

Calibration of 2-Axis Scan Heads with CalWizard - Collect Cross Grid Data- or 'Good Enough'- Method

1. Introduction

A correction table allows the scan controller to compensate for projection distortions caused by the physical geometry of the steering system, non-ideal opto-mechanical fabrication tolerances, electrical non-linearity of the galvanometer position control system, lens distortion, system misalignment and scaling errors. System accuracy is improved by a calibration process which involves creating and measuring scanning artifacts in an iterative fashion until a desired accuracy is reached.

This application note describes how to create and adjust a correction table for CT 2-axis systems. For further details please refer to the [CalWizard Manual](#).

2. Two Axis Calibration

- MOVIA: +/- 10°
- PS1 and PS2: +/-11°
- LXP: +/-11°
- Lightning II: +/-11°

2.1 Needed Equipment

Set System Configuration & Set Focus/Marking Parameters

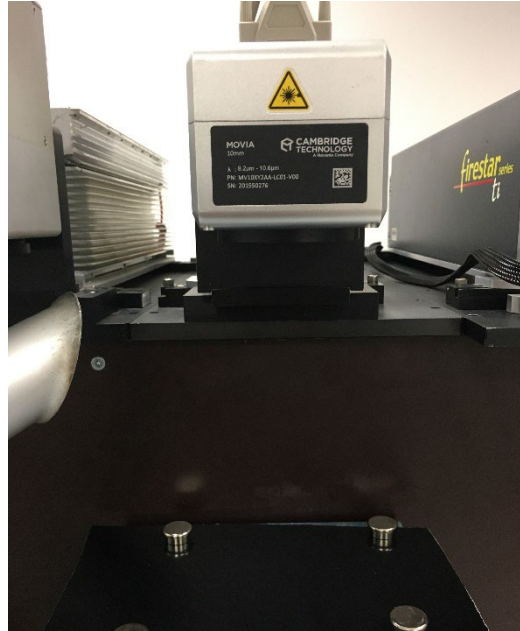


Figure 1: Calibration set up. To make sure that the bindakote paper is positioned straight and level, it is fixated with magnets. On the left you can see an air extrusion to prevent a contamination of the lens.

Before starting the Calibration process, you should make sure you have all the equipment needed. If you need help setting up the scan head please have a look at the [MOVIA Quick Start Up Guide](#).

- The Calibration Wizard Software needs to be installed on your computer.
The newest version of the software is available under the following link:
<https://novantaphotonics.com/secure-download-scanmaster/>
- Marking material: e.g. Bindakote paper (CO2) or black anodized aluminum plate (Fiber) can be used
 - Supplier for anodized aluminum plates: <https://www.gravotech.us/>
 - Supplier for marking paper: <https://com.europapier.com/>
- Ruler for measuring distances (0.5mm resolution preferred)
- Laser safety glasses

2.1.1 Connecting to Controller

Before setting the system configuration the controller must be selected. After opening the CalWizard software a list of all connected controllers will appear under Controller Units. Double click to select a controller. Once the connection is established the green “connected” LED will light up.

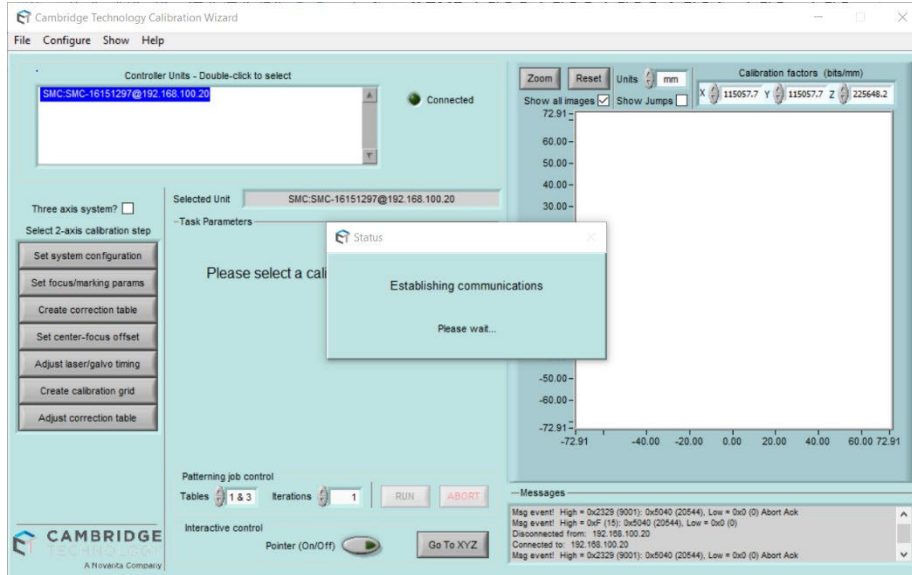


Figure 2: By double clicking a controller can be selected

2.1.2 Set System Configuration

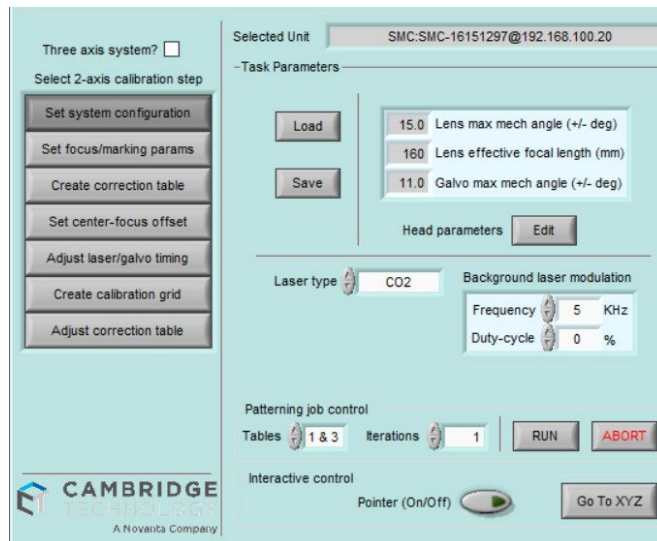


Figure 3: Set laser and scan head parameters

To set the system configuration go to ‘Set system configuration’ as shown in Figure 3. Here you can choose the laser type you are using. The scan head parameter can be left in default at this point. The defined system configuration can be saved through the file menu.

2.1.3 Set Focus/Marking Parameters

In the next tab ‘Set Focus/Marking Parameters’ Marking speed, jump speed, frequency and laser power can be selected for different modes of operation. They can be readjusted during the calibration procedure if necessary.

- Marking: Medium power level to leave a clear mark on the media
- Focusing: Low power level to enhance variations in the mark due to focus quality
- Cutting: High power level to cut the marked pattern to be measured

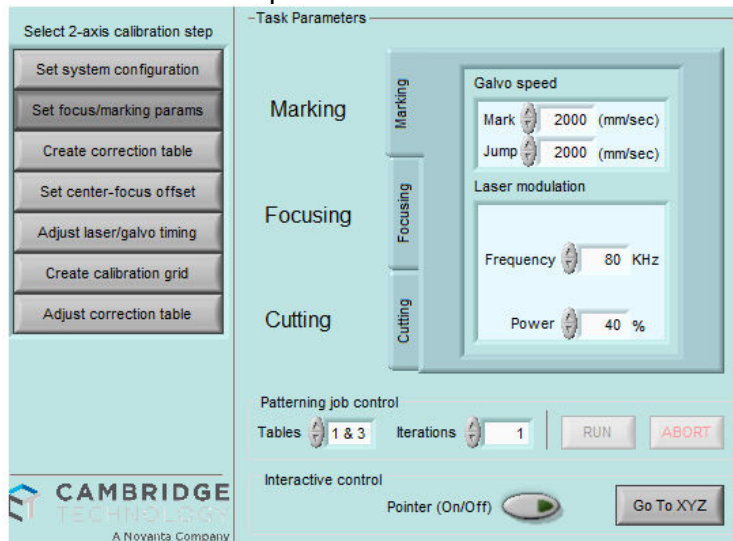
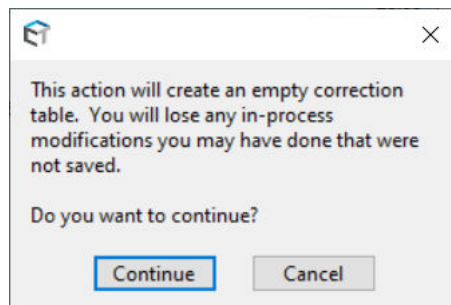


Figure 4: Set marking and focusing parameters

2.2 Create Correction Table

2.2.1 Open Correction table Editor

Start to create a new correction table by clicking on the ‘Create correction table’ tab. To prevent erroneous clearing of information, the following confirmation pop-up appears. Press ‘Continue’ to open the correction table editor window.



2.2.2 Load from dual axis scan head library or Edit Parameters

Go to 'File → Load → Correction table → From the dual-axis scan-head library' to check if there is already a default calibration table available for your scan-head + F-Theta combination. If so, load the correction table, and go to step 1.3.4.

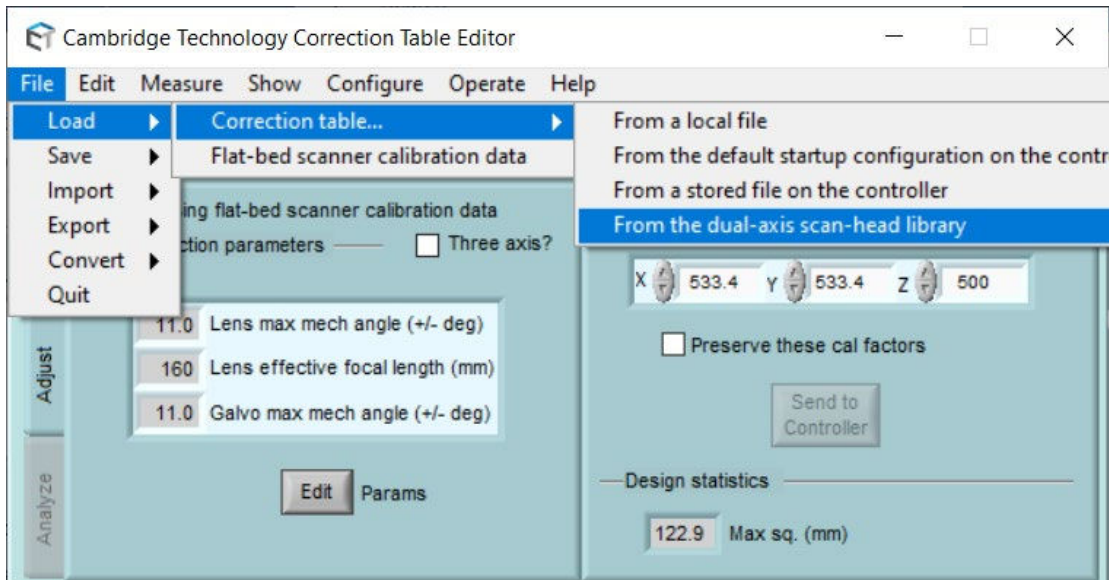


Figure 5: Load a correction table from the scan-head library

If there is no suitable table in the library, press the 'Edit' button and type in the parameters of your scan head and F-theta lens in the parameter box and proceed with step 1.3.3.

For the maximal mechanical angle, the following values apply:

- MOVIA: +/- 10°
- PS1 and PS2: +/-11°
- LXP: +/-11°
- Lightning II: +/-11°

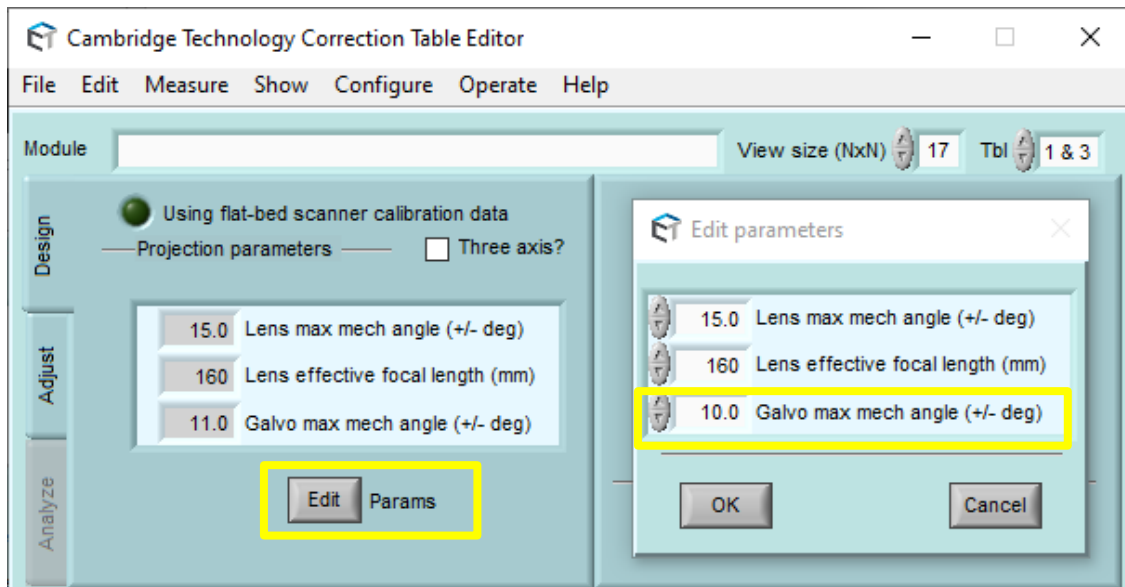


Figure 5: Set parameters in the parameter box: After pressing the Edit button (left), a pop-up window for parameter editing will appear (right). For MOVIA scan heads type in 10 for the max. mechanical angle.

2.2.3 Synthesize Baseline Corrections

Check the Parameter settings, if all is set to your satisfaction go to 'Edit' and select 'Synthesize Baseline corrections'. The editor calculates a pin-cushion distortion compensation derived from mirror spacing, and lens

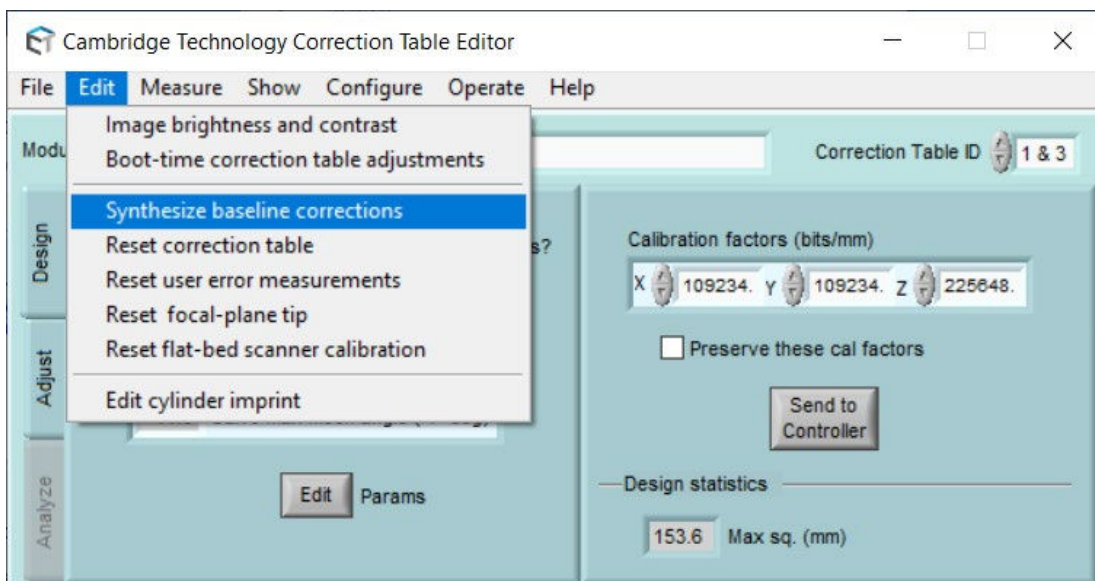


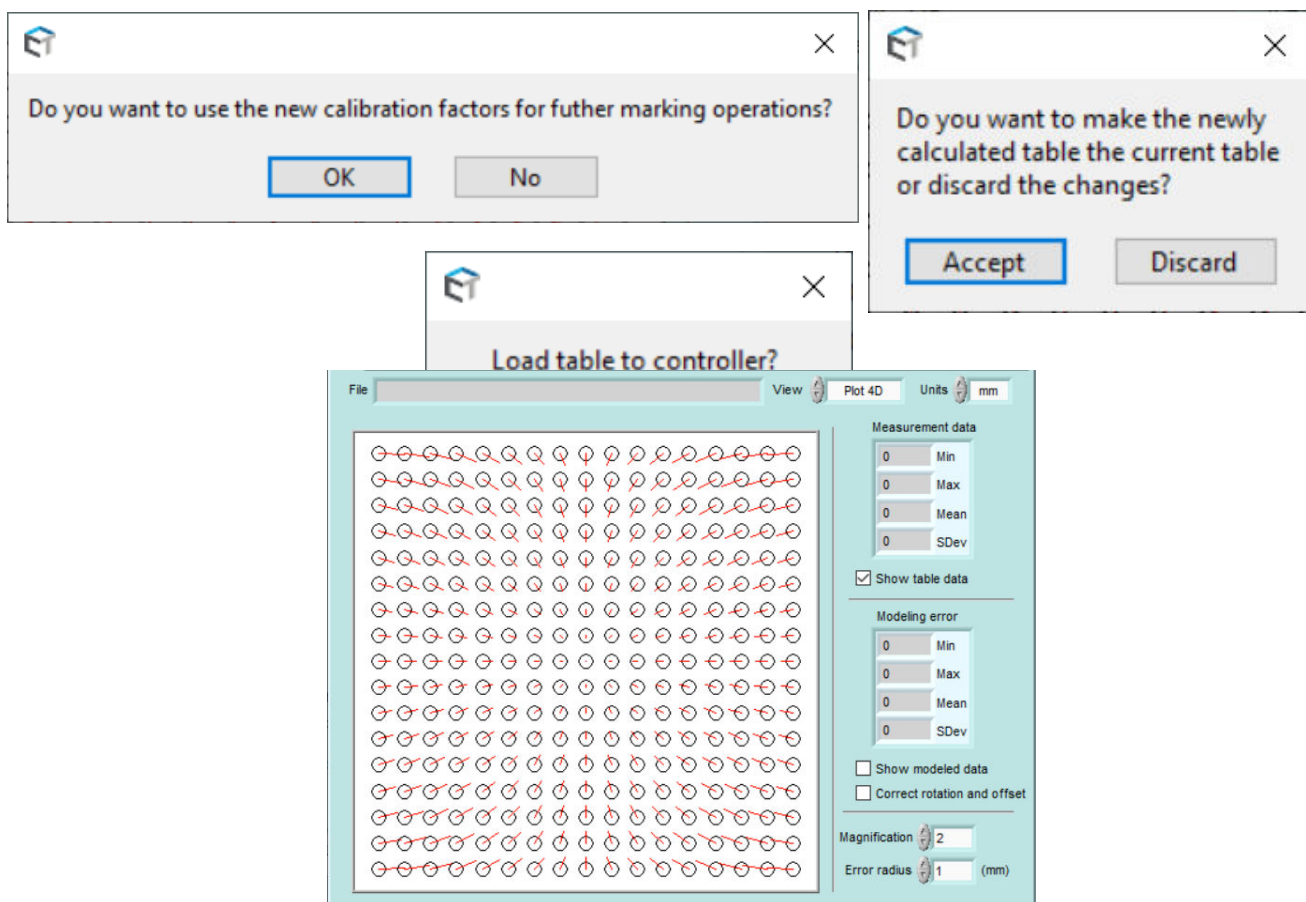
Figure 6: Synthesize Baseline Corrections

distortion compensations. After the process is complete, the new table is displayed. For an example, see figure 8, below.

Figure 7: Presentation of the correction table after synthesizing the baseline corrections

2.2.4 Close Correction table Editor & Save changes

Close the correction table editor window, accept the following pop-up messages, and save your correction table to your computer. File revision is optional and can be left blank.



2.3 Find Focus

In this step, you adjust the system to achieve a focused beam at the center of the field.

1. Go to the 'Set center-focus offset' tab.
2. Define grid size of the pattern
3. Click the "Run" button to mark the grid.
4. Check the marked grid and adjust the working distance.
The closer you get to the focus, the clearer the grid will be marked. Above and beneath the focus the marked grid will faint symmetrically (Figure 12).
5. Repeat steps 3 & 4 until you get a well-focused mark.

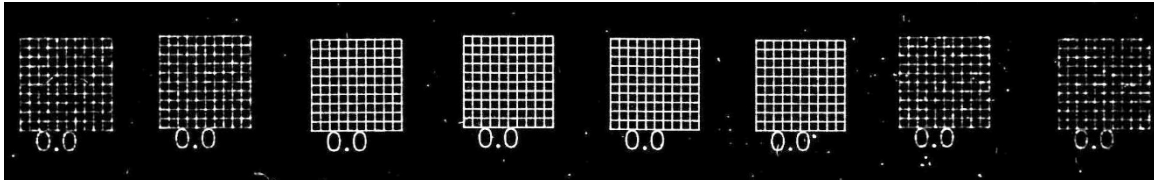


Figure 8: Example of focusing procedure. Above and beneath the focus the grid might look faded or less defined (left and right), once you get closer to the focus the grid appears clearly visible (center).

2.4 Adjust delays

For a quick start use the delays shown in the table below.

	MOVIA 10mm Scan Head	MOVIA 14mm Scan Head
Mark Delay	130 μ s	TBD
Jump Delay	260 μ s	TBD
Poly Delay	65 μ s	TBD
Laser On	Depends on Laser	
Laser Off	Depends on Laser	

For use in the actual application you will want to refine these delays more using CalWizard's "Adjust Laser/Galvo Timing" tab and following the instructions in the [manual](#), Appendix A.



Figure 9: Example of badly adjusted delay settings (left) and well-adjusted delay settings (right)

2.5 Create Calibration Grid & Collect Box/Cross Grid Data

Adjusting the correction table requires comparison of a known pattern's coordinates with measurements of actual coordinates on a marked piece. The 'Adjust correction table' tab provides parameters to define a grid pattern.

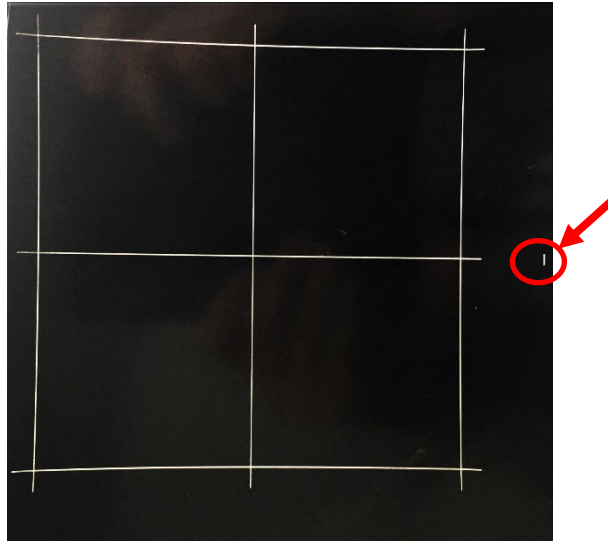


Figure 10: The 1st marked grid will show clear distortion errors. If a correction table from the 2 axis scan head library was used, the grid will show less distortion. On the right, you can find a small orientation marker.

1. Once all parameters are set, press "Run" to mark grid. The marked grid will look like the example in figure 11.
2. Click on "Edit table" to open the Correction Table Editor. Under 'Measure' click 'Collect Box/Cross grid data'.

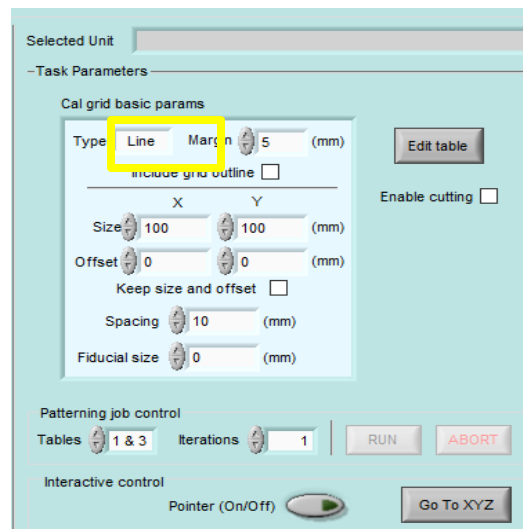


Figure 12: Under "Create Calibration Grid", clic the "Edit table" button to open the Correction Table Editor.

3. A window will open where you can type in the measured distances between the crosses (see figure 14). The orientation mark would be on the right side of the window. Do not change the ideal size of the grid.

4. After all measurements are done, close the window and save the measurement data.
5. Close the correction table editor, as before click 'Ok' on all pop-up windows
6. Repeat step 1) to 5) until the grid looks straight.

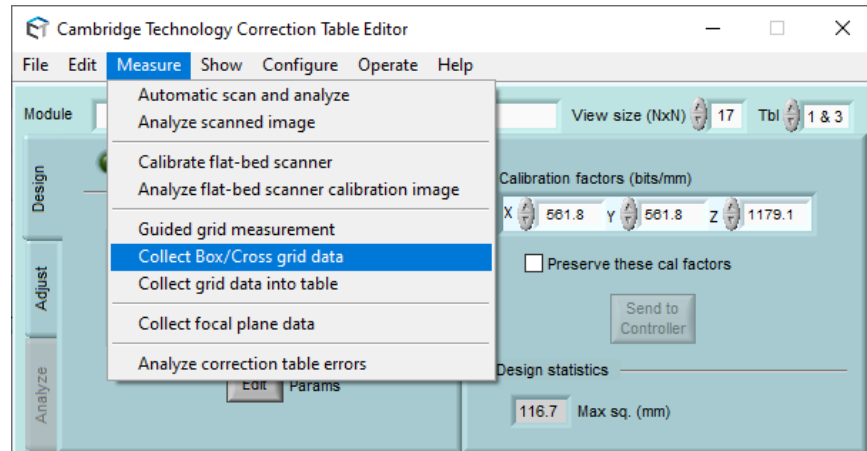


Figure 113: Go to Collect Box/Cross grid data to type in the results of your measurement.

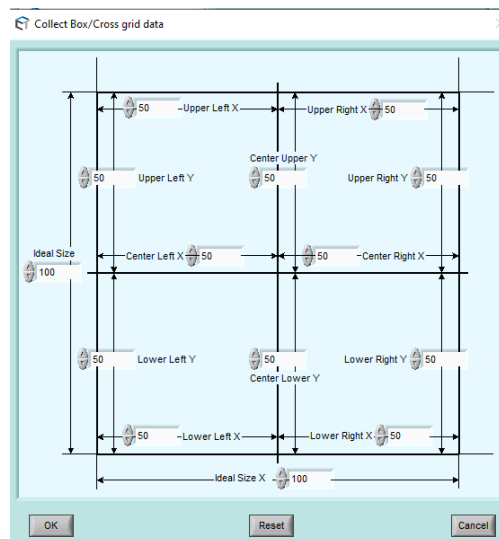
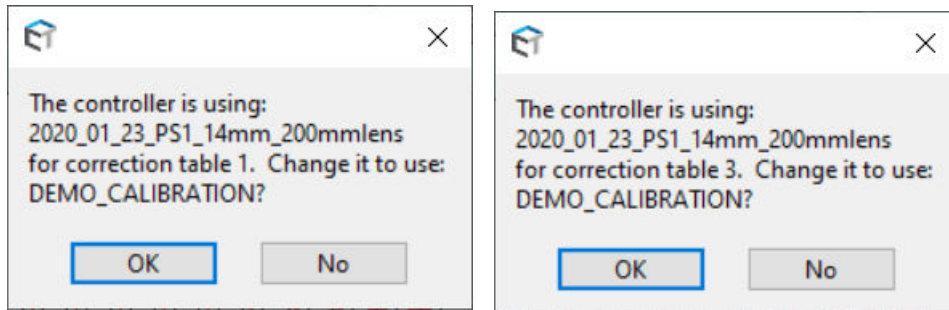


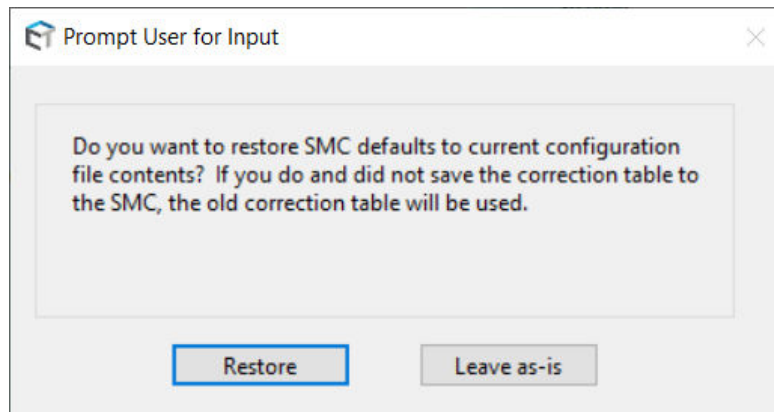
Figure 124: Type in the measured distances into the window. For orientation: The orientation mark would be on the right of the window. Do not change the ideal size of the grid.

2.6 Save Calibration and load to the controller

Once measurement is completed and gives good enough accuracy (+/- 0.5 mm), go to Edit Table → File → Save → Correction table... → To the controller. CalWizard will prompt you to save the calibration file to local



drive, too. Press “Yes” to save on local. CalWizard asks permission to make the most recent calibration file active as Table 1 and Table 3 as shown in figure 14. Press “OK” both times. When Closing the CalibrationWizard you will be asked if you want to restore the SMC to the current configuration file contents, click on Leave as-is and close the program. The SMC controller is ready to use with new correction file.



3. Troubleshooting

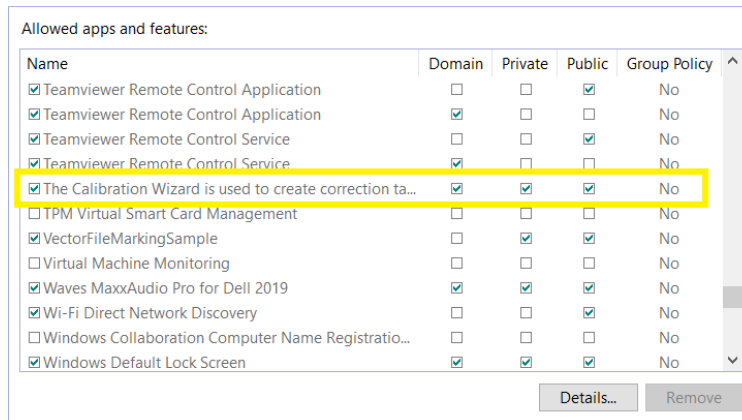
Even though we are continuously working on making the Calibration as user friendly as possible. There might be some troubles you could possibly run into. Some of them are listed here and explained how to solve.

3.1 Error could not connect to SMC

If you cannot connect to the SMC here are some possible reasons:

- SMC is already connected to other software. Disconnect from other software and try again

- firewall settings wrong, allow the software to communicate through the windows defender wall



- IP address is not set correctly, check if the IP address of your ethernet adapter match with the one of the SMC. The default SMC IP-address is: 192.168.100.20

3.2 2. Barrel/Pincushion effect is still strongly visible after several iterations

If, even after several iteration the grid still shows a strong distortion it might be because you forgot to synthesize the baseline correction. Please open a new calibration table and synthesize the baseline correction before marking and measuring the grid.

Another reason for a strong distortion could be that the SMC is missing the Lens File. In this case, open CalWizard and load the correction table from the controller or the saved location. Resave it to the SMC.

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