S-1410 Calibration & Utility Software

for the R-1307-2.4XBE, R-1307C, R-1307B-2.4XBE and R-1307BC Readouts

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HAMAR LASER®
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R-1307 Target Calibration using A-807/A-808 and S-1410 Calibration Software

All PSD sensors used in Hamar Laser's targets need to be calibrated to improve the linearity. In addition, there are several targets where the centering or squareness of the PSD to the housing needs to be checked and calibrated. The typical specifications for cabled targets are:

Span Error (linearity) – error <1-2%
Centering – error <.0005 in. (0.013 mm)
Squareness – error <.0005 in/in (.0005 mm/mm) or <.0005 in/ft.

The S-1410 Calibration software for the R-1307 Readout series provides the capability to upload calibration factors into the readouts to calibrate any Hamar Laser 2-axis and 4-axis cabled targets. The A-807 Center/Angular Calibration fixture comes with a single-axis translation stage plus a single-axis, angular, tilting stage, both with certified micrometers, and is used to calibrate both centering and angular errors for our 4-axis targets.

The A-808 X-Y Angle/Center Calibration Fixture, which comes with the X-Y stage with certified micrometers and a mount for the L-705/L-706 Lasers, is used with the lasers/targets and their appropriate adapters to detect centering (concentricity) and span (linearity) errors. With the use of our T-261 Target, the A-808 can also be used to check the centering error on the L-703/L-705/706 lasers.

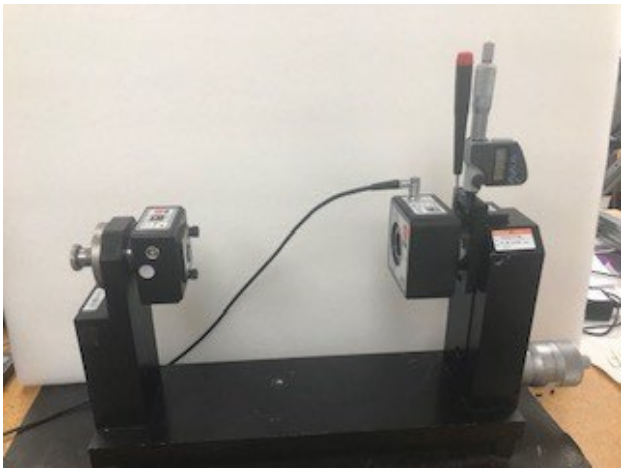


Figure 1 -- *A-807 Calibration Fixture with X-Axis Translation and Angular Stage for T-212 and T-261 Targets and L-700/L-703/L-705/706 Laser Mount*

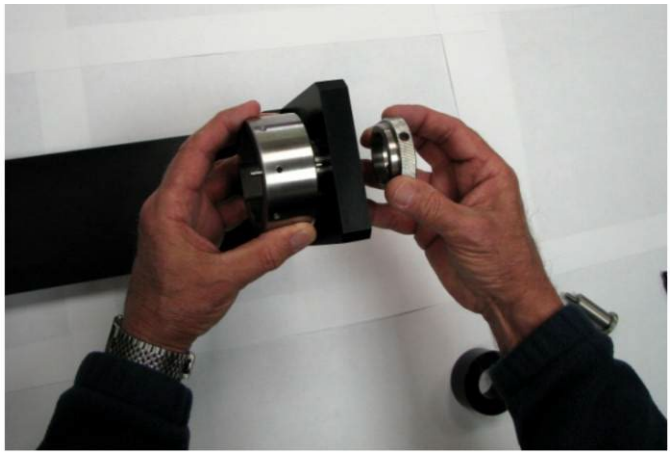
Figure 2 - A-808 Calibration Fixture with X-Y Target Stage

Assembling the A-808 Fixture

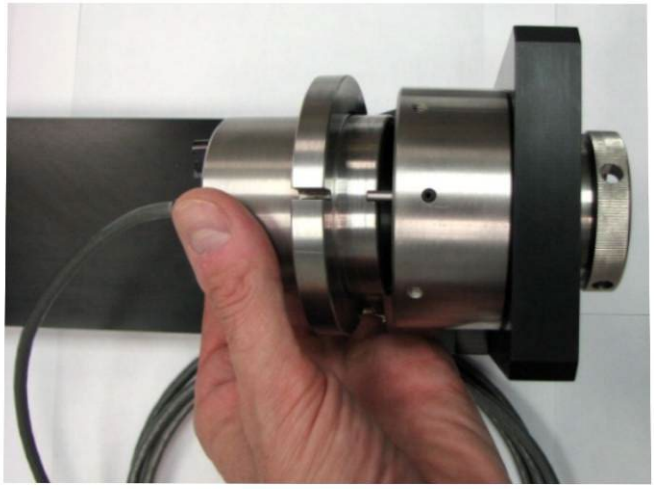
Mounting a Target for Centering on the A-808 Fixture

The following figures display the procedures for mounting lasers and targets into their adapters and for mounting a target to the X-Y Stage.

T-218 Target Centering Adapter



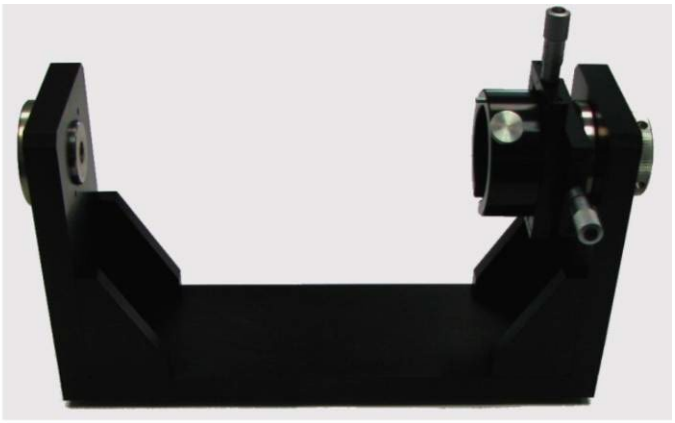
T-218 Target Centering Adapter Mounting



T-218 Target Inserted into Centering Adapter

Mounting a Target for the X-Y Stage

Mounting the X-Y Target Stage



A-808 Calibration Fixture with X-Y Target Stage for T-218/219 Targets and L-705/706 Laser Mount

Inserting T-218 Target in X-Y Stage

Mounting a Laser to the A-808 Fixture

Mounting Hardware for the L-700 Laser

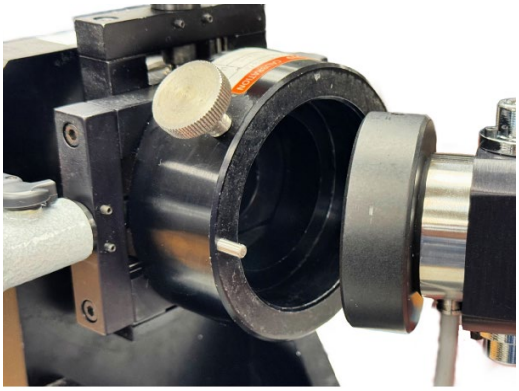
L-700 Laser Mounted

L-705 Laser Mounted

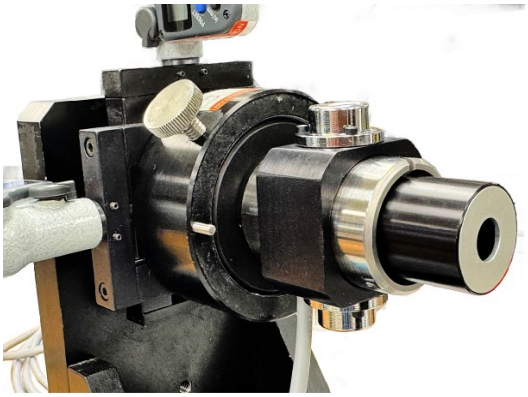
Assembling the A-808-212XY X-Y Mounting Adapter and T-212 for insertion into the A-808 Calibration Fixture.

A-808-212XY X-Y Stage Mounting Adapter for .500 in. Stud

Assembling the A-808-212XY X-Y Stage Mounting Adapter with T-212 Target



Inserting the A-808-212XY X-Y Stage Mounting & T-212 Target into the X-Y Stage



The T-212 Target Ready for an X-Y Span Error Check

How to Check Span and Concentricity Errors

There are two sets of calibration parameters that must be entered into the S-1410 Calibration and Utility Software:

1. **Gain Adjustment (Span) Error)** – this is a measure of how accurately the target (combined with the R-1307 Readout) displays a known amount of displacement, or for angular Span Errors, for a known amount of angular change. Typically, an X-Y micrometer stage is used to move the target a known amount (usually .025 in. or one full turn on a micrometer), and this is compared to the value displayed on the R-1307 Readout. If the value displayed on the R-1307 is not the same as the micrometer value, then a calibration factor is calculated and entered into the S-1410 software to be uploaded to the R-1307 to correct this error.
2. **Concentricity (Center) Error** – this is a measure of how far off center the sensor (PSD) is from the target housing's OD mounting surface. Typically, this is calculated by placing the target into a centering fixture and taking two readings: one at 0° and one at 180°. If the 0 and 180° values are not the same, an offset calibration factor is calculated and entered into the S-1410 software to be uploaded to the R-1307 to compensate for this error.

Span Error (Gain) Calibration Check

1. Mount the L-705 laser and T-218 Target (or another 2-axis target) in the A-808 Fixture (Figure 3).
2. Connect the target to the R-1307 Readout as shown in Figure 3.
3. Click and hold the **Menu** button on the R-1307 until DISP= displays in the upper window.

4. Use the **Up** and **Down** arrow keys to make sure the Display Mode is in ABS mode. If not, then set it to ABS by using the up/down arrows.

5. For the R-1307, continue clicking the **Menu** button (8X) until Funct . displays in the upper window. Use the **Up** and **Down** arrow keys to change the lower display to LOCAL. See the R-1307 Manual for how to use the Menu button for the R-1307B and R-1307BC readouts.
6. Continue clicking the **Menu** button until the target record number displays in the upper window.

Figure 3 – *Laser and Target mounted in A-808 fixture*

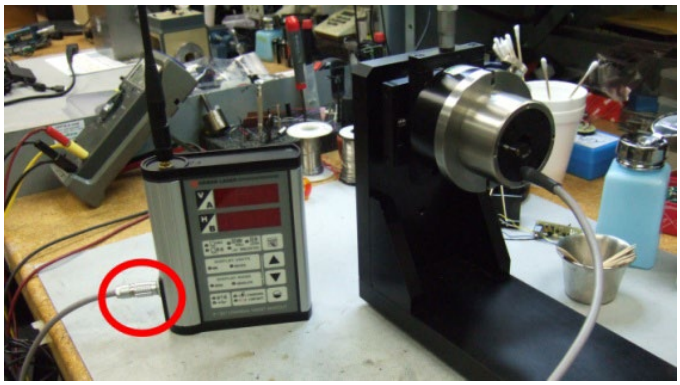


Figure 4 – *Connect target to R-1307*

7. Use the **Up** and **Down** arrow keys to select the target record. For example, **tGt.1** in the upper display window indicates Target Record #1; **tGt.2** indicates Target Record #2, etc. (see Figure 4). The lower display will show the laser mode, either **P 10.10** for Pulsed Mode or **F 10.10** for Fixed Mode.

   Note: *The R-1307 readouts can save separate calibration factor sets for up to 8 targets, so it is important to select the correct target ID when performing this procedure. It is also important to match the target ID on the serial number to the ID in the R-1307. All HLI serial numbers have a 1, 2 or 3, etc. at the end of the serial number to identify the target. You may also use your own ID system to identify the target IDs. Please keep a record of target serial IDs and the target ID used in the R-1307.*

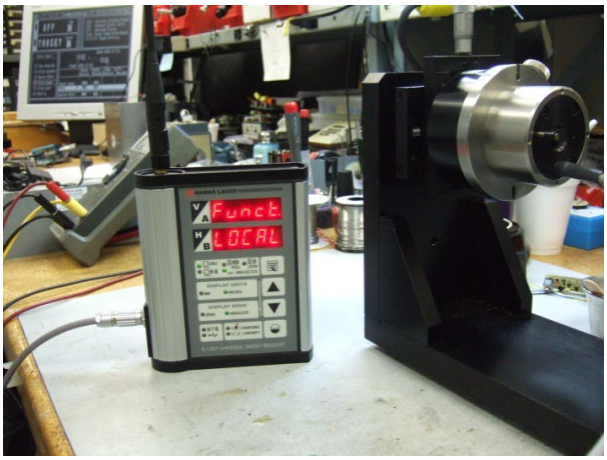


Figure 5 – *R-1307 Menu Setup*

8. Insert the target into the A-807/A-808 Fixture with the cable down (normal orientation).

   For the T-218 Target, ensure that the flip lever is securely seated in the proper position, as seen in Figure 6. This ensures you will get a reading.

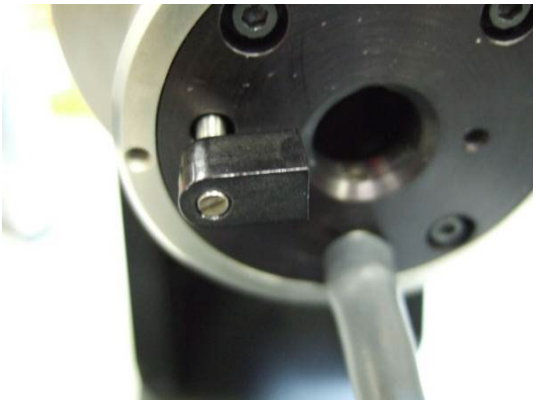
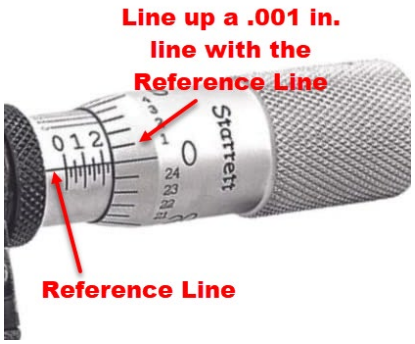


Figure 6 – *T-218 Flip Lever seated in proper position*

9. Set the laser micrometer to the **Nominal** settings (Figure 7) and turn the bubble level vial to the 12 o'clock position.

Figure 7 – *L-705 Laser showing Nominal settings*

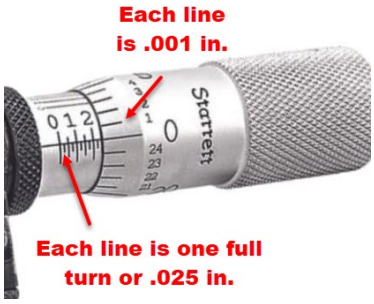
10. Adjust the X-Y Stage micrometer to approximately zero, using the vertical and horizontal micrometers.



Note: *In the event the X-Y Stage micrometer settings are not exactly on a definitive number, for example, between .112 and .113, adjust to the nearest number, turning the micrometer so that the nearest .001 in. line is lined up with the Reference Line.*

Write down the number from the micrometer – for example: **V=.113 H=.126**.

11. Now, the readout values will be slightly off of zero, so zero them out by using the laser micrometers. This gives you an easy reference point to return the target to zero.



12. **Performing a Positive Span Error Check – Vertical Axis**
Using the X-Y Stage micrometers, turn the *Vertical* micrometer clockwise one full turn (.0250 in.) and record the readings. The difference between the R-1307 Vertical reading and .0250 in. is typically less than .002 in. Record the value. This will be used to calculate a calibration error and if out of specification to calculate a correction factor.
Return the readout display to zero by adjusting the Vertical micrometer counterclockwise one full turn and return to the value written down in Step 10.

13. **Performing a Negative Span Error Check – Vertical Axis**
Ensure the R-1307 *Vertical* display reads zero (see step 10). Turn the micrometer one full turn (-.0250 in.) counterclockwise and record the result (see Figure 7). The difference between the actual reading and -.025 in. is typically less than .002 in. Record the value. Return the readout Vertical display to zero by rotating the Vertical micrometer one full turn in the clockwise direction.

14. **Performing a Negative Span Error Check – Horizontal Axis**
Repeat Steps 11-13 and perform the Positive and Negative Span Error checks for *Horizontal* readings. If using the A-808, you can use the *Horizontal* micrometer to perform the check. If using the A-807, you'll need to rotate the target 90 degrees to the left and use the vertical micrometer.
15. Please see the R-1307 Calibration Utility Program beginning on Page 12for the procedure to load calibration factors into R-1307.
16. After the factors have been uploaded, Steps 10-14 will be repeated to confirm the calibration.

Figure 8 – *Vertical reading after a clockwise .0250 in. turn*

Example - Checking the Span Error

V+ = .0242
V- + -.0254

The formula is

$(V_N – V_A) / V_N * 100$, where

V_N – Nominal vertical
V_A – Actual vertical

(.025-.0242)/.025 = .032 * 100 = 3.2%

The Span Error specification is error < 1-2 % (depends on the target), so in this case, it out of specification. However, if the values are in-spec, then you're done! There is no need to calculate cal factors, so this can be skipped.

To calculate the Cal Factor, use this formula:

$CF_V = Vn / V_A$ where

CF_V = *Cal Factor Vertical Axis*
V_N = *Vertical Move - Nominal*
V_A = *Vertical Move - Actual*

Mounting Stud Target Calibration - *Concentricity*

This procedure uses the A-807 or A-808 Calibration Fixtures to determine the V & H axis *concentricity* mounting errors of the PSD relative to the mounting stud. Once these have been calculated, they will be uploaded into the calibration program and into the readout to calibrate out the errors.

1. Mount the laser into the Hamar Laser holding fixture.
2. Mount the centering fixture into the A-808 fixture and then the target into it. Tighten the thumb screw, ensuring that the cable is down. This is the *Normal* position.
3. Connect the target to the R-1307 readout.
4. Turn on the laser and adjust the Laser's V & H angle micrometers until the readout shows zero.
5. Rotate the target 180° and record the number. This is the *Inverted* position.
6. Then divided the values by 2.

Example:

Vertical	N:	.0000
	I:	-.0010
	(N+I)/2 =	**-.0005**
Horizontal	N:	.0000
	I:	+.0012
	(N+I)/2 =	**+.0006**

The concentricity error for each axis should be <.0005 in. (0.013 mm). If the error is less than .0005 in., then you're done! Create a calibration sticker and apply it to the target. If the values are greater than .0005 in. (0.013 mm), then do the following:

7. Enter the values into the calibration program (see Page 16).
8. Repeat steps 1-5 to confirm the error is within specification.

Note *- Even though the concentricity error for each axis is <.0005 in. (0.013 mm), the errors will most likely be .0001 to .0002 in. (0.003 to 0.005 mm).*

Mounting Stud Target Calibration Procedure - *Squareness*

This procedure uses the A-807 or A-808 Calibration Fixtures to determine the V & H axis *squareness* mounting errors of the PSD relative to the mounting stud for the T-212 and T-261 targets. Once these have been calculated, they will be uploaded into the calibration program and into the readout to calibrate out the errors.

1. Mount the laser into the Hamar Laser holding fixture.
2. Set the laser micrometers to their Nominal Settings. This squares up the laser beam to the laser mounting hole.
3. Mount the T-212 target into the centering fixture and tighten the thumb screw, ensuring that the cable is down. This is the *Normal* position. In Center Mode (no lens), make sure the values are less than +/- .030, which they normally are. If so, then insert the lens.

   Note *– if the target is off center by more than .030 in, then you can install the X-Y translation stage and adjust it translation stage+target back to near zero. You can then use this stage to do the squareness check if you are careful and if the readings repeat well (i.e. <.0002 in/in). The center-checking fixture is the most accurate but the X-Y stage can be used, too.*
4. Connect the target to the R-1307 readout.
5. Turn on the laser and adjust the laser's V & H angle micrometers until the readout shows zero.
6. Rotate (Invert) the target 180° and record the numbers. Then divided the values by 2. This is the *Inverted* position.

Example:

Vertical	N:	.0000
	I:	-.0018
	(N+I)/2 =	**-.0009**
Horizontal	N:	.0000
	I:	+.0021
	(N+I)/2	**= +.0010**

The squareness error for each axis should be <.0005 in./in (0.013 mm/25.4mm). If the error is less than .0005 in/in. (0.013 mm/25.4mm), then you're done! Create a calibration sticker and apply it to the target. If they are greater than .0005 in./in. (0.013 mm/25.4mm), then do the following:

7. Enter the squareness error (offset) values into the Center Offset fields in the calibration program (page 16) and upload them into the R-1307.
   Note *– even though the program says "Center Offsets" this can be used as offsets for Squareness errors too.*

8. Repeat steps 1-5 to confirm the error is within specification.

   Note *- Even though the squareness error for each axis is <.0005 in/in. (0.0005 mm/mm), the errors will most likely be .0001 to .0002 in/in. (0.001 to 0.002 mm/mm).*

The R-1307 Calibration Utility Program

Before opening the software, connect the R-1307 USB Calibration Cable to the readout, insert the USB connector into the PC and power on the R-1307. Then open the program and follow the steps below.

***Note** – if connecting a second target to the computer, it is best to close the Utility program before connecting the next target.*

1. **Run the Utility** by clicking **Start>Program>Hamar Laser Software>R-1307 Configuration Utility**. Note that your menu layout may be different than what is displayed, depending on your operating system and desktop settings.

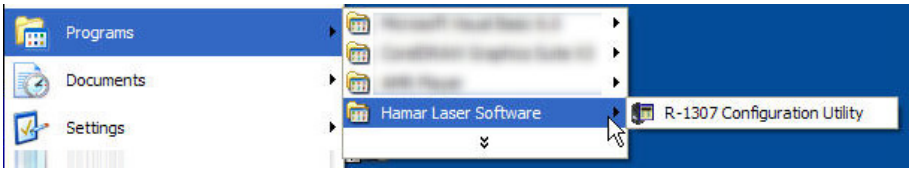
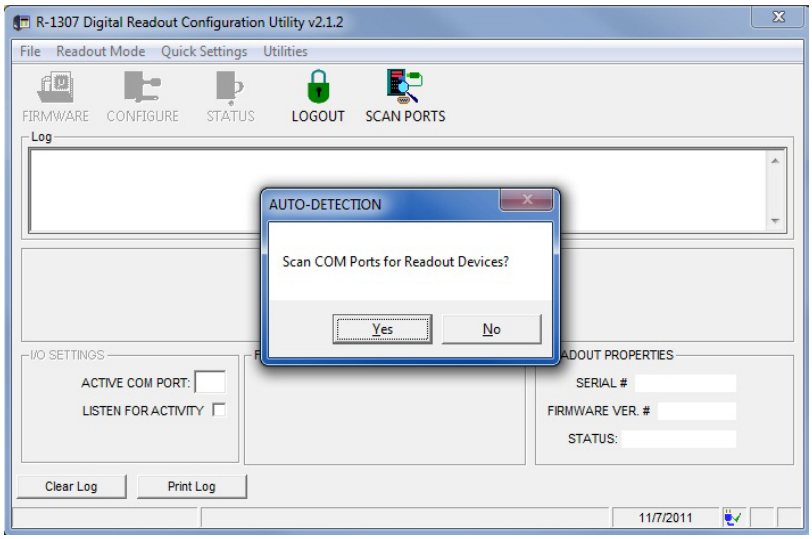


Figure 9 - Starting the utility from the Windows Main Menu

2. **The Initial Screen**. Upon startup, the utility will ask if you want to scan for readout devices. Click **Yes** to begin the scan or **No** to bypass.

- You can click **Scan Ports** at any time to rescan the COM ports if you bypass the initial scan



3. Once you **SCAN PORTS**, you will be asked to confirm if the R-1307 Readout that is detected is the one that you wish to configure. Verify that the Serial Number displayed matches the Serial Number of the attached readout.
   - Click **Yes** to connect to the listed device
   - Click **No** to continue searching for other devices.
   - Click **Cancel** to abort the search.

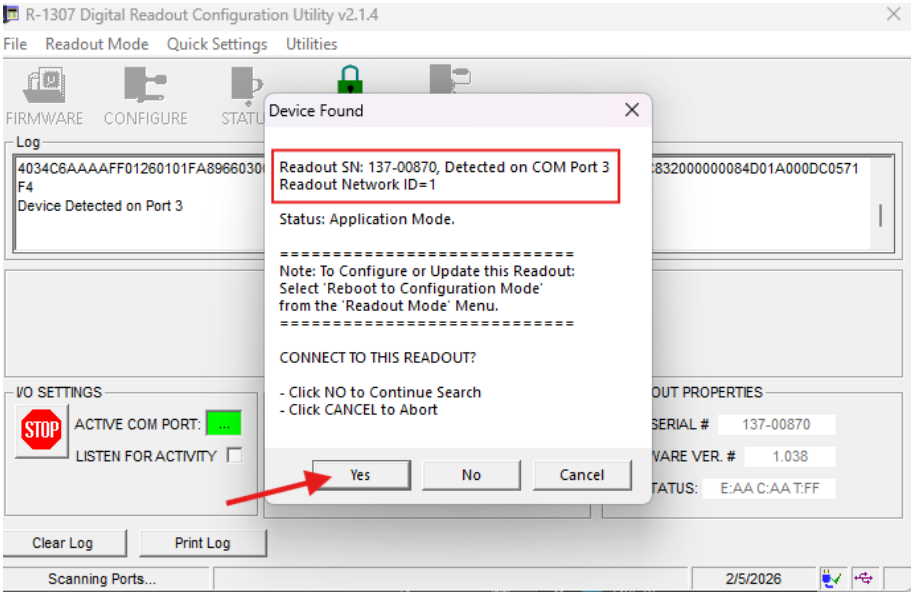


Figure 10 - Confirm Readout Serial Number when connecting

4. If the Utility fails to detect the R-1307, check the following:

   - Is the R-1307 connected to the computer through the USB cable?
   - Is the R-1307 powered on?
   - Is the Common USB driver installed?
   - Restart the connection process by closing the program, and powering off the R-1307. Connect the USB cable to both the computer and readout *first*, power on the R-1307 and then open the program.

     If the driver installation failed or if you have not installed the USB driver, you will need to reinstall it using the provided CD or contact Hamar Laser for support.

5. To configure the R-1307, click the **Readout Mode** in the menu bar and select **Reboot to Configuration Mode** in the drop-down menu (see image below). This switch to Configuration Mode can take a several seconds.

A successful switch to Configuration Mode is indicated by "AP" followed by your firmware version being displayed on the upper display of your R-1307. For example, firmware version 1.39 is displayed as AP1.39 in the R-1307 display.

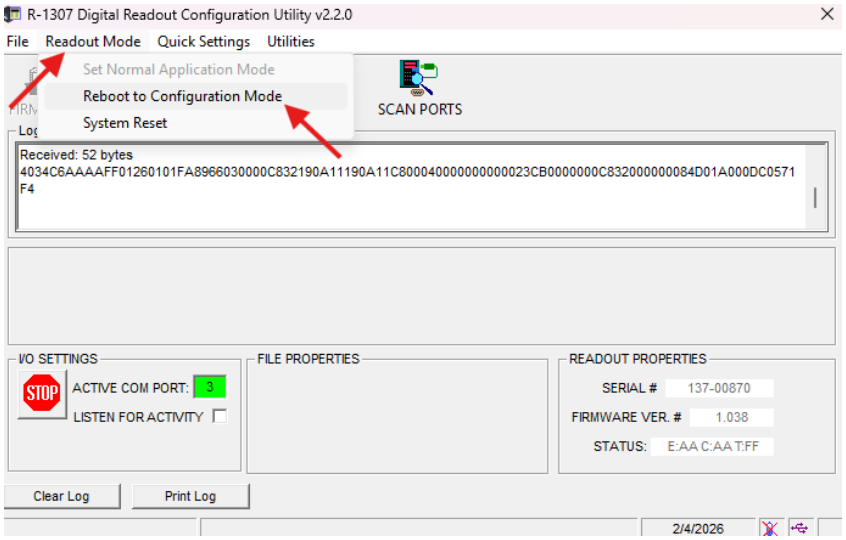
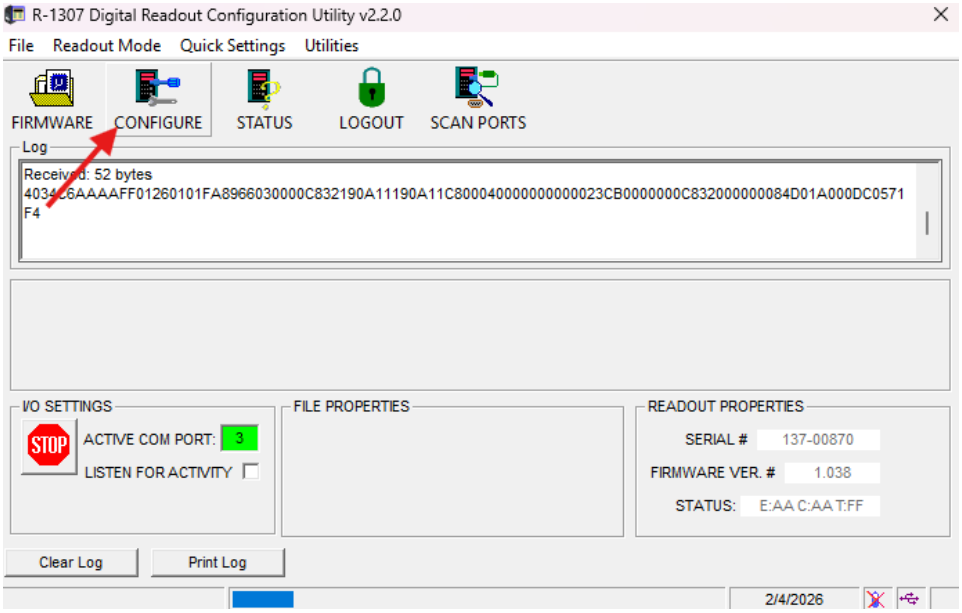


Figure 11 - Rebooting the R-1307 to Configuration Mode

6. Once in Configuration Mode, click **CONFIGURE** to open the **READOUT CONFIGURATION** screen.



7. There are only 4 options on the **READOUT CONFIGURATION** screen that can be changed by the end user:

a) **CAL DATE** - Calibration Date.
b) **AC FILTER SETTING** - Select either 50 or 60Hz, depending on your location. *Do **not** set to Debug!* This mode is intended for Hamar Laser use only.
c) **ENABLE BATTERY CAPACITY DISPLAY** - If enabled, you can briefly press the power button on the readout keypad to view the remaining battery life on the readout display. Battery life is shown as a percentage of 100
d) **EDIT CALIBRATION/COMPENSATION RECORDS** – This opens a screen where you can change the calibration factors and upload them into the readout. See the next page for instructions on how to use this function.

Click **Upload** to program the R-1307 with any changes you've made to these settings. To close the window, click on the red X in upper upper-right part of the screen.

***Note** - If you're not making changes to the above-mentioned fields, you can skip this step.*

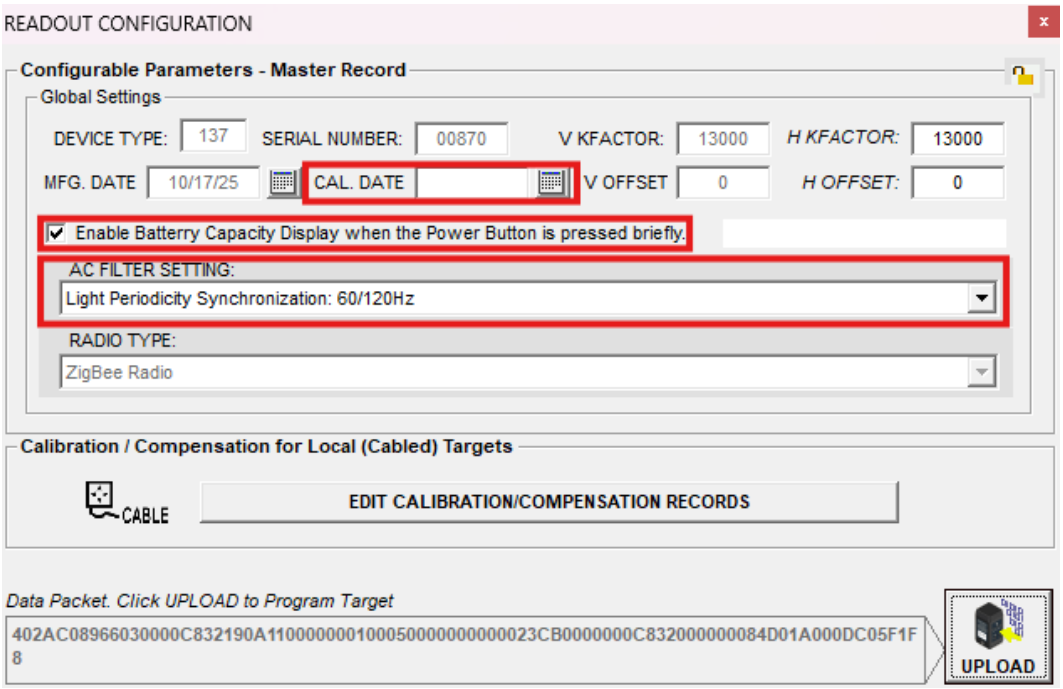
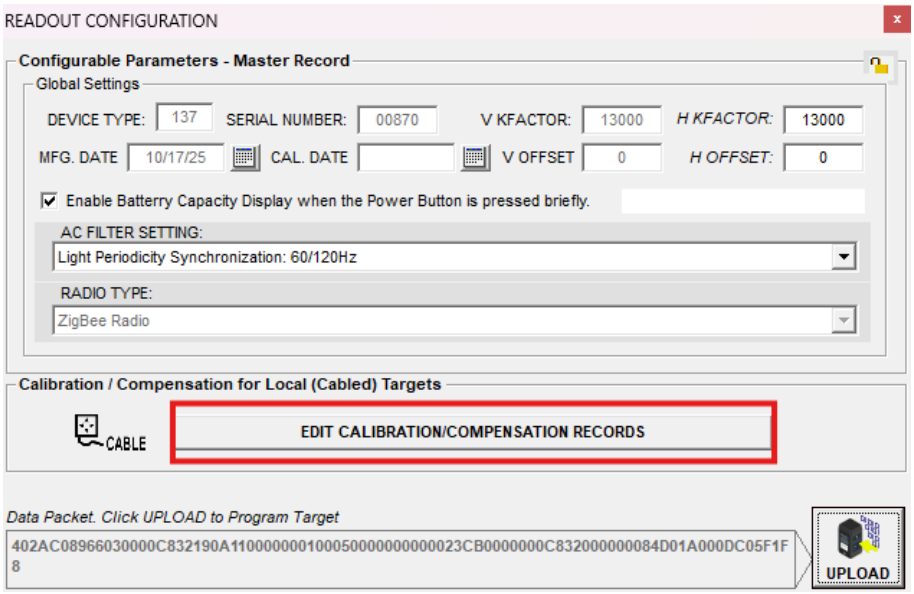


Figure 12 - Readout Configuration screen

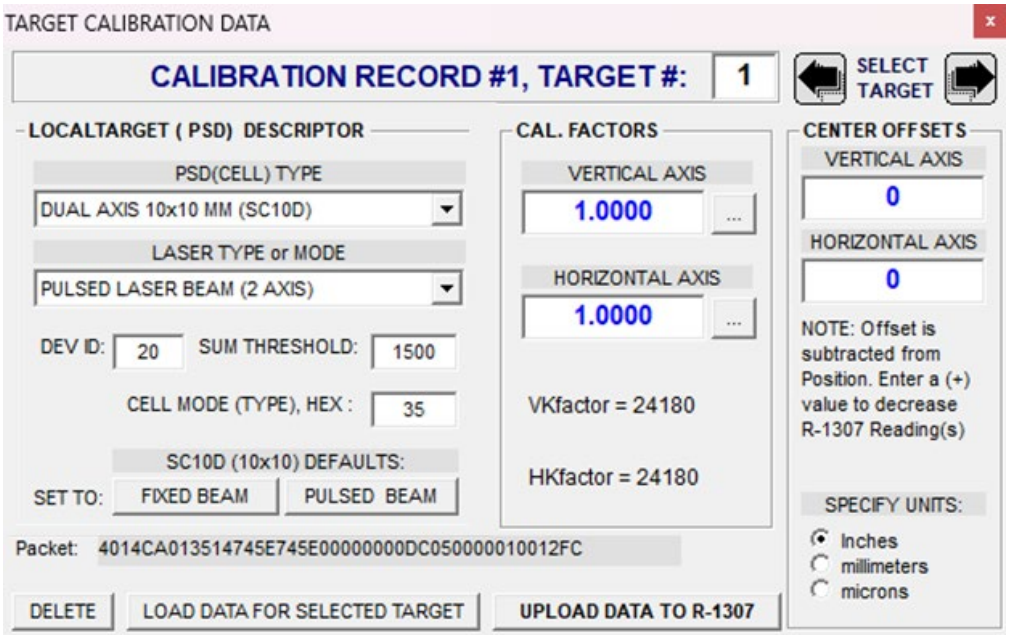
Editing Calibration/Compensation Records

From the *Readout Configuration* screen, click the **EDIT CALIBRATION/COMPENSATION RECORDS** button at the bottom of the screen to open the **TARGET CALIBRATION DATA** screen.



The TARGET CALIBRATION DATA Screen

The **TARGET CALIBRATION DATA** screen allows you to edit and create target calibration records. The R-1307 can hold up to 8 calibration records. The R-1307B can store only one calibration record.



LOCAL TARGET (PSD) DESCRIPTOR Section

This part of the screen allows you to select the PSD type and size and the laser mode. These need to match the target and laser that you are using to function properly.

- **PSD (Cell) TYPE** - This section allows you to set your target's position sensor (PSD) type and size. The most common is 10x10 MM (SC10D).
- **LASER TYPE or MODE** - This section sets what type of laser beam (*fixed* or *pulsed*) will be used with the sensor.
  Note - *if you want to have both fixed and pulsed calibration records, you will have to set up a second target record and change the laser type for it.*

Default values for both fixed and pulsed beams can be set by clicking the FIXED BEAM or PULSED BEAM buttons at the bottom of this section

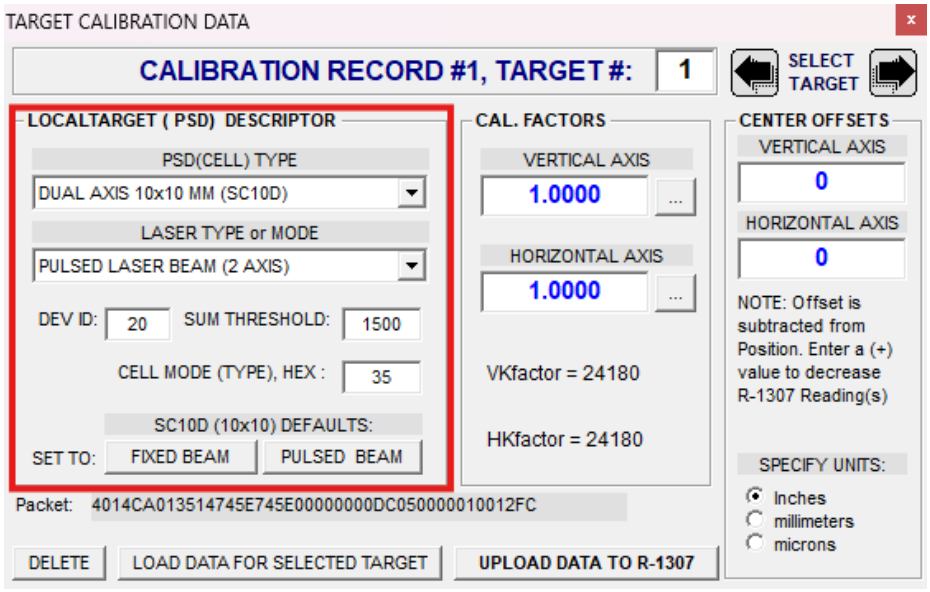


Figure 13 - Local Target (PSD) Descriptor

CAL. FACTORS Section

This section is dedicated to entering the Span Error (gain) calibration factors (see page 4) for your target. There are two cal factors: one for the vertical axis, one for the horizontal axis. When setting up a new record, these fields will be blank and need to be set to "nominal" (1.0). To set calibration factors to nominal, double-click on each cal factor window or manually enter "1.0000". The actual calibration values will typically vary from 0.8 to 1.2.

Note *– there are 2 calibration factors (1. in the positive (+) direction, and 2. in the negative (-) direction) for each target axis (V&H). Once these have been calculated, they will be averaged and the result will be entered below. See page below.*

Note 2 *– If you are recalibrating a target that has previously entered cal factors, then reset them to 1.0 (nominal value) and perform the Span Error checks noted above.*

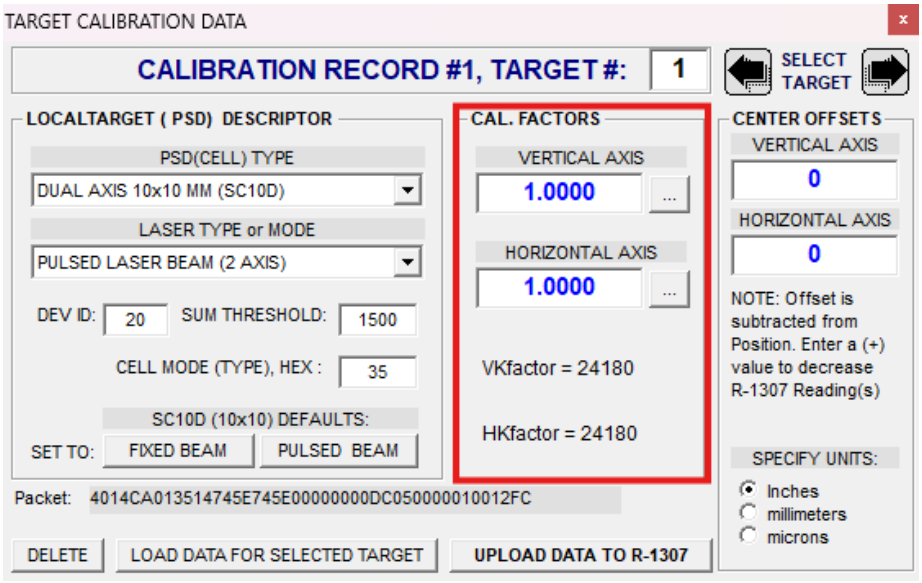


Figure 14 - Cal. Factors Entry

CENTER OFFSETS Section

This part of the program is dedicated to entering offsets for your target that correct either the *centering* error to the mounting stud, or when using the angular measuring stud, the *squareness* error to the mounting stud.

To set offsets to nominal settings, double-click on each offset window or manually enter "0". When setting up a new record, these fields may be blank, if so, then they need to be set to zero.

Note *– If you are recalibrating a target that has previously entered Center Offset factors, reset them to zero and perform the Center (or Squareness) Error checks noted above.*

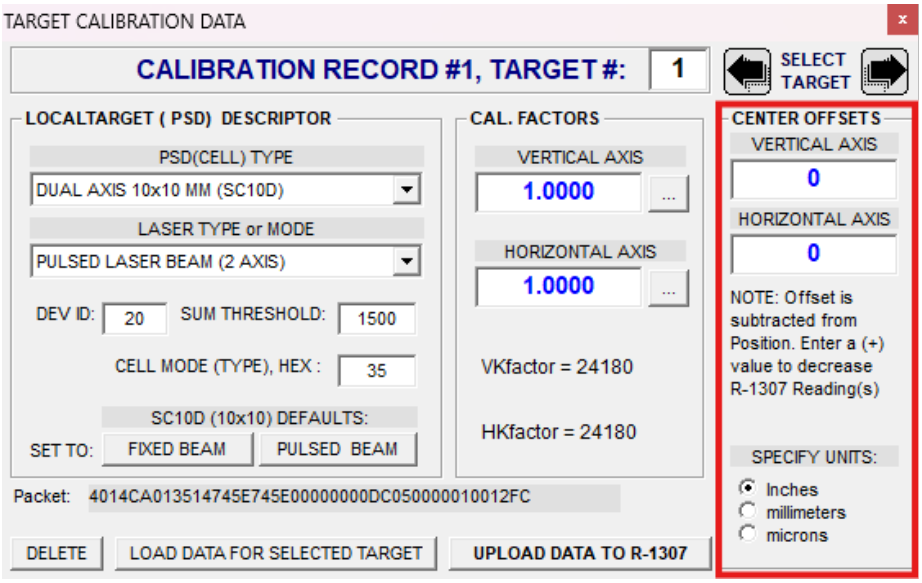


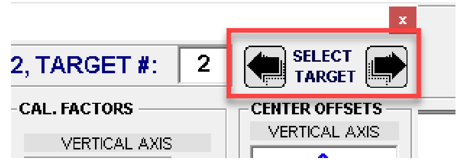
Figure 15 - Center Offsets Entry

After entering the cal. factors and center offsets, click on **UPLOAD DATA TO R-1307,** which will upload the values into the readout and may take several seconds.

You can then click the right or left arrow to go to another record and edit it. Again, after editing each record, you should click on UPLOAD DATA… to upload the factors into the R-1307.

After all the offsets have been uploaded, click on the red X to close the window.

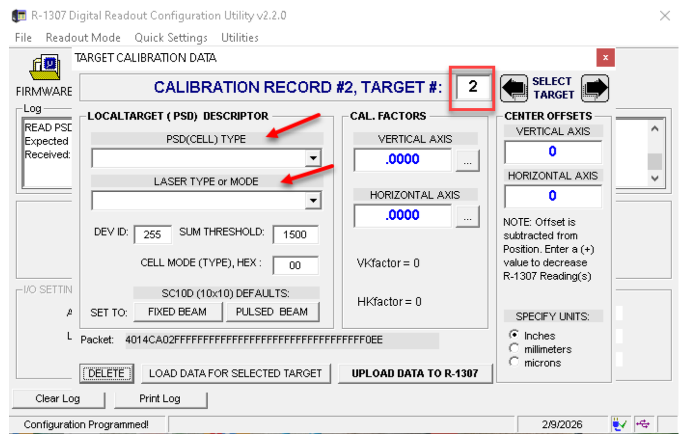
Creating New Target Records or Editing Old Records



1. Use the arrows at the top right of the window to scroll through and select the calibration record you want to view or edit (8 records max)

2. To create a new target record, click on the right arrow to bring up a new record. You will see CALIBRATION RECORD#2 and TARGET# 2. When setting up a calibration record for the first time, the program will create a default Target#. This can be edited if you are creating a *second* record for the *same* target (see examples below). You will also see all zeros for the CAL. FACTORS and CENTER OFFSETS. The CAL FACTORS need to be set to 1.000.

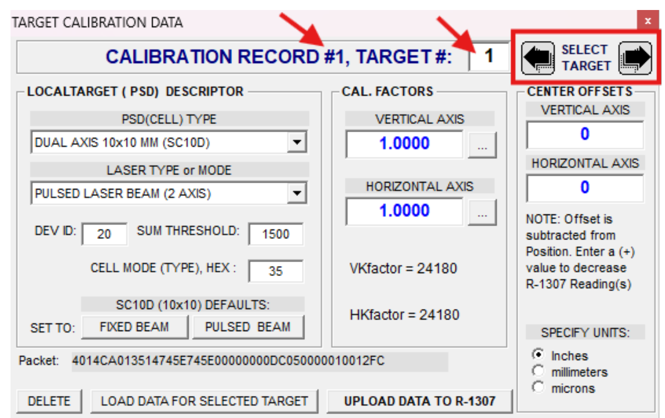
   You also need to select the PSD (CELL) TYPE and LASER TYPE or MODE. The most common Cell Type is "10x10 mm" and the Laser Type is "Pulsed".



3. Generally, each target has one calibration record. If only using one record for each target, the calibration record and target will have the same numerical designator; Record #1 is for Target #1, Record #2 is for Target #2, etc.

   However, for T-212 and similar targets, you will have 2 records for the same target (Record #1 is for Target #1 center, Record #2 is for Target #1 angle).

   ***Note** – when creating a new Target Record for the T-212 for the <u>angle</u> calibration, make sure to set the CAL FACTORS to 1.0 before entering in the angular offsets in the CENTER OFFSET entry boxes.*



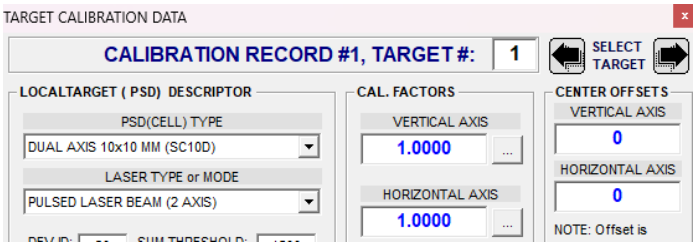
   Another example of having two records for one target is having both Fixed and Pulsed beam records for the same target. In these cases, you have to edit the Target # to match the target, so different calibration records will share the same target number – i.e. Record #1 is for Target #1 (center), Record #2 is for Target #1 (angle), but they will have different record numbers.

4. After calculating the cal. factors and center (or angular) offsets, enter them into the respective fields.
5. Click on UPLOAD DATA TO R-1307 to upload the factors into the R-1307's memory.
6. Click on the red X to close the window.

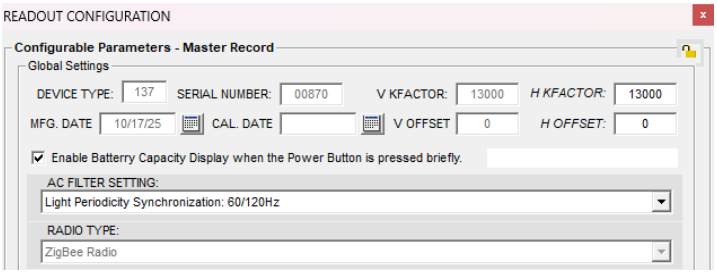
Returning the R-1307 To Normal Operation

To close down the **TARGET CALIBRATION DATA** screen and return the R-1307 to normal operation:

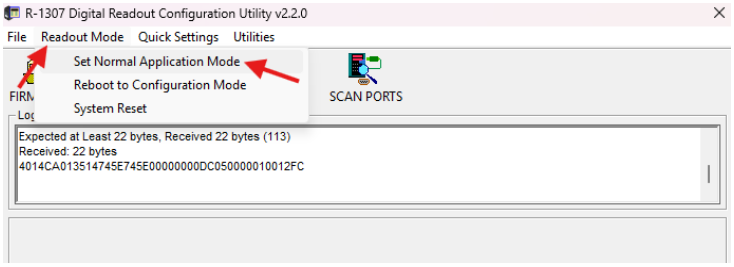
1. Click the X to close the window and return to the **READOUT CONFIGURATION** screen.



2. If you have made no changes to the parameters, then click the red X to close the **READOUT CONFIGURATION** screen.



3. Under the **Readout Mode** dropdown menu (see image below), click **Set Normal Application Mode.** When the readout is ready, the "AP" will disappear and it will show five dashes in both the top and bottom windows. This process will take a few seconds.



4. Power down the R-1307 by pressing and holding the power button and <u>then</u> disconnect the USB configuration cable.

R-1307 Calibration Procedure

In this procedure, we will first check the calibration of each axis of the PSD (V & H) in the positive (+) and negative (-) directions against the specification. For most of our cabled targets, the specification is error <1.0 to 2.0% depending on the target. This means for a .0250 in. turn, if the nominal minus the actual is <.0003 to .0006 in., then it is considered "in-spec". If the error is outside these values, then this procedure is used to calculate new calibration factors to upload into the R-1307 so that the values will be in-spec.

Preparing the R-1307 for Calibration – Clearing Old Cal Factors and Offsets

1. Set the calibration (gain) factors and center offsets to nominal in both the vertical and horizontal axes by double-clicking their respective fields or manually entering the nominal values, as noted on pages 14-17.
2. Click **UPLOAD DATA TO R-1307** to program the R-1307 Calibration Record.

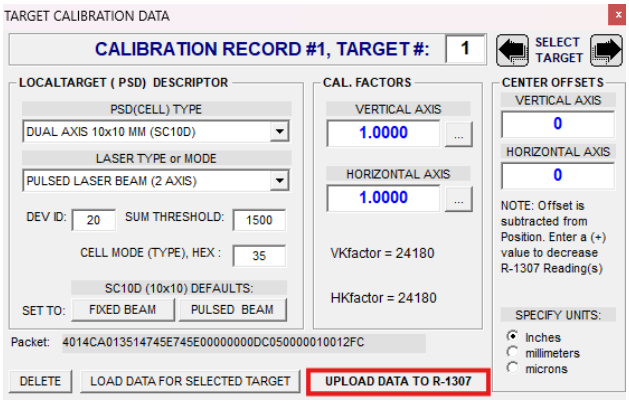


Figure 16 - Upload nominal settings to R-1307

3. Close the **TARGET CALIBRATION DATA** window to go back to the Readout Configuration window.
4. Then close the **READOUT CONFIGURATION** window to return to the main screen.
5. Click **Set Normal Application Mode** under the "Readout Mode" dropdown menu (see image below). When the readout is ready, the R-1307 will show five dashes in both the top and bottom windows. This process will take a few seconds.

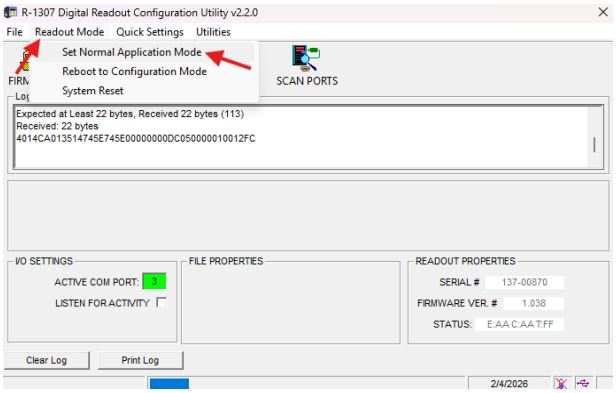


Figure 17 - Disconnect R-1307 from your computer

6. Power down the readout and disconnect the USB configuration cable.

Preparing R-1307 Readout for Target Calibration – Select Target ID

Connect your target to the R-1307 and power it on. If your target's data cable does not have a 14-pin LEMO connector, contact Hamar Laser for an adapter.

Click and hold the **Menu** button to enter the readout's Settings Menu. Once in this mode, you can click the menu button to browse through your readout's available settings. The upper window on your readout displays the currently selected setting. The bottom window on your readout shows the value for each setting.

Use the up and down arrow buttons on the keypad to change the value for the currently selected setting. You can exit the menu by holding down the menu button. The readout will also timeout and exit the menu if no buttons are pressed for approximately 10 seconds.

1. Once in the menu, the first setting you'll see in the top window is **DISP.** While this setting is selected, use the up and down arrows on your keypad to set the value in the bottom window to **ABS**.
2. Continue to click the Menu button to scroll through settings. Once you reach the **Funct** setting (upper display), use the up and down arrows to set the lower window value to **LOCAL**.
3. Click the Menu button once more to enter the target selection screen, where you can change target records. The top display shows which target calibration record is selected. For example, **t 6t .01** equals Target #01. The bottom display shows the type of laser beam the readout will recognize (**F10.10** or **P10.10**), as well as the size of the position sensor (PSD) in your target. Normally, you'll want **p10.10** = Pulsed beam /10mm x 10mm PSD.
4. If you have multiple records for one target, they will both show as **t 6t .01** in the *upper* window. Using the up/down arrows, you can change records by noting the differences shown in the *lower* window. For example: **t 6t .01** in upper display and **p10.10** in the lower display is for pulsed beam, and **t 6t .01** in the upper display and **f 10.10** in the lower display for a fixed (continuous beam). ***Note*** *- If it says* ***t 6t.02*** *in the upper display, then this is a new/separate target.*
5. Use the up and down arrows on your keypad to select the calibration record for the target you are getting ready to calibrate. Hold the Menu button to exit the settings menu. This saves all the changes you've made during the last few steps.

Checking Span Error Calibration Using A-807 or A-808 - Vertical (Y) Axis

1. Insert the laser into the A-807 or A-808 fixture and turn it on in Pulsed Mode.
2. Insert the target into the X/Y stage with the target cable down and connect it to the R-1307. Turn on the readout.
3. Ensure your target and the X/Y stage are positioned so that the vertical travel of the stage is parallel to the vertical axis of the PSD. This can be tested by using the vertical micrometer to move the target up and down (+/- .030 in.) along the vertical axis and seeing if there is any movement in the horizontal axis. There should be very little (<.002 in.).

4. For using the A-808, adjust the V & H *X-Y Stage* micrometers until the R-1307 V and H displays read .0000 (zero). Adjust the micrometer to the nearest .001 and note the value. Zero the value by adjusting the *laser* micrometers. See pages 4-7 for more details. ***Note*** *– if using the A-807 Calibration Fixture, you only have one axis of travel (vertical), so you would adjust the V axis until zero. To do the horizontal axis, you would rotate the target 90 degrees and use the same vertical micrometer.*

5. Using the vertical micrometer, move the target up (positive direction) by +.0250". Record the V-axis measurement shown on your R-1307 (V_P).

   For the example calculation below, we will say the readout read .0242 after a +0.0250" movement.
6. Return the micrometer and target to zero. Now move the Vertical (Y) axis of the target <u>down</u> (negative direction) by -.0250". Record the V-axis measurement shown on your R-1307 as (V_N).

   For the example calculation below, we will say the readout read -.0244 after a -0.0250" movement.

7. Check the Calibration and Calculate the Calibration (Gain) Factor

   Here is the formula to check if the Span Error is in-spec:

   $(V_N - V_A) / V_N * 100$
   V_N – Nominal vertical
   V_A – Actual vertical

   In our example, we have

   V_N – .0250
   V_A – .0242
   (.0250-.0242)/.0250 = .032 or 3.2%. Check this against the specification for your target.

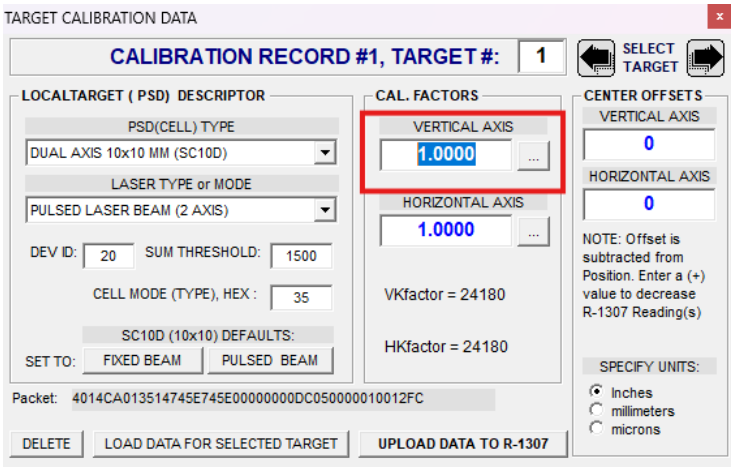
   Since this is out of spec, we need to calculate the Cal Factor, where we treat both V_P and V_N as positive numbers.

   In our example,
   V_P = .0242
   V_N = .0244
   Average V_P and V_N $V_A = (V_P + V_N) / 2$
   Then the calibration factor (CF) is $CF_V = .025 / V_A$

   Here's our example:

   $.025 / [(.0242 + .0244) / 2] = CF_V$
   $.025 / [.0486 / 2] = CF_V$
   $.025 / .0243 = CF_V$
   $1.0288 = CF_V$

   ***Note** – the calibration factor (CF) will be between 0.8 and 1.2. If you calculate a value that is outside this range, then you should redo the calibration to confirm the CF is correct. If it stays outside this range, then it's a good idea to send the target into Hamar to have it evaluated.*



8. Write down this Calibration Factor, which will be entered in the VERTICAL AXIS field of the *CAL. FACTORS* section of the *TARGET CALIBRATION DATA* window.

Checking Span Error Calibration Using A-807 or A-808 - Horizontal (X) Axis

The steps for the horizontal axis are the same as for the vertical axis. However, instead of moving up and down the vertical axis, you will be moving left and right on the horizontal axis.

Note *– If you are using the A-807 Calibration Fixture, then to measure the horizontal axis, you will need to rotate the target to the left by 90 degrees. Then follow the rest of the procedure below.*

1. Using the micrometers on the X/Y stage, translate the target until the R-1307 V & H displays show .0000 (zero). Again, adjust the micrometer to the nearest .001 (pg 4-7 for more details).
2. Using the horizontal micrometer, move the target to the right (positive direction), along the Horizontal (X) axis by +.0250" from zero.
   Record the H-axis measurement shown on your R-1307 (H_P).
3. Move the target micrometers until the R-1307 upper and lower windows display .0000 (zero).
4. Now use the micrometer to move the target to the left (negative direction) on the Horizontal (X) axis by -.0250" from zero.
   Record the H-axis measurement shown on your R-1307 as (H_N).
5. Calculate the error as shown on page 25. If it out of spec, then continue to Step 6.
6. Calculate the Calibration (Gain) Factor for the Horizontal Axis using the same calculation we used for the Vertical axis.
7. Simply replace V_P with H_P and V_N with H_N.
   Don't forget to treat both H_P + H_N as positive numbers
   .025 / [(H_P + H_N) / 2] = CF
8. Write down the Calibration Factor, which will be entered in the Horizontal Axis field of the *CAL. FACTORS* section of the *TARGET CALIBRATION DATA* window.

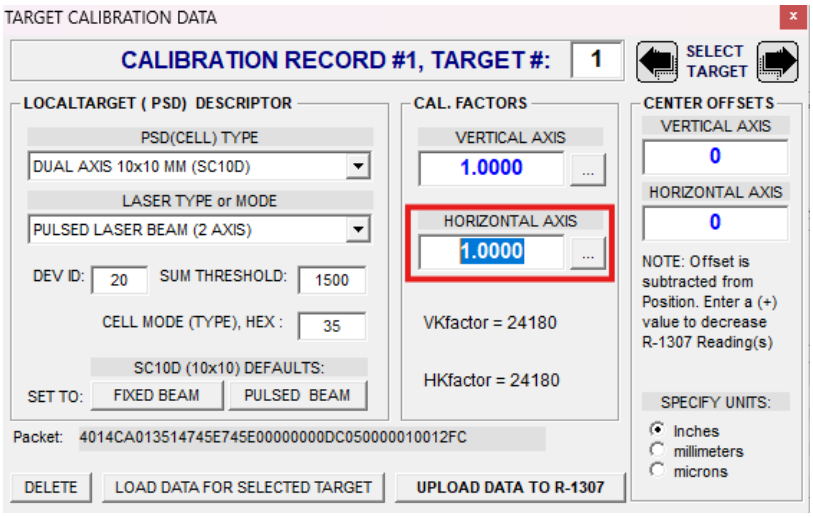


Figure 18 - Data Entry Field for Horizontal Axis Calibration (Gain) Factor

Checking Mounting Stud Target Calibration – *Concentricity*

This procedure uses the A-807 or A-808 Calibration Fixtures to determine the V & H axis *concentricity* mounting errors of the PSD relative to the mounting stud. Once these have been calculated, they will be compared to the specification and if they are out of specification, then the errors will become offsets that are uploaded into the calibration program and into the readout to calibrate-out the errors.

1. Mount the laser into the Hamar Laser holding fixture.
2. Mount the centering fixture into the A-808 fixture and then the target into it. Tighten the thumb screw, ensuring that the cable is down.
3. Connect the target to the R-1307 readout.
4. Turn on the laser and adjust the Laser's V & H angle micrometers until the readout shows zero. This is the *Normal* position.
5. Rotate the target 180° and record the number (Inverted). This is the *Inverted* position. Then divided the values by 2.

   Example:

Vertical	N:	.0000
	I:	-.0010
	(N+I)/2 =	**-.0005**
Horizontal	N:	.0000
	I:	+.0012
	(N+I)/2	**= +.0006**

   The concentricity error for each axis should be <.0005 in. (0.013 mm). If the error is less than .0005 in., then you're done! Create a calibration sticker and apply it to the target. If the values are greater than .0005 in. (0.013 mm), then do the following:

6. Enter the values into the calibration program (see pages 19 & 29).
7. With the new offsets programmed into the R-1307, repeat steps 1-5 to confirm the error is within specification.

   Note *- Even though the concentricity error for each axis is <.0005 in. (0.013 mm), the errors will most likely be .0001 to .0002 in. (0.003 to 0.005 mm).*

Mounting Stud Target Calibration Procedure - *Squareness*

This procedure uses the A-807 or A-808 Calibration Fixtures to determine the V & H axis *squareness* mounting errors of the PSD relative to the mounting stud for the T-212 and T-261 targets. Once these have been calculated, they will be uploaded into the calibration program and into the readout to calibrate out the errors.

1. Mount the laser into the Hamar Laser holding fixture.
2. Set the laser micrometers to their Nominal Settings. This squares up the laser beam to the laser mounting hole.
3. Mount the T-212 target into the centering fixture and tighten the thumb screw, ensuring that the cable is down. In Center Mode (no lens), make sure the values are less than +/- .030, which they normally are. If so, then insert the lens.
   Note *– if the target is off center by more than .030 in, then you can install the X-Y translation stage and adjust it translation stage+target back to near zero. You can then use this stage to do the squareness check if you are careful and if the readings repeat well (i.e. <.0002 in/in). The center-checking fixture is the most accurate but the X-Y stage can be used, too.*
4. Connect the target to the R-1307 readout.
5. Turn on the laser and adjust the laser's V & H angle micrometers until the readout shows zero. This is the *Normal* position.
6. Rotate (Invert) the target 180° and record the numbers. Then divided the values by 2. This is the *Inverted* position.

Example:

<u>Vertical</u>	N:	.0000
	I:	-.0018
	(N+I)/2 =	**-.0009**
<u>Horizontal</u>	N:	.0000
	I:	+.0021
	(N+I)/2	**= +.0010**

The squareness error for each axis should be <.0005 in./in (0.013 mm/25.4mm). If the error is less than .0005 in/in. (0.013 mm/25.4mm), then you're done! Create a calibration sticker and apply it to the target. If they are greater than .0005 in./in. (0.013 mm/25.4mm), then do the following:

7. Enter the values into the calibration program (see page 15) and upload them into the R-1307.
   Note *– even though the program says "Center Offsets" these entry boxes can also be used for Angular Offsets. Since you are working on angular offsets, make sure you are using the <u>second</u> target record for this target. Also, make sure the Span Error values are set to 1.000 in this target record.*

8. With the new offsets programmed into the R-1307, repeat steps 1-5 to confirm the error is within specification.

   Note *- Even though the squareness error for each axis is <.0005 in/in. (0.0005 mm/mm), the errors will most likely be .0001 to .0002 in/in. (0.001 to 0.002 mm/mm).*

Programming the Calibration (Gain) Factors and Offsets into the R-1307

Now we will enter the V & H axis cal factors into the software and upload them into the R-1307.

1. Power down the R-1307 and disconnect the target data cable.

2. Use USB cable to connect the R-1307 to your computer. Power up the R-1307.

3. Run the R-1307 Configuration Utility.

4. Repeat steps on pages 10-13 to connect your readout and navigate to the TARGET CALIBRATION DATA window

5. Enter the Calibration Factors you calculated for both the vertical and horizontal axes in their respective fields in the CAL. FACTORS section, highlighted in the image below.
6. Enter the CENTER OFFSETS (or angular) in their respective fields.

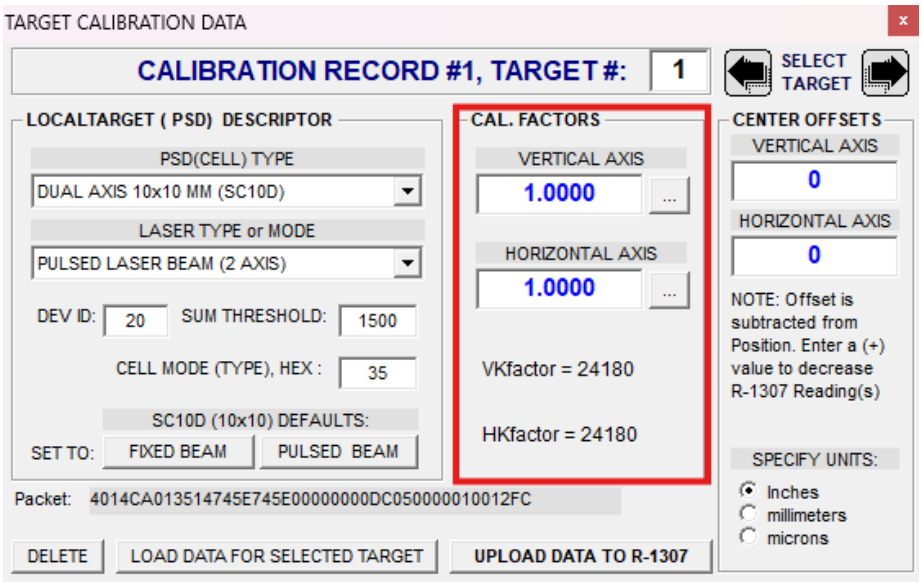


Figure 19 - Enter Vertical and Horizontal Calibration Factors

7. Click on UPLOAD DATA TO R-1307 to upload the cal. factors and offsets into the R-1307's memory.
8. Return the readout to normal operation mode – see Page 21.

Verifying the Calibration

Repeat the calibration checks on pages 22-28 to verify the calibration factors brought the target into spec.

Procedure for Checking the L-705/L-706 Laser Concentricity

This procedure is for checking the concentricity (centering) of the laser beam to the mounting surfaces. This procedure is usually done for the Ø.7495 mounting surface but with the right fixturing can also be done for the Ø2.2495 in. mounting surface. This procedure requires an angle-sensing target, usually the T-261, and either 2 R-1307 Readouts, or one of Hamar Laser's software programs, such as Lathe10 or MultiTurn10 and the R-358 Computer Interface.

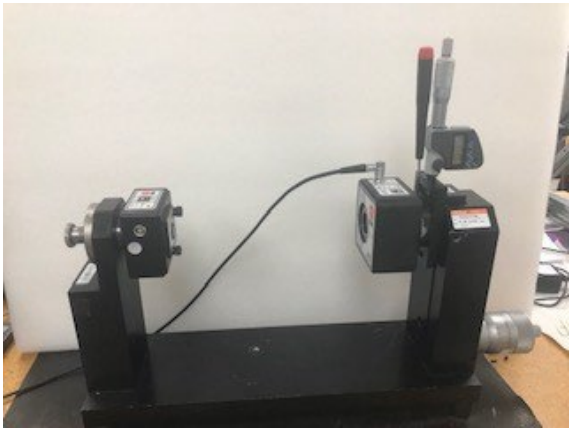


Figure 21 - A-807 Calibration Fixture with X-Axis Translation and Angular Stages and L-700/L-703/L-705/706 Laser Mount

Figure 20 - A-808 Calibration Fixture with X-Y Target Stage *for T-218/219 Targets and L-705/706 Laser Mount*

1. Mount the laser in the A-807 or A-808 fixture. The laser should be set to the **Nominal** settings (Figure 16) and should be rotated until the bubble level is leveled.
2. Power on the laser and allow it to warm up for 15 minutes.
3. Place the test target (T-261) in the A-807/A-808 fixture. Adjust the X-Y translation stage micrometers to zero out the T-261 *Center* Values. If using the A-807, you only have a vertical axis translation slide, so use that to get to zero.
4. If using the A-807 fixture, adjust the *angular* micrometer until the V axis is near zero. If using the A-808 fixture, just write the *angular* values down. This is the *normal* position.
5. Write down the V & H axis *angular* values. These are the "Normal" values.
6. Rotate the L-705 180 degrees until the bubble level is leveled. This is the *inverted* position.
7. Write down the V & H *angular* values. These are the "Inverted" values.
8. Average the V Normal and V Inverted *angular* values and the H Normal and H Inverted *angular* values. This average is what we call the *Set Point*.
9. Adjust the V & H axis laser micrometers until the readings equal the *Set Points.*
10. Rotate the L-705 180 degrees to the Normal position to make sure the values are still equal to the Set Point to within ± .0001 in./ft. If not,

L-705 Laser Mounted

repeat Steps 5-9 until the Set Point values are the within .0001 in/ft. for the Normal and Inverted positions.

11. Now write down the V & H *center* values. These are the "Normal" (N) values.
12. Rotate the L-705 180 degrees until the bubble level is leveled.
13. Write down the V & H *center* values. These are the "Inverted" (I) values.
14. The error in the centering of the laser to the housing is:

    Error V Axis = $(N_V+I_V)/2$
    Error H Axis = $(N_H+I_H)/2$

    The tolerance is error < .0005 in. (0.013 mm)