

Infrared Sensor



Operators manual

thermoMETER CS / CSmicro / CSmicro 2W

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 89/336/EEC .

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.

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Description

1 Description

The sensors of the CS and CSM 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 (IP65/ NEMA-4 rating) and contains the complete sensor electronics. The sensing head of the CSM is also made of stainless steel (IP65/ 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/ CSM are sensitive optical systems. Please use only the thread for mechanical installation.

Avoid mechanical violence on the head – this may destroy the system (expiry of warranty).

1.1 Scope of Supply

- CS/ CSM 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).

Description

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/ CSM, 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
Temperature range:	0...350 °C	0...500 °C
Output signal:	0...3.5 V	4...20 mA
Emissivity:	0.950	
Transmission:	1.000	
Average time:	0.09 s	
Smart averaging:	active	
Ambient temperature source:	Head 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
Environmental rating	IP65 (NEMA-4)	IP65 (NEMA-4)	IP65 (NEMA-4)
Ambient temperature	-20...75 °C	-20...125 °C (sensing head) -20...75 °C (electronic in cabel)	-20...75 °C
Storage temperature	-20...85 °C	-20...85 °C	-20...85 °C
Relative humidity	10...95 %, non condensing	10...95 %, non condensing	10...95 %, non condensing
Material	Stainless steel	Stainless steel	aluminium, black anodized
Dimensions	M12x1, 85 mm long	28 mm x 14 mm (head)/ 70 mm x 12 mm (electronic)	28 mm x 14 mm head 70 mm x 12 mm electronics
Weight	58 g	42 g	350 g
Cable length	1 m (standard), 3 m, 8 m, 15 m	1 m (50 cm between head and electronics)	1 m (50 cm between head and electronics)
Cable diameter	4.3 mm	2.8 mm (head-electronic)/ 4.3 mm (electronic-end of cable)	2.8 mm (head - electronics)/ 4.3 mm (electronic – end of cable)
Vibration	IEC 68-2-6: 3G, 11 – 200 Hz, any axis	IEC 68-2-6: 3G, 11 – 200Hz, any axis	IEC 68-2-6: 3G, 11 – 200 Hz, any axis
Shock	IEC 68-2-27: 50G, 11 ms, any axis	IEC 68-2-27: 50G, 11 ms, any axis	IEC 68-2-27: 50G, 11 ms, any axis
EMI	89/336/EWG	89/336/EWG	89/336/EWG

Tab. 2.1: General specifications

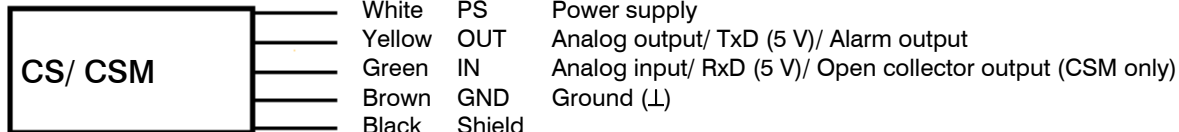
Technical Data

2.2 Electrical Specifications

	CS	CSM
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 impedances	min. 10 kΩ load impedance	min. 10 kΩ load impedance
Input	programmable functional input on green IN pin for: <ul style="list-style-type: none"> external emissivity adjustment [0 V ► $\varepsilon=0,1$ 5 V ► $\varepsilon=1,1$] ambient temperature compensation [0 V ► -20 °C 5 V ► 350 °C] trigger (reset of hold functions) [5V 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...28 VDC	5...28 VDC

Tab. 2.2: Electrical specifications CS / CSM

- 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

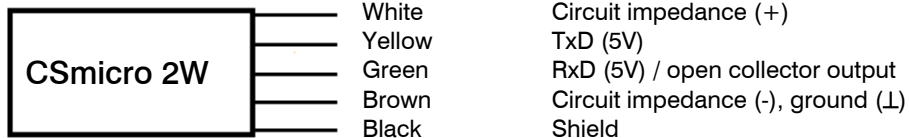


Technical Data

CSmicro 2W	
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 Schleifenwiderstand
Power supply	5...28 VDC

Tab. 2.3: Electrical specification CSmicro 2W

¹⁾ Inverted RS232 signal, TTL, 9.6 kBaud



Technical Data

2.3 Measurement Specifications

	CS / Csmicro	Csmicro 2W
Temperature range IR	-20...350 °C (scalable via software)	-30...+900 °C
Spectral range	8...14 μm	
Optical resolution	10:1	
CF-lens (optional)	1.2 mm@ 10 mm	
Accuracy ¹	±1.5 °C or ±1.5 % of reading	
Repeatability ¹	±0.75 °C or ±0.75 % of reading	
Temperature resolution ²	0.2 °C (NETD)	
Response time (95 % signal/ adjustable via software)	30 ms...2 s	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	

Tab. 2.4: Measurement specification

¹) At ambient temperature 23±5 °C; whichever is greater

²) NETD at object temperatures >20 °C and time constant >0.2 s

Technical Data

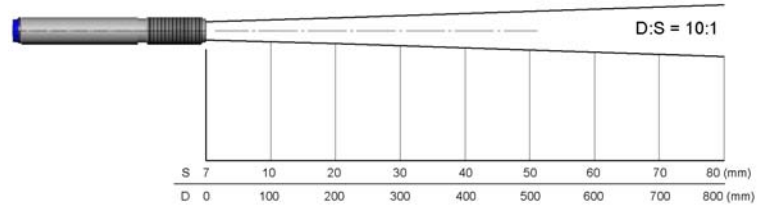
2.4 Optical Charts

The following optical charts show the diameter of the measuring spot in dependence on the distance between measuring object and sensing head. 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.

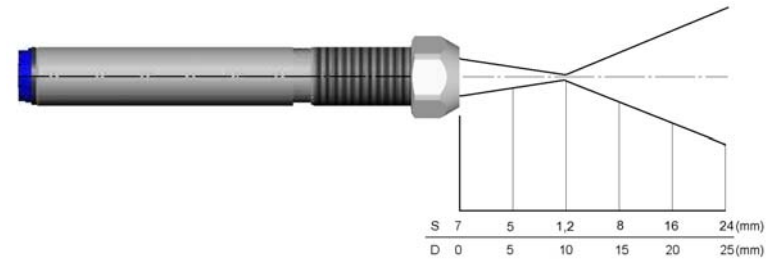
The size of the measuring object and the optical resolution of the infrared thermometer determine the maximum distance between sensing head and measuring object. In order to prevent measuring errors the object should fill out the field of view of the optics completely. Consequently, the spot should at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

Technical Data

CS / CSM
D:S = 10:1



CS / CSM mit CF-lens
CF: 1.2 mm @ 10 mm



Technical Data

2.5 Close Focus Optics

The optional CF-lens allows the measurement of small objects. The CF optics can also be combined with a laminar air purge:

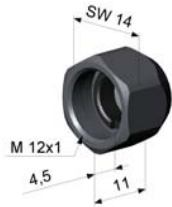


Fig. 2.1: CF-lens [TM-CF-CS]

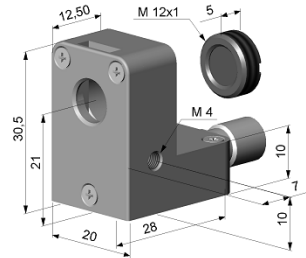


Fig. 2.2: Laminar air purge with integrated CF-lens [TM-APLCF-CS]

If the CF-lens is used, the transmission has to be set to **0.78**.
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.

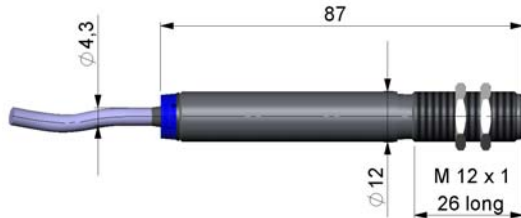


Fig. 3.1: CS with a metric M12x1

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.

Installation

The CSM 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.

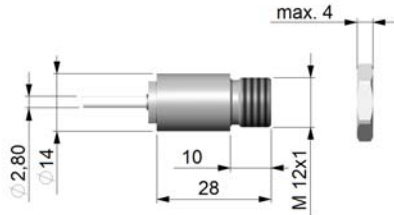


Fig. 3.2: CSM with a metric M12x1

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

Installation

3.2 Mounting Accessories

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

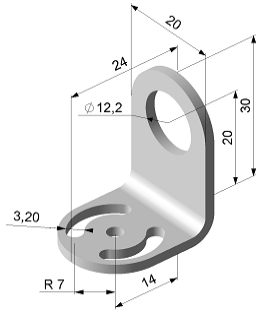


Fig. 3.3: Mounting bracket [TM-FB-CS]

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

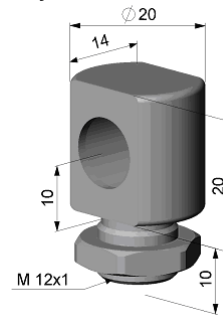


Fig. 3.4: Mounting bold [TM-MB-CS]

Installation

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

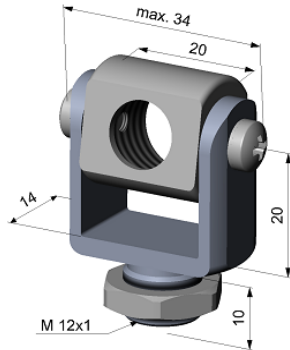


Fig. 3.5: Mounting fork [TM-MG-CS]

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



Fig. 3.6: Mounting bracket [TM-AB-CS]

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

Installation

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]

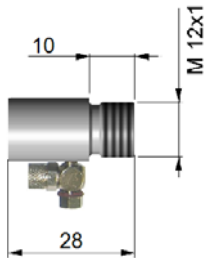


Fig. 3.7: Standard air purge collar [TM-AP-CS]

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]

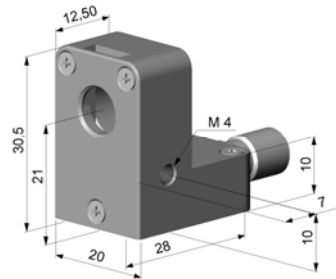


Fig. 3.8: Laminar air purge collar [TM-APL-CS]

Installation

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



Fig. 3.9: 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.

Installation

3.4 Further Accessories

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

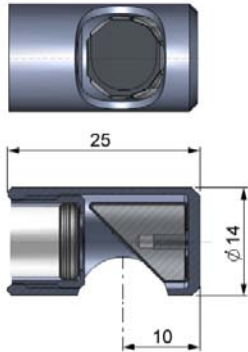


Fig. 3.10: Right angle mirror [TM-RAM-CS]

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



Fig. 3.11: Protective window

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



Fig. 3.12: USB programming adaptor incl. terminal block and software CD [TM-USBK-CS]

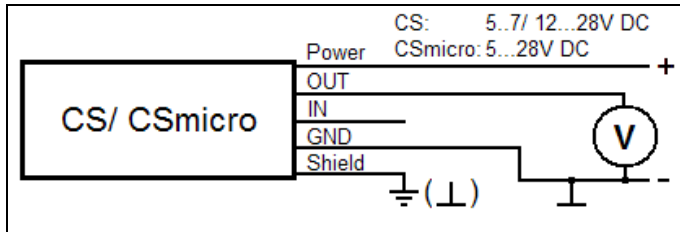
If the protective window is used, the transmission has to be set to **0.83**.
To change this value the optional USB-Kit (including CompactConnect software) is necessary.

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

Installation

3.5 Electrical Installation CS, CSmicro

3.5.1 Analog device (mV output on OUT pin)



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

The output impedance must be $\geq 10\text{k}\Omega$.

Installation

3.5.2 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.

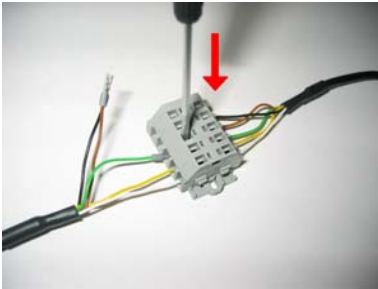
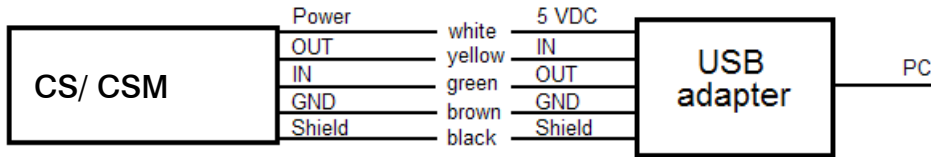


Fig. 3.13: Connect the USB cable with the sensor cable by using the terminal block

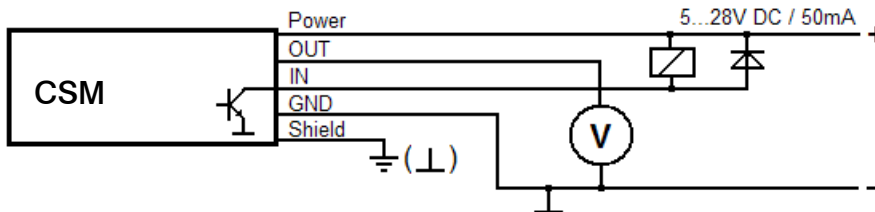
The sensor is offering two ways of digital communication:

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

Installation



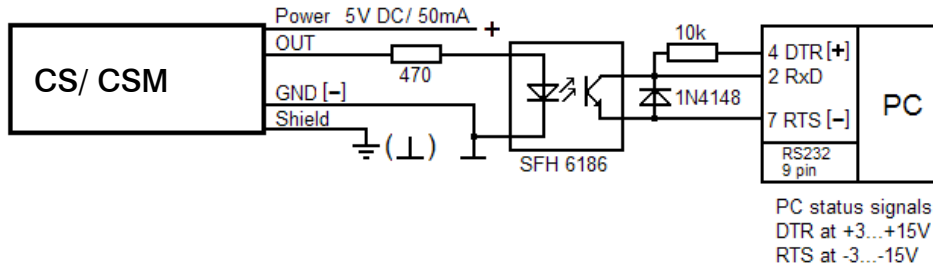
3.5.3 Open collector output (CSmicro only)



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.

Installation

3.5.4 Direct connection to an RS232 interface on the computer

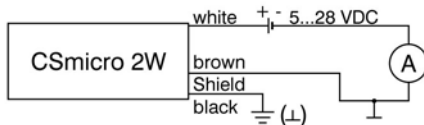


In the digital mode the sensor can be connected directly to a serial port (RS232) on your PC using this circuit.

This connection supports only the unidirectional communication mode.

3.6 Electrical Installation CSmicro 2W

3.6.1 Analog device (mA output)



The output impedance must be ≥ 1000 Ohm.

Installation

3.6.2 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.

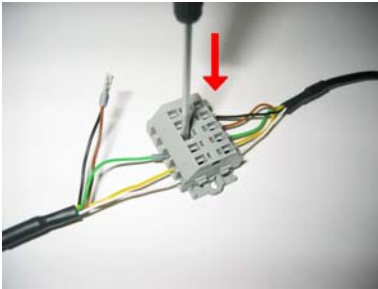
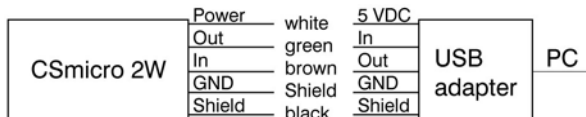


Fig. 3.14: Connect the USB cable with the sensor cable by using the terminal block

The sensor is offering two ways of digital communication:

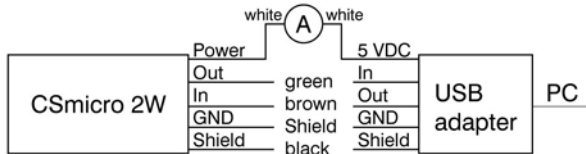
- bidirectional communication (sending and receiving data)
- unidirectional communication (burst mode – the sensor is sending data only)



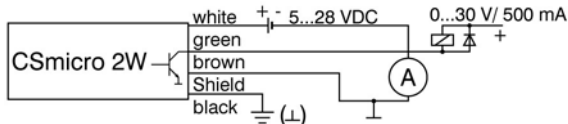
Installation

3.6.3 Analog + Digital

The CSmicro 2W can simultaneously communicate digitally and as an analog device (4 ... 20 mA). In this case, the USB interface (5 V) supplies the sensor with power.



3.6.4 Analog + Alarm



The alarm output (Open-collector output) can control an external relay. In addition the analog output can be used simultaneously.

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

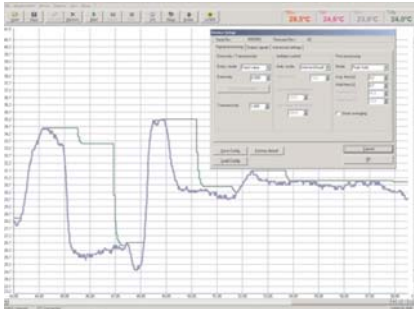
- Windows XP
- USB interface
- Hard disc with a least 30 MByte free space
- At least 128 MByte RAM
- CD-ROM drive

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.

Software CompactConnect

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

5 Command List CS, CSmicro

(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	3A020803B6	-----	word = Dec ⇒ Hex(0,95 x 1000) = 03B6	
[4] switch on loop maintenance mode	3D026190	-----	-----	
[5] set analog output to 0°C (permanent)	3A021203E8	-----	word = Dec ⇒ Hex (0 [°C] x 10 +1000) = 03E8	
[5] set analog output to 200°C (permanent)	3A02120BB8	-----	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

(also available on CD CompactConnect)

Decimal	HEX	Command	Data	Response	Result	Unit
1	0x01	Read object temperature	none	byte1 byte2	$= (\text{byte1} \times 256 + \text{byte2} - 1000) / 10$	°C
2	0x02	Read head temperature	none	byte1 byte2	$= (\text{byte1} \times 256 + \text{byte2} - 1000) / 10$	°C
3	0x03	Read current object temperature	none	byte1 byte2	$= (\text{byte1} \times 256 + \text{byte2} - 1000) / 10$	°C
4	0x04	Read emissivity	none	byte1 byte2	$= (\text{byte1} \times 256 + \text{byte2} - 1000)$	
5	0x05	Read transmissivity	none	byte1 byte2	$= (\text{byte1} \times 256 + \text{byte2} - 1000)$	
9	0x09	Read process temperature	none	byte1 byte2	$= \text{byte1} \times 256 + \text{byte2}$	°C
14	0x0E	Read serial number	none	byte1 byte2 byte3	$= \text{byte1} \times 65536 + \text{byte2} \times 256 + \text{byte3}$	
15	0x0F	Read Firmware-Rev.	none	byte1 byte2	$= \text{byte1} \times 256 + \text{byte2}$	
129	0x81	Set mA output	byte1	Byte1	$\text{byte1} = \text{mA} \times 10$ (e.g. 4 mA = $4 \times 10 = 40$)	mA
132	0x84	Set emissivity	byte1 byte2	byte1 byte2	$= (\text{byte1} \times 256 + \text{byte2}) / 1000$	
133	0x85	Set transmissivity	byte1 byte2	byte1 byte2	$= (\text{byte1} \times 256 + \text{byte2}) / 1000$	

Command List CSmicro 2W

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

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 1μ 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 (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)

Emissivity

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.

Emissivity

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.
- ▶ 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.

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
- 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

Appendix A – Emissivity Table Metals

Material	typical Emissivity
Aluminium non oxidized	0,02-0,1
polished	0,02-0,1
roughened	0,1-0,3
oxidized	0,2-0,4
Brass polished	0,01-0,05
roughened	0,3
oxidized	0,5
Copper polished	0,03
roughened	0,05-0,1
oxidized	0,4-0,8
Chrome	0,02-0,2
Gold	0,01-0,1
Haynes alloy	0,3-0,8
Inconel electro polished	0,15
sandblast	0,3-0,6
oxidized	0,7-0,95
Iron non oxidized	0,05-0,2
rusted	0,5-0,7
oxidized	0,5-0,9
forged, blunt	0,9
Iron, casted non oxidized	0,2
oxidized	0,6-0,95
Lead polished	0,05-0,1

Material	typical Emissivity
Lead roughened	0,4
oxidized	0,2-0,6
Magnesium	0,02-0,1
Mercury	0,05-0,15
Molybdenum non oxidized	0,1
oxidized	0,2-0,6
Monel (Ni-Cu)	0,1-0,14
Nickel electrolytic	0,05-0,15
oxidized	0,2-0,5
Platinum black	0,9
Silver	0,02
Steel polished plate	0,1
rustless	0,1-0,8
heavy plate	0,4-0,6
cold-rolled	0,7-0,9
oxidized	0,7-0,9
Tin non oxidized	0,05
Titanium polished	0,05-0,2
oxidized	0,5-0,6
Wolfram polished	0,03-0,1
Zinc polished	0,02
oxidized	0,1

Appendix B – Emissivity Table Non Metals

Appendix B – Emissivity Table Non Metals

Material	typical Emissivity
Asbestos	0,95
Asphalt	0,95
Basalt	0,7
Carbon non oxidized	0,8-0,9
graphite	0,7-0,8
Carborundum	0,9
Ceramic	0,95
Concrete	0,95
Glass	0,85
Grit	0,95
Gypsum	0,8-0,95
Ice	0,98
Limestone	0,98
Paint non alkaline	0,9-0,95
Paper any color	0,95
Plastic > 50 µm non transparent	0,95
Rubber	0,95
Sand	0,9
Snow	0,9
Soil	0,9-0,98
Textiles	0,95
Water	0,93
Wood natural	0,9-0,95



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