



Operating Instructions  
**thermoMETER CTRatio**

M-1

M-2

Fiber Optics Ratio Thermometer

MICRO-EPSILON  
MESSTECHNIK  
GmbH & Co. KG  
Koenigbacher Str. 15

94496 Ortenburg / Germany

Tel. +49 (0) 8542 / 168-0  
Fax +49 (0) 8542 / 168-90  
e-mail [info@micro-epsilon.com](mailto:info@micro-epsilon.com)  
[www.micro-epsilon.com](http://www.micro-epsilon.com)

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# 1 Safety

System operation assumes knowledge of the operating instructions.

## 1.1 Symbols Used

The following symbols are used in these operating instructions:



Indicates a hazardous situation which, if not avoided, may result in minor or moderate injury.



Indicates a situation that may result in property damage if not avoided.



Indicates a tip for users.



Connect the power supply and the display/output device in accordance with the safety regulations for electrical equipment.

> Risk of injury

> Damage to or destruction of the sensor and/or controller

Avoid shock and vibration to the sensor and the controller.

> Damage to or destruction of the sensor and/or controller

Avoid mechanical violence on the sensor.

> Damage to or destruction of the sensor

The supply voltage must not exceed the specified limits.

> Damage to or destruction of the sensor and/or controller

Protect the sensor cable against damage.

> Destruction of the sensor, failure of the measuring device

Do not kink the sensor cable and bend the sensor cable in tight radius.

The minimum bending radius is 40 mm.

> Damage to the sensor cable, failure of the measuring device

No solvent-based cleaning agents may have an effect on the sensor (neither for the optics nor the housing).

> Damage to or destruction of the sensor

Avoid static electricity.

> Damage to or destruction of the controller

Avoid abrupt changes of the ambient temperature.

> Inaccurate or incorrect measurements



## 1.2 Notes on CE Marking

The following apply to the thermoMETER CTRatio:

- EU Directive 2014/30/EU
- EU Directive 2011/65/EU, „RoHS“ category 9

Products which carry the CE mark satisfy the requirements of the EU directives cited and the European harmonized standards (EN) listed therein. The EU Declaration of Conformity is available to the responsible authorities according to EU Directive, article 10, at:

MICRO-EPSILON MESSTECHNIK  
GmbH & Co. KG  
Koenigbacher Str. 15  
94496 Ortenburg / Germany

The measuring system is designed for use in industrial environments and meets the requirements.

## 1.3 Intended Use

- The thermoMETER CTRatio is designed for use in industrial and laboratory areas. It is used for non-contact temperature measurement.
- The system must only be operated within the limits specified in the technical data [► 4 Technical Data].
- The system must be used in such a way that no persons are endangered or machines and other material goods are damaged in the event of malfunction or total failure of the controller.
- Take additional precautions for safety and damage prevention in case of safety-related applications.

## 1.4 Proper Environment

- Protection class:

- Sensor: IP 65 (NEMA 4)
- Controller: IP 65 (NEMA 4)

- Ambient temperature:

- Sensor: -20 ... +200 °C (-4 ... +392 °F) (optional up to +315 °C (+599 °F))
- Controller: 0 ... +50 °C (0 ... +122 °F) (M-2); 0 ... +60 °C (0 ... +140 °F) (M-1)

**NOTICE**

Avoid abrupt changes of the ambient temperature of both the sensor and the controller.  
> Inaccurate measuring values

- Storage temperature:

- Sensor: -40 ... +200 °C (-40 ... +392 °F)
- Controller: -40 ... +85 °C (-40 ... +185 °F)

- Humidity: 10 ... 95 %, non-condensing

## 2 Laser Security

The CTRatio is equipped with an integrated laser that serves to align the optics with the target. The thermoMETER CTRatio laser sighting [► 5.2 Laser Sighting] operate with a semiconductor laser with a wavelength of 520 nm (visible/green).

The sensor fall within Laser Class 2 (II), the average power is < 1 mW.

¡ Comply with all regulations on lasers!



Never deliberately look into the laser beam!

Consciously close your eyes or turn away immediately if ever the laser beam should hit your eyes.

Although the laser output is low looking directly into the laser beam must be avoided. Due to the visible light beam eye protection is ensured by the natural blink reflex. The housing of the optical sensors may only be opened by the manufacturer [► 12 Liability for Material Defects]. For repair and service purposes the sensors must always be sent to the manufacturer.

Lasers of Class 2 (II) are not subject to notification and a laser protection officer is not required.

The following warning label must be attached to the cover (front) of the controller housing.



**IEC Laser warning and laser label with FDA addition**



**True reproduction of the controller with its actual location of the warning label**

During operation of the sensor the pertinent regulations acc. to IEC 60825-1 on „radiation safety of laser equipment“ must be fully observed at all times.

The sensor complies with all applicable laws for the manufacturer of laser devices.

**i** If the warning label is covered over when the unit is installed the user must ensure that supplementary labels are applied.

## 3 General Information

### 3.1 Description

Thank you for choosing the **thermoMETER CTRatio** infrared thermometer.

The sensors of the 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 [**► 10 Basics of Infrared Thermometry**].

The optical sensor 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 [**► 10.1 The Ratio Principle**].

### 3.2 Unpacking, Included in Delivery

- CTRatio sensor with fibre connection cable and controller
- USB cable (Micro-USB, USB-C and USB-A cable included)
- 1 mounting nut
- Mounting bracket, adjustable in one axis
- Operating Instructions

### 3.3 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).

### 3.4 Cautions

Avoid static electricity. The fiber optical cable has a minimum bending radius of **40 mm**.

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.

### 3.5 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>M-1L</b>	<b>M-1H</b>	<b>M-1H1</b>	<b>M-2L</b>	<b>M-2H</b>	<b>M-2H1</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 >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**



## 4 Technical Data

### 4.1 General Specifications

	Sensor	Controller
Environmental rating	IP 65 (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	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	Ratio Connect / IRmobile Android app	

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

## 4.2 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)
Relay outputs	2 x 60 V DC/ 42 V AC <sub>eff</sub> , 0,4 A; optically isolated (optional plug-in module)

### 4.3 Measurement Specifications [M-1 Models]

	M-1L	M-1H	M-1H1
Temperature range (scalable)	1 color: 450...1400 °C 2 color: 525...1400 °C	1 color: 650...2000 °C 2 color: 700...2000 °C	1 color: 900...3000 °C 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

## 4.4 Measurement Specifications [M-2 Models]

	M-2L	M-2H	M-2H1
Temperature range (scalable)	1 color: 250...1000 °C 2 color: 275...1000 °C	1 color: 375...1500 °C 2 color: 400...1500 °C	1 color: 500...3000 °C 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

## 4.5 Optics

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

<b>Optics</b>	<b>Focus adjustable in the range</b>
SFV	300 mm till infinity

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 sensor.

**D = Distance from front of the sensor to the object**

**S = Spot size**

<b>M-1L / M-2L (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>M-2H2 (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>M-1H / M-1H1 / M-2H1 (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

**Sensor placement [1C mode]**

The size of the measuring object and the optical resolution of the infrared thermometer determine the maximum distance between sensor 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]**

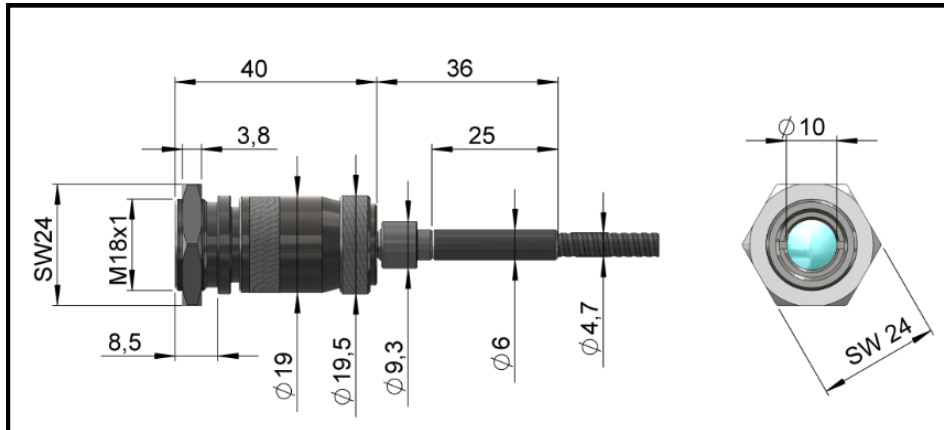
In the 2-color-mode the sensor can be placed under various conditions, like:

- **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**

**[▶ 10.1 The Ratio Principle]**

## 5 Mechanical Installation

The CTRatio sensors 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 sensor easier, can be additionally ordered as accessories.



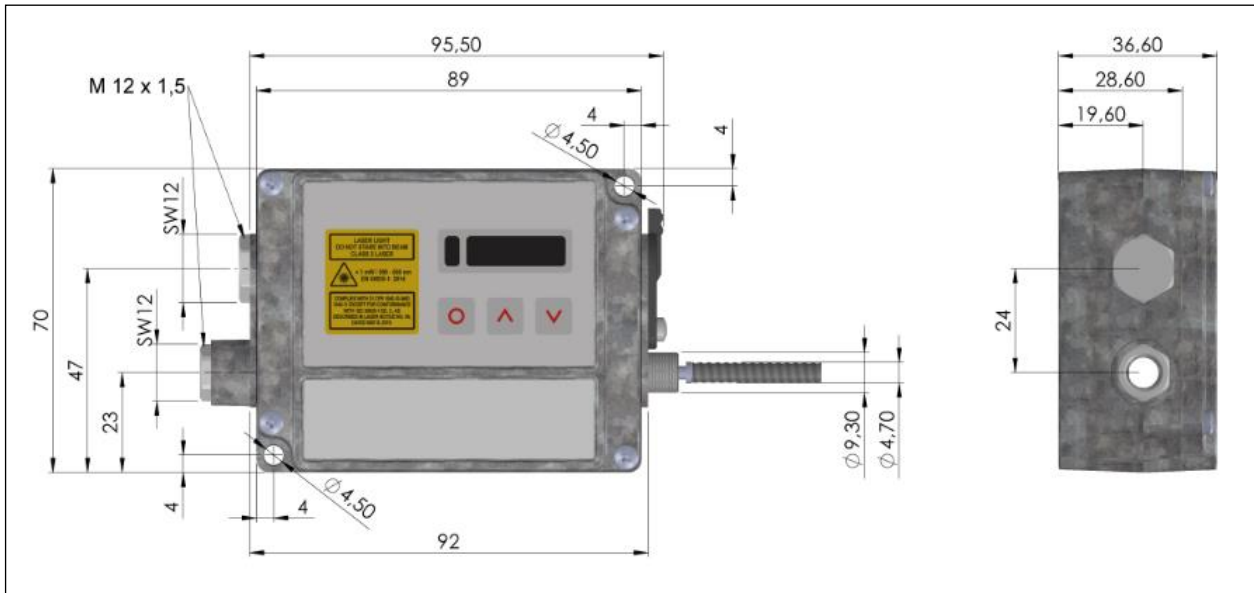
Sensor thermometer CTRatio



Please make sure that the minimum bending radius of the fiber optics of **40 mm** will be considered during installation.

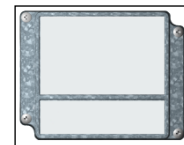
The thermoMETER CTRatio sensor is a sensitive optical system. Please use only the thread for mechanical installation.





### Controller

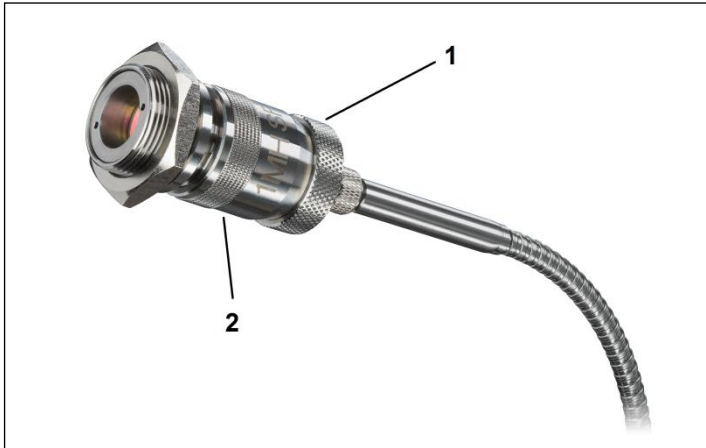
The controller is also available with closed cover (display and programming keys with no access from outside) **[TM-COV-CT]**.



thermoMETER CTRatio

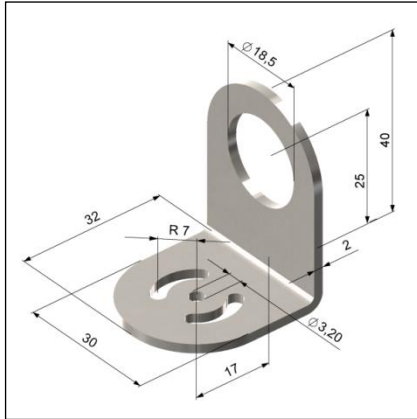
The CTRatio pyrometer is equipped with a vario optics. This enables you to focus the device from a distance of 300 mm to infinity. To focus the sensor, loosen the knurled screw (1) on the sensor. Now you can focus the device on the sensor (2). After alignment, retighten the knurled screw. This secures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

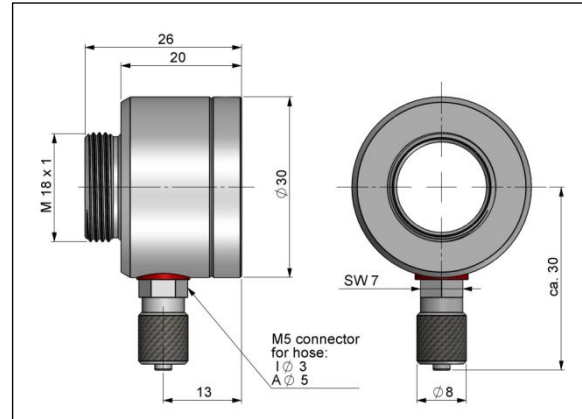


Sensor – Focusing the unit

## 5.1 Accessories



**Mounting bracket, adjustable in one axis  
[TM-FB-CTR]**



**Air purge collar [TM-AP-CTR]**

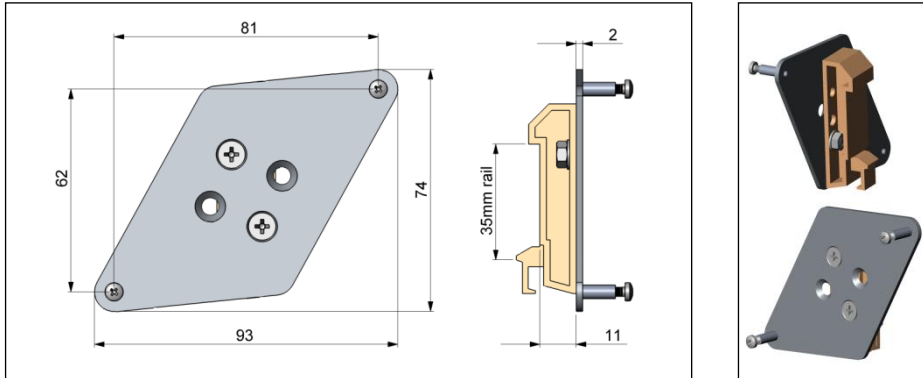
The lens must be kept clean at all times from dust, smoke, fumes and other contaminants in order to avoid reading errors (in the 1-color-mode). These effects can be reduced by using an air purge collar. Make sure to use oil-free, technically clean air, only.



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

## Rail Mount Adapter for Controller

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



[TM-RAIL-CT]

## 5.2 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). [► 6 Electrical Installation, 8 Operating]

**At ambient temperatures >50 °C inside the controller 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 controller, remove the fiber optical cable from the electronics or disassemble the sensor the sensor must be switched off and disconnected from the power supply and USB interface!**

## 6 Electrical Installation

### 6.1 Cable Connections

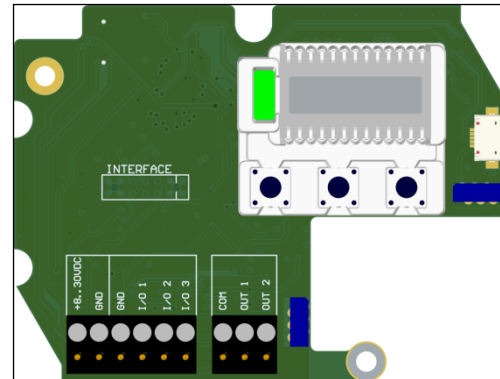
The supplied USB cable can be connected to the side of the controller. The device can be operated directly via the Ratio Connect software.

For the electrical installation of further interfaces and when using the in-/outputs please open at first the cover of the controller (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 controller 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!**

### 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.

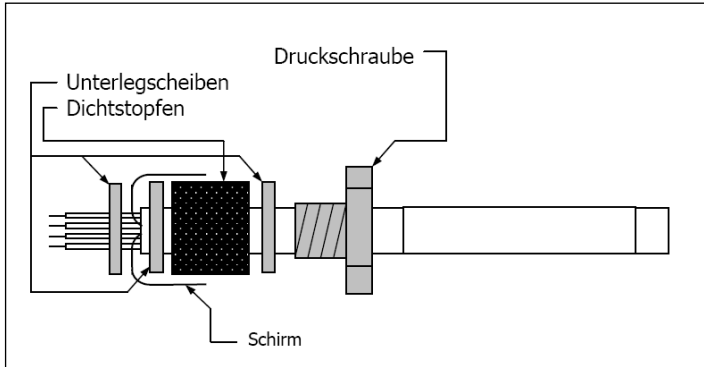
### Cable Assembling

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.

## 6.2 Ground Connection

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

Removing the ground connection is not recommended.



## 7 Outputs and Inputs

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

### 7.1 Analog Output

The selection of the signal on output channel 1 and 2 (0/4-20 mA) can be done via the software Ratio Connect [**►9 Software Ratio Connect**].



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

## 7.2 I/O pins

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

Function	I/O pin acts as	Description
<b>Digital Alarm</b>	output digital	Open collector output/ definition as HIGH- or LOW alarm via norm. open/ norm. close options in software dialog.
<b>Valid LO</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 HI</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 <math>\frac{\uparrow}{=}</math></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 <math>\frac{\downarrow}{=}</math></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 LO</b>	input digital	Reset of Peak or valley hold (HI-LO signal)
<b>Hold Reset HI</b>	input digital	Reset of Peak or valley hold (LO-HI 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>Emiss. 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).

High-level: Via software

Low-level: Via software

### 7.3 Programming Interface

The thermometer CTRatio has on the side of the controller a USB interface for programming and running the sensor. The USB cable is included in the scope of supply. As an option, the device can also be equipped with an RS232 or RS485 interface.



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 controller. 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.

## 7.4 Relay Outputs

The thermometer 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.

## 7.5 Alarms

The thermometer 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

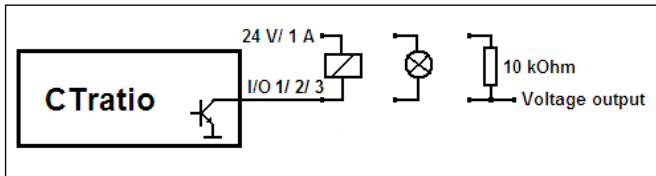
All the I/O pins can be programmed as alarm output. In this case the pin acts as an open collector output (24 V/ 1 A).

### 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.



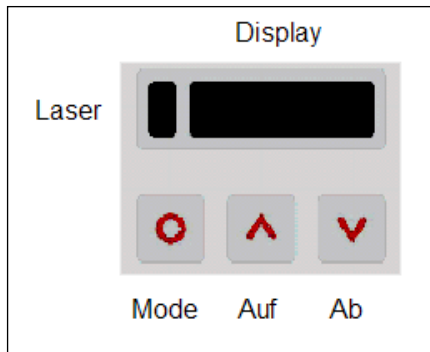
Different wirings of the open collector output

## 8 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 [►7.5 Alarms].

### 8.1 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 CT 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>	Controller 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>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) RS422 mode	<b>01 ... 32</b> <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>

- 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 [**►11 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.

## 9 Software Ratio Connect

### 9.1 Installation

Download the software from the MICRO-EPSILON website. 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 be downloaded via the Micro-Epsilon website under the following link:  
<https://www.micro-epsilon.de/temperature-sensors/>

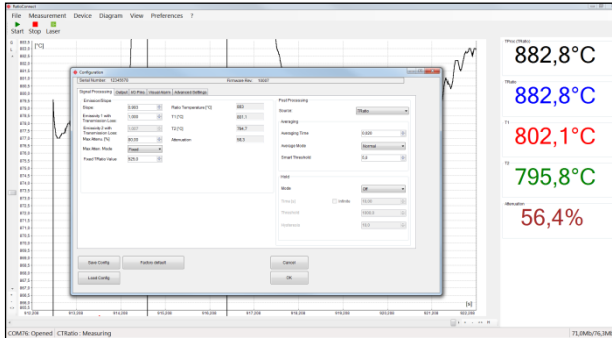
The installation wizard will place a launch icon on the desktop and in the start menu:

**[Start]\Programs\RatioConnect.**

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

## 9.2 Communication Settings

### 9.2.1 Serial Interface

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

### 9.2.2 Protocol

All sensors of the thermometer CTRatio series are using a binary protocol.

## 10 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 (► **11 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.

## 10.1 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.

# 11 Emissivity

## 11.1 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 ( $\varepsilon$  – 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.

## 11.2 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: TM-ED-LS) 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.

- ▶ Cover 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.**

### 11.3 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)

## 11.4 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.

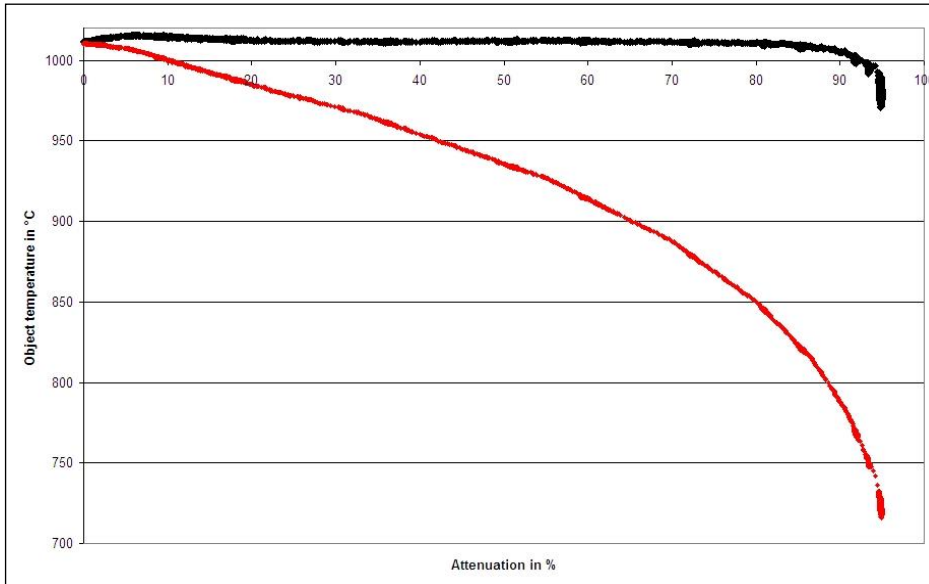
Cobalt, Iron, Nickel, Stainless steel, Steel	▶ oxidized surfaces	<b>Slope: 1,000</b>
Cobalt, Iron (solid, molten), Molybdenum, Nickel, Platinum, Rhodium, Stainless steel, Steel, Tantalum, Tungsten, Wolfram	▶ non-oxidized surfaces	<b>Slope: 1,060</b>

## 11.5 Determination of Unknown Slope Values

Basically you can use the same methods to determine an unknown slope as described under ▶ **11.2 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).

## 11.6 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.



thermoMETER CTRatio

This figure is showing the typical temperature reading of a ratio thermometer 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.

## 12 Liability for Material Defects

All components of the device have been checked and tested for functionality at the factory. However, if defects occur despite our careful quality control, MICRO-EPSILON or your dealer must be notified immediately. The liability for material defects is 12 months from delivery.

Within this period, defective parts, except for wearing parts, will be repaired or replaced free of charge, if the device is returned to MICRO-EPSILON with shipping costs prepaid. Any damage that is caused by improper handling, the use of force or by repairs or modifications by third parties is not covered by the liability for material defects. Repairs are carried out exclusively by MICRO-EPSILON.

Further claims cannot be made. Claims arising from the purchase contract remain unaffected. In particular, MICRO-EPSILON shall not be liable for any consequential, special, indirect or incidental damage. In the interest of further development, MICRO-EPSILON reserves the right to make design changes without notification.

For translations into other languages, the German version shall prevail.

## 13 Service, Repair

If the sensor, controller or the sensor cable is defective, please send us the affected parts for repair or exchange.

If the cause of a fault cannot be clearly identified, please send the entire measuring system to:

For customers in USA applies:

Send the affected parts or the entire measuring system back to:

For customers in Canada or South America applies:  
Please contact your local distributor.

MICRO-EPSILON MESSTECHNIK  
GmbH & Co. KG  
Koenigbacher Str. 15  
94496 Ortenburg / Germany

Tel. +49 (0) 8542/ 168-0  
Fax +49 (0) 8542 / 168-90  
info@micro-epsilon.com  
[www.micro-epsilon.com](http://www.micro-epsilon.com)

MICRO-EPSILON USA  
8120 Brownleigh Dr.  
Raleigh, NC 27617 /USA

Tel. +1 919 / 787-9707  
Fax +1 919 / 787-9706  
me-usa@micro-epsilon.com  
[www.micro-epsilon.com](http://www.micro-epsilon.com)

## 14 Decommissioning, Disposal

Remove the cables from sensor and controller.

Incorrect disposal may cause harm to the environment.

Dispose of the device, its components and accessories, as well as the packaging materials in compliance with the applicable country-specific waste treatment and disposal regulations of the region of use.

## Appendix A – Emissivity Table Metals

Material		typical Emissivity			
Spectral response		1,0 $\mu\text{m}$	1,6 $\mu\text{m}$	5,1 $\mu\text{m}$	8-14 $\mu\text{m}$
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			
Spectral response		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

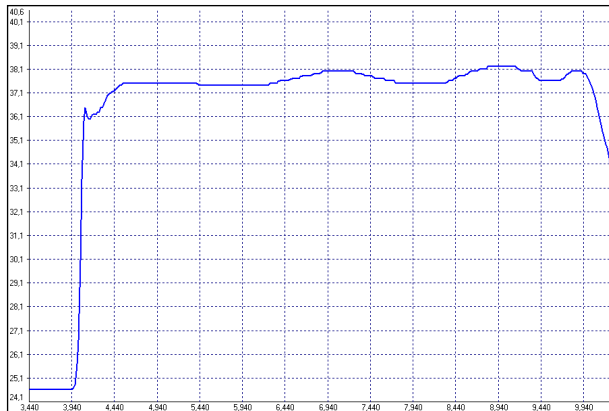
## Appendix B – Emissivity Table Non Metals

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

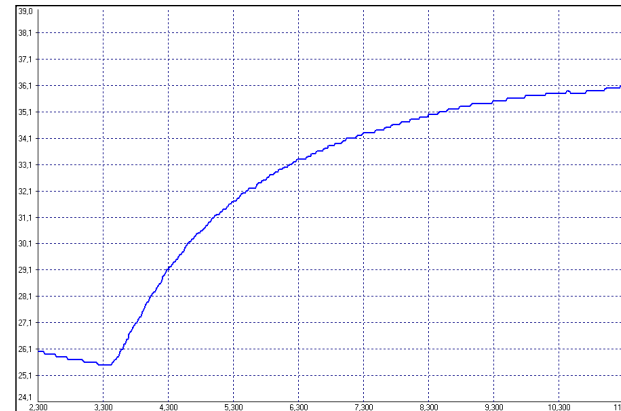
## Appendix C – Smart Averaging

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



MICRO-EPSILON MESSTECHNIK GmbH & Co. KG  
Koenigbacher Str. 15 · 94496 Ortenburg / Germany  
Tel. +49 (0) 8542 / 168-0 · Fax +49 (0) 8542 / 168-90  
info@micro-epsilon.com · www.micro-epsilon.com

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