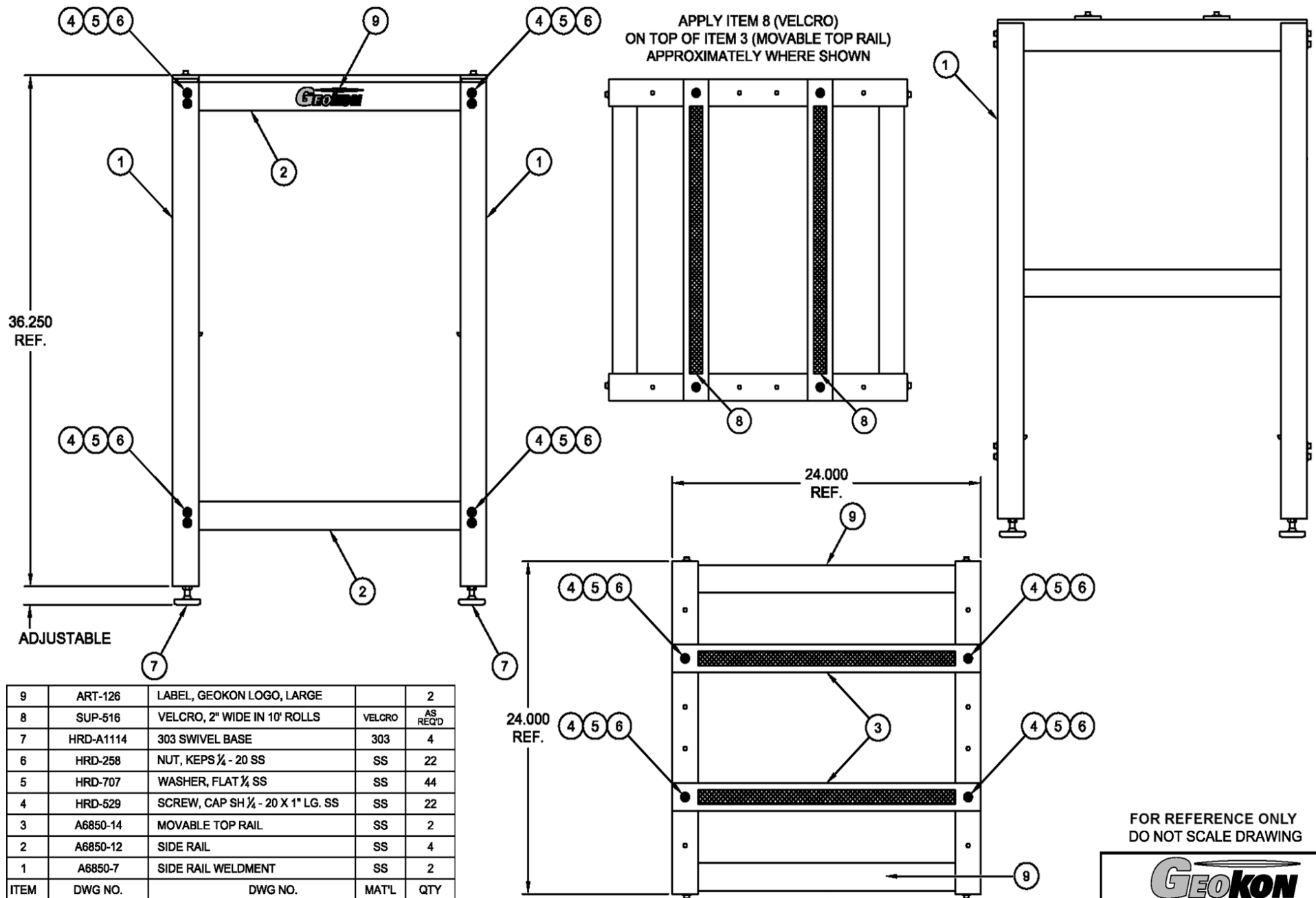


Figure 7 - Direct Pendulum Measurement Table Assembly Print

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 8); 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 1/2" (12 mm) hole, approximately 1 1/2" (37 mm) 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 into the holes. The threaded end of the anchor should be facing out.
 - e. Using the supplied setting pin tool and a hammer set the anchor by striking the setting pin with two or three sharp blows.
 - f. Place a washer over each of the cap screws.
 - g. Attach the bracket to the ceiling by tightening the cap screws into the anchors using the supplied Allen wrench.
- 2) Attach the pendulum wire to the bracket by feeding it through the wire guide and the eye and then twisting it around itself (Figure 8).

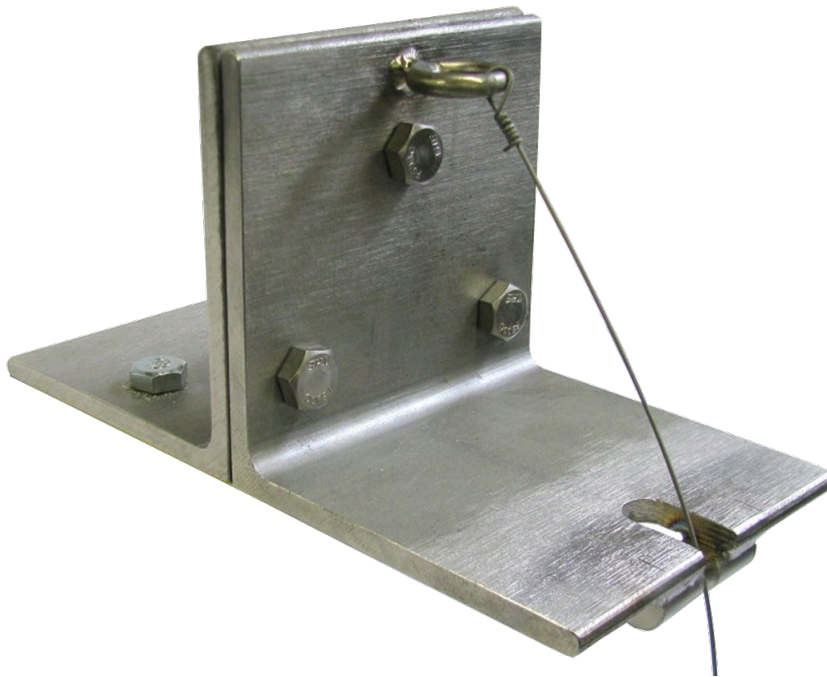


Figure 8 - Mounting Brackets With Twisted

- 3) Cut the pendulum wire so that when the weight is attached it will be suspended about 50 mm above the floor. (The wire will stretch approximately 25 mm for every 30 m of length.)
- 4) Position the measurement table so that the pendulum wire hangs in its center. Orient the table so that the two plates the pendulum readout will sit on are facing in the upstream/downstream direction.

- 5) With the aid of a spirit level, level the table using the adjustment screws on the feet.
- 6) Push the pendulum wire into the wire grip at the top of the weight until it stops.
- 7) Tighten the setscrew against the wire with the wrench provided (Figure 9). Do not use excessive force (18 in/lbs.); experiment with a short piece of wire first.

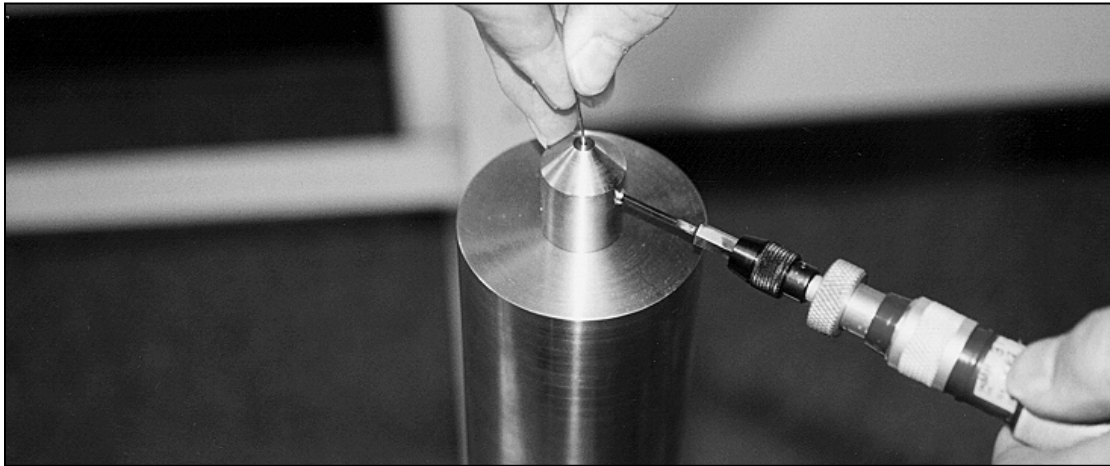


Figure 9 - Tighten the Set Screw to the Wire

- 8) Place the tank underneath the measurement table.
- 9) Allow the weight to hang inside the tank.
- 10) Make any adjustments needed to position the weight correctly inside the tank and then fill the tank with water (or antifreeze solution).
- 11) Place strips of Velcro on the bottom of the readout in such a manner that they will align with the strips on the pendulum table when the readout is set in position.
- 12) Slide the wire through the slot in the readout. Be careful to avoid scratching the photosensitive screens inside the CCD chamber.
- 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.

Lower the readout onto the table so that Velcro strips on the bottom of the cabinet contact the ones on the mounting surface.

- 14) Figure 10 on the following page shows the assembly thus far.

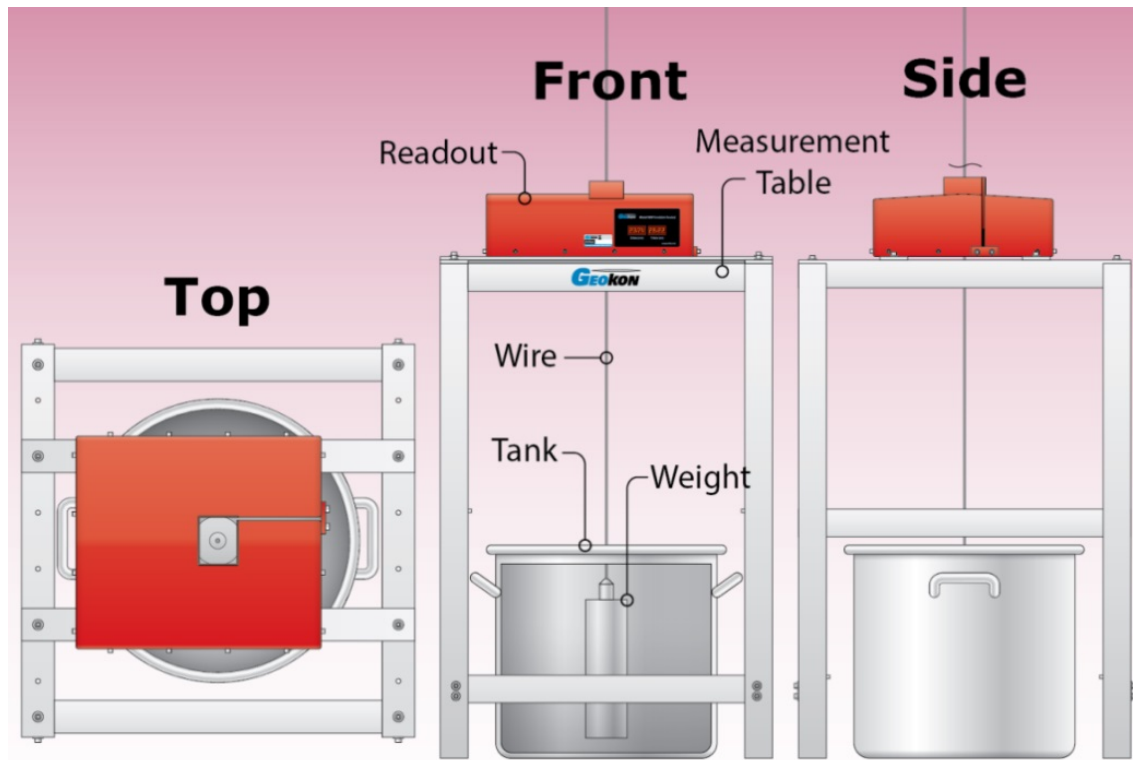


Figure 10 - Direct Pendulum System with Measurement Table

15) Attach the upper and lower light shields to the cabinet as shown in Figure 11.



Figure 11 - Light Shields Installed

- 16) If a conical drip shield was purchased, use the wrench provided to tighten the nylon set screws onto the pendulum wire. Leave about a one-centimeter gap between the shield and the cabinet (Figure 12).



Figure 12 - Conical Drip Shield Installed

- 17) Take initial readings for both axes. See Section 5.1 for data processing.

4.4 Inverted Pendulum Installation

Inverted Pendulum Systems are designed for use in dam embankments. 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 dam embankment 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 motion detector sit.

4.4.1 Inverted Pendulum Table Assembly

If the pendulum readout was purchased with a measurement table, assemble it per the print shown in Figure 14. The pictures shown in Figure 13 can be used as a general assembly guide. **IMPORTANT NOTE: If the hanging pendulum wire is already in place, assemble the table around the wire.**



Figure 13 - Measurement Table for Inverted Pendulum General Assembly Guide



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
ITEM	PART NO.	DESCRIPTION	QTY
MOUNTING HARDWARE			

Figure 14 - Inverted Pendulum Measurement Table Assembly Print

4.4.2 System Assembly

- 1) Assemble the two halves of the grout anchor by threading them together (Figure 15).

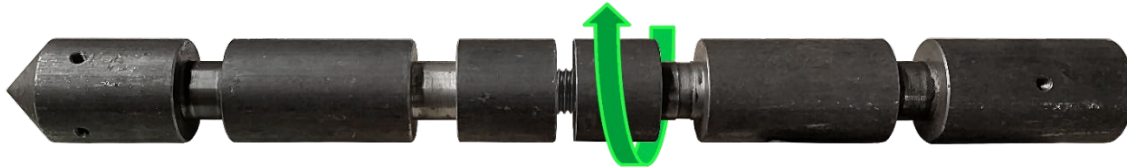


Figure 15 - Assemble the Two Large Anchor Pieces

- 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).

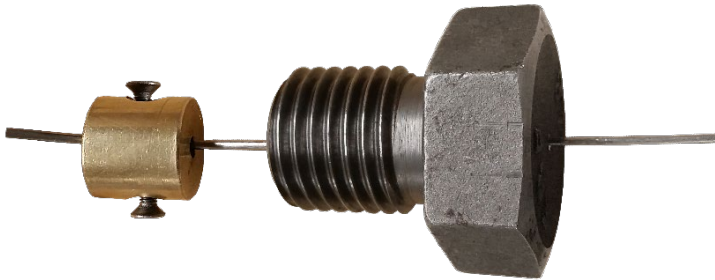


Figure 16 - Wire Inserted Through Anchor Nut and Wire Clamp

- 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 17 shows the completed end block and wire clamp assembly.

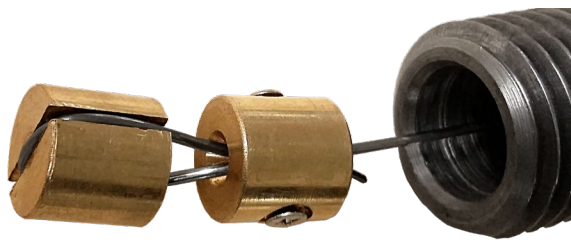


Figure 17 - End Block and Wire Clamp Assembly

- 4) Slide the end block and wire clamp into the anchor nut as shown in Figure 18.



Figure 18 - Wire Clamp and End Block Seated Inside Anchor Nut

- 5) Thread the anchor nut into the mating end of the anchor (Figure 19). The completed anchor and wire assembly is shown in Figure 20.



Figure 19 - Anchor Nut Attachment



Figure 20 - Completed Anchor Assembly

- 6) Tremie cement grout into the borehole so that when the grout anchor is lowered in the grout will almost cover it. The grout should be of a creamy consistency, similar to pancake batter.
- 7) Make centralizers out of wire or cardboard to hold the grout anchor in the middle of the borehole.
- 8) Lower the anchor into the grout and allow it to hang freely.
- 9) Keep the wire centered in the borehole while the grout is setting up.
- 10) 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.
- 11) With the aid of a spirit level, level the table using the adjustment screws on the feet.
- 12) Place the tank on top of the table.
- 13) Pass the wire up through the table and through the central hole in the tank.
- 14) Secure the clamp rod to the top of the float using the two large, knurled nuts.
- 15) Pass the wire up through the clamp rod and out the top.
- 16) Lower the float into the tank.
- 17) Push the end of the stainless steel wire through the hole in the upper wire clamp and out the hole in the side.
- 18) Push the upper wire clamp along the wire until it is approximately 50 mm away from the top of the clamp rod.
- 19) Tighten the upper wire clamp onto the wire. Cut off any excess wire.

- 20) 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.
- 21) Makes sure the float is centralized within the tank.
- 22) Place the tank on top of the table so that it is positioned centrally around the float (move the table if necessary).
- 23) Add more water until the tension on the stainless steel wire is around 60 kilograms. (The float should be submerged approximately 200 mm.)
- 24) Tighten the pin vise to the stainless steel wire.
- 25) Place strips of Velcro on the bottom of the readout in such a manner that they will align with the strips on the pendulum table when the readout is set in position.
- 26) Slide the wire through the slot in the readout. Be careful to avoid scratching the photosensitive screens inside the CCD chamber.
- 27) 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.

Lower the readout onto the table so that Velcro strips on the bottom of the cabinet contact the ones on the mounting surface.

- 28) Figure 10 depicts the assembly thus far.
- 29) Attach the upper and lower light shields to the cabinet as shown in Figure 22 below.

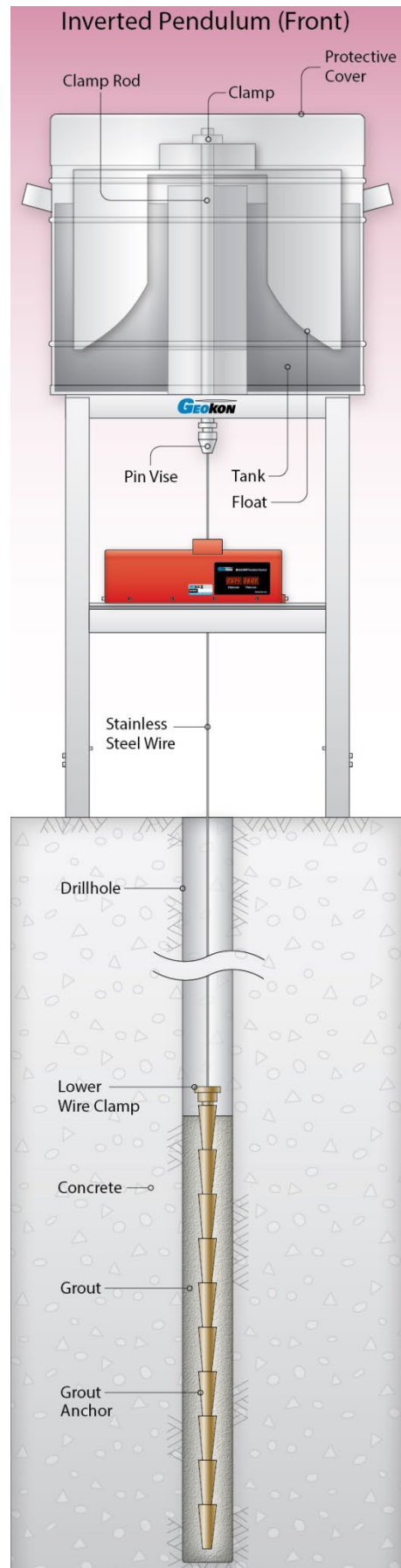


Figure 21 - Inverted Pendulum System



Figure 22 - Light Shields Installed

- 30) If a conical drip shield was purchased, use the wrench provided to tighten the nylon set screws onto the pendulum wire. Leave about a one-centimeter gap between the shield and the cabinet (Figure 23).

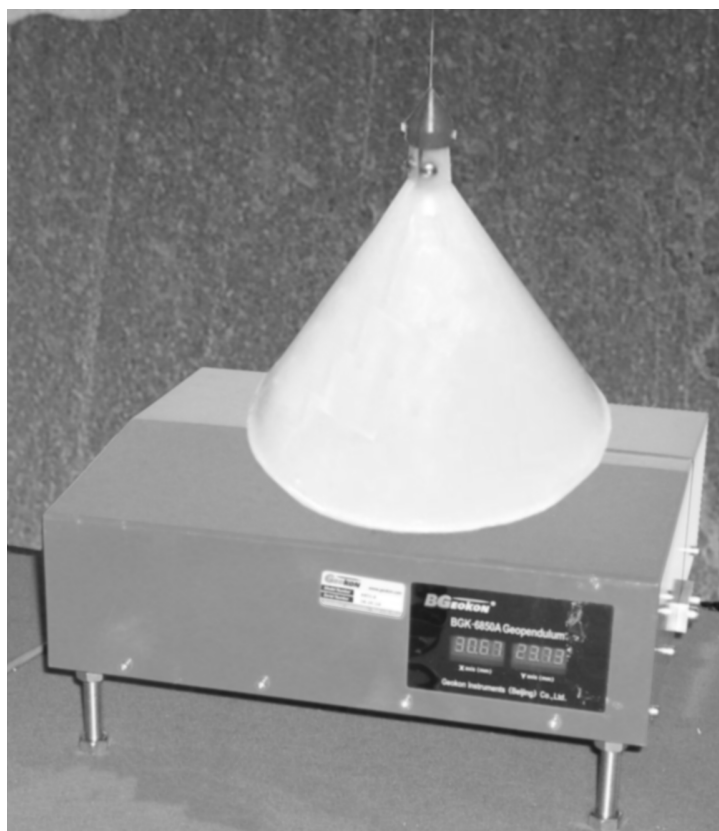


Figure 23 - Conical Drip Shield Installed

- 31) Take initial readings for both axes. See Section 5.1 for data processing.

4.5 Optical Manual Readout with LED Light Beam

Geokon's Model 6850-10 Optical Manual Readout is designed to be used where automated systems are not necessary, or where a manual reading backup is required.

Assemble the table and optical readout per the print found in Appendix G. **Note: If the hanging pendulum wire is already in place, assemble the table around the wire.**

The optical readout may also be purchased with wall mounting brackets (Model 6850-9). Contact Geokon for more information.

Mount the assembled optical readout and table to the top of the measurement table using the four cap screws and lock washers provided (Figure 24). Make sure that the holes in the top rails of the upper table line up with the matching holes in the lower table.



Figure 24 - Optical Readout and Table Mounted to Measurement Table

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, as shown in Figure 25.

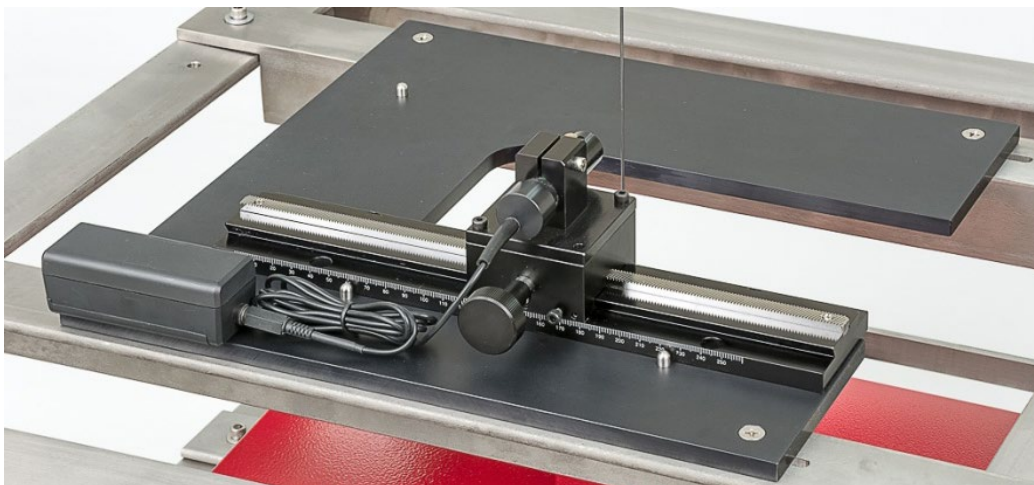


Figure 25 - Manual Readout in Position One

Power the unit by plugging the LED into the battery pack.

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.

Next, 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 26.

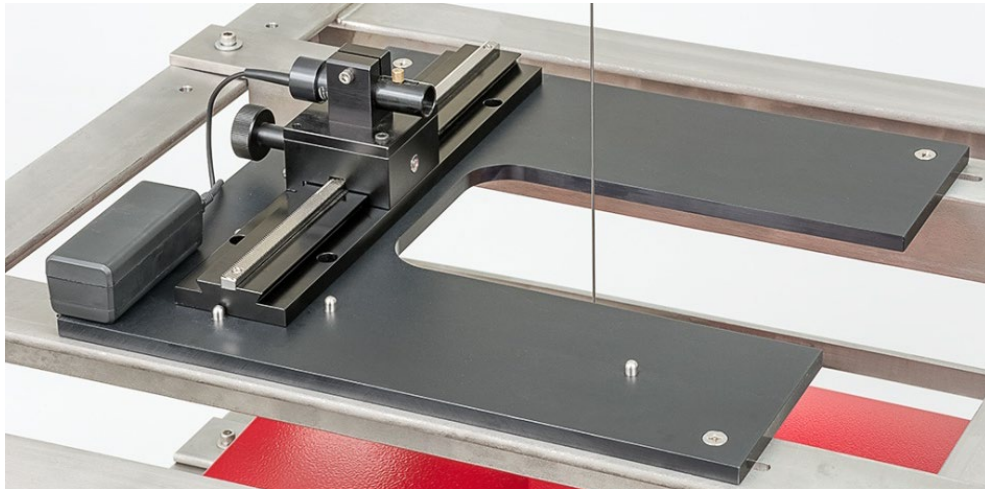


Figure 26 - Manual Readout in Position Two

Take a reading for the current axis. Subsequent readings are taken in the same manner. For information on data processing, see Section 5.1.

4.5.1 Calibration Pointer

The 6850-10 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:

Screw the calibration pointer into the threaded hole in the mounting plate (Figure 27).

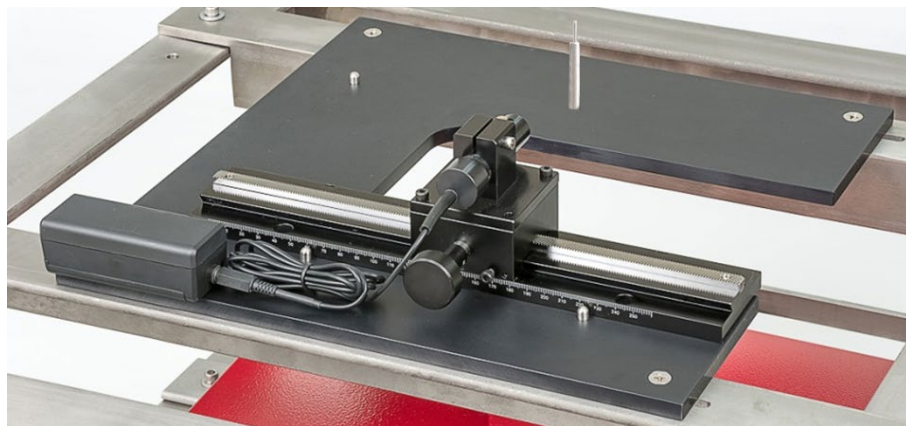


Figure 27 - Calibration Pointer Attached to the Mounting Plate

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 Processing

Initial values of X and Y should be obtained during installation.

Movements of the pendulum wire (ΔX and ΔY) 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 Wire Along the X-axis

$$\Delta Y = Y_1 - Y_0$$

Equation 2 - Movement of the Pendulum Wire Along the Y-axis

Where;

X_0 and Y_0 are the initial readings of the X and Y axes.

X_1 and Y_1 are subsequent readings of the X and Y axes.

When using the 4-20mA 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 onsite monitoring, the 6850 Pendulum 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 28.

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!

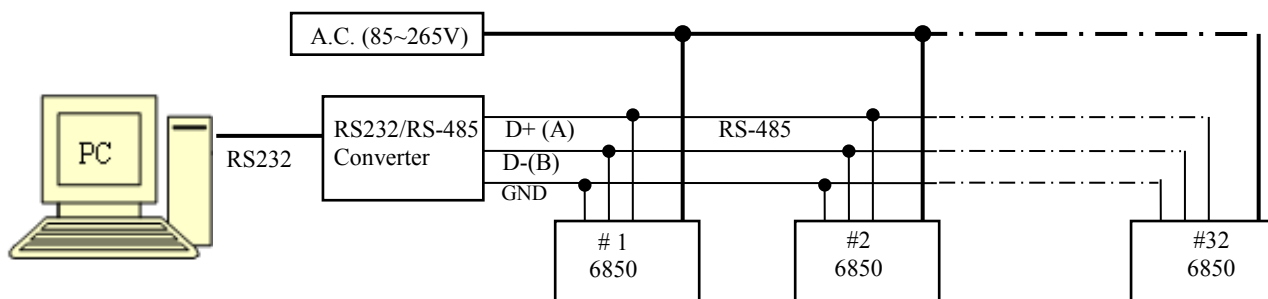


Figure 28 - The RS 485 Addressable Network

When using the RS 485 network the distance to the farthest pendulum should not exceed 1200 meters. 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 meters, a fiber optic cable can be used. (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 4-20mA Analogue Output

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

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 Readout ships with an RS-485/4-20mA 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	4-20mA output X-axis	Red
B	X-axis ground	Red's Black
C	4-20mA output Y-axis	White
D	Y-axis ground	White's Black
E	None	---
F	RS-485 T/R -	Green
G	RS-485 T/R+	Green's Black

Table 2 - RS-485 and 4-20mA connector

6. CCDTEST SOFTWARE

Each Pendulum Readout comes with a copy of **CCDTest** software, which is 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 Readout with MultiLogger software, see Appendix B.)

6.1 Initial Setup

Upon opening, the program will default to the main screen (Figure 29).

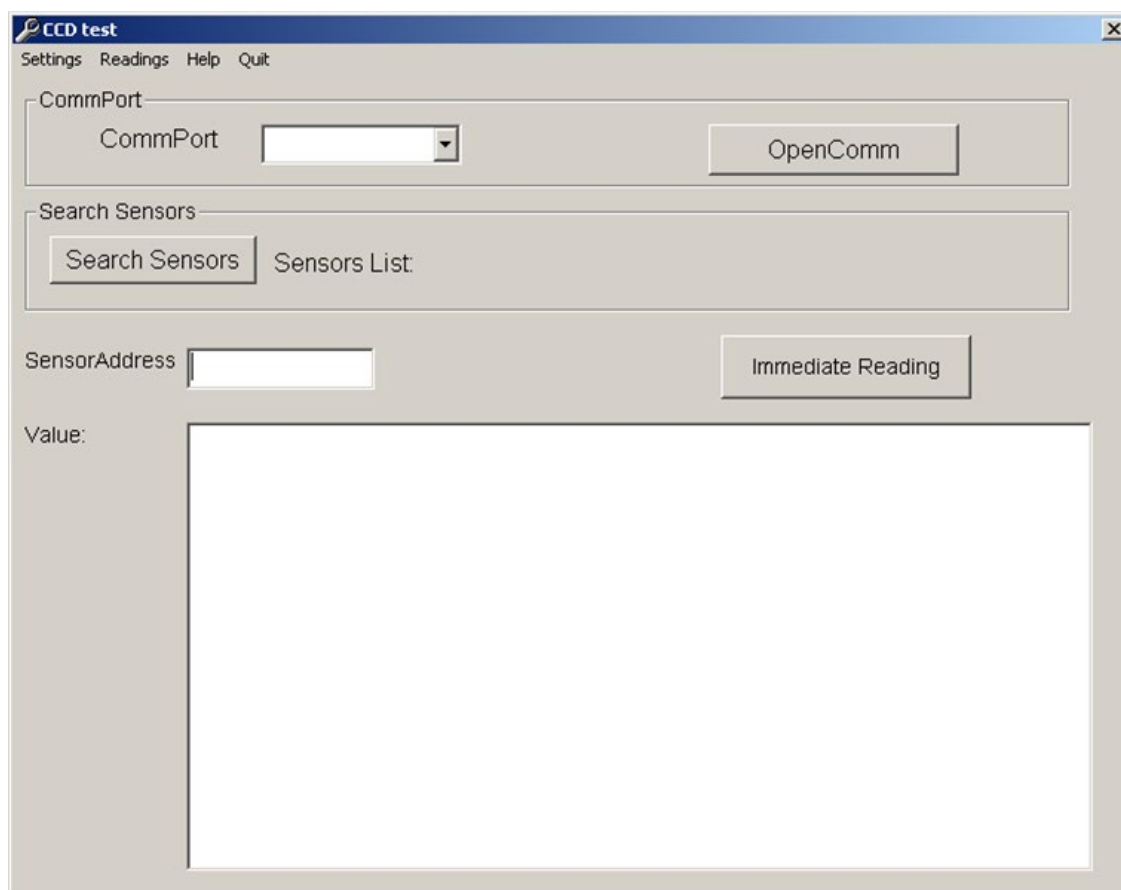


Figure 29 - CCD Test User Interface

In the **CommPort** section of the screen, select the CommPort that has the RS-485 adaptor attached, and then click **OpenComm** (Figure 30).

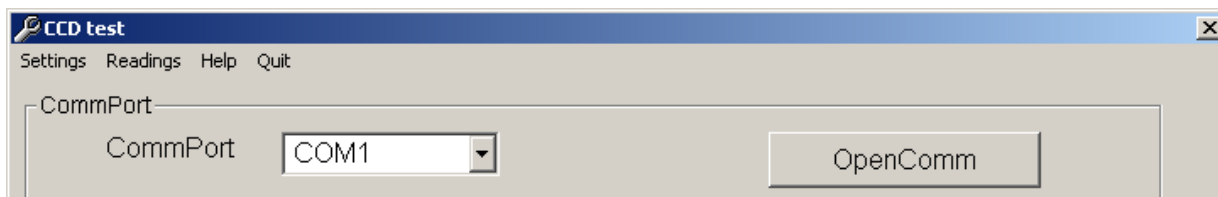


Figure 30 - Select Commport

If unsure of the address, click the **Search Sensors** button. This will cause the software to attempt to locate the correct CommPort (Figure 31).

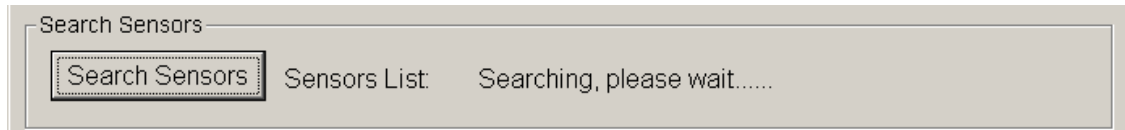


Figure 31 - Search Sensors

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 32 below, sensor address 15 was found and subsequently entered into the SensorAddress field.

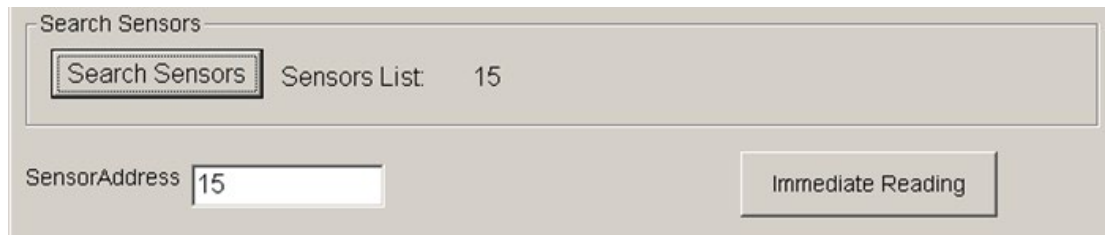


Figure 32 - Sensor Address

Clicking **Immediate Reading** will cause the program to take measurements from the attached pendulum every 10 seconds. These measurements will be displayed in the **Value:** section of the screen (Figure 33). 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 press the **Stop** button then restart the Immediate Readings.

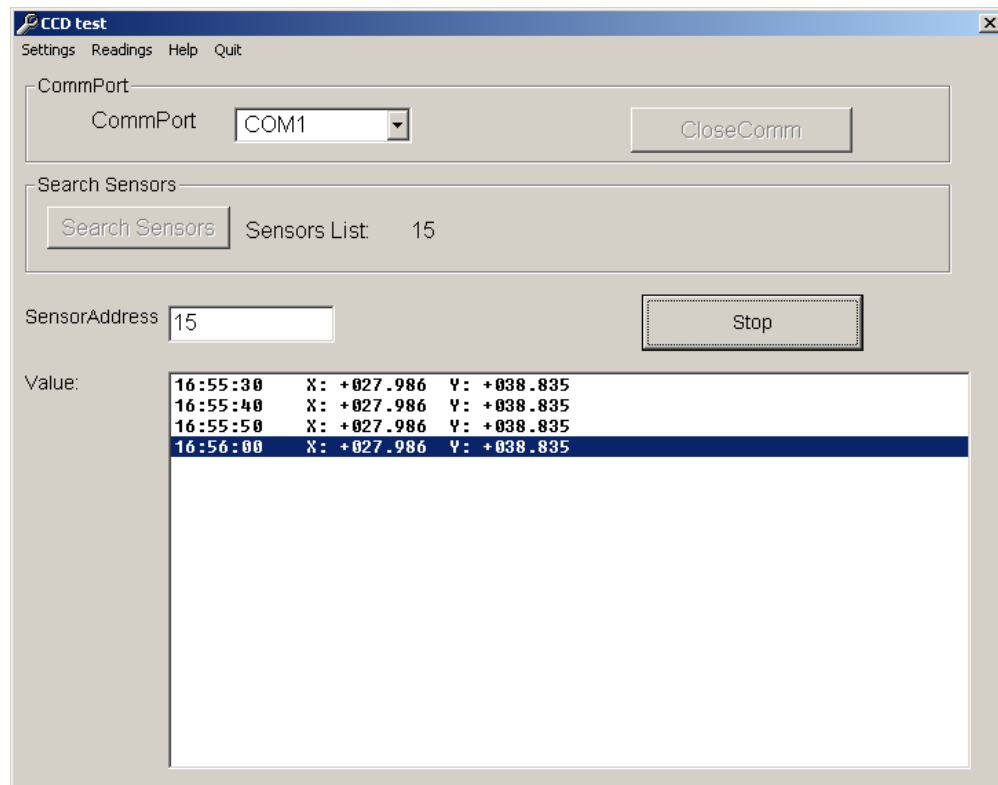


Figure 33 - Time Stamped X and Y Readings

6.2 Settings

The CCDTest software provides several functions related to the configuration of the pendulum. These options are made available by clicking on **Settings** in the upper left portion of the screen (Figure 34). The function of each available setting is described in the subsections below.

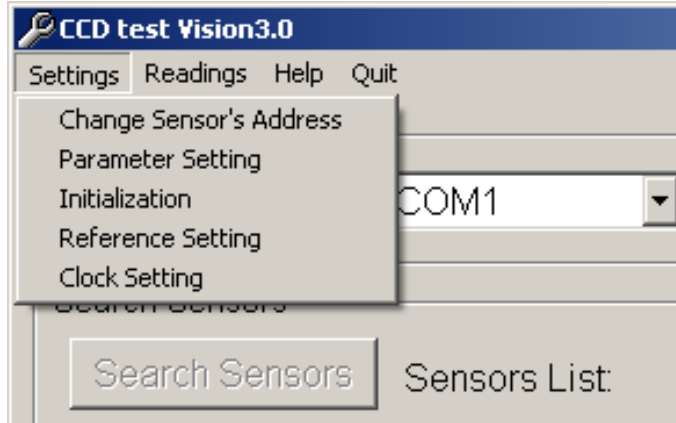


Figure 34 - Settings Dropdown

6.2.1 Change a Sensor's Address

Selecting **Change Sensor's Address** from the Settings dropdown list will cause the Set Sensor's Address form to display (Figure 35). Enter the **Original Address** followed by the **New Address**. Click **OK** when finished. In Figure 35, the sensor address is being updated from 15 to 1.



Figure 35 - Set Sensor's Address Form

The software will attempt to change the sensor address and then show a message stating if the address change was successful (Figure 36). Click **OK** to return to the Set Sensor's Address form.

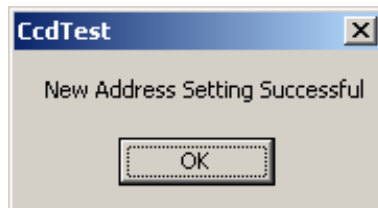


Figure 36 - Address Set Successfully

If the address change fails, try again with a new address. Once all desired address changes have been made, click the **Cancel** button to return to the main screen.

Once a sensor address has been changed, it must be updated in the **SensorAddress** field on the main screen. A **CommError** will be displayed until the new sensor address has been entered (Figure 37).

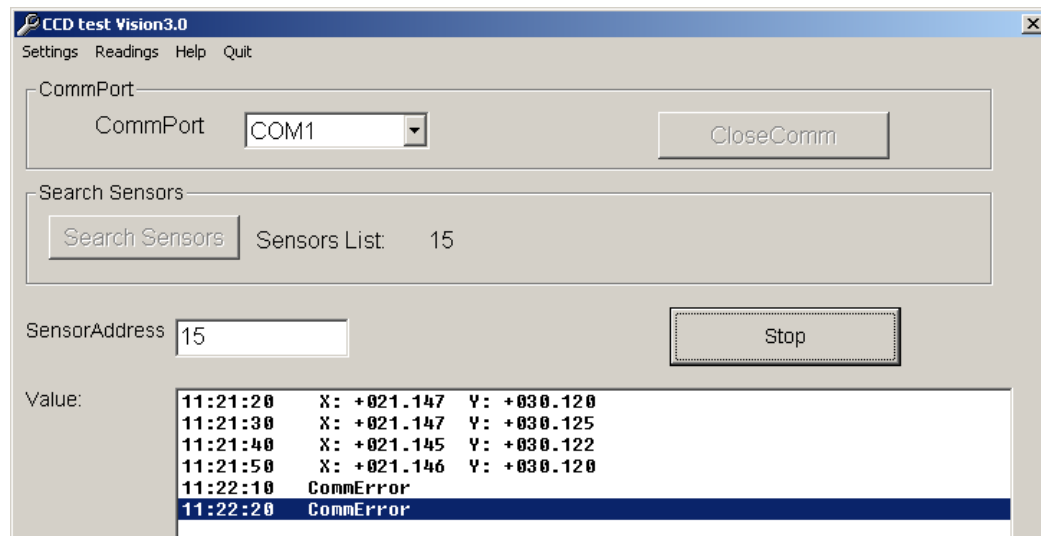


Figure 37 - CommError Caused by Incorrect Sensor Address

Once the Sensor Address field has been updated, the readings should display properly. In Figure 38 the sensor address has been updated from the original address of 15 to the new address of 1, causing the readings to display properly.

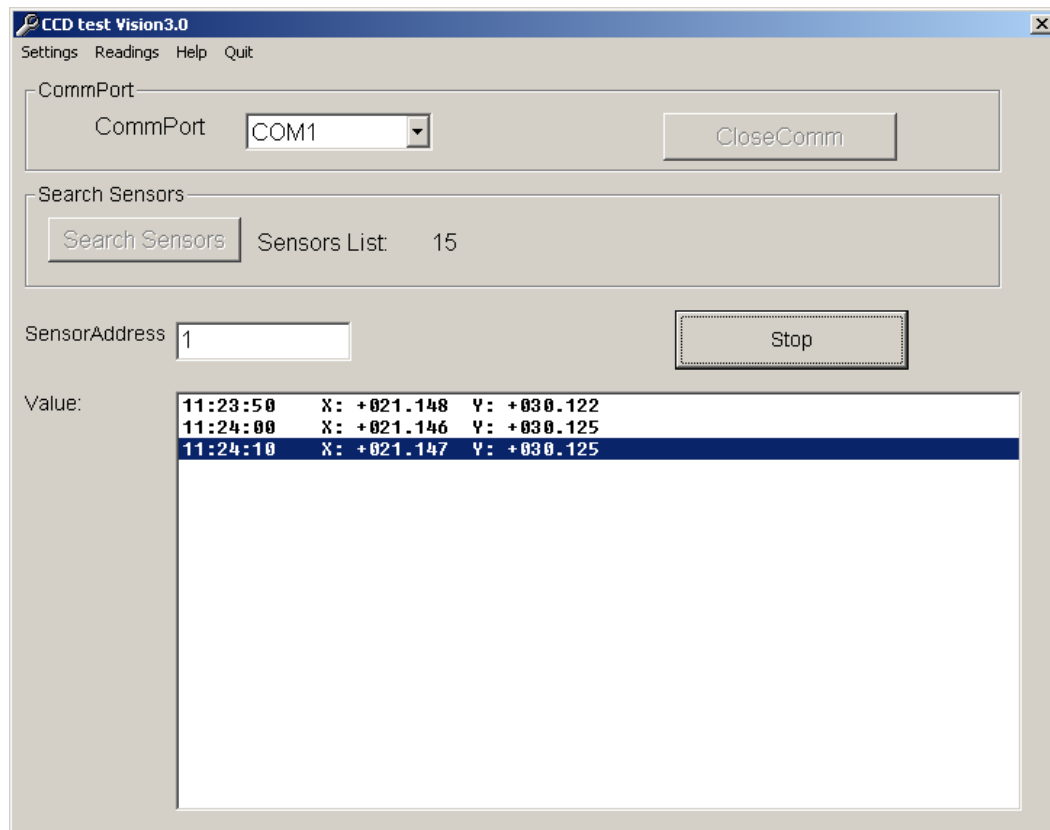


Figure 38 - Updated Sensor Address

6.2.2 Parameter Setting

Select **Parameter Setting** from the Settings menu to configure the wire diameter and the permitted error for each Pendulum (Figure 39).

Figure 39 - Parameter Settings Window

Enter the Sensor address the calibration parameters will be set for in the **Pendulum Readout Addr** field. Next, enter the wire diameter in millimeters in the **Diameter(mm)** field. Lastly, enter the desired permitted error in millimeters in the **Permitted Error(mm)** field. (The recommended Permitted Error is 0.5 mm.)

Once all the information has been entered, click **Set** to adjust the internal pendulum settings. The **Inquiry** button will populate the fields with the current pendulum settings. Click **Exit** when finished to return to the main screen.

6.2.3 Initialization

Please 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 dropdown list will cause the **Swap** window to display (Figure 40). The swap window allows the X and Y axes of the pendulum to be interchanged. (This includes reversing the digital display and the 4-20mA outputs of the unit.) The default is False, meaning no change will take place. This may be changed to True by selecting True from the dropdown menu. If set to true the X and Y axes will be swapped. Once the desired setting has been selected press **Set**. Pressing **Query** will display the pendulum's current setting.

Figure 40 - Swap Readout of X and Y

Clicking **Next** in the Swap window will open the **Invert** window (Figure 41) 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.

To change the direction of movement of an axis, use the dropdown under **X Direction** or **Y Direction** and change the value 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.

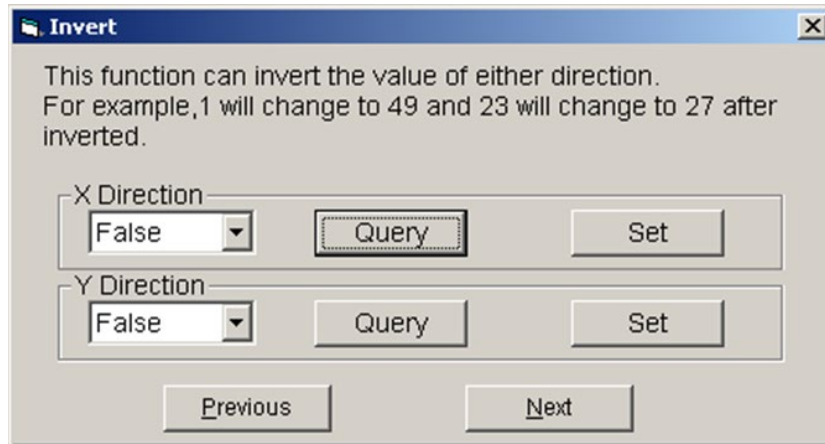


Figure 41 - Invert Window, used to Reverse the Direction of an Axis

Press **Set** to update the pendulum with the chosen settings. Press **Query** to view the current settings. When finished press **Next**; this will advance the program to the Reference Setting window detailed in the next section. Pressing **Previous** will cause the program to return to the Swap form.

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 40) then setting the X Direction to True in the invert screen will invert what was originally the Y-axis.

6.2.4 Reference Setting

Please 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 42) 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.

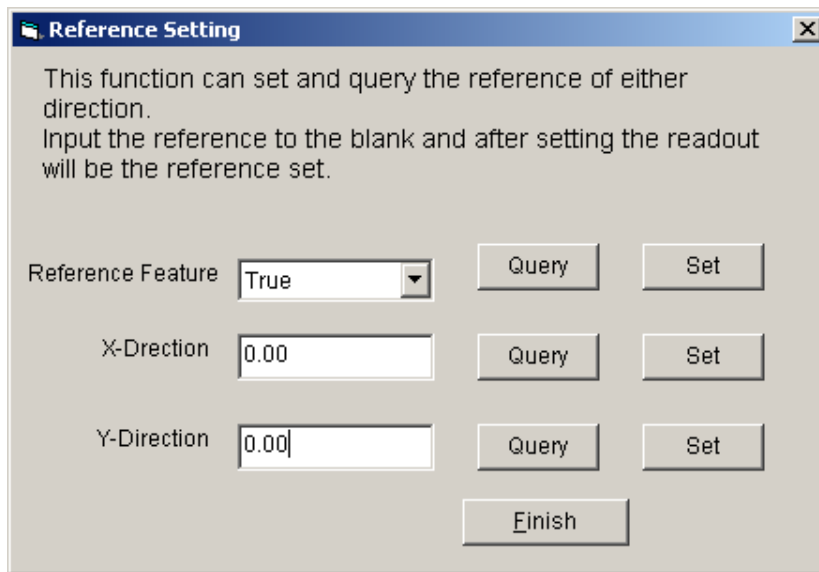


Figure 42 - Reference Setting Window

Enter the desired value for the X-axis reference in the **X-Direction** field then press the **Set** button 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.

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. Once the desired setting has been chosen, press the **Set** button 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). Click **OK** to continue.



Figure 43 - Reference Setting Message

Once the Reference values have been set, the pendulum display will update to account for the new Reference values. Close the form by clicking the X in the upper right corner.

The program will return to the Reference Setting window (Figure 42). Click **Finish** to return to the main screen.

Upon returning to the main screen the X and Y values will be updated according to the values entered (Figure 44).

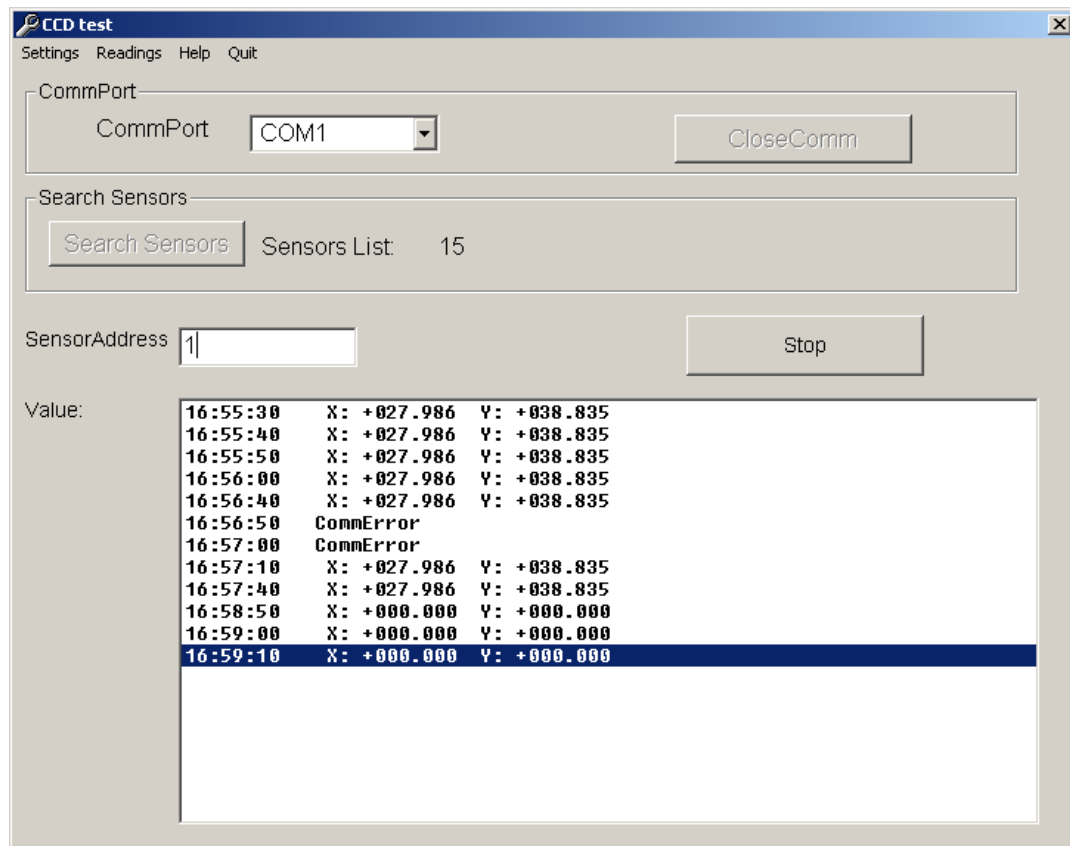


Figure 44 - Updated X and Y Values Coinciding with Reference Changes

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.

(To show changes in movement after installation, configure the fields as shown in Figure 42.)

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 dropdown on the main screen to display the Set Time form (Figure 45).

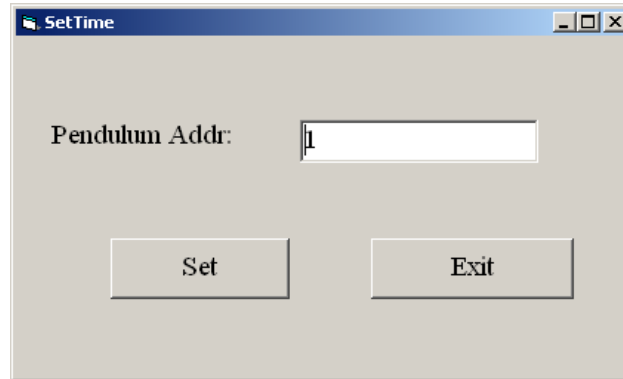


A screenshot of a Windows-style dialog box titled "SetTime". The dialog has a light gray background and a blue title bar. Inside, there is a label "Pendulum Addr:" followed by a text input field containing the number "1". Below the input field are two buttons: "Set" on the left and "Exit" on the right.

Figure 45 - Set Pendulum Time to Match PC Clock

To match the internal pendulum clock to the PC clock, enter the desired pendulum address and press **Set**.

Click **Exit** to return to the main form.

6.3 Quitting the Program

Before closing the program, stop the immediate readings by clicking on  and then close communications to the Comm port by clicking .

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

7. TROUBLESHOOTING

The 6850 Pendulum Readout requires no regular maintenance other than periodic checks to see that the optics are clean. Using a computer and the software supplied with the readout 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 Table 3 below to trace and correct the fault. If the fault still exists after performing the suggested remedy, return the readout to the manufacturer.

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

Displayed Error Code or fault symptom	Problem	Solution
Err2	The ambient light is too bright.	Enhance the light shielding methods or use an additional light shield.
Err3	The light is too weak.	Return to manufacturer for repairs.
Err4	There is no shadow indicating that the pendulum wire has moved out of range.	Readjust the position of the readout.
Err5	A fault has occurred in the CCD image sensor.	Return to the manufacturer for repair.
Err6	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	Power supply has failed.	Restore Power.
Displays work but communications have failed.	The readout address may be incorrect, or there is a fault in the communication line.	Reset the address, or check the communication cable.
No analogue output	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. TECHNICAL SPECIFICATION

Measuring Range	50 mm x 50 mm
Resolution	0.01 mm
Precision	0.1 mm
Wire Diameter:	1.0 mm to 9.9 mm
Electrical drift	Zero
Operating Temperature	-10 °C to +50 °C
Relative Humidity	100%RH
Sensor	CCD
Outputs	Onsite LED display, RS-485 and 4-20mA port
Sample Frequency	Once/10 seconds to Once/day, programmable
Data Storage capacity	2000 readings on nonvolatile RAM. Each reading has values of X, Y, date and time.
Power Supply	100 to 240VAC, 50 to 60Hz, 10Watts
Enclosure	Weatherproof, painted steel (Red)
Dimension	380 x 330 x x145 mm
Weight	9 kg

APPENDIX B. MULTILogger SOFTWARE CONFIGURATION

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

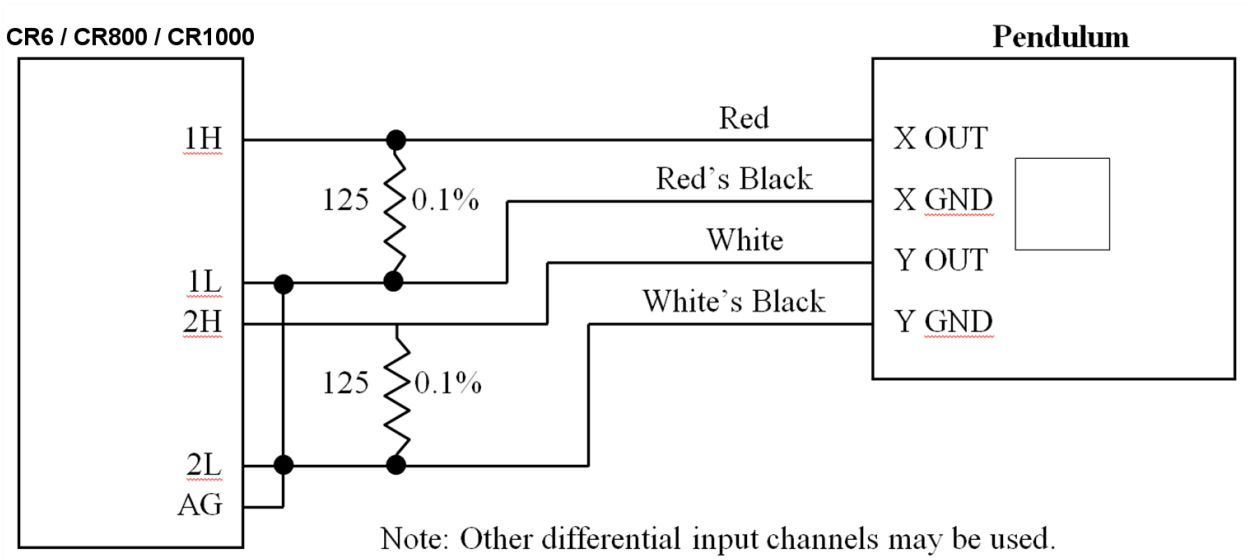
Table 4 shows the pinout for the output connector found on the base of the cabinet.

Pin	Description	Color (Pre-assembled)
A	X-Axis 4-20mA Output	Red
B	Ground	Red's Black
C	Y-Axis 4-20mA Output	White
D	Ground	White's Black
E	No Connection	
F	RS-485-	Green
G	RS-485+	Green's Black
H,J,K	No Connection	

Table 4 - Output Connector Pinout

B.3 4-20mA 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 Figure 46 for a diagram of the 4-20ma connection.



Note: Other differential input channels may be used.

Figure 46 - 4-20mA Connection Diagram

Figure 47 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.

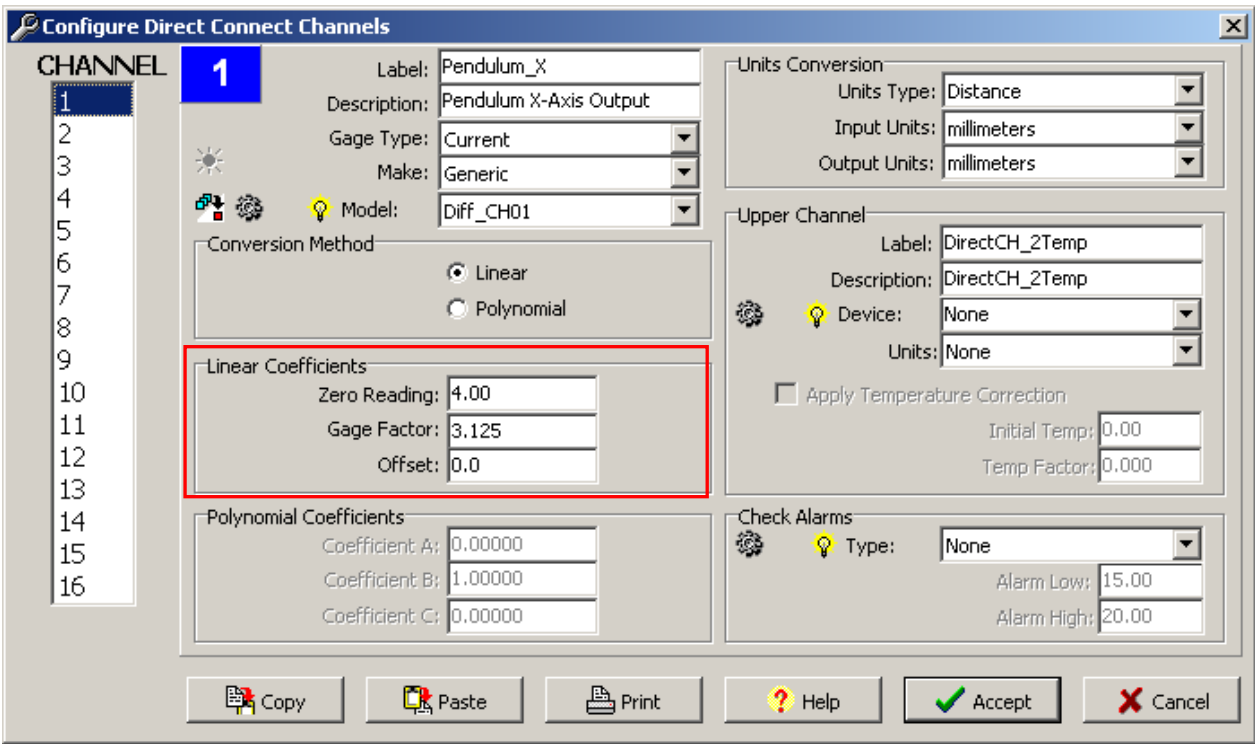


Figure 47 - Linear Coefficients

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.

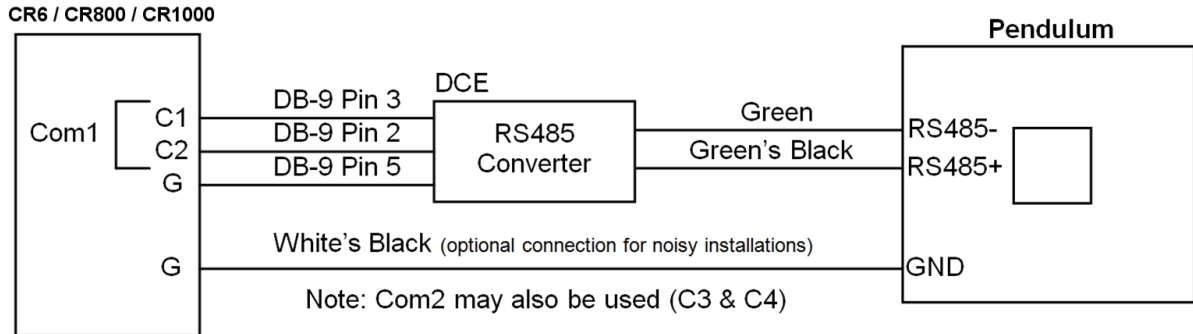


Figure 48 - RS-485 Connection Diagram

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 49 below 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.

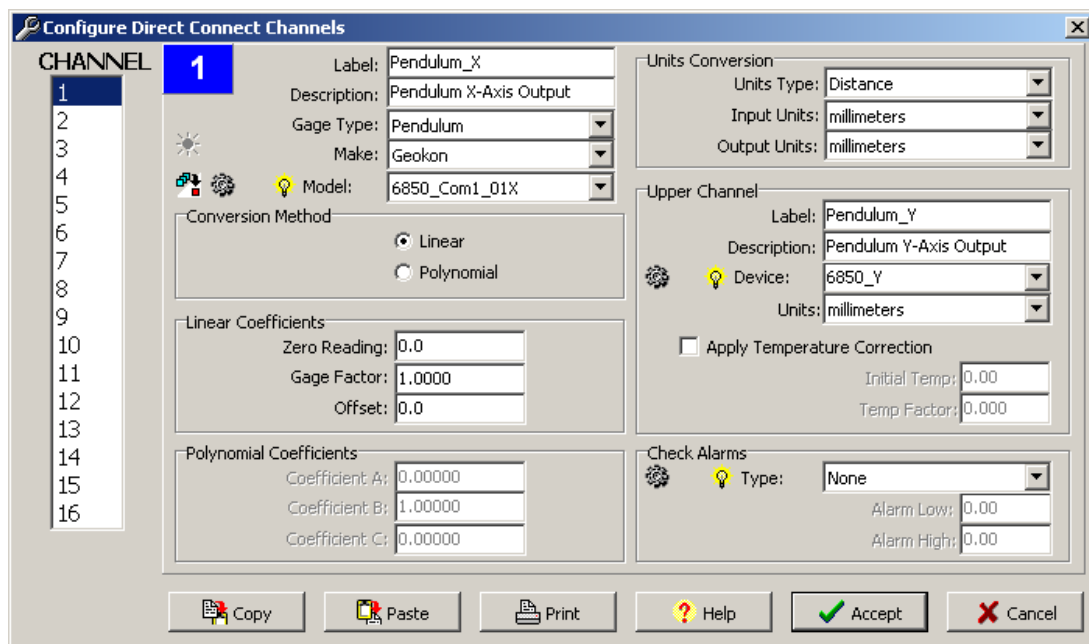


Figure 49 - Typical RS-485 Channel Configuration

The configuration shown in Figure 49 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 50.

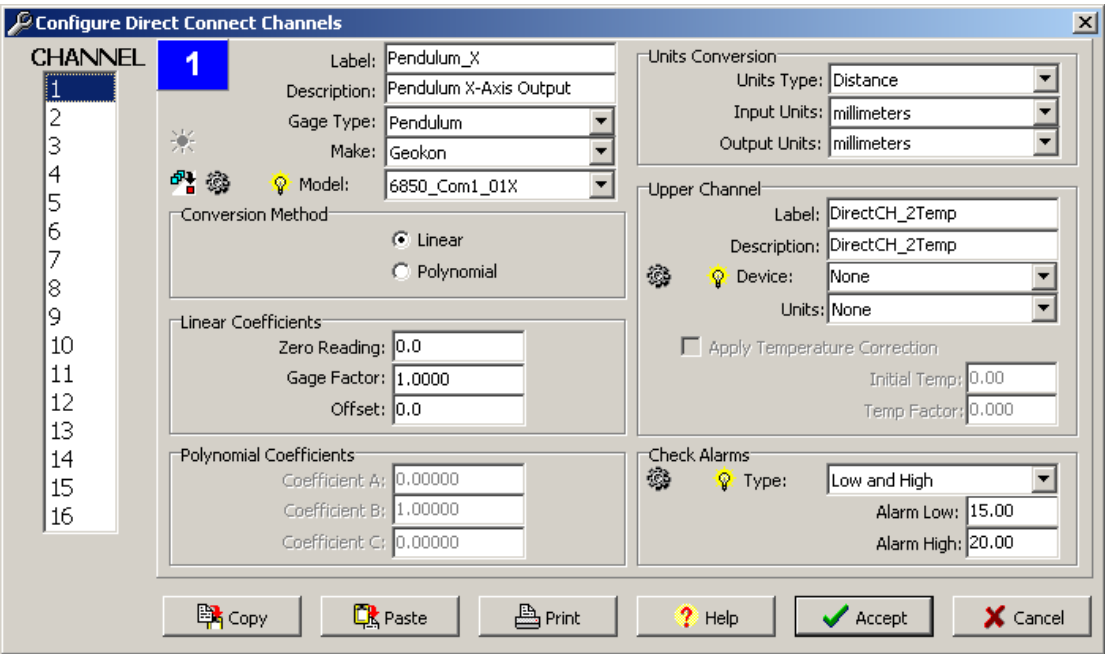


Figure 50 - Channel 1, X-axis Configuration

Channel 2 would then be used to support the Y-axis measurement, and would be configured as shown in Figure 51.

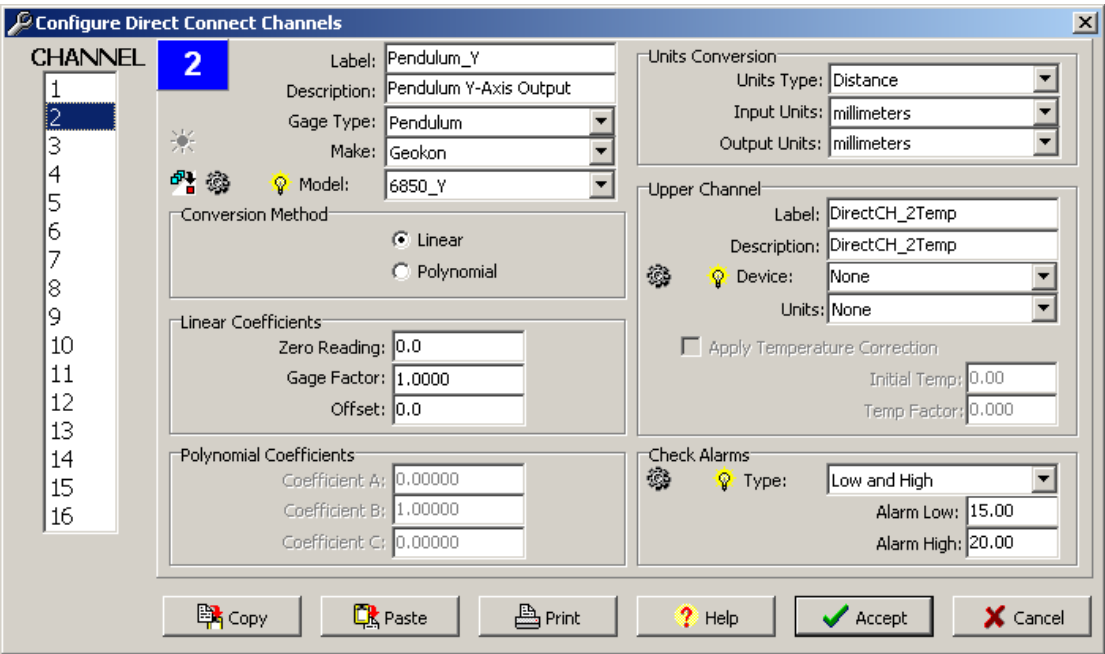


Figure 51 - Channel 2, Y-axis Configuration

B.5 Error Codes

The pendulum has several error codes that indicate problems with the installation or the unit. These codes will be shown on the pendulum display and have equivalent values when automating the systems using MultiLogger.

Use Table 5 below to trace and correct the fault. If the fault still exists after performing the suggested remedy, return the readout to the manufacturer.

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

Displayed Error Code or fault symptom	MultiLogger Code	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 or there is a fault in the communication line.	Restore Power and check the communication cable.

Table 5 - MultiLogger Error Codes

APPENDIX C. PENDULUM COMMANDS

Terminal emulation programs may be programmed with the pendulum commands to help with troubleshooting and configuration of the units. Table 6 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. CR6 PROGRAMMING EXAMPLE

'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

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
```

APPENDIX E. CR800/CR1000 PROGRAMMING EXAMPLE

(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
    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 F. 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 mm x 45 mm angle iron, which are connected together by one strut at the wall and a U shaped top plate (see Figure 52).

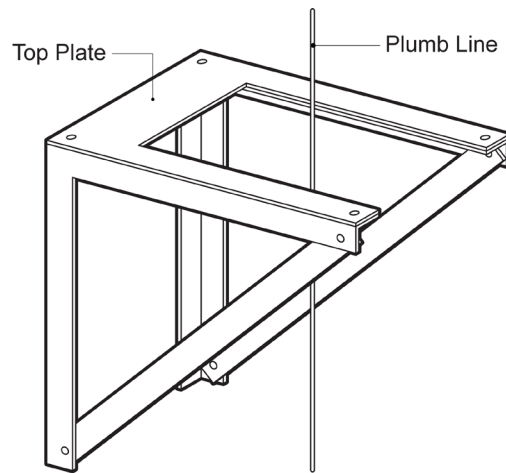


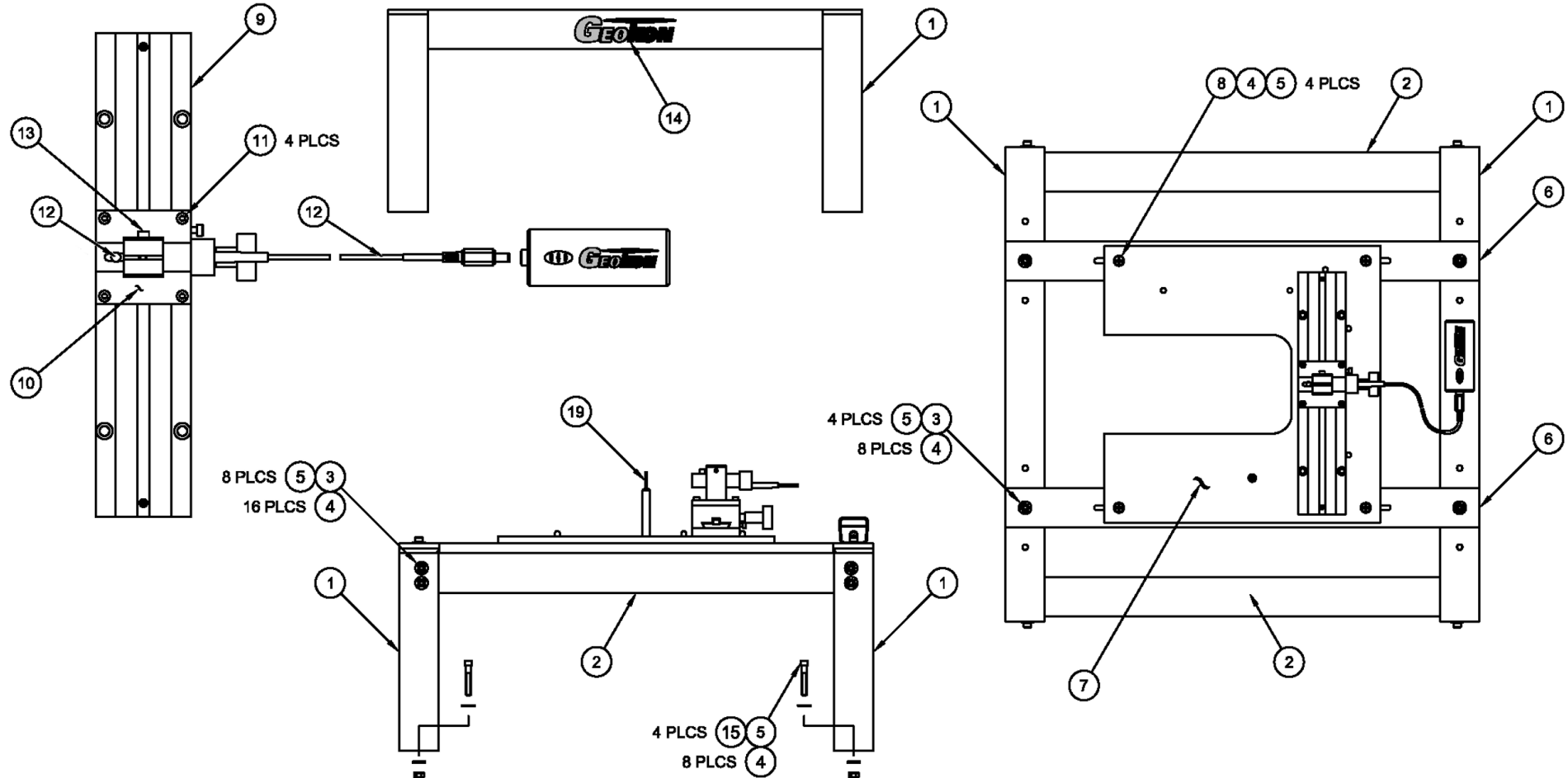
Figure 52 - Mounting Bracket

F.1 Mounting Bracket Installation

The clearance between the wall and the pendulum wire needs to be at least 230 mm (nine inches), large enough so that there is space enough for the readout cabinet, bearing in mind the orientation convention found in Section 4.2.

- 1) Drill four, 12 mm 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 12 mm 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 the adhesive backed Velcro strips to the top plate so that they will contact the strips attached to the Pendulum readout when the readout is put into position.

APPENDIX G. DRAWING OF OPTICAL MANUAL READOUT WITH LED LIGHT BEAM



* INCLUDES SPARES

ITEM	DWG NO.	DESCRIPTION	MAT'L	QTY
9	ELC-257	STAGE & TRACK COMBINATION 250MM	ALUM.	1
8	HRD-766	SCREW, 1/4 - 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 1/4 - 20 SS	SS	30 *
4	HRD-707	WASHER, FLAT 1/4 SS	SS	70 *
3	HRD-529	SCREW, CAP SH 1/4 - 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

GEOKON

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 1/4 - 20 X 1-1/2" LG. SS		8 *
14	ART-126	LABEL, GEOKON LOGO, LARGE		1
13	HRD-421	SCREW, CAP SH 8 - 32 X 3/4 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
ITEM	DWG NO.	DESCRIPTION	MAT'L	QTY