



CLM-195

In-line colorimeter

User Guide
Rev.1.16 - 03/2025

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1 OVERVIEW

Thank you for purchasing the Eoptis' CLM-195, an in-line contactless colorimeter. The CLM-195 colorimeter is a colour sensor system capable of delivering accurate and repeatable measurements of the colour of the surface under inspection. It is a robust system, designed for 24/7 in-line operations. The measured data can be sent as CIELAB coordinates to a remote controlling unit for analysis and logging, or it can be processed on-board and in real-time. Colour measurements can be performed on the surface of a wide range of matte and glossy materials, thanks to a (45°c:0°) measurement geometry and the very uniform illumination provided by integrated LEDs. Long-term stability reduces the need of calibration by the user.

1.1 PACKING LIST

The package contents:

- | | |
|---|---|
| 1 | CLM-195 colorimeter |
| 1 | White reference standard with adapter |
| 1 | CLM-195 evaluation kit E2A0039A |
| 1 | 8 poles (power, RS485, GPIO), 2m cable |
| 1 | RS485-USB converter |
| 1 | User Guide |
| 1 | CLM-195 Interface Software |
| 1 | Certificate of traceable calibration (depending on order options) |

2 INSTRUCTION SET SERIAL PROTOCOL

The user can communicate with the device via RS485 using a proprietary Serial protocol.

2.1 MESSAGE FORMAT

The generic message format is described in the following table.

<i>Message format</i>					
byte id	0	1	2-3	4	5-8
content	R/W*	component address	register address**	0x00***	data
*: set 'r' for read operation, 'w' for write operation **: numerical value, LSB first ***: error code in device answer					

Messages have a fixed length of 9 bytes. The data/info included in these bytes depends on the required register.

2.2 REGISTERS ADDRESSES

2.2.1 COMPONENT "CONFIG"; ADDRESS 0X01

The "Config" component exposes several service registers with device info, and registers to control the system behavior and data generation.

Register address	R/W	Description
0x0005	R	Temperature sensor RAW data
0x0006	R/W	Start measure (software trigger). On write: start measure On read: check measure in progress
0x0008	R	Firmware version, format major.minor.build.revision (one byte per value)
0x0009	R	Ping address. Expected answer: 0xC73194F0
0x000D	R	Device serial number
0x0015	R	System temperature in °C. Fixed point format: actual temperature = (data/16)°C
0x0016	R/W	Enable/disable on board processing
0x0017	R/W	Serial Baudrate. Available settings: 1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200
0x0020	R/W	Target temperature for color sensor board: Fixed point format: actual temperature = (data/100)°C. Power on value: 40°. Max value: 70°
0x0021	R/W	Target temperature form LEDs board: Fixed point format: actual temperature = (data/100)°C. Power on value: 40°. Max value: 70°
0x0024	R/W	Enable/disable hardware trigger on IN1
0x0025	R/W	Define hardware trigger polarity
0x0026	R/W	Trigger delay in milliseconds
0x0027	R	Measure counter, since release from factory
0x0032	R/W	Internal trigger period [ms]
0x0033	R/W	Measure/Reference ΔE^*ab mode 0: CIE 1976 (default) 1: CIE 1994 for graphic arts 2: CIE 1994 for textiles 3: CIE 2000 4: CMC acceptability 5: CMC perceptibility

2.2.2 COMPONENT "RAW RGB SENSOR DATA"; ADDRESS 0X23

These read-only registers return the RAW sensor data, captured during the acquisition period, for the 3 color channels.

Register address	R/W	Description
0x0001	R	Raw measure from sensor, RED channel. Values range 0-32767
0x0002	R	Raw measure from sensor, BLUE channel. Values range 0-32767 †
0x0003	R	Raw measure from sensor, GREEN channel. Values range 0-32767 †
†: Notice that BLU and GREEN channels are sent inverted (not the classic R-G-B order)		

2.3 SERIAL PORT CONFIGURATION

Serial port configuration

Baudrate*	115200
Parity	none
Data bits	8
Stop bits	1
Flow control	None
*: can be configured with CLMConfiguration software (see 4)	

2.3.1 COMPONENT "TEMPERATURE COMPENSATED RGB SENSOR DATA"; ADDRESS 0X33

These read-only registers return the RAW sensor data, captured during the acquisition period, for the 3 color channels. The data is compensated given the current system temperature.

Register address	R/W	Description
0x0001	R	Raw measure from sensor, compensated given system temperature, RED channel. Values range 0-32767
0x0002	R	Raw measure from sensor, compensated given system temperature, GREEN channel. Values range 0-32767
0x0003	R	Raw measure from sensor, compensated given system temperature, BLUE channel. Values range 0-32767

2.3.2 COMPONENT "L*A*B* SENSOR DATA"; ADDRESS 0X43

These read-only registers return the sensor measure after processing and calibration, in CIE L*a*b* color space.

Register address	R/W	Description
0x0001	R	L*a*b* sensor measure, L* channel. Fixed point format: actual measure = value/100
0x0002	R	L*a*b* sensor measure, a* channel. Fixed point format: actual measure = value/100
0x0003	R	L*a*b* sensor measure, b* channel. Fixed point format: actual measure = value/100

2.3.3 COMPONENT "SYSTEM TEMPERATURE ON MEASURE"; ADDRESS 0X53

The component exposes a single read-only register with the system temperature, in °C, measured during the last color acquisition.

Register address	R/W	Description
0x0001	R	System temperature in °C detected on measure. Fixed point format: actual temperature = (data/16)°C

2.3.4 COMPONENT "GPIO INPUT"; ADDRESS 0XA1

This component exposes the status of the 2 General Purpose Inputs.

Register address	R/W	Description
0x0001	R	Status of GPIO input 1
0x0002	R	Status of GPIO input 2

2.3.5 COMPONENT "GPIO OUTPUT"; ADDRESS 0XB1

This component allows to set and check the status of the 2 General Purpose Outputs.

Register address	R/W	Description
0x0001	R/W	Check or set status of GPIO output 1
0x0002	R/W	Check or set status of GPIO output 2

2.3.6 COMPONENT "REFERENCE COLOR L*A*B*"; ADDRESS 0XC1

This component allows the user to set a reference color, in CIE L*a*b* color space, that will be used to compute a measure/reference error during the measure processing (see 2.3.7)

Register address	R/W	Description
0x0001	R/W	L*a*b* color reference, L* channel. Fixed point format: actual measure = value/100
0x0002	R/W	L*a*b* color reference, a* channel. Fixed point format: actual measure = value/100
0x0003	R/W	L*a*b* color reference, b* channel. Fixed point format: actual measure = value/100

2.3.7 COMPONENT "MEASURE/REFERENCE ERROR"; ADDRESS 0XC3

This component's register returns the colorimetric difference between the current measure and the reference set (see 2.3.6).

The error computation standard is set in the "Measure/Reference ΔE^*_{ab} mode" register of the "Config" component (see 2.2.1).

Register address	R/W	Description
0x0001	R	ΔE^* between current measure and set reference color. Fixed point format: actual error = value/1000

2.3.8 COMPONENT "FACTORY DARK RGB"; ADDRESS 0X0B

This component contains the RAW RGB measure of the Dark performed during the factory calibration. Can be used to compare the user target measure during calibration (see 2.5).

Register address	R/W	Description
0x0001	R	Raw measure from sensor of factory Dark, RED channel. Values range 0-32767
0x0002	R	Raw measure from sensor of factory Dark, GREEN channel. Values range 0-32767
0x0003	R	Raw measure from sensor of factory Dark, BLUE channel. Values range 0-32767

2.3.9 COMPONENT "FACTORY WHITE TARGET RGB"; ADDRESS 0X0D

This component contains the RAW RGB measure of the White Target performed during the factory calibration. Can be used to compare the user target measure during calibration (see 2.5).

Register address	R/W	Description
------------------	-----	-------------

0x0001	R	Raw measure from sensor of factory White Target, RED channel. Values range 0-32767
0x0002	R	Raw measure from sensor of factory White Target, GREEN channel. Values range 0-32767
0x0003	R	Raw measure from sensor of factory White Target, BLUE channel. Values range 0-32767

2.3.10 COMPONENT "FACTORY DARK MEASURE TEMPERATURE"; ADDRESS 0X0F

This component contains the RAW temperature detected during factory Dark measure. Can be used to compare the user target measure during calibration (see 2.5).

Register address	R/W	Description
0x0001	R	Temperature sensor raw read value when factory Dark measure was acquired

2.3.11 COMPONENT "FACTORY WHITE TARGET MEASURE TEMPERATURE"; ADDRESS 0X11

This component contains the RAW temperature detected during factory White Target measure. Can be used to compare the user target measure during calibration (see 2.5).

Register address	R/W	Description
0x0001	R	Temperature sensor raw read value when factory White Target measure was acquired

2.3.12 COMPONENT "USER DARK RGB"; ADDRESS 0X13

This component contains the RAW RGB measure of the Dark performed by the user (see 2.5).

Register address	R/W	Description
0x0001	R/W	Raw measure from sensor of user Dark, RED channel. Values range 0-32767
0x0002	R/W	Raw measure from sensor of user Dark, GREEN channel. Values range 0-32767
0x0003	R/W	Raw measure from sensor of user Dark, BLUE channel. Values range 0-32767

2.3.13 COMPONENT "USER WHITE TARGET RGB"; ADDRESS 0X15

This component contains the RAW RGB measure of the White Target performed by the user (see 2.5).

Register address	R/W	Description
0x0001	R/W	Raw measure from sensor of user White Target, RED channel. Values range 0-32767
0x0002	R/W	Raw measure from sensor of user White Target, GREEN channel. Values range 0-32767
0x0003	R/W	Raw measure from sensor of user White Target, BLUE channel. Values range 0-32767

2.3.14 COMPONENT "USER DARK MEASURE TEMPERATURE"; ADDRESS 0X61

This component contains the RAW temperature detected during user Dark measure (see 2.5).

Register address	R/W	Description
0x0001	R/W	Temperature sensor raw read value when user Dark measure was acquired

2.3.15 COMPONENT "USER WHITE TARGET MEASURE TEMPERATURE"; ADDRESS 0X63

This component contains the RAW temperature detected during user White Target measure (see 2.5).

Register address	R/W	Description
0x0001	R/W	Temperature sensor raw read value when user White Target measure was acquired

2.4 PERFORM COLOR MEASURE

To measure a target and get its CIE $L^*a^*b^*$ color coordinates, follow these steps

1. Position the device to perform a measure of the target
2. Send the *Start measure* command (address 0x01, register 0x0006)
3. Read the *L*a*b* sensor measure data* (address 0x43, registers 0x0000-0x0002)
 - Rescale the data to have the correct values; coordinate = data/100
4. Perform color analysis on the acquired $L^*a^*b^*$ coordinates

2.5 PERFORM USER CALIBRATION

To perform the user calibration, the user must perform the White Target measure and the Dark measure. The White Target acquisition procedure is described in the next paragraphs.

2.5.1 RETRIEVE CURRENT USER TARGET MEASURE DATA

1. Read the current *User White Target measure RW RGB* coordinates (address 0x13, registers 0x0000-0x0002)
2. Store the read coordinates; will be used to check the correctness of the next target acquisition

2.5.2 ACQUIRE NEW USER TARGET

1. Ensure the White Target, provided by EOPTIS with the device, is clean. Otherwise clean it with a moist cloth. Do not use acetone or alcohol
2. Apply the calibration adapter to the devices (if not already mounted)
3. Perform a normal measure using the *Start measure* command (address 0x01, register 0x0006)
4. Read the *RAW RGB sensor data* (address 0x23, registers 0x0000-0x0002)

WARNING: GREEN and BLUE channels are inverted in this read
5. Read the current system temperature in RAW format (address 0x01, register 0x0005)

2.5.3 CHECK ACQUIRED DATA AND UPDATE DEVICE

1. Compare the just performed RAW measure with the previous White Target measure. For lab measures we consider a good measure when the RAW RGB coordinates are within a 10% from the previously acquired ones. If not, the target was probably misplaced; retry the measure. If the measure is still out of range after some careful tests, contact EOPTIS
2. If the measure is right, write the acquired target measure in the *User White Target measure RAW RGB* registers (address 0x13, registers 0x0000-0x0002) and the RAW temperature in the *User White Target measure temperature register* (address 0x63, register 0x0000)

The new data will be used to calibrate in the next measures, and are permanently stored in the device's memory.

2.5.4 DARK TARGET ACQUISITION

The previous steps describe the White Target acquisition and update. To perform the Dark user calibration, follow the same procedure, using the registers related to the Dark. Note that there is no physical "dark target"; it is requested to place the colorimeter at 1 m (or more) above the ground, pointing it to the ground, and preferably with weak external light.

It is rarely needed to perform a user Dark calibration. It is advised only if the Field of View is below 10mm.

3 INSTRUCTION SET MODBUS PROTOCOL

The user can communicate with the device using the standard Modbus RTU protocol.

3.1 SERIAL PORT CONFIGURATION

Serial port configuration

Baudrate*	115200
Parity	none
Data bits	8
Stop bits	1
Flow control	None
*: can be configured with CLMConfiguration software (see 4)	

3.2 SLAVE ID

The default Slave ID is 10. The ID can be modified using CLMConfiguration software (see 4).

3.3 FUNCTION CODE REFERENCE

3.3.1 READ COILS (FUNCTION CODE 1)

COMMAND

Read Coils command

byte id	0	1	2-3	4-5	6-7
content	ID (10)	Function (1)	Starting address*	Tot Coils to read*	CRC16
*: MSB first format					

ANSWER

Read Coils answer

byte id	0	1	2	3-N	LSBs
content	ID (10)	Function (1)	Tot Data bytes	Data*	CRC16
*: each data can contain up to 8 Coils. Unused bits are set to 0.					

Coils are read/write single bit data. The device answer with the requested coils status. The bits are packed in the *Data* field; each *Data* byte can contain up to 8 Coils status (unused bits are set to 0). First bit (lsb) of first *Data* byte is the status of the Coil at *Starting address* position. Second bit of the first *Data* byte is the status of the Coil at *Starting address + 1* position. And so on.

3.3.2 WRITE SINGLE COIL (FUNCTION CODE 5)

COMMAND

Write single Coil command

byte id	0	1	2-3	4-5	6-7
content	ID (10)	Function (5)	Starting address*	Data* **	CRC16
*: MSB first format					
**: set Coil status					
0xFF00 turn Coil ON					
0x0000 turn Coil OFF					

ANSWER

Write single Coil answer

byte id	0	1	2-3	4-5	6-7
content	ID (10)	Function (5)	Starting address*	Data* **	CRC16
*: MSB first format					
**: set Coil status					
0xFF00 turn Coil ON					
0x0000 turn Coil OFF					

Coils are read/write single bit data. Still, to write a Coil a 2 bytes data is sent. Sending 0xFF00 will turn the Coil ON (a '1' will be read with Read Coils request); sending 0x0000 will turn the Coil OFF (a '0' will be read with Read Coils request).

3.3.3 WRITE MULTIPLE COILS (FUNCTION CODE 15)

COMMAND

Write multiple Coils command

byte id	0	1	2-3	4-5	6	7-N	LSBs
content	ID (10)	Function (15)	Starting address*	Tot Coils to write*	Tot Data bytes	Data**	CRC16
*: MSB first format							
**: each data can contain up to 8 Coils. Unused bits are set to 0.							

ANSWER

Write multiple Coils answer

byte id	0	1	2-3	4-5	6-7
content	ID (10)	Function (15)	Starting address*	Tot Coils to write*	CRC16
*: MSB first format					

Coils are read/write single bit data. The bits are packed in the *Data* field; each Data byte can contain up to 8 Coils status (unused bits are set to 0). First bit (lsb) of first *Data* byte is the status of the Coil at *Starting address* position. Second bit of the first *Data* byte is the status of the Coil at *Starting address* + 1 position. And so on.

3.3.4 READ DISCRETE INPUTS (FUNCTION CODE 2)

COMMAND

Read Discrete Inputs command

byte id	0	1	2-3	4-5	6-7
content	ID (10)	Function (2)	Starting address*	Tot Inputs to read*	CRC16

*: MSB first format

ANSWER

Read Discrete Inputs answer

byte id	0	1	2-3	3-N	LSBs
content	ID (10)	Function (2)	Tot Data bytes	Data*	CRC16

*: each data can contain up to 8 Discrete Inputs. Unused bits are set to 0.

Discrete Inputs are read-only single bit data. The device answer with the requested Discrete Inputs status. The bits are packed in the *Data* field; each *Data* byte can contain up to 8 Discrete Inputs status (unused bits are set to 0). First bit (lsb) of first *Data* byte is the status of the Discrete Input at *Starting address* position. Second bit of the first *Data* byte is the status of the Discrete Input at *Starting address* + 1 position. And so on.

3.3.5 READ INPUT REGISTERS (FUNCTION CODE 4)

COMMAND

Read Input Registers command

byte id	0	1	2-3	4-5	6-7
content	ID (10)	Function (4)	Starting address*	Tot registers to read*	CRC16

*: MSB first format

ANSWER

Read Input Registers answer

byte id	0	1	2-3	3-N	LSBs
content	ID (10)	Function (4)	Tot Data bytes	Data*	CRC16

*: each Data is 2 bytes long, MSB first format

Input Registers are read-only 16 bits registers. *Data* are formatted as 2 bytes Words, MSB first. If N Input Registers are requested (*Tot registers to read* = N), the device will answer with 2*N *Data* bytes (*Tot Data bytes* = 2*N). First *Data* Word is the value of the Input Register at *Starting address* position. Second *Data* Word is the value of the Input Register at *Starting address* position + 1. And so on.

3.3.6 READ HOLDING REGISTERS (FUNCTION CODE 3)

COMMAND

Read Holding Registers command

byte id	0	1	2-3	4-5	6-7
content	ID (10)	Function (3)	Starting address*	Tot registers to read*	CRC16

*: MSB first format

ANSWER

Read Holding Registers answer

byte id	0	1	2-3	3-N	LSBs
content	ID (10)	Function (3)	Tot Data bytes	Data*	CRC16

*: each Data is 2 bytes long, MSB first format

Holding Registers are read/write 16 bits registers. *Data* are formatted as 2 bytes Words, MSB first. If N Holding Registers are requested (*Tot registers to read* = N), the device will answer with 2*N *Data* bytes (*Tot Data bytes* = 2*N). First *Data* Word is the value of the Holding Register at *Starting address* position. Second *Data* Word is the value of the Holding Register at *Starting address* position + 1. And so on.

3.3.7 WRITE SINGLE HOLDING REGISTER (FUNCTION CODE 6)

COMMAND

Write single Holding Register command

byte id	0	1	2-3	4-5	6-7
content	ID (10)	Function (6)	Starting address*	Data*	CRC16

*: MSB first format

ANSWER

Write single Holding Register answer

byte id	0	1	2-3	3-N	LSBs
content	ID (10)	Function (6)	Starting address*	Data*	CRC16

*: MSB first format

Holding Registers are read/write 16 bits registers. *Data* are formatted as 2 bytes Words, MSB first.

3.3.8 WRITE MULTIPLE HOLDING REGISTERS (FUNCTION CODE 16)

COMMAND

Write multiple Holding Registers command

byte id	0	1	2-3	4-5	6	7-N	LSBs
content	ID (10)	Function (16)	Starting address*	Tot registers to write*	Tot Data bytes	Data* **	CRC16
*: MSB first format							
**: each Data is 2 bytes long, MSB first format							

ANSWER

Write multiple Holding Registers answer

byte id	0	1	2-3	4-5	6-7
content	ID (10)	Function (16)	Starting address*	Tot registers to write*	CRC16
*: MSB first format					

Holding Registers are read/write 16 bits registers. *Data* are formatted as 2 bytes Words, MSB first. If N Holding Registers are requested (*Tot registers to write* = N), the device will answer with $2*N$ *Data* bytes (*Tot Data bytes* = $2*N$).

3.4 EXCEPTION MESSAGES

If the request is not valid, the device will answer with an exception message.

EXCEPTION

Exception message

byte id	0	1	2	3-4
content	ID (10)	Function code	Exception code	CRC16

The ANSWER message will have a *Function code* dependant to the command's *Function code*:

Command Function code	Exception Function code
1 (Read Coils)	129
2 (Read Discrete Inputs)	130
3 (Read Holding Registers)	131
4 (Read Input Registers)	132
5 (Write single Coil)	133
6 (Write single Holding Register)	134
15 (Write multiple Coils)	143
15 (Write multiple Holding Registers)	144

The device can send these *Exception codes*:

Code	Description
1	Illegal function; function code not implemented
2	Illegal data address; requested register addresses don't exist or can't be accessed with the requested code. Can be due to the value of <i>Starting address</i> as well as the <i>Tot register to read/write</i> (last register address to access can be out of bound)
3	Illegal data value; not a valid data for the given register

3.5 COILS

Register	Register number	Register address
Start measure	000001	0
GPIO OUT1	000002	1
GPIO OUT2	000003	2
Store on EEPROM	000004	3
Trigger enabled	000005	4
Trigger polarity	000006	5

3.5.1 AVAILABLE FUNCTIONS

Function	Code
Read Coils	1
Write single Coil	5
Write multiple Coils	15

3.5.2 START MEASURE

Register number: 000001

Register address: 0

The device start a measure when a '0' -> '1' transitino is detected on this Coil.

When the measure is ready the master will be alerted with the Discrete Input *Measure Ready* (see 3.6.1).

3.5.3 GPIO OUT1

Register number: 000002

Register address: 1

Set OUT1 signal status:

'0': low

'1': high

3.5.4 GPIO OUT2

Register number: 000003

Register address: 2

Set OUT2 signal status:

'0': low

'1': high

3.5.5 STORE ON EEPROM

Register number: 000004

Register address: 3

When a transition '0' -> '1' is detected, the device will store the temporary data on EEPROM and reboot. The data that will be stored (and loaded on boot) are:

- Reference CIE $L^*a^*b^*$
- User calibration data white target/dark RAW coordinates, temperature)

3.5.6 TRIGGER ENABLED

Register number: 000005

Register address: 4

When set to '1' the external trigger function is enabled.

3.5.7 TRIGGER POLARITY

Register number: 000006

Register address: 5

Defines the signal edge that triggers the measure start.

0: start measure on falling edge (signal HIGH -> LOW transition)

1: start measure on rising edge (signal LOW -> HIGH transition)

3.6 DISCRETE INPUTS

Register	Register number	Register address
Measure ready	100001	0
GPIO IN1	100002	1
GPIO IN2	100003	2

3.6.1 AVAILABLE FUNCTIONS

Function	Code
Read Discrete Inputs	2

3.6.1 MEASURE READY

Register number: 100001

Register address: 0

Will signal when the measure is completed and the updated data can be read.

When the device receives a *Start measure* command (see 3.5.2), *Measure ready* becomes '0'. When the measure is ready it will switch to '1'. Will remain '1' until the next *Start measure* command.

3.6.2 GPIO IN1

Register number: 100002

Register address: 1

Get IN1 signal status:

'0': low

'1': high

3.6.3 GPIO IN2

Register number: 100003

Register address: 2

Get IN2 signal status:

'0': low

'1': high

3.7 INPUT REGISTERS

Register	Register number	Register address
Serial number LO	300001	0
Serial number HI	300002	1
Firmware Major version	300003	2
Firmware Minor version	300004	3
Firmware Build version	300005	4
Firmware Revision	300006	5
Ping LO	300007	6
Ping HI	300008	7
System temperature	300009	8
Measure RAW Red	300010	9
Measure RAW Blue †	300011	10
Measure RAW Green †	300012	11
Measure RAW Temperature compensated Red	300013	12
Measure RAW Temperature compensated Green	300014	13
Measure RAW Temperature compensated Blue	300015	14
Measure CIE L*a*b* L*	300016	15
Measure CIE L*a*b* a*	300017	16
Measure CIE L*a*b* b*	300018	17
System temperature on measure	300019	18
Measure/Reference ΔE^*ab	300020	19
System temperature RAW	300021	20
Measure counter	300022	21

(†) Notice that BLU and GREEN channels are sent inverted (not the classic RGB order)

3.7.1 AVAILABLE FUNCTIONS

Function	Code
Read Input Registers	4

3.7.1 SERIAL NUMBER LO

Register number: 300001

Register address: 0

LSB of the device Serial number. Merge with Serial number HI (see 3.7.2) to get the full device Serial number.

3.7.2 SERIAL NUMBER HI

Register number: 300002

Register address: 1

MSB of the device Serial number. Merge with Serial number HI (see 3.7.1) to get the full device Serial number.

3.7.3 FIRMWARE MAJOR VERSION

Register number: 300003
Register address: 2

Major version of the device firmware.

3.7.4 FIRMWARE MINOR VERSION

Register number: 300004
Register address: 3

Minor version of the device firmware.

3.7.5 FIRMWARE BUILD VERSION

Register number: 300005
Register address: 4

Build version of the device firmware.

3.7.6 FIRMWARE REVISION

Register number: 300006
Register address: 5

Device firmware revision.

3.7.7 PING LO

Register number: 300007
Register address: 6

LSB of the Ping word. Merge with Ping HI (see 3.7.8) to get the full word.
Can be used to test the communication with device.
Expected Ping: 3341915376 (0xC73194F0)

3.7.8 PING HI

Register number: 300008
Register address: 7

MSB of the Ping word. Merge with Ping LO (see 3.7.7) to get the full word.
Can be used to test the communication with device.
Expected Ping: 3341915376 (0xC73194F0)

3.7.9 SYSTEM TEMPERATURE

Register number: 300009
Register address: 8

Current system temperature in °C. Fixed point format: actual temperature = (data/16) °C

3.7.10 MEASURE RAW RED

Register number: 300010

Register address: 9

RAW color sensor measure, Red channel. Values range 0-32767.
 Use this format for user calibration.

3.7.11 MEASURE RAW BLUE

Register number: 300011

Register address: 10

RAW color sensor measure, Blue channel. Values range 0-32767.
 Use this format for user calibration.

3.7.12 MEASURE RAW GREEN

Register number: 300012

Register address: 11

RAW color sensor measure, Green channel. Values range 0-32767.
 Use this format for user calibration.

3.7.13 MEASURE RAW TEMPERATURE COMPENSATED RED

Register number: 300013

Register address: 12

RAW color sensor measure compensated for temperature drift, Red channel. Values range 0-32767.

3.7.14 MEASURE RAW TEMPERATURE COMPENSATED GREEN

Register number: 300014

Register address: 13

RAW color sensor measure compensated for temperature drift, Green channel. Values range 0-32767.

3.7.15 MEASURE RAW TEMPERATURE COMPENSATED BLUE

Register number: 300015

Register address: 14

RAW color sensor measure compensated for temperature drift, Blue channel. Values range 0-32767.

3.7.16 MEASURE CIE L*A*B* L*

Register number: 300016

Register address: 15

CIE L*a*b* sensor measure, L* channel. Fixed point format: actual measure = value/100.

3.7.17 MEASURE CIE L*A*B* A*

Register number: 300017

Register address: 16

CIE L*a*b* sensor measure, a* channel. Fixed point format: actual measure = value/100.

3.7.18 MEASURE CIE L*A*B* B*

Register number: 300018

Register address: 17

CIE L*a*b* sensor measure, b* channel. Fixed point format: actual measure = value/100.

3.7.19 SYSTEM TEMPERATURE ON MEASURE

Register number: 300019

Register address: 18

System temperature, in °C, detected on measure. Fixed point format: actual temperature = (data/16) °C

3.7.20 MEASURE/REFERENCE ΔE*AB

Register number: 300020

Register address: 19

Difference (CIE ΔE*ab) between the current measure and the set reference color. Fixed point format: actual error = value/1000.

3.7.21 SYSTEM TEMPERATURE RAW

Register number: 300021

Register address: 20

System temperature in RAW sensor format.
Use this format for user calibration.

3.7.22 MEASURE COUNTER

Register number: 300022

Register address: 21

Measure counter since factory calibration.
A change on this register can be used to detect when new hardware triggered measure data are ready on the system.

3.8 HOLDING REGISTERS

Register	Register number	Register address
Reference CIE L*a*b* L*	400001	0
Reference CIE L*a*b* a*	400002	1
Reference CIE L*a*b* b*	400003	2
User Dark measure RAW Red	400004	3
User Dark measure RAW Green	400005	4
User Dark measure RAW Blue	400006	5
User White Target measure RAW Red	400007	6
User White Target measure RAW Green	400008	7
User White Target measure RAW Blue	400009	8
User Dark temperature RAW	400010	9
User White Target temperature RAW	400011	10
Trigger delay ms	400012	11
Target temperature color sensor	400013	12
Target temperature LED board sensor	400014	13
Internal trigger period [ms]	400015	14
Measure/Reference ΔE^*_{ab} mode	400016	15

3.8.1 AVAILABLE FUNCTIONS

Function	Code
Read Holding Registers	3
Write single Holding Register	6
Write multiple Holding Registers	16

3.8.1 REFERENCE CIE L*A*B* L*

Register number: 400001

Register address: 0

Reference color CIE L*a*b*, L* coordinate.

3.8.2 REFERENCE CIE L*A*B* A*

Register number: 400002

Register address: 1

Reference color CIE L*a*b*, a* coordinate.

3.8.3 REFERENCE CIE L*A*B* B*

Register number: 400003

Register address: 2

Reference color CIE L*a*b*, b* coordinate.

3.8.4 USER DARK MEASURE RAW RED

Register number: 400004

Register address: 3

User Dark measure in RAW format, Red channel. Values range 0-32767.

3.8.5 USER DARK MEASURE RAW GREEN

Register number: 400005
Register address: 4

User Dark calibration measure in RAW format, Green channel. Values range 0-32767.

3.8.6 USER DARK MEASURE RAW BLUE

Register number: 400006
Register address: 5

User Dark calibration measure in RAW format, Blue channel. Values range 0-32767.

3.8.7 USER WHITE TARGET MEASURE RAW RED

Register number: 400007
Register address: 6

User White Target calibration measure in RAW format, Red channel. Values range 0-32767.

3.8.8 USER WHITE TARGET MEASURE RAW GREEN

Register number: 400008
Register address: 7

User White Target calibration measure in RAW format, Green channel. Values range 0-32767.

3.8.9 USER WHITE TARGET MEASURE RAW BLUE

Register number: 400009
Register address: 8

User White Target calibration measure in RAW format, Blue channel. Values range 0-32767.

3.8.10 USER DARK TEMPERATURE RAW

Register number: 400010
Register address: 9

System temperature in RAW format during User Dark calibration acquisition.

3.8.11 USER WHITE TARGET TEMPERATURE RAW

Register number: 400011
Register address: 10

System temperature in RAW format during User White Target calibration acquisition.

3.8.12 TRIGGER DELAY MS

Register number: 400012
Register address: 11

Hardware trigger delay in milliseconds.

3.8.13 TARGET TEMPERATURE COLOR SENSOR

Register number: 400013

Register address: 12

Target temperature, in °C, for sensor board. Fixed point format: actual temperature = (data/16) °C.
Setting valid only for heated systems.

3.8.14 TARGET TEMPERATURE LED BOARD SENSOR

Register number: 400014

Register address: 13

Target temperature, in °C, for LED board. Fixed point format: actual temperature = (data/16) °C.
Setting valid only for heated systems.

3.8.15 INTERNAL TRIGGER PERIOD [MS]

Register number: 400015

Register address: 14

Interval, in milliseconds, between successive measures in automatic mode.

3.8.16 MEASURE/REFERENCE ΔE^*AB MODE

Register number: 400016

Register address: 15

Computation mode for colorimetric difference between measure and reference.

Available standards:

- 0: CIE 1976 (default)
- 1: CIE 1994 Graphic Arts
- 2: CIE 1994 Textiles
- 3: CIE 2000
- 4: CMC Acceptability
- 5 : CMC Perceptibility

3.9 PERFORM COLOR MEASURE

To measure a target and get its CIE $L^*a^*b^*$ color coordinates, follow these steps

1. Position the device to perform a measure of the target
2. Set the *Start measure* Coil (see 3.5.2 Start measure)
3. Monitor a change in the Discrete Input *Measure Ready* (see 3.6.1)
4. Clear the *Start measure* Coil (see 3.5.2 Start measure)
5. Read the *Measure CIE $L^*a^*b^*$* coordinates from the corresponding Input registers (see 3.7.16 Measure CIE $L^*a^*b^*$ L^* , 3.7.17 Measure CIE $L^*a^*b^*$ a^* , 3.7.18 Measure CIE $L^*a^*b^*$ b^*)
 - Rescale the data to have the correct values; coordinate = data/100
6. If a reference color was set (see 3.8.1 Reference CIE $L^*a^*b^*$ L^* , 3.8.2 Reference CIE $L^*a^*b^*$ a^* , 3.8.3 Reference CIE $L^*a^*b^*$ b^*), check the measure ΔE^*ab reading Input register *Measure/Reference ΔE^*ab* (see 3.7.20 Measure/Reference ΔE^*ab)

3.10 PERFORM USER CALIBRATION

To perform the user calibration, the user must perform a White Target measure and a Dark measure. The White target acquisition procedure is described in the next paragraphs.

3.10.1 RETRIEVE CURRENT USER TARGET MEASURE DATA

1. Read the current *User white target measure RAW RGB* coordinates from the corresponding Holding registers (see 3.8.7 User White Target measure RAW Red, 3.8.8 User White Target measure RAW Green, 3.8.9 User White Target measure RAW Blue)
2. Store the read coordinates; will be used to check the correctness of the next target acquisition

3.10.2 ACQUIRE NEW USER TARGET

1. Ensure the White standard, provided by EOPTIS with the device, is clean. Otherwise clean it with a moist cloth. Do not use acetone or alcohol
2. Apply the calibration adapter to the devices (if not already mounted)
3. Perform a normal measure setting the *Start measure* Coil (see 3.5.2 Start measure)
4. Monitor a change in the Discrete Input *Measure Ready* (see 3.6.1)
5. Read the *Measure RAW RGB* coordinates from the corresponding Input registers (see 3.7.10 Measure RAW Red, 3.7.11 Measure RAW Blue, 3.7.12 Measure RAW Green)

3.10.3 CHECK ACQUIRED DATA AND UPDATE DEVICE

1. Compare the just performed RAW measure with the previous white target measure. For lab measures we consider a good measure when the RAW RGB coordinates are within a 10% from the previously acquired ones. If not, the target was probably misplaced; retry the measure. If the measure is still out of range after some careful tests, contact EOPTIS
2. If the measure is right, write the acquired target measure in the *User white target measure RAW RGB* Holding registers (see 3.8.7 User White Target measure RAW Red, 3.8.8 User White Target measure RAW Green, 3.8.9 User White Target measure RAW Blue) and the RAW temperature in the *User white target temperature RAW* Holding register (see 3.8.11 User White Target temperature RAW)

The new data will be used to calibrate the next measures, but are not yet stored in the device's memory (see 3.5.5 Store on EEPROM).

3.10.4 DARK ACQUISITION

The previous steps describe the White Target acquisition and update. To perform the Dark user calibration, follow the same procedure, using the registers related to the Dark. Note that there is no physical "dark target"; it is requested to place the colorimeter at 1 m (or more) above the ground, pointing it to the ground, and preferably with weak external light.

It is rarely needed to perform a user Dark calibration. It is advised only if the Field of View is below 10mm.

3.10.5 DATA STORAGE

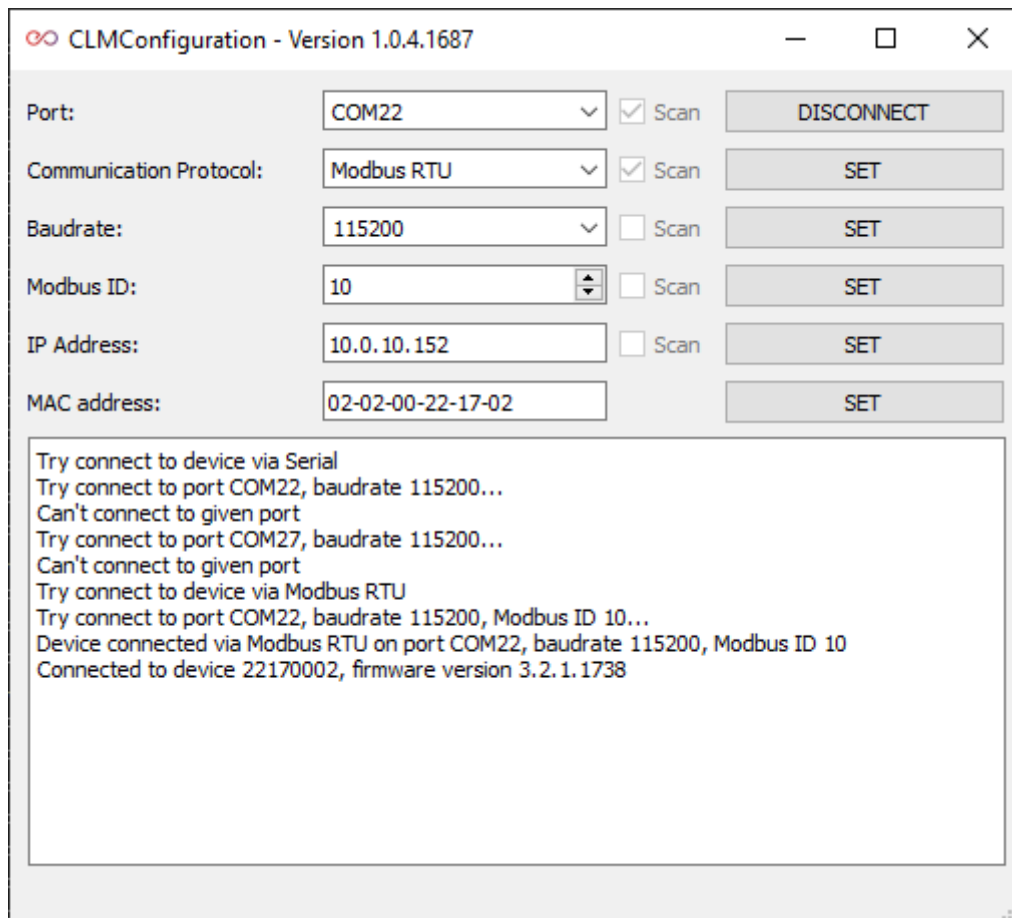
The user calibration data will be discarded when CLM195 powers off! To store the new calibration data in the device memory, and have it available on the next power on, set the corresponding Coil (see 3.5.5 Store on EEPROM).

4 CLMCONFIGURATION SOFTWARE

CLM195 Software Suite contains a tool that can be used to configure the device communication interface. In details, the user can configure:

- Communication protocol (SERIAL or MODBUS RTU)
- Baudrate of serial communication
- ModbusID for Modbus RTU protocol

In case of a previous misconfiguration, the software can also scan for the device, using all configuration combinations.



4.1 DEVICE CONNECTION

The user can manually set the COM port, baudrate, communication protocol and, if Modbus is used, the slave ID to match the device configuration. When the CONNECT button is pressed, the software will try to connect with the device using the user settings. Confirmation/error messages are visible in the log area.

If the user is not sure about the configuration of the device he can check the Scan checkbox for one or more parameters. The software will then scan all the possible value for these parameters when trying to connect to the device.

NOTE: using the Scan function for the Modbus ID parameter will be time consuming (the value can range between 1 and 247).

Once the device is connected the user can disconnect it using the DISCONNECT button.

Since the SET operation of a parameter will reboot the system, the software will automatically disconnect from the device when a SET operation is performed.

4.2 PARAMETERS SETTING

Once the device is connected the user can set a device communication parameter. Select the desired value from the given parameter control, then press the relative SET button. The software will send the new parameter to the device and then disconnect. The device will reboot with the new desired setting. To check the correct set of the parameter simply reconnect to the device. Remember to uncheck the parameter Scan checkbox (if checked) before reconnecting, to avoid the scan process.

4.2.1 LIMITATIONS

Baudrate

Can be set to any standard baudrate.

If the device will be used with EOPTIS's softwares, the user must set baudrate = 115200.

Modbus ID

Valid values for the Modbus RTU protocols are between 1 and 247.

If the device will be used with EOPTIS's softwares, the user must set Modbus ID = 10.

5 CLM195 INTERFACE SOFTWARE

In order to evaluate the Colorimeter CLM-195 functionality an application software with a graphical interface is provided. This section explains the software features. The buttons, checkboxes or active items in the user interface include a pop-up help function which appears when the mouse is held over the item for few seconds.

5.1 SOFTWARE INSTALLATION

Install the software running the program "CLM195 Setup.exe" found in the attached USB drive. The software will guide during the setup process.

5.2 RS485-USB CONVERTER DRIVER

If you plan to connect the device to the PC using the provided RS485-USB converter you need to install the proper driver. The driver is located in the "Driver RS-422-485" folder. You'll find a ZIP file containing the instructions to install the driver and all the needed files.

5.3 LICENCE INSTALLATION

To use your CLM-195 with the test software you need to install the device licence in you PC. From Windows Start menu, run "EOPTIS/CLM Licence Installer". The software starts with admin privileges. Once started, select the ".lic" file associated with the CLM-195 colorimeter you'd like to use and install it. A confirmation message will be displayed on the interface.

NOTE: the software needs administrator privileges. If the software doesn't automatically ask for administrator privileges, right click on the launcher and select "Run as administrator". If you don't have administrator rights on your PC ask support to your IT manager.

5.4 MAIN CONTROLS

This section describes the main controls of the user interface.

5.4.1 CONNECT DEVICES DIALOG

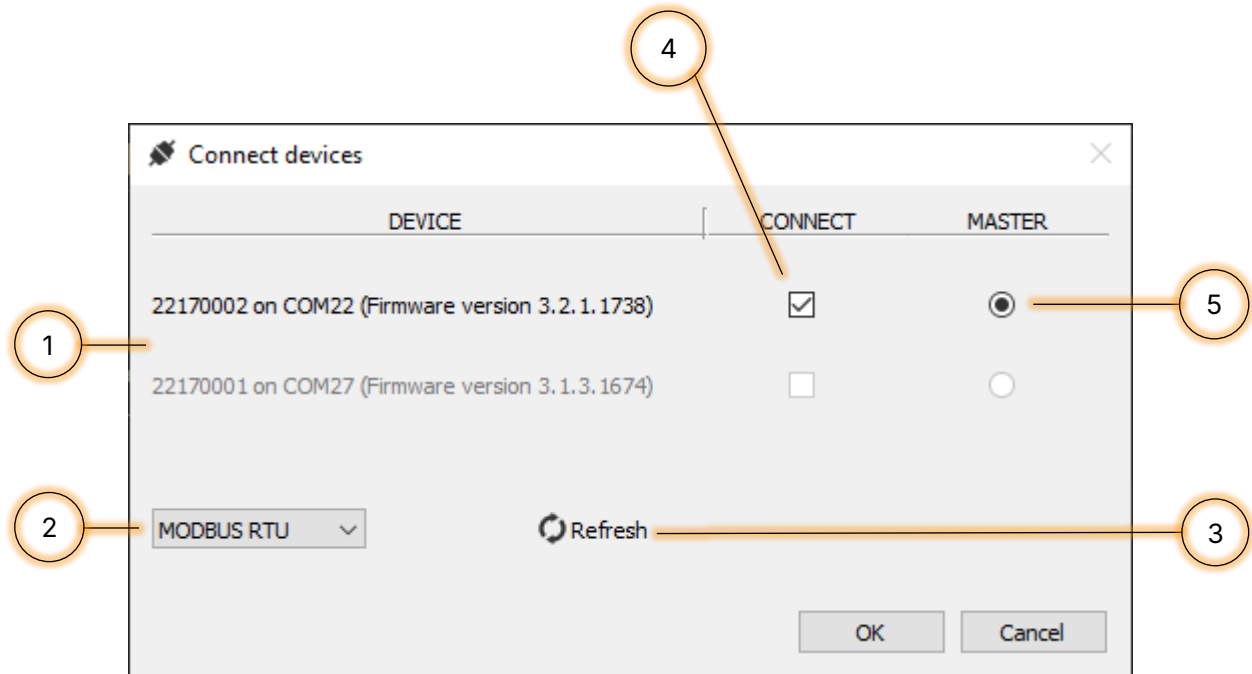


Figure 1: Connect devices dialog

Main controls

Item	Description
①	Available devices list
②	Protocol/interface selector
③	Refresh available device list button
④	Connect devices checkbox
⑤	Master device selectors

On software startup, the *Connect devices dialog* appears. Here the user can select which devices to connect, and select a master in case multiple devices will be connected. The user must select the protocol/interface used to communicate with the devices (see 4 CLMConfiguration software). The dialog can also be opened at runtime to change devices connections.

First, the user select the protocol/interface with the selector ②. By pressing the refresh button ③ the software will search for all devices configured with the selected protocol on given interface (see 4 CLMConfiguration software).

SERIAL and MODBUS RTU protocols are used via RS485/Serial port; the software will scan all PC serial ports for devices.

All connected/searched devices are displayed in the list ①. A grayed out entry indicates that no valid licence was found for the given device serial number; see 5.3 for instructions regarding licence installation.

The user can select which devices to connect and use with the software by checking the CONNECT checkboxes ④. A maximum of 3 devices can be connected simultaneously. If multiple devices will be used, one has to be set as Master by checking the respective control ⑤.

The new connections can be confirmed via button OK, or discarded via button Cancel.

5.4.2 MAIN WINDOW

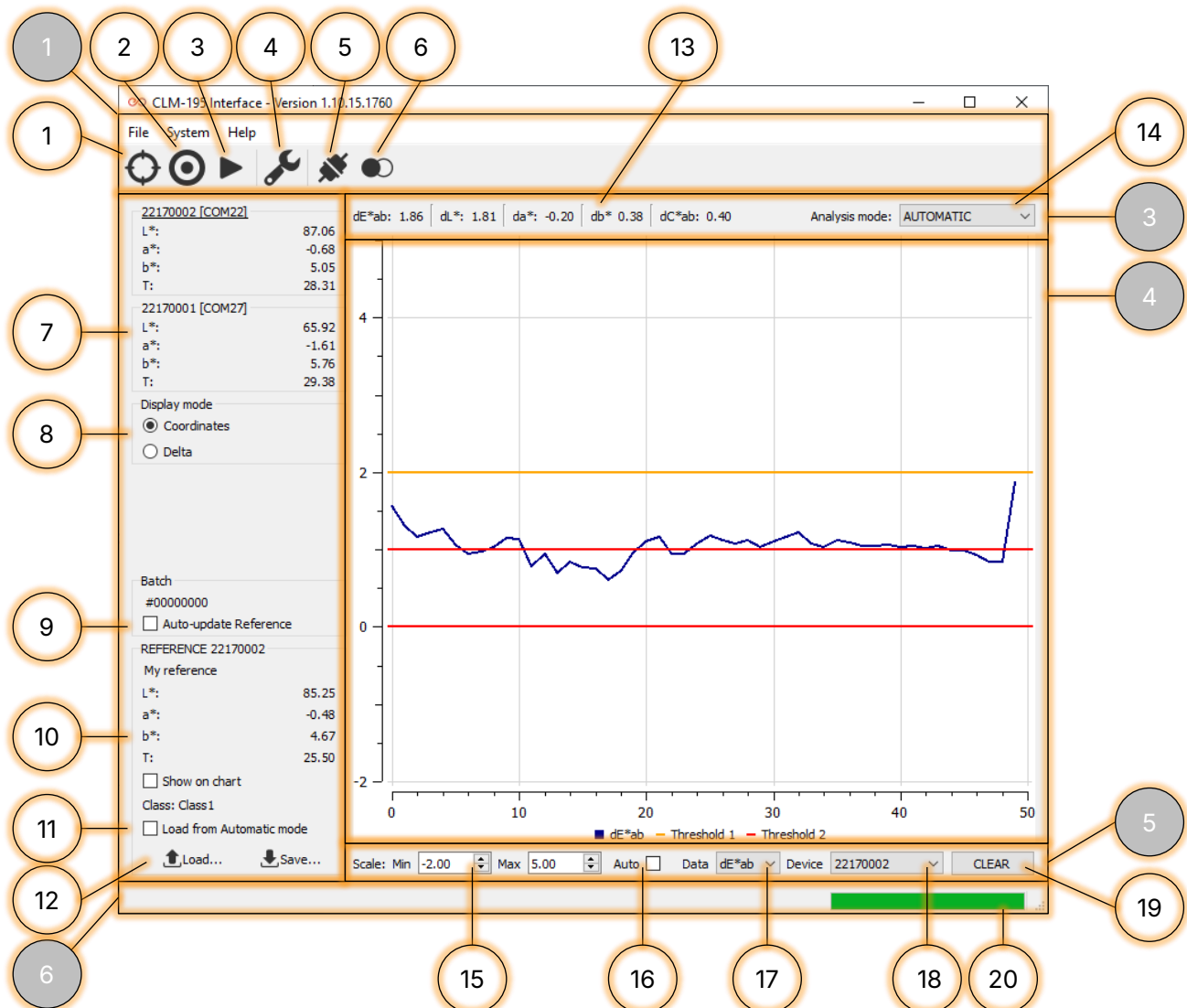


Figure 2: Software main window

Main controls

Item	Description
1	Main menu with toolbar
1	Measure Acquisition button
2	Reference Acquisition button
3	Continuous measure Start/stop
4	Open Settings dialog
5	Open Connect devices dialog
6	Perform user calibration
3	Analysis results panel
13	Analysis results
14	Analysis mode selector

Item	Description
2	Devices' mesures panel
7	Device mesures/delta
8	Display mode selector
9	Batch control
10	Current reference
11	Automatic mode class control
12	Load/Save reference buttons
4	Results chart
6	Status bar
20	Multiple measures acquisition status indicator

5	Charts control panel
15	Y axes limits
16	Y axes autoscale enable
17	Coordinate/quantity selector
18	Reference device selector
19	Clear graph button

The main menu ① on the top of the interface allows you to:

restart anew	-	File→New
configure acquisition	see 5.4.3	System→Settings...
connect/disconnect devices	see 5.4.1	System→Connect Disconnect devices...
perform user calibration	see 5.10	System→User calibration...
define software preferences	see 5.11	System→Preferences...
lock controls while running	see 5.12.1	System→Lock controls...
get system information	-	Help→About

The main toolbar ① features three pushbuttons that allow you to perform measures manually:

- ① Acquire *Measure* data
- ② Acquire *Reference* data
- ③ Start/stop automatic *Measure* data acquisition

Additional buttons allow fast access to system functions:

- ④ Opens Settings dialog see 5.4.3
- ⑤ Disconned devices or open Connect devices dialog see 5.4.1
- ⑥ Start user calibration procedure see 5.10

Measures and reference are shown in the *Devices' measure left panel* ②. For each connected device a *Device measure/delta panel* ⑦ will be displayed. The respective device serial number and connection port is shown on each panel. An underlined serial indicates that the device is used as Master (see 5.4.1, 5.5). Measure data can be displayed as color coordinates (*Display mode selector* ⑧ on "Coordinates") or as delta with respect to the reference (*Display mode selector* ⑧ on "Delta"). The *Current reference* box ⑩ indicates the color coordinates of the current reference. A reference can be acquired via *Reference Acquisition button* ② or loaded from file using the *Load reference from file button* ⑫. The acquired reference can also be saved on file with the corresponding button. If there are references file in the path defined in the "Saved references" field of the Prefrences dialog (opened via System->Preferences...), the list of the available references will be loaded and displayed in the currente refrence name; the user can select the reference to use from the combo box. New reference acquisitions will be used in place of the selected one; save the new reference in the defined path to have it in the list.

If the software is in automtmc analysis mode ⑭, the current class will be displayed ⑪. A control to use the current automatic class reference ⑪ will also appear in automatic mode.

The user can set a batch identifier ⑨ (to identify production batch, ...) that will be written in the software log. When starting new batch the user can choose to auto-update the reference by checking the appropriate control ⑨; the next measure (done manually or automatically) will be used as new reference (see 5.7.3).

Analysis results ⑬ are shown in the *Analysis results panel* ③. The labels show the various differences between the selected device ⑱ and the current reference ⑩. The user can select the analysis mode ⑭ (see 5.6).

The measures history is shown in the *Results chart* ④. The chart can be configured using the controls in the *Chart control panel* ⑤:

- ⑮ Set min/max Y axes value to scale graph
- ⑯ Enable/Disable automatic Y axes scale
- ⑰ Select quantity to display on chart
- ⑱ Select the reference device; the chart will display the measures/delta from this device
- ⑲ Clear the graph

If *Multiple Measures* are selected (see 5.4.3, 5.8) the *Multiple measures acquisition status* indicator ⑳ in the *Status bar* ⑥ will display the progress of the measures.

5.4.3 SETTINGS DIALOG

The *Settings dialog* allows the user to finely configure the acquisition process and the software analysis.

5.4.3.1 ACQUISITION SETTINGS

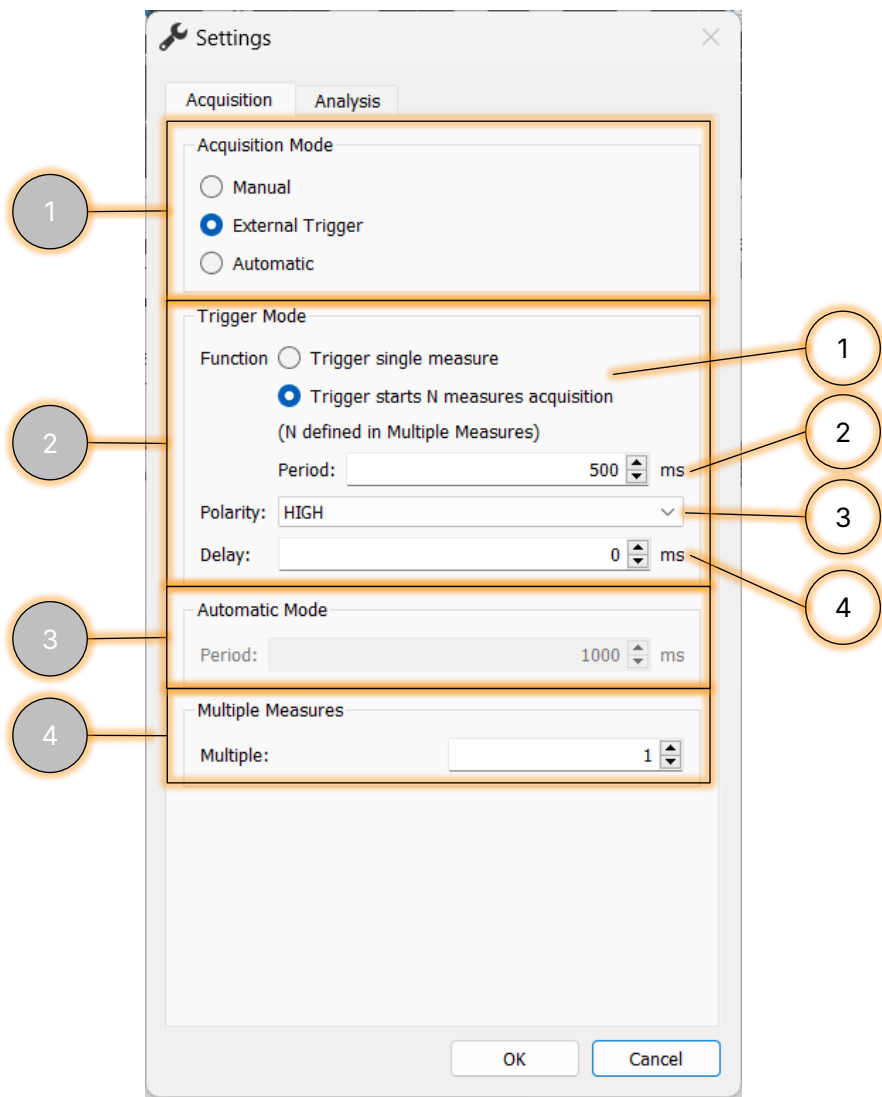


Figure 3: Settings dialog; Acquisition settings tab

Main controls

Item	Description
1	Acquisition Mode selector
2	Trigger Mode settings
1	Trigger function
2	Period in trigger-started mode
3	Trigger polarity
4	Acquisition delay
3	Automatic Mode settings
4	Multiple measures settings

The *Acquisition mode selector* ① will set the way the software acquire measures data from the device. In *Manual mode* the user will use the *Measure Acquisition button* from the *Main window* to acquire data. In *External Trigger mode* is selected, the acquisition is controlled via a hardware trigger connected to Master device's GPIO IN1. The *Trigger Mode settings* controls ② allow to configure the use of the trigger signal:

- ① Select trigger signal functionality
- ② Define period of automatic acquisition in trigger-started mode
- ③ Define trigger polarity
- ④ Set a fixed delay between trigger signal transition and actual event (measure capture/acquisition start)

Given the functionality selected, the trigger signal will generate one of these events:

- *Trigger single measure*: when the trigger edge is detected, the device acquires a single measure
- *Trigger starts N measures acquisition*: when the trigger edge is detected, an automatic acquisition starts. The device acquires a new measure periodically, given the period set in the *Period in trigger-started mode* control ②. The number of measures acquired is defined in the *Multiple measures settings* ④. The acquired measures will be averaged and the result will be returned.

In *Automatic mode* the user will manually start/stop the acquisition process using the *Continuous measure start/stop button* from the *Main window*; the software will trigger a new measure periodically, given the period set in the *Automatic mode settings* ③.

Each measure acquired and analyzed can be generated by a single measure or as an average of multiple measures. The number of measures used will be configured in the *Multiple measures settings* ④.

5.4.3.2 ANALYSIS SETTINGS

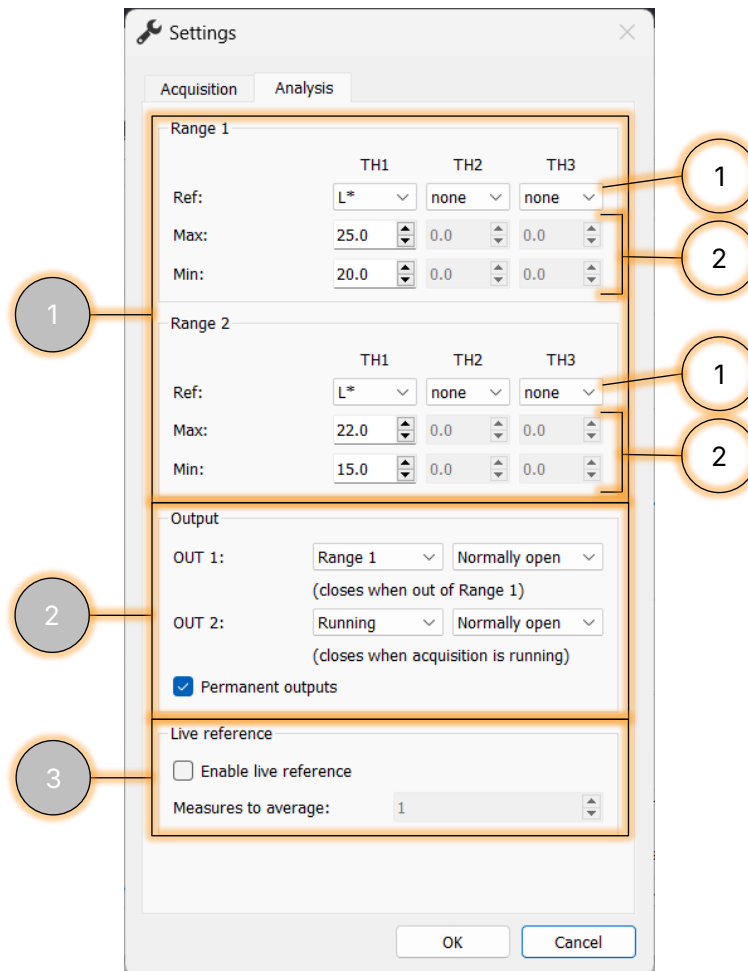


Figure 4: Settings dialog; Analysis settings tab

Main controls

Item	Description
①	Analysis thresholds settings
①	Controlled quantities
②	Min/Max thresholds
②	Device GPOutput settings
③	Live reference settings

The software will perform several computations on the acquired measures. All data can be seen on the *Main Window*.

The software can be configured to control the master device's GPOutput if some conditions are met. The user can define two acceptance ranges ①, that will control the respective master device's GPOutputs ②. For each range up to 3 quantities ① can be monitored, defining an acceptance range via the *Min/Max* ②. The controls will define when the GPOutputs will switch, given the current measure and/or the relation with the current reference. The GPOutputs will be driven accordingly to the analysis results on every measure. In automatic/triggered acquisition, if the *Permanent outputs* control is checked, when a GPOutput is driven due to a threshold overflow it will remain in fault status until a the acquisition is stopped.

It is also possible to control the output given the "running" status of an automatic/triggered acquisition (see 5.4.3.1).

The thresholds will also be displayed in the *Main Window* measure chart when monitoring a quantity for which an acceptance range was set.

The master device can signal the processing status to the control line (PLC, ...) using its GPOutputs. The GPOutputs normal status can be configured from the *Device GPOutput settings* [2](#).

Each measure will be compared to the current reference. Such reference can be automatically computed as an average of the last N measures. The functionality can be enabled and configured from the *Live reference settings* [3](#).

5.5 ANALYSIS SETTINGS

The software can be configured to monitor specific quantities and signal when the measurements are out of range via master device's GPOutputs. The configurations will be done on the *Settings dialog* (see 5.4.3).

For every range the user can select up to 3 quantities to monitor:

- L^* , a^* , b^* : specify min/max thresholds for the measure coordinates
- dL^* , da^* , db^* : specify min/max thresholds for the coordinate difference between the current measure and the reference
- dE^* : specify min/max thresholds for the colorimetric difference between the current measure and the reference
- dC^*ab : specify min/max thresholds for the chromatic difference between the current measure and the reference
- none: disable a min/max threshold

When any of the monitored quantities in a given range will fall outside min/max threshold for any of the connected devices, the condition will be signaled on the related master device's GPOutput.

The GPOutput normal status can be configured from the *Settings dialog*, controlling the *Devices GPOutput settings* controls.

When monitoring a given quantity on the *Results chart*, if min/max thresholds are defined on any range for the given quantity, such thresholds will be plotted on the graph (see Figure 1).

5.6 ANALYSIS MODES

The software compares the current measure with the reference, and given the analysis settings display different results.

Analysis settings can be adjusted in the Settings dialog (see 5.4.3). Analysis settings can also be automatically loaded by the software given the selected analysis mode (see 5.4.2).

5.6.1 FULL MANUAL MODE

This is the base analysis mode, set when the software starts up. The user can fully adjust the analysis settings from the Settings dialog (see 5.4.3). The software will compute results given such settings. On any change, settings will be saved in file

```
C:\Users\Public\Documents\EOPTIS\CLM195 Software Suite\ini\settings.ini
```

This file can be used to generate automatic and manual modes (see 5.6.2 and 5.6.3).

5.6.2 AUTOMATIC MODE

In automatic mode the software automatically loads analysis settings given the current reference. The acquired referenced will be compared with references stored in automatic mode config folders. The configuration with the reference that is nearest (minimum dE^*ab) to the current reference will be used. The settings are loaded and visible in the Settings Dialog (see 5.4.3), but can't be edited by the user.

5.6.2.1 AUTOMATIC MODE CONFIG FOLDER

Automatic mode config files are stored in folder

```
C:\Users\Public\Documents\EOPTIS\CLM195 Software Suite\ini\workingModes\automatic
```

On startup, the software will check all subfolders and load all settings file contained in them. Each folder must contain a settings file and a reference file. Subfolder name will be used as automatic mode/class name.

5.6.2.2 POPULATE AUTOMATIC MODE FOLDER

Create folder

First, create a new folder for the new automatic class. Name the folder as desired (ex. class1); the name will be used to identify which automatic mode/class the software is currently using.

The created folder must contain:

- a settings file
- a reference file

Settings file

The settings file can be generated on the corresponding CLM195 Interface's dialog. Pressing the OK button will update settings.ini file in the software ini folder

```
C:\Users\Public\Documents\EOPTIS\CLM195 Software Suite\ini\settings.ini
```

Copy such file in the created automatic mode subfolder.

NOTE: acquisition parameters (ACQUISITION_MODE, AUTOMATIC_MODE_PERIOD, ...) will be ignored.

Reference file

The reference file contains the coordinates that will be compared to the current reference to select which automatic mode/class to load for processing.

The file can be generated in two ways:

- via software: press the "Save..." button to save the current reference in reference.ini file
- manually: copy the sample reference.ini file and edit it manually, following the instructions on the file header

Copy the generated reference.ini file in the created folder.

See 0 for further details on reference acquisition/storing.

5.6.2.3 AUTOMATIC MODE USAGE

On next software startup, all automatic mode subfolders will be scanned, generating an equal number of automatic modes/classes.

"Analysis mode" combo box will only list "AUTOMATIC" mode, without signaling how many modes were loaded. The software will automatically select the mode/class given the distance between the current reference and each mode/class reference, and loads the corresponding analysis setting.

5.6.2.4 SETTINGS EDIT

Manual edit

The settings files can be manually edited on any text editor. Follow the instructions on the file's header.

Software edit

Settings can also be edited on CLM195 Interface's Settings dialog:

1. open software
2. select Analysis Mode AUTOMATIC
3. load reference of desired mode/class: use the "Load..." button to load reference.ini file from the desired mode/class configuration folder; settings for such class will also be automatically loaded
4. select FULL MANUAL mode; settings won't change, but become editable
5. edit settings on Settings dialog and press OK
6. close software
7. replace automatic mode settings.ini file with settings.ini in main ini folder

5.6.2.5 REFERENCE EDIT

Follow reference file creation notes to edit the file.

5.6.3 MANUAL MODES

Manual mode can be used to load preconfigured settings for the analysis. The user selects a manual mode from the list; the relative settings are loaded and visible in the Settings Dialog (see 5.4.3), but can't be edited by the user.

5.6.3.1 MANUAL MODE CONFIG FOLDER

Manual mode config files are stored in folder

```
C:\Users\Public\Documents\EOPTIS\CLM195 Software Suite\ini\workingModes>manual
```

On startup, the software will check and load all settings files (.ini) found.

Each file will be used as a manual configuration. The single manual configuration name will be the file name (without ".ini" extension).

5.6.3.2 GENERATE SETTINGS FILE

Configure software settings on the corresponding CLM195 Interface's dialog. Pressing the OK button will update settings.ini file in the software ini folder.

Copy such file in

```
C:\Users\Public\Documents\EOPTIS\CLM195 Software Suite\ini\workingModes>manual
```

rename it, preserving ".ini" extension.

NOTE: acquisition parameters (ACQUISITION_MODE, AUTOMATIC_MODE_PERIOD, ...) will be ignored.

5.6.3.3 MANUAL MODE USAGE

On next software startup, the files will be loaded and the corresponding manual modes will be listed in the "Analysis mode" combo box. Selecting a manual mode will load the corresponding analysis settings.

5.6.3.4 SETTING EDIT

Manual edit

The settings files can be manually edited on any text editor. Follow the instructions on the file's header.

Software edit

Settings can also be edited on CLM195 Interface's Settings dialog:

1. open software
2. select Analysis Mode FULL MANUAL
3. select FULL MANUAL mode
4. edit settings on Settings dialog and press OK
5. close software
6. replace manual mode .ini file with settings.ini in main ini folder (remember to rename the file), or replace manual mode .ini file content with settings.ini

5.7 REFERENCE SETTINGS

The reference measure can be acquired in two ways: from the device and from a file.

5.7.1 REFERENCE ACQUISITION FROM THE DEVICE

Prepare the reference sample and the CLM195 devices for the acquisition, then press the *Reference Acquisition button* on the interface. The measure will be displayed in the *Current reference panel*. The results on the interface (e.g. measure/reference differences) will be updated using the new reference acquired.

The new reference will be used for the following measures analysis.

The reference name can be changed manually by clicking on the reference name and writing a new one.

5.7.2 REFERENCE LOAD FROM FILE

A reference file can be loaded using the *Reference Load button*. The reference coordinates from the file will be loaded and used for the following measures analysis. An example reference file *reference.ini*, with all the info to edit/generate reference files, can be found in the main configuration folder

```
C:\Users\Public\Documents\EOPTIS\CLM195 Software Suite\ini\
```

Reference files are text files that define various parameters of the reference (name, coordinates, ...).

A reference file can be created:

- Using the *Reference Save button* after acquiring a reference from the device
- Creating/editing a .ini file (e.g. the example *reference.ini* one)

5.7.3 AUTO-UPDATE REFERENCE

When the Auto-update Reference control is checked (see 5.4.2) the software will interpret the next acquisition as a new reference. This can be useful when the software is doing continuous measures in automatic or trigger mode, without stopping/starting the acquisition.

5.8 MULTIPLE ACQUISITIONS

Multiple Acquisition should always be performed in cases of uneven or structured surfaces. The advantage of Multiple Acquisition is that the visual evaluation is supplemented by the calculation of a mean for the measured values. The Multiple Acquisition feature is enabled by specifying a number greater than 1 in the *Multiple Measures* control (see 5.4.3). The user will need to acquire a number of samples (manually or automatically/triggered) equal to the set value; the software will average the samples and return the result as the new measure.

When Multiple Acquisition mode is active, the intermediate samples acquisition progress will be displayed on the *Multiple measures acquisition status indicator*.

5.9 RESULTS CHART

The results of the measurement analysis are displayed in various ways.

The current measure for the connected devices is displayed on the *Device measure/delta panels* in terms of:

- Measure coordinates
- Measure coordinates difference with respect to the current reference

The display mode can be selected using the *Display mode selector*.

The interface features a chart that will be update on every new measure/reference acquisition.

The quantities displayed on the chart will be selected using the *Coordinates/quantity selector*. The chart displays the requested quantities related to the device selected on the *Reference device selector*. An average of all the devices can also be selected. The *Reference device selector* configuration will also affect the data displayed on the *Analysis results panel*.

The graph's Y axis can be scaled setting the min/max values manually, or by enabling the autoscale. The autoscale will fit the real time monitored quantity in the graph. Note that the thresholds (if set for the monitored quantity) can fall outside the autoscaled range.

The graph can be manually cleared using the *Clear graph button*.

5.10 USER CALIBRATION

Each colorimeter is supplied with its own white reference standard, necessary to perform the user calibration. The standard is manufactured from highly stable materials and labelled with a unique serial number. Ensure that the colorimeter is used with its matching white reference standard and that the serial numbers match, otherwise calibration will lead to unpredictable results that may compromise system accuracy. It is recommended to calibrate the system every 3 months.

To perform the calibration:

1. Ensure the standard is clean otherwise clean it with a moist cloth. Do not use acetone or alcohol.
2. Apply the calibration adapter to the devices (if not already mounted)
3. Access the calibration panel on the "System→User calibration" software menu or via the *User calibration button*
4. For every device:
 - Apply the White reference standard to the colorimeter aperture. The target will fit perfectly in the adapter; ensure that there is full contact between the target and the adapter on the device aperture side
 - Hit the measure button



Figure 5: white reference standard positioning for user calibration

5.11 MEASURES LOG

Every measure performed by the software will be logged on a CSV file. The file path can be set from the main menu, under System→Preferences.... Be careful to select a path where you have write permission (e.g. the user Documents folder).

For every measure, the coordinates and the analysis results for all devices are logged.

The file can be analyzed with any spreadsheet software, by setting the char ';' as fields separator.

5.12 ADVANCED FEATURES

5.12.1 CONTINUOUS ACQUISITION AND CONTROLS LOCK

When the acquisition mode is set to Automatic or External Trigger, the user can start the Continuous measure mode (see 5.4.2 Main window). The device will automatically perform periodic measures with the frequency, or acquire measure whenever an external trigger is received.

To ensure the acquisition will go on without any inadvertent stop or settings changes, the user can lock several controls under a password. When the acquisition has started, the user can access System→Lock controls menu entry. This will open a password form that allows to lock following controls:

- Stop continuous acquisition button
- Start new or close window
- Acquisition and analysis settings and controls
- Device disconnect button
- User calibration controls

To enable the controls again the user must access the password form again via System→Unlock controls.

The password is needed both for locking and unlocking controls.

The default password after installation is: password.

The user can change the password from the Lock controls dialog.

5.12.2 CIE L*a*b* DIFFERENCE MODES

The user can select the CIE L*a*b* difference computation mode editing the settings file

`C:\Users\Public\Documents\EOPTIS\CLM195 Software Suite\ini\deltaEMode.ini`

The file can be edited with any text editor.

A list of standard CIE L*a*b* difference modes and relative indexes is described in the file header.

Set the DELTA_E_MODE parameter according to your need.

Note that the file is read by CLM195 interface software at startup.

6 TECHNICAL SPECIFICATIONS

Item	Description
Instrument class	Tristimulus colorimeter
Sensor type	Colour sensor based on the standard spectral value of the CIE 1931 colour matching functions as per DIN ISO 13655 and DIN 5033
Measurement mode	Reflective
Working distance	From 6 to 12 mm
Measurement geometry	Circumferential 45° illumination and 0° viewing, according to CIE15:2004, ASTM E1164
Light source	16 LEDs
Colour scales	CIE-L*a*b*
Colour differences	ΔE^*_{ab} (CIE 1976), ΔC^*_{ab} , ΔL^* , Δa^* , Δb^*
Illuminant/Observer	D65/CIE1931-2°
Available Illuminants (**)	D65, D55, D50, A, C, FL2, FL7, FL11
Available Observer (**)	CIE1931-2° and CIE1964-10° standard colorimetric observers
Short-term repeatability	0.03 ΔE^*_{ab} typ – D65/2°, standard deviation of 30 measurements every 5 s on white reference standard under Eoptis standard conditions (*)
Illumination/Measurement area	Ø10mm with a working distance of 12mm Ø6mm with a working distance of 7,5mm
Measurement time	<0.1 s, with 5 s minimum recommended measurement interval
Recommended warm-up time	20 minutes
Dimensions	74 x 100 x 100 mm
Weight	700gr
Enclosure type	IP54 per IEC 60529
Ambient temperature	0°C ; +45°C
Supply voltage	+24VDC nominal, Voltage range +9 ; +36 VDC
Interface	RS-485 + 1 digital input (trigger) + 2 digital outputs
Connection	Panel male connector M12 8poles
Repeatability	0.03 ΔE^*_{ab} typ
Software language	English

(*) 25 °C, 50% RH, 20' warm-up

(**) Illuminant/Observer pairs different from the default D65/2° must be explicitly requested in the order

Specifications subject to change without notice.


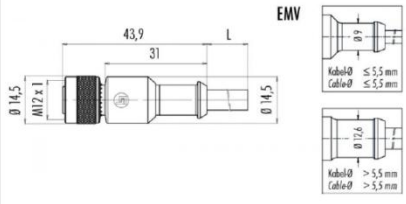
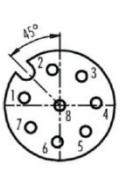
7 CONNECTIONS

7.1 CLM-195.CBL2 / CLM-195.CBL5

There is a 8-pole connector on the device and it's possible to connect to the CLM-195 with a 2 meters or a 5 meters cable.

The pinout of the connector and the provided cable is the following:

Pole	Color	Name
1	White	VDC
2	Brown	GND
3	Green	A
4	Yellow	B
5	Grey	GND
6	Pink	IN1
7	Blue	OUT1
8	Red	OUT2
SHLD	Black	SHIELD

Illustration	Scale drawing	Contact Arrangement																				
		 <table border="1"> <thead> <tr> <th>geschirmt/ shielded</th> <th>nicht geschirmt/ not shielded</th> </tr> </thead> <tbody> <tr><td>1 weiß/white</td><td>1 weiß/white</td></tr> <tr><td>2 braun/brown</td><td>2 braun/brown</td></tr> <tr><td>3 grün/green</td><td>3 grün/green</td></tr> <tr><td>4 gelb/yellow</td><td>4 gelb/yellow</td></tr> <tr><td>5 grau/grey</td><td>5 grau/grey</td></tr> <tr><td>6 rosa/pink</td><td>6 rosa/pink</td></tr> <tr><td>7 blau/blue</td><td>7 blau/blue</td></tr> <tr><td>8 rot/red</td><td>8 Schirm/shield</td></tr> <tr><td colspan="2">Gehäuse-Schirm/ Housing-shield</td></tr> </tbody> </table>	geschirmt/ shielded	nicht geschirmt/ not shielded	1 weiß/white	1 weiß/white	2 braun/brown	2 braun/brown	3 grün/green	3 grün/green	4 gelb/yellow	4 gelb/yellow	5 grau/grey	5 grau/grey	6 rosa/pink	6 rosa/pink	7 blau/blue	7 blau/blue	8 rot/red	8 Schirm/shield	Gehäuse-Schirm/ Housing-shield	
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7 blau/blue	7 blau/blue																					
8 rot/red	8 Schirm/shield																					
Gehäuse-Schirm/ Housing-shield																						

7.2 POWER SUPPLY

To properly power the system is necessary to have a wall mount power supply with these characteristics:

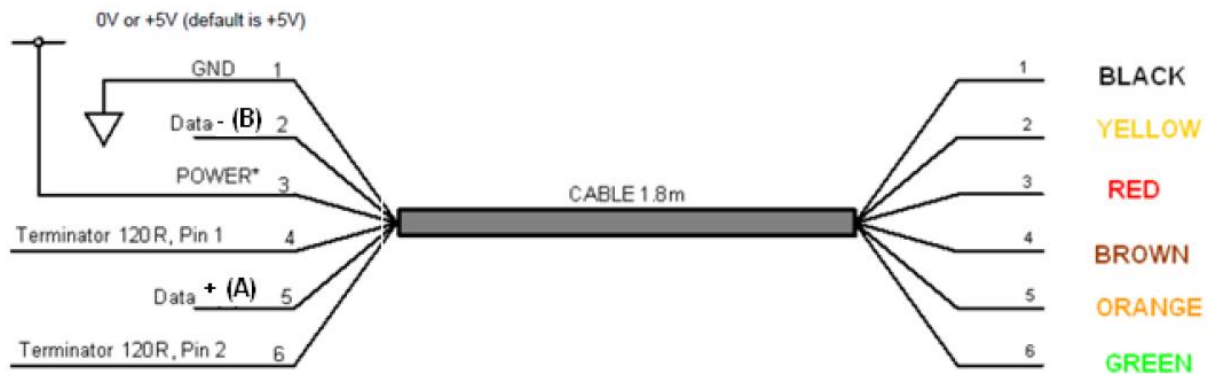
1. INPUT: 100-240 V ~ 0.3 A
2. FREQUENCY: 50/60 Hz
3. OUPUT: 24.0 V with DC Current at 1.0 A



7.3 USB TO RS-485 CONVERTER

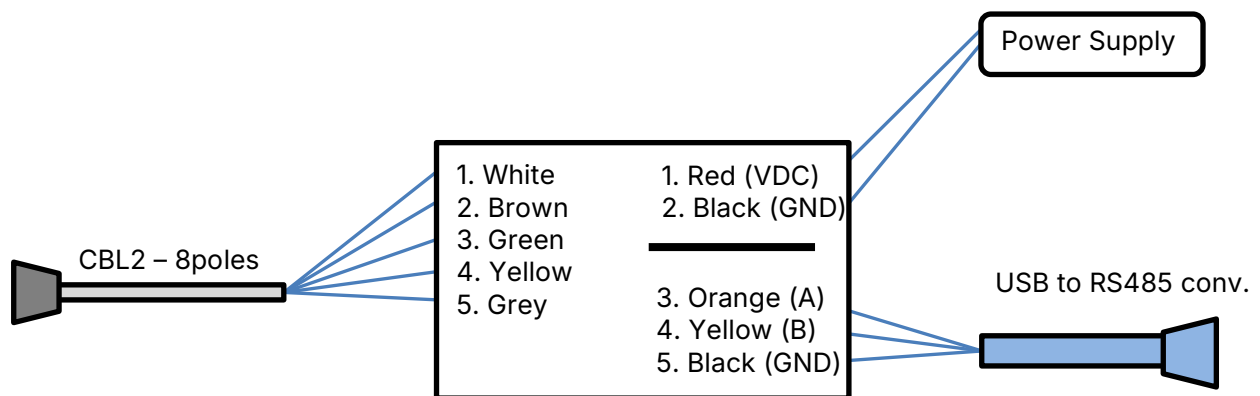
An USB to RS-485 converter is necessary for the CLM-195/PC connection.
To establish a proper working connection the pins of the converter must be associated to their respective pins of the CLM-195 cable.

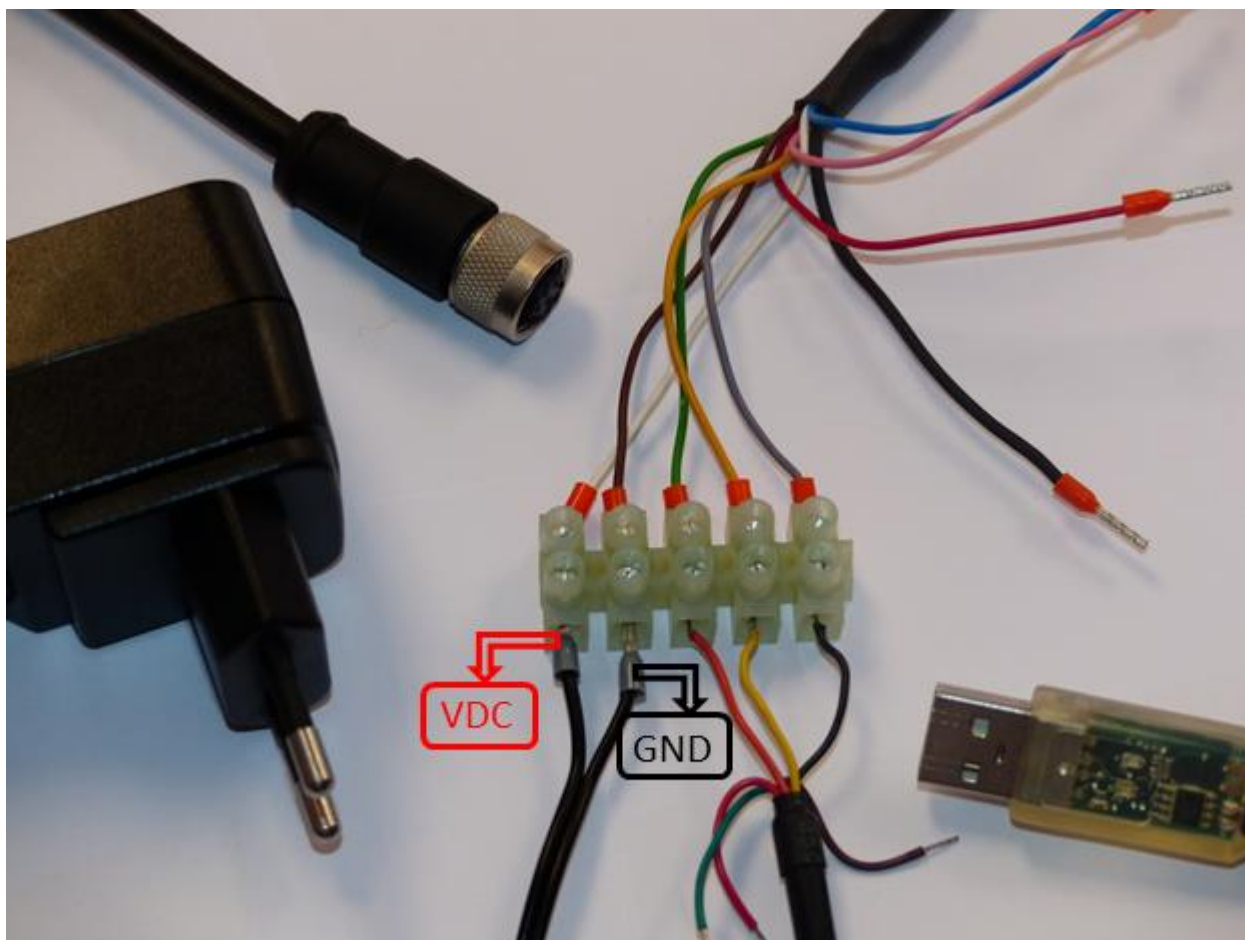
The pins of the USB/RS-485 converter are:



7.4 CONNECTION DIAGRAM

The last operation before start is to connect everything following this diagram:





8 REVISION HISTORY

Version	Date	Description
Rev.1.01	05.2016	Initial version
Rev.1.02	12.2016	Added Serial Baudrate register
Rev.1.03	05.2019	Removed RAW temperature sensor register Added target temperature registers (for temperature-controlled systems)
Rev.1.04	11.2019	Update to package content Updated installation instructions Added CLM195 Interface software guide Removed CLM19x Interface software guide
Rev.1.05	06.2020	Added Modbus protocol description Added CLMConfiguration software description
Rev.1.06	06.2020	Added external trigger control registers Added measure counter register
Rev.1.07	11.2020	Added Analysis mode description Added Display mode description Added Batch control description Added reference auto-update functionality
Rev.1.08	09.2021	Added back RAW temperature sensor register Added user calibration procedure description
Rev.1.09	01.2022	Added measure procedure description
Rev.1.10	03.2022	Edit to measure/user calibration procedure description Modified Settings panel description following new panel layout Added Live reference settings description
Rev.1.11	10.2022	Modified CLMConfiguration software description following new layout; added limits for parameters Modified Connect devices panel description following new mode (Interface selector) Modified main window screenshots following new layout Updated reference file format Added Connection diagram photo Added controls lock functionality Explicated default Illuminant/Observer
Rev.1.12	06.2023	Corrected Measure/Reference ΔE^*_{ab} Modbus register scale factor Added Measure/Reference ΔE^*_{ab} mode and internal trigger period registers
Rev.1.13	07.2023	Corrected RAW measure registers descriptions (inverted Green and Blue channels); updated descriptions of user calibration steps accordingly.
Rev.1.14	09.2024	Documented trigger-started acquisition mode
Rev.1.15	11.2024	Documented saved references list management
Rev.1.16	03.2025	Rebranding Expanded some registers' descriptions

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