Infrared Sensor

Operation manual

thermoMETER CX

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.

Content

1 Description

The sensors of the thermoMETER CX 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 thermoMETER CX is made of aluminium (IP65/ NEMA-4 rating) and contains the complete sensor electronics. The sensor has a fixed mounted connection cable.

The CX sensors 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

- CX 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 sensor, 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:

Temperature range:	-18...500 °C/ according 4-20 mA
Emissivity:	0.950
Transmission:	1.000
Smart averaging:	Active
Ambient temperature source:	Head temperature

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

If the unit is supplied together with the USB-kit (optional) the output will be set to digital communication (bidirectional).

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

Environmental rating	IP65 (NEMA-4)
Ambient temperature	-20...75 °C
Storage temperature	-40...85 °C
Relative humidity	10...95 %, non condensing
Material	aluminium, black anodized
Dimensions	Diameter: 42 mm/ Length: 130 mm
Weight	350 g
Cable length	5 m
Cable diameter	4.3 mm
Vibration	IEC 68-2-6: 3G, 11 – 200 Hz, any axis
Shock	IEC 68-2-27: 50G, 11 ms, any axis
EMI	89/336/EWG

Tab. 2.1: General Specification

2.2 Electrical Specifications

Output/ analog	4-20 mA/ scalable
Output/ serial digital [1)]	uni- (burst mode) or bidirectional
Alarm output	Programmable open collector output/ 0...30 VDC; 500 mA
Output impedances	max. 1000 Ω loop impedance
Power supply	5...28 VDC

Tab. 2.2: Electrical Specification

[1)] inverted RS232, TTL, and 9.6 kBaud

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

2.3 Measurement Specifications

	CX-SF22-C8	CX-SF15-C8
Temperature range IR	-30...900 °C (scalable via software)	-30...150 °C (scalable via software)
Spectral range	8...14 μm	8...14 μm
Optical resolution	22:1	15:1
CF-lens (optional)	0,6 mm@ 10 mm	0.8 mm@ 10 mm
Accuracy[1)]	±1.5 °C or ±1.5 % of reading	±1 °C oder ±1 % of reading
Repeatability[1)]	±0.75 °C or ±0.75 % of reading	±0.3 °C oder ±0.3 % of reading
Temperature resolution	0.2 °C	0.025 °C
Response time	150 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)	
Software (optional)	CompactConnect	

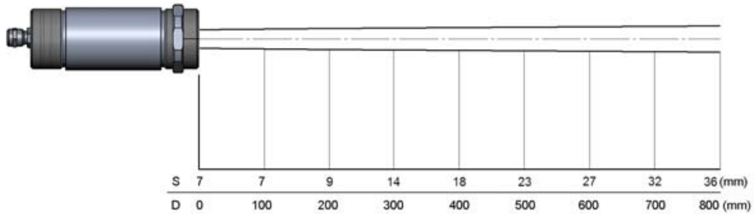
Tab. 2.3: Measurement Specification

[1)] at ambient temperature 23±5 °C; whichever is greater

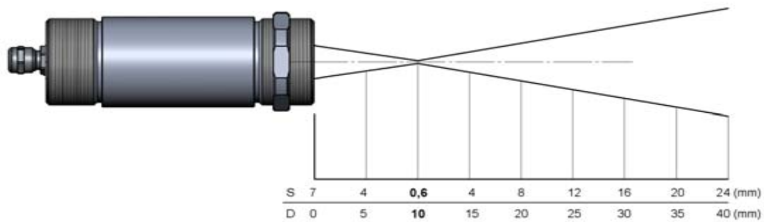
2.4 Optical Charts

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.

Optical chart CX (22:1)



Optical chart
CX with CF-lens (0.6 mm @ 10 mm)



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.

2.5 CF Optics and Protective Window

The optional CF-lens allows the measurement of small objects.
For protection of the sensing head optics a protective window is available. The mechanical dimensions are equal to the CF lens.

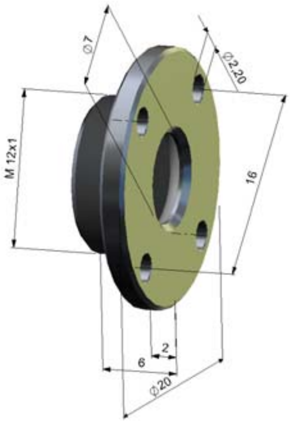


Fig. 2.1: CF-lens [TM-CF-CX]/ Protective window [TM-PW-CX]

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.

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.

3 Installation

3.1 Mechanical Installation

The CX is equipped with a 20 UNF-2B 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.

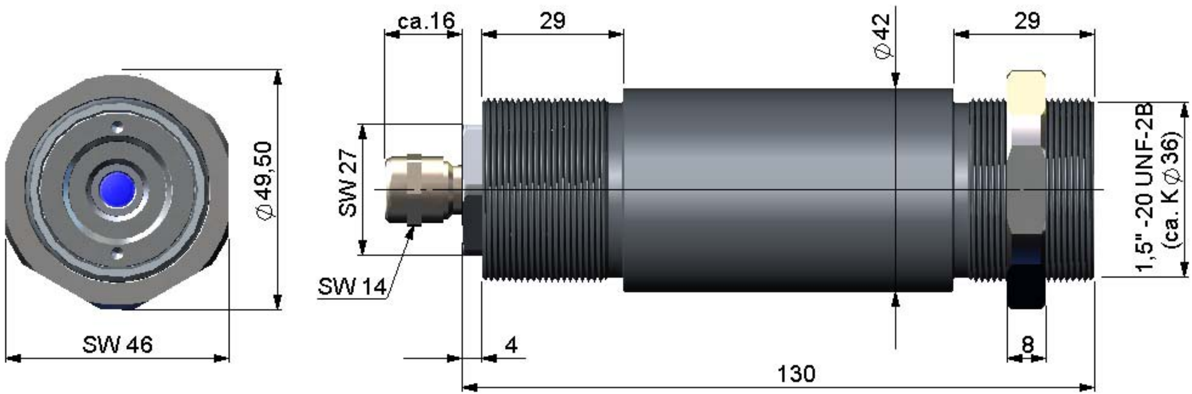


Fig. 3.1: CX – Dimensions

3.2 Air Purge Collar

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.

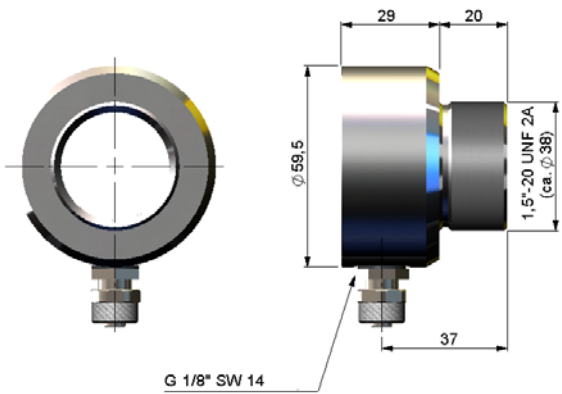
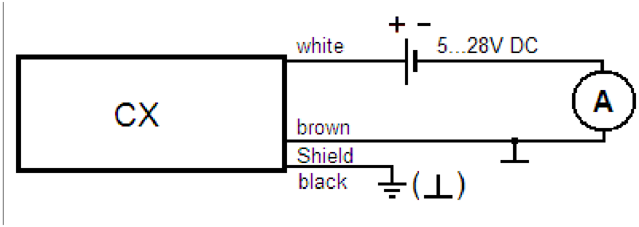


Fig. 3.2: Air purge collar [TM-AP-CX]; Hose connection: 6x8 mm

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

3.3 Electrical Installation

3.3.1 Analog device (mA output)



The maximum loop impedance is 1000 Ω.

3.3.2 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.

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

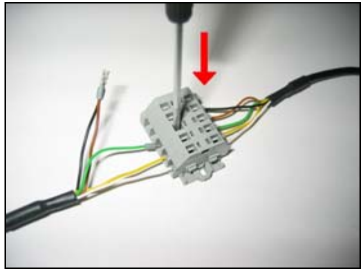
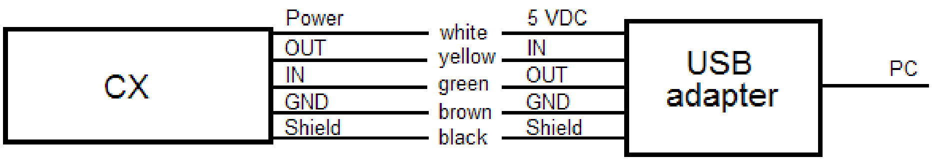


Fig. 3.3: USB-Kit

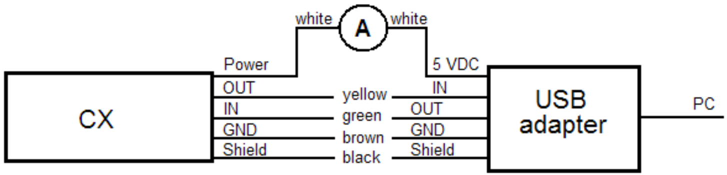
The sensor is offering two ways of digital communication:

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

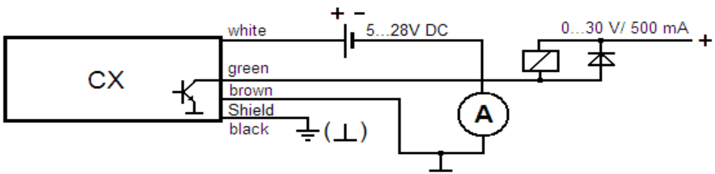


3.3.3 Analog + Digital

The CX is 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).



3.3.4 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.

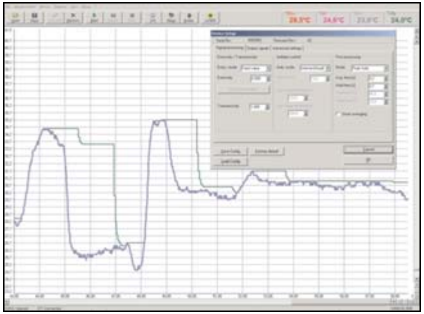
The installation wizard will place a launch icon on the desktop and in the start menu:
[Start]\Programs\CompactConnect.
If you want to uninstall the software from your system please use the uninstall icon in the start menu.

You will find a detailed software manual on the CD.

4.2 System requirements

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

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 Digital Command Set

Decimal	HEX	Command	Data	Answer	Result	Currency
1	0x01	READ Object temperature	no	byte1 byte2	= (byte1 x 256 + byte2 - 1000) / 10	°C
2	0x02	READ Head temperature	no	byte1 byte2	= (byte1 x 256 + byte2 - 1000) / 10	°C
3	0x03	READ current Object temperature	no	byte1 byte2	= (byte1 x 256 + byte2 - 1000) / 10	°C
4	0x04	READ Emissivity	no	byte1 byte2	= (byte1 x 256 + byte2) / 1000	
5	0x05	READ Transmission	no	byte1 byte2	= (byte1 x 256 + byte2) / 1000	
9	0x09	READ Process temperature	no	byte1 byte2	= byte1 x 256 + byte2	°C
14	0x0E	READ Serial number	no	byte1 byte2 byte3	= byte1 x 65536 + byte2 x 256 + byte3	
15	0x0F	READ Firmware revision	no	byte1 byte2	= byte1 x 256 + byte2	
129	0x81	SET mA-Output (loop maintenance)	byte1	byte1	byte 1= mA*10 (z.B. 4mA = 4*10=40)	mA
132	0x84	SET Emissivity	byte1 byte2	byte1 byte2	= (byte1 x 256 + byte2) / 1000	
133	0x85	SET Transmission	byte1 byte2	byte1 byte2	= (byte1 x 256 + byte2) / 1000	

Interface Settings:
8 Data bits, 1 Stop bit, no parity, no flow control

EXAMPLES
Read out of object temperature:
(all bytes in HEX)

Send: 01 Command to read the object temperature
Receive: 04 D3 Object temperature in tenth degrees + 1000

04 D3 = dez.1235
1235 - 1000 = 235
235 / 10 = 23,5 °C

Set-up of Emissivity:
(all bytes in HEX)

Send: 84 03 B6 Command to set the emissivity to 0.950
Receive: 03 B6 Emissivity x 1000

03 B6 = dez. 950
950 / 1000 = 0,950

6 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 *µ*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.

7 Emissivity

7.1 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.

7.2 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-CT) 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.

7.3 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

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	0.03
	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
	Sandblase	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
	Roughened	0.4
	Oxidized	0.2 – 0.6

Appendix A – Emissivity Table Metals

Material		Typical Emissivity
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

Material		Typical Emissivity
Asbestos		0.95
Asphalt		0.95
Basalt		0.7
Carbon	Non oxidized Graphite	0.8 – 0.9 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 $>50\,\mu m$	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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