DCMS

Display Consistency Management Software

User Manual

K5960008-03

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1 About

1.1 Contents of the user manual

This guide consists of the following chapters:

Chapter 1: About

Chapter 2: Important notice

Chapter 3: About DCMS

Chapter 4: Installing DCMS

Chapter 5: Connecting the components

Chapter 6: Running the DCMS application

Chapter 7: Display connection and calibration options

Chapter 8: Calibration process

Chapter 9: Verification

Chapter 10: The log file

Chapter 11: List of abbreviations

Chapter 12: Appendix A: Open Source Software

Chapter 13: Appendix B: Specifications

1.2 Change record

Revision	Date	Description
00	March-08	Initial Release
01	May-08	Added/changed RS232 connection issues
02	July-09	Added NSL-4601
03	April-10	Software update V1.03

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1.3 Notation convention

Following notations are applicable to this manual and should be respected through the manual.

WARNING:

Warnings – presented in this manual, provide information, which if not adhered to, may result in personal injury or death.

CAUTION:

Cautions – presented in this manual, provide information, which if not adhered to, may result in damage to the equipment.

NOTE:

Notes – presented in this manual, provide information, which emphasize points, significant to understand and operate the unit.

IMPORTANT:

Important – presented in this manual, provide information, which is important to highlight.

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The RXTXComm library used to communicate over RS232 is Open Source. The library carries the RXTX License (http://users.frii.com/jarvi/rxtx/license.html), which is a modified LGPL 2.1. LGPL can be found at http://www.gnu.org/licenses/lgpl.txt. The RXTX library is included in its whole (including sources) to the DCMS CD-ROM.

The RXTX extension to the LGPL is for completeness listed in appendix A.

2.4 Embedded pictures

NOTE:

The pictures embedded in this document are for illustration purposes only and may look different depending on the device used to visualize this document (printer, display, ...).

2.5 Product safety notice

CAUTION:

Check the documentation of your display before physically connecting the monitor. Check that the cable you are about to use is fit for use with your monitor.

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3 About DCMS

3.1 What is DCMS?

The Barco Display Consistency Management Software (DCMS) is a software tool to calibrate displays in terms of luminance, gamma and gray tracking*. DCMS is able to calibrate displays to a predefined set of parameters or match displays to each other. The software uses a USB color sensor to measure color and luminance.

The term Display Consistency applies to the consistency of color throughout the gray scale and the consistency of color and luminance between multiple displays of the same or different type.

**Gray tracking means that the color of every gray level from black to white is constant, and equal to the white point target. In practice, because of LCD limitations, this holds for gray levels higher than 20% drive.*

3.2 Why using DCMS?

Because of spread in backlight, color filter and liquid crystal properties, all LCDs have different native white points and gamma. The same user settings will effectively produce different images, visible when the displays are put next to each other. Appropriate calibration can solve this by matching the luminances, gammas and white points.

This calibration requirement is general for all markets that use tiled LCD displays. More specifically, broadcasters must be able to trust the color they are seeing, so as good as possible absolute calibration (to an absolute, defined target) is also necessary. This is a matter of cost – used sensor, bit-depth of display and electronics, cost of color correction software and cross-talk removal, spread of color filters etc.

DCMS consists of software and sensor performing the given calibration.

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3.3 Key components

3.3.1 Calibration system

Calibration with internal test pattern generation (without disconnecting the display from its source)

The calibration can be done without disconnecting the display. In this case, a laptop or desktop PC is needed to run the DCMS software. This laptop/PC needs to be connected to the RS232 service port of the display. The USB color sensor should be connected to the laptop/PC. The internal test pattern generator of the display is used to create the colored fields needed for the calibration.

Figure 1: External calibration system

Calibration with external computer graphics (by using the input source as calibration system)

Another way of setting up the calibration system is by using the input source as calibration system. The computer is connected to the display via RS232 and the color sensor is connected via USB. In this scenario, the colored test fields are generated as computer graphics.

For this, the display needs to be connected through DVI and driven at native resolution at 24 bits per pixel color depth.

Figure 2: The input source as part of the calibration system

There is no difference in calibration results between the two calibration systems.

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IMPORTANT:

When calibration is done with external computer graphics, please restore all color settings of the host's graphics controller to their default value and disable any host services that may affect the color of the output picture.

3.3.2 Display

Each pixel of the display has 3 sub-pixels. These sub-pixels each have a color that corresponds with the three wavelengths for which the human eye is the most sensitive. These colors are red, green and blue (RGB). Each of these sub-pixels typically has 256 discrete levels. Colors are reproduced by combinations of these three primary colors.

Gamma is the perceptual linearity of light. Gamma is expressed by a power function.

Color temperature (or white point) is the 'color' of white. We say that the display has a warm white point or color temperature if the white of the display is reddish. The display has a cold or cool white point or color temperature if the white of the display is bluish. The color temperature or white point is expressed as coordinates in a color space (for example: xy values in CIE1931xyY space) or the temperature in degrees Kelvin at which a black body gets this color. Contradictory, we speak of warm white when the color temperature is low (for example: 3200K) and cold white when the color temperature is high (for example: 9300K). Daylight has a color temperature of 6500K.

Gray tracking is keeping the color temperature constant for all gray levels between black and white.

The brightness (light intensity of full white) is also calibrated as the power applied to the backlights. If the brightness target is set lower than the dimming capabilities of the backlight driver then additional dimming can be applied in the video if the display supports this function.

3.3.3 Sensor

The sensor used for calibration is the Barco USB color sensor (not sold separately). This sensor has a USB interface to the host PC running the DCMS application. Accuracy of the sensor is < 0.005 xy in CIE1931xyY color space. Luminance accuracy is < 5%. The sensor is shipped with a suction cap to attach the sensor to the monitor and a pod for dark current calibration of the sensor.

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3.4 Package content

- USB color sensor (Marked ‘Configured for DCMS’)
- RS232 cable male-female, 3-wire straight, 1.8m
- RS232 cable male-female, 3-wire crossed, 1.8m
- Calibration sheet of the sensor
- Sensor pod for sensor calibration
- Contra weight for sensor
- Felt cup to prevent damage to displays without front glass
- Suction cup for attaching sensor to front glass of display
- CD-ROM containing DCMS software
- CD-ROM containing DCMS User Manual
- Installation manual
- DCMS license certificate

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4 Installing DCMS

4.1 System requirements

- Host: Pentium II or later
- Memory: 256MB
- Hard disk space: 80MB (including Java Run-Time Environment)
- Drives: CD-ROM + HDD
- Operating system: Windows XP
- Run-Time Environments: Java SE 1.5 minimum (installed with DCMS)
- Boards & drivers: Driver for USB Optisense color sensor is available in the installation folder.
- Display: DVI capable of driving the display at its native resolution in 24bpp (optional)
- Other peripherals: USB, RS232

4.2 Before installing DCMS

- You must have Administrator privileges to install the software
- If there are older versions of DCMS installed, remove them first. Refer to the paragraph "*Uninstalling DCMS*" further in this chapter.

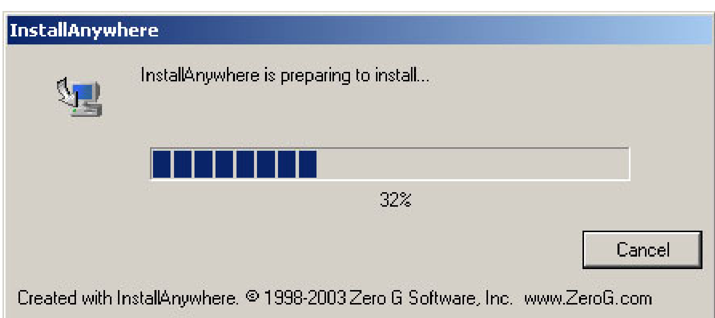
4.3 Installing DCMS

The DCMS software installer is available as an executable '**install.exe**' in the following folder on the installation CDROM: Disk1\InstData\VM.

The DCMS installer is a standard application installer which guides you through the installation and gives the option to go to the next window, go back to the previous window or cancel the installation at any time.

To install the DCMS software, follow these steps:

- **Double click the 'install.exe'**



The installer unpacks the necessary files. A dialog with progress bar is displayed.

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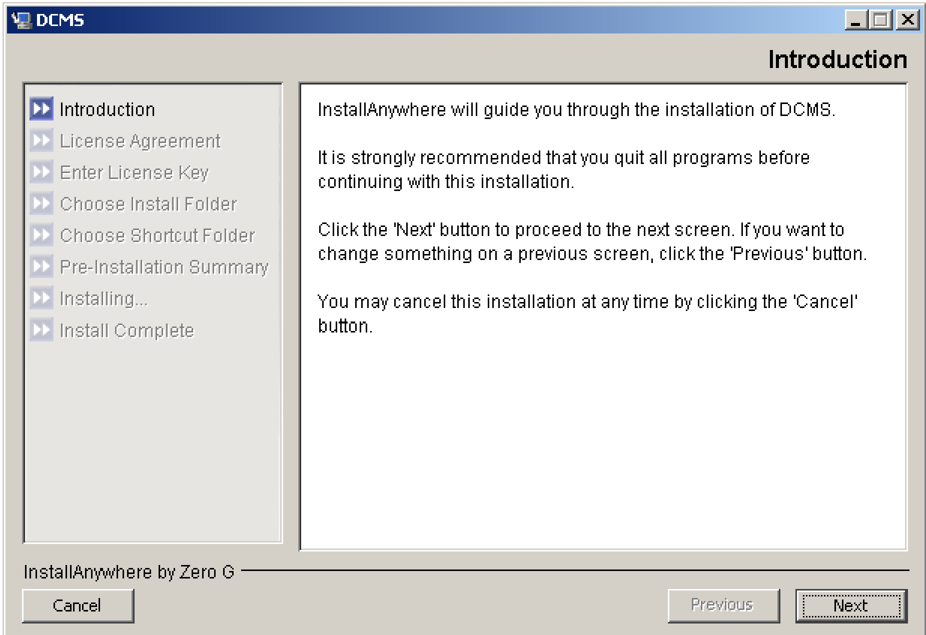
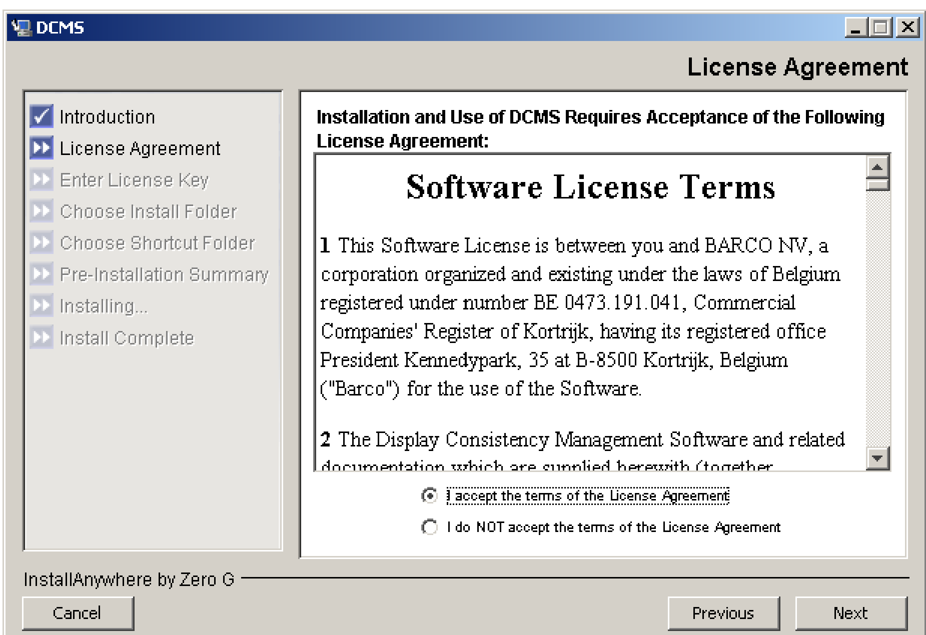
- **Introduction**



Read the introduction and press '**Next**' to continue.

It is strongly recommended to quit all programs before continuing with the installation. If you want to change something on a previous screen, click the 'Previous' button. The installation can be cancelled by clicking the 'Cancel' button.

- **License Agreement**



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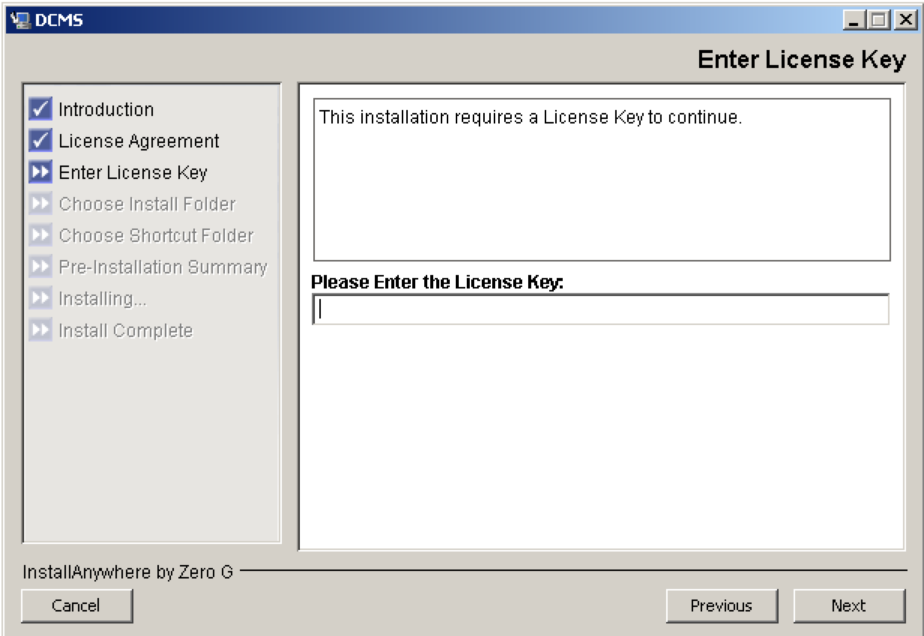
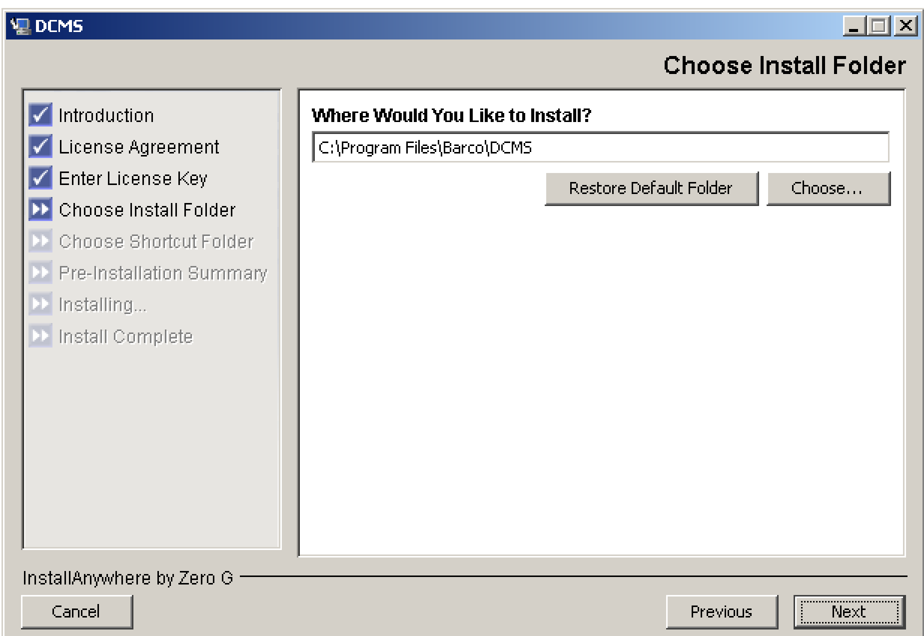
- **Enter License Key**



To continue the installation, enter your personal License Key, supplied on the DCMS license certificate. Press '**Next**' to continue.

- **Choose Install Folder**



Type or choose (with the folder browser) a location to install DCMS. The default location is 'C:\Program Files\Barco\DCMS'. By pressing the 'Restore Default Folder' button, you can always reset the default location.

Press '**Next**' to continue.

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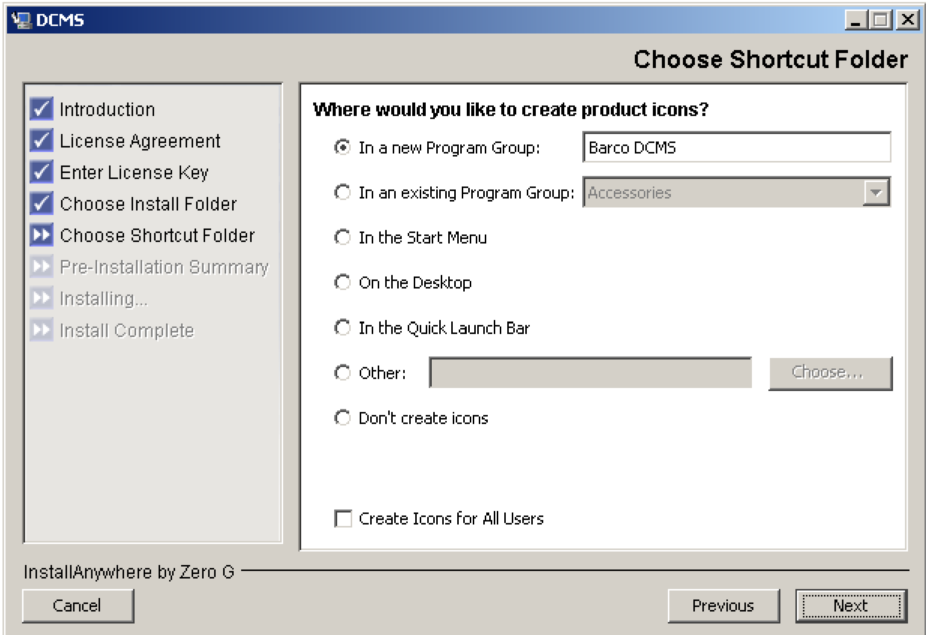
- **Choose Shortcut Folder**

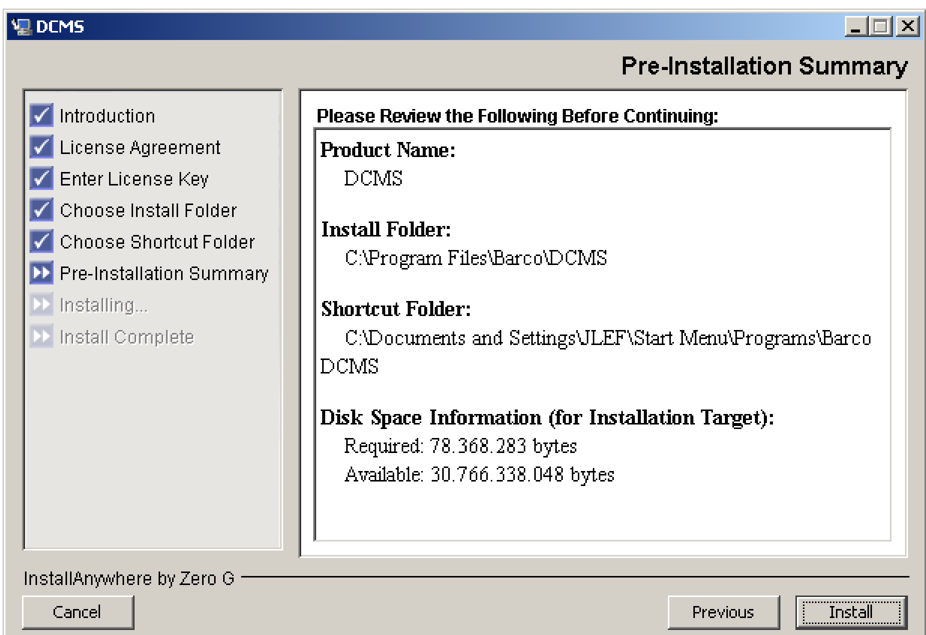


Choose the location where the shortcuts will be located. There is a shortcut available for the DCMS application in the Barco DCMS program Group.

It is also possible to skip the creation of shortcuts.

Press '**Next**' to continue.

- **Pre-Installation Summary**



This window gives a summary of the selected/specified options. This panel gives the user the chance to review the settings before starting the actual installation.

To start the actual installation, press '**Install**'.

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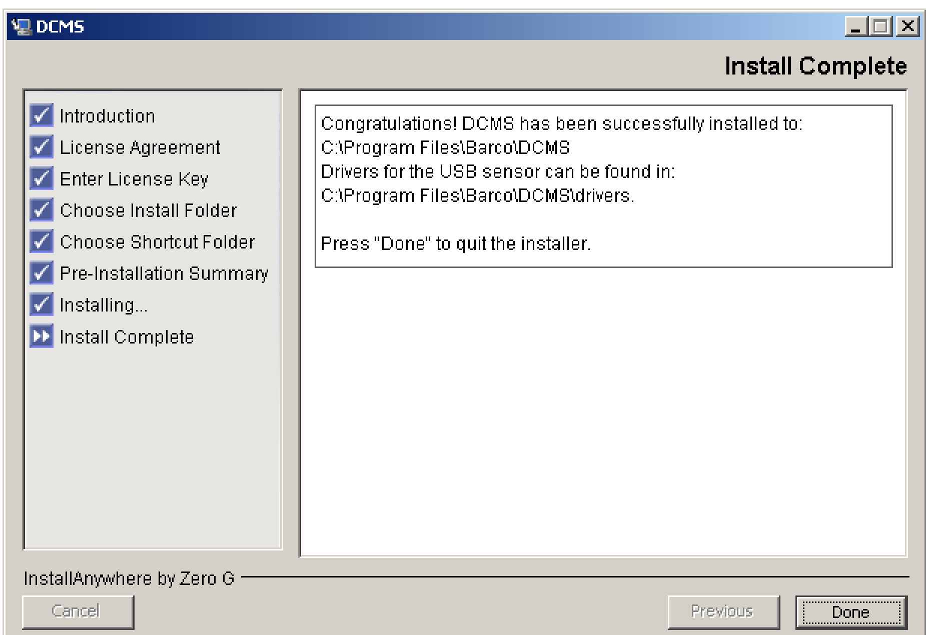
- **Installing...**

During the installation, a dialog with progress bar is displayed.

- **Install Complete**



The Install Complete panel shows if the installation was successful or not. If not successful, the installer will refer to the installation log for more details.

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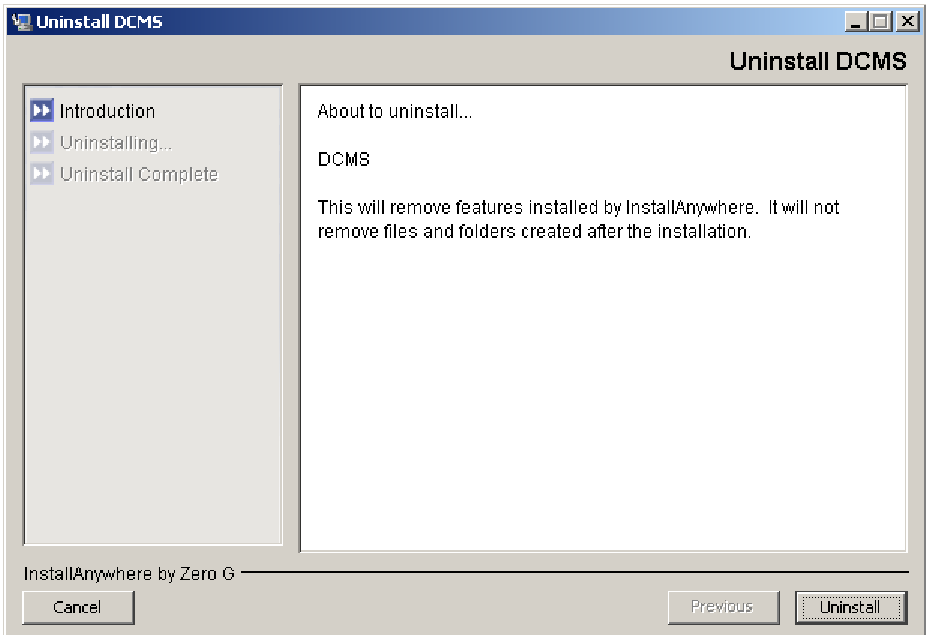
4.4 Uninstalling DCMS

To remove DCMS from your system:

- Be sure you have Administrator privileges to uninstall the software
- Exit the DCMS program
- From the Start menu, select Settings > Control Panel
- Double-click the Add/Remove Programs icon
- Select DCMS from the list box
- Click the Add/Remove... button



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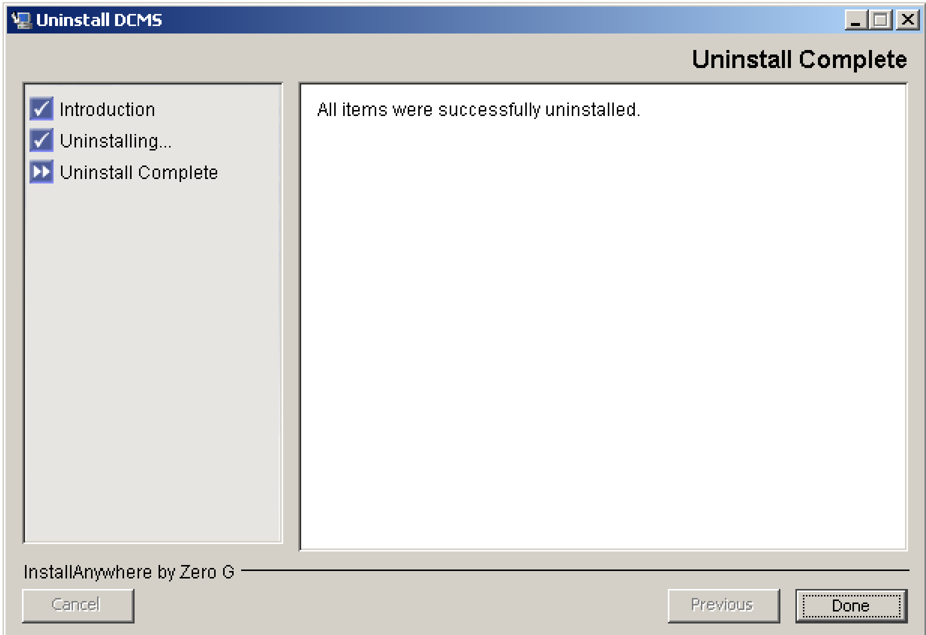
- Click the Uninstall button to remove the DCMS program.



NOTE:
Log files and files containing calibration parameters are not automatically removed.

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5 Connecting the components

5.1 Optical sensor connection

CAUTION:
The USB sensor is delivered with a suction cup head that can be attached to the sensor for easy attachment to a display with front glass. The use of this suction cup on displays without front glass is not advised. Therefore a felt cup head is also delivered.
If you decide to use the suction cup head despite this warning, be sure to turn the sensor when removing the sensor from the LCD and do not pull it off perpendicular to the LCD.

To change the sensor head:

- Remove the suction cup head by turning the head adapter in counterclockwise sense as illustrated below.
- Place the felt cup sensor head on the sensor and turn the head adapter in clockwise sense.

Figure 3: Sensor head removal

To connect the sensor:

- Plug in the sensor in one of the USB connectors of your PC. See also ‘Calibration system connections’ paragraph below.
- Windows pops up a message box ‘Found new hardware’

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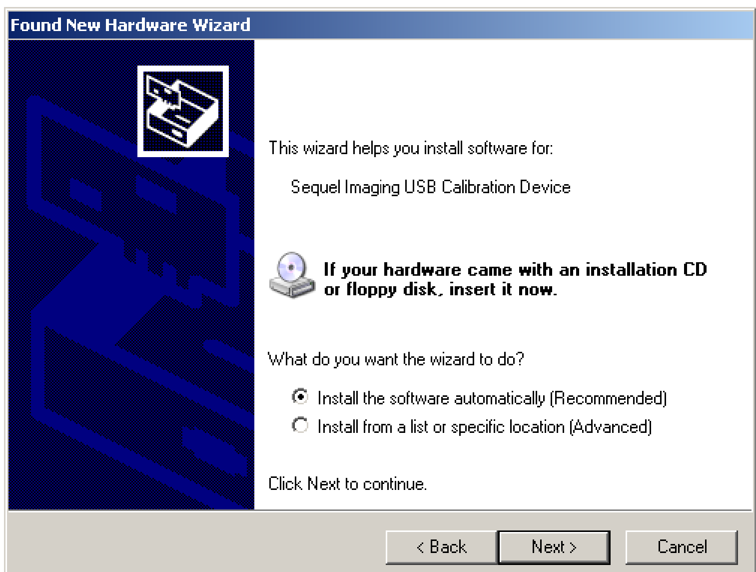
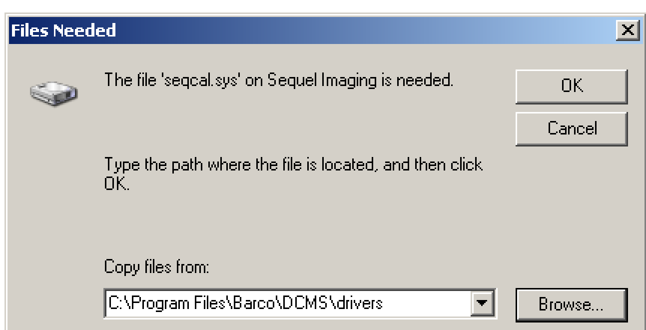
- Select ‘No, not this time’ and click ‘Next’ to continue.



- Select ‘Install the software automatically’ and click ‘Next’ to continue.



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- Browse to the path where the file ‘seqcal.sys’ is located and click ‘OK’.
  If the DCMS is successfully installed, the file should be available in the sub-folder ‘drivers’ of the installation folder on your hard disk.

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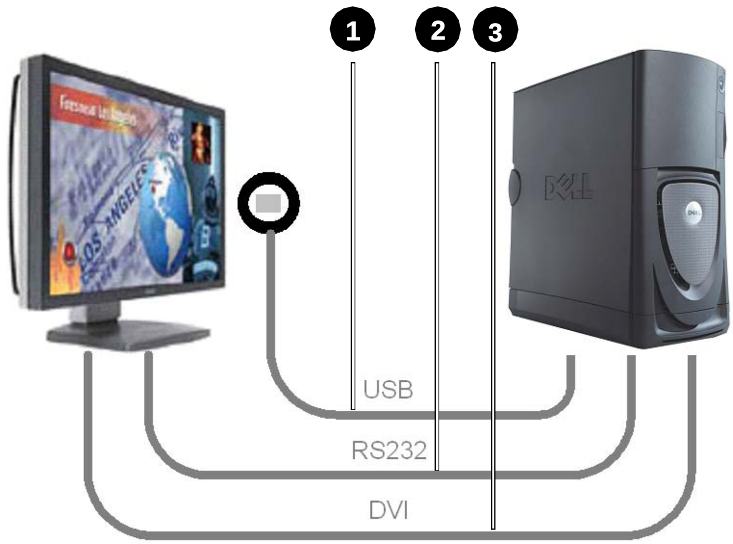
5.2 Calibration system connection



1	USB connection color sensor
2	RS232 connection from display to PC
3	DVI connection from display to PC

Figure 4: Calibration system connection

- Plug the sensor (delivered together with the DCMS software) in one of the USB connections of your PC. See also 'Optical sensor connection' paragraph. The USB color sensor measures color and luminance.
- Connect the display to be calibrated to the PC by using the correct RS232 cable. The RS232 is used to control the display and to upload the calibration parameters. The RS232 can also be used to set RGB test patterns in stead of DVI or when no DVI connection to the monitor is available.
- Connect a DVI cable (not delivered) between PC and display to be calibrated. The DVI connection is used to display color patches.

NOTE:

If the display is already connected to a different DVI source, the serial connection can be used to control the display's internal test pattern generator for colored test fields.
In this case, the input source is part of the calibration system and the colored test fields are generated as computer graphics.

IMPORTANT:

The DVI of the PC must be capable of driving the display at its native resolution with 24 bit color resolution.

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CAUTION:

Barco displays are connected with a 3-wire, crossed or straight serial cable. DCMS provides 2 serial cables: one 3-wire crossed cable and one 3-wire straight cable. The 3-wire crossed cable (Z3498894) is to be used for ISIS and MDPW displays; The 3-wire straight cable (K3494481) is to be used for ADP, NSL-4601 and LC displays.

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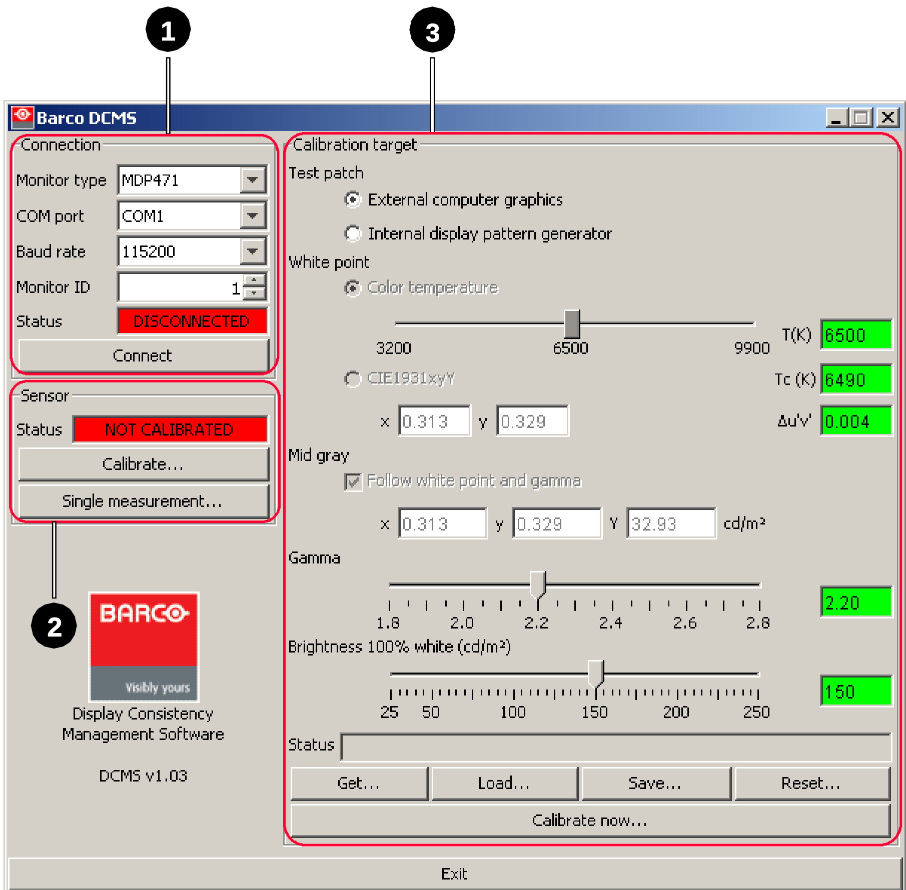
6 Running the DCMS application

6.1 User Interface

6.1.1 DCMS User Interface

The DCMS User Interface window has 3 main panels:



1	Connection panel
2	Sensor panel
3	Calibration target panel

Figure 5: DCMS User Interface

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6.1.2 Connection panel

The user can select the display type and display communication details in the Connection Panel. The displays that are supported are the Barco ISIS, MDPW476, ADP361, NSL-4601 and the LCx4x series displays. The specifics for each of these displays are described later in this document. Display communication is done via serial communication. Every serial port of the host is listed in the ‘COM port’ combo box. The Baud rate of the selected serial port can be chosen in the ‘Baud rate’ combo box. In the ‘Monitor ID’ spinner, the user can select the serial communication ID of the monitor. This is useful for displays that are chained after each other on the same serial port. How to change the Monitor ID of your display is described in the User Manual of the display.

Once the correct display type and communication details are set, press ‘Connect’ to start communication with the display. On successful communication with the display, the button will change text to ‘Disconnect’ and the Status field will color green and show ‘CONNECTED’. Press the button that is now labeled ‘Disconnect’ to stop communication with the selected monitor. The Status field will color red again and show ‘DISCONNECTED’. Changing display type or communication details is not possible as long as the connection is active.

6.1.3 Sensor panel

Calibration of the sensor

The Sensor Panel contains the USB sensor related functions. Press the ‘Calibrate’ button to open a connection to the sensor and calibrate it. After pressing the ‘Calibrate’ button, a dialog window will appear that explains the actions to be taken: Connect the USB color sensor to the PC and Place the USB color sensor on a dark surface or in the sensor pod and press 'Calibrate Sensor'. Perform this step in dark room conditions for optimal results.

Figure 6: Sensor Calibration Dialog

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Press the ‘Calibrate Sensor’ button to start calibration. This process takes about 10 seconds to complete.

After successful connection and calibration of the sensor, the progress bar of the Sensor Calibration dialog will color green and show ‘Calibration passed’. The Status field of the Sensor panel will color green and show ‘CALIBRATED’. If connection or calibration failed, both progress bar and Status field will color red and show ‘CALIBRATION FAILED’ and ‘NOT CALIBRATED’. The calibration will fail if the sensor is not plugged in or if the sensor is placed on a bright surface.

Press the ‘Close’ button to return to the main application.

IMPORTANT:

For optimal performance of the sensor it is necessary to place the sensor on a black and darkened surface or place the sensor in the sensor pod. An incorrect calibration of the sensor leads to invalid results. If the sensor is taken from a cold storage room, allow the sensor to acclimatize to the ambient temperature before use.

A recalibration of the sensor is required in the following conditions:

- the sensor was disconnected
- the ambient temperature has changed
- the last calibration of the sensor is more than a few hours old

Single measurement

For various reasons, the user may wish to know the color coordinates and luminance of a test patch on a display. This function is provided under ‘Single Measurement’. This button hides a dialog box. Place the sensor on the sample and press ‘Measure’. When the measurement is done, the progress bar will stop running and the color coordinates and luminance are shown. Press ‘Close’ to return to the main application window. The measurement is done in CIE1931xyY color space.

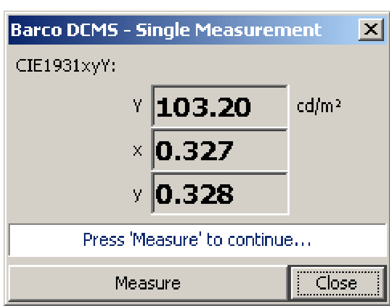

Figure 7: Single measurement

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6.1.4 Calibration target panel

The Calibration Target Panel contains 8 sections. Each of these sections are listed and described below. Depending on the type of display that is selected, some of these sections may be disabled. A disabled section means that this functionality is not supported by the display.

Test patch

The user can select the preferred way of measuring. To acquire calibration parameters (the 'Get' function that is described below) or to calibrate a display, the DCMS software needs to measure colored test patches. These test patches can be generated as a colored field in the application itself or use the internal built-in-test pattern generator that is available in each display.

Select 'External computer graphics' to generate the test patches as a colored field in the application itself. Choose this option if your host is the video source for the display that you wish to calibrate. Note that the calibration dialog window will always be on top of all applications to prevent obfuscation of the test patches by other applications or dialog windows during the calibration.

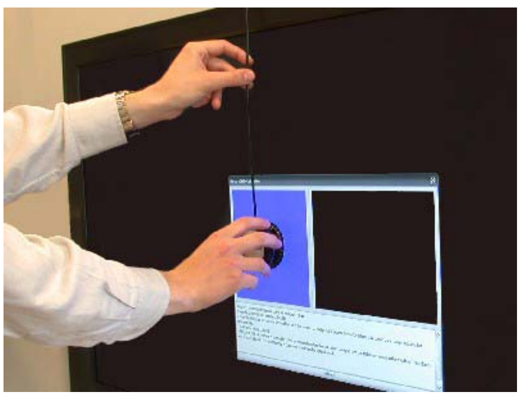

Figure 8: External test patch

Select 'Internal display pattern generator' to let DCMS instruct the display to generate the test patches. Choose this option if your host is not the video source for the display that you whish to calibrate. The size of the test patch depends on the display's implementation of this function.

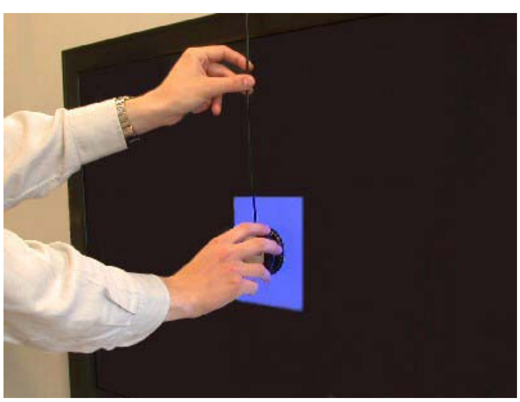

Figure 9: Internal test patch

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Note that the input source will not be visible for the duration of the calibration when the display pattern generator is selected.

White point

The White point of a display is the color of full white. A color display's white is the combination of all three primary colors red, green and blue. The proportion red, green and blue defines the color of white.

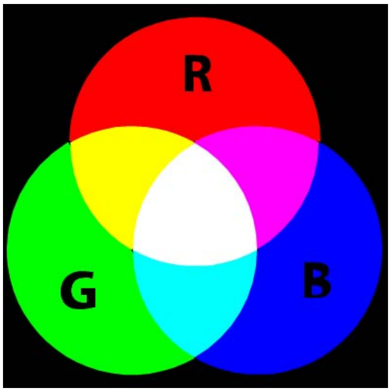

Figure 10: Additive colors

The White point can be expressed in Color Temperature (the temperature in degrees Kelvin at which a heated black-body radiator matches the color of the light source's color). A bluish white has a high color temperature (commonly referred to as cold white) while a reddish white has a low color temperature (commonly referred to as warm white).

Example of 5000K **Example of 7500K**

Figure 11: Color temperature examples

Figure 12: Color temperature scale*

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Select the ‘Color temperature’ radio button to define the white point in color temperature and use the slider to set the desired color temperature between 3200 and 9900K. Note that daylight is typically 6500K. The selected color temperature can be read in the text field on right of the slider.

For expert use, you can also give the desired white point in CIE1931xyY coordinates. Figure below shows the CIE1931xyY color space. In this chart, all color temperatures between 2000 and 10000K are also shown.

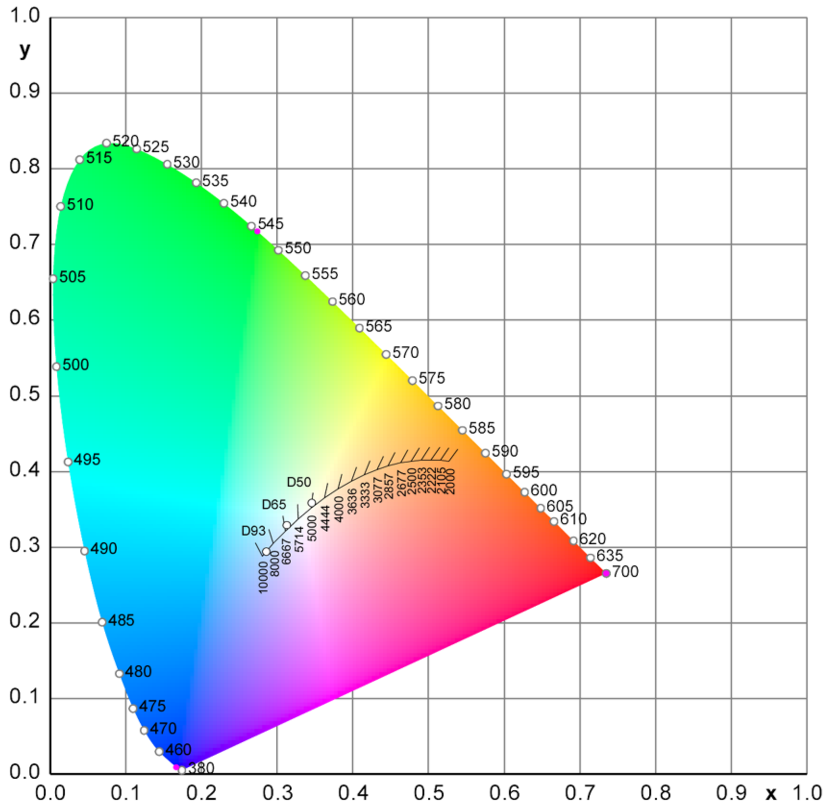

Figure 13: CIE1931xyY color space

Select the ‘CIE1931xyY’ radio button if you wish to set the desired white point in CIE1931xyY color coordinates in the two text fields below, labeled ‘x’ and ‘y’. For your convenience, the color temperature slider may still be used to set an initial x and y value to start from. In the text field on the right, labeled ‘Tc(K)’ you can read the correlated color temperature. Below this text field, a second text field labeled ‘u’v’’ shows how far the entered x and y coordinates deviate from the Planckian locus (this is the path that a black-body follows as it is heated). This deviation is expressed in distance in the CIE1976UCS color space (which is a color space that is proportional to human perception of color differences). Both these text fields will color red if no correlated color temperature can be calculated for the entered x and y coordinates.

Mid gray

For some applications (like color matching of displays) the mid* gray point can also be defined. This setting is intended for expert use. The desired color coordinates and luminance (in CIE1931xyY) of mid gray can be changed here.

**Mid gray in 3x8 bit RGB color space is defined here as (128, 128, 128)*

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The three input text fields ‘x’, ‘y’ and ‘Y’ are disabled as long as the check box ‘Follow white point and gamma’ is selected. This means that changing white point, gamma or brightness settings will influence the mid gray point. The color coordinates will match those of the white point and the luminance is calculated from the gamma and the brightness.

Uncheck the ‘Follow white point and gamma’ will allow you to set the desired mid grey point if this should differ from the white point.

Figure 14: Match of white and mid gray color

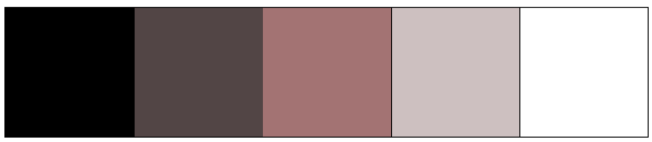

Figure 15: Mismatch of white and gray color

Gamma

Human vision has a non-linear perception of changes in luminance (light intensity). This non-linearity can be characterized by a power-law expression. This power-law is used in display technologies to map the number of possible gradations in luminance to a more perceptually uniform space. The Greek letter gamma is the power in this power-law expression. Typical gamma values for displays range from 1.8 to 2.8. The pictures below illustrate changes in gamma.

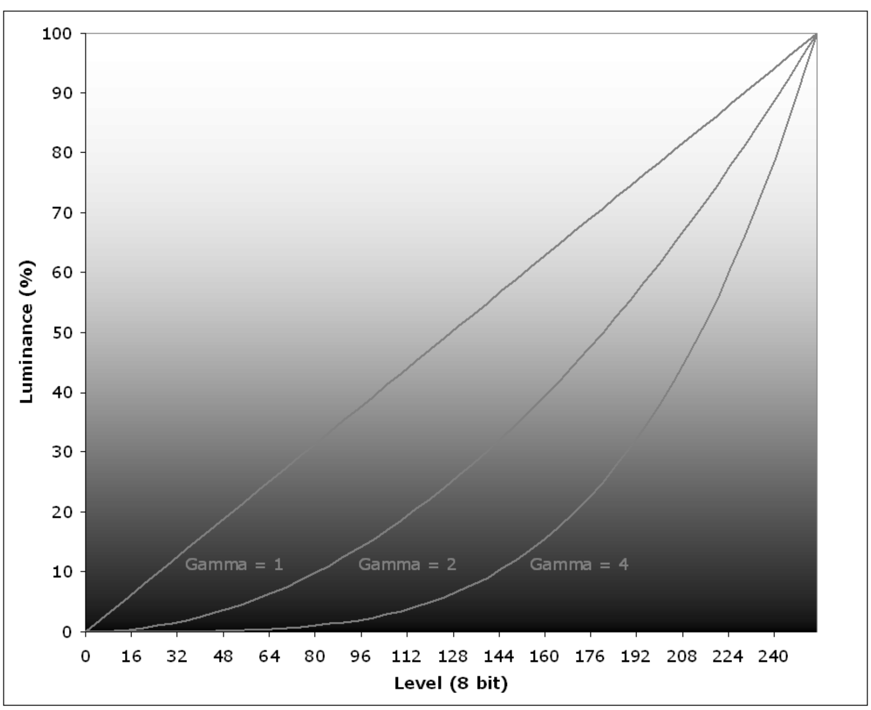

Figure 16: The gamma power-law

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Figure 17: Gamma 4

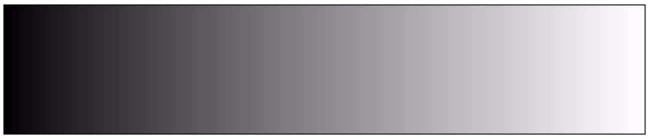

Figure 18: Gamma 2

Figure 19: Gamma 1

The gamma slider can be used to set the desired gamma of the display. This value can also be seen in the text field on the right of the gamma slider. The luminance of the gray point changes by definition when the gamma changes.

Note that the gamma slider is disabled when the mid grey point is defined by the user (when the ‘Follow white point and gamma’ is unchecked). The user defined luminance of the mid grey point now defines by definition also the gamma. The text field of the gamma value will color red if the resulting gamma is out of the slider’s range. So, the mid grey luminance is in function of the desired gamma or the gamma is in function of the desired mid grey luminance.

Brightness

The brightness of a display is the maximum luminance of full white. The slider allows the user to set the desired brightness. Values between 25 and 250 cd/m2 in steps of 5 can be chosen for almost all displays exept for NSL-4601 displays, where the brightness can be set from 100 to maximum 650 cd/m² in steps of 10. The text field on the right shows the desired brightness. If the desired brightness cannot be reached because of the limitations of the display, the calibration routine will continue with the closest match but will report a failed calibration at the end of the routine.

Status field

The Status field has 4 possible states:

	No display has been connected
Unknown Calibration History	Display
CALIBRATION SUCCESSFUL	Display was calibrated successfully
CALIBRATION FAILED	Display calibration failed, target settings were out of range or calibration was interrupted

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Get, Load, Save and Reset

Besides using the controls above, the user has the option to ‘Load’ a previously defined set of parameters from file or ‘Save’ the current set to file.

Use the ‘Get’ function to acquire these settings by measurement. This is useful for display matching purposes. How to match displays is explained in the section “*Using DCMS, Match displays*” further in this document.

Use the ‘Reset’ function to perform a reset of all calibration parameters (gamma, brightness,...) to their factory default values. Since not all prameters are supported by every display, unsupported parameters will be skipped.

Calibrate

Once the parameters are set to the desired values, press the ‘Calibrate now...’ button to start the calibration routine. See the section on “*Using DCMS, Calibrate a display*” for a complete explanation of the functionality behind this button.

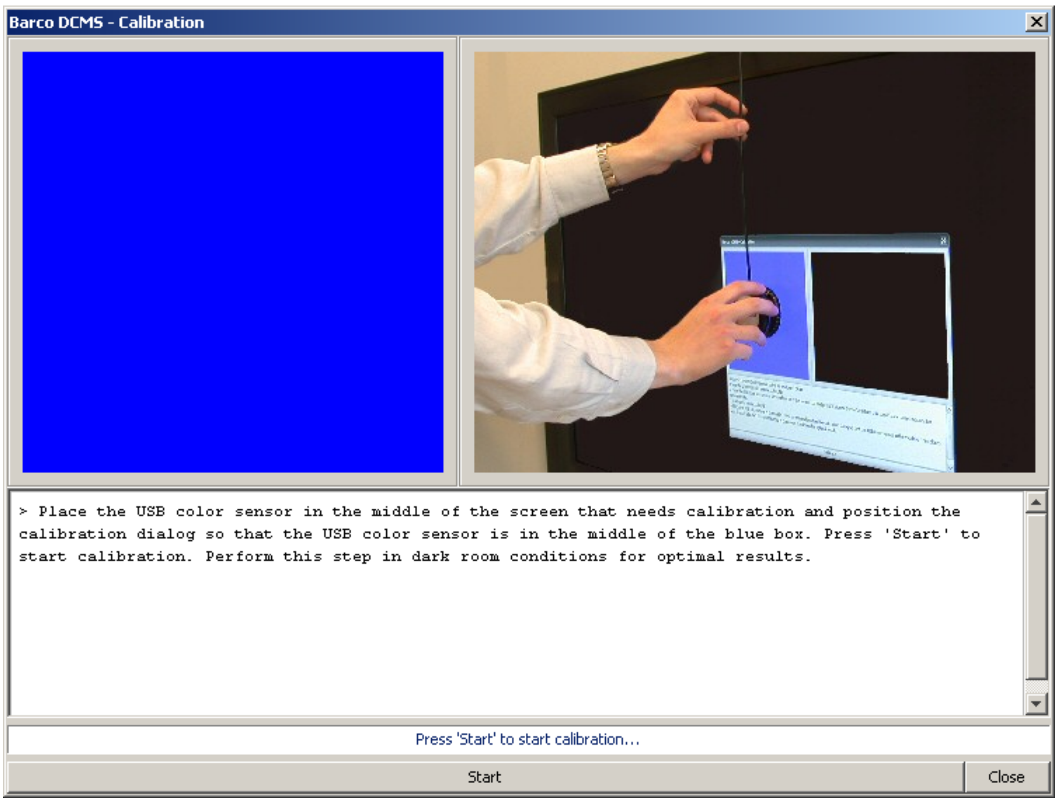

Figure 20: Barco DCMS – Calibration window

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6.2 Using DCMS

6.2.1 Proper use and general remarks

- Store the sensor at the same ambient temperature as the display, facing down in the sensor pod.
- When placing the sensor on the test patch, lead the cable over the top of the display. Use the contra weight on the USB cable of the sensor to balance the weight of the sensor. This prevents damage to the sensor if the suction cup would release its grip.
- If the suction cup does not hold, slightly moisten the suction cup.
- Allow displays a warm up time of a few hours to stabilize before calibrating them.

6.2.2 Calibrate a display

In this section we will calibrate a display to a set of target values. Calibrating several displays is just a matter of repeating these steps for each of the displays that need calibration.

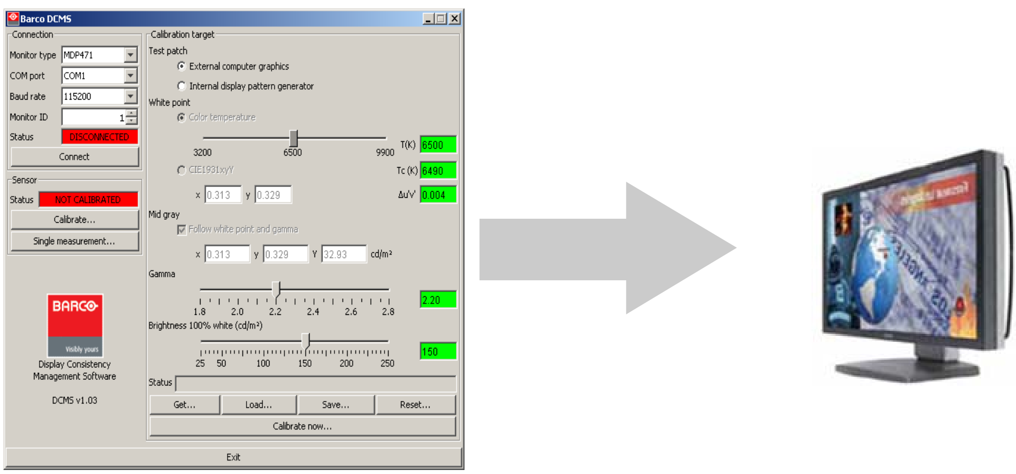

Figure 21: Display calibration

Step 1: Connection and startup

- Physically connect the display via serial connection to the host. Refer to the documentation of the display for pin-out of the serial port.
- Connect the USB sensor to the host.
- Start the DCMS application.

Step 2: Calibration and serial communication

- Select the display type, serial port number, baud rate and monitor ID (Default monitor ID is 1). Press ‘Connect’ and verify in the connection status field that the connection to the display says ‘CONNECTED’.
- Start the sensor calibration routine by pressing ‘Calibrate...’. Follow the instructions of the calibration dialog as mentioned in the *“User Interface,*

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Calibration target panel" paragraph above. Verify that the sensor status field states 'CALIBRATED'.

Step 3: Calibration target

- Select the type of test patches to be used. Select 'External computer graphics' if the host is the input source of the display and you want the want the test patterns to be created in the calibration dialog. Select 'Internal display pattern generator' when the display has an input source different from the host. See the *"User Interface, Sensor panel"* paragraph for more details on the selection of the test patch.
- Set the desired white point, mid gray, gamma and brightness by manually changing the settings or load a previous set from file. See the *"Sensor panel"* paragraph for details on calibration target settings and the paragraph *"Display connection and calibration"* for specifics of the display.

Step 4: The calibration routine

- Press 'Calibrate now...' to open the calibration dialog.
- Follow the instructions as given in the calibration dialog and press 'Start' to start the calibration routine.
- During the calibration routine, the user may interrupt at any time by pressing the 'Close' button to return to the main application.

NOTE:

Note that the display will not return to a previously known state but will leave the display in the state that it was at the time of pressing the 'Close' button.

- The user is informed of each step of the calibration in the text area of the calibration dialog.
- During calibration the progress bar is colored blue.
- When the calibration is finished, the progress bar will display if the calibration was successful or not and color green when successful, red if failed. The same message will appear in the calibration status field of the main application window. As soon as this message appears, you may close this dialog box.
- If the dialog box is not closed after calibration, a verification process will start. This process measures all gray levels in steps of 16 from 0 to 255 and displays the measured results together with the desired values. See section 6 for details on the verification table.
- After the verification routine, the test patch will show a green color if the calibration was successful or red if it failed. Text in the text area of the calibration window can be copied and pasted into your favorite text editor and saved to file.
- Press 'Close' to return to the main application. Pressing 'Start' will redo the calibration routine all over again. If 'Internal display pattern generator' was selected, the display will switch back to the previously selected input when the calibration dialog is closed.

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6.2.3 Match displays

In this section we will calibrate a display (target display) to match another display (reference display). The displays do not need to be of the same type.

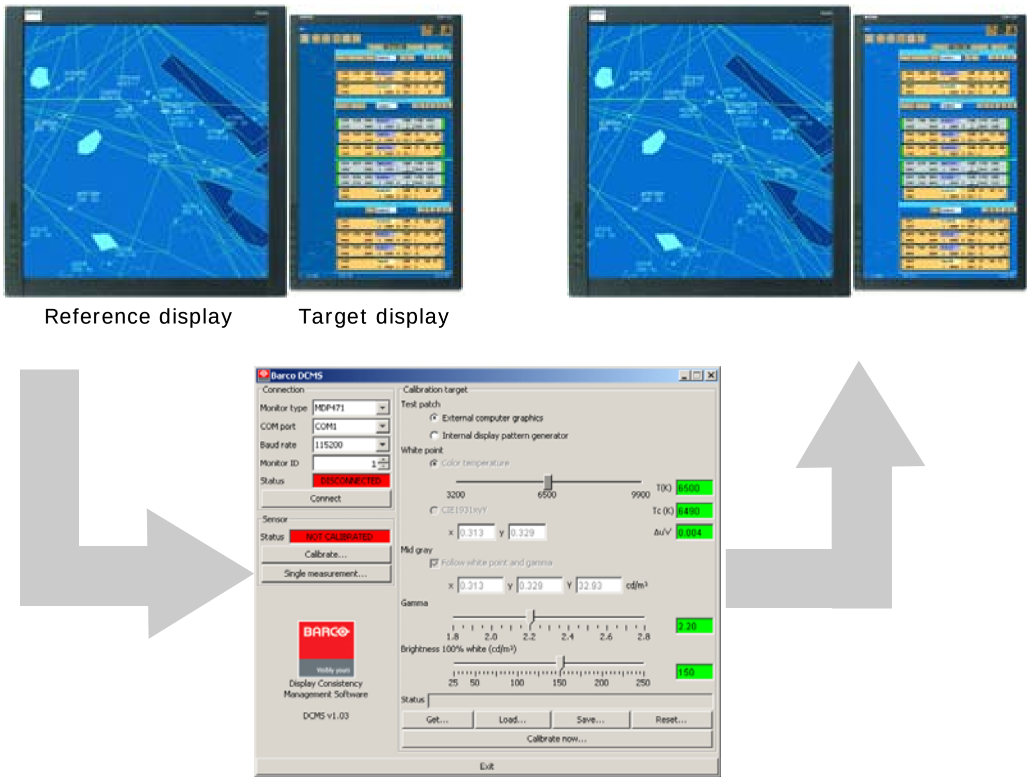

Figure 22: Matching of displays

Step 1: Connection and startup

- Physically connect the reference display via serial connection to the host. Refer to the documentation of the display for pin-out of the serial port.
- Connect the USB sensor to the host.
- Start the DCMS application.

Step 2: Calibration and the reference display

- Select the display type, serial port number, baud rate and monitor ID (Default monitor ID is 1). Press ‘Connect’ and verify in the connection status field that the connection to the display says ‘CONNECTED’.
- Start the sensor calibration routine by pressing ‘Calibrate...’. Follow the instructions of the calibration dialog as mentioned in the ‘Sensor Panel’ section described above. Verify that the sensor status field says ‘CALIBRATED’.

Step 3: Set parameters

- Select the type of test patches to be used. Select ‘External computer graphics’ if the host is the input source of the display and you want the want the test patterns to be created in the calibration dialog. Select ‘Internal display pattern generator’ if the display has an input source different from the host.

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See the *"User Interface, Sensor panel"* paragraph above for more details on the selection of the test patch.

- There is no need to set other parameters as it is the objective of this process to acquire these from the reference display.

Step 4: The acquisition

- Press 'Get...' to open the acquisition dialog.
- Follow the instructions as given in the calibration dialog and press 'Start' to start the acquisition routine.
- During the acquisition routine, the user may interrupt at any time by pressing the 'Close' button to return to the main application.
- The user is informed of each step of the acquisition in the text area of the acquisition dialog.
- During acquisition the progress bar is colored blue.
- When the acquisition in finished, the progress bar will display if the acquisition was successful or not and color green when successful, red if failed. As soon as this message appears, you may close this dialog box.
- After the routine, the test patch will show a green color if the routine was successful or red if it failed. Text in the text area of the calibration window can be copied and pasted into your favorite text editor and saved to file. White point, mid gray, gamma* and brightness are automatically copied to the main application window.
- Press 'Close' to return to the main application. Pressing 'Start' will redo the routine all over again. If 'Internal display pattern generator' was selected, the display will switch back to the previously selected input when the acquisition dialog is closed.

** Gamma and mid gray luminance may differ slightly if recalculated as gamma is calculated as a best fit from 8 gray levels between 0 and 255.*

Step 5: The target display

- Press 'Disconnect' to stop communication with the reference display.
- Physically connect the target display via serial connection to the host. Refer to the documentation of the display for the serial port pinning.
- Select the display type, serial port number, baud rate and monitor ID (Default monitor ID is 1) of the target display. Press 'Connect' and verify in the connection status field that the connection to the display says 'CONNECTED'.

Step 6: Set parameters

- Select the type of test patches to be used. Select 'External computer graphics' if the host is the input source of the display and you want the want the test patterns to be created in the calibration dialog. Select 'Internal display pattern generator' when the display has an input source different from the host. See the "*User Interface, Calibration Target Panel"* paragraph above for more details on the selection of the test patch.
- All calibration target values are automatically set during the acquisition routine on the reference monitor. If needed, changes can be still be made here.

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Step 7: The calibration routine

- Press ‘Calibrate now...’ to open the calibration dialog.
- Follow the instructions as given in the calibration dialog and press ‘Start’ to start the calibration routine.
- During the calibration routine, the user may interrupt at any time by pressing the ‘Close’ button to return to the main application.

NOTE:

Note that the display will not return to a previously known state but will leave the display in the state that it was at the time of pressing the ‘Close’ button.

- The user is informed of each step of the calibration in the text area of the calibration dialog.
- During calibration the progress bar is colored blue.
- When the calibration in finished, the progress bar will display if the calibration was successful or not and color green when successful, red if failed. The same message will appear in the calibration status field of the main application window. As soon as this message appears, you may close this dialog box.
- If the dialog box is not closed after calibration, a verification process will start. This process measures all gray levels in steps of 16 from 0 to 255 and displays the measured results together with the desired values. See section 6 for details on the verification table.
- After the verification routine, the test patch will show a green color if the calibration was successful or red if it failed. Text in the text area of the calibration window can be copied and pasted into your favorite text editor and saved to file.
- Press ‘Close’ to return to the main application. Pressing ‘Start’ will redo the calibration routine all over again. If ‘Internal display pattern generator’ was selected, the display will switch back to the previously selected input when the calibration dialog is closed.

6.2.4 Single measurement

The single measurement function allows the user to use DCMS as a simple luminance and chromaticity meter. Note that a serial connection to a display is not required for this function.

Step 1: Connection and startup

- Connect the USB sensor to the host.
- Start the DCMS application.

Step 2: Calibration

- Start the sensor calibration routine by pressing ‘Calibrate...’. Follow the instructions of the calibration dialog as mentioned in the ‘Sensor Panel’ section above. Verify that the sensor status field says ‘CALIBRATED’.

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Step 3: Measurement

- Press the ‘Single measurement’ button to open the measurement dialog.
- Place the sensor on a color patch on the display to be measured and press ‘Measure’. The luminance and xy color coordinates will appear in the text field as soon as the measurement is done. Press ‘Close’ to return to the main window or press ‘Measure’ for another measurement.

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7 Display connection and calibration options

7.1 ADP361

Connection

The Barco ADP361 can be connected to the host by means of a 3-wire straight (Rx-Rx, Tx-Tx, GND-GND) male-female cable. This cable is provided in the DCMS package.

Calibration options

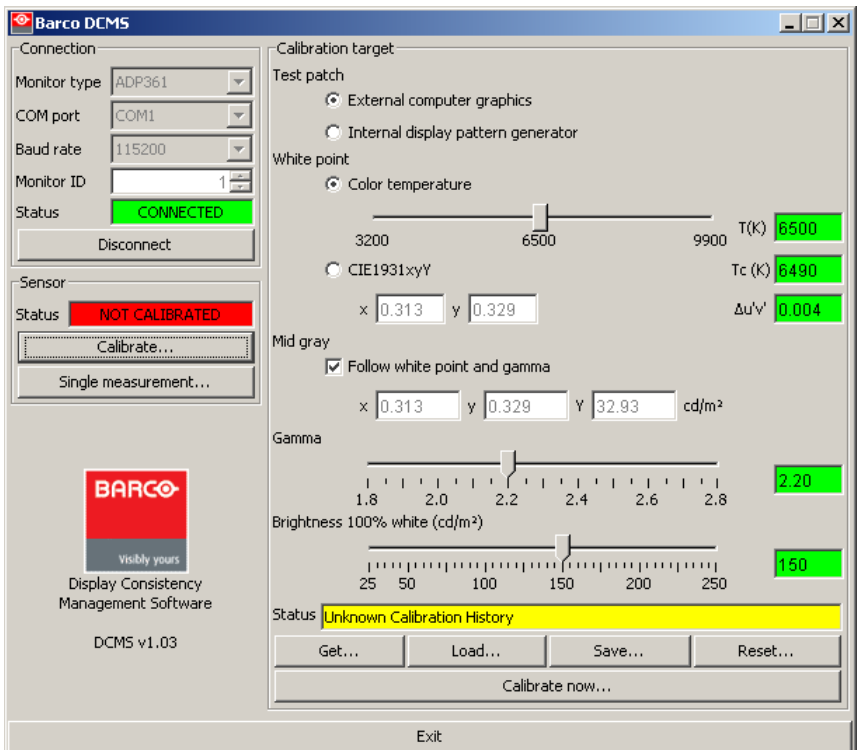

Figure 23: DCMS with ADP361

The ADP display supports all the functionality of DCMS. However, for calibration of the gray levels, only the mid gray (RGB 128, 128, 128) is calibrated. The color of the mid gray point can be set to a value different from the white point as this display is typically used in combination with the Barco MDP471 which has a mid gray point that is slightly different from its white point.

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7.2 LCx-4x

Connection

The Barco LCx-4x series displays (LCN/LCS-42/47) can be connected to the host by means of a 3-wire straight (Rx-Rx, Tx-Tx, GND-GND) male-female cable. This cable is provided in the DCMS package.

Calibration options

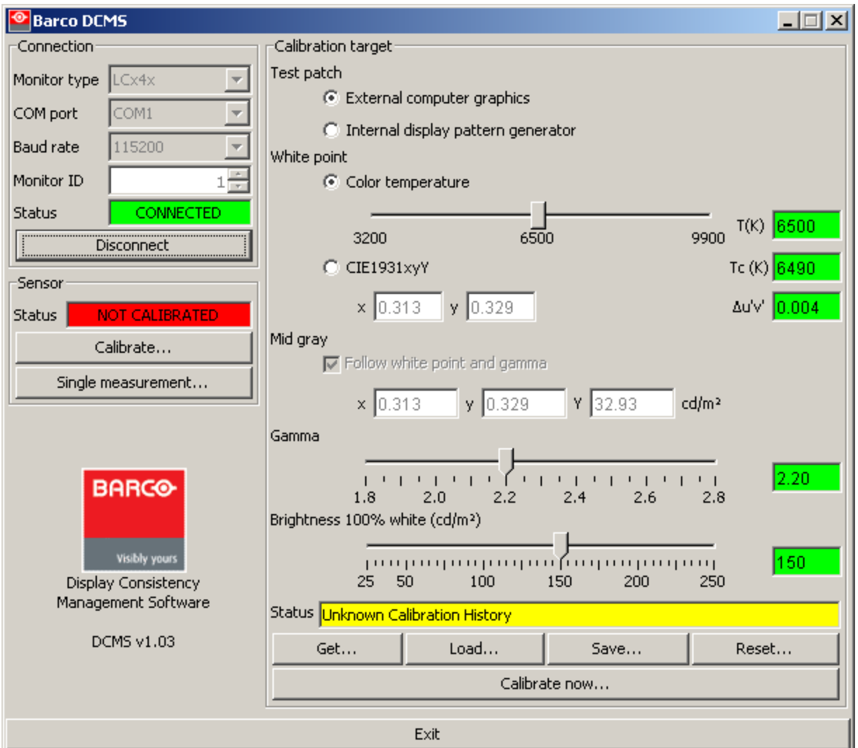

Figure 24: DCMS with LCx-4x

The LCx-4x display supports all the functionality of DCMS. Note that the option to set the mid gray color is disabled. Mid gray calibration is not needed as a full gray tracking is done. Gray tracking is done with the help of high precision look-up tables embedded in the display and programmed by DCMS.

Note that a valid input source is required on this type of display for the internal test pattern generator to work as the generator uses the applied input timing for the generation of the test patches.

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7.3 MDP471 (ISIS)

Connection

The Barco MDP471 (code name ISIS) display can be connected to the host by means of a 3-wire crossed male-female cable (Rx-Tx, Tx-Rx, GND-GND). This cable is provided in the DCMS package.

Calibration options

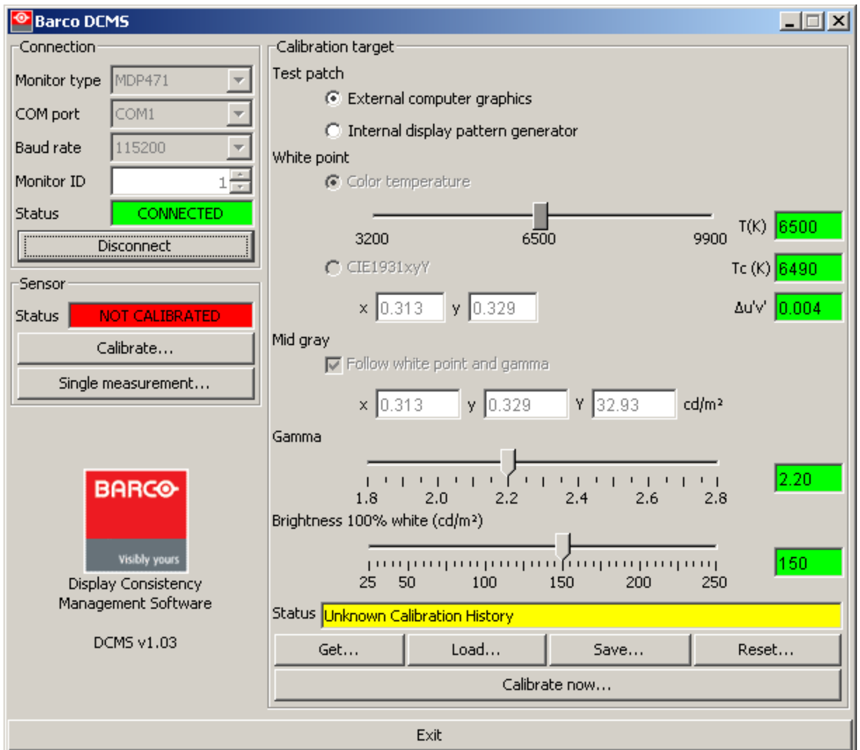

Figure 25: DCMS with MDP471

The ISIS display currently only supports the calibration of luminance. All other controls are disabled. In typical use, this display is often the reference display for the matching functionality of DCMS in combination with the Barco ADP361.

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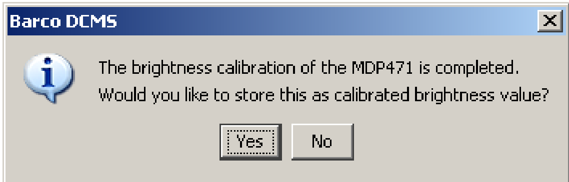
After calibration following dialog box pops up:



Here you can choose whether the calibration value should be stored or not. Pressing the Cal pushbutton on the MDP471 control unit will take the stored brightness value and set the brightness of your display to that value.

NOTE:

This can only be done when no OSD menu is active or when OSD level 1 is active. More info about the OSD and its levels can be found in the user manual of the unit.

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7.4 MDPW476

Connection

The Barco MDPW476 display can be connected to the host by means of a 3-wire crossed male-female cable (Rx-Tx, Tx-Rx, GND-GND). This cable is provided in the DCMS package.

Calibration options

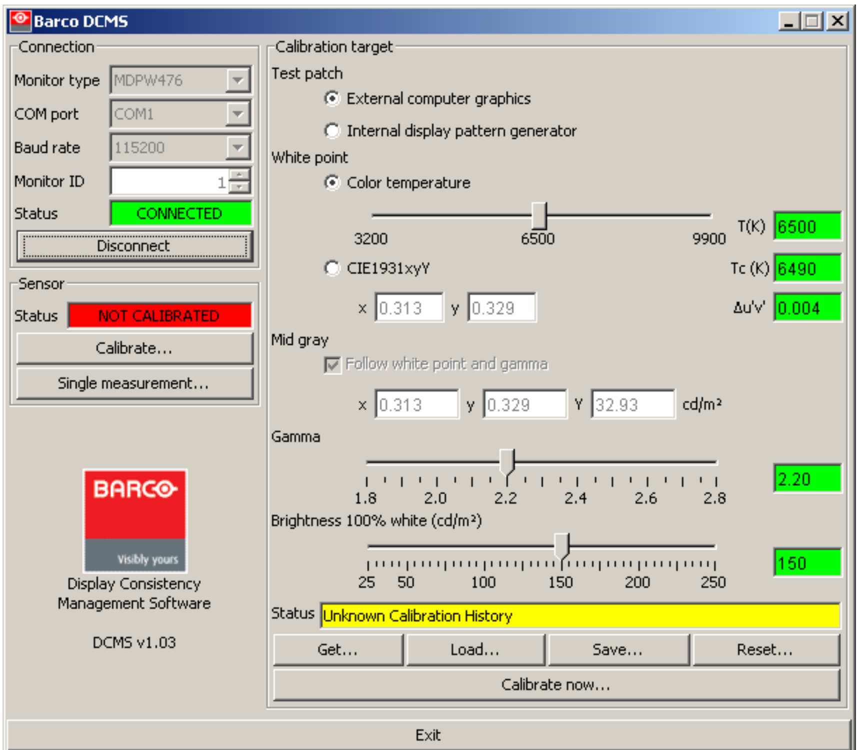

Figure 26: DCMS with MDPW476

The MDPW476 display supports all the functionality of DCMS. Mid gray calibration is not needed as a full gray tracking is done. Gray tracking is done with the help of high precision look-up tables (LUTs) embedded in the display and programmed by DCMS. The MDPW is able to store up to 4 color calibration settings that are also selectable via OSD menu (on-screen-display menu). Before the calibration dialog is displayed, an MDPW specifics dialog is displayed first. The progress bar below is colored blue while DCMS is retrieving this information from the display and will color green as soon as this information is available.

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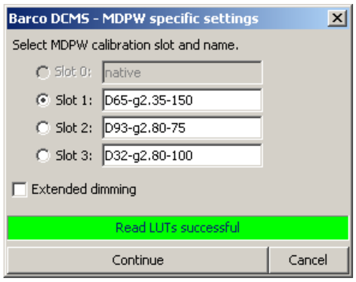

Figure 27: MDPW LUT selection

The user can now select which of the 3 look-up-table slots the user wishes to overwrite with the new calibration (slot 0 is reserved for a native 1-to-1 LUT). Select one of the 3 available slots. Each slot can also be given a name for easy identification of the calibration settings that is stored in the slots. Do not use special characters for the naming of these slots.

A second MDPW specific function is the 'Extended dimming'. In case of low ambient light, the user may wish to dim the maximum luminance beyond the maximum dimming point of the display's backlight system. This function uses the high-precision look-up-tables to dim the display beyond this point.

Press 'Cancel' to return to the main window application or 'Continue' to advance to the calibration dialog.

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7.5 NSL-4601

Connection

The Barco NSL-4601 displays can be connected to the host by means of a 3-wire straight (Rx-Rx, Tx-Tx, GND-GND) male-female cable. This cable is provided in the DCMS package.

For a single display calibration:

- Connect the RS cable (delivered with DCMS) and the signal cable (RGB/DVI) to the NSL-4601 display. Disconnect all other cables (e.g. DVI out).
- Make sure the display is set as master display.

For the calibration of a display in a wall structure:

- Connect the RS cable (delivered with DCMS) to the master display
- Make sure that you can display the BCM dialog on the to be calibrated display in the wall.
  See BCM manual for more detailed information about the BCM software package.

Calibration options

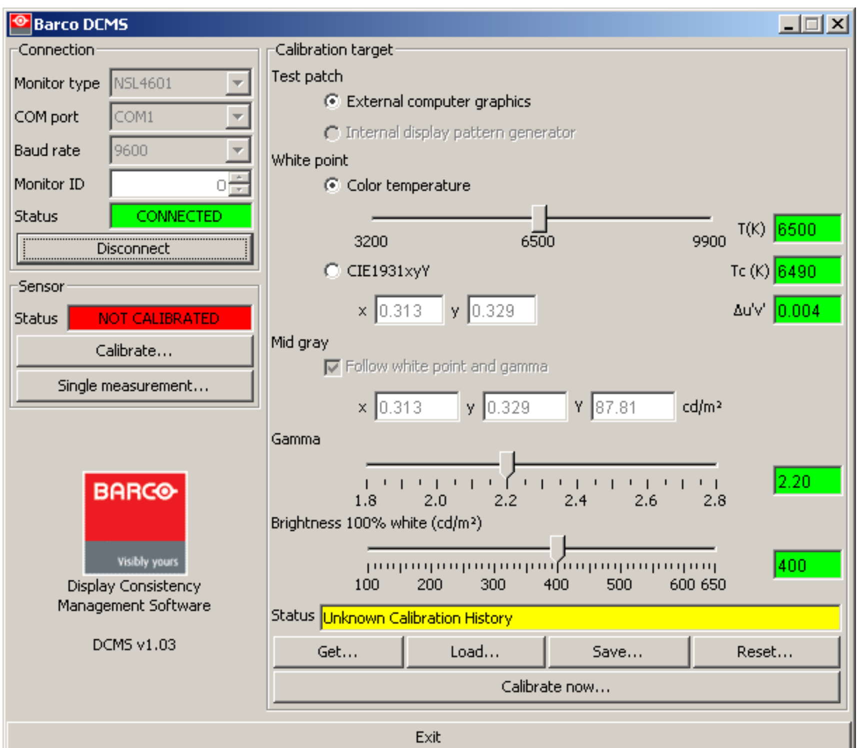

Figure 28: DCMS with NSL-4601

The NSL-4601 displays support all the functionality of DCMS. Note that the option to set the mid gray color is disabled. Mid gray calibration is not needed as a full gray tracking is done. Gray tracking is done with the help of high precision look-up tables embedded in the display and programmed by DCMS.

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The monitor ID is the address of a monitor. The monitor address is a double (x, y) where x represents the horizontal position (column) and y the vertical position (row) of the monitor in the wall. The top left monitor (seen from front) has the address (0,0):Numbering starts with zero and goes from left to right and from top to bottom. The address is set in binary code via two 4-dip switches at rthe rear sid of the monitor, one for x and one for y. The following table shows how the dip-switch settings are mapped to monitor ID's:

Vertical Dip Switches	Horizontal Dip Switches															
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
0	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
2	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
3	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63
4	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79
5	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
6	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111
7	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127
8	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143
9	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159
10	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175
11	176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191
12	192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207
13	208	209	210	211	212	213	214	215	216	217	218	219	220	221	222	223
14	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239
15	240	241	242	243	244	245	246	247	248	249	250	251	252	253	254	255

Figure 29: Monitor ID mapping table

Note that a valid input source is required on this type of display for the internal test pattern generator to work as the generator, as it uses the applied input timing for the generation of the test patches.

Once the calibration is completed, a dialog box appears to ask if you want to continue. When pressing continue, the calibration data will be written to the flash. When finished, the display will be automatically restart.

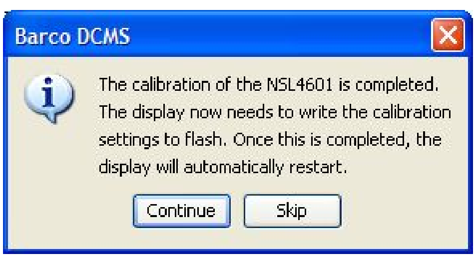

Figure 30: Calibration NSL-4601 completed

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Color versus brightness

NOTE:

Note that reducing the color temperature reduces the overall achievable brightness.
The table below provides an indication of the relative brightness compared to the brightness at native color temperature, which is 10000K.

Color temperature	Brightness (relative)
3200K	between 50% and 55%
5000K	between 70% and 75%
5500K	between 75% and 80%
6500K	approx. 85%
7500K	between 90% and 95%
9300K	approx. 95%
10000K	100% as this is the native color temperature

Table 1: Color temperature versus brightness

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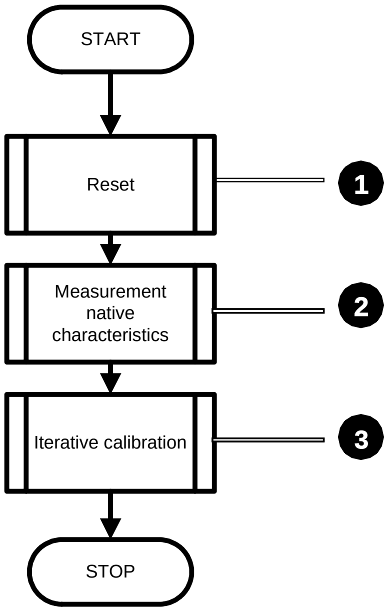
8 Calibration

Calibration is done in 3 major steps:



1 Calibration reset
2 Measurement of native characteristics
3 Interative calibration

Figure 31: Calibration steps flowchart

Each of these steps is explained in detail in the following subparagraphs.

Calibration reset

The first step in the calibration process is resetting all parameters that are to be calibrated or may influence the calibration. Not all parameters are supported by every display. Unsupported parameters are skipped.

Resetting these parameters to their default, neutral or disabled value allows us to measure the native characteristics of the display in the next step.

Native characteristics

In the second step of the calibration process, the native characteristics are measured and calculated. First, the black is measured. This will later be used in the algorithms to compensate for black. In this context, black is not the total absence of light but is the darkest possible luminance that can be achieved. Since this black has a luminance that is not equal to zero, it also has a color and therefore needs to be reckoned with when calibrating the display.

Next, we loop over the three primary colors red, green and blue. For each of these colors, we measure luminance, color and native gamma.

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Finally, we measure the luminance and color of the maximum native white. This is our starting point from where we calibrate to the required white point.

Calibration

The third step in the calibration process is the actual calibration. Everything is done by gray tracking calibration as full white can be seen as just a special kind of gray. This gray tracking is done for a reduced set of gray levels to reduce calibration time without compromising the end result.

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9 Verification

The verification table below lists an example output of a verification table. After the calibration process, the user can start a verification of the results by pressing the ‘Start verification’ button in the calibration dialog. The layout of this table is always the same but the content may depend on the type of display that is calibrated. The example below is taken after calibration of a Barco MDPW476.

```
Verifying results ...
Target white point: (Y: 150.00, x: 0.313, y: 0.329)
      DAC  Y       Yth       dY(%) dEuv*,L x      y      du'v'   dEuv*,C  dEuv*  Tc
      255  151.28  150.00    0.85    0.33  0.312  0.329  0.000    0.40    0.52   6522
      240  128.80  130.11   -1.02    0.37  0.312  0.330  0.001    1.06    1.12   6553
      224  110.63  110.66   -0.03    0.01  0.313  0.330  0.001    0.65    0.65   6499
      208   93.79   93.01    0.84    0.28  0.312  0.329  0.000    0.35    0.45   6515
      192   77.06   77.09   -0.05    0.01  0.312  0.329  0.000    0.48    0.48   6526
      176   62.49   62.87   -0.61    0.18  0.313  0.331  0.001    0.95    0.97   6468
      160   50.32   50.29    0.05    0.01  0.313  0.331  0.001    0.93    0.93   6483
      144   39.67   39.30    0.91    0.23  0.313  0.330  0.000    0.21    0.31   6486
      128   30.65   29.85    2.62    0.60  0.312  0.329  0.001    0.54    0.81   6562
      112   22.06   21.86    0.91    0.19  0.313  0.328  0.001    0.35    0.40   6497
       96   15.97   15.28    4.33    0.81  0.318  0.332  0.003    1.63    1.82   6223
       80   10.22   10.02    1.93    0.31  0.313  0.328  0.001    0.39    0.49   6521
       64    6.02    6.01    0.17    0.02  0.311  0.329  0.001    0.30    0.30   6586
       48    3.15    3.15   -0.13    0.01  0.305  0.320  0.006    1.34    1.34   7026
       32    1.35    1.33    1.57    0.13  0.300  0.309  0.013    1.37    1.38   7511
       16    0.54    0.42   22.34    0.75  0.299  0.294  0.023    0.95    1.19   7950
        0    0.19    0.19    0.17    0.00  0.313  0.280  0.036    0.53    0.53   7082
Gamma:
      Target: 2.35
      Measured (least square log-log): 2.34
      Correlation coefficient        : 0.99905
VERIFICATION COMPLETED
```

Table 2: Verification table

Verification is done by measuring the color and luminance of a set of gray levels, including white. The measured results are compared to the calculated theoretical values and printed on screen.

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The report shows:

Target white point:	Shows the target luminance and color coordinates for full white.
Target mid gray point:	Shows the target luminance and color coordinates for mid gray.
DAC:	Gray levels from 255 to 0 in steps of 16.
Y:	Measured luminance in cd/m2.
Yth:	Theoretical target luminance in cd/m2.
dY(%):	Luminance error in percentage from theoretical target.
dEuv*,L:	Luminance error in ΔEu*v* from theoretical target.
X:	Color coordinate x in CIE1931xyY color space.
Y:	Color coordinate x in CIE1931xyY color space.
du'v':	Color deviation from target in CIE1976UCS color space.
dEuv*,C:	Chromaticity error (color error) in ΔEu*v*.
dEuv*:	Total error of luminance and chromaticity in ΔEu*v*
Tc:	Correlated color temperature in degrees Kelvin.
Gamma target:	Target gamma.
Gamma measured:	Gamma calculated as best fit over the measured gray levels. (Calculation is done with least square error linear regression on logarithmic levels and luminance)
Gamma correlation coefficient:	This coefficient gives an indication of the reliability of the calculated gamma. The result is more reliable as it approaches 1.

Table 3: Verification table explanation

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10 The log file

Each time the DCMS application is started, a new log file is created. This file is named ‘dcmsxxx.log’ where xxx is the timestamp of creation. The log file contains all text that is displayed in the instructions panel of the ‘calibration dialog’ and ‘get calibration dialog’. It also lists the measurement results of the verification routine and single measurements. The file is stored in the installation folder of DCMS.

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11 List of abbreviations

A

ADP	Auxiliary Display Panel
ALC	Ambient Light Controller
B	
BCM	Barco wall Control Manager
BIT	Built In Test
Bkl	Backlight
BLOS	Backlight OpticaL Stabilisation
Bri	Brightness
C	
Cal	Calibrate
CCFL	Cold Cathode Fluorescent Lamp
cd	candela
COMM	Communication
Conn.	Connector
CRT	Cathode Ray Tube
D	
DCMS	Display Consistency Management Software
Diff	Differential
DVI	Digital Video Interface
L	
LCD	Liquid Crystal Display
LUT	Look-Up Table
M	
MDPW	Main Display Panel Wide screen
MISC	Miscellaneous (keypad)
ms	Millisecond
N	
N/A	Not Applicable
Nr	Number
NSL	Near Seamless LCD
O	
Opt	Optical
OSD	On Screen Display
P	
PWR	Power
R	
RGB	Red Green Blue
RX	Receiver
S	

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SMPTE	Society of Motion Picture and Television Engineers
STD	Standard
SVGA	Super Video Graphic Array
SW	Software
SXGA	Super extended Graphics Array
S/N	Serial Number
T	
Temp	Temperature
TX	Transmitter
U	
UMAN	User Manual
USB	Universal Serial Bus
UXGA	Ultra eXtended Graphic Array
V	
V	Volt
VGA	Video Graphic Array
VHDL	Is the VHSIC Hardware Description Language
W	
WUXGA	Widescreen Ultra eXtended Graphics Array
X	
XGA	EXtended Graphic Array
Y	
Y	Luminance

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12 Appendix A: Open Source Software

DCMS copyright

DCMS is copyrighted by Barco nv with exception of the RXTXComm library. RXTXComm is open source software, licensed under the 'RXTX extension to LGPL'. The full RXTXComm and LGPL license can be found on the DCMS CD-ROM.

RXTX extension to LGPL

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13 Appendix B: Specifcations

13.1 Specifications of the USB sensor

- Connection type: USB
- Power supply: through USB.
- Accuracy: $\bar{y}(\lambda) = V(\lambda)$
- Maximum deviation from reference sensor (Minolta CA 210) on reference color and grayscale LCD displays:
  - ✓ Δ Y $\leq$ 5% from 0.2 to 1000 cd/m^2 (typical)
  - ✓ Δ x $\leq$ 0.005 from 1 to 1000 cd/m^2 (typical)
  - ✓ Δ y $\leq$ 0.005 from 1 to 1000 cd/m^2 (typical)
  - ✓ Δ x $\leq$ 0.01 from 0.2 to 1 cd/m^2 (typical)
  - ✓ Δ y $\leq$ 0.01 from 0.2 to 1 cd/m^2 (typical)
- Repeatability over 5 measurements:

Y:

- ✓ 0.01 cd/m2 in the range of 0.2 to 1 cd/m^2 (typical)
- ✓ 0.05 cd/m2 in the range of 1 cd/m^2 to 10 cd/m^2 (typical)
- ✓ 0.1 cd/m2 in the range of 10 cd/m^2 to 100 cd/m^2 (typical)
- ✓ 1 cd/m2 in the range of 100 cd/m^2 to 1000 cd/m^2 (typical)

x, y :

- ✓ 0.005 in the range of 0.2 cd/m^2 to 0.5 cd/m^2 (typical)
- ✓ 0.003 in the range of 0.50 cd/m^2 to 1000 cd/m^2 (typical)

13.2 DCMS specifications

For a typical target of 6500 K, gamma 2.35 and luminance 150 cd/m^2, the user may expect an accuracy of

- ✓ ΔEu*v* $\leq$ 2 for MDPW476
- ✓ ΔEu*v* $\leq$ 3 for ADP361 and LCx-4x
- ✓ gamma 2.35 ± 0.025

for gray levels down to 20% drive level.

These values are not binding as results may vary depending specified targets, display and display type.

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