MICRO-EPSILON

Infrared Sensors

Operation manual

thermoMETER CT / CTF / CTH / CTM-1 / CTM-2 / CTM-3

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 CT 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 CT sensor is made of stainless steel (IP 65/ NEMA-4 rating) – the sensor electronics is placed in a separate box made of die casting zinc.

The CT sensor is a sensitive optical system. 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

- CT sensor with connection cable and controller
- 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 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 CT, please contact our service department.

1.4 Factory Default Settings

The unit has the following presetting at time of delivery:

Signal output object temperature	0-5 V
Emissivity	0.970 (1.000 at CTM-1/ CTM-2 / CTM-3)
Transmissivity	1.000
Average time (AVG)	0.2 s / CTF: 0.1 s / CTM-1, CTM-2, CTM-3: inactive
Smart Averaging	inactive/ CTF, CTM-1, CTM-2, CTM-3: active
Peak hold	inactive
Valley hold	inactive

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

	CT / CTF	CTM-1SF40	CTM-1SF75	CTM-2SF40	CTM-2SF75
Lower limit temperature range [°C]	0	485	650	250	385
Upper limit temperature range [°C]	500	1050	1800	800	1600
Lower alarm limit [°C]	30	600	800	350	500
Upper alarm limit [°C]	100	900	1400	600	1200
Lower limit signal output	0 V				
Upper limit signal output	5 V				
Temperature unit	°C				
Ambient temperature compensation	sensor temperature probe [1]	sensor temperature probe			
Baud rate [kBaud]	9.6	115			

1) output at OUT-AMB: 0-5 V ► -20–180 °C

	CTM-3SF22	CTM-3SF33
Lower limit temperature range [°C]	50	100
Upper limit temperature range [°C]	375	600
Lower alarm limit [°C]	100	200
Upper alarm limit [°C]	300	500
Lower limit signal output	0 V	
Upper limit signal output	5 V	
Temperature unit	°C	
Ambient temperature compensation	sensor temperature probe	
Baud rate [kBaud]	115	

2 Technical Data

2.1 General Specifications

	Sensor	Controller
Environmental rating	IP 65 (NEMA-4)	IP 65 (NEMA-4)
Ambient Temperature	see: Measurement Specifications	0...85 °C
Storage temperature	see: Measurement Specifications	-40...85 °C
Relative humidity	10...95 %, non condensing	10...95 %, non condensing
Material	stainless steel	die casting zinc
Dimensions	28 mm x 14 mm, M12x1	89 mm x 70 mm x 30 mm
Dimensions CTH	55 mm x 29,5 mm, M18x1 (with massive housing)	
Weight	40 g	420 g
Cable length	1 m (only CT-SF02, CT-SF15, CT-SF22, CTF-SF10), 3 m, 8 m, 15 m	
Cable diameter	2.8 mm	
Ambient temperature cable l	180 °C max. [High temperature cable for CThot: 250 °C]	
Vibration	IEC 68-2-6: 3 g, 11 – 200 Hz, any axis	
Shock	IEC 68-2-27: 50 g, 11ms, any axis	
EMC	2004/108/EC	

Tab. 2.1: General specifications

2.2 Electrical Specifications

Power Supply	8–36 VDC
Current draw	max. 100 mA
Outputs/ analog Channel 1	selectable: 0/ 4–20 mA, 0–5/ 10 V, thermocouple (J or K) or alarm output (Signal source: object temperature)
Channel 2 (only CT)	Sensor temperature [-20...180 °C],[-20...250 °C at CTH-SFO2 or CTH-SF10] as 0–5 V or 0–10 V output or alarm output (Signal source switchable to object temperature or electronic box temperature if used as alarm output)
Alarm output	Open-collector-Output on Pin AL2 [24 V/ 50 mA]
Output impedances mA mV Thermocouple	 max. loop resistance 500 Ω (at 8-36 VDC) min. 100 KΩ load impedance 20 Ω
Digital interfaces	USB, RS232, RS485, CAN, Profibus DP, Ethernet (optional plug-in modules)
Relay outputs	2 x 60 VDC/ 42 VAC_{RMS}, 0,4 A; optically isolated (optional plug-in module)
Functional inputs	F1-F3; software programmable for the following functions: • external emissivity adjustment, • ambient temperature compensation, • trigger (reset of hold functions)

Tab. 2.2: Electrical specifications

3 Measurement Specifications [CT-models]

	CT-SF02	CT-SF15	CT-SF22
Temperature range (scalable)	-50...600 °C	-50...600 °C	-50...975 °C
Ambient temperature (sensor)	-20...130 °C	-20...180 °C	-20...180 °C
Storage temperature (sensor)	-40...130 °C	-40...180 °C	-40...180 °C
Spectral range	8...14 µm	8...14 µm	8...14 µm
Optical resolution	2:1	15:1	22:1
System accuracy [1) 2)]	±1 °C oder ±1 % [3)]		
Repeatability [1)]	±0.5 °C oder ±0.5 % [3)]		
Temperature resolution (NETD)	0.1 °C [3)]		
Response time (95% signal)	150 ms		
Warm-up time	10 min		
Emissivity/ Gain	0.100…1.100 (adjustable via programming keys or software)		
Transmissivity	0.100…1.000 (adjustable via programming keys or software)		
Signal processing	Average, peak hold, valley hold (adjustable via programming keys or software)		
Software (optional)	CompactConnect		

Tab. 3.1: Measurement specifications [CT-models]

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

[2)] Accuracy for thermocouple output: ±2,5 °C or ±1%

[3)] at object temperatures >0 °C

4 Measurement Specifications [CTF- / CTH-models]

	CTF-SF10	CTH-SF02	CTH-SF10
Temperature range (scalable)	-50 … 900 °C	-40 … 975 °C	-40 … 975 °C
Ambient temperature (sensor)	-20 … 120 °C	-20 … 250 °C	-20 … 250 °C
Storage temperature (sensor)	-40 … 120 °C	-40 … 250 °C	-40 … 250 °C
Spectral range	8 … 14 µm	8 … 14 µm	8 … 14 µm
Optical resolution	10:1	2:1	10:1
System accuracy [1) 2)]	±2 °C oder ±1% [3)]	±1.5 °C oder ±1 % [3)]	±1.5 °C oder ±1 % [3)]
Repeatability [1) 2)]	±0.75 °C oder ±0.75 % [3)]	±0.5 °C oder ±0,5 % [3)]	±0.5 °C oder ±0.5 % [3)]
Temperature resolution (NETD)	1 °C [3)]	0.5 °C [3)]	0.5 °C [3)]
Response time (90% signal)	9 ms	100 ms	100 ms
Acquisition time (50% signal)	3 ms	---	---
Warm-up time	10 min		
Emissivity/ Gain	0.100…1.100 (adjustable via programming keys or software)		
Transmissivity	0.100…1.000 (adjustable via programming keys or software)		
Signal processing	Average, peak hold, valley hold (adjustable via programming keys or software)		
Software (optional)	CompactConnect		

Tab. 4.1: Measurement specifications [CTF- / CTH-models]

[1)] at ambient temperature 23 ±5 °C; whichever is greater
[2)] Accuracy for thermocouple output: ±2.5 °C or ±1 %
[3)] at object temperatures ≥ 20 °C

On the CTH models [CTH-SF02/ CTH-SF10] the sensor cable must not be moved during the measurement.

5 Measurement Specifications [CTM-1- / CTM-2- / CTM-3-models]

	CTM-1SF40	CTM-1SF75	CTM-2SF40	CTM-2SF75
Temperature range (scalable)	485 … 1050 °C	650 … 1800 °C	250 … 800 °C	385 … 1600 °C
Ambient temperature (sensor)	-20 … 100 °C	-20 … 100 °C	-20 … 125 °C	-20 … 125 °C
Storage temperature (sensor)	-40 … 100 °C	-40 … 100 °C	-40 … 125 °C	-40 … 125 °C
Spectral range	1 µm		1.6 µm	
Optical resolution	40:1	75:1	40:1	75:1
System accuracy [1) 2)]	±(0,3 % of reading +2 °C) [3]			
Repeatability [1) 2)]	±(0,1 % of reading +1 °C) [3)]			
Temperature resolution	0,1 °C			
Exposure time (90 % signal)	1 ms [4)]			
Emissivity/ Gain	0.100…1.100 (adjustable via programming keys or software)			
Transmissivity	0.100…1.000 (adjustable via programming keys or software)			
Signal processing	Average, peak hold, valley hold (adjustable via programming keys or software)			
Software (optional)	CompactConnect			

Tab. 5.1: Measurement Specifications [CTM-1- / CTM-2-models]

[1)] at ambient temperature 23 ±5 °C; whichever is greater
[2)] Accuracy for thermocouple output: ±2.5 °C or ±1%
[3)] ε = 1/ Response time 1s
[4)] with dynamic adaptation at low signal levels

		CTM-3SF22	CTM-3SF33	CTP-7 SF10
Temperature range (scalable) [1]		50 to 375 °C	100 to 600 °C	0 ° to 500 °C
Ambient temperature	Sensor	-20 …to 85 °C		
	Controller	0 …to 85 °C		
Storage temperature	Sensor	-40 … to 125 °C		-40 … to 85 °C
	Controller	-40 … to 85 °C		-40 … to 85 °C
Spectral range		2.3 µm		7.9 µm
Optical resolution		22:1	33:1	10:1
System accuracy [2]		± (0.3 % T_{Mess} + 2 °C) [2]		< 1 % or < 1.5 % °C
Repeatability		± (0.1 % T_{Mess} + 1 °C)		< 0.5 % or < 0.5 °C
Temperature resolution		0.1 °C		< 0.5 °C
Exposure time (90 % signal) [3]		1 ms		150 ms
Emissivity / Gain		0.100…1.100 (adjustable via programming keys or software)		0.100 or 1.100
Transmissivity		0.100…1.000 (adjustable via programming keys or software)		0.100 or 1.100
Signal processing		Average, peak hold, valley hold (adjustable via programming keys or software)		
Software (optional)		CompactConnect		

Tab. 5.2: Measurement Specifications [CTM-3-models]

[1] TObjekt > Measuring sensor + 25 °C

[2] E = 1, Response time 1 s

[3]) with dynamic adjustment at low signal levels

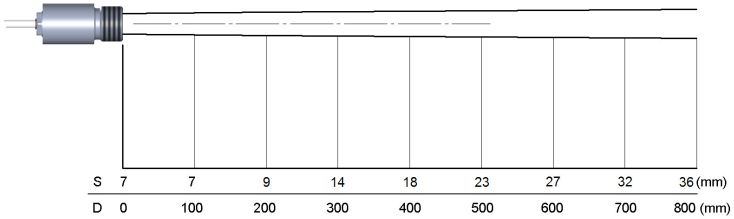
6 Optical Charts

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.

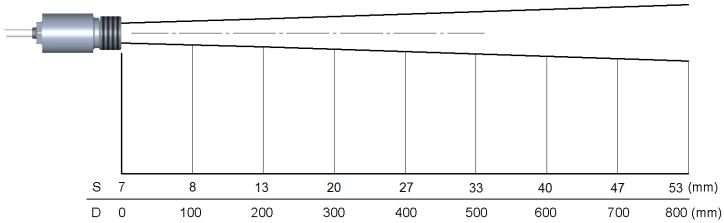
The size of the measuring object and the optical resolution of the infrared thermometer determine the maximum distance between sensor and measuring object. In order to prevent measuring errors the object should fill out the field of view of the optics completely.
Consequently, the spot should at all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

D = Distance from front of the sensor to the object
S = Spot size
The D:S ratio is valid for the focus point.

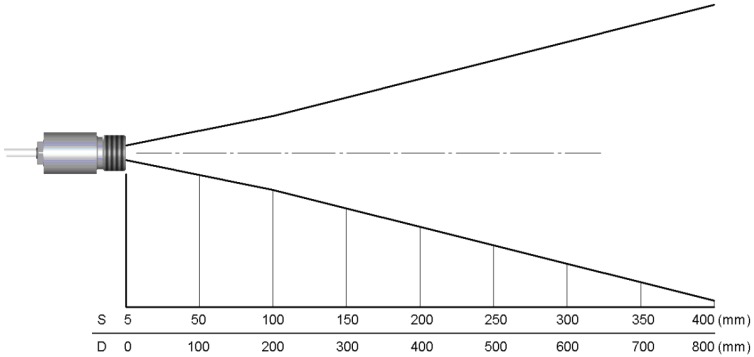
CT-SF22
D:S = 22:1



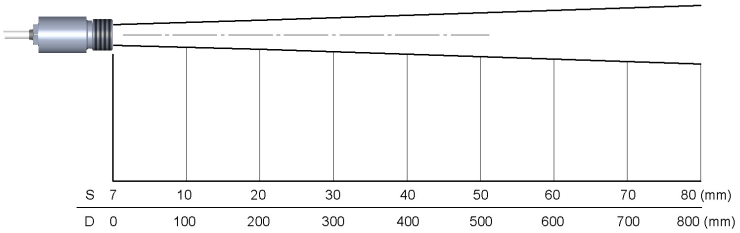
CT-SF15
D:S = 15:1



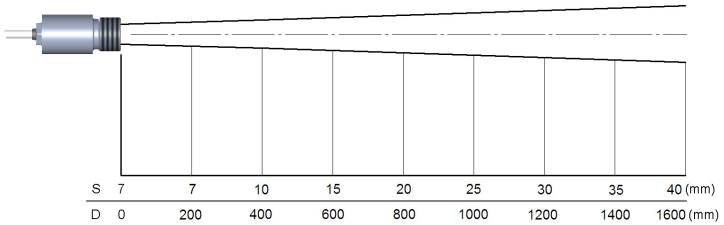
CT-SF02 **CTH-SF02**
D:S = 2:1



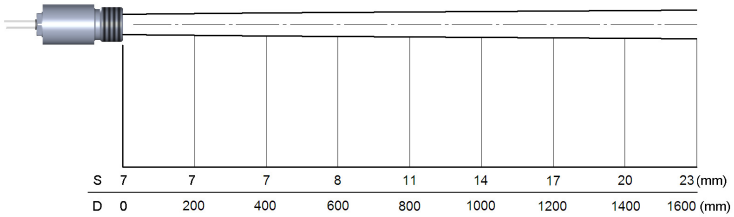
CTF-SF10 **CTH-SF10** **CTP-7SF10**
D:S = 10:1



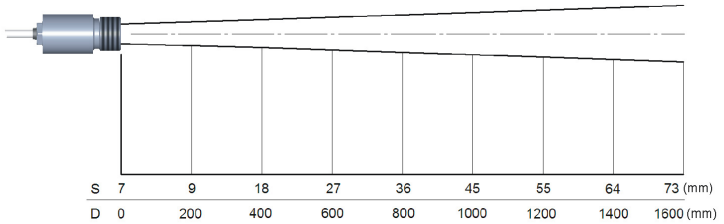
CTM-1SF40 **CTM-2SF40**
D:S = 40:1
CF: 2.7 mm @ 110 mm
D:S (Far field CF) = 12:1



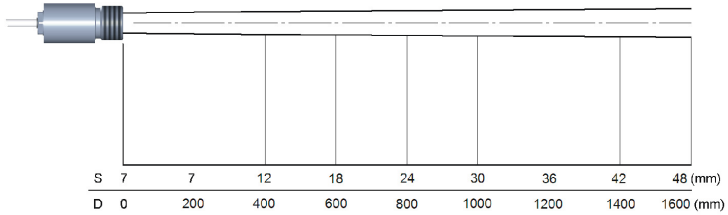
CTM-1SF75 **CTM-2SF75**
D:S = 75:1
CF: 1.5 mm @ 110 mm
D:S (Far field CF) = 14:1



CTM-3SF22
D:S = 22:1
CF: 5 mm @ 110 mm
D:S (Far field CF) = 9:1



CTM-3SF33
D:S = 33:1
CF: 3.4 mm @ 110 mm
D:S (Far field CF) = 11:1



7 CF Lens and Protective Window

The optional CF lens allows the measurement of very small objects and can be used in combination with all LT models. 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 [TM-CF-CT] until end stop. To combine it with the massive housing please use the version with external thread M12x1 [TM-CFAG-CT].

If the CF lens is used, the transmission (at CT systems) has to be set to **0.78** [CT]

TM-CF–CT	CF lens for installation on sensor [CT]
TM–CFH–CT	CF lens for installation on sensor [CTM-1/ CTM-2/ CTM-3]
TM–CFAG–CT	CF lens with external thread for installation in massive housing [CT]
TM-CFHAG-CT	CF lens with external thread for installation in massive housing [CTM-1/ CTM-2/ CTM-3]

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-CT	Protective window for installation on sensor [CT]
TM-PWAG-CT	Protective window for installation on sensor [CTM-1/ CTM-2/ CTM-3]
TM-PWAG-CT	Protective window with external thread for installation in massive housing [CT]
TM-PWHAG-CT	Protective window with external thread for installation in massive housing [CTM-1/ CTM-2/ CTM-3]

If the protective window is used, the transmission has to be set to **0.83** [CT systems] or **0.93** [1M/ 2M/ 3M].

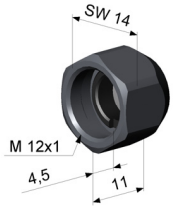


Fig. 7.1: CF lens [TM-CF-CT] resp. protective window [TM-PW-CT]

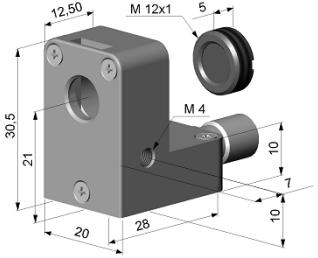


Fig. 7.2: Laminar air purge with integrated CF lens [TM-APLCF-CT]

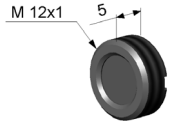
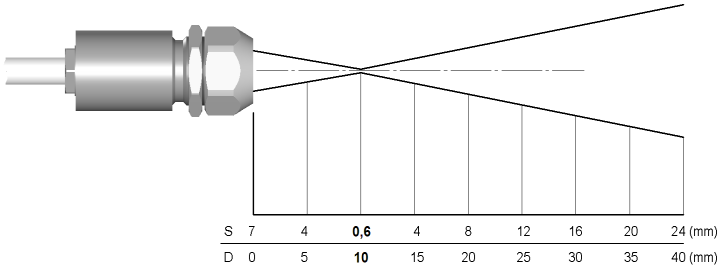
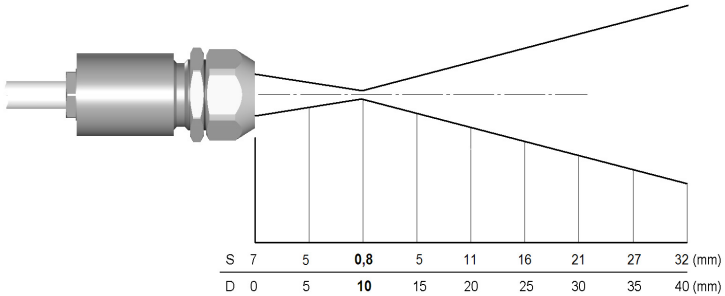


Fig. 7.3: CF lens [TM-CF-CT] resp. protective window [TM-PW-CT] with external thread

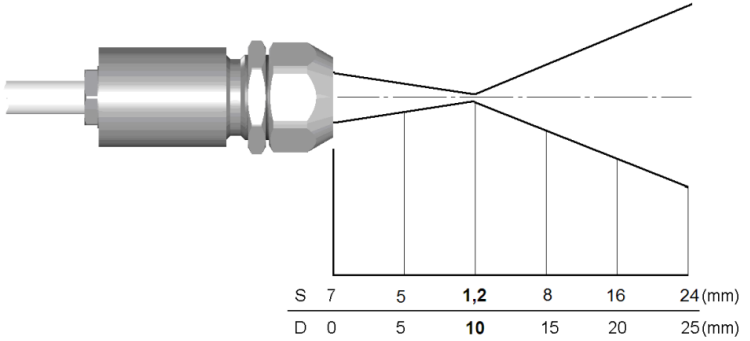
CT-SF22 + CF-Optic
0.6 mm @ 10 mm
0.6 mm @ 8 mm [TM-APLCF-CT]
D:S (Far field) = 1.5:1



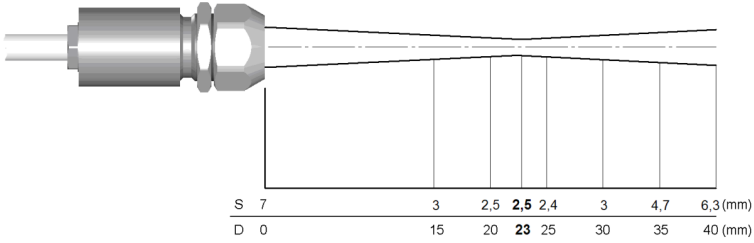
CT-SF15 + CF-Optic
0.8 mm @ 10 mm
0.8 mm @ 8 mm [TM-APLCF-CT]
D:S (Far field) = 1.2:1



CTF-SF10 / CTH-SF10 / CF-Optic
1.2 mm @ 10 mm
1.2 mm @ 8 mm [TM-APLCF-CT]
D:S (Far field) = 1.2:1



CT-SF02 / CTH-SF02 + CF-Optic
2.5 mm @ 23 mm
2.5 mm @ 21 mm [TM-APLCF-CT]
D:S (Far field) = 5:1



8 Mechanical Installation

The CT sensors are equipped with a metrical M12x1-thread and can be installed either directly via the sensor thread or by means of the hex nut (included in scope of supply) to the mounting bracket available. Various mounting brackets, which make the adjustment of the sensor easier, can be additionally ordered as accessories.
The CT hot will be delivered with the massive housing and can be installed via the M18x1-thread.

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

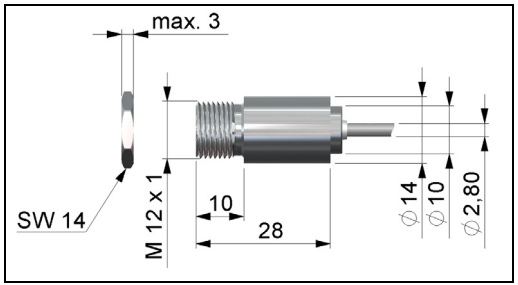


Fig. 8.1: Sensor

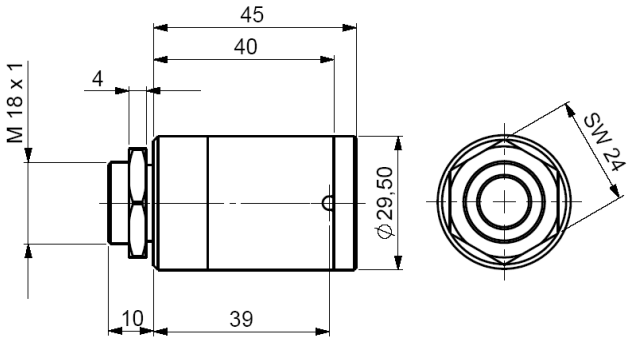


Fig. 8.2 Massive housing (Standard on CTH)

Make sure to keep the optical path clear of any objects.

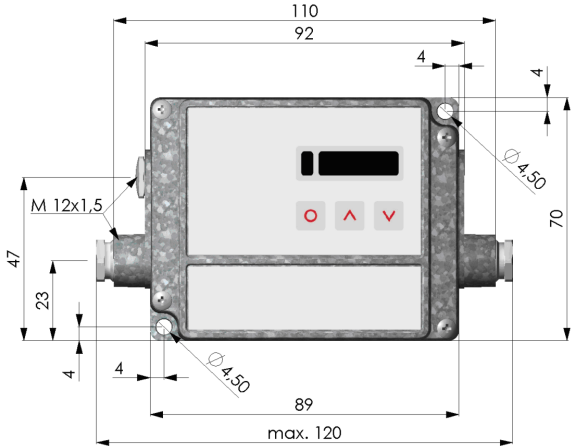
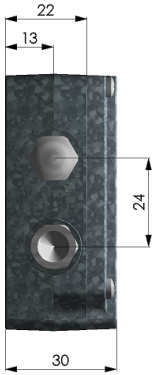


Fig. 8.3: Controller



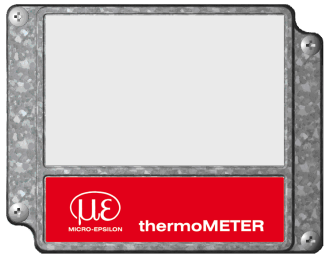


Fig. 8.4: Controller with closed cover [TM-COV-CT]

The controller is also available with closed cover (display and programming keys with no access from outside).

8.1 Mounting Accessories

The Mounting bracket [TM-FB-CT] is adjustable in one axis.

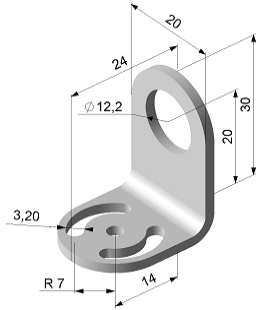


Fig. 8.5: Mounting bracket [TM-FB-CT]

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

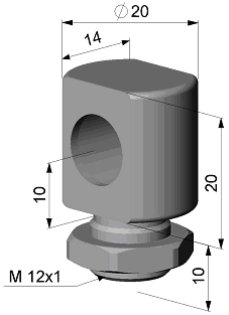


Fig. 8.6: Mounting bold [TM-MB-CT]

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

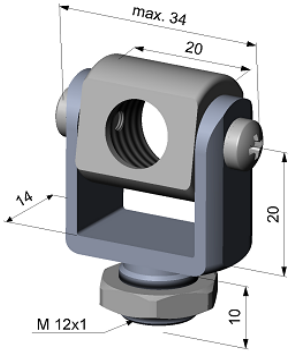


Fig. 8.7: Mounting fork [TM-MG-CT]

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

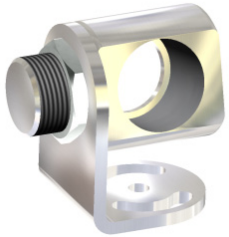


Fig. 8.8: Mounting bracket [TM-AB-CT]

8.2 Air Purges 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 [TM-AP-CT] for CT-SF22, CT-SF15 and CTF-SF10 fits to the mounting bracket
Hose connection: 3x5 mm
Thread (fitting): M5

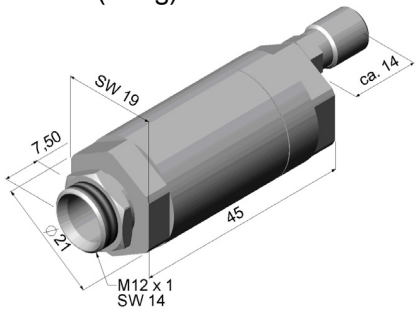


Fig. 8.9: Standard air purge collar [TM-AP-CT]

Standard air purge collar [TM-AP2-CT] for CT-SF02 fits to the mounting bracket
Hose connection: 3x5 mm
Thread (fitting): M5

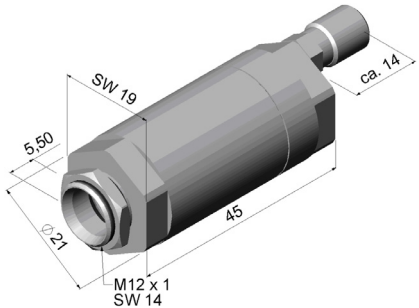


Fig. 8.10: Standard air purge collar [TM-AP2-CT]

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

The sideward air outlet TM-APL-CT prevents a cooling down of the object in short distances.
Hose connection: 3 x 5 mm
Thread (fitting): M5

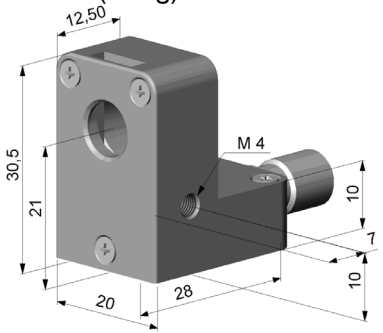


Fig. 8.11: Laminar air purge collar [TM-APL-CT]

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

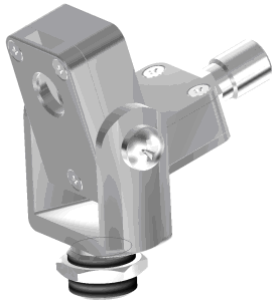


Fig. 8.12: Laminar air purge collar and mounting fork [TM-APL-CT + TM-MG-CT]

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

8.3 Further Accessories

The right angle mirror [TM-RAM-CT] enables measurements with 90 ° angle to sensor axis.

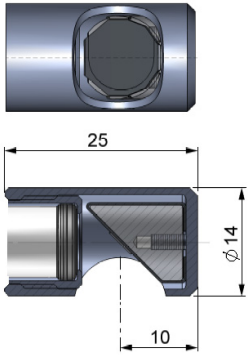


Fig. 8.13: Right angle mirror [TM-RAM-CT]

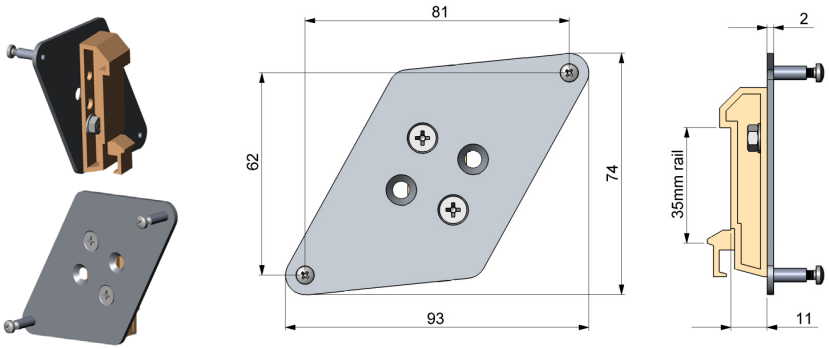


Fig. 8.14: Rail mount adapter for controller [TM-TRAIL-CT]

Laser sighting tool [TM-LST-CT], battery powered (2x Alkaline AA), for alignment of CT sensors. The laser head has similar mechanical dimensions as the CT sensor.

WARNING: Do not point the laser directly at the eyes of persons or animals! Do not stare into the laser beam. Avoid indirect exposure via reflective surfaces!

Fig. 8.15: Laser sighting tool [TM-LST-CT]

OEM laser sightingtool

The OEM laser sightingtool is available with 3.5 m [TM-LSTOEM-CT] and 8 m connection cable [TM-LSTOEM-CT (008)]. The laser can be connected to the pins 3V SW and GND [Electrical installation] and switched on and off via the programming keys or via the software.

The special double-hole mounting bracket [TM-FB2-CT] allows a simultaneous mounting of the CT sensor and the laser head.

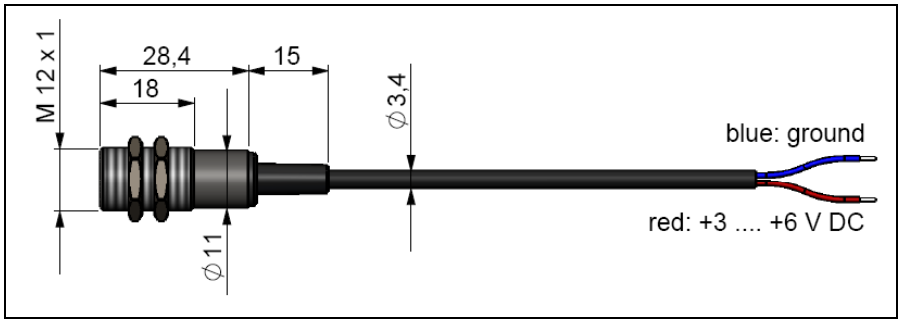


Abb. 8.16: TM-LSTOEM-CT

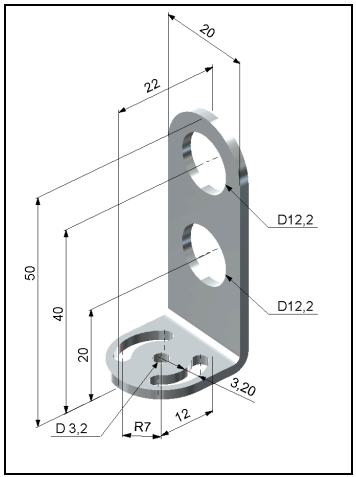


Abb. 8.17: TM-FB2-CT

The massive housing [TM-MHS-CT] is available in aluminium (anodized) or brass.

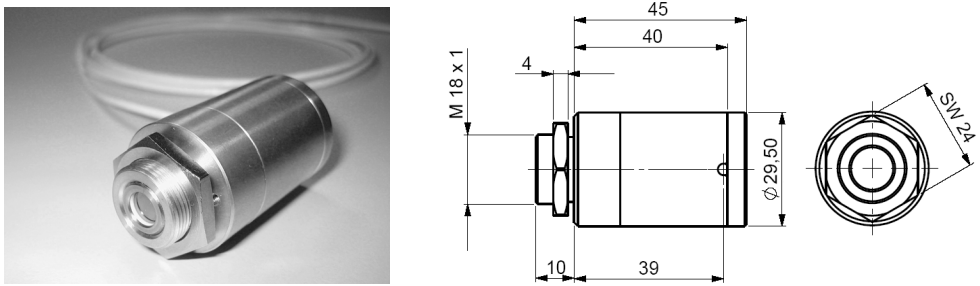


Fig. 8.16: Massive housing, stainless steel [TM-MHS-CT]

The massive housing allows reproducible and stable measurements on applications with significant and short-term variation in ambient temperatures. It can be combined with the CF lens [TM-CFAG-CT] or with the protective window [TM-PWAG-CT].

IMPORTANT: For an optimum function of the massive housing **10 cm** of the sensor cable must be installed in loops inside the housing.

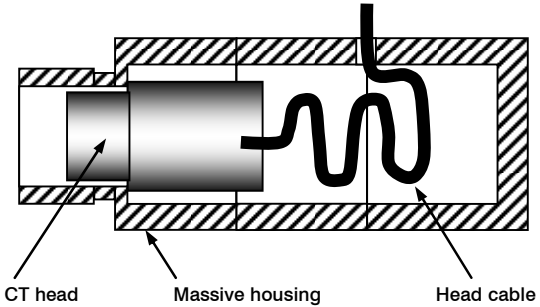


Fig. 8.17: Massive housing

Pipe Adapter and Sighting Tubes
The pipe adapter [TM-PA-CT] allows an assembling of sighting tubes directly on the CT sensor. The sighting tubes are available in 3 different lengths:

TM-ST20-CT	Length: 20 mm
TM-ST40-CT	Length: 40 mm
TM-ST88-CT	Length: 88 mm

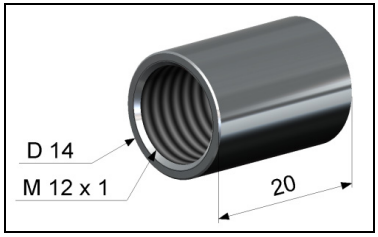


Abb. 8.20: TM-PA-CT

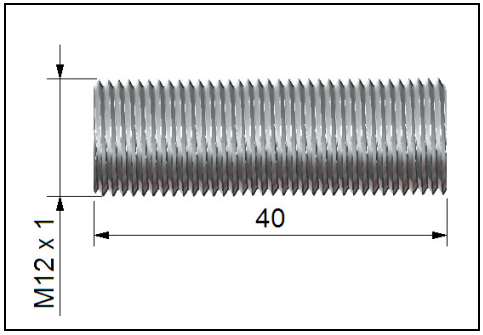


Abb. 8.19: TM-ST40-CT

The sighting tubes can only be used for sensors with a distance-to-spot ratio (D:S) of ≥ 15:1.

9 Electrical Installation

9.1 Cable Connections

For the electrical installation of the CT, please open at first the cover of the controller (4 screws). Below the display are the screw terminals for the cable connection.

Designation (CT models)	
+8..36 VDC	Power supply
GND	Ground (0 V) of power supply
GND	Ground (0 V) of internal in- and outputs
OUT-AMB	Analog output sensor temperature (mV)
OUT-TC	Analog output thermocouple (J or K)
OUT-mV/mA	Analog output object temperature (mV or mA)
F1-F3	Functional inputs
AL2	Alarm 2 (Open collector output)
3V SW	not used
GND	not used
BROWN	Temperature probe sensor
WHITE	Temperature probe sensor
GREEN	Detector signal (–)
YELLOW	Detector signal (+)

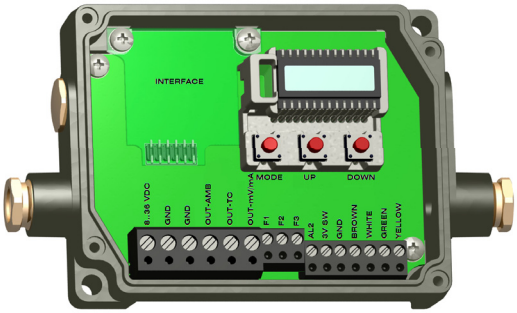


Fig. 9.1: Opened controller with terminal connections

Designation (models 1M/ 2M/ 3M)	
+8..36 VDC	Power supply
GND	Ground (0 V) of power supply
GND	Ground (0 V) of internal in- and outputs
AL2	Alarm 2 (Open collector output)
OUT-TC	Analog output thermocouple (J or K)
OUT-mV/mA	Analog output object temperature (mV or mA)
F1-F3	Functional inputs
GND	Ground (0 V)
3V SW	3 VDC, switchable, for laser-sightingtool
GND	Ground (0 V) for laser-sightingtool
BROWN	BROWN/ Temperature probe sensor (NTC)
WHITE	WHITE/ sensor ground
GREEN	GREEN/ sensor power
YELLOW	YELLOW/ Detector signal

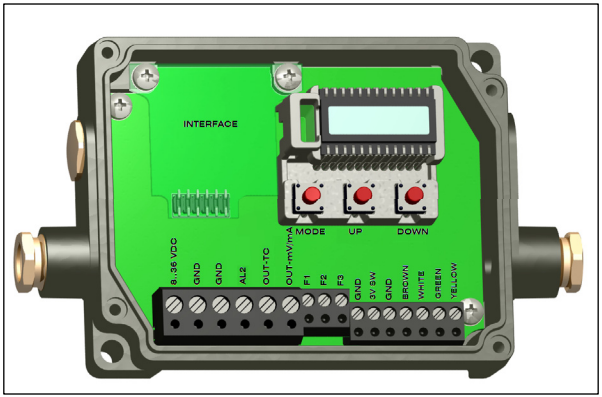


Abb. 9.2: Opened controller with terminal connections

9.2 Power Supply

Please use a power supply unit with an output voltage of 8–36 VDC/ 100 mA.

CAUTION: Please do never connect a supply voltage to the analog outputs as this will destroy the output!
The CT ist not a 2-wire sensor!

9.3 Cable Assembling

The cable gland M12x1.5 allows the use of cables with a diameter of 3 to 5 mm.
Remove the isolation from the cable (40 mm power supply, 50 mm signal outputs, 60 mm functional inputs). Cut the shield down to approximately 5 mm and spread the strands out. Extract about 4 mm of the wire isolation and tin the wire ends. Place the pressing screw, the rubber washer and the metal washers of the cable gland one after the other onto the prepared cable end. Spread the strands and fix the shield between two of the metal washers. Insert the cable into the cable gland until the limit stop. Screw the cap tight.
Every single wire may be connected to the according screw clamps according to their colors.

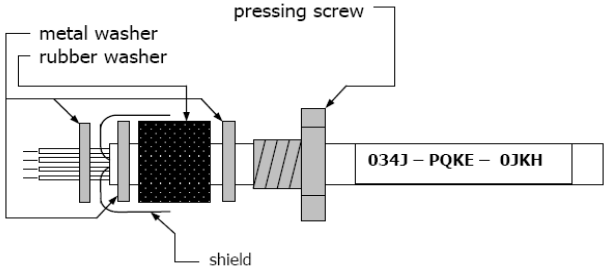


Fig. 9.3: Cable Assembling

Use shielded cables only. The sensor shield has to be grounded.

9.4 Ground Connection

At the bottom side of the main board PCB you will find a connector (jumper) which has been placed from factory side as shown in the picture [left and middle pin connected]. In this position the ground connections (GND power supply/ outputs) are connected with the ground of the controller housing. To avoid ground loops and related signal interferences in industrial environments it might be necessary to interrupt this connection. To do so, please put the jumper in the other position [middle and right pin connected]. If the thermocouple output is used the connection GND – housing should be interrupted generally.

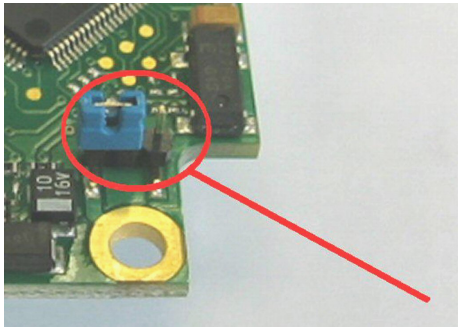


Fig. 9.4: Connector (Jumper)

9.5 Exchange of the Sensor

From factory side the sensor has already been connected to the controllers and the calibration code has been entered. Inside the model group CT-SF22, CT-SF15, CT-SF02, CTH-SF10, CTH-SF02 any exchange of sensors and controllers is possible. The sensors and controllers of the models CTF, CTM-1, CTM-2 and CTM-3 cannot be exchanged.

9.5.1 Entering of the Calibration Code

Every sensor has a specific calibration code, which is printed on the sensor cable. For a correct temperature measurement and functionality of the sensor this calibration code must be stored into the controller. The calibration code consists of 3 blocks (CTF, CTM-1, CTM-2 and CTM-3 = 5 blocks) with 4 characters each.

Example: **A6FG – 22KB – 0AS0**
block1 block2 block3

After exchanging a sensor the calibration code of the new sensor must be entered into the controller.

Fig. 9.5: Calibration Code

For entering the code, please press the Up and Down key (keep pressed) and then the Mode key.
The display shows HCODE and then the 4 signs of the first block. With Up and Down each sign can be changed; Mode switches to the next sign or next block.
The entering of a new calibration code can also be made via the CompactConnect software (optional).

You will find the calibration code on a label fixed on the sensor cable (near the controller). Please do not remove this label or make sure that the code is noted anywhere. The code is needed if the controller has to be exchanged or in case of a necessary recalibration of the sensor.

9.5.2 Sensor Cable

On the models CT-SF22, CT-SF15, CT-SF02, CTH-SF10, CTH-SF02 the sensor cable can be shorten if necessary. A shortening of the cable will cause an additional measuring error of about 0.1 K/ m.
On the models CTF, CTM-1, CTM-2 and CTM-3 the senor cable may not be changed in its length.

On the CTH models [CTHSF-0F / CTH-SF10] the sensor cable must not be moved during the measurement.

10 Outputs and Inputs

10.1 Analog Outputs

The CT has two analog output channels.

CAUTION: Please do never connect a supply voltage to the analog outputs as this will destroy the output. **The CT is not a 2-wire sensor!**

10.1.1 Output Channel 1

This output is used for the object temperature. The selection of the output signal can be done via the programming keys [► Operating]. The CompactConnect software allows the programming of output channel 1 as an alarm output.

Output signal	Range	Connection pin on CT board
Voltage	0 ... 5 V	OUT-mV/mA
Voltage	0 ... 10 V	OUT-mV/mA
Current	0 ... 20 mA	OUT-mV/mA
Current	4 ... 20 mA	OUT-mV/mA
Thermocouple	TC J	OUT-TC
Thermocouple	TC K	OUT-TC

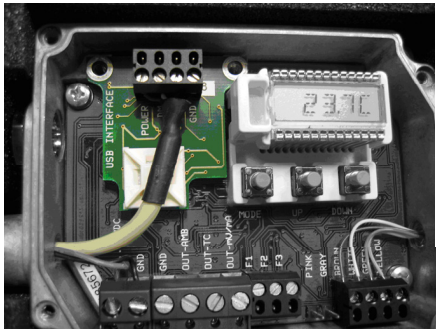
According to the chosen output signal different connection pins on the main board are used (**OUT-mV/mA** or **OUT-TC**).

10.1.2 Output Channel 2

The connection pin OUT-AMB is used for output of the sensor temperature [-20–180 °C as 0–5 V or 0–10 V signal]. The CompactConnect software allows the programming of output channel 2 as an alarm output. Instead of the sensor temperature THead also the object temperature TObj or controller temperature TBox can be selected as alarm source.

10.2 Digital Interfaces

All CT sensors can be optionally equipped with an USB-, RS232-, RS485-, CAN Bus-, Profibus DP- or Ethernet-interface. If you want to install an interface, plug the interface board into the place provided, which is located beside the display. In the correct position the holes of the interface match with the thread holes of the electronic box. Now press the board down to connect it and use both M3x5 screws for fixing it. Plug the preassembled interface cable with the terminal block into the male connector of the interface board.



Please pay attention to the notes on the according interface manuals.

Fig. 10.1: Interface board

10.2.1 USB Interface Kit

10.2.1.1 Scope of Supply

USB interface board	Terminal block
Software CD	Cable gland
USB adapter cable	Mounting screws and cable tie

10.2.1.2 Installation

Please plug the USB interface into the place provided, which is located beside the display. In the correct position the holes of the USB interface match with the thread holes of the CT box,
(see Fig. 10.2). Now press the PCB downwards and fix it using both M3x5 screws. Exchange the blind screw on the CT box by the cable gland and install the USB adapter cable. Make sure the wiring is correct according to the wire colors printed on the interface board.

NOTE: For industrial installations it is recommended to connect the shield of the USB adapter cable with the controller housing (inside the cable gland). The CT needs no external power supply for operation – it will be powered by the USB interface. If an external power supply has already been installed, this will not affect the functionality of the CT.

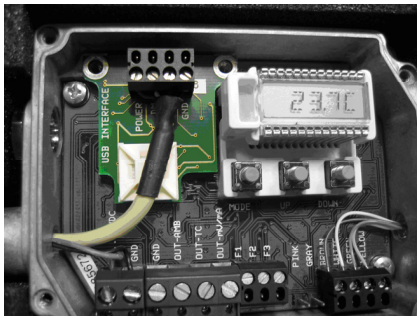


Fig. 10.2: CT box with USB-Interface

10.2.1.3 Driver Installation

Please install the software as described in the operator's manual. After you have connected the USB-cable to your PC the computer will recognize a new USB-device and (if connected the first time) will ask for installation of the according driver software. The drivers are located in the path \Driver\ Infrared Sensor Adapter. Please select Search and the drivers will be automatically installed from the delivered CD. After this you can start the software and the communication will be established.

10.2.2 RS232 Interface Kit

10.2.2.1 Scope of Supply

1 pcs.	Packaging	1 pcs.	Cable gland M12x1.5
1 pcs.	Quick reference	1 pcs.	RS232-Interface
1 pcs.	Software CD	2 pcs.	Screw M3x5
1 pcs.	RS232-interface cable preassembled	1 pcs.	Cable tie

10.2.2.2 Installation

- Please take the RS232-interface out from the packaging and plug it into the place provided, which is located beside the display. In the correct position the holes of the RS232 interface match with the thread holes of the CT box. Now press the RS232-interface down to connect it with the CT.
- Use both M3x5 screws for fixing the interface. Plug the preassembled RS232-interface cable with the terminal block into the male connector of the RS232-interface. In the case that you want to use the delivered cable gland M12x1.5 for the RS232 cable, the terminal block has to be disassembled/ assembled.
- Make sure the wiring is correct.

The CT always needs an external power supply for operation.
Please install the software CT connect as described in the operators manual. After you have connected the RS232-cable to your PC and started the software the communication will be established. The setting for baud rate in the software must be the same as on the CT unit (factory default: 9.6 kBaud).

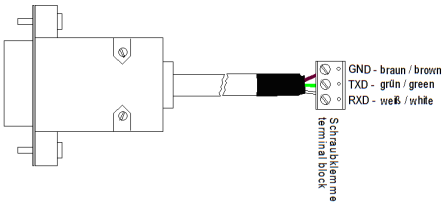


Fig. 10.3: Correct wiring

10.2.3 RS485 Interface Kit

10.2.3.1 Scope of Supply

1 pcs.	Packaging	1 pcs.	RS485-USB-Adapter
1 pcs.	Quick reference	1 pcs.	Cable gland M12x1.5
1 pcs.	Software CD (CTconnect, CTmulti)	2 pcs.	Screw M3x5
1 pcs.	USB cable	1 pcs.	Cable tie
1 pcs.	RS485-interface	1 pcs.	Terminal block on the board

10.2.3.2 Installation

- Please connect the RS485-USB-adapter (TM-RS485USBK-CT) via the supplied USB cable with your computer. After it has been connected the computer will recognize a new USB-device and (if connected the first time) will ask for installation of the according driver software. Please select Search and install the RS485 Adapter USB Driver from the software CD.
- Please take the RS485-interface out from the packaging and plug it into the place provided, which is located beside the display. In the correct position the holes of the RS485 interface match with the thread holes of the CT box.
- Now press the RS485-interface down to connect it with the CT. Use both M3x5 screws for fixing the board (see
- Fig. 10.4).
- The RS485-USB-adapter is providing a 2-wire half-duplex mode. Please connect terminal A of the adapter with terminal A of the RS485-interface of the first CT and from there to terminal A of the next CT and so on. With the B terminals proceed as well.

- Make sure, that you always connect A to A and B to B, not reverse. You may run up to 32 CT units on one RS485-USB-adapter. The 120R-switch is to be turned to ON at one of the connected CT units, only.
- Each CT unit connected to the RS485 (TM-RS485USBK-CT) needs a different multidrop address (1…32). Please adjust the address by pressing the mode button until M xx appears in the display. Using the Up- and Down-keys you can change the shown address (xx) The address can also be changed with the CTconnect software. The setting for baud rate in the software must be the same as on the CT unit (factory default: 9.6 kBaud.)

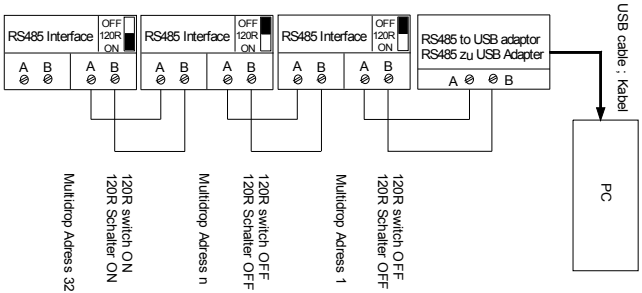


Fig. 10.4: Correct wiring

10.2.4 CAN Bus Interface

CAN Protocol
CAN open (see documentation on CD)

Wiring
CAN Bus:
CAN_H on terminal „H“
CAN_L on terminal „L“

Analog signal:
Black cord on terminal „GND“
Black cord on terminal „OUT-mV“

The controller contains additional terminals to connect other devices (power supply, CAN bus, terminating resistor).

CAN module settings

Module address:	20 (14 H)
Baud rate:	250 kBaud
Analog input:	0 … 10 V
Temperature range:	0 … 60 °C (2 decimal places)
Emission ratio:	0.970

Note: The settings for “Analog output 0 … 10 V“ and "Temperature range 0 … 60 °C" must be identical with the CAN bus module values.

Settings Address and Baud rate
CAN open service "LSS / Layer Setting Services"

Index Temperature Value:
The temperature information is located in the object register 7130h (Sub01):

	B4: LB	B5: HB	
e.g.	B4: DA	B5: 07	T = 20.10 °C

Diagnosis
If the power supply is on, the LED displays one of the following conditions:

State	Meaning
Flashes quickly	Device is in preoperational mode
Off	Power supply is not correct / faulty hardware
Illuminates	Device is in operational mode
Sparkles	Device is stopped

10.2.5 Profibus Accessory Kit

10.2.5.1 Scope of Supply

1 pcs.	Packaging	1 pcs.	Cable gland M12x1.5
1 pcs.	Quick reference	1 pcs.	Profibus-DPv1-interface
1 pcs.	Software CD	2 pcs.	Screw M3x5
1 pcs.	Profibus-interface cable preassembled		

10.2.5.2 Installation

- Please take the Profibus-DPv1-interface out from the packaging and plug it into the place provided, which is located beside the display. In the correct position the holes of the Profibus-DPv1-interface match with the thread holes of the CT box. Now press the Profibus DPv1 interface down to connect it with the CT.
- Use both M3x5 screws for fixing the interface. Plug the preassembled Profibus-DPv1 interface cable with the terminal block into the male connector of the Profibus-DPv1-interface. In the case that you want to use the delivered cable gland M12x1.5 for the Profibus cable, the terminal block has to be disassembled/ assembled.
- Make sure the wiring is correct (see Fig. 10.5).

NOTE: For industrial installations it is recommended to connect the shield of the Profibus cable with the controller housing (inside the cable gland).

The CT always needs an external power supply for operation.

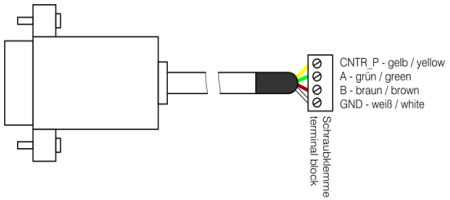
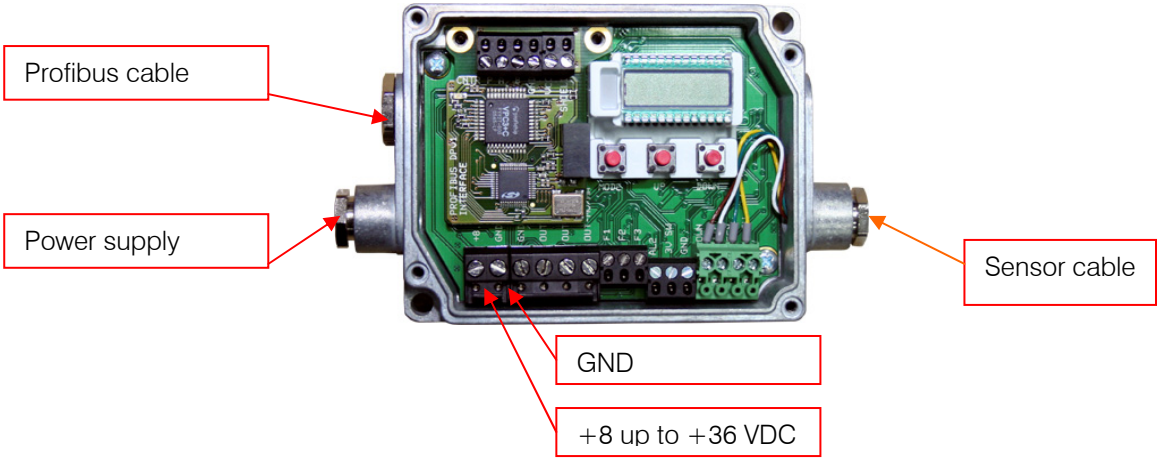


Fig. 10.5: Correct wiring

10.2.5.3 Commissioning Profibus

1. Read in the „IT010A90.gsd“ GSD file into the PLC configuration tool and configure the controller. At least one module must be selected. You will find more information about the Profibus interface on the enclosed CD-ROM.
2. Open the controller and connect the power supply, see figure below.



3. Switch on the power supply.
4. Press the Mode button 18 times until the item „SL001“ appears. Set the slave address with the „UP“ and „DOWN“ buttons. Valid slave addresses start with 001 up to 125. Use the same address as in the PLC configuration tool, see page 4 in the manual.
5. Switch off the controller for at least 3 seconds.
6. Connect the connector of the Profibus cable with a Profibus port. Take care on the terminating resistor of the Profibus.
7. The controller with Profibus-DPv1 is now ready for data exchange with the Profibus master; see the instruction manual on page 7.
8. The measurements are displayed in hex format and must be converted into decimals; see the manual on page 7.
9. The settings of the Profibus-DPv1 interface and the communication with the Profibus master are described in the manual on CD.

10.2.6 Ethernet-interface

10.2.6.1 Scope of supply

1 pcs.	Packaging	1 pcs.	Cable gland M12x1.5
1 pcs.	Quick reference	1 pcs.	Ethernet-interface
1 pcs.	Software CD	2 pcs.	Screw M3x5
1 pcs.	Ethernet-interface preassembled	1 pcs.	Cable tie

10.2.6.2 Installation

- Please take the Ethernet interface out from the packaging and plug it into the place provided, which is located beside the display. In the correct position the holes of the interface match with the thread holes of the CT box. Now press the interface down to connect it with the CT.
- Use both M3x5 screws for fixing the interface. Plug the interface box with the preassembled terminal block into the male connector of the Ethernet interface. In case you want to use the delivered cable gland M12x1.5 for the Ethernet box, the terminal block has to be disassembled/ assembled.

The CT requires an external power supply in each case.

10.2.6.3 Installation of the CT Ethernet Adapter in a Network

First install the driver software of the Ethernet adapter on the supplied CD (Compact Connect CD).

To start the installation, start the file SETUP.EXE in the path: Driver/Ethernet.

The following dialog appears:

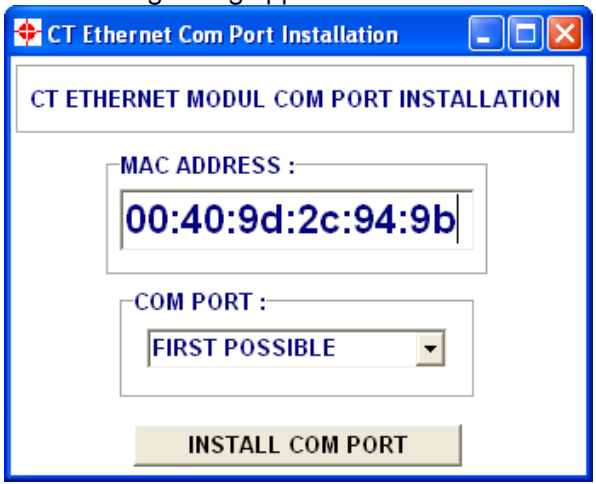
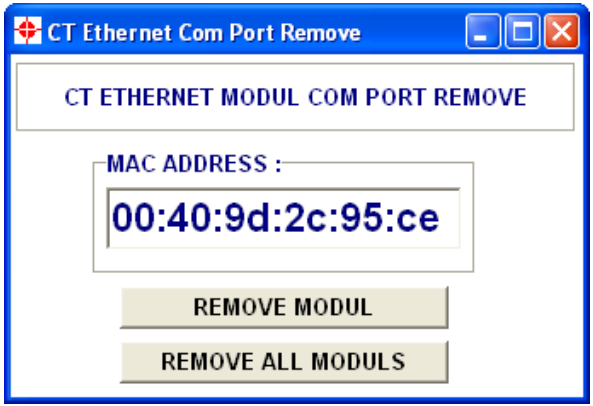


Fig. 10.6: CT Ethernet Com Port Installation

Enter the MAC address of the adapter in the field MAC Address. You will find the address on the housing.
Select in the pull-down menu COM PORT the desired COM port or FIRST POSSIBLE for the first available COM port.
Now click on the button INSTALL COM PORT. Installation is completed, if the letters in the button are black again.
The COM port is now set in the Device Manager and can be used from the software Compact Connect. You will find a manual for installation and operation of the Compact Connect software on the CD.

10.2.6.4 Uninstall the CT Ethernet Adapter in a Network

To uninstall the driver software, start the file REMOVE.EXE on the supplied CD.
The file is located in the path: Driver/Ethernet_Adapter.
The following dialog appears:



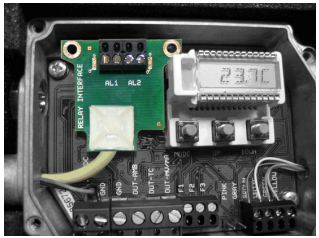
The dialog allows to permanently remove a single module or all modules from the system.

To install the CT Ethernet adapter in a direct connection to a PC you will find more information in the path: Manuals\Interfaces on the Compact Connect CD.

10.3 Relais Outputs

The CT can be optionally equipped with a relay output. The relay board will be installed the same way as the digital interfaces. A simultaneous installation of a digital interface and the relay outputs is not possible. The relay board provides two fully isolated switches, which have the capability to switch max. 60 VDC/ 42 VAC_{RMS}, 0.4 A DC/AC. A red LED shows the closed switch.

The switching thresholds are in accordance with the values for alarm 1 and 2 [► Alarms/ Visual Alarms].
The factory default preset alarm values are:
Alarm 1 = 30 °C/ norm. Closed (Low-Alarm) and Alarm 2 = 100 °C/ norm. Open (High-Alarm).
The adjustment of the alarms can result from the modification of the alarm 1 and alarm 2 via the programming keys.
To make advanced settings (change of low- and high alarm) a digital interface (USB, RS232) and the software CompactConnect is needed.



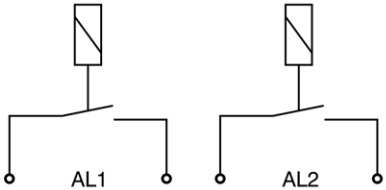


Fig. 10.6: Relays-Interface with pin assignment

10.4 Functional Inputs

The three functional inputs F1 – F3 can be programmed with the CompactConnect software, only.

F1 (digital): trigger (a 0 V level on F1 resets the hold functions)
F2 (analog): external emissivity adjustment [0–10 V: 0 V ► ε=0.1; 9 V ► ε=1; 10 V ► ε=1.1]
F3 (analog): external compensation of ambient temperature/ the range is scalable via software [0–10 V ► -40–900 °C / preset range: -20–200 °C]
F1-F3 (digital): emissivity (digital choice via table, non-connected input F1 represents high-level) with F2/ F3 = low-level.
High-level: ≥ +3 V…+36 V
Low-level: ≤ +0.4 V…–36 V

10.5 Alarms

The CT has the following alarm features:

All alarms (alarm 1, alarm 2, output channel 1 and 2 if used as alarm output) have a fixed **hysteresis of 2 K**.

10.5.1 Output Channel 1 and 2

To activate the according output channel has to be switched into digital mode. For this the software CompactConnect is required.

10.5.2 Visual Alarms

These alarms will cause a change of the color of the LCD display and will also change the status of the optional relays interface. In addition the Alarm 2 can be used as open collector output at pin AL2 on the main board [24 V/ 50 mA].

From factory side the following threshold values (alarm values) are preset:

Alarm 1	30 °C	[norm. closed/ Low-Alarm]
Alarm 2	100 °C	[norm. open/ High-Alarm]

Both of these alarms will have effect on the LCD color:

BLUE: Alarm 1 active
RED: Alarm 2 active
GREEN: No alarm active

For extended setup like definition as low or high alarm [via change of normally open/ closed], selection of the signal source [TObj, THead, TBox] a digital interface (e.g. USB, RS232) including the software CompactConnect is needed.

11 Operating

After power up the unit the sensor starts an initializing routine for some seconds. During this time the display will show INIT. After this procedure the object temperature is shown in the display. The display backlight color changes according to the alarm settings [► Alarms/ Visual Alarms].

11.1 Sensor Setup

The programming keys Mode, Up and Down enable the user to set the sensor on-site. The current measuring value or the chosen feature is displayed. With Mode the operator obtains the chosen feature, with Up and Down the functional parameters can be selected – a change of parameters will have immediate effect. If no key is pressed for more than 10 seconds the display automatically shows the calculated object temperature (according to the signal processing).

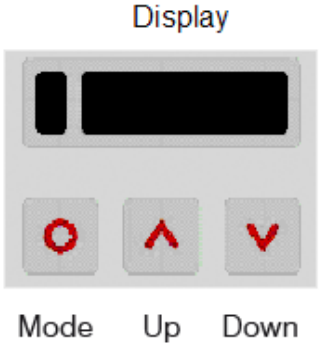


Fig. 11.1: Display and programming keys

Pressing the Mode button the last called function is displayed again. The signal processing features **Peak hold** and **Valley hold** cannot be selected simultaneously.

11.2 Set Factory Defaults

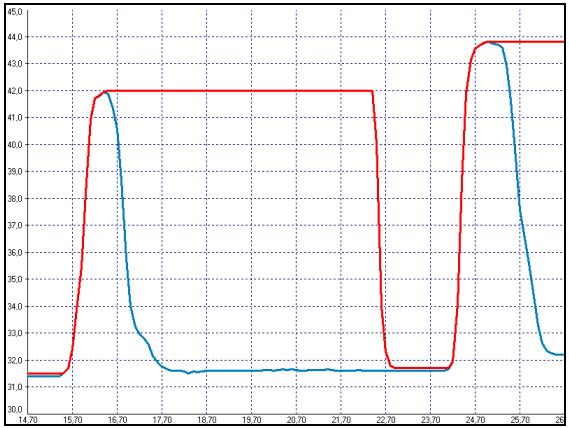
Factory default setting: To set the CT back to the factory default settings, please press at first the **Down**-key and then the **Mode**-key and keep both pressed for approx. 3 seconds. The display will show RESET for confirmation.

Display	Mode [Sample]	Adjustment Range
142.3C	Object temperature (after signal processing) [142.3 °C]	fixed
127CH	Sensor temperature [127 °C]	fixed
25CB	Box temperature [25 °C]	fixed
142CA	Current object temperature [142 °C]	fixed
□ MV5	Signal output channel 1 [0-5 V]	□0-20 = 0–20 mA/ □4-20 = 4–20 mA/ □MV5 = 0–5 V/ □MV10 = 0–10 V/ □TCJ = Thermocouple type J/ □TCK = Thermocouple type K
E0.970	Emissivity [0.970]	0.100 ... 1.100
T1.000	Transmissivity [1.000]	0.100 ... 1.100
A 0.2	Signal output Average [0.2 s]	A---- = inactive/ 0.1 … 999.9 s
P----	Signal output Peak hold [inactive]	P---- = inactive/ 0.1 … 999.9 s/ P ∞ = infinite
V----	Signal output Valley hold [inactive]	V---- = inactive/ 0.1 … 999.9 s/ V ∞ = infinite
u 0.0	Lower limit temperature range [0 °C]	-40.0 … 975.0 °C/ inactive at TCJ- and TCK-output
n 500.0	Upper limit temperature range [500 °C]	-40.0 … 975.0 °C/ inactive at TCJ- and TCK-output
[0.00	Lower limit signal output [0 V]	according to the range of the selected output signal
] 5.00	Upper limit signal output [5 V]	according to the range of the selected output signal
U °C	Temperature unit [°C]	°C/ °F
| 30.0	Lower alarm limit [30 °C]	depending on model
|| 100.0	Upper alarm limit [100 °C]	depending on model
XHEAD	Ambient temperature compensation [sensor temperature]	XHEAD = sensor temperature/ -40.0 … 900.0 °C as fixed value for compensation/ returning to XHEAD (sensor temperature) by pressing Up and Down together
M 01	Multidrop address [1] (only with RS485 interface)	01 … 32
B 9.6	Baud rate in kBaud [9.6]	9.6/ 19.2/ 38.4/ 57.6/ 115.2 kBaud
S ON	Laser eyepiece (3 VDC-switches to the connection pin „3 VSW“)	ON/ OFF This menu item appears at the models 1M/ 2M/ 3M on first position.

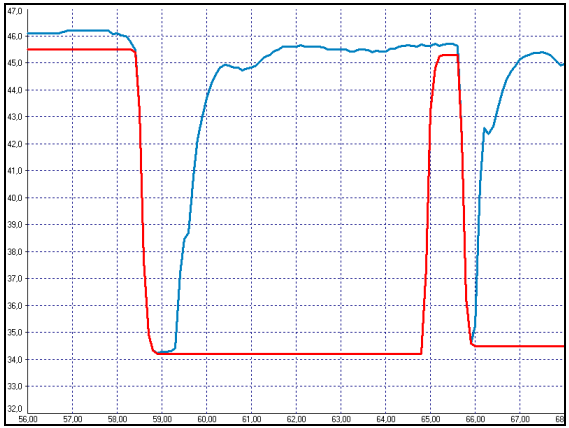
11.3 Emissivity, Statistic, Prescriptive Limits

□ MV5	Selection of the Output signal. By pressing Up or Down the different output signals can be selected [► Outputs and Inputs].
E0.970	Setup of Emissivity. Pressing Up increases the value, Down decreases the value (also valid for all further functions). The emissivity is a material constant factor to describe the ability of the body to emit infrared energy [► Emissivity].
T1.000	Setup of transmissivity. This function is used if an optical component (protective window, additional optics e.g.) is mounted between sensor and object. The standard setting is 1.000 = 100 % (if no protective window etc. is used).
A 0.2	Setup of Average time. If the value is set to 0.0 the display will show --- (function deactivated). In this mode an arithmetic algorithm will be performed to smoothen the signal. The set time is the time constant. This function can be combined with all other post processing functions.
P----	Setup of Peak hold. If the value is set to 0.0 the display will show --- (function deactivated). In this mode the sensor is waiting for descending signals. If the signal descends the algorithm maintains the previous signal peak for the specified time.
V----	Setup of Valley hold. If the value is set to 0.0 the display will show --- (function deactivated). In this mode the sensor waits for ascending signals. If the signal ascends the algorithm maintains the previous signal valley for the specified time.

Signal graphs with **P----** and **V----**



— TObj with Peak hold
— Temperature without post processing



— TObj with Valley hold
— Temperature without post processing

u 0.0	Setup of the Lower limit of temperature range. The minimum difference between lower and upper limit is 20 K. If you set the lower limit to a value ≥ upper limit the upper limit will be adjusted to [lower limit + 20 K] automatically.
n 500.0	Setup of the Upper limit of the temperature range. The minimum difference between upper and lower limit is 20 K. The upper limit can only be set to a value = lower limit +20 K.
[0.00	Setup of the Lower limit of the signal output. This setting allows an assignment of a certain signal output level to the lower limit of the temperature range. The adjustment range corresponds to the selected output mode (e.g. 0-5 V).
] 5.00	Setup of the Upper limit of the signal output. This setting allows an assignment of a certain signal output level to the lower limit of the temperature range. The adjustment range corresponds to the selected output mode (e.g. 0-5 V).
U °C	Setup of the Temperature unit [°C or °F].
| 30.0	Setup of the Lower alarm limit. This value corresponds to Alarm 1 [► Alarms/ Visual Alarms] and is also used as threshold value for relay 1 (if the optional relay board is used).
|| 100.0	Setup of the Upper alarm limit. This value corresponds to Alarm 2 [► Alarms/ Visual Alarms] and is also used as threshold value for relay 2 (if the optional relay board is used).

XHEAD Setup of the ambient temperature compensation. In dependence on the emissivity value of the object a certain amount of ambient radiation will be reflected from the object surface. To compensate for this impact, this function allows the setup of a fixed value which represents the ambient radiation.

Especially if there is a big difference between the ambient temperature at the object and the sensor temperature the use of **Ambient temperature compensation** is recommended.

If XHEAD is shown the ambient temperature value will be taken from the sensor-internal probe.
To return to XHEAD, please press Up and Down together.

M 01 Setup of the Multidrop address. In a RS485 network each sensor will need a specific address. This menu item will only be shown if a RS485 interface board is plugged in.

B 9.6 Setup of the Baud rate for digital data transfer.

11.4 Error Messages

The display of the sensor can show the following error messages:

- OVER temperature overflow
- UNDER temperature underflow
- ^ ^ ^CH sensor temperature to high
- vvvCH sensor temperature to low

12 Software CompactConnect

12.1 Installation

Insert the installation CD into the according drive on your computer. If the auto run 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 detailed software manual on the CD.

12.2 System Requirements

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

12.3 Features

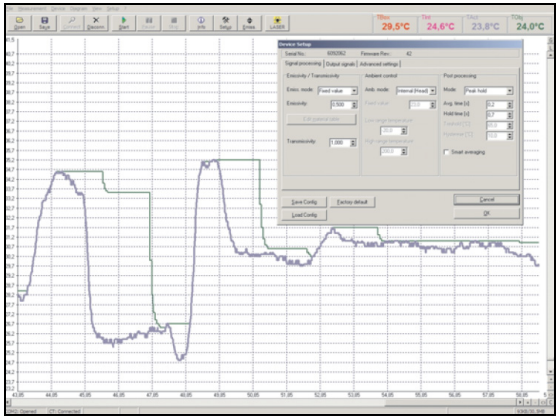


Fig. 12.1: Graphic display

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

13 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
- controller (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.

14 Emissivity

14.1 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.

14.2 Determination of Unknown Emissivity

- ► First of all, determine the current temperature of the measuring object with a thermocouple or contact sensor. The second step is to measure the temperature with the infrared thermometer and modify the emissivity until the displayed result corresponds to the current temperature.
- ► If you monitor temperatures of up to 380 °C you may place a special plastic sticker (Part number: TM-ED-CT emissivity dots) 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.

14.3 Characteristic Emissivity

In the case that 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			
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	0.2-0.5	0.25	0.15	0.15
	Sandblast	0.3-0.4	0.3-0.6	0.3-0.6	0.3-0.6
	Oxidized	0.4-0.9	0.6-0.9	0.6-0.9	0.7-0.95
Iron	Non oxidized	0.35	0.1-0.3	0.05-0.25	0.05-0.2
	Rusted		0.6-0.9	0.5-0.8	0.5-0.7
	Oxidized	0.7-0.9	0.5-0.9	0.6-0.9	0.5-0.9
	Forged, blunt	0.9	0.9	0.9	0.9
	Molten	0.35	0.4-0.6		
Iron, casted	Non oxidized	0.35	0.3	0.25	0.2
	Oxidized	0.9	0.7-0.9	0.65-0.95	0.6-0.95

Material		Typical Emissivity			
Spectral response		1.0 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	0.05-0.3	0.03-0.15	0.02-0.1
Mercury			0.05-0.15	0.05-0.15	0.05-0.15
Molybdenum	Non oxidized	0.25-0.35	0.1-0.3	0.1-0.15	0.1
	Oxidized	0.5-0.9	0.4-0.9	0.3-0.7	0.2-0.6
Monel (Ni-CU)		0.3	0.2-0.6	0.1-0.5	0.1-0.14
Nickel	Electrolytic	0.2-0.4	0.1-0.3	0.1-0.15	0.05-0.15
	Oxidized	0.8-0.9	0.4-0.7	0.3-0.6	0.2-0.5
Platinum	Black		0.95	0.9	0.9
Silver		0.04	0.02	0.02	0.02
Steel	Polished plate	0.35	0.25	0.1	0.1
	Rustless	0.35	0.2-0.9	0.15-0.8	0.1-0.8
	Heavy plate			0.5-0.7	0.4-0.6
	Cold-rolled	0.8-0.9	0.8-0.9	0.8-0.9	0.7-0.9
	Oxidized	0.-8-0.9	0.8-0.9	0.7-0.9	0.7-0.9
Tin	Non oxidized	0.25	0.1-0.3	0.05	0.05
Titanium	Polished	0.5-0.75	0.3-0.5	0.1-0.3	0.05-0.2
	Oxidized		0.6-0.8	0.5-0.7	0.5-0.6
Wolfram	Polished	0.35-0.4	0.1-0.3	0.05-0.25	0.03-0.1
Zinc	Polished	0.5	0.05	0.03	0.02
	Oxidized	0.6	0.15	0.1	0.1

Appendix B – Emissivity Table Non Metals

Material		Typical Emissivity			
Spectral response		1.0 μm	1.6 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		0.4	0.8-0.95	0.8-0.95	0.95
Ceramic		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

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