## Infrared Sensor


# Operators Manual

thermoMETER CSmicro SF02/ SF15/ 2W/ 2WH/ 2WM-2/ HS

## CE-Conformity

The product complies with the following standards:

| | |
|---|---|
| EMC: | EN 61326-1: 2006 |
| | EN 61326-2-3: 2006 |
| Safety regulations: | EN 61010-1: 2001 |

The product accomplishes the requirements of the EMC Directive 2004/108/EC.

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. References to other chapters are marked as: ►

## Warranty

All components of the device have been checked and tested for perfect function in the factory. In the unlikely event that errors should occur despite our thorough quality control, this should be reported immediately to MICRO-EPSILON. The warranty period lasts 12 months following the day of shipment. Defective parts, except wear parts, will be repaired or replaced free of charge within this period if you return the device free of cost to MICRO-EPSILON.

This warranty does not apply to damage resulting from abuse of the equipment and devices, from forceful handling or installation of the devices or from repair or modifications performed by third parties. No other claims, except as warranted, are accepted. The terms of the purchasing contract apply in full. MICRO-EPSILON will specifically not be responsible for eventual consequential damages.

MICRO-EPSILON always strives to supply the customers with the finest and most advanced equipment. Development and refinement is therefore performed continuously and the right to design changes without prior notice is accordingly reserved.

For translations in other languages, the data and statements in the German language operation manual are to be taken as authoritative.

# Contents

# 1 Description

The sensors of the CSmicro series are noncontact infrared temperature sensors.
They calculate the surface temperature based on the emitted infrared energy of objects **[► Basics of Infrared Thermometry].**
The sensor housing of the CSmicro is made of stainless steel (IP 65/ NEMA-4 rating) – the sensor electronics is integrated inside the connection cable.

## 1.1 Scope of Supply

- CSmicro inclusive connection cable
- Mounting nut
- Operators manual

## 1.2 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 water based glass cleaner.

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

## 1.3 Cautions

Avoid abrupt changes of the ambient temperature.
In case of problems or questions which may arise when you use the sensor, please contact our service department.

> The sensors CSmicro are sensitive optical systems. Please use only the thread for mechanical installation.
> Avoid mechanical violence on the sensor – this may destroy the system (expiry of warranty).

## 1.4 Model Overview

The sensors of the CSmicro series are available in the following versions:

| Model | Measurement range | spectral response | Output |
|---|---|---|---|
| CSmicro SF02/ SF15 | -40 to 1030 °C | 8 - 14 $\mu$m | Voltage output 0 - 5 V/ 0-10 V |
| CSmicro 2W | -40 to 1030 °C | 8 - 14 $\mu$m | Two-wire sensor (4 - 20 mA) |
| CSmicro 2WH | -40 to 1030 °C | 8 - 14 $\mu$m | Two-wire sensor (4 - 20 mA) |
| CSmicro 2WM-2 | 385 to 1600 °C | 1.6 $\mu$m | Two-wire sensor (4 - 20 mA) |
| CSmicro HS | -20 to 150 °C | 8 - 14 $\mu$m | Two-wire sensor (4 - 20 mA)/ Detection of smallest temperature differences (0.025 K) |

## 1.5 Factory Default Settings

The units have the following presetting at time of delivery:

| | SF02/SF15 | 2W | 2WH | 2WM-2 | HS |
|---|---|---|---|---|---|
| Temperature range: | 0 ... 350 °C | 0 ... 350 °C | 0 ... 500 °C | 385 ... 1600 °C | -20 ... 150 °C |
| Output: | 0 ... 3.5 V | 0 ... 20 V | 4 ... 20 mA | 4 ... 20 mA | 4 ... 20 mA |
| Emissivity: | 0.950 | 0.950 | 0.950 | 1.000 | 0.950 |
| Transmission: | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| Average time: | 0.09 s | 0.3 s | 0.3 s | 0.09 s | 0.2 s |
| Smart Averaging: | active | active | active | active | active |

Smart Averaging means a dynamic average adaptation at high signal edges [activation/ deactivation via software only]. ► **Appendix C**

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.

For a usage of the CS- micro for online maintenance applications (in electrical cabinets e.g.) the following recommend settings are already included in the factory default setting (but not active):

| | | |
|---|---|---|
| OUT | At **3-state output** the following settings are default: | |
| | Pre-alarm difference: | 2 °C |
| | No alarm level: | 8 V |
| | Pre-alarm level: | 5 V |
| | Alarm level: | 0 V |
| | Service voltage: | 10 V |
| IN/ OUT: | At **Alarm output (open collector)** the following settings are default: | |
| | Mode: | normally closed |
| | Temp code output: | activated (for values above alarm level) |
| | Range settings: | 0 °C = 0 %/ 100 °C = 100 % |
| Vcc adjust: | If **activated** the following settings are default: | |
| | Output voltage range: | 0-10 V |
| | Difference mode: activated | |

# 2 Technical Data

## 2.1 General Specifications

| | | |
|---|---|---|
| Environmental rating | IP 65 (NEMA-4) | |
| Ambient temperature | Sensor: | see: Measurement Specifications |
| | Electronics (inside cable) | -20 ... 80 °C [ all SF models] |
| | | -20 ... 75 °C [ all 2W models] |
| Storage temperature | -40 ... 85 °C | |
| Relative humidity | 10 ... 95 %, non condensing | |
| Material (Sensor) | Stainless steel | |
| Dimensions | 28 mm x 14 mm (sensor) [SF02/ SF15/ 2W/ 2WH/ 2WM-2] | |
| | 55 mm x 29.5 mm (sensor inclusive massive housing) [HS] | |
| | 35 mm x 12 mm (electronics) | |
| Weight | 42 g [SF02/ SF15/ 2W/ 2WH/ 2WM-2] | |
| | 200 g [HS] | |
| Cable length | 1 m standard/ 3.5 m optional [SF02/ SF15/ 2W/ 2WH/ 2WM-2] | |
| | 3.5 [HS] | |
| Position of electronics | 50 cm after sensor | |
| Cable diameter | 2.8 mm (sensor – electronics) | |
| | 4.3 mm (electronics – end of cable) | |
| Vibration | IEC 68-2-6: 3 G, 11 – 200 Hz, any axis | |
| Shock | IEC 68-2-27: 50 G, 11 ms, any axis | |
| Software (optional) | Compact Connect | |

[1)] for Vcc (supply voltage) 5-12 VDC/ at Vcc > 12 VDC the max. ambient temperature of the electronics is 65 °C.

## 2.2 Electrical Specifications

| Used pin: OUT | Used pin: IN/ OUT | Function | SF02/SF15 | 2W |
|---|---|---|---|---|
| x | | Analog | 0 - 5 V [1] or 0-10 V [2]/ scalable | 4 - 20 mA/ scalable (current loop between Power and GND pin) |
| x | | Alarm | output voltage adjustable; N/O or N/C | output current adjustable; N/O or N/C (current loop between Power and GND pin) |
| x | | Alarm | 3-state alarm output (three voltage level for no alarm, pre-alarm, alarm) | - |
| | x | Alarm | programmable open collector output [0 - 30 V DC/ 50 mA] [4] | programmable open collector output [0 - 30 V DC/ 500 mA] |
| | x | Temp. Code | Temp. Code Output (open collector) [0 - 30 V DC/ 50 mA] [4] | Temp. Code Output (open collector) [0 - 30 V DC/ 500 mA] |
| | x | Input | programmable functions:<br>-external emissivity adjustment<br>-ambient temperature compensation<br>-triggered signal output and peak hold function [5] | programmable functions:<br>-triggered signal output and peak hold function [5] |
| x | x | Serial digital [3] | uni- (burst mode) or bidirectional | uni- (burst mode) or bidirectional |
| Output impedances | | | min. 10 kΩ load impedance | max. 1000 Ω loop impedance |
| Current draw | | | 9 mA | 4 - 20 mA |
| Power supply | | | 5 ... 30 VDC | 5 ... 30 VDC |

| | |
|---|---|
| Status LED | green LED with programmable functions:<br>• Alarm indication (threshold independent from alarm outputs)<br>• Automatic aiming support<br>• Self diagnostics<br>• Temperature code indication |
| Vcc adjust mode | 10 adjustable emissivity and alarm values by variation of supply voltage/ Service mode for analog output [only SF02/ SF15] |

[1)] 0 ... 4.6 V at supply voltage 5 VDC; also valid for alarm output
[2)] only at supply voltage ≥ 11 V
[3)] inverted RS232, TTL, 9.6 kBaud
[4)] 500 mA if the mV output is not used
[5)] High level: > 0.8 V/ Low level: < 0.8 V

## 2.3 Connection Diagrams


| | |
|---|---|
| white | Power supply |
| yellow | Analog output/ TxD (5 V)/ Alarm output |
| green | Analog input/ RxD (5 V)/ Open collector output |
| brown | Ground (⊥) |
| black | Shield |


| | |
|---|---|
| white | Current loop (+) |
| yellow | TxD (5 V) |
| green | RxD (5 V)/ Open collector output |
| brown | Current loop (-)/ Ground (⊥) |
| black | Shield |

You will find a detailed description of the different sensor connections in chapter ► **Electrical Installation.**

## 2.4 Measurement Specifications

| | SF02/ SF15 | 2W | 2WH |
|---|---|---|---|
| Temperature range IR (scalable via software) | -40 ... 1030 °C | -40 ... 1030 °C | -40 ... 1030 °C |
| Ambient temperature (sensor) | -20 ... 120 °C | -20 ... 120 °C | -20 ... 180 °C |
| Spectral range | 8 ... 14 $\mu$m | 8 ... 14 $\mu$m | 8 ... 14 $\mu$m |
| Optical resolution | 15:1/ 2:1 | 15:1 | 15:1 |
| CF-lens (optional) | 0.8 mm@ 10 mm/ 2.5 mm@ 23 mm | 0.8 mm@ 10 mm | 0.8 mm@ 10 mm |
| Accuracy[1)] | ±1.5 °C or ±1.5 % [2)] | ±1.5 °C or ±1.0 % [2)] | ±1.5 °C or ±1.0 % [2)] |
| Repeatability[1)] | ±0.75 °C or ±0.75 % [2)] | ±0.75 °C or ±0.75 % [2)] | ±0.75 °C or ±0.75 % [2)] |
| Temperature coefficient [3)] | ±0.05 K/ K or ±0.05 %/ K (whichever is greater) | | |
| Temperature resolution | 0.1 K | 0.1 K | 0.1 K |
| Response time | 30 ms (90 % signal) | 30 ms (90 % signal) | 30 ms (90 % signal) |
| Warm-up time | 10 min | 10 min | 10 min |
| Emissivity/ Gain | 0,100...1,100 (adjustable via software) | | |
| Transmissivity | 0,100...1,000 (adjustable via software) | | |
| Interface (optional) | USB programming interface | | |
| Signal processing | Average, Peak hold, Valley hold (adjustable via software) | | |

[1)] at ambient temperature 23±5 °C, whichever is greater; Epsilon = 1; Response time 1 s
[2)] at object temperatures > 0 °C
[3)] for ambient temperatures <18 °C and >28 °C

## Technical Data

| | HS | 2WM-2 |
|---|---|---|
| Temperature range IR (scalable via software) | -20 ... 150 °C | 385 ... 1600 °C |
| Ambient temperature (sensor) | -20 ... 75 °C | -20 ... 125 °C |
| Spectral range | 8 - 14 $\mu$m | 1.6 $\mu$m |
| Optical resolution | 15:1 | 75:1 |
| Accuracy[1)] | ±1 °C or ±1 % [3)] | ±(0.3 % of reading + 2 °C) [2)] |
| Repeatability[1)] | ±0.3 °C or ±0.3 % [3)] | ±(0.1 % of reading + 1 °C) [2)] |
| Temperature coefficient [5)] | ±0,05 K/ K or ±0,05 %/ K (whichever is greater) | |
| Temperature resolution | 0.025 K [3) 4)] | 0.1 K |
| Response time | 150 ms (90 % signal) | 10 ms (95 % signal) |
| Warm-up time | 10 min | - |
| Emissivity/ Gain | 0,100...1,100 (adjustable via software) | |
| Transmissivity | 0,100...1,000 (adjustable via software) | |
| Interface (optional) | USB programming interface | |
| Signal processing | Average, Peak hold, Valley hold (adjustable via software) | |

1) at ambient temperature 23±5 °C; Epsilon = 1; Response time = 1 s
2) at object temperatures > 450 °C
3) at object temperatures > 20 °C
4) at time constants > 0.2 s
5) for ambient temperatures <18 °C and >28 °C

## 2.5 Optical Charts

The following optical charts show the diameter of the measuring spot in dependence on the distance between measuring object and sensor. The spot size refers to 90 % of the radiation energy.
The distance is always measured from the front edge of the sensor housing/ CF-lens holder/ air purge.

| |
|---|
| The size of the measuring object and the optical resolution of the infrared thermometer determine the maximum distance between sensor and measuring object.<br>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. |

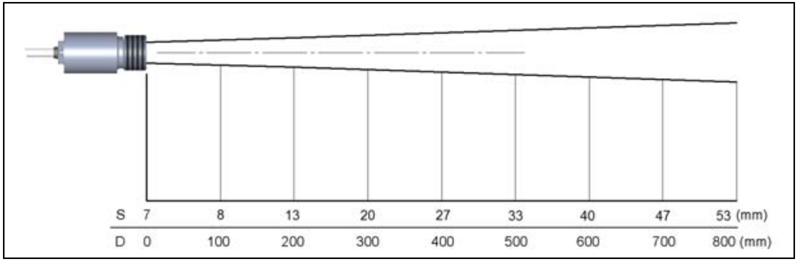



**Fig. 2.1: SF15/2W/HS D:S = 15:1**

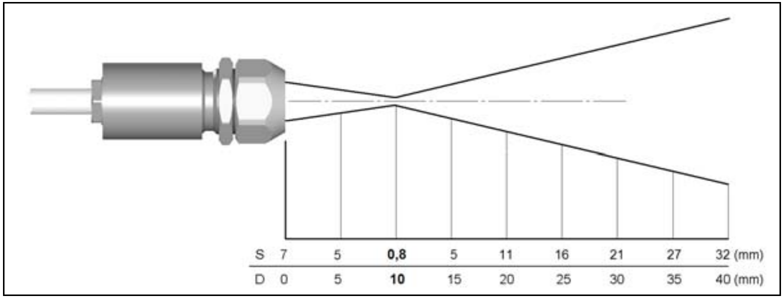



**Fig. 2.2: SF15/2W/HS with CF lens (0.8 mm@ 10 mm)**

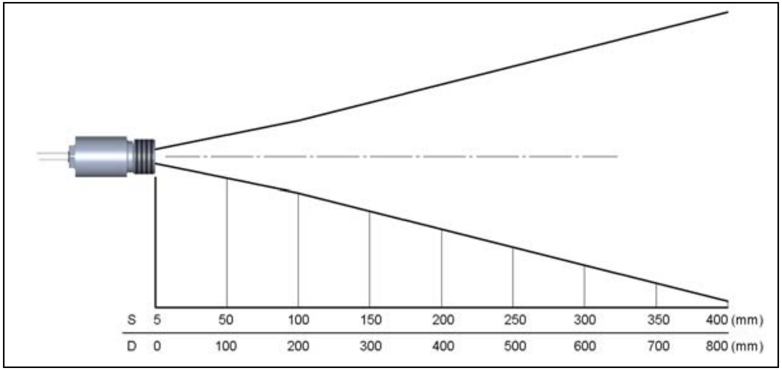



**Fig. 2.3: SF02 D:S = 2:1**

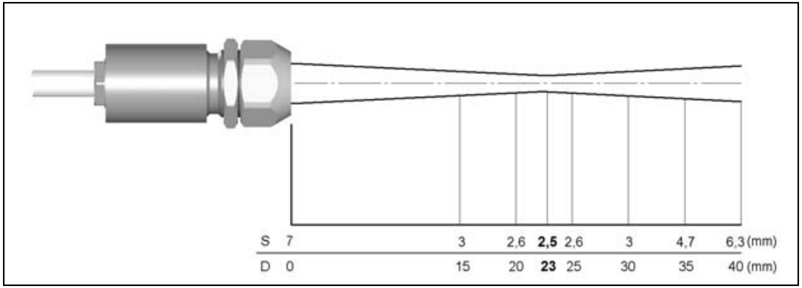



**Fig. 2.4: SF02 with CF lens (2.5 mm@ 23 mm)**

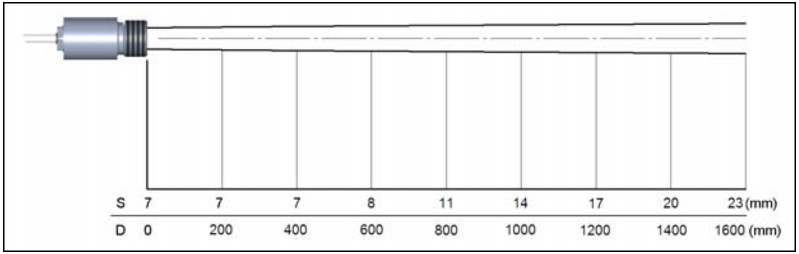



**Fig. 2.5: 2WM-2 SF D:S = 75:1**

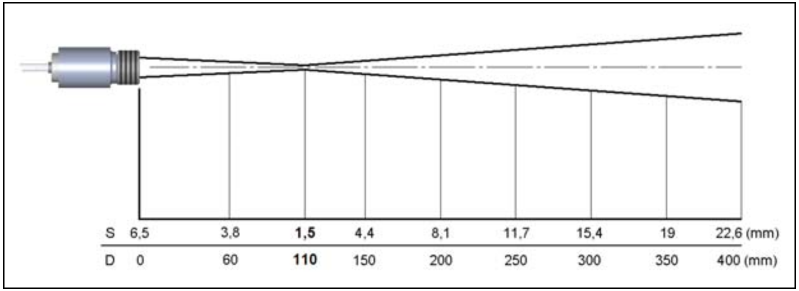



**Fig. 2.6: 2WM-2 CF D:S = 75:1/D:S Far field = 14:1**

If the CF lens (TM-CF-CS or TM-CFH-CS) is used in connection with 2WM-2 units (SF or CF optics) the focus is shifted to a distance of 11 mm.

## 2.6 CF Lens and Protective Window

> If the CF lens is used, the transmission has to be set to **0.78** [SF15/ 2W/ HS].

**The optional CF lens allows the measurement of very small objects. The minimum spot size depends on the used sensor. The distance is always measured from the front edge of the CF lens holder or laminar air purge collar. The installation on the sensor will be done by turning the CF lens until end stop. To combine it with the HS model please use the version with external thread M12x1.**

**Versions Overview:**

| | |
|---|---|
| TM-CF-CS | CF lens for installation on sensor [SF15/ 2W/ HS] |
| TM-CFH-CS | CF lens for installation on sensor [2WM-2] |
| TM-CFAG-CS | CF lens with external thread for installation in massive housing [SF15/ 2W/ HS] |
| TM-CFHAG-CS | CF lens with external thread for installation in massive housing [2WM-2] |

For protection of the sensor optics a protective window is available. The mechanical dimensions are equal to the CF lens. It is available in the following versions:

| | |
|---|---|
| TM-PW-CS | Protective window for installation on sensor [SF15/ 2W/ HS] |
| TM-PWH-CS | Protective window for installation on sensor [2WM-2] |
| TM-PWAG-CS | Protective window with external thread for installation in massive housing [SF15/ 2W/ HS] |
| TM-PWHAG-CS | Protective window with external thread for installation in massive housing [2WM-2] |

> If the protective window is used, the transmission has to be set to **0.83** [SF15/ 2W/ HS] or **0.93** [2WM-2].

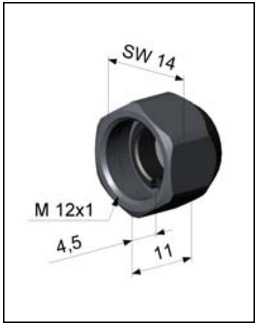



Fig. 2.7: CF lens: [TM-CF-CS/ TM-CFH-CS] Protective window: [TM-PW-CS/ TM-PWH-CS]

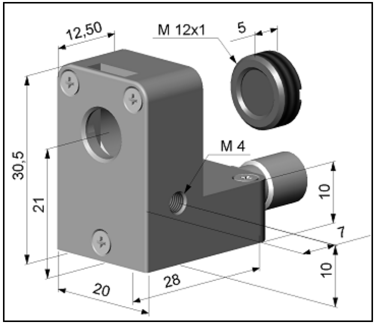



Fig. 2.8: Laminar air purge with integrated CF lens: [TM-APLCF-CS/ TM-APLCFH-CT]

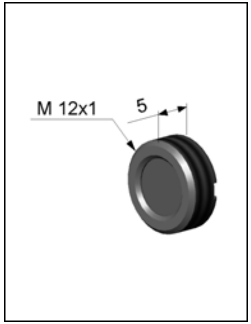



Fig. 2.9: CF lens with external thread: [TM-CFAG-CS] Protective window with external thread: [TM-PWAG-CS]

| |
|---|
| To change the transmission value the optional USB-Kit (including software) is necessary. |

# 3 LED Functions

The green LED can be programmed for the following functions. For the programming the USB adapter cable inclusive software (option) is necessary. The factory default setting for the LED is self diagnostic.

| | |
|---|---|
| LED Alarm | LED lights up if the object temperature exceeds or deceeds an alarm threshold |
| Automatic aiming support | Sighting feature for an accurate aiming of the CS to hot or cold objects |
| Self diagnostic | LED is indicating different states of the sensor |
| Temperature Code indication | Indication of the object temperature via the LED |
| Off | LED deactivated |

## 3.1 Automatic Aiming Support

The automatic aiming support helps to adjust the unit to an object which has a temperature different to the background. If this function is activated via software the sensor is looking for the highest object temperature; means the threshold value for activating the LED will be automatically tuned.
This works also if the sensor is aimed at a new object (with probably colder temperature). After expiration of a certain reset time (default setting: 10 s) the sensor will adjust the threshold level for activation of the LED new.

## 3.2 Self Diagnostic

With this function the current status of the sensor will be indicated by different flash modes of the LED.

If activated, the LED will show one out of five possible states of the sensor:

| Status | LED mode | |
|---|---|---|
| Normal | intermittent off | - - - - |
| Sensor overheated | fast flash | - - - - - - - - - - - - - |
| Out of measuring range | double flash | -- -- -- -- -- -- -- |
| Not stable | intermittent on | —— —— —— —— |
| Alarm fault | always on | ———————— |

Sensor overheated: The internal temperature probes have detected an invalid high internal temperature of the CSmicro.

Out of measuring range: The object temperature is out of measuring range.

Not stable: The internal temperature probes have detected an unequally internal temperature of the CSmicro.

Alarm fault: Current through the switching transistor of the open-collector output is too high.

## 3.3 Temperature Code Indication

With this function the current measured object temperature will be indicated as percentage value by long and short flashing of the LED.
At a range setting of 0 - 100 °C → 0-100 % the LED flashing indicates the temperature in °C.

| | |
|---|---|
| Long flashing → first digit: | **x**x |
| Short flashing → second digit: | x**x** |
| 10-times long flashing → first digit = 0: | **0**x |
| 10-times short flashing → second digit = 0: | x**0** |

**Examples**

| | | |
|---|---|---|
| **87 °C** | 8-times long flashing indicates | **8**7 |
| and afterwards | 7-times short flashing indicates | 8**7** |
| **31 °C** | 3-times long flashing indicates | **3**1 |
| and afterwards | 1-time short flashing indicates | 3**1** |
| **8 °C** | 10-times long flashing indicates | **0**8 |
| and afterwards | 8-times short flashing indicates | 0**8** |
| **20 °C** | 2-times long flashing indicates | **2**0 |
| and afterwards | 10-times short flashing indicates | 2**0** |

# 4 Installation

## 4.1 Mechanical Installation

The CSmicro is equipped with a metric M12x1 thread and can be installed either directly via the sensor thread or with the help of the hex nut (standard) to the mounting bracket available. The CSmicro HS will be delivered with the massive housing and can be installed via the M18x1-thread.

> The sensors CSmicro are sensitive optical systems. Please use only the thread for mechanical installation. Avoid mechanical violence on the sensor – this may destroy the system (expiry of warranty).

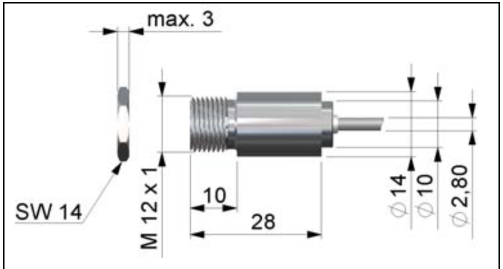



Fig. 4.1: Sensor SF15/ 2W/ 2WM-2

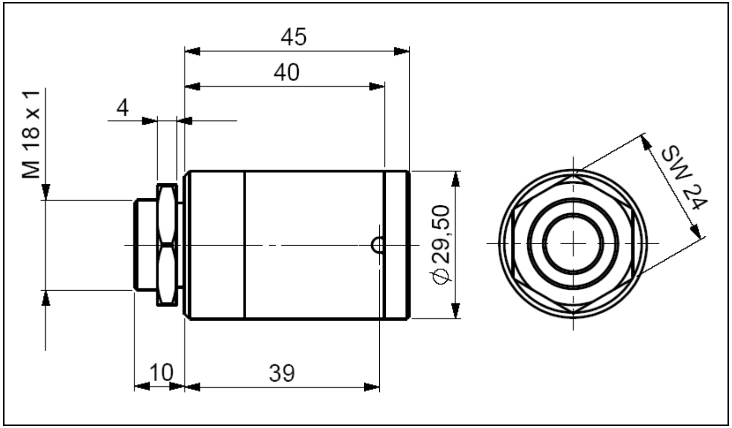



Fig. 4.2: Sensor HS

### 4.1.1 Mounting Accessories [SF02/ SF15/ 2W/ 2WM-2]

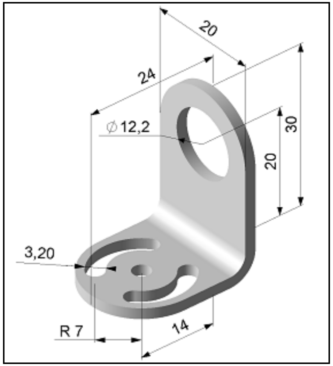



**Fig. 4.3: Mounting bracket, adjustable in one axis [TM-FB-CS]**

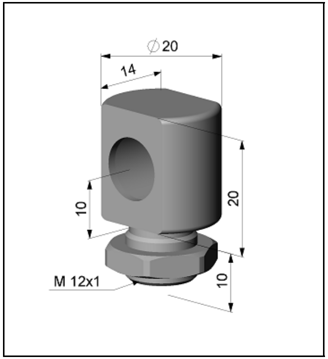



**Fig. 4.4: Mounting bolt with M12x1 thread, adjustable in one axis [TM-MB-CS]**

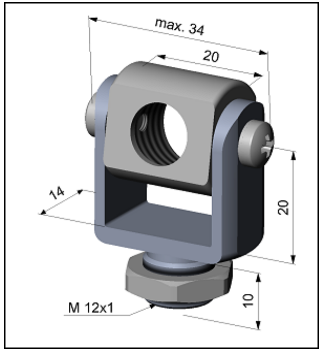



**Fig. 4.5: Mounting fork with M12x1 thread, adjustable in 2 axes [TM-MG-CS]**

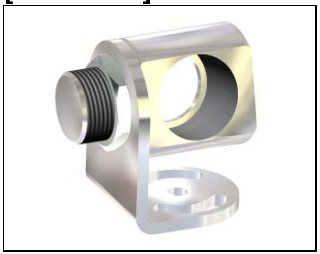


**Fig. 4.6: Mounting bracket adjustable in two axes, [TM-AB-CS]**

The Mounting fork can be combined with the Mounting bracket [TM-FB-CS] using the M12x1 thread.

## 4.1.2 Mounting Accessories [HS]

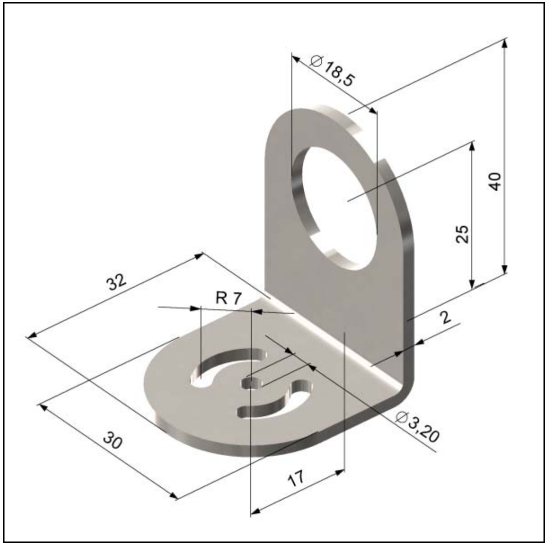



**Fig. 4.7: Mounting bracket, adjustable in one axis for HS [TM-FBMH-CT]**

### 4.1.3 Air Purge Collars [SF02/ SF15/ 2W/ 2WM-2]

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

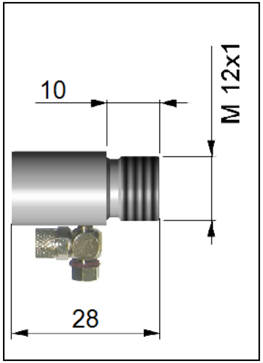



**Fig. 4.8: Standard air purge collar: fits to the mounting bracket; hose connection: 3x5 mm [TM-AP-CS] for sensors with a D:S ratio ≥ 10:1**

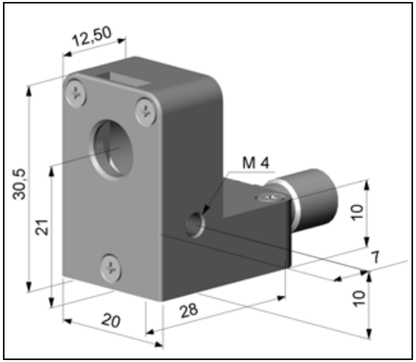
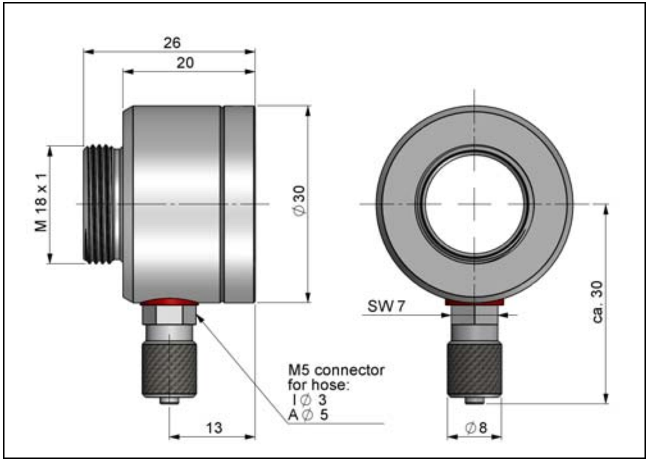



**Fig. 4.9: Laminar air purge collar – the sideward air outlet prevents a cooling down of the object in short distances; hose connection: 3x5 mm [TM-APL-CS]**

A combination of the Laminar air purge collar with the bottom section of the Mounting fork allows an adjustment in two axes. [TM-APL-CS +TM-MG-CS]

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

## 4.1.4 Air Purge Collar [HS]



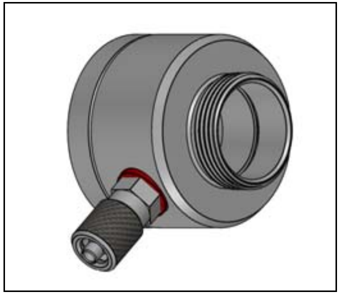



**Fig. 4.10: Air purge collar for HS sensor [TM-APMH-CT]**

### 4.1.5 Further Accessories

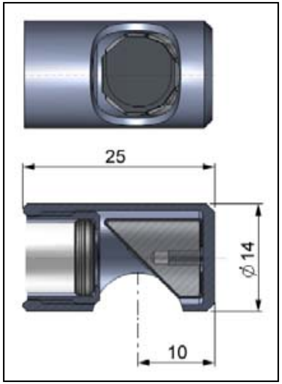



**Fig. 4.11: Right angle mirror enables measurement with 90° angle [TM-RAM-CS]**

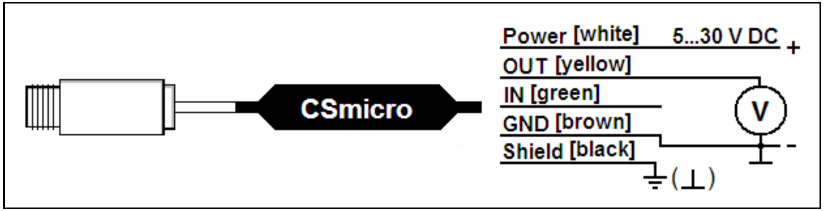

**Fig. 4.12: USB-Kit: USB programming adaptor inclusive terminal block and software CD [TM-USBK-CS]**

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

## 4.2 Electrical Installation

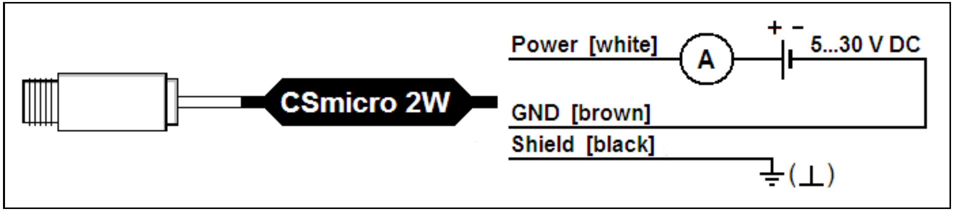
### 4.2.1 Analog Mode

**CSmicro [SF15/ SF02] as analog device (mV output on OUT pin)**




The output impedance must be ≥ 10 kΩ.

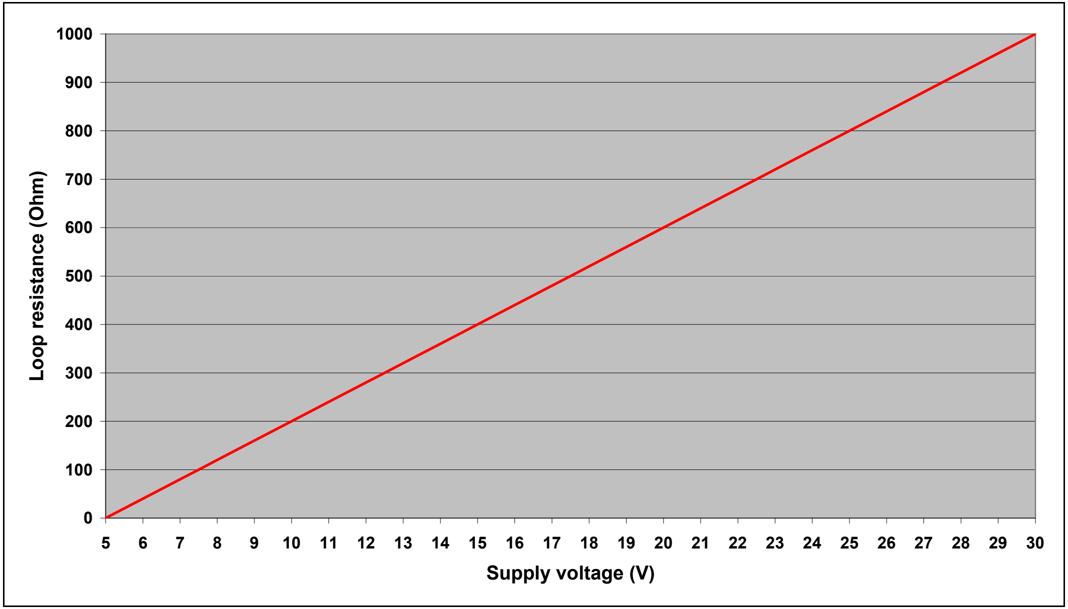
**CSmicro [2W/ 2WM-2/ HS] as analog device (mA two-wire-output)**




The maximum loop impedance is 1000 Ω.

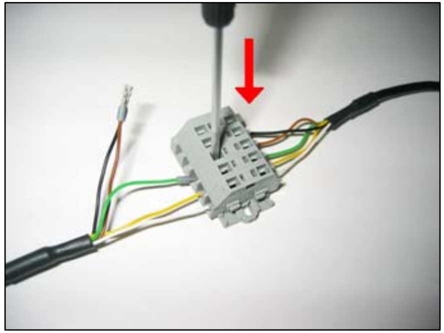
## 4.2.2 Maximum Loop Impedance [2W/ 2WM-2/ HS]

The maximum impedance of the current loop depends on the supply voltage level:



### 4.2.3 Digital Mode

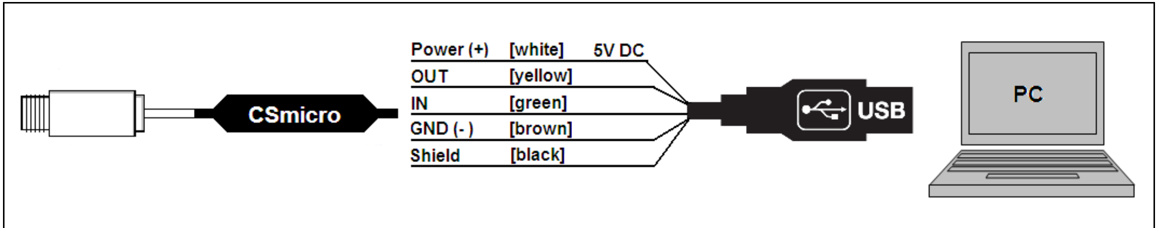
For a digital communication the optional USB programming kit is required. Please connect each wire of the USB adapter cable with the same coloured wire of the sensor cable by using the terminal block. Press with a screw driver as shown in the picture to loose a contact.



The sensor is offering two ways of digital communication:

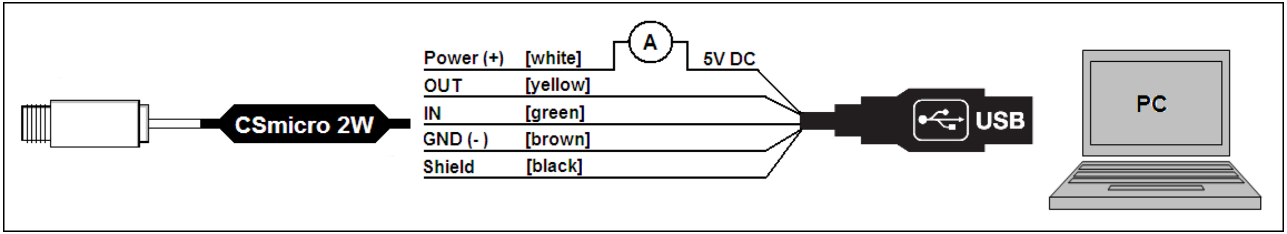
- bidirectional communication (sending and receiving data)
- unidirectional communication (burst mode – the sensor is sending data only)

**Digital mode [SF15/ SF02]**

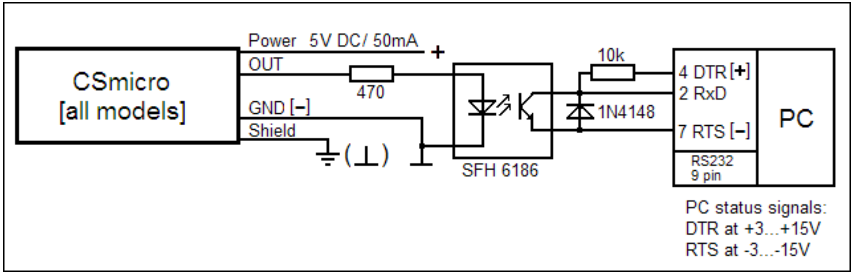


## Analog + Digital mode combined [2W/ 2WM-2/ HS]

The two-wire models are able to work in the digital mode and simultaneously as analog device (4 - 20 mA). In this case the sensor will be powered by the USB interface (5 V).



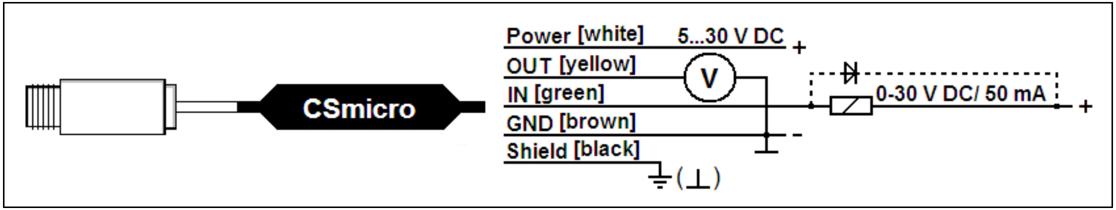

## Direct connection to an RS232 interface on the computer [SF15/ SF02]




In the digital mode the sensor can be connected directly to a serial port (RS232) on your PC using this circuit. This connection supports only the unidirectional communication mode.

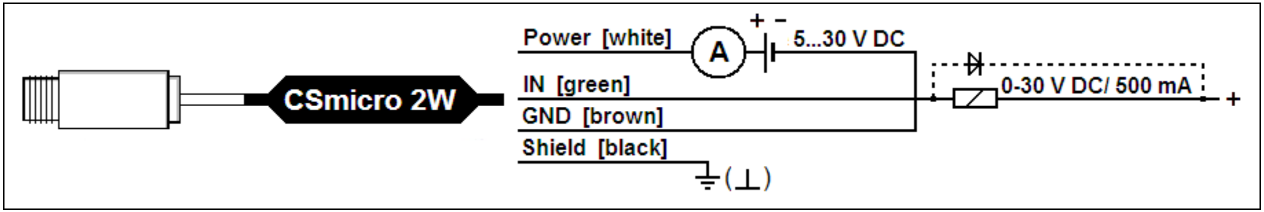
### 4.2.4 Alarm Output

**Open collector output [SF15/ SF02]**




The open collector output is an additional alarm output on the CSmicro and can control an external relay e.g. In addition the analog output can be used simultaneously.

**Open collector output [2W/ 2WM-2/ HS]**



# 5 Software

## 5.1 Installation

Insert the installation CD into the according drive on your computer. If the autorun option is activated the installation wizard will start automatically.
Otherwise please start setup.exe from the CD-ROM. Follow the instructions of the wizard until the installation is finished.

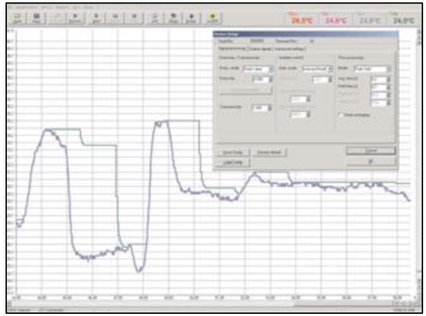
The installation wizard will place a launch icon on the desktop and in the start menu.
If you want to uninstall the software from your system please use the uninstall icon in the start menu.

You will find a detailed software manual on the CD.

## 5.2 Minimum System Requirements

- Windows XP
- USB interface
- Hard disc with at least 30 MByte free space
- At least 128 MByte RAM
- CD-ROM drive

## 5.3 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

## 5.4 Communication Settings

**Serial Interface**

| | |
|---|---|
| Baud rate: | 9600 baud |
| Data bits: | 8 |
| Parity: | none |
| Stop bits: | 1 |
| Flow control: | off |

**Protocol**

All sensors of the CSmicro series are using a binary protocol. To get a fast communication the protocol has no additional overhead with CR, LR or ACK bytes.
To power the sensor the control signal „DTR“ has to be set.

# 6 Digital Command Set [SF02/ SF15]

| **Communication mode (bidirectional)** | | | | |
|---|---|---|---|---|
| **Read commands** | **Header bytes** | **Response** | **Conversion Response to Decimal value** | **Example** |
| read process temperature [1)] | 3E0200 | word (hiByteLobyte) | process temp [°C] = (Hex ⇒ Dec(word)-1000)/10 | [1] |
| read sensor temperature | 3E0202 | word (hiByteLobyte) | sensor temp [°C] = (Hex ⇒ Dec(word)-1000)/10 | |
| read current target temperature [1)] | 3E0204 | word (hiByteLobyte) | current temp [°C] = (Hex ⇒ Dec(word)-1000)/10 | |
| read current ambient temperature | 3E0206 | word (hiByteLobyte) | ambient temp [°C] = (Hex ⇒ Dec(word)-1000)/10 | |
| read current emissivity | 3E0208 | word (hiByteLobyte) | emissivity = Hex ⇒ Dec(word)/1000 | [2] |
| | | | | |
| **Set commands** | **Header bytes** | **Set value** | **Generation of the set value** | |
| set emissivity | 3A0208 | word (hiByteLobyte) | word = Dec ⇒ Hex (emissivity x 1000) | [3] |
| switch on loop maintenance mode | 3D026190 | ------ | ------ | [4] |
| set target temperature for maintenance | 3A0212 | word (hiByteLobyte) | word = Dec ⇒ Hex (target temperature [°C] x 10 +1000) | [5] |
| switch off loop maintenance mode | 3D026180 | ------ | ------ | [6] |
| | | | | |
| **Examples** | **Send** | **Receive** | **Comment** | |
| [1] read process temperature | 3E0200 | **0519** | process temp [°C] = (Hex ⇒ Dec(**0519**)-1000)/10 = 30.5 | |
| [2] read current emissivity | 3E0208 | **036C** | emissivity = (Hex ⇒ Dec(**036C**)/1000) = 0.876 | |
| [3] set emissivity to **0.95** | 3A0208**03B6** | ------ | word = Dec ⇒ Hex(**0.95** x 1000) = **03B6** | |
| [4] switch on loop maintenance mode | 3D026190 | ------ | ------D32 | |
| [5] set analog output to **0**°C (permanent) | 3A0212**03E8** | ------ | word = Dec ⇒ Hex (**0** [°C] x 10 +1000) = **03E8** | |
| [5] set analog output to **200**°C (permanent) | 3A0212**0BB8** | ------ | word = Dec ⇒ Hex (**200** [°C] x 10 +1000) = **0BB8** | |
| [6] return to standard mode | 3D026180 | ------ | ------ | |

1) if **peak/ valley hold is activated** the "process temperature" holds the detected peak or valley whereas the "current target temperature" shows the real process temperature (without post processing); in **standard mode** "process temperature" and "current ta

| **Burstmode (unidirectional)** | | | | |
|---|---|---|---|---|
| After switch on a continuous serial signal will be created. The burst string can be configured with CompactConnect software. | | | | |
| | | | | |
| **Burst string** | **Example** | **Complete burst string** | **Conversion to Decimal value** | |
| 2 synchronisation bytes: AAAA | ------ | | ------ | |
| 2 bytes for each output value (hi lo) | 03B8 | AAAA 03B8 | process temp [°C] = (Hex ⇒ Dec(**03B8**)-1000)/10 = **-4.8** | |

# 7 Digital Command Set [2W/ 2WM-2/ HS]

**Commands CSmicro 2W/ HS/ CX**

| Decimal | HEX | Binary/ ASCII | Command | Data | Answer | Result | Unit |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| 1 | 0x01 | binary | READ Temp - Target | keine | byte1 byte2 | = (byte1 x 256 + byte2 - 1000) / 10 | °C |
| 2 | 0x02 | binary | READ Temp - Sensor | keine | byte1 byte2 | = (byte1 x 256 + byte2 - 1000) / 10 | °C |
| 3 | 0x03 | binary | READ current Temp - Target | keine | byte1 byte2 | = (byte1 x 256 + byte2 - 1000) / 10 | °C |
| 4 | 0x04 | binary | READ Emissivity | keine | byte1 byte2 | = (byte1 x 256 + byte2) / 1000 | |
| 5 | 0x05 | binary | READ Transmission | keine | byte1 byte2 | = (byte1 x 256 + byte2) / 1000 | |
| 9 | 0x09 | binary | READ Processor Temperature | keine | byte1 | = (byte1 x 256 + byte2 - 1000) / 10 | |
| 14 | 0x0E | binary | READ Serial number | keine | byte1 byte2 byte3 | = byte1 x 65536 + byte2 x 256 + byte3 | |
| 15 | 0x0F | binary | READ FW Rev. | keine | byte1 byte2 | = byte1 x 256 + byte2 | |
| 129 | 0x81 | binary | SET DAC mA | byte1 | byte1 | byte 1= mA x 10 (z.B. 4mA = 4 x 10=40) | °C |
| 130 | 0x82 | binary | RESET of DAC mA output | | | | |
| 132 | 0x84 | binary | SET Emissivity | byte1 byte2 | byte1 byte2 | = (byte1 x 256 + byte2) / 1000 | |
| 133 | 0x85 | binary | SET Transmission | byte1 byte2 | byte1 byte2 | = (byte1 x 256 + byte2) / 1000 | |

**Temperature calculation at CSmicro HS: (byte1 x 256 + byte2 - 10000) / 100**

**EXAMPLES (all bytes in HEX)**

**Readout of object temperature**

| | | | |
|---|---|---|---|
| Send: | 01 | Command for readout of object temperature | |
| Receive: | 04 D3 | Object temperature in tenth degree + 1000 | 04 D3 = dec. 1235 |
| | | | 1235 - 1000 = 235 |
| | | | 235 / 10 = **23,5 °C** |

**Readout of object temperature (at CSmicro HS)**

| | | | |
|---|---|---|---|
| Send: | 01 | Command for readout of object temperature | |
| Receive: | 30 3E | Object temperature in hundredth degree + 10000 | 30 3E = dec. 12350 |
| | | | 12350 - 10000 = 2350 |
| | | | 2350 / 100 = 23.50 °C |

**Set of emissivity**

| | | | |
|---|---|---|---|
| Send: | 84 03 B6 | | 03B6 = dec. 950 |
| Receive: | 03 B6 | | 950 / 1000 = **0,950** |

# 8 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 $\mu$ and 20 $\mu$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 (see enclosed table 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 Distance to Spot 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 Emissivity

## 9.1 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 (ε – 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.

## 9.2 Determination of Unknown Emissivities

- ► 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.

► 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.

## 9.3 Characteristic Emissivities

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

- Temperature
- Measuring angle
- Geometry of the surface (plane, convex, concave)
- Thickness of the material
- Constitution of the surface (polished, oxidized, rough, sandblast)
- Spectral range of the measurement
- Transmissivity (e.g. with thin films)

# Appendix A – Emissivity Table Metals

| Material | | typical Emissivity | | | |
|---|---|---|---|---|---|
| Spectral response | | 1.0 µm | 1.6 µm | 5.1 µm | 8-14 µm |
| 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-.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 |

## Appendix A – Emissivity Table Metals

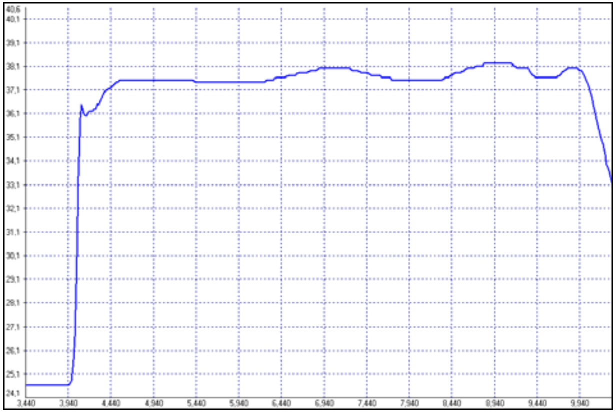
| Material | | typical Emissivity | | | |
|---|---|---|---|---|---|
| **Spectral response** | | **1.0 $\mu$m** | **1.6 $\mu$m** | **5.1 $\mu$m** | **8-14 $\mu$m** |
| Lead | polished | 0.35 | 0.05-0.2 | 0.05-0.2 | 0.05-0.1 |
| | roughened | 0.65 | 0.6 | 0.4 | 0.4 |
| | oxidized | | 0.3-0.7 | 0.2-0.7 | 0.2-0.6 |
| Magnesium | | 0.3-0.8 | .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 Non Table Metals

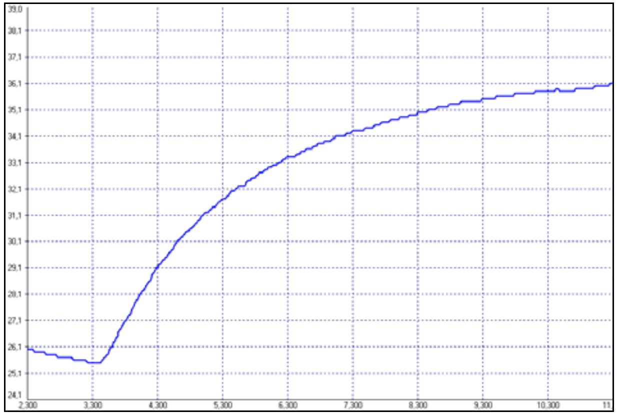
| Material | | typical Emissivity | | | |
|---|---|---|---|---|---|
| Spectral response | | 1.0 $\mu$m | 2.2 $\mu$m | 5.1 $\mu$m | 8-14 $\mu$m |
| Asbestos | | 0.9 | 0.8 | 0.9 | 0.95 |
| Asphalt | | | | 0.95 | 0.95 |
| Basalt | | | | 0.7 | 0.7 |
| Carbon | non oxidized | | 0.8-0.9 | 0.8-0.9 | 0.8-0.9 |
| | 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 $>50\ \mu$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
Königbacher Str. 15 · 94496 Ortenburg / Deutschland
Tel. +49 (0) 8542 / 168-0 · Fax +49 (0) 8542 / 168-90
info@micro-epsilon.de · www.micro-epsilon.de

X9751246-A021071HDR