Infrared Sensor

Operators manual

thermoMETER CS / CSmicro / CSmicro 2W
CSmicro hs / CSmicro 2WM-2

CE-Conformity

The product complies with the following standards:

EMC:	EN 61326-1
Safety Regulations:	EN 61010-1:1993/ A2:1995

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.

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.

Content

1 Description

The sensors of the CS and CSmicro series are non-contact 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 CS is made of stainless steel (IP 65/ NEMA-4 rating) and contains the complete sensor electronics. The sensor of the CSmicro is also made of stainless steel (IP 65/ NEMA-4 rating) – the sensor electronics is part of the connection cable in that case.
Both of the sensors have a fixed mounted connection cable.

The sensors CS/ 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).

1.1 Scope of Supply

- CS/ CSmicro incl. connection cable, mounting nut and 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 static electricity, arc welders, and induction heaters. Keep away from very strong EMF (electromagnetic fields). Avoid abrupt changes of the ambient temperature.
In case of problems or questions which may arise when you use the CS/ CSmicro, please contact our service department. The customer service staff will support you with questions concerning the optimization of the work with the infrared thermometer, calibration procedures or with repairs.

1.4 Factory Default Settings

The unit has the following presetting at time of delivery:

	CS/CSmicro	CSmicro 2W	CSmicro 2WM-2	CSmicro hs
Temperature range:	0...350 °C	0…500 °C	385…1600 °	-20…150 °C
Output signal:	0...3.5 V	4…20 mA	4…20 mA	4…20 mA
Emissivity:	0.950		1.000	0.950
Transmission:	1.000			
Average time:	0.09 s			
Smart averaging:	active			
Ambient temperature source:	Sensor temperature			

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.

2 Technical Data

2.1 General Specifications

	CS	CSmicro	CSmicro 2W	CSmicro 2WM-2	CSmicro hs
Environmental rating	IP 65 (NEMA-4)				
Ambient temperature	-20...75 °C	-20...120 °C	-20...85 °C	-20…125 °C	-20…75 °C
Sensor		-20...75 °C (elektronics in cable)			
Storage temperature	-20...85 °C				
Relative humidity	10...95 %, non condensing				
Material	Stainless steel	Stainless steel	Stainless steel	Stainless steel	Stainless steel
Sensor dimensions	M12x1, 85 mm long	ø14 mm x 28 mm	ø14 mm x 28 mm	ø14 mm x 28 mm	Ø29.5 mm x 55 mm
Electronic dimensions	---	12 mm x 70 mm	12 mm x 45 mm	12 mm x 45 mm	12 mm x 45 mm
Weight sensor	58 g	42 g			200 g
Cable length	1 m (standard), 3 m, 8 m, 15 m	1 m (50 cm between sensor and electronics)			4 m (50 cm between sensor / electronics)
Cable diameter	4.3 mm	2.8 mm (sensor and electronics)/ 4.3 mm (electronics and end of cable)			
Vibration	IEC 68-2-6: 3G, 11 – 200 Hz, any axis				
Shock	IEC 68-2-27: 50G, 11 ms, any axis				
EMC	2004/108/EG				

2.2 Electrical Specifications

	CS	CSmicro
Output [used pin]	only alternatively selectable	
Analog [OUT]	0-5 V[1] or 0-10 V[2]/ scalable	0-5 V[1] or 0-10 V[2]/ scalable
Serial digital[3] [OUT+IN]	uni- (burst mode) or bidirectional	uni- (burst mode) or bidirectional
Alarm [OUT]	output voltage adjustable; N/O or N/C	output voltage adjustable; N/O or N/C
Additional features	LED alarm indication/ LED aiming support	Programmable open collector output 24 VDC/ 50 mA [IN pin]
Output impedance	min. 10 kΩ load impedance	min. 10 kΩ load impedance
Input	programmable functional input on green IN pin for: • external emissivity adjustment [0 V ► ε=0.1 | 5 V ► ε=1.1] • ambient temperature compensation [0 V ► -20 °C | 5 V ► 350 °C] • trigger (reset of hold functions) [5 V at IN pin resets the selected hold function]	
Current draw	9 mA (12...28 VDC)/ 15 mA (5 VDC)	9 mA
Power supply	5...7 VDC or 12...30 VDC	5...30 VDC

Tab. 2.1: Electrical specifications CS / CSmicro

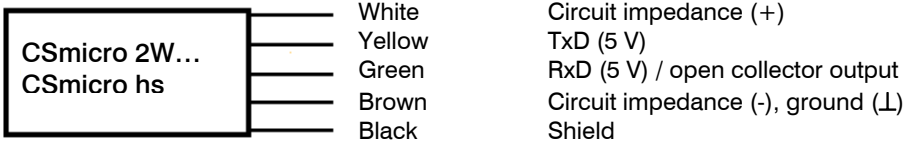
[1] 0...4.6 V at supply voltage 5 VDC; also valid for alarm output
[2] Only at supply voltage ≥ 11 V
[3] Inverted RS232, TTL, 9.6 kBaud

White	PS	Power supply
Yellow	OUT	Analog output/ TxD (5 V)/ Alarm output
Green	IN	Analog input/ RxD (5 V)/ Open collector output (CSmicro only)
Brown	GND	Ground (⊥)
Black		Shield

	CSmicro 2W / CSmicro 2WM-2 / CSmicro hs
Analog output	4…20 mA, scalable
Digital [1] output	uni- (burst mode) or bidirectional
Alarm output	Programmable open collector output, 0…30 V; 500 mA
Output impedance	max. 1000 Ohm
Power supply	5...30 VDC / 4…20 mA

Tab. 2.2: Electrical specification CSmicro 2W, CSmicro 2WM-2, CSmicro hs

[1)] Inverted RS232 signal, TTL, 9.6 kBaud



2.3 Measurement Specifications

	CS / CSmicro	CSmicro 2W	CSmicro 2WM-2	CSmicro hs
Temperature range IR (scalable via software)	-20...350 °C	-30…+900 °C	+385…+1600 °C	-20…+150 °C
Spectral range	8...14 µm			1.6 µm
Optical resolution	10:1	15:1	75:1	15:1
CF-lens (optional)	1.2 mm@ 10 mm	0.8 mm@ 10 mm	---	0.8 mm@ 10 mm
Accuracy [1]	±1.5 °C or ±1.5 % of reading [2]		±(0.3 % T_{Mess} + 2 °C) [3]	±1 °C oder ±1 of reading [4]
Repeatability [1]	±0.75 °C or ±0.75 % of reading [2]		±(0.1 % T_{Mess} + 1 °C) [3]	±0.3 °C oder ±0.3 % of reading [4]
Temperature resolution	0.2 °C	0.1 °C	0.1 °C	0.025 °C [4, 5]
Response time (95 % signal/ adjustable via software)	30 ms...2 s	150 ms	10 ms	150 ms
Warm-up time	10 min			
Emissivity / Gain	0.100...1.100 (adjustable via 0-5 VDC input or software)			
Transmissivity	0.100...1.000 (adjustable via software)			
Interface (optional)	USB programming interface			
Signal processing	Average, Peak hold, Valley hold (adjustable via software)			
Software (optional)	CompactConnect			

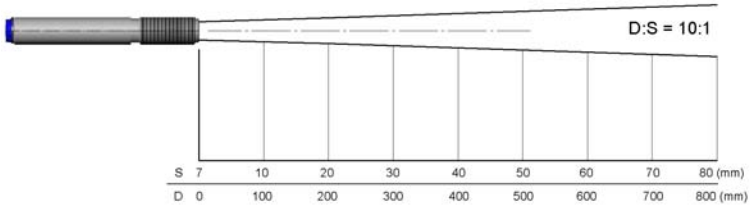
[1] At ambient temperature 23±5 °C; whichever is greater, Epsilon = 1, time 1 s
[2] at object temperatures >0 °C
[3] at object temperatures >450 °C
[4] at object temperatures >20 °C
[5] at time constant >0.2 s

2.4 Optical Charts

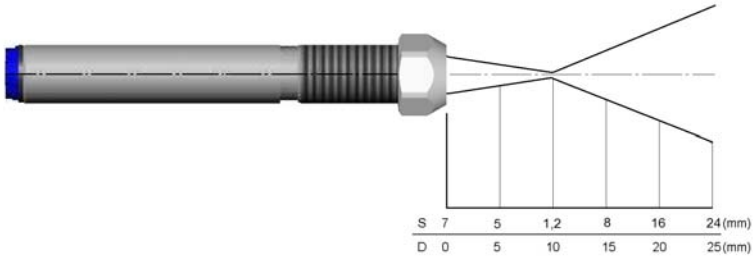
The following optical charts show the diameter of the measuring spot in dependence on the distance between measuring object and sensor. The spot size refers to 90 % of the radiation energy.
The distance is always measured from the front edge of the sensor housing/ CF-lens holder/ air purge.

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

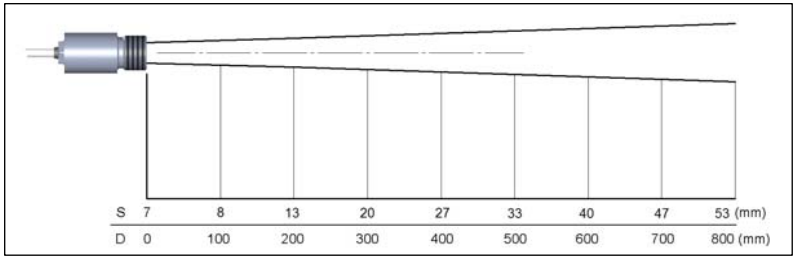
CS / CSmicro
D:S = 10:1



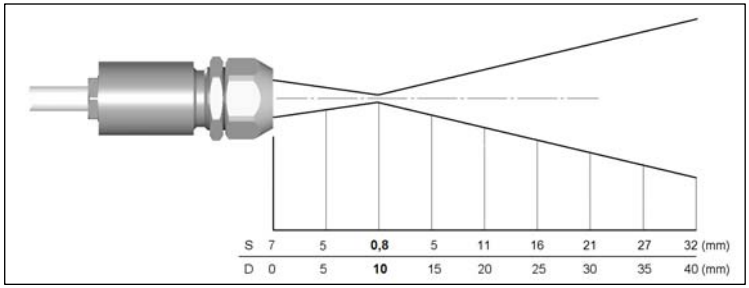
CS / CSmicro with CF-lens
CF: 1.2 mm @ 10 mm



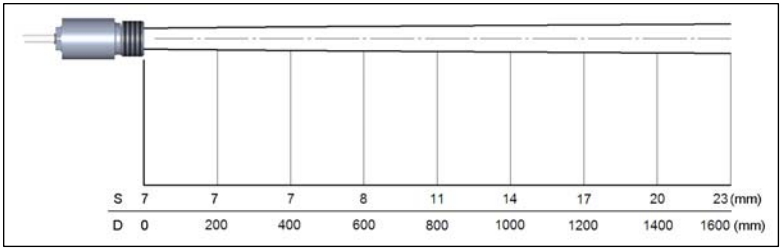
CSmicro 2W / CSmicro hs
D:S = 15:1



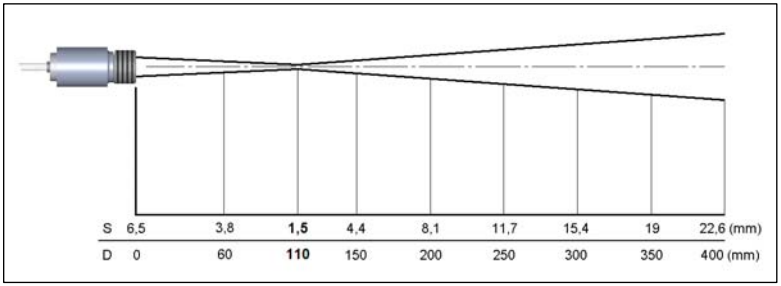
CSmicro 2W / CSmicro hs with CF-lens
CF: 0.8 mm @ 10 mm



CSmicro 2WM-2SF
D:S = 75:1



CSmicro 2WM-2CF
D:S Distant field = 14:1



2.5 Close Focus Optics

The optional CF-lens allows the measurement of small objects. The minimum spot size depends on the measuring head. In each case the measurement of distances is effected at the leading edge of the CF lens holder or laminar air purge collar. The assembling of the measuring head is effected by bolting the lens up to the stop. Please use the alternative M12x1 external thread for the combination model hs.
The CF optics can also be combined with a laminar air purge:
Alternative overview:

TM-CF-CS	Close focus optics for mounting on sensor [CS/ CS micro-SF10/ CS micro 2W-SF10/ CS micro hs]
TM-CFH-CS	Close focus optics for mounting on sensor [CS micro 2WM-2]
TM-CFAG-CS	Close focus optics with external thread for mounting in solid housing [CS/ CS micro-SF10/ CS micro 2W-SF10/ CS micro hs]
TM-CFHAG-CS	Close focus optics with external thread for mounting in solid housing [CS micro 2WM-2]

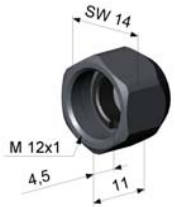


Fig. 2.1: CF-lens [TM-CF-CS]
Protective window: [TM-PW-CS]

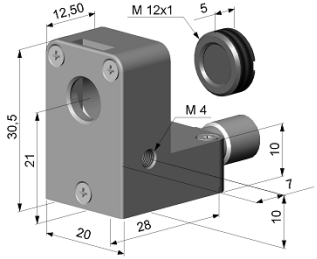


Fig. 2.2: Laminar air purge with integrated CF-lens [TM-APLCF-CS]

If the CF-lens is used, the transmission has to be set to **0.78** [CSmicro-SF10/ 2W / hs].
To change this value the optional USB-Kit (including CompactConnect software) is necessary.

A protective window is available for the protection of the measuring head lens. This window has the same mechanical dimensions as the CF lens and is offered in the following variants:

TM-PW-CS	Protective window for mounting on sensor [CS / CS micro-SF10/ CS micro 2W-SF10/ CS micro hs]
TM-PWH-CS	Protective window for mounting on sensor [CS micro 2WM-2]
TM-PWAG-CS	Close focus optics with external thread for mounting in solid housing [CS / CS micro-SF10/ CS micro 2W-SF10/CS micro hs]
TM-PWHAG-CS	Close focus optics with external thread for mounting in solid housing [CS micro 2WM-2]

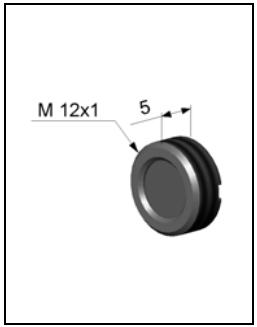


**Fig. 2.3: Close focus optics with external thread [TM-CFAG-CS];
Protective window with external thread [TM-PWAG-CS]**

The transmission has to be set to **0.83** [CS micro-SF10/ 2W/ hs] respectively **0.93** [2WM-2] by application of the protective window. **To change this value the optional USB-Kit (including CompactConnect software) is necessary.**

3 Installation

3.1 Mechanical Installation

The CS is equipped with a metric M12x1 thread and can be installed either directly via the sensor thread or with the help of the both hex nuts (standard) to the mounting bracket available.

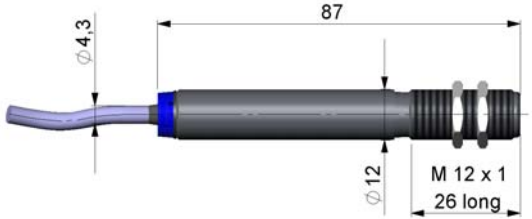


Fig. 3.1: CS with a metric M12x1

The **LED aiming support** helps to adjust the unit to an object which has a temperature different to the background. For this reason it might be necessary to adjust the alarm value with the CompactConnect software. With the factory default setting (alarm value: 100 °C) the LED (ring at the junction sensor housing – cable) will give blue light when the unit aims at a target with a temperature >100 °C.

The CSmicro is also 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 is delivered with solid housing and can be installed about the M18x1-thread.

The CS-micro sensors are sensitive optical systems. The assembling may therefore only be effected using the present thread. Please avoid unnecessary force on the sensor as this could result in destruction. Furthermore, please note that in this case any warranty claim expires.

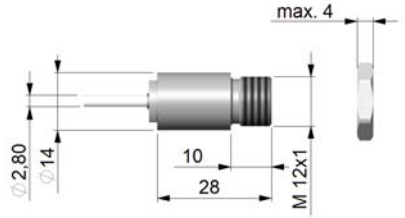


Fig. 3.2: CSmicro with a metric M12x1 thread

Various mounting accessories, fitting both CS and CSmicro, can be ordered additionally.

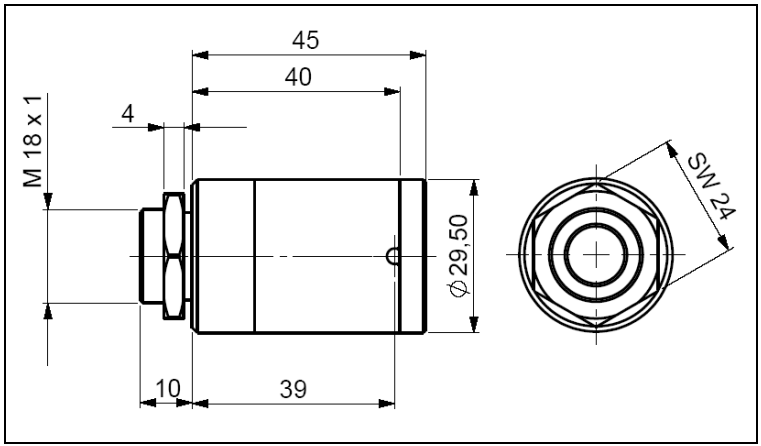


Fig. 3.3: CSmicro hs with a metric M18x1 thread (fitting mounting bracket TM-FBMH-CT)

3.2 Mounting Accessories

The Mounting bracket [TM-FB-CS], adjustable in one axis.

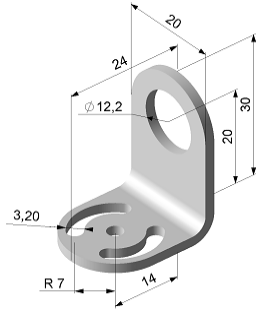


Fig. 3.4: Mounting bracket [TM-FB-CS]

The Mounting bold [TM-MB-CS] with M12x1 thread, adjustable in one axis.

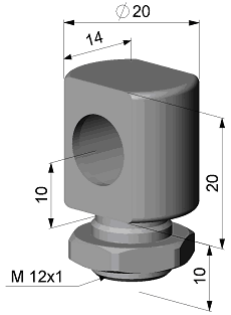


Fig. 3.5: Mounting bold [TM-MB-CS]

The Mounting fork with M12x1 thread, adjustable in 2 axes [TM-MG-GS]

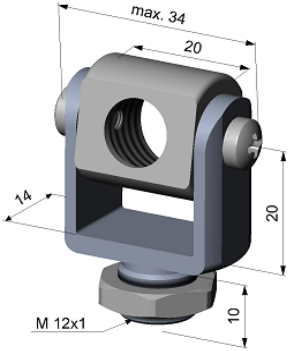


Fig. 3.6: Mounting fork [TM-MG-CS]

Mounting bracket, adjustable in two axes [TM-AB-CS] consisting of: TM-FB-CT and TM-MB-CT

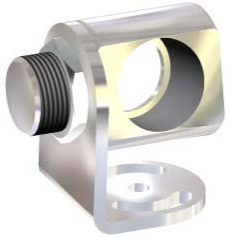


Fig. 3.7: Mounting bracket [TM-AB-CS]

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

3.3 Air Purge Collars

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.

Standard air purge collar; fits to the mounting bracket;
hose connection: 3x5 mm [TM-AP-CS]

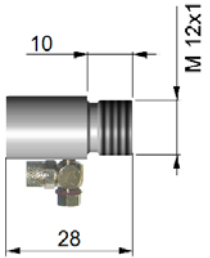


Fig. 3.8: Standard air purge collar [TM-AP-CS]

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

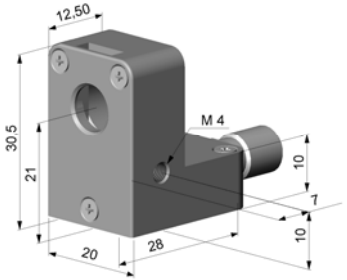


Fig. 3.9: Laminar air purge collar [TM-APL-CS]

A combination of the laminar air purge collar with the bottom section of the mounting fork allows an adjustment in two axes.

Fig. 3.10: Laminar air purge collar and mounting fork [TM-APL-CT + TM-MG-CS]

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

3.4 Further Accessories

Right angle mirror Enables measurement with 90° angle [TM-RAM-CS]

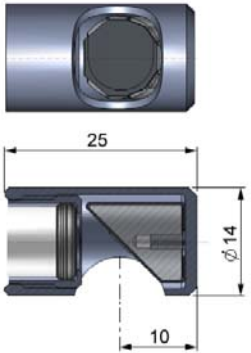


Fig. 3.3: Right angle mirror [TM-RAM-CS]

Protective window same mechanical size as CF lens [TM-PW-CS]

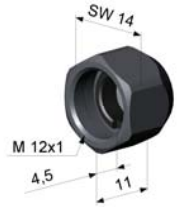


Fig. 3.4: Protective window [TM-PWH-CS]

USB-Kit: USB programming adaptor incl. terminal block and software CD [TM-USBK-CS]

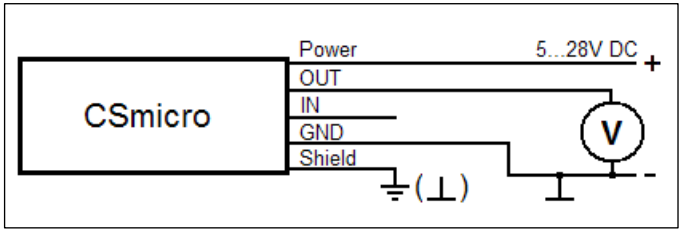
Fig. 3.5: USB programming adaptor incl. terminal block and software CD [TM-USBK-CS]

If the protective window is used, the transmission has to be set, see Chap. 2.5.
To change this value the optional USB-Kit (including CompactConnect software) is necessary.

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

3.5 Electrical Installation CS, CSmicro

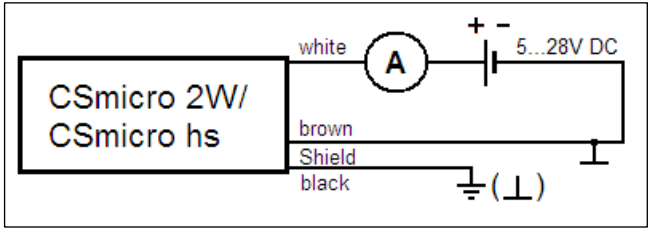
3.5.1 CSmicro-SF10 as Analog Device (mV output)



Wire colors	
Power	White
OUT	Yellow
IN	Green
GND	Brown
Shield	Black

The output impedance must be ≥ 10 kΩ.

3.5.2 CSmicro 2W-SF10/ 2WM-2/ SF15 as Analog Device (mA output)



The maximum loop impedance is 1000 Ω.

3.5.3 Digital Communication

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.

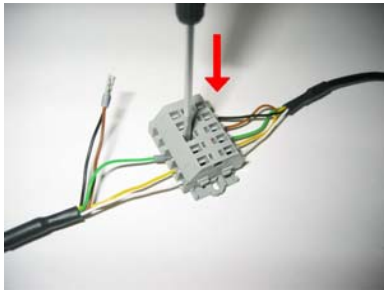
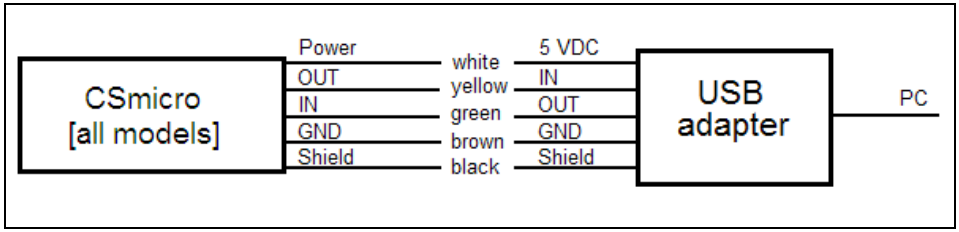


Fig. 3.14: Connect the USB cable with the sensor cable by using the terminal block

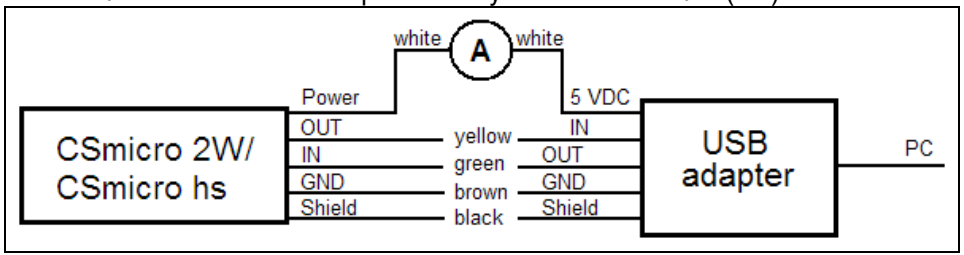
The sensor is offering two ways of digital communication:

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

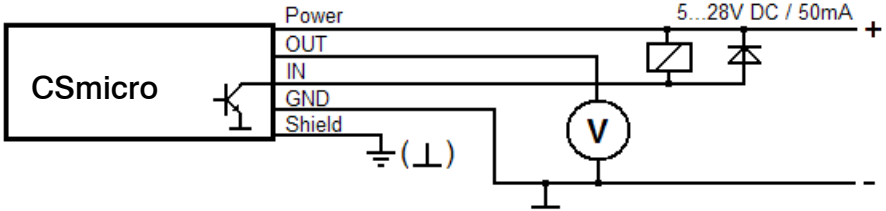


3.5.4 Analog + Digital (CSmicro 2W / 2WM-2/ and CSmicro hs)

The CSmicro 2W and CSmicro hs 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).

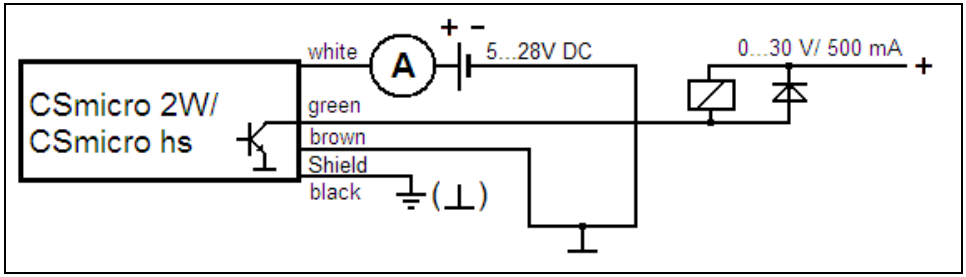


3.5.5 Open Collector Output (CSmicro only)

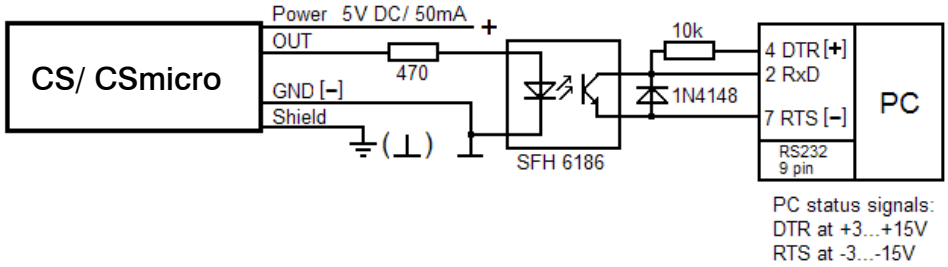


The open collector output is an additional alarm output on the CSmicro and can control an external relay. In addition the analog output can be used simultaneously.

3.5.6 Open Collector Output (CSmicro 2W-SF10/ 2WM-2/ hs)



3.5.7 Direct Connection to an RS232 Interface on the Computer



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 Software CompactConnect

4.1 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.

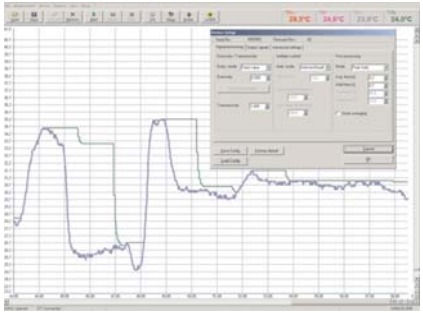
You will find a detailed software manual on the CD.

4.2 System Requirements

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

The installation wizard will place a launch icon on the desktop and in the start menu:
[Start]\Programs\CompactConnect.
If you want to uninstall the software from your system please use the uninstall icon in the start menu.

4.3 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

4.4 Communication Settings

Serial interface

Baud rate:	9600 baud
Data bits:	8
Parity:	no
Stop bits:	1
Flow control:	out

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.

5 Command List CS, CSmicro-SF10

(also available on CD CompactConnect)

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 head temperature	3E0202	word (hiByteLobyte)	head 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	------	------	
[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 target temperature" are the same				
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**	

6 Command List CSmicro 2W / CS micro 2WM-2 / CS micro hs

(also available on CD CompactConnect)

CSmicro 2W/ CSmicro hs / CX Commands							
Decimal	**HEX**	**Binary/ ASCII**	**Command**	**Data**	**Response**	**Result**	**Unit**
1	0x01	binary	Read object temperature	none	byte1 byte2	= (byte1 x 256 + byte2 – 1000) /10	°C
2	0x02	binary	Read sensor temperature	none	byte1 byte2	= (byte1 x 256 + byte2 – 1000) /10	°C
3	0x03	binary	Read current object temperature	none	byte1 byte2	= (byte1 x 256 + byte2 – 1000) /10	°C
4	0x04	binary	Read emissivity	none	byte1 byte2	= (byte1 x 256 + byte2 / 1000)	
5	0x05	binary	Read transmissivity	none	byte1 byte2	= (byte1 x 256 + byte2 / 1000)	
9	0x09	binary	Read process temperature	none	byte1 byte2	= byte1 x 256 + byte2 - 1000 /10	°C
14	0x0E	binary	Read serial number	none	byte1 byte2 byte3	= byte1 x 65536 + byte2 x 256 + byte3	
15	0x0F	binary	Read Filmware-Rev.	none	byte1 byte2	= byte1 x 256 + byte2	
129	0x81	binary	Set mA output	byte1	Byte1	byte1 = mA*10 (e.g. 4 mA = 4*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 transmissivity	byte1 byte2	byte1 byte2	= (byte1 x 256 + byte2) /1000	

Temperature calculation at CSmicro hs: (byte1 x 256 + byte2 – 1000) / 100

Interface settings
8 Data bits, 1 Stop bit, No parity, No flow control
Examples
Reading the object temperature (all bytes in hex):

Transmit:	01	Command for reading the object temperature
Receive:	04D3	Object temperature in 0.1 degree Celsius + 1000

04D3 = dez. 1235
1235 – 1000 = 235
235 / 10 = 23.5 °C

Reading the object temperature at CSmicro hs (all bytes in hex):

Transmit:	01	Command for reading the object temperature
Receive:	04D3	Object temperature in 0.1 degree Celsius + 10000

04D3 = dez. 12350
1235 – 10000 = 2350
2350 / 100 = 23.50 °C

Setting the emissivity (all bytes in hex):

Transmit:	84 03 B6	Command for setting the emissivity on 0.950
Receive:	03 B6	Emissionsgrad x 1000

03 B6 = dez. 950
950 / 1000 = 0.950

7 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 μ and 20 μm.
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.

8 Emissivity

8.1 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 (Micro – 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.

8.2 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 name: TM-ED-CS) 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.

8.3 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 (for example 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

Material		typical Emissivity			
Spectral response		1.0 µm	1.6 µm	5.1 µm	8-14 µm
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 Table Metals

Material		typical Emissivity			
Spectral response		1.0 μm	2.2 μm	5.1 μm	8-14 μm
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 μm	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

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

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