metralight

C-frame Sensor

Technical specification (rev.B, November 2018), sensor firmware: 130 0v2

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1. Introduction

The C-frame Li-Ion powered handheld device is unique device allowing thickness and profile measurement. Two opposing projected laser lines on the measured surface captured by CMOS area sensors guarantees high accuracy results. Desk materials, like plywood, sheet metal, paper can be easily measured with no external controller or PC required for its operation. Integrated OLED display for quick result display allows simple operation.

2. Specification

Thickness measurement range	100 µm to 52 mm (0.004 to 2.05")
Height measurement range	max. 20 mm
Line size *	40 µm × 20.5 mm
Detector	CMOS (1280x1024 pixels)
Resolution	1 µm
Nonlinearity	25 µm
Height Resolution	24 µm
Response Time	33.34 ms for full readout or faster for partial readout
Interface	USB 2.0
Power	5V/700mA or 24V/500mA
Weight	300 g
Dimensions	204 × 134 × 25 mm (8.04 × 5.28 × 0.98 in)
Laser	650 nm, Class IM, P<3mW

Table 1: Sensor specifications

3. Description

3.1 Dimensions

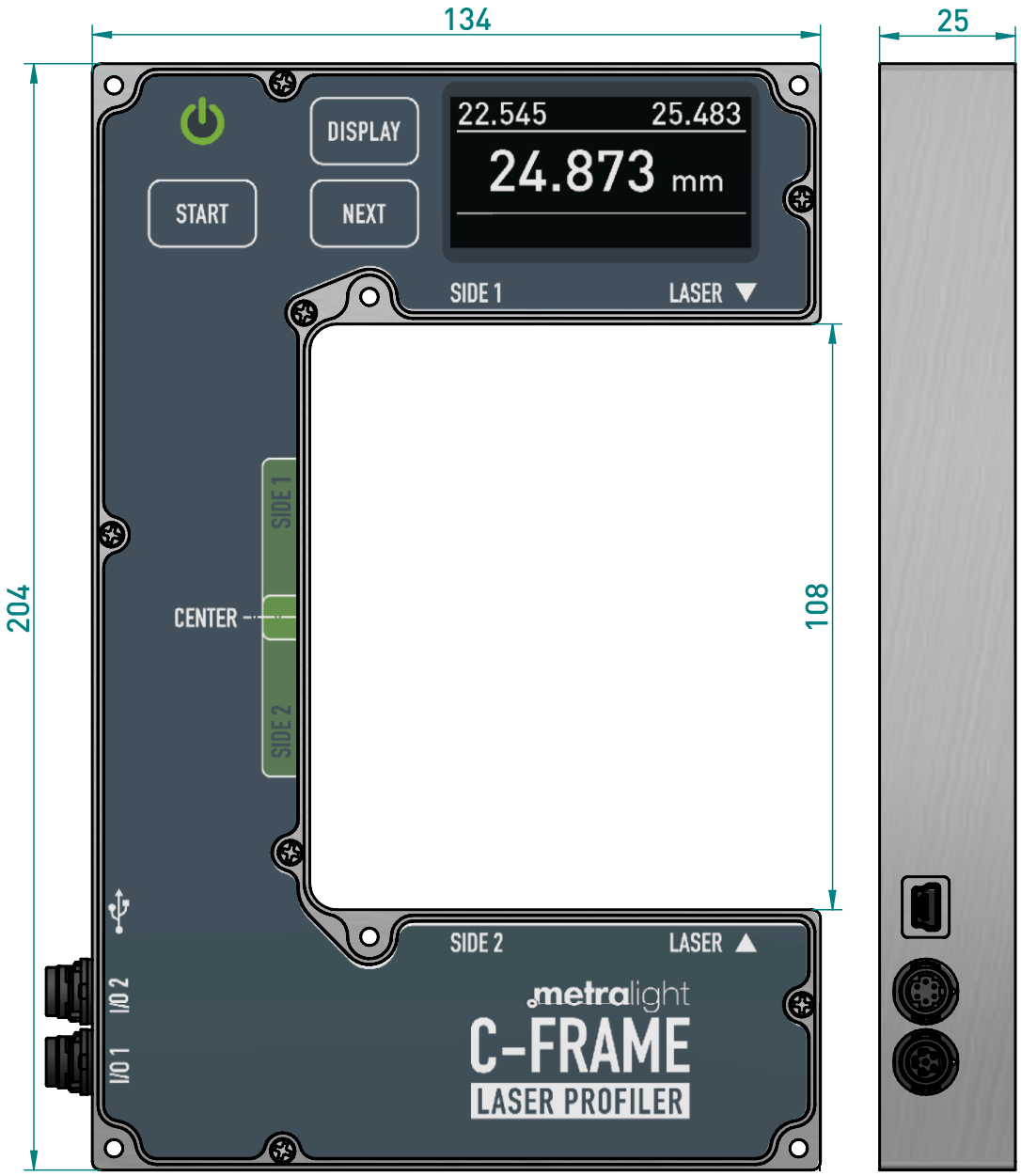


Image 1: C-frame sensor dimensions (mm)

3.2 Interface

3.2.1 USB 2.0

Full communication with sensor is provided by Mini-B USB connector. WinUSB driver needs to be installed for communication in OS Windows (see chapter Driver installation (page 13) for details). Charging over USB is not supported, use I/O 2 for charging and powering sensor.

3.2.2 I/O 1 connector

Serial connection is available over I/O 1. Only DATA and DATA_EXTENDED commands are available using this interface.

Serial parameters:

- baud rate 115200bps
- 1 start bit
- 1 stop bit
- no parity

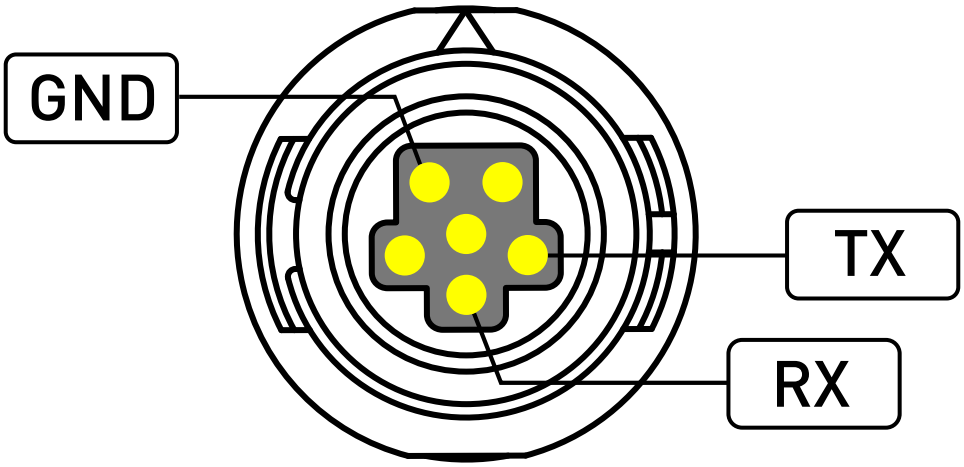


Image 2: I/O 1 connector

Connector specification:

Number of pins	6
Manufacturer	Hirose Electric (www.hirose.com)
Mnf. Part #	HR30-6R-6S(71)

3.2.3 I/O 2 connector

Power connection.

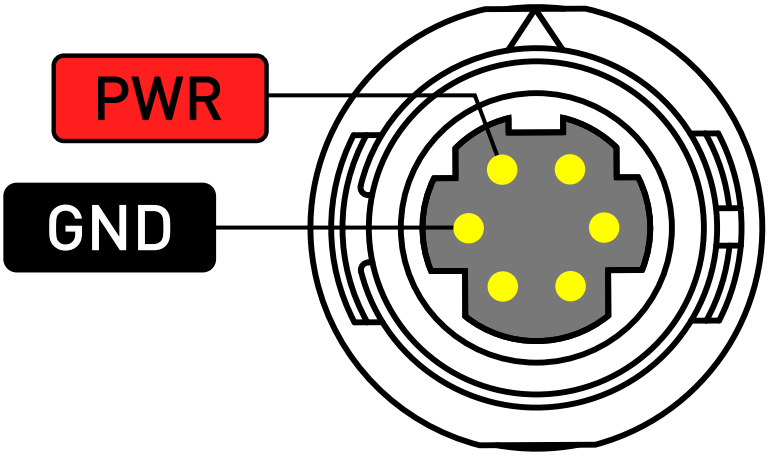


Image 3: I/O 2 connector

Connector specification:

Number of pins	6
Manufacturer	Hirose Electric (www.hirose.com)
Mnf. Part #	HR30-6R-6P(71)

3.3 Measuring range

See image below to understand how the sensor captures and handles the measured range. Red dashed reactangle represents measuring range displayed in TLTStudio.

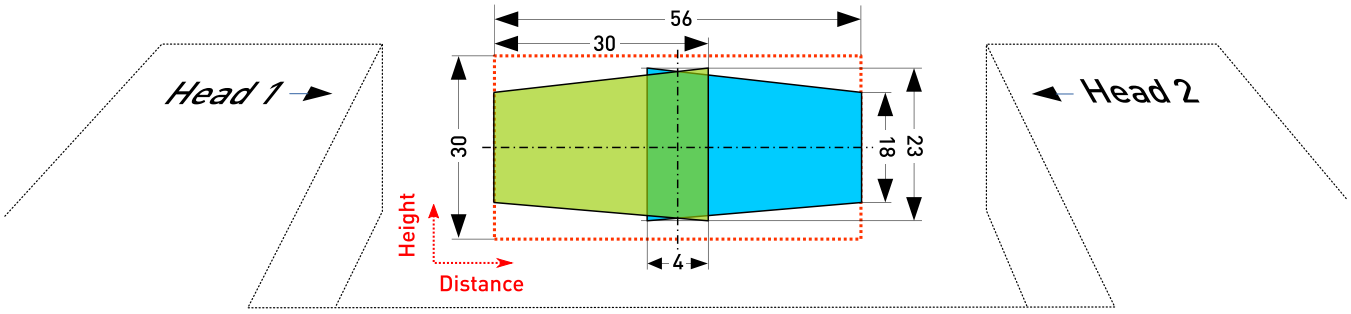


Image 4: Measuring range visualization

3.4 Firmware

Firmware of the C-frame sensor can be uploaded via TLT Studio SW.

3.5 Battery charging

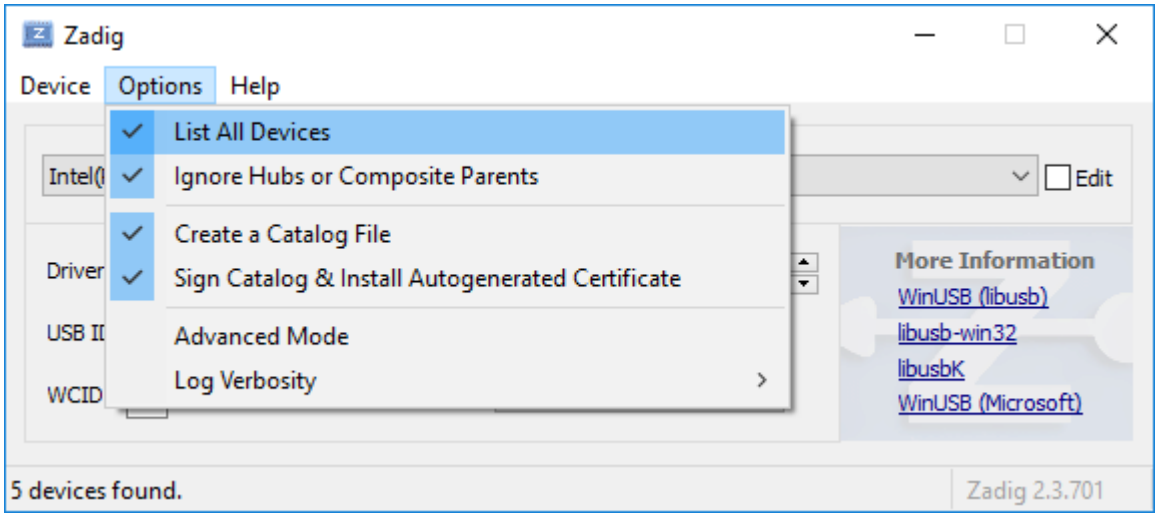
Sensor can be charged using provided charger via I/O 2 connector or via USB port. To charge using USB connection, special charging downstream port or dedicated USB charger have to be used. When sensor is ON, charging is slower, because sensor consumes some of the power for its operation.

The charging icon is visible on main screen when sensor is charging (see Display screens (page 16) for details).

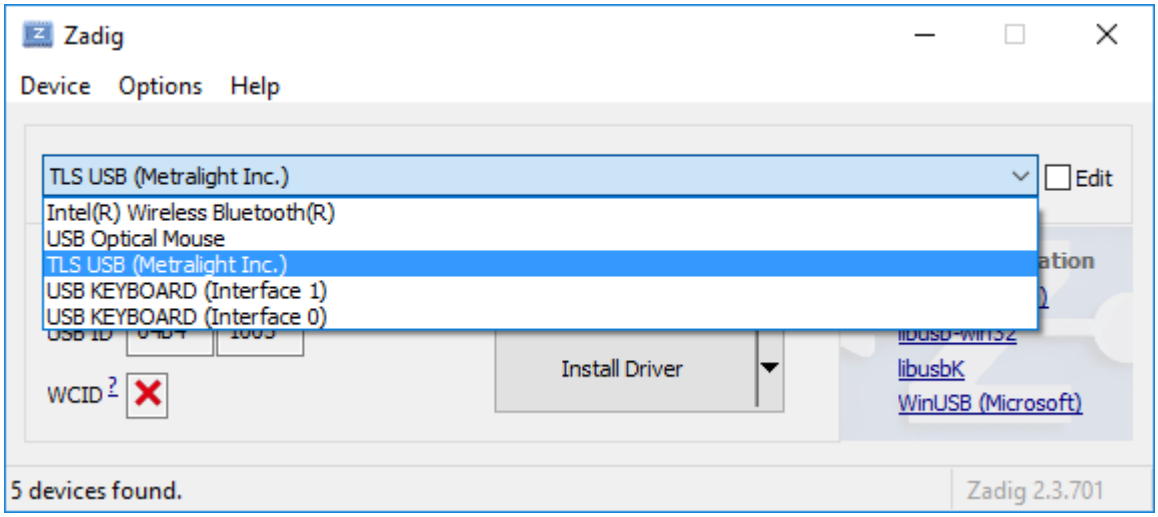
4. Driver installation

WinUSB driver has to be installed to communicate with sensor over USB. Complete following steps to install the driver:

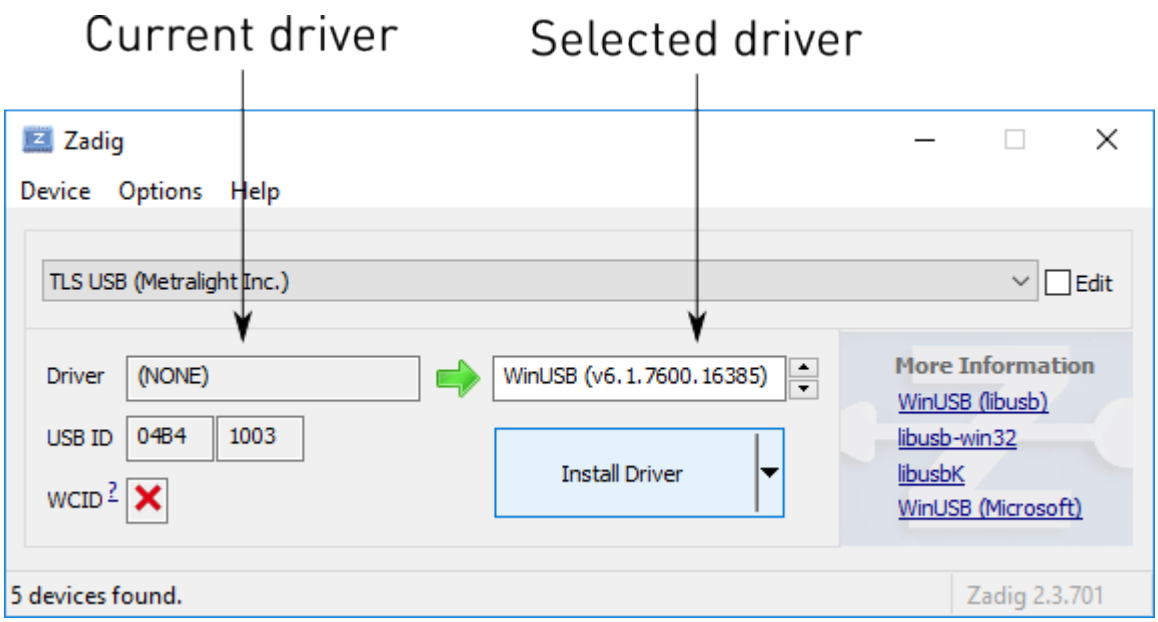
1. Download Zadig from zadig.akeo.ie or metralight.com
2. Run program
3. Check "List all devices" option in Options menu



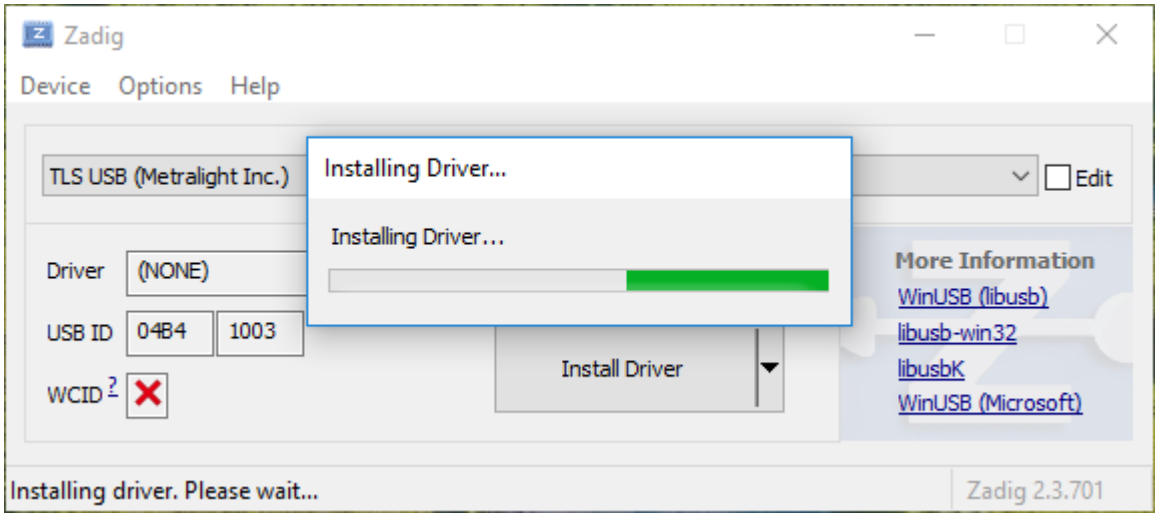
4. In devices list, select "TLS USB (Metralight Inc.)"



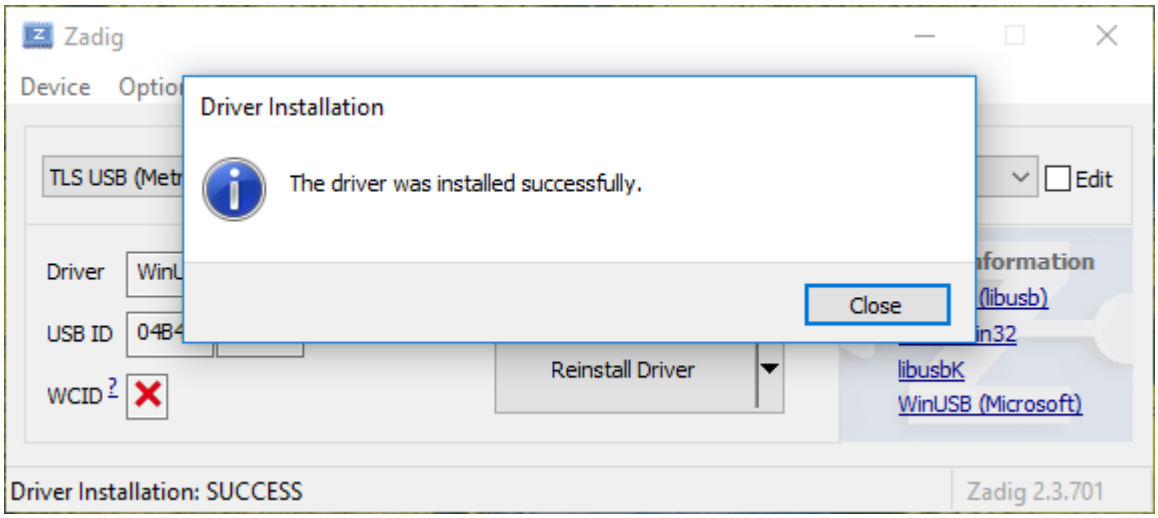
5. On left side, current driver is displayed. On right side in available drivers list, choose WinUSB"



6. Important! Make sure you have "TLS USB (Metralight Inc.)" selected in devices list
7. Press install to install WinUSB driver for C-frame sensor



8. "The driver was installed succesfully" message should be displayed


Zadig
Device
Driver Installation
The driver was installed successfully.
Close
Edit
Driver
USB ID
WCID
Reinstall Driver
libusbK
WinUSB (Microsoft)
Driver Installation: SUCCESS
Zadig 2.3.701

5. Display screens

Display screen can be changed using DISPLAY button. To change the value, use NEXT button.

5.1 Measuring

Main screen contains:

- **Min, Max:** Minimum and maximum measured values. Can be reset using START button when in Continuous or Start-stop measuring mode.
- **Current value:** Display currently measured value if in Continuous mode or last measured value if in Smaple or Start-stop mode.
- **Measuring status:** Displays ▶ when sensor is measuring or ❚❚ when not measuring - depends and running mode.
- **Running mode:** Displays ST-ST when in Start-stop mode, CONT when in continuous mode, SMPL when in Sample mode.
- **Units:** Selected measuring units.
- **Usb connection:** Icon is displayed when Usb communication cable is connected and recognized by the sensor.
- **Charging status:** Icon is displayed when battery is charging (see chapter Charging (page 12) for more details).
- **Battery status:** Icon indicates battery power status.
- **Object indicator:** Helps to recognize object position and size inside measuring range.

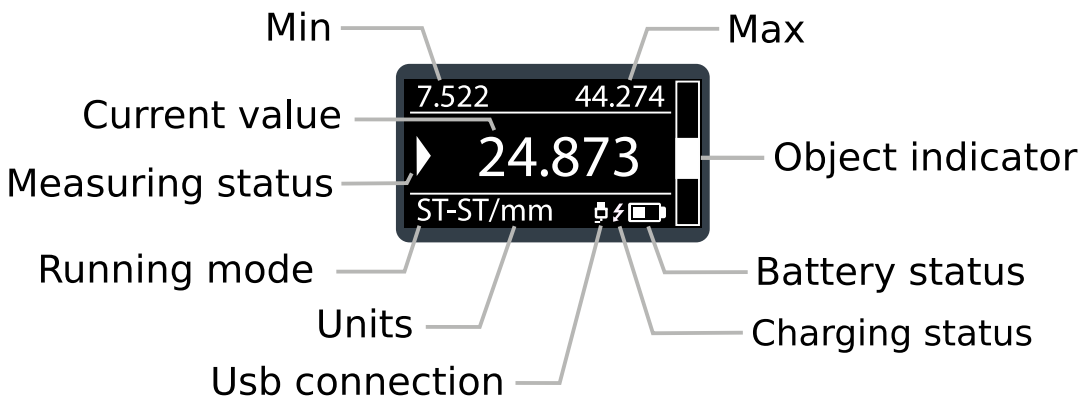


Image 5: Measuring screen

5.2 Units

Units can be selected from milimeters and inches.

Image 6: Units screen

5.3 Running mode

Running mode can be changed on this screen

- **Continuous:** Sensor continuously measures object and updates min/max. To reset min/max use START button.
- **Start-stop:** In this mode, continuous measuring can be turned on and off. With each start, min/max are reset.
- **Sample:** With each press of START button, sensor makes one measurement.

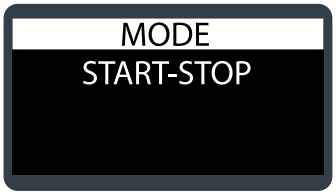


Image 7: Running mode screen

5.4 Contrast

Display contrast can be selected from low/medium/high options.

Image 8: Contrast screen

5.5 Exposure

Auto exposure can be turned on and off on the screen. Indicators display current time of integration on each sensor head.

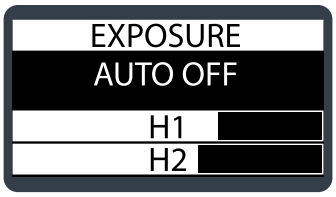


Image 9: Exposure screen

6. Command set

6.1 DATA

Hex: <0x1X>, where X specifies amount of requested data.

Sensor response: 2^X × DATA - see chapter Data format (page 24) for more details.

> **Example 1**
>
> PC request: <0x10> (request for 1 data)
>
> Sensor response: <38> <16> <39> <ab> <82> <1d> <39> <be> <4a> <07> <04> <10> <03> <e8> <e0> <e0>
> // H1_POINT1_DISTANCE = 0x3816 = 14358 µm
> // H1_POINT1_HEIGHT = 0x39AB = 14763 µm
> // H2_POINT1_DISTANCE = 0x821D = 33309 µm
> // H2_POINT1_HEIGHT = 0x39BE = 14782 µm
> // RESULT = H1_POINT1_DISTANCE - H2_POINT1_DISTANCE = 0x4A07 = 14782 µm

> **Example 2**
>
> PC request: <0x12> (request for 4 data)
>
> Sensor response: 4×16 bytes (see above)

6.2 DATA_EXTENDED

Hex: <0x3X>, where X specifies amount of requested data.

Sensor response: 2^X × DATA - see chapter Data format (page 24) for more details.

6.3 DATA_STREAM_start

Hex: <0x21>, continuous data stream start
Sensor response: measured data stream

Data format in the returned stream depends on type of the last used data command (DATA or DATA_EXTENDED). If DATA command was previously used, then standard data stream is returned. If DATA_EXTENDED command was previously used or if no data command was issued, extended data stream is returned. See chapter Data format (page 24) for info about data formats.

6.4 DATA_STREAM_stop

Hex: <0x20>, continuous DATA_EXTENDED stream stop
Sensor response: no response

See chapter Data format (page 24) for info about returned data.

6.5 PROFILE

Hex: <0x6X>, where X specifies number of requested profiles

Sensor response: 2^X × profile data

Profile data consists of profile rows (each row contains point from head 1 and point from head 2), extended data and profile counter. Number of rows is read from PRF_LENGTH register (see Registers map (page 19) and Register read command (page 22) for details).

PROFILE_DATA structure			
Section	profile rows (point from head 1 and head for each row)	extended data (see chapter Data format (page 24) for details)	profile counter
Bytes count	PROFILE_LENGTH * 8	64	2

Table 2: PROFILE_DATA structure

When multiple profile command is sent then profile counter sequencialy increases (+1). Missing number indicates lost of frame (communication slowdown). Position and length of sent profile is given by the ROI parameters of sensor heads. This way user can select only region of interest and decrease amount of transferred data.

6.6 FIRMWARE

Hex: <0xF0>, reads firmware version
Sensor response: two bytes

6.7 IMAGE

Hex: <0xD0>, read full images from sensor heads
Sensor response: NUMRW_WIN × NUMCL_WIN × 2 pixels (1 byte per pixel - grayscale image)

6.8 IMAGE_REDUCED

Hex: <0xD1>, read downsized images from sensor heads
Sensor response: floor(NUMRW_WIN × NUMCL_WIN × / 4) × 2 pixels (1 byte per pixel - grayscale image)

6.9 LASER_ON/OFF

For sensor head 1:
Hex: <0x91> for Laser ON, <0x90> for Laser OFF
Sensor response: <0x91> / <0x90>

For sensor head 2:

Hex: <0x93> for Laser ON, <0x92> for Laser OFF
Sensor response: <0x93> / <0x92>

6.10 AUTO_EXPO_ON/OFF

For sensor head 1:
Hex: <0x95> for Auto expo ON, <0x94> fro Auto expo OFF
Sensor response: <0x95> / <0x94>

For sensor head 2:
Hex: <0x97> for Auto expo ON, <0x96> fro Auto expo OFF
Sensor response: <0x97> / <0x96>

6.11 SET_BANK_PARAMETERS

Hex: <0x4X> to load parameters from EEPROM bank number X (cached). Data from EEPROM are cached only during sensor start-up sequence
Sensor response: <0x4X>

6.12 USER_EEPROM_WRITE

Hex: <0xB0> <ADDR_HIGH> <ADDR_LOW> <N_BYTES-1> <BYTE_1> ... <BYTE_N>
Sensor response: <N_BYTES-1>

ADDR range: 0 ÷ 65535
N_BYTES range: 1 ÷ 256

This command can write data in one memory page only. It's not possible to write data to more pages at once.

Example 1

Parameters to write:	head 1 STARTRW (2B)	0x0180	= 384
	head 1 NUMRW (2B)	0x0100	= 256
	head 1 SUBSEGMENT (1B)	0x00	= 0
	head 1 SEGMENT (1B)	0x20	= 32
	head 1 THRESHOLD (2B)	0x0060	= 90
	head 1 TINT (2B)	0x0419	= 1049
	head 1 DEF_LSR_OFF (1B)	0x00	= 0
	head 1 LSR_PWR (1B)	0x80	= 128

PC request: <0xB0> <0xFE> <0x00> <0x0B> <0x01> <0x80> <0x01> <0x00>
<0x00> <0x20> <0x00> <0x60> <0x04> <0x19> <0x00> <0x80>

Sensor response: <0x0B>

6.13 USER_EEPROM_READ

Hex: <0xA0> <ADDR_HIGH> <ADDR_LOW> <N_BYTES-1>
Sensor response: <N_BYTES-1> requested bytes

ADDR range: 0 ÷ 65535
N_BYTES range: 1 ÷ 256

> **Example 1**
>
> Read sensor parameters:
>
> PC request: <0xA0> <0xFE> <0x00> <0x0B>
>
> Sensor response: <0x01> <0x80> <0x01> <0x00> <0x00> <0x20> <0x00> <0x60>
> <0x04> <0x19> <0x00> <0x80>
>
> | | | |
> |---|---|---|
> | head 1 STARTRW (2B) | 0x0180 | = 384 |
> | head 1 NUMRW (2B) | 0x0100 | = 256 |
> | head 1 SUBSEGMENT (1B) | 0x00 | = 0 |
> | head 1 SEGMENT (1B) | 0x20 | = 32 |
> | head 1 THRESHOLD (2B) | 0x0060 | = 90 |
> | head 1 TINT (2B) | 0x0419 | = 1049 |
> | head 1 DEF_LSR_OFF (1B) | 0x00 | = 0 |
> | head 1 LSR_PWR (1B) | 0x80 | = 128 |

6.14 REGISTER_WRITE

For writing volatile sensor parameters - time of integration, laser power, etc.

Hex: <0x0D> <ADDR_HIGH> <ADDR_LOW> <PARAM_HIGH_BYTE> <PARAM_LOW_BYTE>
Sensor response: <0x0D>
Parameters with initial value stored in EEPROM have ADDR_HIGH=0x00 and ADDR_LOW is same as for EEPROM.

> **Example 1**
>
> Parameters to write: TINT - address <0x09> - value 0x012C (300)
>
> PC request: <0x0D> <0x00> <0x09> <0x01> <0x2C>
>
> Sensor response: <0x0D>

6.15 REGISTER_READ

For reading volatile sensor parameters - time of integration, laser power, etc. Addresses of parameters are the same as for

eeprom - use low byte of eeprom address.

Hex: <0x0C> <ADDR_HIGH> <ADDR_LOW>
Sensor response: <PARAM_HIGH_BYTE> <PARAM_LOW_BYTE>

> **Example 1**
>
> Parameters to read: TINT - address 0x09
>
> PC request: <0x0C> <0x00> <0x09>
>
> Sensor response: <0x01> <0x2C> (TINT is 300)

7. Data format

Sensor is able to return simple data on standard DATA command or extended on DATA_EXTENDED, PROFILE, IMAGE, IMAGE_REDUCED and DATA_STREAM commands. Standard data can be used for simple measure-and-compare tasks to limit number of transfered bytes. For more complex measurements or data processing, extended data can be used.

Standard data format contains one point and one aux byte for each sensor head and one result value:

Byte no.	Value
1-4	H1_POINT1
5-8	H2_POINT1
9-10	RESULT
11-14	reserved for future use
15	H1_AUX
16	H2_AUX

Table 3: Standard data format

Extended DATA contains four points for each head, one result value and two aux bytes for each head:

Byte no.	Value
1-4	H1_POINT1
5-8	H1_POINT2
9-12	H1_POINT3
13-16	H1_POINT4
17-20	H2_POINT1
21-24	H2_POINT2
25-28	H2_POINT3
29-32	H2_POINT4
33-34	RESULT
35-60	reserved for future use
61	H1_EXT_AUX
62	H1_AUX
63	H2_EXT_AUX
64	H2_AUX

Table 4: Extended data format

Each point consists of two coordinates - distance and height, each occupies two bytes:

Byte no.	Value (where x = 1|2, y = 1|2|3|4)
1	Hx_POINTy_DISTANCE high byte
2	Hx_POINTy_DISTANCE low byte
3	Hx_POINTy_HEIGHT high byte
4	Hx_POINTy_HEIGHT low byte

Table 5: Point format

AUX_BYTE format		
Bit #	**Bit name**	**Description**
7 (MSB)	OIN	Object detected in measurement range
6	ZERO_CNT	Indicates Line in processing window which has 0 pixels over threshold
5	OVER410_CNT	Indicates Line in processing window with signal width>410 pixels
4	0	unused
3	USER_PAR_CHG	User's parameters changed after power-up
2...0	MODES	Measuring mode, see chapter Measuring modes (page 34)

Table 6: AUX_BYTE format

8. EEPROM memory map

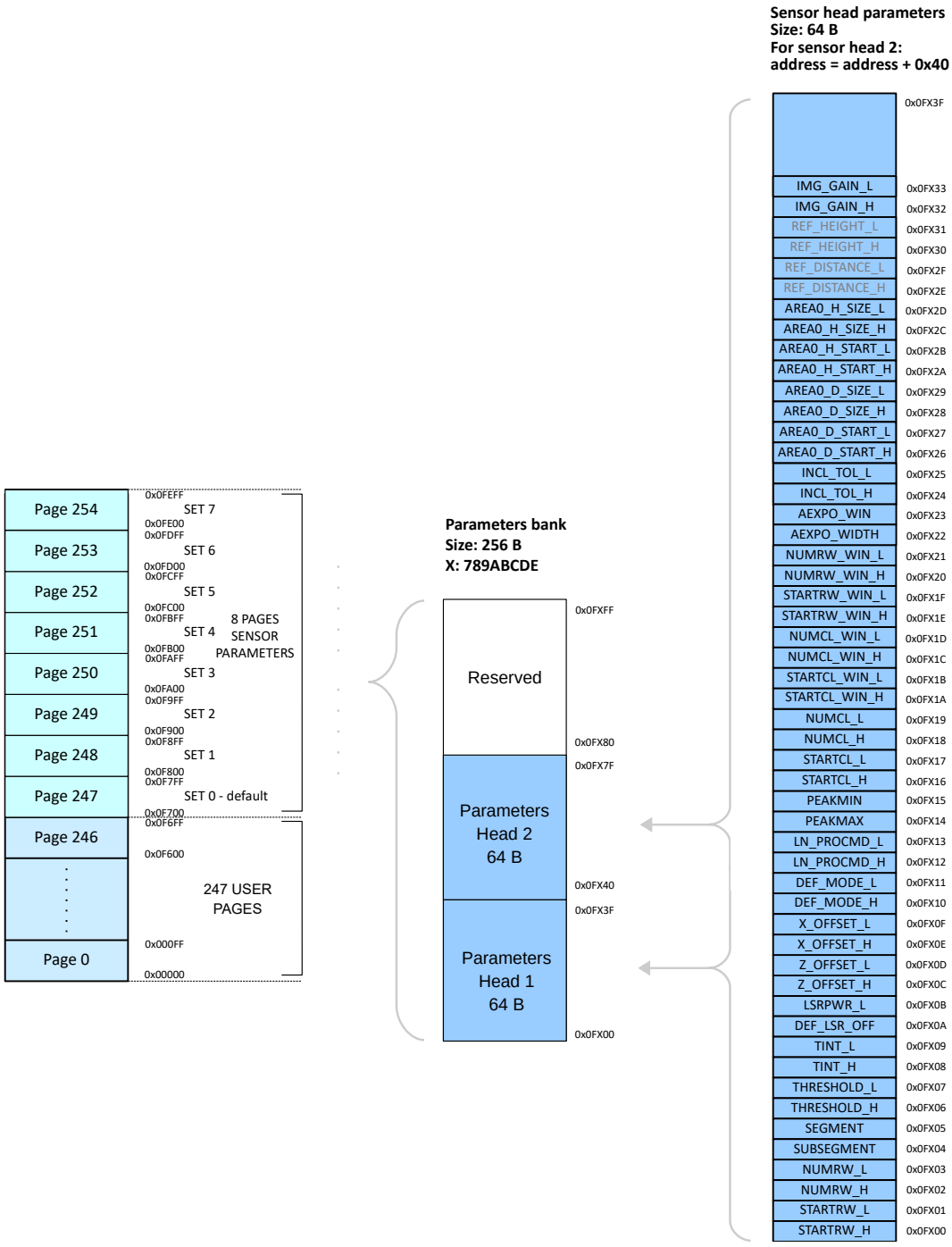


Image 10: Sensor memory structure

Sensor is equiped with 64kb EEPROM memory. Memory is divided into 256 pages (numbered 0-255) with size 256B. Pages

0-246 are user pages. Pages 247-254 are sensor parameter banks.

Each sensor parameter bank (247-254) consists of sensor parameters for each head and currently unused space.

Sensor parameters occupies 64 bytes. Most of parameters consists of two bytes, a few occupies only 1 byte. Complete list of parameters is visible in the image above and is also described in chapter Sensor parameters (page 30).

9. Registers map

Besides sensor parameters, which are present both in volatile registers and EEPROM map (volatile parameters, which has its initialization value in eeprom - same addressing for volatile registers and eeprom), there are some volatile registers which are not present in EEPROM banks.

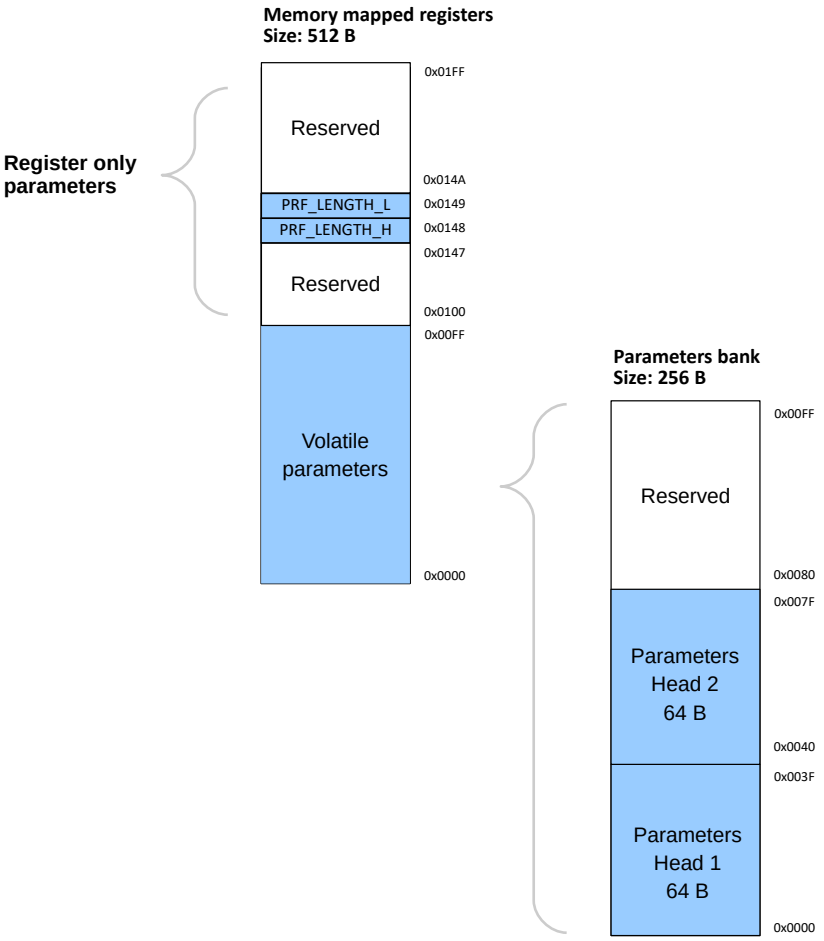


Image 11: Register map

10. Sensor parameters

This chapter describes sensor parameters which can adjust measuring, image processing and workflow. Changes of volatile parameters (see chapter Command set (page 19)) have immediate effect to sensor behavior. Set of sensor parameters can be saved in one EEPROM bank. Total 8 EEPROM banks are available (BANK 0-7). BANK_0 contains default setting used on power-up. User can switch between banks to quickly change sensor parameters - see EEPROM memory map (page 27).

Sensor consists of two measuring heads, therefore Image, Profile, Profile processing and Other parameters are available separately for each head.

10.1 Image

Name	Description	Unit	Range
TINT	time of integration	-	1-1049
IMG_GAIN	image gain	-	1-15
LSRPWR	laser power	-	0-255
DEF_LSR_OFF	laser off	-	0 | 1
Active window on image sensor (affect sensor frame rate) - must have same size for head 1 and head 2			
STARTRW_WIN	first row of window	pixel	0-1020
NUMRW_WIN	number of rows of window	pixel	3-1024
STARTCL_WIN	first column of window	pixel	0-680, only even
NUMCL_WIN	number of columns of window	pixel	600-1280, only even

Table 7: Image sensor parameters

10.2 Profile

Name	Description	Unit	Range
THRESHOLD	minimal pixel value for peak detection on the line	light intensity	1-255
LN_PROC_MODE	Mode of peak selection on the line: 0 - ALL OVER THR 1 - LAST PEAK (CLOSEST TO SENSOR) 2 - FIRST PEAK (FURTHEST FROM SENSOR) 3 - BIGGEST PEAK	-	0 | 1 | 2 | 3
PEAK_MIN	minimal valid peak width	pixel	1-255
PEAK_MAX	maximal valid peak width	pixel	1-255
Region Of Interest (ROI) definition (ROI specifies area in raw image for Profile computation), ROI has to be inside active window of image sensor			
STARTRW_ROI	first row of ROI	pixel	1-1022
NUMRW_ROI	number of rows of ROI	pixel	1-1022
STARTCL_ROI	first column of ROI	pixel	1-1278
NUMCL_ROI	number of columns of ROI	pixel	1-1278

Table 8: Profile sensor parameters

10.3 Profile processing

Name	Description	Unit	Range
SEGMENT	segment size for profile filtering	pixel	1-255
SUBSEGMENT	required continuity of profile, higher number = lower tolerance for missing profile points	pixel	SUBSEGMENT<SEGMENT
INCL_LIM	inclination limit for object search	-	0-255

Table 9: Profile processing parameters

10.4 Other parameters

Name	Description	Unit	Range
AEXPO_SEGMENT	flatness of measured surface (recommended value is 64)	-	2-255
AEXPO_INTENSITY	required exposure level for SET_AUTO_EXPO command (recommended value is 16)	-	1-64

Table 10: Other sensor parameters

10.5 Register only

Following parameters are available only as volatile registers.

Name	Description	Unit	Range
H_RANGE	Sensor height range (read only) *	µm	-
D_RANGE	Sensor distance range (read only	µm	-
CFG_FLAGS	configuration flags (read only)	-	0 | 1

Table 11: Register only parameters

* Real height measuring range is always smaller than H_RANGE (to avoid negative numbers).

More information about DIGI_IO register can be found in chapter I/O read/write (page 0).

CFG_FLAGS register has following structure:

Address	**0x0100**							
Param	**CFG_FLAGS_H**							
Bit #	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Bit usage	unused					SYNC_ERR	CONF_CHANGED	unused

Table 12: Configuration flags - high byte

SYNC_ERR bit: '1' if heads are out of sync, '0' otherwise, if out of sync, try to send SYNC command
CFG_CHANGED bit: '1' if some sensor parameter was changed, '0' otherwise

Address	0x0101							
Param	CFG_FLAGS_L							
Bit #	7	6	5	4	3	2	1	0
Bit usage	unused		H2_AEXPO_ON	H1_AEXPO_ON	POS_ENC_CNT	PROFILE_ON_IMG	H2_LSR_ON	H1_LSR_ON

Table 13: Configuration flags - low byte

H2_AEXPO_ON, H1_AEXPO_ON bits: '1' auto expo on, '0' auto expo off for each sensor head
POS_ENC_CNT:
PROFILE_ON_IMG: '1' if profile type is set to be displayed on image (values are recalculated), '0' otherwise
H1_LSR_ON, H2_LSR_ON bits: '1' laser on, '0' laser off for each sensor head

11. Measuring modes

C-frame sensor was primarily designed to measure thickness of desk materials. For this task and other simple measurements, the measuring mode of both sensor heads is set to Mode 0 - mean distance. Result thickness is difference between distance measured by head 1 and distance measured by head 2. Using different modes for sensor heads, it is possible to measure in various other tasks. Available modes:

- **MODE 0 - Mean Distance:** MODE 0 is intended for measuring of distance from basic plane. Plane can be straight or curved. Result data is average distance of the number of points - user can set the length of processed line using ROI.
- **MODE 1 - Closest Segment:** In this mode, sensor finds closest part of the object to the sensor. Size of this object (part of the laser line) is given by the SEGMENT parameter.
- **MODE 2 - First Light Segment:** MODE 2 is primarily intended for measuring of object EDGE. Measured object has to be presented from sensor top side. SEGMENT parameter specifies the portion of projected line used for calculating.
- **MODE 3 - Last Light Segment:** Same as MODE 2, but object is inserted from the bottom side of the sensor.
- **MODE 4 - Furthest Segment:** Same as MODE 1, but algorithm finds furthest part of laser line from the front side of the sensor (with biggest distance from the sensor).

12. Installation

USE APPROPRIATE MOUNTING SCREWS (SEE MECHANICAL DRAWING)
AVOID ESPECIALLY DIRECT SUNLIGHT AND ALL OTHER LIGHT SOURCES WITH WAVELENGTH CLOSE TO 650nm (see Optical filter transmittance on figure below).
ALWAYS KEEP OPTICAL WINDOWS CLEAN, FREE FROM DUST AND FINGERPRINTS, AVOID SCRATCHES ON THE OPTICAL WINDOWS.
USE CORRECT VOLTAGE - SEE ELECTRICAL SPECIFICATION

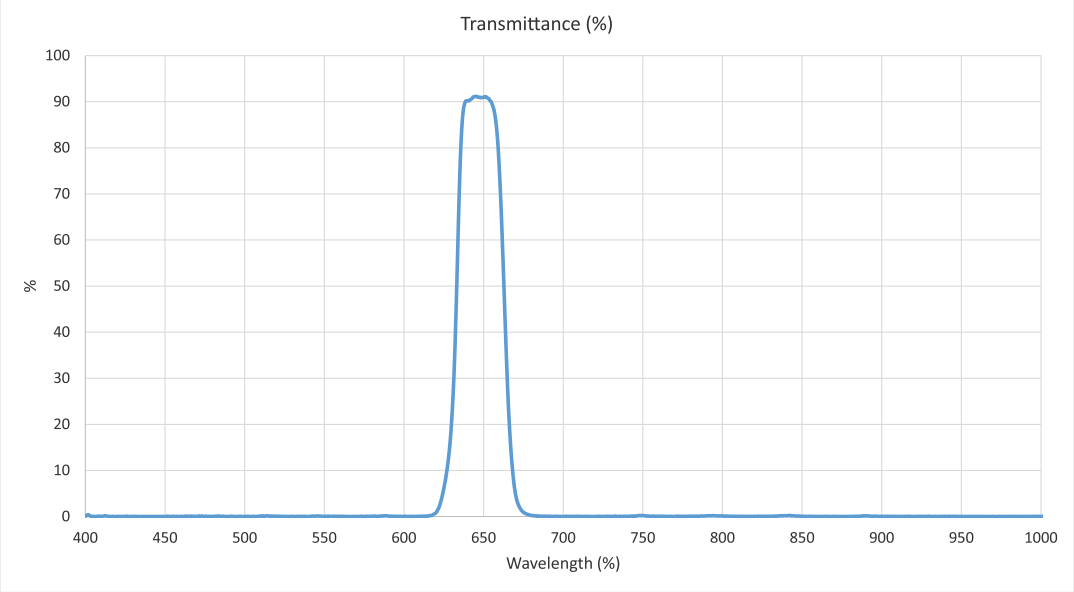


Image 12: Ambient light optical filter transmittance

Laser Safety

C-frame sensor is classified as Class 1M Laser device (Laser power < 3mW according to IEC 60825-1 or ANSI Z136.1). A Class 1M laser is safe for all conditions of use except when passed through magnifying optics such as microscopes and telescopes. Class 1M lasers produce large-diameter beams, or beams that are divergent.

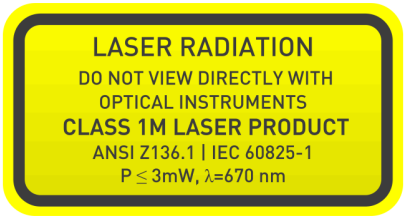


Image 13: Class 1M Laser safety label

13. Package, warranty, contacts

Package components:

- 1x Laser sensor

  Optional:
- RJ45 CAT5 cable straight or right angle
- Power injector
- I/O cable

Warranty
METRALIGHT provides a ONE YEAR manufacturer's limited warranty against defective materials and workmanship. Please do not attempt to open the unit, as this will void all warranties.

Contacts
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