

# 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 <u>CalWizard Manual</u>.

# 2. Two Axis Calibration

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

**Technical Bulletin AN00038** 



# 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 <u>MOVIA Quick Start Up Guide</u>.

- 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: <u>https://www.gravotech.us/</u>
  - Supplier for marking paper: <u>https://com.europapier.com/</u>
- 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.

R Cambridge Technology Cal	ibration Wizard					
File Configure Show Help						
. Controller SMC:SMC-16151297@192.1	r Units - Double-click to select 68:10020	Connected	Zoom Reset Show all images 7 72.91 _ 60.00 - 50.00 - 40.00 -	Units mm Show Jumps X	Calibration factors (b)	and the second se
Three axis system?	Selected Unit SMC:SM	C-16151297@192.168.100.20	30.00 -			
Set system configuration		😭 Status	<u>×.</u>			
Set focus/marking params	Please select a cal	Establishing commun	ications			
Create correction table						
Set center-focus offset		Please wait				
Adjust laser/galvo timing			-50.00 -			
Create calibration grid			-60.00 -			
Adjust correction table			-72.91-	-40.00 -20.00	0.00 20.00 40.00	60.00 72.91
	Patterning job control Tables	1 RUN ABORT	Messages			
	Interactive control Pointer (On/O		Msg event! High = 0x2325 Msg event! High = 0xF (1) Disconnected from: 192.1 Connected to: 192.188.10		be0 (0)	< ×

Figure 2: By double clicking a controller can be selected

### 2.1.2 Set System Configuration

Three axis system?	Selected Unit SMC:SMC-16151297@192.168.100.20 -Task Parameters	
Set system configuration Set focus/marking params Create correction table	Load           15.0         Lens max mech angle (+/- deg)           160         Lens effective focal length (mm)           11.0         Galvo max mech angle (+/- deg)	
Set center-focus offset Adjust laser/galvo timing Create calibration grid Adjust correction table	Head parameters Edit Laser type CO2 Background laser modulation Frequency 5 KHz Duty-cycle 0 %	
	Patterning job control Tables () 1 & 3 Iterations () 1 RUN ABOR Interactive control Pointer (On/Off) O Go To XY2	

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



## 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.

~	
This action will create an	
table. You will lose any in	
modifications you may h	ave done that were
not saved.	
not saved.	



#### 2.2.2 Load from dual axis scan head library or Edit Parameters

Go to 'File  $\rightarrow$  Load  $\rightarrow$  Correction table  $\rightarrow$  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.

😭 Cambr	idge Technology Correction Table Editor	- 🗆 X
File Edit	Measure Show Configure Operate Help	0
Load Save Import	<ul> <li>Correction table</li> <li>Flat-bed scanner calibration data</li> </ul>	From a local file From the default startup configuration on the contr From a stored file on the controller
Export Convert Quit	ing flat-bed scanner calibration data	K     633.4     Y     633.4     Z     500
Adjust	11.0       Lens max mech angle (+/- deg)         160       Lens effective focal length (mm)         11.0       Galvo max mech angle (+/- deg)	Preserve these cal factors
Analyze	Edit Params	Design statistics

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°



Ê	Cambridge Technology Correction Table Editor	- 🗆 X
File	Edit Measure Show Configure Operate H	Help
Modu	le	View size (NxN) 👌 17 Tbl 👌 1 & 3
Design	Using flat-bed scanner calibration data —Projection parameters — Three axis?	Edit parameters ×
Adjust	15.0       Lens max mech angle (+/- deg)         160       Lens effective focal length (mm)         11.0       Galvo max mech angle (+/- deg)	15.0 Lens max mech angle (+/- deg) 160 Lens effective focal length (mm) 10.0 Galvo max mech angle (+/- deg)
Analyze	Edit Params	ОК Сапсеі

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

Ê	Cambridge Technology Correction Table Editor	- 🗆 X
File	Edit Measure Show Configure Operate	Help
Modu	Image brightness and contrast Boot-time correction table adjustments	Correction Table ID 👌 1 & 3
	Synthesize baseline corrections	
Design	Reset correction table	s? Calibration factors (bits/mm)
De	Reset user error measurements	X 쉬 109234. Y 쉬 109234. Z 쉬 225648.
-	Reset focal-plane tip	
st	Reset flat-bed scanner calibration	Preserve these cal factors
Adjust	Edit cylinder imprint	Send to Controller
Analyze	Edit Params	Design statistics

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.

ধি		×	ÊÎ	×
Do you want to use the new calibr	ration factors for futher mark	ing operations?		to make the newly ble the current table changes?
	Êî	×	Accept	Discard
	Load table to co	ontroller?		
File		View Dlot 4	D Units mm	
	$\begin{array}{c} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 $	0     0 </td <td>Measurement data</td> <td></td>	Measurement data	

# 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.
- 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 fainted 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 μs	TBD
Jump Delay	260 μs	TBD
Poly Delay	65 μs	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 <u>manual</u>, 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 1<sup>st</sup> 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'.

Selected Unit	
-Task Parameters	
Cal grid basic params	
Type Line Marc n 💮 5	(mm) Edit table
include gna outline	]
XY	Enable cutting
Size	(mm)
Offset 👌 0 👌 0	(mm)
Keep size and offset	
Spacing 쉬 10 (r	nm)
Fiducial size 👌 0 (r	nm)
Patterning job control	
Tables 1 & 3 Iterations	1 RUN ABORT
Interactive control	
Pointer (On/Off)	Go To XYZ

Figure 12: Under "Create Calibration Grid", clcik 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  $\rightarrow$  File  $\rightarrow$  Save $\rightarrow$  Correction table... $\rightarrow$  To the controller. CalWizard will prompt you to save the calibration file to local

€î ×	€î ×
The controller is using: 2020_01_23_PS1_14mm_200mmlens for correction table 1. Change it to use: DEMO_CALIBRATION?	The controller is using: 2020_01_23_PS1_14mm_200mmlens for correction table 3. Change it to use: DEMO_CALIBRATION?
OK No	OK No

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.

rompt User for Input	×
Do you want to restore SMC defaults to current configuration file contents? If you do and did not save the correction table to the SMC, the old correction table will be used.	
Restore Leave as-is	

# 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

Name	Domain	Private	Public	Group Policy
Teamviewer Remote Control Application			<b>~</b>	No
Teamviewer Remote Control Application	✓			No
Teamviewer Remote Control Service			$\checkmark$	No
Teamviewer Remote Control Service	<b>~</b>	Π	П	No
The Calibration Wizard is used to create correction ta	<b>~</b>	<b>~</b>	$\checkmark$	No
□ TPM Virtual Smart Card Management				No
✓ VectorFileMarkingSample		<b>~</b>	<b>~</b>	No
□Virtual Machine Monitoring				No
Waves MaxxAudio Pro for Dell 2019	<b>~</b>	$\checkmark$	$\checkmark$	No
☑ Wi-Fi Direct Network Discovery			$\checkmark$	No
UWindows Collaboration Computer Name Registratio				No
Windows Default Lock Screen	<b>~</b>	<b>~</b>	<b>~</b>	No

- 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.

#### **Contact Us**

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