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Technical Documentation

MTCS-C2

with
JENCOLOR color sensors

µC Version 2.22 PC SW Version 4.02

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1. Introduction

Industrial color detection, measurement and monitoring are becoming easier. Notably, where it is claimed that colors are to be detected, measured or compared "like human eyes" in a highly dynamic working environment and with little technical effort, MAZeT's Colorimeter from the JENCOLOR product line provides the optimal solution.

Sensors of this type use the RGB Tri-Stimulus method, imitating the human eye's natural color perception (MCS series), or, alternatively, a method according to DIN 5033, Part 2 – Color Measurement; Standard Colorimetric Systems – CIE 1931 Tri-Stimulus Value Function (MTCS series)[1]. JENCOLOR ICs are available in different styles and package versions and can be fitted with a broad range of accessory items (e.g., demonstrator of system testing, testing and function boards, software libraries).

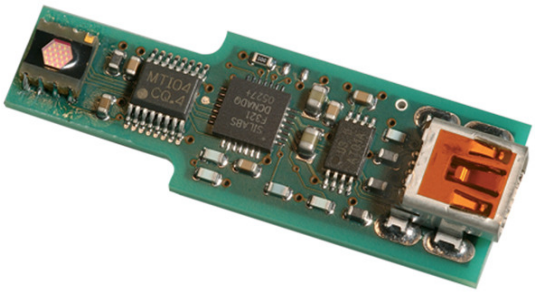


Figure 1: MTCS-C2 Board Colorimeter 2

In addition to its IC solutions, MAZeT offers a MTCS-C2 hardware solution based on the MTCS series, which is also referred to as "colorimeter 2." Alongside the color sensor IC, the board integrates all signal processing resources, including interfacing and measuring control and can be adapted within a Design In project.

The MTCS-C2 (Colorimeter 2) kit includes PC software "colorimeter2.exe" under Windows XP™ to handle functions like sensor calibration and anything in connection with measured value representation and output, e.g., in the CIE Lab color space. Furthermore, an API Application Programming Interface (MTCSApi.DLL) with test software can also be supplied (optional).

If required, dedicated drivers and software libraries (tools for calculating the color range and calibration) can be produced and supplied for necessary adjustments to the software.

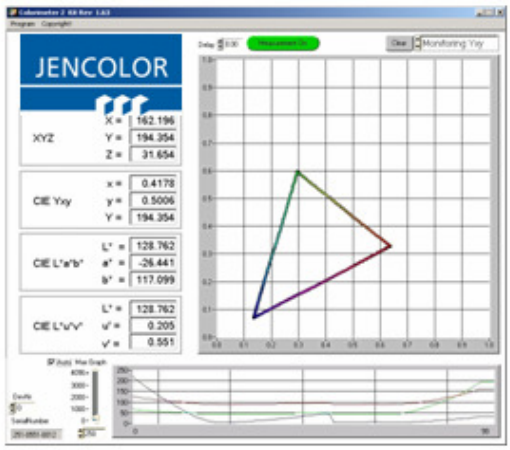


Figure 2: Operator interface mtcs-Software

Please do not hesitate to contact us for the latest information on available components and scopes of delivery.

2. Starting Up

[1] For data and application sheets, you should contact one of our sales offices.

2.1 Scope of Delivery

MTCS-C2 (Colorimeter 2) delivery includes[2]:

- MTCS-C2 (μC Version 2.22) (Colorimeter 2)
- Documentation
- Optional USB cable
- Optional "colorimeter2.exe" PC software (with USB driver of SYS and MTCSApi.dll type)[4]
- Optional macro functions library
- Optional 10° optics consisting of shutter

2.2 System Requirements

For start-up procedures, the following system resources are required:

- PC Pentium 150 MHz or higher
- 8 MB RAM
- 5 MB free hard drive memory
- One free USB (2.0) port
- MS Windows™ XP / 2000

2.3 Components Hook-up

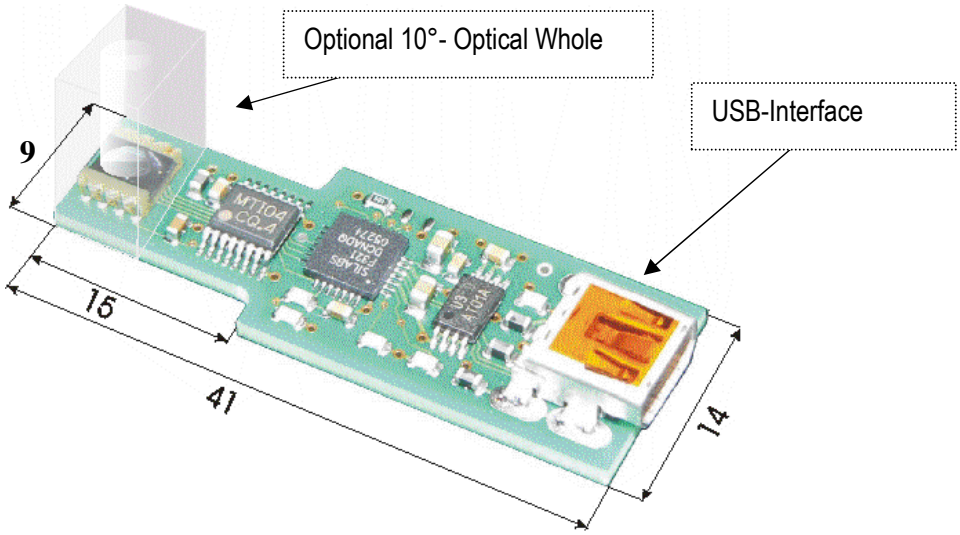


Figure 3: MTCS-C2 Board Colorimeter 2

[2] Please note, all components must be ordered as single items. Indicate specifically when ordering.

[4] See document db05171 Software Description MTCS-ME1, Library Description (MTCSApi.dll)

2.4 Software/Driver Installation

The "colorimeter2.exe" PC software (with USB driver of SYS and MTCSApi.dll type) is installed on your PC by using the setup.exe program.

After a successful installation, the setup procedure should have copied the files “usbcolor2.inf“ and “usbio.sys“ files to the directories “windows\inf“ and the “windows\system32\drivers“. Use the USB cable (supplied) to connect the MTCS-C2 to one of your PC's free USB (2.0) ports. The device manager will output a message “found new hardware“ on the screen.

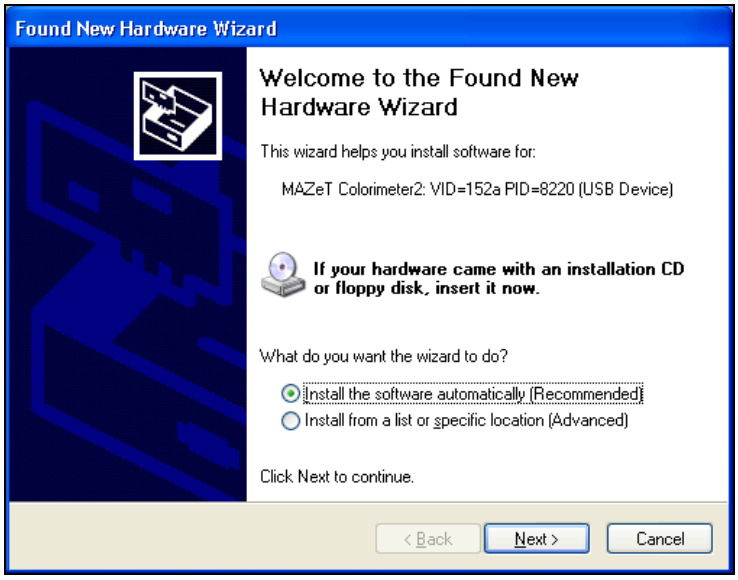


Figure 4: Assistant for USB driver installation, page 1

In accordance with Figure 4, select the "Install the software automatically" checkbox and then press "Next."

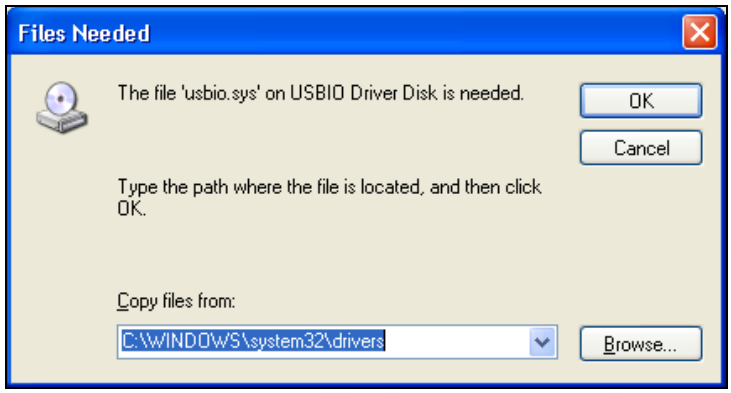


Figure 5 Assistant for USB driver installation

In case the software does not install automatically (i.e., Windows cannot find the required files), you should check the directory to which the setup procedure had copied the *.inf and *.sys files. Use this directory for the further driver installation. (The default directory is either \windows\inf or \windows\system32\drivers.)

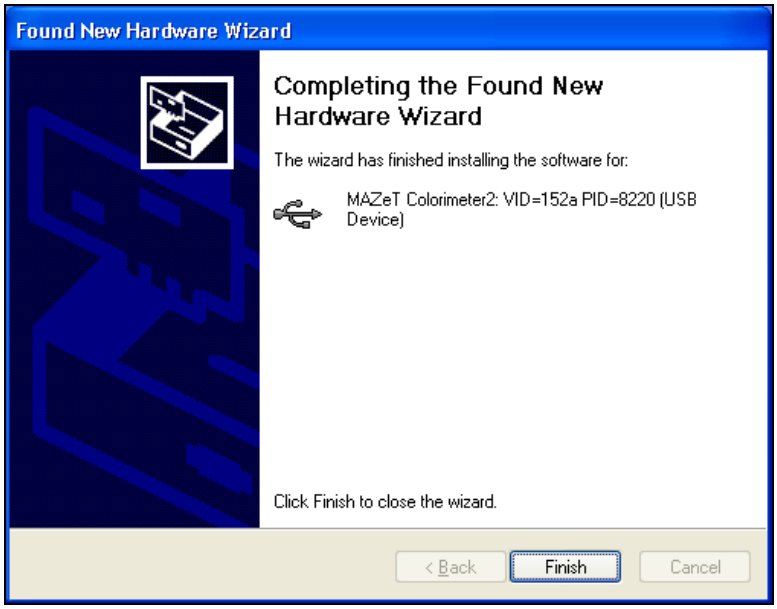


Figure 6: Assistant for USB driver installation, final page

After pressing "Finish," the USB driver installation is complete.

After a successful driver and software installation, please connect the colorimeter board via USB to the PC and start the MTCS software.

3. Hardware

3.1 MTCS-C2 Board

The following components are integrated on this board[5]:

- MTCSiCS True – Color – Sensor
- MTI04CQ transimpedance amplifier
- C8051F321 microcontroller with 10 bit AD converter and USB interface
- EEPROM – Free memory space for compensation and correction data

The board is supplied with voltage via the USB interface.

The microcontroller has the following functions:

- Controlling and analyzing of the color sensor signals
- Activating the EEPROM for external memory space

[5] The data sheets for the individual devices can be obtained from the MAZeT sales office.

- Communication via USB

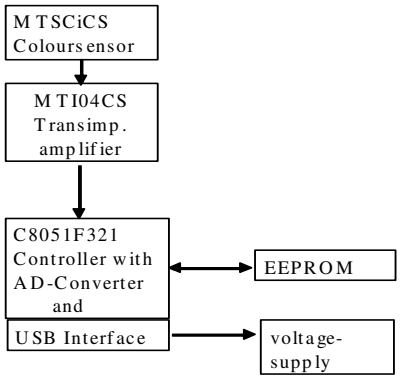


Figure 7: MTCS-C2 principle block diagram

The μC C8051F321 firmware is designed to support communication via the USB interface, to handle all customized measuring algorithms, simple ADC access operations and averaging of multiple ADC access operation, and to manage customized settings and data for calibrating the sensors.

4. Software

4.1 Software Start

Based on an *.ini file, some functions and parameters are to be defined in the C2 software. Please do not change the details in the *.ini file without support by MAZeT or your distribution partner[6]. The *.ini file includes the following sections and parameters:

*.ini file: conf.ini (standard)

```
[section1]
// if more than one device is plugged in
// wenn mehr als 1 device angeschlossen
DeviceAnzahl=1
// automatische Suche
// AutoSearch
AutoSearch=0
// decimal dot for Excel
// Dezimalpunkt fuer Excel
Trennzeichen = ","
// = 1 mit Protokollierung
// = 1 with protocol
Protokoll=1
```

[6] Furthermore, do not change the values in the *.ini file under [COLORIMETER2] and [modEVA].

```
// after program start, Excel will be opened
// beim Start wird Excel geoeffnet
Excel=0
Column=1
//Wait =1 wait for confirmation and single measurement
//Wait =1 auf Bestaetigen warten und Einzelmessung
Wait=0
// upper Limit fuer AutoGraph
AutoGraph=2000

[COLORIMETER2]
productid = 8220
vendorid = 152a
AnzeigeText=MTCS-C2 Colorimeter 2

[modEVA]
productid = c35d
vendorid = 400
AnzeigeText=MTCS_ME1 Mod Eva
```

DeviceAnzahl bigger than 1:	some devices with the same IDs can be connected.
Trennzeichen: “.” or “,”	are possible. It is the description of the decimal point when saving.
Protokoll=1	The protocol function is activated.
Excel=1	At startup, Excel® will be running. All measurements will be written to the Excel-form. If Excel = 0, the protocol function will write the measurement results to a *.csv form when Protokoll is set to 1.

A user software session can be started by selecting “mtcs.exe“ (START/PROGRAM/modEVA_Rev___/modeva___). The window for USB System-Setup will open (Figure 8 or Figure 9). It contains standard entries for “Vendor_ID“ and “Product_ID“ representing specific Colorimeter conventions. These should not be changed. Please check whether the “BoardType” window includes the right hardware type connected to the PC (colorimeter2) and, if necessary, correct it.

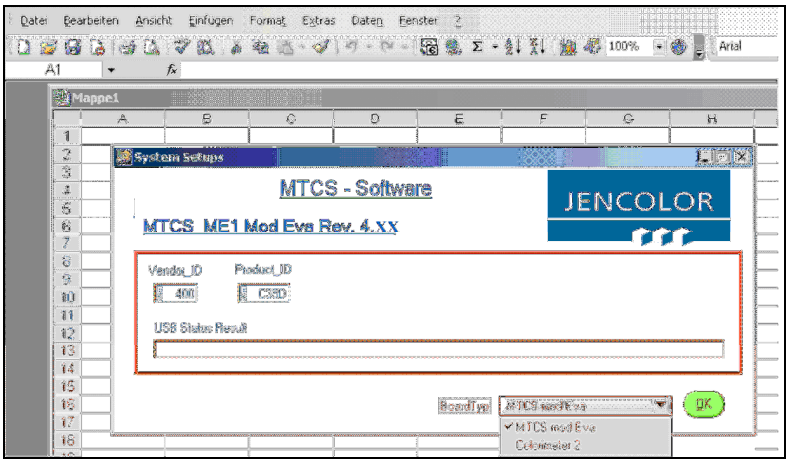


Figure 8: System Setups – Startup window with excel=1

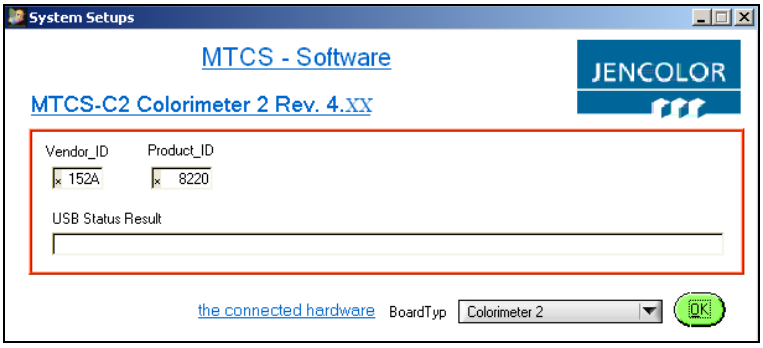


Figure 9: System Setups – Startup window

To check interface communication, click the OK button or press the F8 function key.

When the Colorimeter2 is correctly installed as a USB device, the firmware revision number 0.1x is read and displayed (Figure 10).

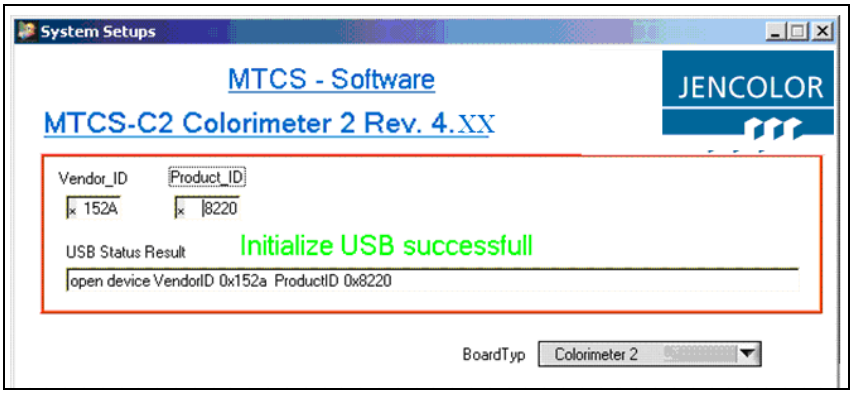


Figure 10: System setups – USB communication successfully established

After Figure 10, the window is automatically closed and the main window for carrying out measurements (see Section **4.2**) or the window for configuring the measuring environment on the erased memory space (see Section 4.3) is opened.

If "....resetUSB" appears in the "USB Status Result" line, it is recommended to terminate the program, to disconnect and then re-establish the USB connection on the hardware side (Reset hardware) and to restart the PC software.

4.2 Color Detection and Measurement

Figure 11 shows the main window for color measurement visualization.

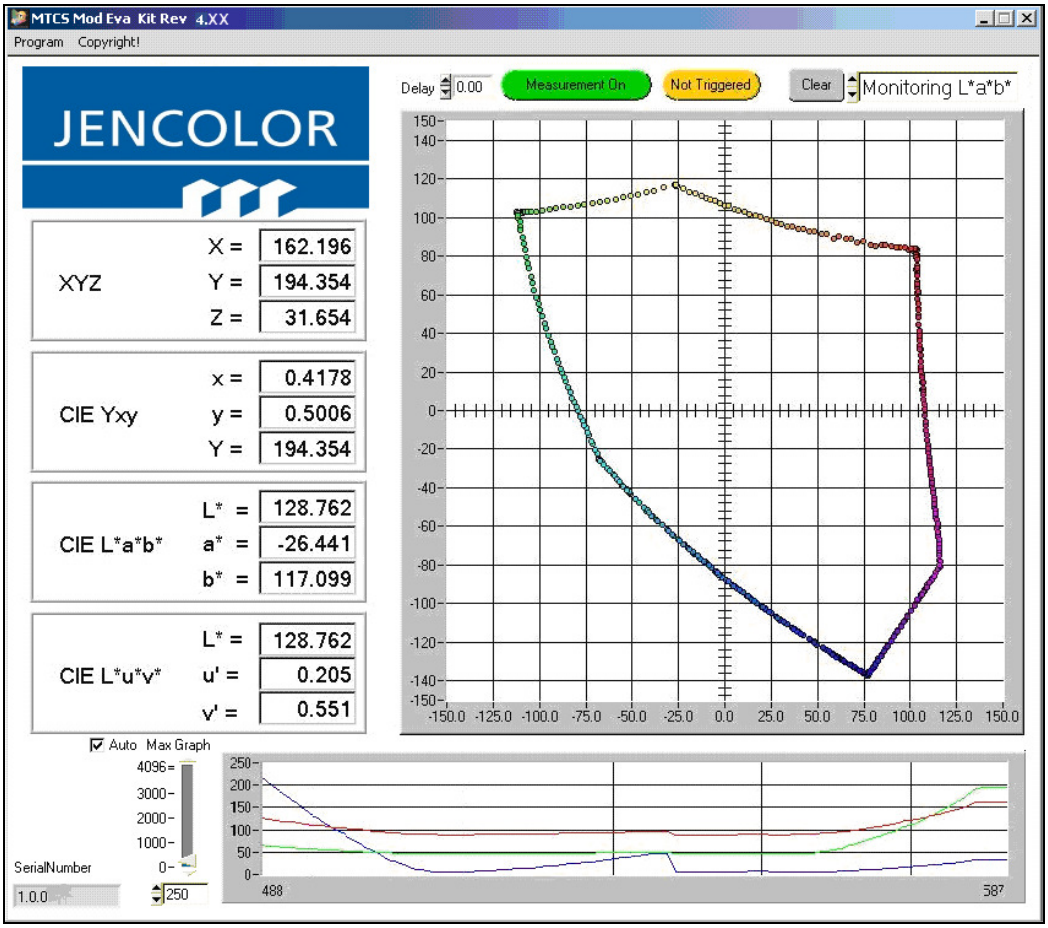


Figure 11: Main window for color measurement

The measured results are represented graphically as XYZ standard Tri-Stimulus values, in a standard chromaticity chart of CIE 1976 L*a*b*and as L*u*v color space.

Please ensure that the color values can only be interpreted more or less in the sense of the color measurement when the board is calibrated to a measurement standard.[7]

A measurement can be triggered and cancelled by clicking the green “Measurement On / Off“ or “ENTER” button (if the focus is on the "Measurement On / Off“ button). By varying the “delay” time (next to "Measurement On / Off" – input in seconds), the waiting time between two measurements can be changed as desired. The "delay“ time also changes the measurement time provided that the other values set in the program (e.g., averaging) and the computing power of the data processor allow this.

[7] We would be happy to provide you with application guidelines on this subject. Please contact one of our sales offices.

For graphical display, you may choose between Yxy, L*a*b* or L*u*v* from the list in the top right. A given graphic can be deleted with the “Clear Graph“ button or the “DELETE” key.

At the bottom of the window there is an additional area in which the progression of recent values is displayed (Figure 12: Graph of the values
). On the left, the display scale can be adjusted by setting a maximum value for the y-axis. If no progression gauge is displayed for continuous measurement, it may be necessary for the area to be adapted. Selecting "Auto" automatically adjusts the area.
On the left side, you can read the serial number of the current device.
DevNr is used for the selection of the device. It is only visible, if

- The DeviceAnzahl in the conf.ini file is greater than 1
- More than 1 device with the same VendorID and ProductID have been connected

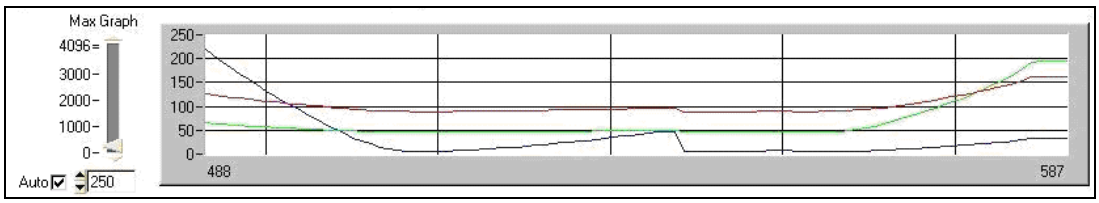


Figure 12: Graph of the variation over time of measured values

4.3 Data Logging

Data logging is divided into two categories. It is possible to store the measurement data in a *.csv file or to write the data directly to Excel®. For data logging in Excel®, it is necessary to install MS Office® 2003. By default, logging to a *.csv file is activated by the conf.ini. The data is stored in the program directory during the measurement process. The settings for data logging can be configured in the conf.ini file. Figure 13 below gives an overview of the logging settings.

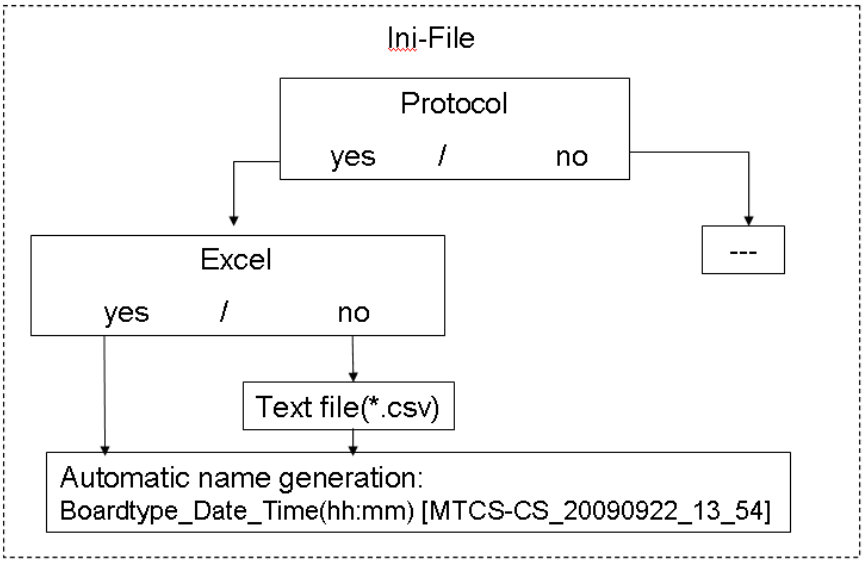


Figure 13: Overview of data logging

4.4 Menu

A variety of actions ("Program," **Figure 15**) can be selected by using the menu next to the program information ("Copyright," Figure 14). This is described below.

Figure 14: Copyright

Figure 15: Menu

4.4.1 Color Patch

Selecting “Color Patch“ from the menu enables the measured colors to be visualized as a corresponding colored window on the user interface. In addition, RGB values are indicated (Figure 16).

A comprehensible matrix for the calculation of the RGB monitor values from the ADC raw data is a prerequisite for enabling the correct colors to be displayed (see Section 4.6).

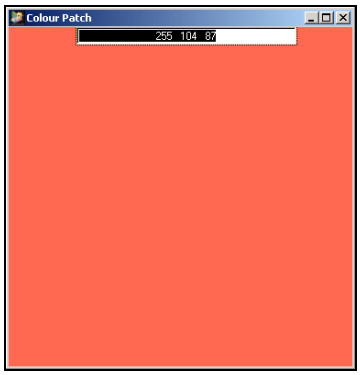


Figure 16: Color Patch display

Attention!
Clear differences may occur in the color reproduction of the measured targets due to different display types or different settings in the color management of the PC and graphics card.

4.4.2 Config File

Selecting “Config File“ from the “Program“ menu enables application-specific system configuration and calibration data to be loaded and stored (see Section 4.6: Configuration of the application (measuring mode)).

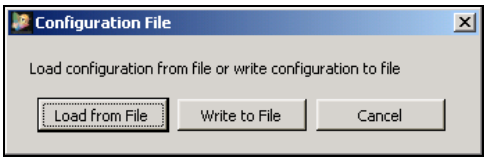
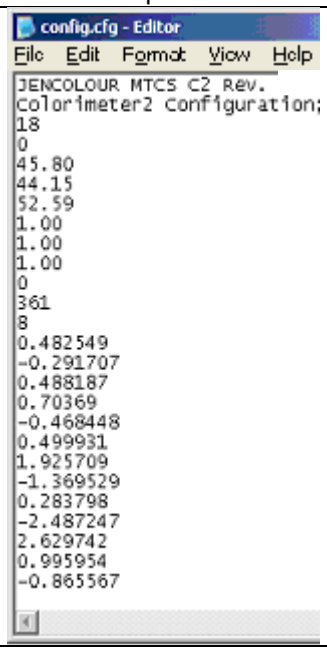


Figure 17: Accessing the system configuration file

The data is stored in a *.cfg file, organized in the following way:

Line	Contents	Example
1-2	SW Revision / Date / Time	
3	Type of configuration	
4	0	
5-7	Offset measurement value	
8-10	X, Y, Z for type of illumination	
11	0	
12	Max. number of integration intervals	
13	Intensification	
14-22	Matrix raw data => XYZ	
23-31	Matrix raw data => RGB monitor	

4.4.3 System Configuration

The sensor system is set to corresponding types of measurement with specific parameters by using System Configuration. There is a detailed description in Section 4.5.

4.4.4 Exit

Selecting “Exit“ from the “Program“ menu terminates the PC software.

4.5 Changing the System Configuration

It is only necessary to change the system configurations during initial operation or when changing the measurement type.

The window for changing the system configuration is opened by going to the ”Program/ System Configuration“ menu or by pressing the F8 key. When the program is run, this user interface is automatically loaded if no configuration data is stored (initial operation).

Figure 18: Reference to empty EEPROM

The following tasks are carried out via the ”Application Setups“ dialog:

- Application requirement (measurement type)
- Adjustment of measurement conditions (integration time, mean values, etc.)
- Definition of colorimetric ambient conditions (offset, type of standard light, gamma correction)
- Determination of the gain matrix for color range transformation due to target-specific comparison
- Memory allocation on the board

If no configuration is saved (“no saved configuration“), the notification in Figure 18 appears directly after the USB initialization and then the user interface appears, as shown in Figure 19.

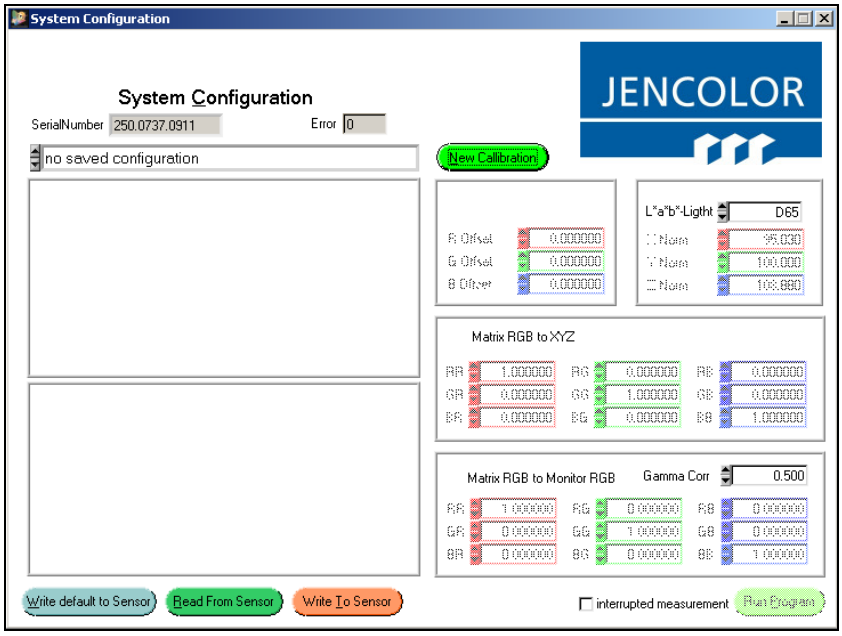


Figure 19: Example of configuration

The choice of application complies with the measurement type used and is selected from the list at the top left.

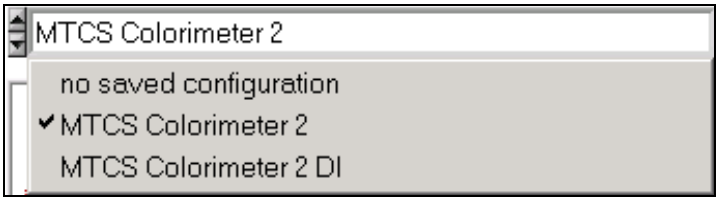


Figure 20: Application configuration (measurement type)

Depending on the application selected, the fields permitted for change are activated.

The configuration data is managed using the ”Write default to Sensor,“ ”Read From Sensor,“ and ”Write To Sensor“ buttons in the memory on the mainboard.

After the configuration is changed, the “Run Program“ button remains inactive until the data is saved, using ”Write To Sensor,“ or is reset, using ”Read From Sensor.“

Once the system is successfully configured, you can return to measuring mode by pressing the “Run Program“ button or F8 key (Main window for color measurement, Figure 11).

4.5.1 MTCS-C2 Configuration MTCS-C2

In the MTCS-C2 configuration, “Average Counts“ determines the number of measurement values by averaging. For example, the MTCS-C2 board can be set to measure light sources, e.g., LEDs or TFT monitors.

An adjustment of the 10 bit ADC value can be entered in the “Shift“ field and transmitted via the firmware.

The “Amplification“ control dial adjusts the intensification on the MTI. There are 7 intensification levels.

If the intensification=0, the intensification is automatically determined. In order to do this, the tolerance value is required.

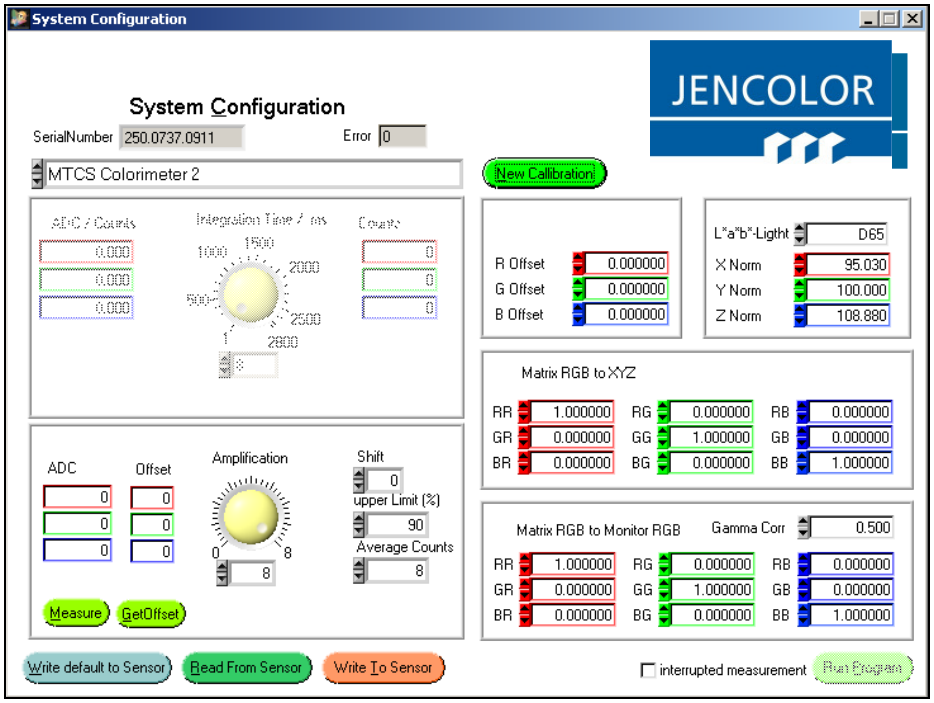


Figure 21: Example of configuration for MTCS-C2

In order for the system to be configured, the sensor must be directed at a white surface. With TFT monitors, this can be carried out directly on the screen with an appropriate light background.
Pressing the “Measure” button triggers a measurement and the corresponding measurement values (ADC values with fixed adjustment “Shift”) of the three measuring channels are displayed.

After the measuring conditions are adjusted, the system can be calibrated by generating a target-oriented gain matrix. This is explained in more detail in Section 4.6.

4.5.2 MTCS-C2 DI Configuration

DI stands for Digital Integration, which means that the ADC values (with fixed adjustment “Shift“) are added up over a fixed period of time.

The configuration is carried out by means of the active fields, as shown in Figure 22.
The integration time is entered into the “Integration Time / ms” field. It can vary between 0 ms and 2,800 ms.

A measurement is carried out in the given integration time. The measurement value (“ADC/Counts") represents the integral deviation of the signal lever divided by the number of integration intervals (“Counts”).

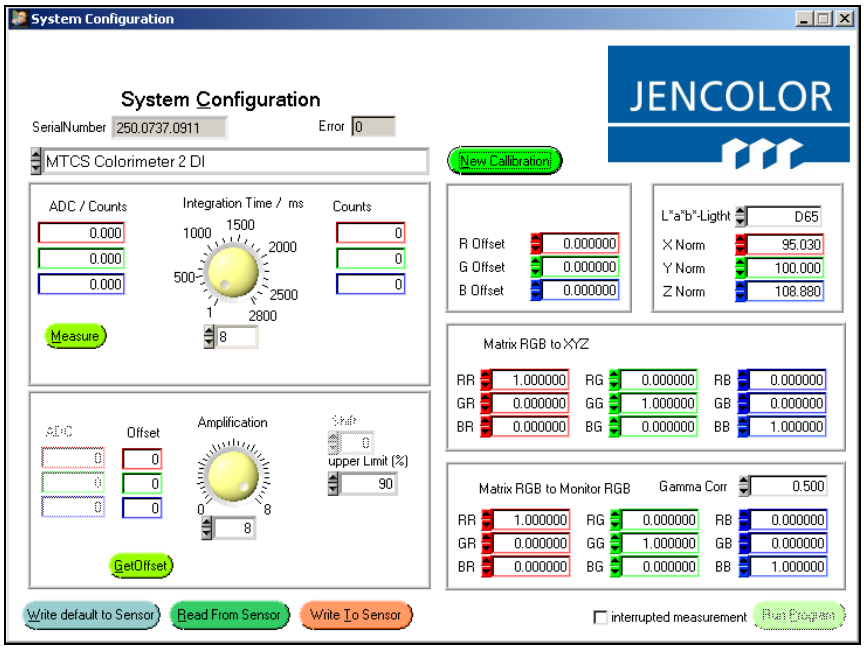


Figure 22: Example configuration for MTCS-C2 DI

The integration time is adjusted using the top control dial. The intensification is adjusted using the bottom control dial.

The intensification on the MTI is adjusted in the “Amplification“ field.

A measurement is triggered when the “Measure“ button is pressed and the corresponding measurement values (ADC/Counts-Values) are displayed on the three measuring channels.

If “Interrupted Measurement” is selected, no continuous measurements are carried out in the main window, only single measurements. Please note: If Wait=1 in the conf.ini file, "Interrupted Measurement" is automatically selected.

4.6 Target-oriented Calibration

The system comparison (Figure 23) is carried out on a known target set when the “New Calibration“ button is pressed. In the process, the actual system values are calculated to the targets with known XYZ values and, as a result, the offset values and the gain matrix are calculated. The comparison starts with the following window:

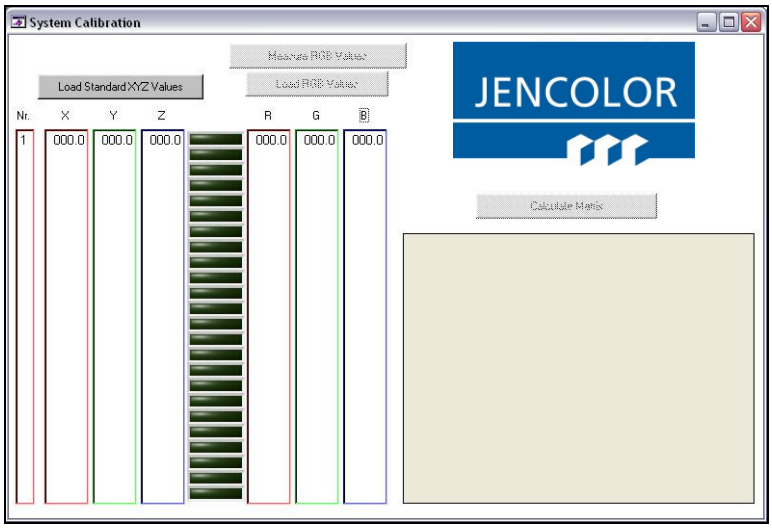


Figure 23: Start of System Calibration

The data for a known and measured target set is loaded by pressing the ”Load Standard XYZ Values“ button. This data set consists of a minimum of 3 (24 recommended) target XYZ and RGB values for the monitor display.

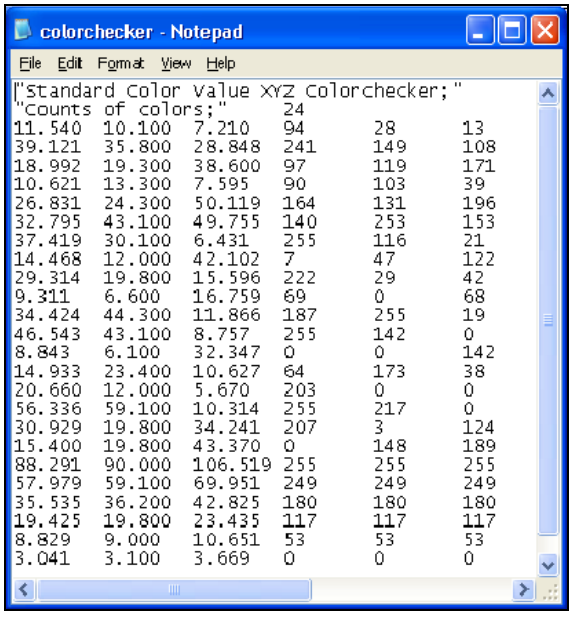


Figure 24: Target data set

The data set can be calculated using the radiance measurement, for example, from the color range data provided by a ColorChecker from the company GretagMacbeth (Figure 25).

Figure 25: GretagMacbeth ColorChecker

The use of other targets presumes knowledge of the XYZ values. By monitoring with a spectrometer, an appropriate target file can be created for luminescent objects.

The loaded target file is displayed with the XYZ numerical values and the combination color of the monitor in tabular form (Figure 26).

The actual values are entered automatically during a comparison on a calibrated monitor. To do so, the sensor is positioned in the middle of the colored surface or in the separate color patch field and the comparison is started by clicking “Measure RGB Values.” The RGB monitor values stored in the file are successively adjusted and the corresponding actual values are recorded.

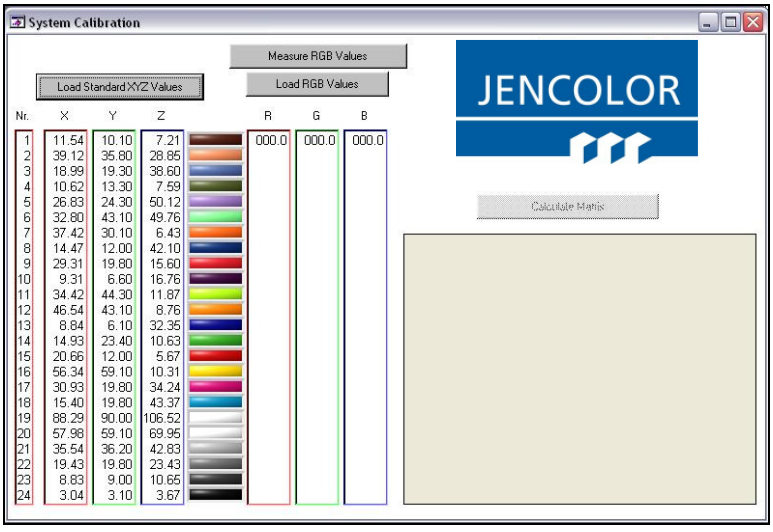


Figure 26: System Calibration: Required Values

When the comparison is carried out on a reflecting target set, the sensors are successively adjusted to measured target colors and the respective actual value is entered when “Measure” is activated (Figure 27).

In the case of incorrect measurements, the last measurement can be deleted and repeated by pressing the “Repeat” button.

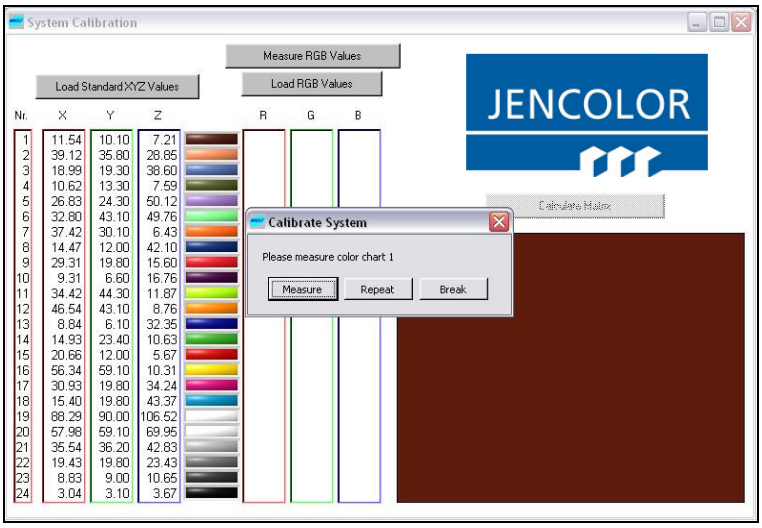


Figure 27: System Calibration: Entering the actual values

Use the “Break” button to cancel the calibration and return to the “Application Setups“ dialog.

If a continuous calibration (Wait=0 in the conf.ini file) is carried out, this can be canceled using the ESC key.

Once all 24 actual values have been entered, the file is saved and the offset values are calculated. An existing actual value file can be loaded by pressing “Load RGB Values.“

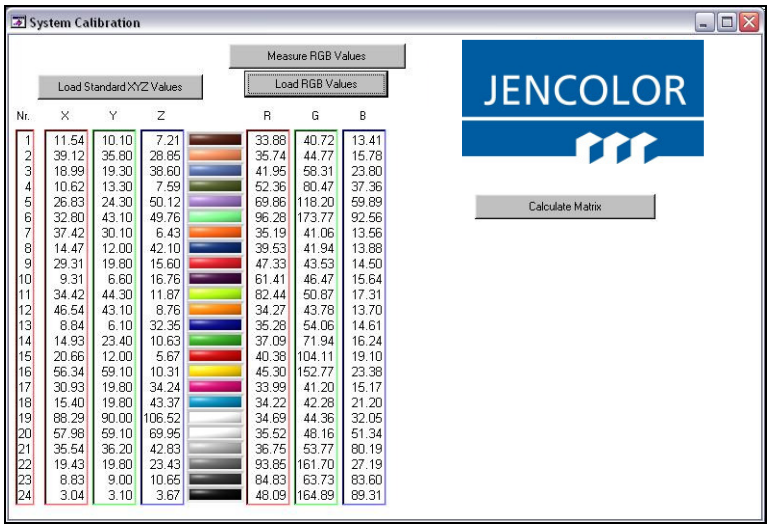


Figure 28: System Calibration: Matrix Calculation

If the offset-corrected actual values are available, the “Calculate Matrix” button is activated (Figure 28). You can click to calculate the gain matrices, complete the comparison and revert the software back to the “Application Setups” dialog, in which the determined offset values and matrices are displayed.

For the lab values calculated in the measurement, it is still necessary to enter the type of illumination, for which the calibration was carried out (“L*a*b*Light“ in Figure 22).

The determined calibration data is stored in the onboard memory when the “Write to Sensor” button is pressed. It becomes available automatically after the system is rebooted, without the need to carry out a new comparison.

For further information please contact:

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