

Color Calibration with ChromaCalc Manual

CD40192

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Table of Contents

1	General information	3
1.1	About Chromasens	3
1.1.1	Contact information	3
1.1.2	Support	3
1.2	Firmware and software version in this manual	3
2	Color calibration with ChromaCalc	4
3	Installing ChromaCalc	5
4	Performing Color Calibration with ChromaCalc	7
4.1	Creating a calibration image	7
4.2	Working with ChromaCalc	7
4.3	Preparing the input image	8
4.3.1	Required marker positions	9
4.4	Specifying calibration parameters	10
4.5	Calculating and saving calibration data	11
4.6	Applying the calibration results	11
4.7	Loading calibration data to the camera	12
4.8	Displaying information about color spaces	12
4.9	Specifying the color distance metric	12
5	Working with CIE color spaces	13
5.1	Using the CIELAB D50 color space	13
5.2	Using the XYZ color space	13
6	Working with a user-defined color chart	14

1 General information

1.1 About Chromasens

The name of our company, Chromasens, is a combination of 'Chroma' which means color, and 'Sens' which stands for sensor technology.

Chromasens designs, develops and produces high-quality and user-friendly products:

- Line scan cameras
- Camera systems
- Camera illumination systems
- Image acquisition systems
- Image processing solutions

Today, Chromasens GmbH is experiencing steady growth and is continually penetrating new sales markets around the globe. The company's technologies are used, for example, in products and for applications such as book and document scanners, sorting systems and inspection systems for quality assurance monitoring.

Customers from all over the world of a wide range of industrial sectors have placed their trust in the experience of Chromasens in the field of industrial image processing.

1.1.1 Contact information

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1.1.2 Support

Should you ever have problems with ChromaCalc that you cannot solve by yourself, look into this manual for additional information, contact your local distributor, or send us an e-mail.

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Visit our website at <http://www.chromasens.de> which features detailed information on our company and products.

1.2 Firmware and software version in this manual

This document refers to the following version:

ChromaCalc: Version 1.6

The recent version might have additional functions. Therefore, contact the Chromasens support.

2 Color calibration with ChromaCalc

The aim of color calibration is to transfer the color space determined by the properties of camera and lighting to a standardized output color space. Typical color spaces are for example XYZ, sRGB, Adobe RGB, ECI RGB, and CIELAB.

ChromaCalc provides an easy way to calibrate Chromasens chromaPIXA cameras.

It compares scanned image data with a reference data set measured with a calibrated device and determines a color conversion matrix, which can then be loaded into the camera.

3 Installing ChromaCalc

ChromaCalc uses Mathematica for its calculations. Therefore, after ChromaCalc has been installed, the **Wolfram CDF Player** is downloaded and installed if it is not found on the computer.

Important note: If the **Wolfram CDF Player** is not present, your user account must have administrator rights. Otherwise, the ChromaCalc setup is not able to start the player installation. It is not sufficient to grant administrator rights to the ChromaCalc setup when you start it.

To install ChromaCalc:

1. Run Chromacalc_1_6_##.exe and click **Next** on the **Welcome** page.

The **Select Destination Location** page is shown. By default, the program is installed below the Program Files folder.

2. If you want to install the program to a different location, enter the folder or click **Browse** and select a suitable folder.

3. Click **Next**.

4. If a desktop icon should be created for the program, select the check box on the **Select Additional Tasks** page. Click **Next**.

5. On the **Ready to Install** page, click **Install**. A progress bar indicates installation of the ChromaCalc files.

If the **Wolfram CDF Player** is not found on the computer, its download is started and the **DOWNLOAD MANAGER** shows a progress bar if the setup file is not present on the computer:



Due to the file size of 1.3 GB, download takes some time.

6. To start installation of the player, click the **Launch** button, which appears as soon as download is complete.
7. On the **Completing the ChromaCalc Setup** page click **Finish**.
8. On the **Wolfram CDF Player Setup** page, click **Install**.

Note: When the **Completing the ChromaCalc Setup** page is shown, the player setup is already starting. If you do not click **Finish** immediately, the player setup page will also be shown.

9. Installation takes a few minutes. When it is completed, the player is started and it shows a Welcome page. For ChromaCalc, the user interface of the player is not needed. Therefore you should close it.

Note: If you want to save disk space, you can remove the setup program of the **Wolfram CDF Player** after installation has been completed successfully. The file with the name `setup.exe` can be found in the `Downloads` folder of the current user.

4 Performing Color Calibration with ChromaCalc

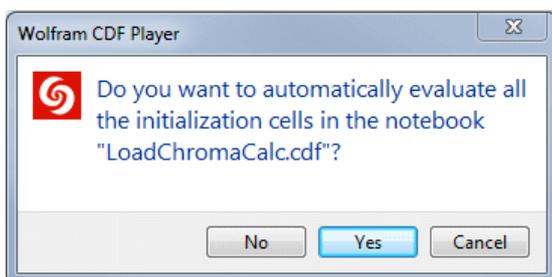
4.1 Creating a calibration image

When you scan the color chart to create a calibration image, take care of the following:

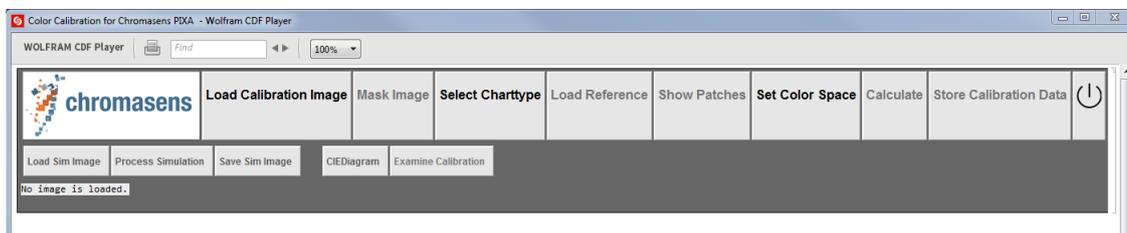
- Make sure that shading correction has been performed.
- Don't use a gamma correction
- Don't use a color conversion matrix.

4.2 Working with ChromaCalc

When you start ChromaCalc, the **Wolfram CDF Player** is also started. When the **Wolfram CDF Player** message is shown, click **Yes**:



The ChromaCalc user interface shows a series of buttons for the different steps of the calibration process and an area for the prepared image used for calibration:



The buttons in the uppermost row show the steps of the calibration process in a meaningful order. To perform a calibration successfully, each step must be performed. When you complete a step successfully, the button shows a green check mark. If a button is not available, this indicates that a preceding step must be performed first. Thus, you should normally perform the first step in the row that doesn't show a check mark.

If you make a change in an already completed step, check marks in the following steps may disappear and some steps may no longer be available, indicating that you must perform a preceding step first.

4.3 Preparing the input image

To prepare the input image:

1. Click **Load Calibration Image**.
2. Select the image you want to use for calibration, and then click **Open**.

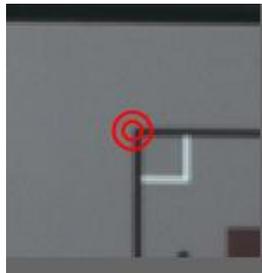
The image is then shown. To prepare the image, you must remove borders and bring the image to upright orientation if necessary.

3. Click **Mask Image**.
4. The buttons below the image permit to adjust the image. If the image was scanned in wrong orientation, click **Rotate** until the image is in upright orientation. To mirror the image, click **Reflect**.
5. Four markers are shown near the image corners:



For a standard color chart supported by ChromaCalc, move the markers to the required positions as described below.

6. Afterwards, use the markers on the magnified image snippets on the right side to adjust the markers if necessary:



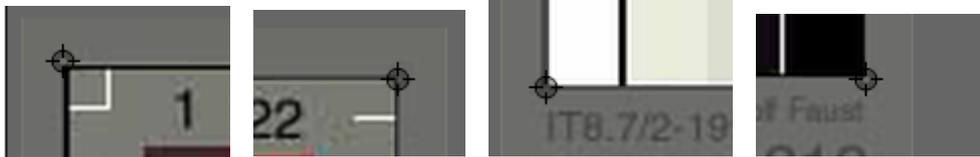
Note: Don't move a marker on the image after you have moved the marker on the corresponding image snippet because the position of the two markers is no longer synchronized after you moved the right one.

7. To apply the mask and remove the borders outside the marked area, click **Align to Mask**. If you then detect that you have set a marker to a wrong position, click **Undo Mask**. You can then return to step 5.

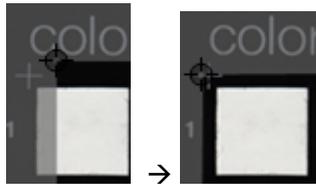
4.3.1 Required marker positions

The required marker positions depend on the color chart type.

- For the **IT8** color chart, move the markers to the edges of the area containing the colored areas as shown here:



- For the **Color Checker Digital** and the **Color Checker Classic** color charts, move the markers to the crosshairs shown near the edges of the colored areas:



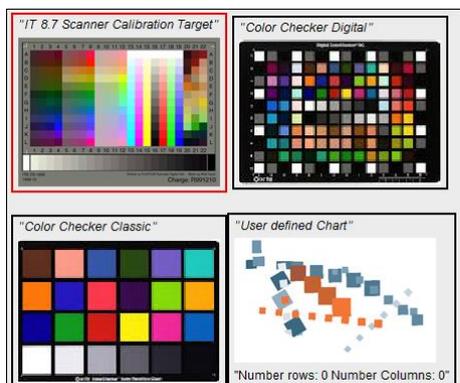
- For a user-defined color chart, move the markers to the edges of the colored areas.

4.4 Specifying calibration parameters

To specify the calibration parameters:

1. Click **Select Chart Type**.

With this release ChromaCalc supports three standard color charts and user-defined charts. For the standard charts an example image is shown:

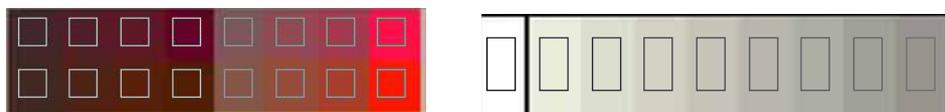


2. Click on the respective chart. A red rectangle around the selected chart type is shown.
3. Click **Load Reference**. A file dialog box opens.

For the supported standard color charts, reference files can be found in the `ColorReferences` subfolder of the ChromaCalc installation folder. For a user-defined chart, you must prepare your own reference file.

Take notice that for the IT 8.7 color chart, charge-dependent reference files are available at <http://www.targets.coloraid.de/>. The reference files in the `ColorReferences` folder are just samples for testing. For calibration of your camera you should download the correct file for your color chart.

4. Select a suitable reference file and click **Open**. ChromaCalc now shows the colors that are specified by the reference file.
5. Click **Show Patches**. Rectangles on the calibration image now indicate the areas that are used for the calibration. They should all be inside a colored area:



If rectangles touch or traverse the border between two different color areas, either the image was not masked correctly, or a wrong reference file was used.

6. Click **Set Color Space**. The supported color spaces sRGB, ECI RGB, Adobe RGB, XYZ, and CIELAB are shown.
7. Click on a color space. A red rectangle indicates the selected type. For more information about working with the color spaces XYZ and CIELAB, see chapter 5.

4.5 Calculating and saving calibration data

To calculate calibration data:

1. Click **Calculate**.

ChromaCalc now determines a color conversion that tries to adjust the colors of the calibration image to the colors specified by the reference files.

Afterwards the results are shown:

3.	1.57	1.93	2.89	3.64	1.83	1.77	2.25
1.51	1.89	2.3	3.27	4.38	1.34	2.21	1.36
1.17	3.89	4.1	6.53	6.39	2.12	3.83	1.72

...

For each color, the distance between scanned color and reference color is shown. A dashed rectangle indicates that the adjusted color would lie outside the specified color space.

2. To save the results, click **Store Calibration Data**, specify a file name, and then click **Save**.

The results are saved as a file with extension `.dd`, which can then be loaded into the camera.

3. In the appearing dialog box, enter a name in the **Comment** box, and then click **OK**.

4.6 Applying the calibration results

After you have created calibration data, you can check its effect on test images.

To apply the results:

1. In the second button row, click **Load Sim Image**.
2. Select a test image and click **Open**.
3. Click **Process Simulation**.

The calibration results are now applied to the test image and the resulting image is shown.

4. If you want to save the processed test image, click **Save Sim Image**, specify folder and file name, and click **Save**.

4.7 Loading calibration data to the camera

To load calibration data to the camera:

1. Run CST.
2. On the toolbar, click **Set system settings** .
3. Click **Send files to camera**.
4. In the **Send data files to camera** file dialog box, select the calibration data file, and then click **OK**.
5. On the toolbar, click **Basic parameter settings** .
6. In the tree view, under the **Image parameter** node, click **Image processing**.
7. In the **Color conversion mode** list, click **use ChromaCalc-generated data**.
8. On the toolbar, click **Transfer setting to camera** , or press **F9**.
9. To save the settings permanently, click **Burn setting permanently** , or press **F10**.

4.8 Displaying information about color spaces

When you click **CIEDiagram**, CIE diagrams of different color spaces can be displayed.

4.9 Specifying the color distance metric

When you start ChromaCalc, as color distance metric always CIE2000 is used per default.

To modify the color distance metric:

1. Click **Color Process Config**.
2. In the **Config Color Processing** dialog box, click **CIE76** or **CIE2000**, and then click **OK**.

5 Working with CIE color spaces

5.1 Using the CIELAB D50 color space

ChromaCalc permits to use the CIELAB (L*a*b*) color space. If you select **CIELAB D50** as color space, and load the created calibration data into the camera, the chromaPIXA then transmit its images in CIELAB format. The a and b values are coded as signed integers (i.e. as two's complement).

Take notice that most frame grabbers do not directly support the CIELAB color space. Therefore, the images sent from the camera will not be displayed meaningfully. If you want to display images in CIELAB format on a screen, you will have to provide your own software.

For conversion from CIELAB D50 to XYZ use the following formulas:

$$X = 96.4212 * f^{-1} \left(\frac{L^* + 16}{116} + \frac{a^*}{500} \right)$$

$$Y = 100 * f^{-1} \left(\frac{L^* + 16}{116} \right)$$

$$Z = 82.5188 * f^{-1} \left(\frac{L^* + 16}{116} + \frac{b^*}{200} \right)$$

where

$$f^{-1}(t) = \begin{cases} t^3 & \text{if } t > \delta \\ 3 * \delta^2 * \left(t - \frac{4}{29} \right) & \text{otherwise} \end{cases}$$

where

$$\delta = \frac{6}{29}$$

Afterward, use the matrix shown in the following section for conversion from XYZ to sRGB.

5.2 Using the XYZ color space

ChromaCalc permits to use the XYZ color space. If you select **XYZ** as color space, and load the created calibration data into the camera, the chromaPIXA then transmit its images in XYZ format with a value range of 0..255.

For conversion from XYZ to sRGB use the following matrix:

$$\begin{pmatrix} 3.1336 & -1.61682 & -0.490742 \\ -0.97865 & 1.91606 & 0.0335129 \\ 0.0335129 & -0.229066 & 1.40536 \end{pmatrix}$$

6 Working with a user-defined color chart

Instead of the supported standard color charts, you can use your own color chart.

In this case you must also provide a corresponding reference file.

The reference file must be a text file with the format described in ISO 12641, section 4.7.

The following example shows the first lines of the reference file for the IT8 color chart:

```
IT8.7/2
ORIGINATOR "wolf Faust"
DESCRIPTOR "Kodak Professional Paper, L* a* b* (light D50, viewing angle 2)"
MANUFACTURER "wolf Faust - http://www.coloraid.de"
CREATED "AUGUST 15, 2014"
PROD_DATE "2014:08"
SAMPLE_BACKING "black"
SERIAL "5x7 R140603 Batch Average Data"
MATERIAL "Kodak Professional Endura Premier"
KEYWORD "MEAN_DE" # Mean Delta E of samples compared to batch average
NUMBER_OF_FIELDS 18
BEGIN_DATA_FORMAT
SAMPLE_ID XYZ_X XYZ_Y XYZ_Z LAB_L LAB_A LAB_B LAB_C LAB_H D_RED D_GREEN D_BLUE D_VIS STDEV_X STDEV_Y STDEV_Z MEAN_DE STDEV_DE
END_DATA_FORMAT
NUMBER_OF_SETS 288
BEGIN_DATA
A1 3.47 2.92 2.02 19.71 11.21 3.46 11.73 17.15 1.35 1.64 1.59 1.50 0.05 0.05 0.04 0.26 0.29
A2 4.31 2.92 1.71 19.73 23.49 6.67 24.42 15.85 1.20 1.82 1.67 1.46 0.07 0.05 0.03 0.27 0.31
A3 5.29 3.01 1.44 20.09 34.44 10.30 35.94 16.65 1.08 2.04 1.75 1.41 0.07 0.04 0.04 0.34 0.40
A4 5.69 3.20 1.54 20.84 35.83 10.53 37.35 16.38 1.05 2.03 1.72 1.38 0.07 0.04 0.03 0.39 0.43
A5 12.38 10.71 7.82 39.08 14.80 3.78 15.27 14.31 0.80 1.06 1.02 0.94 0.12 0.12 0.11 0.26 0.29
A6 14.84 10.93 6.84 39.45 28.91 8.43 30.12 16.25 0.68 1.17 1.08 0.90 0.17 0.15 0.12 0.27 0.30
```

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