

# optris<sup>®</sup> CTratio

1M/ 2M

**Fiber Optics Ratio Thermometer**



**Optris GmbH**

Ferdinand-Buisson-Str. 14  
13127 Berlin  
Germany

Tel.: +49 30 500 197-0  
Fax: +49 30 500 197-10

E-mail: [info@optris.global](mailto:info@optris.global)  
Internet: [www.optris.global](http://www.optris.global)



# Table of Contents

|  |           |
|--|-----------|
| <b>Table of Contents .....</b>                   | <b>3</b>  |
| <b>1 General Information .....</b>               | <b>7</b>  |
| 1.1 Description .....                            | 7         |
| 1.2 Warranty .....                               | 9         |
| 1.3 Scope of Supply .....                        | 9         |
| 1.4 Maintenance .....                            | 10        |
| 1.5 Safety Note .....                            | 10        |
| 1.6 Cautions .....                               | 10        |
| 1.7 Factory Default Settings .....               | 11        |
| <b>2 Technical Data .....</b>                    | <b>13</b> |
| 2.1 General Specifications .....                 | 13        |
| 2.2 Electrical Specifications .....              | 14        |
| 2.3 Measurement Specifications [1M models] ..... | 15        |

|          |  |           |
|----------|--|-----------|
| 2.4      | Measurement Specifications [2M models] ..... | 16        |
| 2.5      | Optics .....                                 | 17        |
| <b>3</b> | <b>Mechanical Installation.....</b>          | <b>20</b> |
| 3.1      | Accessories .....                            | 25        |
| 3.2      | Laser Sighting .....                         | 29        |
| <b>4</b> | <b>Electrical Installation .....</b>         | <b>30</b> |
| 4.1      | Cable Connections .....                      | 30        |
| 4.2      | Ground Connection .....                      | 33        |
| <b>5</b> | <b>Outputs and Inputs .....</b>              | <b>34</b> |
| 5.1      | Analog Output .....                          | 34        |
| 5.2      | I/O pins .....                               | 35        |
| 5.3      | Programming Interface.....                   | 36        |
| 5.4      | Relay Outputs.....                           | 37        |
| 5.5      | Alarms .....                                 | 38        |

|           |  |           |
|-----------|--|-----------|
| <b>6</b>  | <b>Operating .....</b>                     | <b>39</b> |
| 6.1       | Sensor Setup.....                          | 39        |
| <b>7</b>  | <b>IRmobile app.....</b>                   | <b>43</b> |
| <b>8</b>  | <b>Software CompactPlus Connect .....</b>  | <b>45</b> |
| 8.1       | Installation .....                         | 45        |
| 8.2       | Communication Settings .....               | 47        |
| 8.2.1     | Serial Interface.....                      | 47        |
| 8.2.2     | Protocol.....                              | 47        |
| <b>9</b>  | <b>Basics of Infrared Thermometry.....</b> | <b>48</b> |
| 9.1       | The Ratio Principle .....                  | 49        |
| <b>10</b> | <b>Emissivity .....</b>                    | <b>51</b> |
| 10.1      | Definition.....                            | 51        |
| 10.2      | Determination of unknown Emissivity .....  | 51        |
| 10.3      | Characteristic Emissivity .....            | 52        |

|   |   |           |
|---|---|-----------|
| 10.4  | Characteristic Slope Values .....           | 53        |
| 10.5  | Determination of unknown Slope values ..... | 53        |
| 10.6  | Attenuation .....                           | 53        |
| <b>Appendix A – Emissivity Table Metals .....</b>     |   | <b>55</b> |
| <b>Appendix B – Emissivity Table Non Metals .....</b> |   | <b>57</b> |
| <b>Appendix C – Smart Averaging .....</b>             |   | <b>58</b> |
| <b>Appendix D – Declaration of Conformity .....</b>   |   | <b>59</b> |

# 1 General Information

## 1.1 Description

Thank you for choosing the **optris® CTratio** infrared thermometer.

The sensors of the optris CTratio series are noncontact infrared temperature sensors.

They calculate the surface temperature based on the emitted infrared energy of objects. The CTratio can work in the 1-color-mode as well as in the ratio- or 2-color-mode [**► 9 Basics of Infrared Thermometry**].

The optical sensing head of the CTratio is made of stainless steel (IP65/ NEMA-4 rating) and is connected via a rugged fiber optics, which is protected by a stainless steel armour, with the sensor electronics (die casting zinc box).

### **1-color-mode [1C]**

The 1-color-mode is best for measuring the temperature of objects in areas where no sighting obstructions (solid, gases or dust) exist. The measurement object must fill completely the measurement spot, if the 1-color-mode is used.

### **2-color-mode [2C]**

In this mode the object temperature will be determined from the ratio of the signal of two separate and overlapping infrared bands. The 2-color-mode is best for measuring the temperature of objects which are partially obscured by other objects, openings or viewing windows that reduce energy and by dirt, smoke or steam in the atmosphere. Another benefit of the 2-color-mode is that the measurement object can be smaller than the measurement spot, provided the background is cooler than the target [**► 9.1 The Ratio Principle**].



The CTratio sensing head is a sensitive optical system. Please use only the thread for mechanical installation.



- Avoid abrupt changes of the ambient temperature.
- Avoid mechanical violence on the head – this may destroy the system (expiry of warranty).
- If you have any problems or questions, please contact our service department.



Read the manual carefully before the initial start-up. The producer reserves the right to change the herein described specifications in case of technical advance of the product.



► All accessories can be ordered according to the referred part numbers in brackets [ ].



### How-to video

CTratio

<https://www.optris.global/tutorial-ctratio>



## 1.2 Warranty

Each single product passes through a quality process. Nevertheless, if failures occur please contact the customer service at once. The warranty period covers 24 months starting on the delivery date. After the warranty is expired the manufacturer guarantees additional 6 months warranty for all repaired or substituted product components. Warranty does not apply to damages, which result from misuse or neglect. The warranty also expires if you open the product. The manufacturer is not liable for consequential damage or in case of a non-intended use of the product.

If a failure occurs during the warranty period the product will be replaced, calibrated or repaired without further charges. The freight costs will be paid by the sender. The manufacturer reserves the right to exchange components of the product instead of repairing it. If the failure results from misuse or neglect the user has to pay for the repair. In that case you may ask for a cost estimate beforehand.

## 1.3 Scope of Supply

- CTratio sensing head with fibre connection cable and electronic box
- Micro USB cable (USB-C and USB-A adapter included)
- 1 mounting nut
- Mounting bracket, adjustable in one axis
- Operator's Manual
- USB stick with software package CompactPlus Connect

## 1.4 Maintenance

**Lens cleaning:** Blow off loose particles using clean compressed air. The lens surface can be cleaned with a soft, humid tissue (moistened with water) or a lens cleaner (e.g. Purosol or B+W Lens Cleaner).



Never use cleaning compounds which contain solvents (neither for the lens nor for the housing).

## 1.5 Safety Note

The CTratio is equipped with an integrated laser that serves to align the optics with the target.

### ► 3.2 Laser Sighting



## 1.6 Cautions

Avoid static electricity. The fiber optical cable has a minimum bending radius of **29 mm for 1MH/ 1MH1/ 2MH1, 54 mm for 2MH** and **80 mm for 1ML/ 2ML**.

In case of problems or questions which may arise when you use the CTratio, please contact our service department.

Read the manual carefully before the initial start-up. The producer reserves the right to change the herein described specifications in case of technical advance of the product.

## 1.7 Factory Default Settings

The unit has the following presetting at time of delivery:

|                                    |  |            |             |            |            |             |
|------------------------------------|--|------------|-------------|------------|------------|-------------|
| Output 1                           | Analog: TProc/ max. temperature range (according to model) = 4-20 mA |            |             |            |            |             |
| Output 2                           | Analog: Attenuation/ 0-100 % = 0-20 mA                               |            |             |            |            |             |
| Emissivity                         | 1,000  |            |             |            |            |             |
| Slope                              | 1,000  |            |             |            |            |             |
| Averaging (AVG)                    | 0,02 s   |            |             |            |            |             |
| Smart Averaging                    | inactive   |            |             |            |            |             |
| Hold mode (Peak/Valley hold)       | inactive   |            |             |            |            |             |
|                                    | <b>1ML</b>   | <b>1MH</b> | <b>1MH1</b> | <b>2ML</b> | <b>2MH</b> | <b>2MH1</b> |
| Lower limit temperature range [°C] | 525  | 700        | 1000        | 275        | 400        | 550         |
| Upper limit temperature range [°C] | 1400   | 2000       | 3000        | 1000       | 1500       | 3000        |
| Max. attenuation                   | 95 %   |            |             |            |            |             |
| Temperature unit                   | °C   |            |             |            |            |             |
| Baud rate [kBaud]                  | 115  |            |             |            |            |             |
| Main Display Source                | TProc  |            |             |            |            |             |
| Visual Alarm Source                | Attenuation  |            |             |            |            |             |
| Visual Alarm                       | 0-95 % green<br>>95 % red  |            |             |            |            |             |
| I/O pins                           | No function  |            |             |            |            |             |



**Smart Averaging** means a dynamic average adaptation at high signal edges [activation via software only].

▶ **Appendix C – Smart Averaging**

## 2 Technical Data

### 2.1 General Specifications

|                            | Sensing head                               | Electronic box                  |
|----------------------------|--|---------------------------------|
| Environmental rating       | IP65 (NEMA-4)                              |                                 |
| Ambient Temperature        | -20...200 °C (optional to 315 °C)          | 0...50 °C (2M) / 0...60 °C (1M) |
| Storage temperature        | -40...200 °C                               | -40...85 °C <sup>1)</sup>       |
| Relative humidity          | 10...95%, non condensing                   |                                 |
| Material                   | stainless steel                            | die casting zinc                |
| Dimensions                 | length: 40 mm, thread: M18x1               | 89 mm x 70 mm x 36,6 mm         |
| Weight                     | 210 g (incl. fiber optics 3 m)             | 420 g                           |
| Fiber optics <sup>2)</sup> | Single mode fiber, stainless steel armour  |                                 |
| Fiber optics length        | 3 m (standard), 8 m, 15 m                  |                                 |
| Vibration                  | IEC 68-2-6: 3 G, 11 – 200 Hz, any axis     |                                 |
| Shock                      | IEC 68-2-27: 50 G, 11 ms, any axis         |                                 |
| Software / App             | CompactPlus Connect / IRmobile Android app |                                 |

<sup>1)</sup> The functionality of the LCD display can be limited at ambient temperatures below 0 °C

<sup>2)</sup> Sensing head and fiber cable are electrically isolated to the electronic box

## 2.2 Electrical Specifications

|                   |   |
|-------------------|---|
| Power Supply      | 8–30 VDC  |
| Power             | max. 5 W  |
| Aiming laser      | 520 nm, <1 mW, On/ Off via programming keys or software   |
| Outputs/ analog   | 2x 0/ 4–20 mA (12 bit) / optional: 2x 0/ 4–20 mA (16 bit) isolated  |
| Digital I/O pins  | 3 programmable in-/ outputs, usable as: <ul style="list-style-type: none"><li>• Alarm output (open collector output [24 V/ 1 A])</li><li>• Digital input for triggered signal output and peak hold function</li></ul> |
| Output impedance  | max. loop resistance 500 $\Omega$ (at 8-30 VDC)   |
| Digital interface | USB (optional: RS232, RS485, Ethernet, Modbus RTU)  |
| Relay outputs     | 2 x 60 V DC/ 42 V AC <sub>eff</sub> , 0,4 A; optically isolated (optional plug-in module)   |

## 2.3 Measurement Specifications [1M models]

|   | 1ML  | 1MH  | 1MH1  |
|---|--|--|---|
| Temperature range (scalable)              | 1 color: 450...1400 °C<br>2 color: 525...1400 °C   | 1 color: 650...2000 °C<br>2 color: 700...2000 °C | 1 color: 900...3000 °C<br>2 color: 1000...3000 °C |
| Spectral range                            | 0,8 - 1,1 µm   |  |   |
| Optical resolution                        | 38:1   | 100:1  |   |
| Vario focus                               | 300 mm to infinity, infinitely adjustable  |  |   |
| System accuracy <sup>1), 2), 3)</sup>     | ±(0,5 % of reading +2 °C)  |  |   |
| Repeatability <sup>1), 2), 3)</sup>       | ±0,3 % of reading  |  |   |
| Temperature resolution                    | 0,1 K  |  |   |
| Response time (90 % signal) <sup>4)</sup> | 1 ms...10 s  |  |   |
| Emissivity                                | 0,050...1,000 (adjustable via programming keys or analog input)  |  |   |
| Slope                                     | 0,800...1,200 (adjustable via programming keys or analog input)  |  |   |
| Signal processing                         | One-color-, Two-color-mode, Attenuation monitoring, Alarm, Average, Peak hold, Valley hold, Advanced peak hold with threshold and hysteresis (adjustable via programming keys or software) |  |   |

<sup>1)</sup> Measurements within specification over 5-95% of range

<sup>2)</sup> at ambient temperature 23±5 °C

<sup>3)</sup> ε = 1/ Response time 1 s

<sup>4)</sup> with dynamic adaptation at low signal levels

## 2.4 Measurement Specifications [2M models]

|   | 2ML  | 2MH  | 2MH1   |
|---|--|--|--|
| Temperature range (scalable)              | 1 color: 250...1000 °C<br>2 color: 275...1000 °C   | 1 color: 375...1500 °C<br>2 color: 400...1500 °C | 1 color: 500...3000 °C<br>2 color: 550...3000 °C |
| Spectral range                            | 1,45 - 1,75 µm   |  |  |
| Optical resolution                        | 38:1   | 50:1   | 100:1  |
| Vario focus                               | 300 mm to infinity, infinitely adjustable  |  |  |
| System accuracy <sup>1), 2), 3)</sup>     | ±(0,5 % of reading +2 °C)  |  |  |
| Repeatability <sup>1), 2), 3)</sup>       | ±0,3 % of reading  |  |  |
| Temperature resolution                    | 0,1 K  |  |  |
| Response time (90 % signal) <sup>4)</sup> | 1 ms...10 s  |  |  |
| Emissivity                                | 0,050...1,000 (adjustable via programming keys or analog input)  |  |  |
| Slope                                     | 0,800...1,200 (adjustable via programming keys or analog input)  |  |  |
| Signal processing                         | One-color-, Two-color-mode, Attenuation monitoring, Alarm, Average, Peak hold, Valley hold, Advanced peak hold with threshold and hysteresis (adjustable via programming keys or software) |  |  |

<sup>1)</sup> Measurements within specification over 5-95% of range

<sup>2)</sup> at ambient temperature 23±5 °C

<sup>3)</sup>  $\varepsilon = 1$  / Response time 1 s

<sup>4)</sup> with dynamic adaptation at low signal levels



## 2.5 Optics

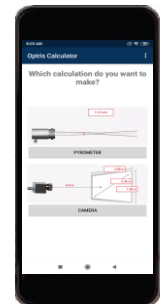
The vario optics of the CTratio allows a smooth focusing of the optics to the desired distance.

| Optics | Focus adjustable in the range |
|--------|-------------------------------|
| SFV    | 300 mm till infinity          |
| CF     | 150 to 350 mm                 |

The following tables show the diameter of the measuring spot for some selected distances. The spot size refers to 90 % of the radiation energy.

The distance is always measured from the front edge of the sensing head.

As an alternative to the optical diagrams, the spot size calculator can also be used on the Optris website (<https://www.optris.global/spot-size-calculator>) or via the Optris calculator app. The app can be downloaded for free from the Google Play Store (see QR code).



**D** = Distance from front of the sensing head to the object  
**S** = Spot size

| <b>1ML / 2ML: SF optics (D:S=38:1)</b> |    |     |      |      |      |      |      |      |       |  |
|--|----|-----|------|------|------|------|------|------|-------|--|
| Spot size                              | mm | 7,9 | 13,2 | 19,7 | 26,3 | 39,5 | 52,6 | 65,8 | 131,6 |  |
| Measurement distance                   | mm | 300 | 500  | 750  | 1000 | 1500 | 2000 | 2500 | 5000  |  |

| <b>2MH: SF optics (D:S=50:1)</b> |    |     |     |     |      |      |      |      |      |  |
|----------------------------------|----|-----|-----|-----|------|------|------|------|------|--|
| Spot size                        | mm | 6   | 10  | 15  | 20   | 30   | 40   | 50   | 100  |  |
| Measurement distance             | mm | 300 | 500 | 750 | 1000 | 1500 | 2000 | 2500 | 5000 |  |

| <b>1MH / 1MH1 / 2MH1: SF optics (D:S=100:1)</b> |    |     |     |     |      |      |      |      |      |  |
|---|----|-----|-----|-----|------|------|------|------|------|--|
| Spot size                                       | mm | 3   | 5   | 7,5 | 10   | 15   | 20   | 25   | 50   |  |
| Measurement distance                            | mm | 300 | 500 | 750 | 1000 | 1500 | 2000 | 2500 | 5000 |  |

| <b>1ML / 2ML: CF optics (D:S=38:1)</b> |    |     |     |     |     |     |     |     |     |     |
|--|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Spot size                              | mm | 3,9 | 4,6 | 5,3 | 5,9 | 6,6 | 7,2 | 7,9 | 8,6 | 9,2 |
| Measurement distance                   | mm | 150 | 175 | 200 | 225 | 250 | 275 | 300 | 325 | 350 |

| <b>2MH: CF optics (D:S=50:1)</b> |    |     |     |     |     |     |     |     |     |     |
|----------------------------------|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Spot size                        | mm | 3   | 3,5 | 4   | 4,5 | 5   | 5,5 | 6   | 6,5 | 7   |
| Measurement distance             | mm | 150 | 175 | 200 | 225 | 250 | 275 | 300 | 325 | 350 |

| <b>1MH / 1MH1 / 2MH1: CF optics (D:S=100:1)</b> |    |     |     |     |     |     |     |     |     |     |
|---|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Spot size                                       | mm | 1,5 | 1,8 | 2,0 | 2,3 | 2,5 | 2,8 | 3,0 | 3,3 | 3,5 |
| Measurement distance                            | mm | 150 | 175 | 200 | 225 | 250 | 275 | 300 | 325 | 350 |

### Sensor placement [1C mode]

The size of the measuring object and the optical resolution of the infrared thermometer determine the maximum distance between sensing head and measuring object. In order to prevent measuring errors the object should fill out the field of view of the optics completely. Consequently, the spot should at all times have at least **the same size** like the object or should be **smaller than** that.

### Sensor placement [2C mode]

In the 2-color-mode the sensing head can be placed under various conditions, like:

- **Measurement through holes smaller than the spot size**
- **Measurement through dust, smoke or steam in the atmosphere**
- **Measurement of objects smaller than the measurement spot**
- **Measurement through a dirty lens or dirty sighting window**

### [▶ 9.1 The Ratio Principle]



#### How-to video

Particle chamber experiment  
<https://www.optris.global/particle-chamber>

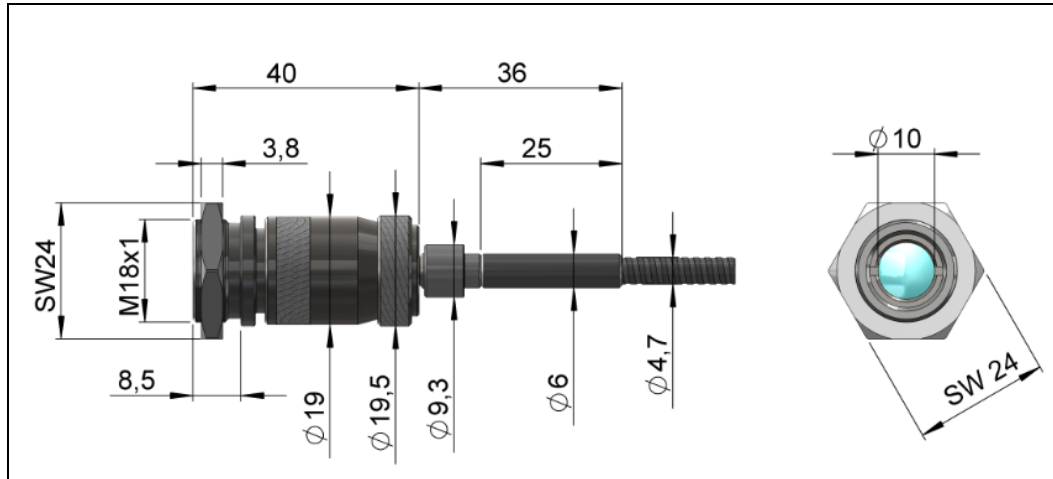


#### How-to video

Grid structure experiment  
<https://www.optris.global/grid-structure>

### 3 Mechanical Installation

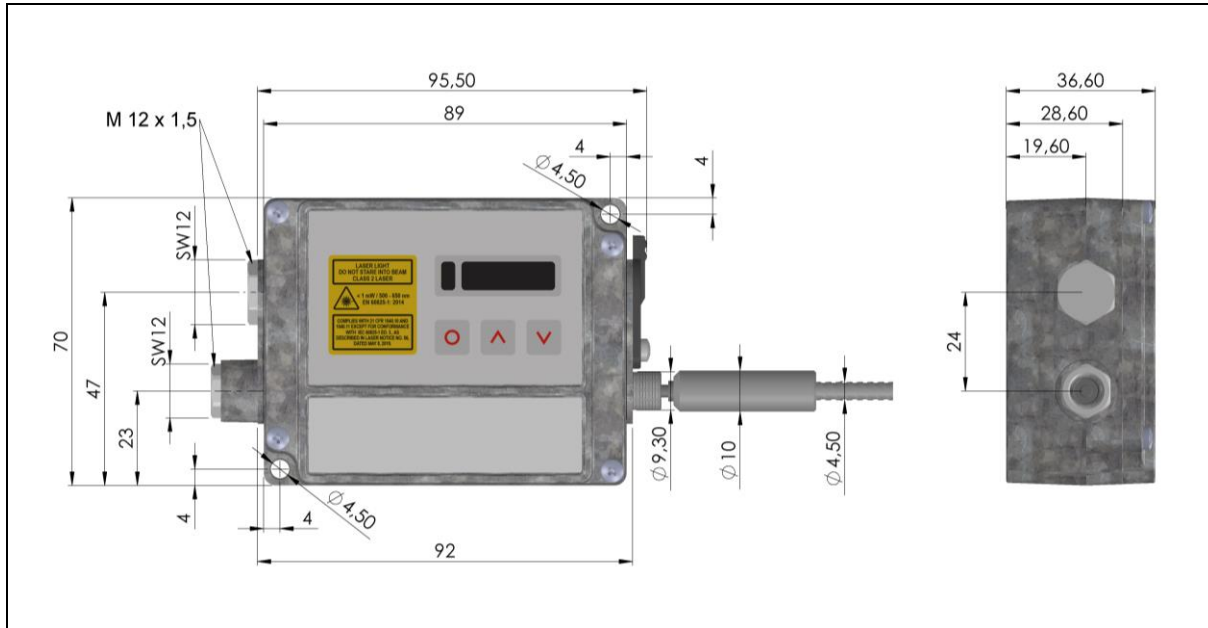
The CTratio sensing heads are equipped with a metrical M18x1-thread and can be installed either directly via the sensor thread or with help of the hex nuts (1 piece included in scope of supply) to the mounting bracket available. Various mounting brackets, which make the adjustment of the sensing head easier, can be additionally ordered as accessories.



Sensing head



- Please make sure that the minimum bending radius of the fiber optics of **29 mm for 1MH/ 1MH1/ 2MH1**, **54 mm for 2MH** and **80 mm for 1ML/ 2ML** will be considered during installation.
- If the fiber or measuring head is defective, the device must be sent in. A recalibration is necessary.



### Electronic box

The electronic box is also available with closed cover (display and programming keys with no access from outside) [**ACCTCOV**].



## Fiber connection at sensor head and electronic box

When mechanically connecting the fiber to the sensor head and the electronics box, the correct sequence must be ensured. Both connections are labeled with the corresponding side ("Head" and "Box").



Fiber connection sensor head „Head“



Fiber connection electronic box „Box“

To connect the fiber correctly, plug the cable into the device and turn the fiber until it locks into place. Then fix the cable with the knurled screw.



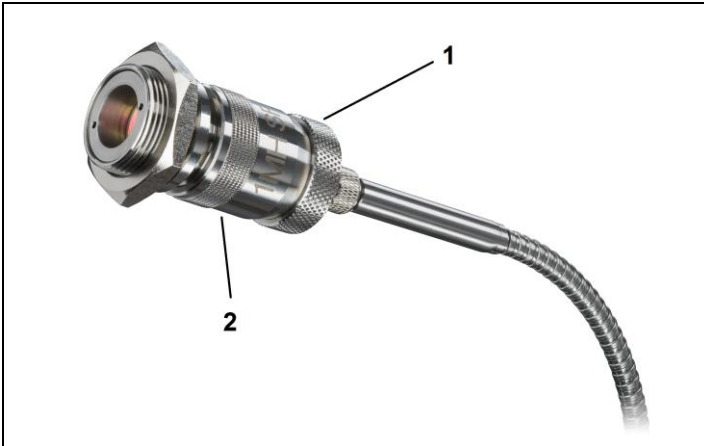
Never pull on the fiber. This can damage and destroy the fiber. When removing the fiber, the screw connection must be loosened first.



## Focusing of the sensor head

The CTratio pyrometer is equipped with a vario optics. This enables you to focus the device from a distance of 300 mm to infinity. To focus the sensor, loosen the knurled screw (1) on the head. Now you can focus the device on the head (2). After alignment, retighten the knurled screw. This secures the focus.

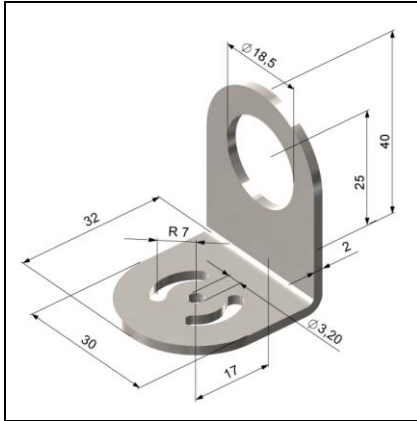
By turning the rotary button **clockwise** you will change the focus in direction **far**. By turning **counterclockwise** you will change the focus in direction **close**.



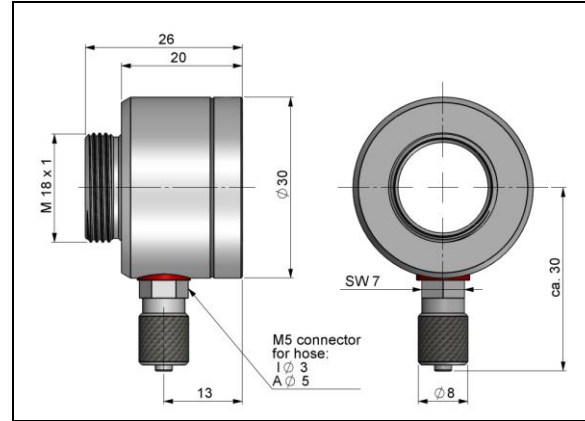
Sensing head – Focusing the unit



### 3.1 Accessories



**Mounting bracket, adjustable in one axis  
[ACCTFBMH]**



**Air purge collar [ACCTAPMH]**

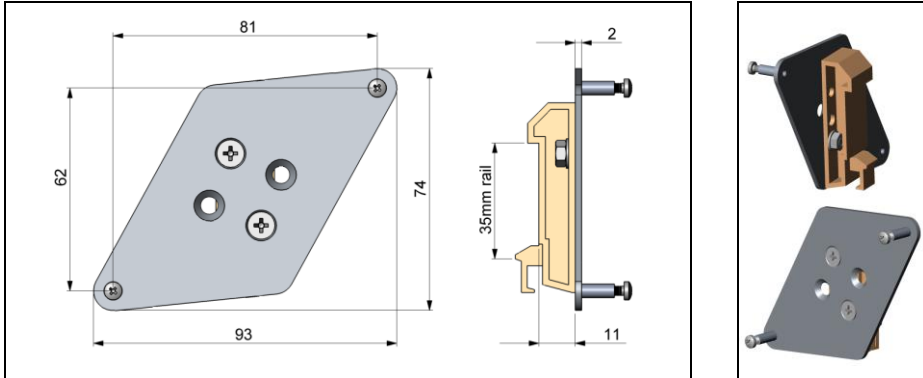
The lens must be kept clean at all times from dust, smoke, fumes and other contaminants in order to avoid reading errors (in the 1-color-mode). These effects can be reduced by using an air purge collar. Make sure to use oil-free, technically clean air, only.



The needed amount of air (approx. 2...10 l/ min.) depends on the application and the installation conditions on-site.

## Rail Mount Adapter for Electronic box

With the rail mount adapter the CTRatio electronics can be mounted easily on a DIN rail (TS35) according EN50022.



**ACCTRAIL**

## Spare fibers

For a fast field exchange max. two spare fibers of the same length including optical sensing head can be ordered together with the main CTratio unit. As they will be adjusted together with the CTratio a subsequent order of spare fibers is not possible.



**Spare fibers (ACCTRFxxx)**



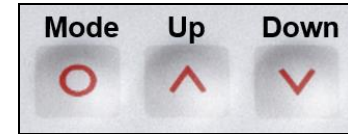
**Serial number Head of device 1**



**Serial number Fiber of device 1**

The serial number of the device is located on the sensor head and on the fiber. Each head and associated fiber has its own unique number for its identification (\_1, \_2, \_3). This number must be set on the device or in the software. The device is set with fiber 1 (\_1) at factory default.

For entering the code please press the **Up** and **Down** key (keep pressed) and then the Mode key. The display shows OPTIC SET. With Up and Down the number can be changed.



To change the spare fiber in the CompactPlus Connect software, go to the **Setup** menu and to the **Advanced Settings** tab. Under **optical set** you can now change the **number**.

Optical Set

Number

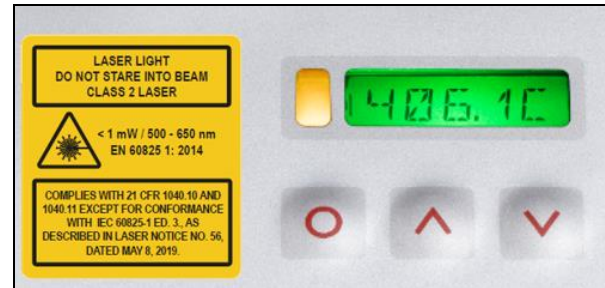
## 3.2 Laser Sighting

The integrated laser sighting supports the alignment and focusing of the optics. The size of the laser dot is equal to the real measurement spot size at any distance.



The laser can be activated/ deactivated via the programming keys on the unit or via the software. If the laser is activated a yellow LED will shine (beside temperature display). **[▶ 4 Electrical Installation, 6 Operating]**

**At ambient temperatures  $>50\text{ }^{\circ}\text{C}$  inside the electronic box the laser will switch off automatically.**



- **Do not point the laser directly at the eyes of persons or animals! Do not stare into the laser beam. Avoid indirect exposure via reflective surfaces!**
- **The laser is not suitable for continuous operation.**
- **Before you open the box, the sensor must be switched off and disconnected from the power supply and USB interface!**

## 4 Electrical Installation

### 4.1 Cable Connections

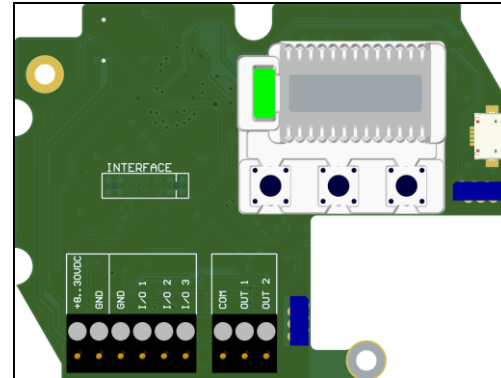
The supplied USB cable can be connected to the side of the electronics box. The device can be operated directly via the CompactPlus Connect software or the IRmobile App.

For the electrical installation of further interfaces and when using the in-/outputs please open at first the cover of the electronic box (4 screws). Below the display are the screw terminals for the cable connection.



### Designation

|                   |  |
|-------------------|--|
| <b>+8..30 VDC</b> | <b>Power supply</b>                                    |
| <b>GND</b>        | <b>Ground (0 V) of power supply</b>                    |
| <b>GND</b>        | <b>Ground (0 V) of in- and outputs</b>                 |
| <b>I/O 1</b>      | <b>I/O pin 1 (digital In-/ Output or analog input)</b> |
| <b>I/O 2</b>      | <b>I/O pin 2 (digital In-/ Output or analog input)</b> |
| <b>I/O 3</b>      | <b>I/O pin 3 (digital In-/ Output or analog input)</b> |
| <b>COM</b>        | <b>Ground of OUT</b>                                   |
| <b>OUT 1</b>      | <b>Analog current output 1</b>                         |
| <b>OUT 2</b>      | <b>Analog current output 2</b>                         |



Opened electronic box with terminal connections



**Please do never connect a supply voltage to the analog outputs as this will destroy the output!**  
**The CTratio is not a 2-wire sensor!**



The USB socket built into the side is only intended for setting up the sensor and any subsequent changes to the settings. Permanently plugging and unplugging the USB cable can cause damage. The USB interface is not designed for continuous use. For this purpose, please use the optionally available USB interface **ACCTMIAC**.

### **Power supply**

Please use a power supply unit with an output voltage of **8–30 VDC** with a power of **5 W**. The ripple should be max. **200 mV**. Please use shielded cables only for all power and data lines.

The sensor shield has to be grounded.

### **Cable Assembling**

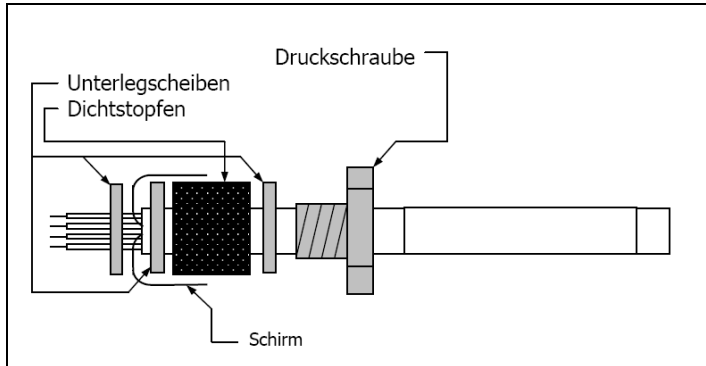
The cable gland M12x1,5 allows the use of cables with a diameter of 3 to 5 mm.

Remove the isolation from the cable (40 mm power supply, 50 mm signal outputs, 60 mm functional inputs).

Cut the shield down to approximately 5 mm and spread the strands out. Extract about 4 mm of the wire isolation and tin the wire ends.

Place the pressing screw, the rubber washer and the metal washers of the cable gland one after the other onto the prepared cable end. Spread the strands and fix the shield between two of the metal washers. Insert the cable into the cable gland until the limit stop. Screw the cap tight.

Every single wire may be connected to the according screw clamps according to their colors.



- Use shielded cables only. The sensor shield has to be grounded.
- Sensing head and fiber cable are electrically isolated to the electronic box



## 4.2 Ground Connection

On the left side of the mainboard PCB you will find a black switch which is connecting factory-default the ground connections (GND power supply/ outputs) with the ground of the electronics housing.

To avoid ground loops and related signal interferences in industrial environments it might be necessary to interrupt this connection. For this purpose, the switch must be changed.



## 5 Outputs and Inputs

The CTratio has two analog output and three digital I/O pins (programmable as in- or output).

### 5.1 Analog Output

The selection of the signal on output channel 1 and 2 (0/4-20 mA) can be done via the software CompactPlus Connect [**► 8 Software CompactPlus Connect**] or the IRmobile app [**► 7 IRmobile app**].



Please do never connect a supply voltage to the analog outputs as this will destroy the output.  
**The CTratio is not a 2-wire sensor!**

**The following signal sources can be selected for output channel 1 and 2:**

|             |                         |
|-------------|-------------------------|
| TProc       | Process temperature     |
| TRatio      | Ratio temperature       |
| T1          | 1C temperature          |
| T2          | 2C temperature          |
| Attenuation | Signal attenuation in % |
| TDet        | Detector temperature    |
| TBox        | Box temperature         |

## 5.2 I/O pins

The CTratio has three digital pins which can be programmed as outputs (digital) or as inputs (digital or analog) using the CompactPlus Connect software. The following functions are available:

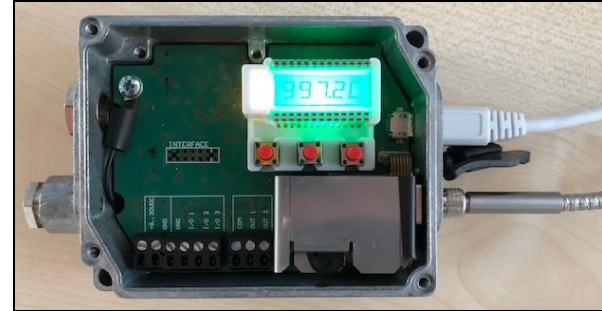
| Function                   | I/O pin acts as | Description   |
|----------------------------|-----------------|---|
| <b>Alarm</b>               | output digital  | Open collector output/ definition as High- or Low alarm via normally open/ normally close options in software dialog.   |
| <b>Valid Low</b>           | input digital   | The output follows the object temperature as long as there is a Low level at the I/O pin. After discontinuation of the Low level the last value will be held.   |
| <b>Valid High</b>          | input digital   | The output follows the object temperature as long as there is a High level at the I/O pin. After discontinuation of the High level the last value will be held. |
| <b>Hold Low-High</b>       | input digital   | The last value will be held if there is a signal with a rising edge on the I/O pin.   |
| <b>Hold High-Low</b>       | input digital   | The last value will be held if there is a signal with a falling edge on the I/O pin.  |
| <b>Hold Reset Low</b>      | input digital   | Reset of Peak or valley hold (High-Low signal)  |
| <b>Hold Reset High</b>     | input digital   | Reset of Peak or valley hold (Low-High signal)  |
| <b>Slope external</b>      | input analog    | The slope value can be adjusted via a 0-10 V signal on the I/O pin (scaling possible via software).   |
| <b>Emissivity external</b> | input analog    | The emissivity value can be adjusted via a 0-10 V signal on the I/O pin (scaling possible via software).  |
| <b>Uncommitted value</b>   | Input analog    | Display of a uncommitted value  |
| <b>Laser on Low</b>        | Input digital   | Turning on the laser (Low signal)   |
| <b>Laser on High</b>       | Input digital   | Turning on the laser (High signal)  |

**High-level:** Via software

**Low-level:** Via software

### 5.3 Programming Interface

The CTratio has on the side of the electronic box a USB interface for programming and running the sensor. The USB cable is included in the scope of supply. This interface is not recommended for permanent use. As an option, the device can also be equipped with an USB, RS232, RS485, Modbus RTU or Ethernet interface, which is mounted directly on the board.



If you want to install the optionally available interfaces, plug the interface board into the place provided, which is located beside the display. In the correct position the holes of the interface match with the thread holes of the electronic box. Now press the board down to connect it and use both M3x5 screws for fixing it. Plug the preassembled interface cable with the terminal block into the male connector of the interface board.



When using the current outputs, an external power supply (8-30 V) is recommended, since the maximum power consumption is 5 W.

## 5.4 Relay Outputs

The CTratio can be optionally equipped with a relay output. The relay board will be installed the same way as the programming interface.

The relay board provides two fully isolated switches, which have the capability to switch max. 60 VDC/ 42 VAC<sub>RMS</sub>, 0,4 A DC/AC. A red LED shows the closed switch.



The switching thresholds are in accordance with the values for the visual alarms (LCD backlight). To set the alarm values the digital programming interface (USB) and the software is needed.

## 5.5 Alarms

The CTratio has the following Alarm features:

All alarms have a fixed **hysteresis of 2 K**.

### Visual Alarms

These alarms will cause a change of the color of the LCD display.

### Digital Alarm 1, 2, 3

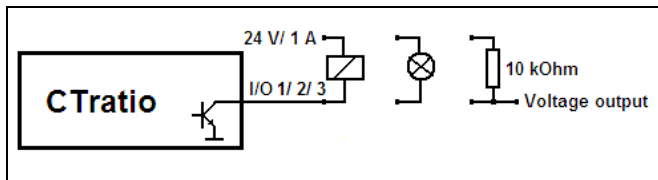
All the I/O pins can be programmed as alarm output. In this case the pin acts as an open collector output (24 V/ 1 A).

**The following signal sources can be selected:**

TProc/ TRatio/ T1/ T2/ Attenuation/ TDet/ TBox



For a setup of the alarm values, selection of the signal sources and definition as high or low alarm (via change of normally open/ closed) the programming interface (USB) including the software is needed.



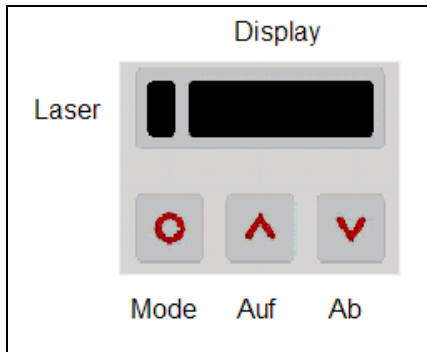
Different wirings of the open collector output

## 6 Operating

After power up the unit the sensor starts an initializing routine for some seconds. During this time the display will show **INIT**. After this procedure the process temperature is shown in the display. The display backlight color changes according to the alarm settings [► 5.5 Alarms].

### 6.1 Sensor Setup

The programming keys **Mode**, **Up** and **Down** enable the user to set the sensor on-site. The current measuring value or the chosen feature is displayed. With **Mode** the operator obtains the chosen feature, with **Up** and **Down** the functional parameters can be selected – **a change of parameters will have immediate effect**. If no key is pressed for more than 10 seconds the display automatically shows the calculated object temperature (according to the signal processing).



Pressing the Mode button again recalls the last called function on the display. The signal processing features **Peak hold** and **Valley hold** cannot be selected simultaneously.

#### Factory Default Setting

To set the CTratio back to the factory default settings, please press at first the **Down**-key and then the **Mode**-key and keep both pressed for approx. 3 seconds.

The display will show **RESET** for confirmation.

| Display            | Mode [Sample]   | Adjustment Range  |
|--------------------|---|---|
| <b>S OFF</b>       | Laser Sighting  | <b>ON/ OFF</b>  |
| <b>T RAT 878.9</b> | Ratio temperature after signal processing) [878,9 °C]           | fixed   |
| <b>T1 897,1</b>    | 1 channel temperature [879,1 °C]                                | fixed   |
| <b>T2 879,0</b>    | 2 channel temperature [879,0 °C]                                | fixed   |
| <b>ATT 0.0</b>     | Attenuation[0,0 %]  | fixed   |
| <b>T DET 50.1</b>  | Detector temperature [50,1 °C]                                  | fixed   |
| <b>T BOX 38.6</b>  | Electronic box temperature [38,6 °C]                            | fixed   |
| <b>SLOPE 0.993</b> | Emissivity ratio [0,993]  | <b>0,8...1,2</b>  |
| <b>EMISS 1.000</b> | Emissivity [1,000]  | <b>0,050 ... 1,100</b>                                      |
| <b>AVG 0.020</b>   | Signal output Average [0,020 s]                                 | <b>AVG 0.000</b> = inactive/ <b>0,1 ... 999,9 s</b>         |
| <b>MIN A</b>       | Minimum Attenuation   | <b>0,1 ... 99 %</b>   |
| <b>MAX A 80.0</b>  | Maximum Attenuation   | <b>0,1 ... 99 %</b>   |
| <b>HOLD</b>        | OFF   | <b>OFF/ PEAK/ VALL/ APEAK/ AVALL</b>                        |
| <b>H TIM</b>       | PEAK/ VALL  | <b>0...65 s</b> (65 = infinity)                             |
| <b>H TH</b>        | APEAK/ AVALL  | Starting temperature...end temperature                      |
| <b>H HY</b>        | APEAK/ AVALL  | Hysteresis setting in °C/°F                                 |
| <b>U °C</b>        | Temperature unit [°C]   | <b>°C/ °F</b>   |
| <b>M 01</b>        | Multidrop address [1] (only with RS485 interface)<br>RS422 mode | <b>01 ... 32</b><br><b>RS422</b> (Press Down button on M01) |
| <b>BAUD 115.2K</b> | Baud rate in kBaud [115.2K]                                     | <b>115.2 / 921.6 kBaud</b>                                  |
| <b>E ATN</b>       | Out of measuring range / no valid measuring condition           | -   |

**S OFF**

Activating (**ON**) and Deactivating (**OFF**) of the **Sighting Laser**. By pressing Up or Down



the laser can be switched on and off.

**SLOPE**

The **Slope** is the quotient of the emissivity's of both of the overlapping wavelengths and therewith the deciding parameter for measurements in 2-color-mode.

**EMISS 1.000**

Setup of **Emissivity**. Pressing **Up** increases the value, **Down** decreases the value (also valid for all further functions). The emissivity is a material constant factor to describe the ability of the body to emit infrared energy [**► 10 Emissivity**].

**AVG 0.020**

Setup of **Average time**. In this mode an arithmetic algorithm will be performed to smoothen the signal. The set time is the time constant. This function can be combined with all other post processing functions. The shortest value is 0,001 s. If the value is set to **0.0** the function is deactivated.

**HOLD**

Setup of **signal processing**. By pressing **Up** or **Down** the mode can be selected.

**PEAK:** Setup of **Peak hold**. In this mode the sensor is waiting for descending signals. If the signal descends the algorithm maintains the previous signal peak for the specified time.

After the hold time the signal will drop down to the second highest value or will descend by 1/8 of the difference between the previous peak and the minimum value during the hold time. This value will be held again for the specified time. After this the signal will drop down with slow time constant and will follow the current object temperature.

If the value is set to **0.0** the display will show --- (function deactivated).

**VALL:** Setup of **Valley hold**. In this mode the sensor waits for ascending signals. The definition of the algorithm is according to the peak hold algorithm (inverted).

If the value is set to **0.0** the function deactivated.

**APEAK** (Advanced Peak Hold): In this mode the sensor waits for local peak values. Peak values which are lower than their predecessors will only be taken over if the temperature

has fallen below the **Threshold** value beforehand. If **Hysteresis** is activated a peak in addition must decrease by the value of the hysteresis before the algorithm takes it as a new peak value.

**AVALL** (Advanced Valley Hold): This mode is the inverted function of Advanced Peak hold. The sensor waits for local minima. Minimum values which are higher than their predecessors will only be taken over if the temperature has exceeded the **Threshold** value beforehand. If **Hysteresis** is activated a minima in addition must increase by the value of the hysteresis before the algorithm takes it as a new minimum value.

**U °C**

Setup of the **Temperature unit** [°C or °F].

**M 01**

Setup of the **Multidrop address**. In a **RS485** network each sensor will need a specific address. This menu item will only be shown if a RS485 interface board is plugged in. For using the **RS422** mode, press once the down button on M01.

**BAUD 115.2K**

Setup of the **Baud rate** for digital data transfer.

## 7 IRmobile app

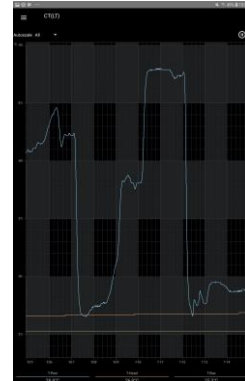
The CTratio sensor has a direct connection to an Android smartphone or tablet. All you have to do is download the IRmobile app for free in the Google Play store. This can also be done via the QR code. The supplied USB cables can be used for connection to the device.



With IRmobile you are able to monitor and analyse your infrared temperature measurement on a connected smartphone or tablet. This app works on most Android devices running 5.0 or higher with a micro USB or USB-C port supporting USB-OTG (On The Go). It is easy to operate: after you plug your CTratio device to your phone or tablet, the app will start automatically. The device is powered by your phone. Different digital temperature values can be displayed in the temperature time diagram. You can easily zoom-in the diagram to see more details and small signal changes.

### IRmobile app features:

- Temperature time diagram with zoom function
- Digital temperature values
- Setup of emissivity, transmissivity and other parameters
- Scaling of the analog output and setting of the alarm output
- Change of temperature unit: Celsius or Fahrenheit
- Saving/loading of configurations and T/t diagrams
- Restore factory default sensor settings
- Integrated simulator



### Supported for:

- Optris pyrometers: Compact series, high performance series and video thermometers
- Optris IR cameras: PI and Xi series
- For android devices running 5.0 or higher with a micro USB or USB-C port supporting USB-OTG (On The Go)

## 8 Software CompactPlus Connect

### 8.1 Installation

The software is located on the included USB stick. Please start **Setup.exe** and follow the instructions of the wizard until the installation is finished.

#### Minimum system requirements:

- Windows 7, 8, 10
- USB interface
- Hard disc with at least 30 MByte free space
- At least 128 MByte RAM



The software can also be downloaded via the Optris website under the following link: <https://www.optris.global/downloads-software>

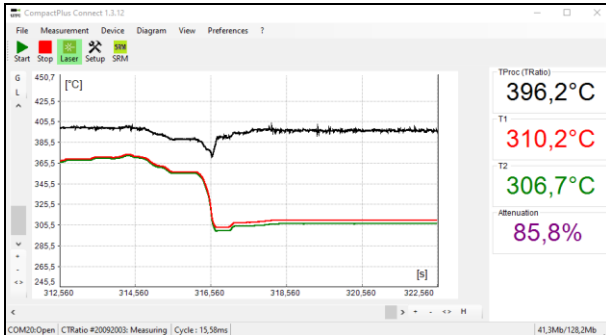
The installation wizard will place a launch icon on the desktop and in the start menu:

**[Start]\Programs\ CompactPlus Connect.**

If you want to uninstall the software from your system please use the **uninstall icon** in the start menu.



A detailed description of the software is provided in the documentation folder.



## Main Features:

- Graphic display for temperature trends and automatic data logging for analysis and documentation
- Complete sensor setup and remote controlling
- Adjustment of signal processing functions
- Programming of outputs and functional inputs

## 8.2 Communication Settings

### 8.2.1 Serial Interface

Baudrate: 115,2 / 921,6 kBaud  
Data bits: 8  
Parity: none  
Stop bits: 1  
Flow control: off

### 8.2.2 Protocol

All sensors of the CTratio series are using a binary protocol.

## 9 Basics of Infrared Thermometry

Depending on the temperature each object emits a certain amount of infrared radiation. A change in the temperature of the object is accompanied by a change in the intensity of the radiation. For the measurement of “thermal radiation” infrared thermometry uses a wave-length ranging between 1  $\mu\text{m}$  and 20  $\mu\text{m}$ .

The intensity of the emitted radiation depends on the material. This material contingent constant is described with the help of the emissivity which is a known value for most materials (► **10 Emissivity**).

Infrared thermometers are optoelectronic sensors. They calculate the surface temperature on the basis of the emitted infrared radiation from an object. The most important feature of infrared thermometers is that they enable the user to measure objects contactless. Consequently, these products help to measure the temperature of inaccessible or moving objects without difficulties. Infrared thermometers basically consist of the following components:

- lens
- spectral filter
- detector
- electronics (amplifier/ linearization/ signal processing)

The specifications of the lens decisively determine the optical path of the infrared thermometer, which is characterized by the ratio **D**istance to **S**pot size.

The spectral filter selects the wavelength range, which is relevant for the temperature measurement. The detector in cooperation with the processing electronics transforms the emitted infrared radiation into electrical signals.



## 9.1 The Ratio Principle

The 2-color ratio technology makes possible accurate and repeatable temperature measurements that are free from dependence on absolute radiated energy values. In use, a 2-color sensor determines temperature from the ratio of the radiated energies in two separate wavelength bands (colors). The benefits of 2-color sensors are that accurate measurements can be made under the following conditions:

- ▶ When the field of view to the target is partially blocked or obscured.
- ▶ When the target is smaller than the sensor's field of view.
- ▶ When target emissivity are low or changing by the same factor in both wavelength bands.

Another benefit is that 2-color sensors measure closer to the highest temperature within the measured spot (spatial peak picking) instead of an average temperature. A 2-color sensor can be mounted farther away, even if the target does not fill the resulting spot size. The convenience is that you are not forced to install the sensor at some specific distance based upon target size and the sensor's optical resolution.

### Partially Obscured Targets

The radiated energy from a target is, in most cases, equally reduced when objects or atmospheric materials block some portion of the optical field of view. It follows that the ratio of the energies is unaffected, and thus the measured temperatures remain accurate.

A 2-color sensor is better than a 1-color sensor in the following conditions:

- ▶ Sighting paths are partially blocked (either intermittently or permanently).
- ▶ Dirt, smoke, or steam is in the atmosphere between the sensor and target.
- ▶ Measurements are made through items or areas that reduce emitted energy, such as grills, screens, channels or small openings.



1-color sensors see polluted atmosphere and dirty windows and lenses as a reduction in energy and give much lower than actual temperature readings.

### **Targets Smaller Than Field of View**

When a target is not large enough to fill the field of view, or if the target is moving within the field of view, radiated energies are equally reduced, but the ratio of the energies is unaffected and measured temperatures remain accurate. This remains true as long as the background temperature is much lower than the target temperature.

Example:

- ▶ Measuring of wire or rod — often too narrow for field of view or moving or vibrating unpredictably. It is much easier to obtain accurate results because sighting is less critical with 2-color sensors.

### **Low or Changing Emissivity**

If the emissivity in both wavelengths (colors) were the same, as they would be for any blackbody (emissivity = 1.0) or greybody (emissivity < 1.0 but constant), then their ratio would be 1, and target emissivity would not be an influence. However, in nature there is no such thing as a greybody. The emissivity of all real objects changes with wavelength and temperature, at varying degrees, depending on the material.

When emissivity is uncertain or changing, a 2-color sensor can be more accurate than a 1-color instrument as long as the emissivity changes by the same factor in both wavelength bands. Note, however, that accurate measurement results are dependent on the application and the type of material being measured. To determine how to use 2-color sensors with your application when uncertain or changing emissivity are a factor, please contact your sales representative.

## 10 Emissivity

### 10.1 Definition

The intensity of infrared radiation, which is emitted by each body, depends on the temperature as well as on the radiation features of the surface material of the measuring object. The emissivity ( $\epsilon$  – Epsilon) is used as a material constant factor to describe the ability of the body to emit infrared energy. It can range between 0 and 100 %. A “blackbody” is the ideal radiation source with an emissivity of 1,0 whereas a mirror shows an emissivity of 0,1.

If the emissivity chosen is too high, the infrared thermometer may display a temperature value which is much lower than the real temperature – assuming the measuring object is warmer than its surroundings. A low emissivity (reflective surfaces) carries the risk of inaccurate measuring results by interfering infrared radiation emitted by background objects (flames, heating systems, chamottes). To minimize measuring errors in such cases, the handling should be performed very carefully and the unit should be protected against reflecting radiation sources.

### 10.2 Determination of unknown Emissivity

- ▶ First, determine the actual temperature of the measuring object with a thermocouple or contact sensor. Second, measure the temperature with the infrared thermometer and modify the emissivity until the displayed result corresponds to the actual temperature.
- ▶ If you monitor temperatures of up to 380 °C you may place a special plastic sticker (emissivity dots – part number: ACLSED) onto the measuring object, which covers it completely. Now set the emissivity to 0,95

and take the temperature of the sticker. Afterwards, determine the temperature of the adjacent area on the measuring object and adjust the emissivity according to the value of the temperature of the sticker.

- ▶ Cove a part of the surface of the measuring object with a black, flat paint with an emissivity of 0,98. Adjust the emissivity of your infrared thermometer to 0,98 and take the temperature of the colored surface. Afterwards, determine the temperature of a directly adjacent area and modify the emissivity until the measured value corresponds to the temperature of the colored surface.

**CAUTION: On all three methods the object temperature must be different from ambient temperature.**

### 10.3 Characteristic Emissivity

In case none of the methods mentioned above help to determine the emissivity you may use the emissivity tables ▶ **Appendix A – Emissivity Table Metals** and **Appendix B – Emissivity Table Non Metals**. These are average values, only. The actual emissivity of a material depends on the following factors:

- temperature
- measuring angle
- geometry of the surface
- thickness of the material
- constitution of the surface (polished, oxidized, rough, sandblast)
- spectral range of the measurement
- transmissivity (e.g. with thin films)

## 10.4 Characteristic Slope Values

The slope is the quotient of the emissivity of both of the overlapping wavelength bands. The factory default value for the slope is 1,000. The following slopes are typical reference values. The real slope can vary depending on the metal alloy and surface finish.

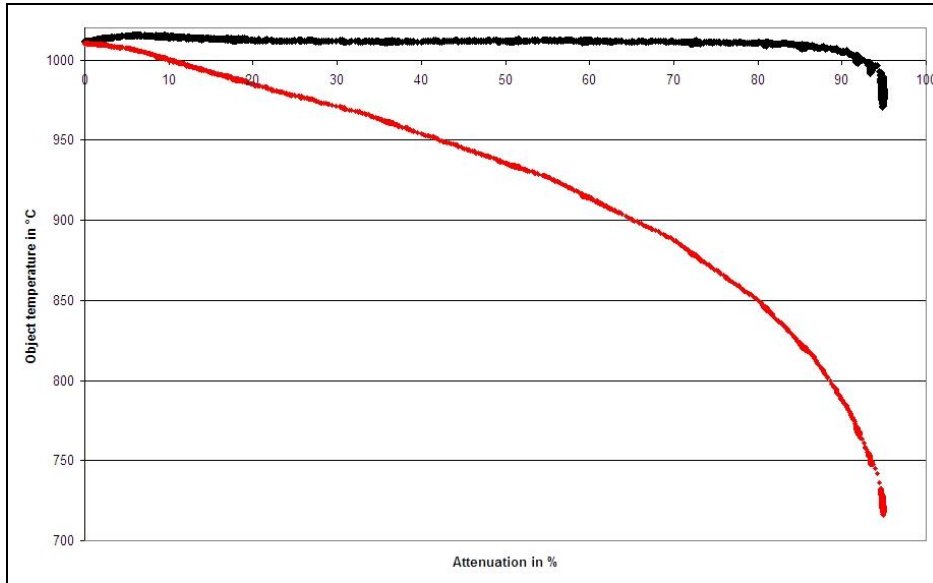
|  |                         |                     |
|--|-------------------------|---------------------|
| Cobalt, Iron, Nickel, Stainless steel, Steel   | ▶ oxidized surfaces     | <b>Slope: 1,000</b> |
| Cobalt, Iron (solid, molten), Molybdenum, Nickel, Platinum, Rhodium, Stainless steel, Steel, Tantalum, Tungsten, Wolfram | ▶ non-oxidized surfaces | <b>Slope: 1,060</b> |

## 10.5 Determination of unknown Slope values

Basically you can use the same methods to determine an unknown slope as described under ▶ **10.2 Determination of unknown Emissivity**. As the CTratio is dedicated for high temperature applications, only the first method may be practically applicable (use of a t/c or other contact probe).

## 10.6 Attenuation

The CTratio is able to measure the temperature of targets smaller than the field of view (FOV). If the target size is smaller than the FOV (and thus attenuating the signal) this may cause a small inaccuracy of the reading. The inaccuracy is dependent on the object temperature and value of attenuation. The higher the object temperature and attenuation the higher the inaccuracy of the sensor.



This figure is showing the typical temperature reading of a ratio thermometer optris CTRatio in both the 1-color- and the 2-color-mode in addition of increasing contamination of the optical transmission path in-between the target and the ratio thermometer. Due to the ratio principle the 2 channel signal (upper curve) stays very stable over a wide range of attenuation up to over 90 %. The signal of the 1 channel mode (lower curve), acting like in a standard pyrometer with one measuring wavelength only, is decreasing rapidly with the contamination of the transmission path.

## Appendix A – Emissivity Table Metals

| Material          |                  | typical Emissivity |                   |                   |                    |
|-------------------|------------------|--------------------|-------------------|-------------------|--------------------|
|                   |                  | 1,0 $\mu\text{m}$  | 1,6 $\mu\text{m}$ | 5,1 $\mu\text{m}$ | 8-14 $\mu\text{m}$ |
| Spectral response |                  |                    |                   |                   |                    |
| Aluminium         | non oxidized     | 0,1-0,2            | 0,02-0,2          | 0,02-0,2          | 0,02-0,1           |
|                   | polished         | 0,1-0,2            | 0,02-0,1          | 0,02-0,1          | 0,02-0,1           |
|                   | roughened        | 0,2-0,8            | 0,2-0,6           | 0,1-0,4           | 0,1-0,3            |
|                   | oxidized         | 0,4                | 0,4               | 0,2-0,4           | 0,2-0,4            |
| Brass             | polished         | 0,35               | 0,01-0,05         | 0,01-0,05         | 0,01-0,05          |
|                   | roughened        | 0,65               | 0,4               | 0,3               | 0,3                |
|                   | oxidized         | 0,6                | 0,6               | 0,5               | 0,5                |
| Copper            | polished         | 0,05               | 0,03              | 0,03              | 0,03               |
|                   | roughened        | 0,05-0,2           | 0,05-0,2          | 0,05-0,15         | 0,05-0,1           |
|                   | oxidized         | 0,2-0,8            | 0,2-0,9           | 0,5-0,8           | 0,4-0,8            |
| Chrome            |                  | 0,4                | 0,4               | 0,03-0,3          | 0,02-0,2           |
| Gold              |                  | 0,3                | 0,01-0,1          | 0,01-0,1          | 0,01-0,1           |
| Haynes            | alloy            | 0,5-0,9            | 0,6-0,9           | 0,3-0,8           | 0,3-0,8            |
| Inconel           | electro polished | 0,2-0,5            | 0,25              | 0,15              | 0,15               |
|                   | sandblast        | 0,3-0,4            | 0,3-0,6           | 0,3-0,6           | 0,3-0,6            |
|                   | oxidized         | 0,4-0,9            | 0,6-0,9           | 0,6-0,9           | 0,7-0,95           |
| Iron              | non oxidized     | 0,35               | 0,1-0,3           | 0,05-0,25         | 0,05-0,2           |
|                   | rusted           |                    | 0,6-0,9           | 0,5-0,8           | 0,5-0,7            |
|                   | oxidized         | 0,7-0,9            | 0,5-0,9           | 0,6-0,9           | 0,5-0,9            |
|                   | forged, blunt    | 0,9                | 0,9               | 0,9               | 0,9                |
|                   | molten           | 0,35               | 0,4-0,6           |                   |                    |
| Iron, casted      | non oxidized     | 0,35               | 0,3               | 0,25              | 0,2                |
|                   | oxidized         | 0,9                | 0,7-0,9           | 0,65-0,95         | 0,6-0,95           |

| Material      |                | typical Emissivity |                   |                   |                    |
|---------------|----------------|--------------------|-------------------|-------------------|--------------------|
|               |                | 1,0 $\mu\text{m}$  | 1,6 $\mu\text{m}$ | 5,1 $\mu\text{m}$ | 8-14 $\mu\text{m}$ |
| Lead          | polished       | 0,35               | 0,05-0,2          | 0,05-0,2          | 0,05-0,1           |
|               | roughened      | 0,65               | 0,6               | 0,4               | 0,4                |
|               | oxidized       |                    | 0,3-0,7           | 0,2-0,7           | 0,2-0,6            |
| Magnesium     |                | 0,3-0,8            | 0,05-0,3          | 0,03-0,15         | 0,02-0,1           |
| Mercury       |                |                    | 0,05-0,15         | 0,05-0,15         | 0,05-0,15          |
| Molybdenum    | non oxidized   | 0,25-0,35          | 0,1-0,3           | 0,1-0,15          | 0,1                |
|               | oxidized       | 0,5-0,9            | 0,4-0,9           | 0,3-0,7           | 0,2-0,6            |
| Monel (Ni-Cu) |                | 0,3                | 0,2-0,6           | 0,1-0,5           | 0,1-0,14           |
| Nickel        | electrolytic   | 0,2-0,4            | 0,1-0,3           | 0,1-0,15          | 0,05-0,15          |
|               | oxidized       | 0,8-0,9            | 0,4-0,7           | 0,3-0,6           | 0,2-0,5            |
| Platinum      | black          |                    | 0,95              | 0,9               | 0,9                |
| Silver        |                | 0,04               | 0,02              | 0,02              | 0,02               |
| Steel         | polished plate | 0,35               | 0,25              | 0,1               | 0,1                |
|               | rustless       | 0,35               | 0,2-0,9           | 0,15-0,8          | 0,1-0,8            |
|               | heavy plate    |                    |                   | 0,5-0,7           | 0,4-0,6            |
|               | cold-rolled    | 0,8-0,9            | 0,8-0,9           | 0,8-0,9           | 0,7-0,9            |
|               | oxidized       | 0,8-0,9            | 0,8-0,9           | 0,7-0,9           | 0,7-0,9            |
| Tin           | non oxidized   | 0,25               | 0,1-0,3           | 0,05              | 0,05               |
| Titanium      | polished       | 0,5-0,75           | 0,3-0,5           | 0,1-0,3           | 0,05-0,2           |
|               | oxidized       |                    | 0,6-0,8           | 0,5-0,7           | 0,5-0,6            |
| Wolfram       | polished       | 0,35-0,4           | 0,1-0,3           | 0,05-0,25         | 0,03-0,1           |
| Zinc          | polished       | 0,5                | 0,05              | 0,03              | 0,02               |
|               | oxidized       | 0,6                | 0,15              | 0,1               | 0,1                |



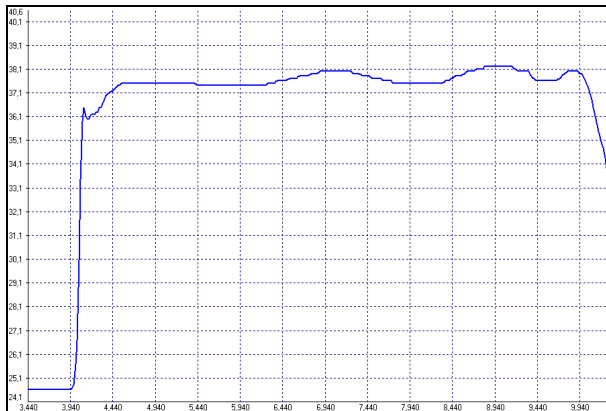
## Appendix B – Emissivity Table Non Metals

| Material                  | typical Emissivity |                   |                   |                   |                    |
|---------------------------|--------------------|-------------------|-------------------|-------------------|--------------------|
|                           | Spectral response  | 1,0 $\mu\text{m}$ | 2,2 $\mu\text{m}$ | 5,1 $\mu\text{m}$ | 8-14 $\mu\text{m}$ |
| Asbestos                  |                    | 0,9               | 0,8               | 0,9               | 0,95               |
| Asphalt                   |                    |                   |                   | 0,95              | 0,95               |
| Basalt                    |                    |                   |                   | 0,7               | 0,7                |
| Carbon                    | non oxidized       |                   | 0,8-0,9           | 0,8-0,9           | 0,8-0,9            |
|                           | graphite           |                   | 0,8-0,9           | 0,7-0,9           | 0,7-0,8            |
| Carborundum               |                    |                   | 0,95              | 0,9               | 0,9                |
| Ceramic                   |                    | 0,4               | 0,8-0,95          | 0,8-0,95          | 0,95               |
| Concrete                  |                    | 0,65              | 0,9               | 0,9               | 0,95               |
| Glass                     | plate              |                   | 0,2               | 0,98              | 0,85               |
|                           | melt               |                   | 0,4-0,9           | 0,9               |                    |
| Grit                      |                    |                   |                   | 0,95              | 0,95               |
| Gypsum                    |                    |                   |                   | 0,4-0,97          | 0,8-0,95           |
| Ice                       |                    |                   |                   |                   | 0,98               |
| Limestone                 |                    |                   |                   | 0,4-0,98          | 0,98               |
| Paint                     | non alkaline       |                   |                   |                   | 0,9-0,95           |
| Paper                     | any color          |                   |                   | 0,95              | 0,95               |
| Plastic >50 $\mu\text{m}$ | non transparent    |                   |                   | 0,95              | 0,95               |
| Rubber                    |                    |                   |                   | 0,9               | 0,95               |
| Sand                      |                    |                   |                   | 0,9               | 0,9                |
| Snow                      |                    |                   |                   |                   | 0,9                |
| Soil                      |                    |                   |                   |                   | 0,9-0,98           |
| Textiles                  |                    |                   |                   | 0,95              | 0,95               |
| Water                     |                    |                   |                   |                   | 0,93               |
| Wood                      | natural            |                   |                   | 0,9-0,95          | 0,9-0,95           |

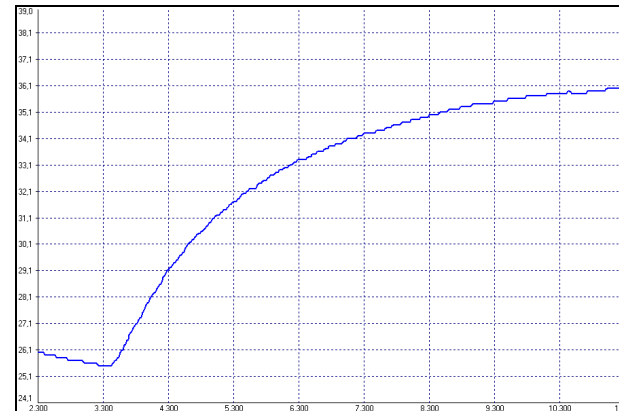
## Appendix C – Smart Averaging

The average function is generally used to smoothen the output signal. With the adjustable parameter time this function can be optimal adjusted to the respective application. One disadvantage of the average function is that fast temperature peaks which are caused by dynamic events are subjected to the same averaging time. Therefore those peaks can only be seen with a delay on the signal output.

The function **Smart Averaging** eliminates this disadvantage by passing those fast events without averaging directly through to the signal output.



Signal graph with Smart Averaging function



Signal graph without Smart Averaging function

## Appendix D – Declaration of Conformity

### EG-Konformitätserklärung EU Declaration of Conformity



Wir / We

Optris GmbH  
Ferdinand Buisson Str. 14  
13127 Berlin  
Deutschland / Germany

erklären in alleiniger Verantwortung, dass  
declare on our own responsibility that

die Produktserie optris CTratio  
the product group optris CTratio

den Anforderungen der EMV-Richtlinie 2014/30/EU und der allgemeinen Produktsicherheits-  
richtlinie 2007/95/EG entspricht,  
meets the provisions of the EMC Directive 2014/30/EU and the General Product Safety Directive  
2007/95/EC.

Angewandte harmonisierte Normen:  
Applied harmonized standards:

EMV Anforderungen / EMC General Requirements:

EN 61326-1:2013 (Grundlegende Prüfanforderungen / Basic requirements)  
EN 61326-2-3:2013

Gerätesicherheit von Messgeräten / Safety of measurement devices:

EN 61010-1:2010  
EN 60825-1:2014 (Lasersicherheit / Laser safety)

Dieses Produkt erfüllt die Vorschriften der Richtlinie 2015/863/EU (RoHS) des Europäischen  
Parlaments und des Rates vom 4. Juni 2015 zur Beschränkung der Verwendung bestimmter  
gefährlicher Stoffe in Elektro- und Elektronikgeräten.  
This product is in conformity with Directive 2015/863/EU (RoHS) of the European Parliament and of  
the Council of 4 June 2015 on the restriction of the use of certain hazardous substances in  
electrical and electronic equipment

Berlin, 07.08.2020

Ort, Datum / place, date

Dr. Ulrich Kienitz  
Geschäftsführer / General Manager

optris CTratio-MA-E2021-08-A