Infrared Sensor with Laser Aiming

Operators manual

thermoMETER CTL/CTLF/CTLG/CTLM-1/CTLM-2/CTLM-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 CTL series are noncontact infrared temperature sensors.
They calculate the surface temperature based on the emitted infrared energy of objects [► Basics of Infrared Thermometry]. An integrated double laser aiming marks the real measurement spot location and spot size at any distance on the object surface.
The sensor housing of the CTL 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 CTL 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

- CTL sensor with connection cable and controller
- Mounting nut and mounting bracket (fixed)
- 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 CTL, please contact our service department.

1.4 Model Overview

The sensors of the CTL series are available in the following basic versions:

Model	Measurement range	Spectral response	Typical applications
CTL	-50 to 975 °C	8-14 μm	non-metallic surfaces
CTLF	-50 to 975 °C	8-14 μm	fast processes
CTLM-1	485 to 1800 °C	1 μm	metals and ceramic surfaces
CTLM-2	250 to 1600 °C	1.6 μm	metals and ceramic surfaces
CTLM-3	50 to 600 °C	2.3 μm	metals and composite materials
CTLG	100 to 1650 °C	5.2 μm	measurement of glass

On the CTLM-1, CTLM-2, CTLM-3 and CTLG models the whole measurement range is split into two sub ranges (L and H).

	CTL/CTLF	M-1L	M-1H	M-2L	M-2H	M-3L	M-3H	GL	GH
Lower limit temperature range [°C]	0	485	650	250	385	50	100	100	250
Upper limit temperature range [°C]	500	1050	1800	800	1600	375	600	1200	1650
Lower alarm limit [°C] (normally closed)	30	600	800	350	500	100	200	200	3500
Upper alarm limit [°C] (normally open)	100	900	1400	600	1200	300	500	500	900
Lower limit signal output	0 V								
Upper limit signal output	5 V								
Temperature unit	°C								
Ambient temperature compensation	sensor temperature probe (output at OUT-AMB: 0-5 V ► -20–180 °C; not available on 1M and 2M models)								
Baud rate [kBaud]	CTL: 9.6 / M-xL, M-xH: 115/ CTLG: 9.6								
Laser	inactive								

1.5 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 CTLM)
Transmissivity	1.000
Average time (AVG)	0.2 s/ CTLF: 0.1 s/ M-1, M-2, M-3: inactive
Smart Averaging	inactive (CTLF: M1, M2, M3 active)
Peak hold	inactive
Valley hold	inactive

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

2 Technical Data

2.1 General Specifications

	Sensor	Controller
Environmental rating	IP 65 (NEMA-4)	IP 65 (NEMA-4
Ambient temperature [1)]	-20...85 °C	0...85 °C
Storage temperature	-40...85 °C	-40...85 °C
Relative humidity	10...95 %, non condensing	10...95 %, non condensing
Material	stainless steel	die casting zinc
Dimensions	100 mm x 50 mm, M48x1,5	89 mm x 70 mm x 30 mm
Weight	600 g	420 g
Cable length	3 m (Standard), 8 m, 15 m	
Cable diameter	5 mm	
Ambient temperature cable	105 °C max. [High temperature cable (optional): 180 °C]	
Vibration	IEC 68-2-6: 3G, 11 – 200 Hz, any axis	
Shock	IEC 68-2-27: 50G, 11 ms, any axis	
EMC	2004/108/EC	

Tab. 2.1: General specifications

[1)] Laser will turn off automatically at ambient temperatures > 50 °C.

2.2 Electrical Specifications

Power Supply	8–36 VDC
Current draw	max. 160 mA
Aiming laser	635 nm, 1 mW, On/ Off via programming keys or software
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 (L/ LF/ G5)	Sensor temperature [-20...180 °C] as 0–5 V or 0–10 V output or alarm output (Signal source switchable to object temperature or controller temperature if used as alarm output)
Alarm output	Open collector output at Pin AL2 [24 V/ 50 mA]
Output impedances	
mA	max. loop resistance 500 Ω (at 8-36 VDC),
mV	min. 100 KΩ load impedance
Thermocouple	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 [CTL, CTL F]

	CTL	CTLF
Temperature range (scalable)	-50...975 °C	-50...975 °C
Spectral range	8...14 μm	8...14 μm
Optical resolution	75:1	50:1
System accuracy [1) 2)]	±1 °C or ±1 % [3)]	±1.5 °C or ±1.5 % [4)]
Repeatability [1) 2)]	±0.5 °C or ±0,5 % [3)]	±1 °C or ±1 % [4)]
Temperature resolution (NETD)	0.1 °C [3)]	0.5 °C [4)]
Response time (90 % signal)	120 ms	9 ms
Warm-up time	10 min	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	

Tab. 3.1: Measurement specifications [CTL, CTL F]

[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)] at object temperatures ≥20 °C

4 Measurement Specifications [M-1/ M-2 models]

	M-1L	M-1H	M-2L	M-2H
Temperature range (scalable)	485...1050 °C	650...1800 °C	250...800 °C	385...1600 °C
Spectral range	1 µm	1 µm	1.6 µm	1.6 µm
Optical resolution	150:1	300:1	150:1	300:1
System accuracy [1) 2)]	±(0.3 % of reading +2 °C) [3)]			
Repeatability [1)]	±(0.1 % of reading +1 °C) [3)]			
Temperature resolution [3)]	M-xL: 0.1 °C / M-xH: 0.2 °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			

Tab. 4.1: Measurement specifications [M-1/ M-2 models]

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

5 Measurement Specifications [M-3 models]

	M-3L	M-31H
Temperature range (scalable)	50...375 °C	100...600 °C
Spectral range	2.3 µm	2.3 µm
Optical resolution	60:1	100:1
System accuracy [1] [2]	±(0.3 % of reading +2 °C) [3]	
Repeatability [1]	±(0.1 % of reading +1 °C) [3]	
Temperature resolution [3]	0,1 °C [3]	
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	

Tab. 5.1: Measurement specifications [M-3 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 1 s
[4] with dynamic adaptation at low signal levels

6 Measurement Specifications [G models]

	GL	GH
Temperature range (scalable)	100...1200 °C	250...1650 °C
Spectral range	5.2 µm	5.2 µm
Optical resolution	45:1	70:1
Accuracy [1] [2]	±1 °C or ±1 %	±1 °C or ±1 %
Repeatability [1] [2]	±0.5 °C or ±0.5 %	±0.5 °C or ±0.5 %
Temperature resolution (NETD)	0.1 °C	0.2 °C
Response time (90 % signal)	120 ms	80 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	

Tab. 6.1: Measurement specifications [G models]

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

7 Optical Charts

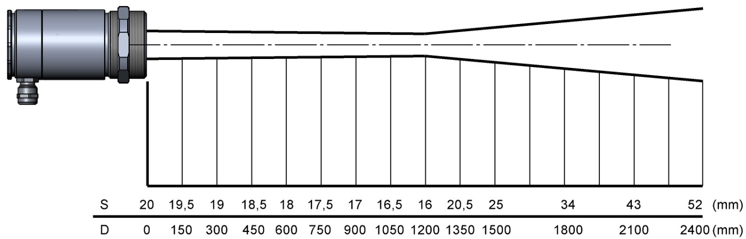
The following optical charts show the diameter of the measuring spot in dependence on the distance between measuring object and sensor. The spot size refers to 90 % of the radiation energy.
The distance is always measured from the front edge of the sensor.

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.

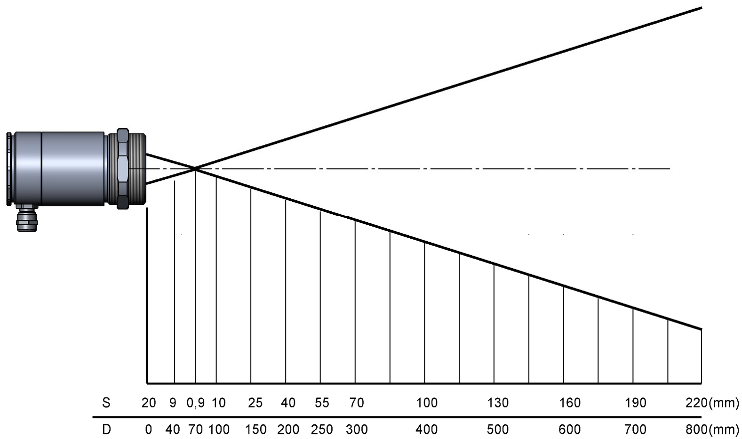
D = Distance from front of the sensor to the object
S = Spot size

Optical Charts

CTL
Optik: SF
D:S (Focus distance) = 75:1
16 mm @ 1200 mm
D:S (Far field) = 34:1

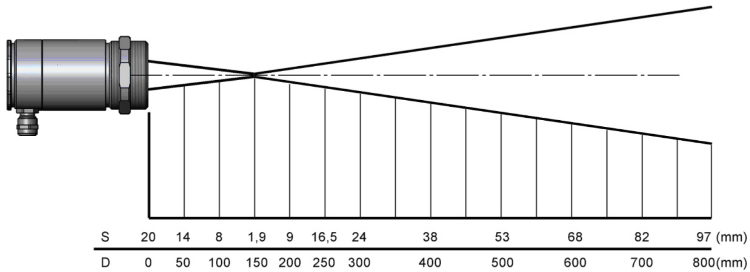


CTL
Optik: CF1
D:S (Focus distance) = 75:1
0.9 mm @ 70 mm
D:S (Far field) = 3,5:1

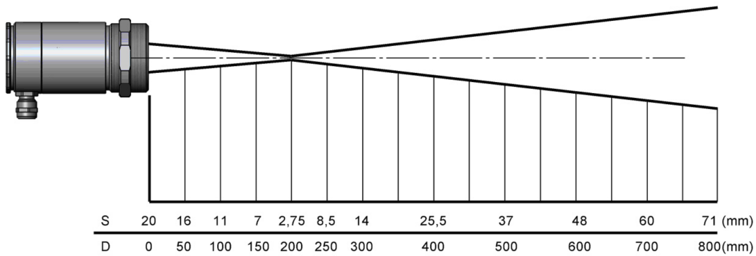


Optical Charts

CTL
Optik: CF2
D:S (Focus distance) = 75:1
1.9 mm @ 150 mm
D:S (Far field) = 7:1

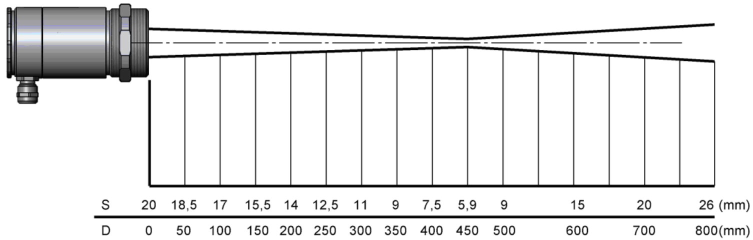


CTL
Optik: CF3
D:S (Focus distance) = 75:1
2.75 mm @ 200 mm
D:S (Far field) = 9:1

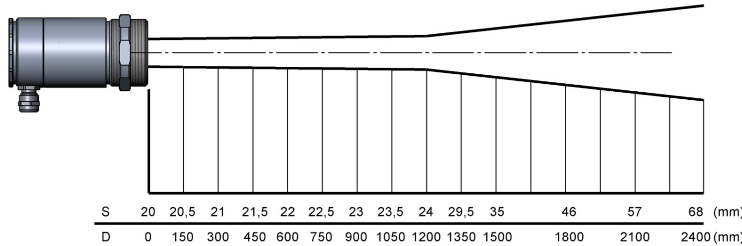


Optical Charts

CTL
Optik: CF4
D:S (Focus distance) = 75:1
5.9 mm @ 450 mm
D:S (Far field) = 18:1

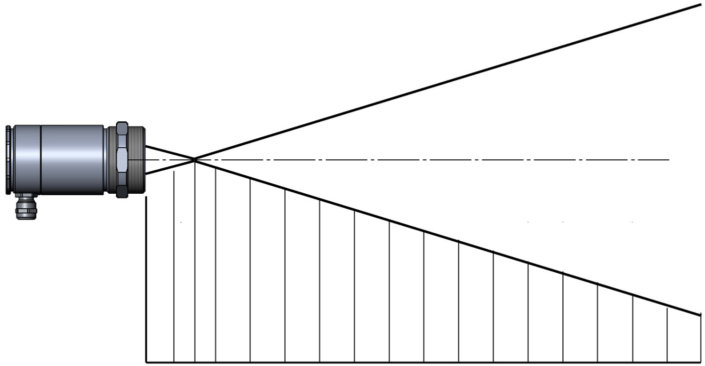


CTLF
Optik: SF
D:S (Focus distance) = 50:1
24 mm @ 1200 mm
D:S (Far field) = 20:1



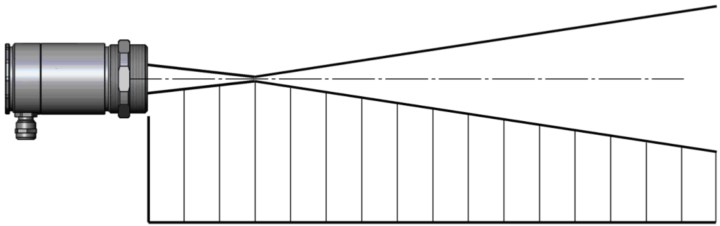
Optical Charts

CTLF
Optik: CF1
D:S (Focus distance) = 50:1
1.4 mm @ 70 mm
D:S (Far field) = 1,5:1



S	20	10	1,4	11	26	41	57	72	103	133	164	194	225(mm)
D	0	40	70	100	150	200	250	300	400	500	600	700	800(mm)

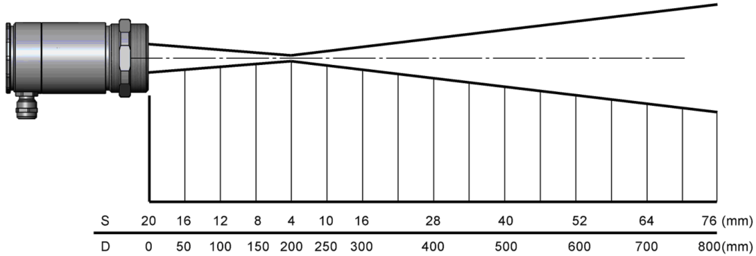
CTLF
Optik: CF2
D:S (Focus distance) = 50:1
3 mm @ 150 mm
D:S (Far field) = 6:1



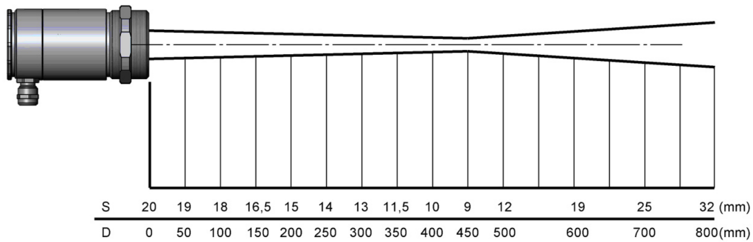
S	20	15	9	3	11	19	26	42	57	72	88	103(mm)
D	0	50	100	150	200	250	300	400	500	600	700	800(mm)

Optical Charts

CTLF
Optik: CF3
D:S (Focus distance) = 50:1
4 mm @ 200 mm
D:S (Far field) = 8:1



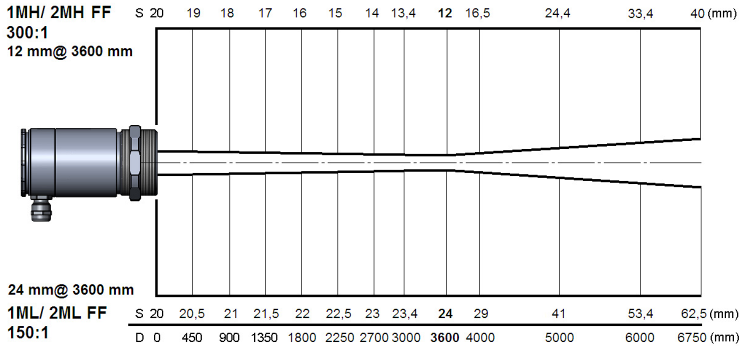
CTLF
Optik: CF4
D:S (Focus distance) = 50:1
9 mm @ 450 mm
D:S (Far field) = 16:1



Optical Charts

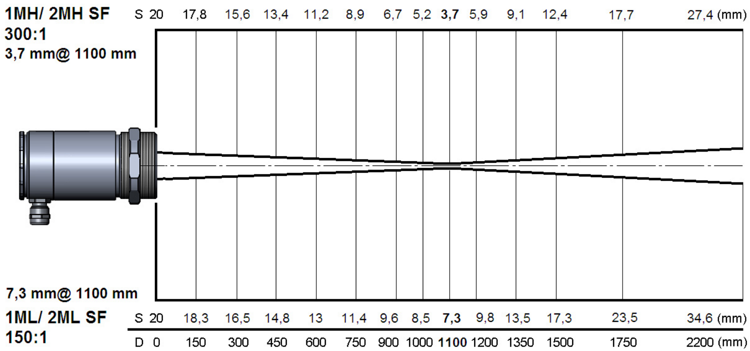
M-1H/ M-2H
Optik: FF
D:S (Focus distance) = 300:1
12 mm @ 3600 mm
D:S (Far field) = 115:1

M-1L/ M-2L
Optik: FF
D:S (Focus distance) = 150:1
24 mm @ 3600 mm
D:S (Far field) = 84:1



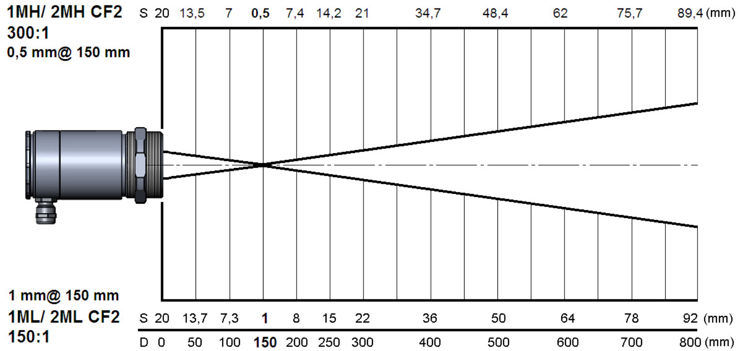
M-1H/ M-2H
Optik: SF
D:S (Focus distance) = 300:1
3.7 mm @1100 mm
D:S (Far field) = 48:1

M-1L/ M-2L
Optik: SF
D:S (Focus distance) = 150:1
7.3 mm @ 1100 mm
D:S (Far field) = 42:1



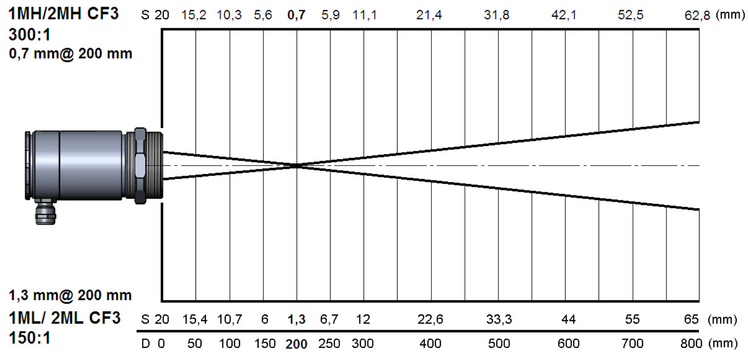
M-1H/ M-2H
Optik: CF2
D:S (Focus distance) = 300:1
0.5 mm @ 150 mm
D:S (Far field) = 7,5:1

M-1L/ M-2L
Optik: CF2
D:S (Focus distance) = 150:1
1 mm @ 150 mm
D:S (Far field) = 7:1



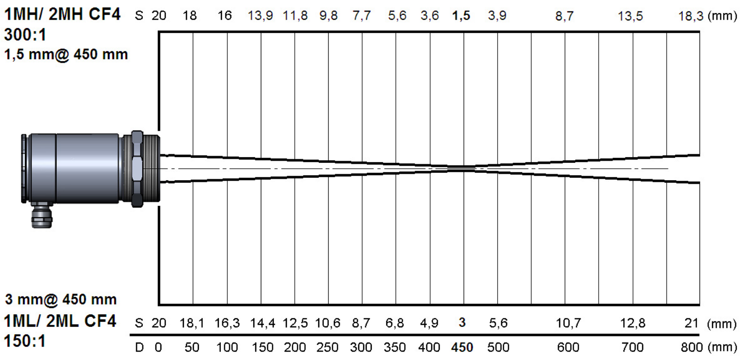
M-1H/ M-2H
Optik: CF3
D:S (Focus distance) = 300:1
0.7 mm @ 200 mm
D:S (Far field) = 10:1

M-1L/ M-2L
Optik: CF3
D:S (Focus distance) = 150:1
1.3 mm @ 200 mm
D:S (Far field) = 10:1



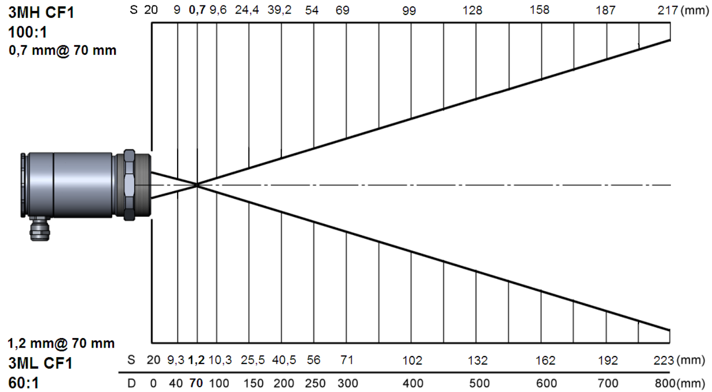
M-1H/ M-2H
Optik: CF4
D:S (Focus distance) = 300:1
1.5 mm @ 450 mm
D:S (Far field) = 22:1

M-1L/ M-2L
Optik: CF4
D:S (Focus distance) = 150:1
3 mm @ 450 mm
D:S (Far field) = 20:1



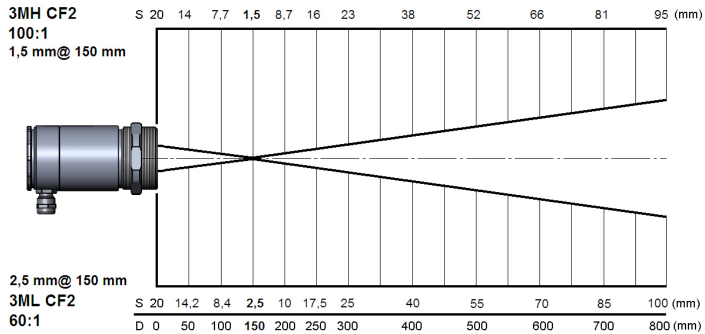
M-3H
Optik: CF1
D:S (Focus distance) = 100:1
0.7 mm @ 70 mm
D:S (Far field) = 3:1

M-3L
Optik: CF1
D:S (Focus distance) = 60:1
1.2 mm @ 70 mm
D:S (Far field) = 3:1



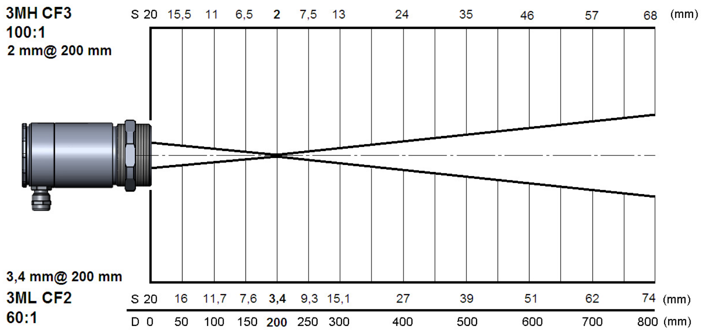
M-3H
Optik: CF2
D:S (Focus distance) = 100:1
1.5 mm @ 150 mm
D:S (Far field) = 7:1

M-3L
Optik CF2
D:S (Focus distance) = 60:1
2.5 mm @ 150 mm
D:S (Far field) = 6:1



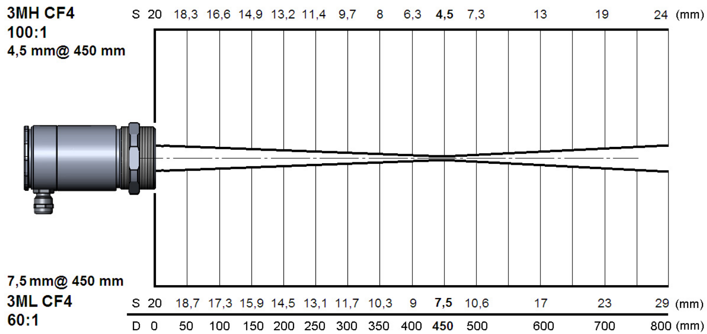
M-3H
Optik: CF3
D:S (Focus distance) = 100:1
2 mm @ 200 mm
D:S (Far field) = 9:1

M-3L
Optik: CF3
D:S (Focus distance) = 60:1
3.4 mm @ 200mm
D:S (Far field) = 8:1



M-3H
Optik: CF4
D:S (Focus distance) = 100:1
4.5 mm @ 450 mm
D:S (Far field) = 19:1

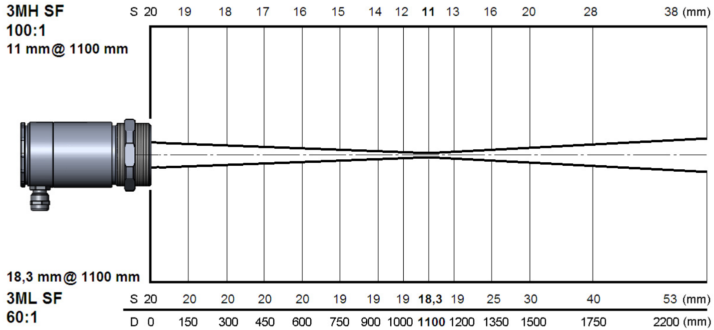
M-3L
Optik: CF4
D:S (Focus distance) = 60:1
7.5 mm @ 450 mm
D:S (Far field) = 17:1



Optical Charts

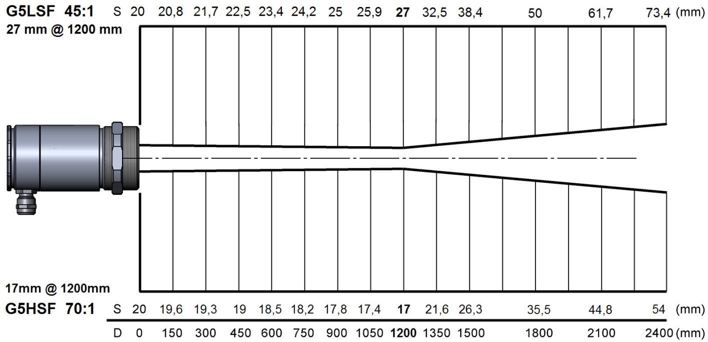
M-3H
Optik: SF
D:S (Focus distance) = 100:1
11 mm @ 1100 mm
D:S (Far field) = 38:1

M-3L
Optik: SF
D:S (Focus distance) = 60:1
8.3 mm @ 1100 mm
D:S (Far field) = 30:1



GL
Optik: SF
D:S (Focus distance) = 45:1
27 mm @ 1200 mm
D:S (Far field) = 25:1

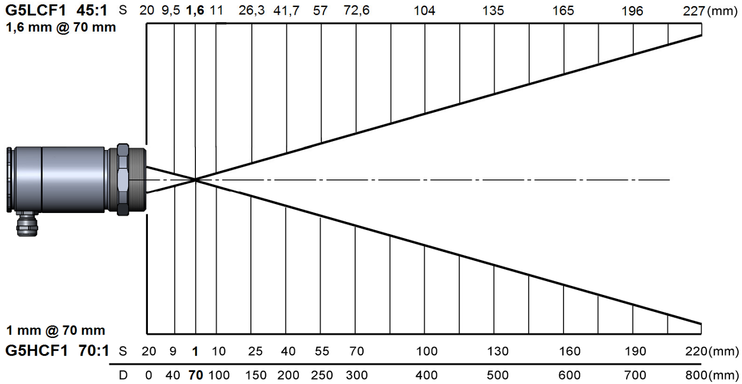
GH
Optik: SF
D:S (Focus distance) = 70:1
17 mm @ 1200 mm
D:S (Far field) = 33:1



Optical Charts

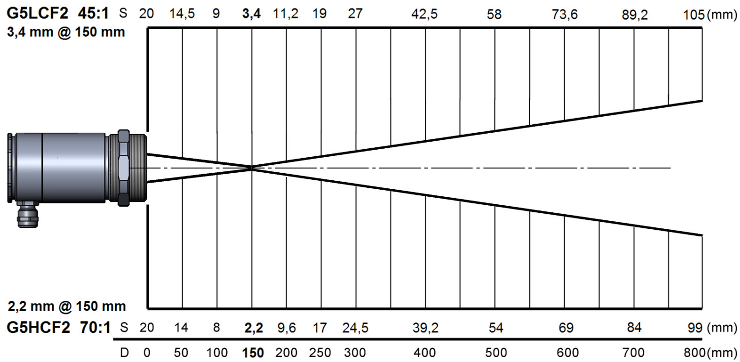
GL
Optik: CF1
D:S (Focus distance) = 45:1
1.6 mm @ 70 mm
D:S (Far field) = 3:1

GH
Optik: CF1
D:S (Focus distance) = 70:1
1 mm @ 70 mm
D:S (Far field) = 3.4:1



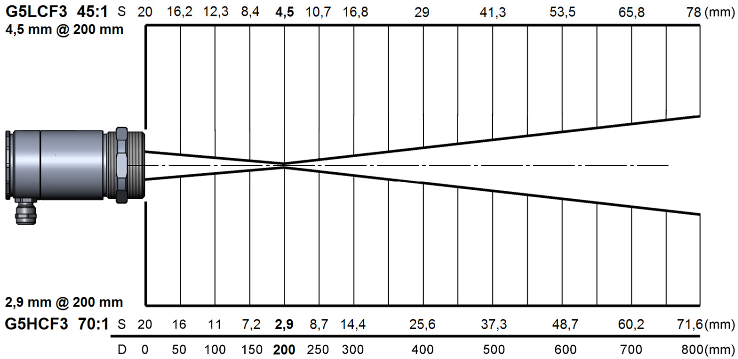
GL
Optik: CF2
D:S (Focus distance) = 45:1
3.4 mm @ 150 mm
D:S (Far field) = 6:1

GH
Optik: CF2
D:S (Focus distance) = 70:1
2.2 mm @ 150 mm
D:S (Far field) = 6.8:1



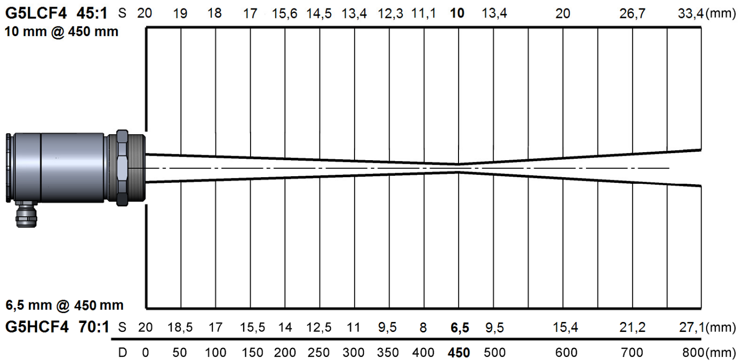
GL
Optik: CF3
D:S (Focus distance) = 45:1
4.5 mm @ 200 mm
D:S (Far field) = 8:1

GH
Optik: CF3
D:S (Focus distance) = 70:1
2.9 mm @ 200 mm
D:S (Far field) = 9.2:1



GL
Optik: CF4
D:S (Focus distance) = 45:1
10 mm @ 450 mm
D:S (Far field) = 15:1

GH
Optik: CF4
D:S (Focus distance) = 70:1
6.5 mm @ 450 mm
D:S (Far field) = 17.7:1



8 Mechanical Installation

The CTL is equipped with a metric M48x1.5 thread and can be installed either directly via the sensor thread or with help of the supplied mounting nut (standard) and fixed mounting bracket (standard) to a mounting device available.

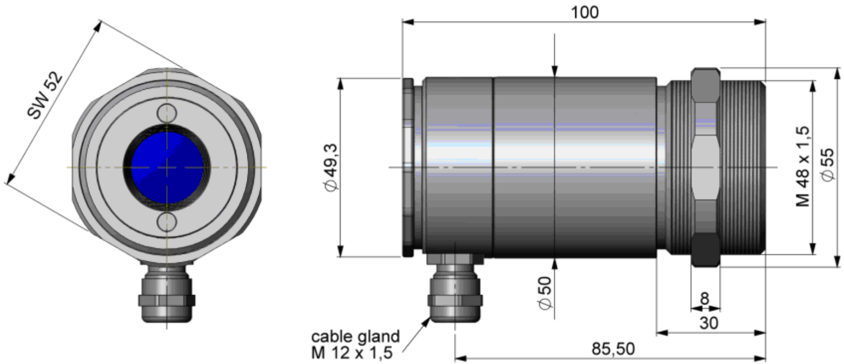


Fig. 8.1: CTL sensor

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

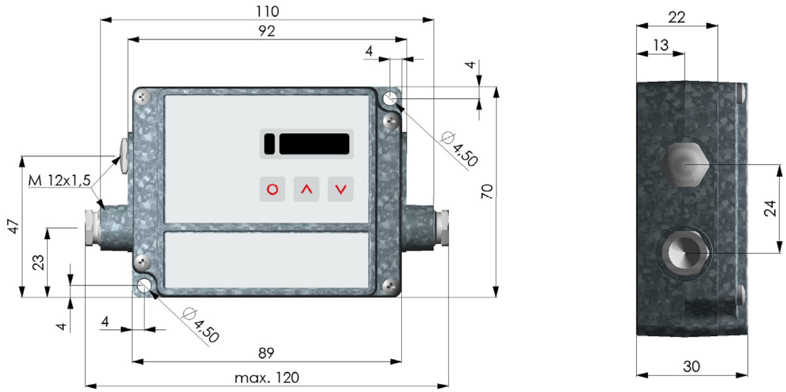


Fig. 8.2: Controller

For an exact alignment of the head to the object, please activate the integrated double laser. [► Operating/ Laser sighting]

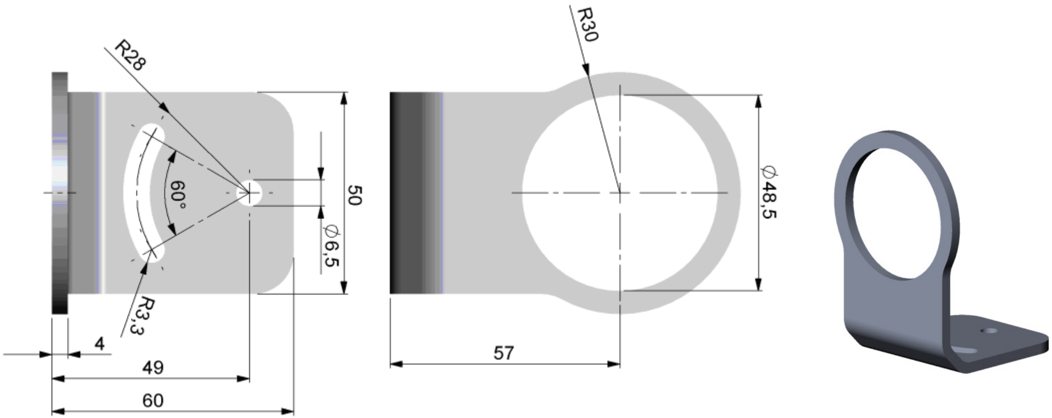


Fig. 8.3: Mounting bracket, fixed – standard scope of supply

9 Mounting Accessories

9.1 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.

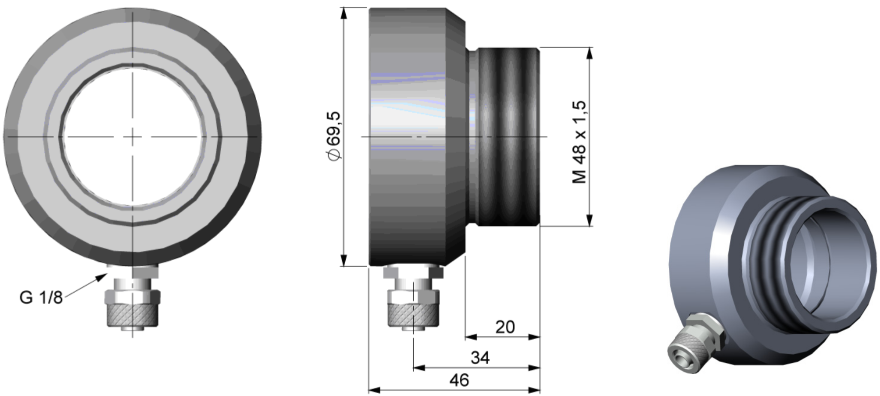


Fig. 9.1: Air purge collar [TM-AP-CTL]

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

9.2 Mounting Bracket

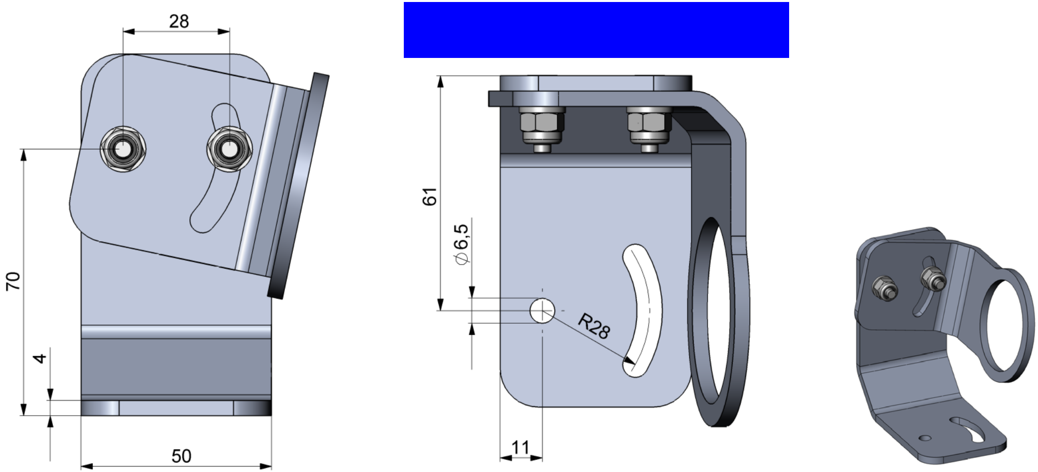


Fig. 9.2: Mounting bracket, adjustable [TM-AB-CTL]

The adjustable mounting bracket allows an adjustment of the sensor in two axis.

9.3 Water Cooled Housing

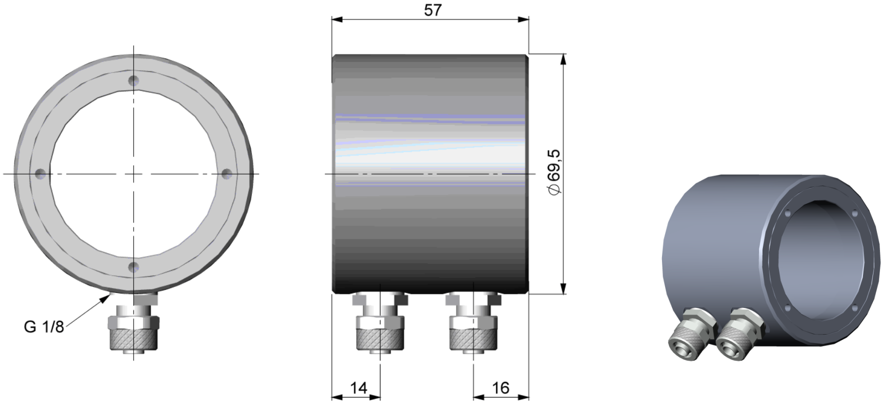


Fig. 9.3: Water cooled housing [TM-W-CTL]

To avoid condensation on the optics an air purge collar is recommended.

The sensor can be used at ambient temperatures up to 85 °C without cooling. For applications, where the ambient temperature can reach higher values, the usage of the optional water cooled housing is recommended (operating temperature up to 175 °C). The sensor should be equipped with the optional high temperature cable (operating temperature up to 180 °C).

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

10 Electrical Installation

10.1 Cable Connections

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

Designation [models CTL/ CTLF/ G]		Designation [models M]	
+8..36 VDC	Power supply	+8..36 VDC	Power supply
GND	Ground (0 V) of power supply	GND	Ground (0 V) of power supply
GND	Ground (0 V) of internal in- and outputs	GND	Ground (0 V) of internal in- and outputs
OUT-AMB	Analog output sensor temperature (mV)	AL2	Alarm 2 (Open collector output)
OUT-TC	Analog output thermocouple (J or K)	OUT-TC	Analog output thermocouple (J or K)
OUT-mV/mA	Analog output object temperature (mV or mA)	OUT-mV/mA	Analog output object temperature (mV or mA)
F1-F3	Functional inputs	F1-F3	Functional inputs
AL2	Alarm 2 (Open collector output)	GND	Ground (0 V)
3V SW	PINK/ Power supply Laser (+)	LASER	PINK/ Power supply Laser (+)
GND	GREY/ Ground Laser (–)	GND	GREY/ Ground Laser (–)
BROWN	Temperature probe sensor	PWR	GREEN/ Sensor power
WHITE	Temperature probe sensor	GND	WHITE/ Sensor ground
GREEN	Detector signal (–)	NTC	BROWN/ Temperature probe sensor (NTC)
YELLOW	Detector signal (+)	VV	YELLOW/ Detector signal

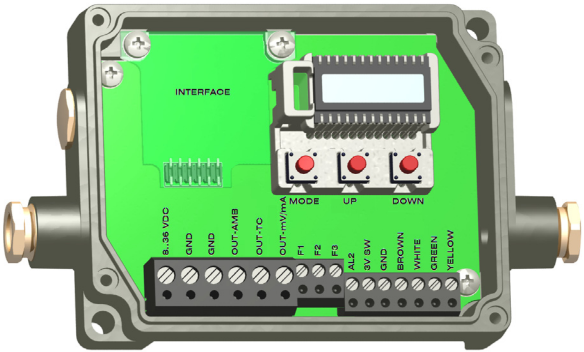


Fig. 10.1: Opened electronic box with terminal connections

10.2 Power Supply

Please use a power supply unit with an output voltage of 8–36 VDC which can supply 160 mA.

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

10.3 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.

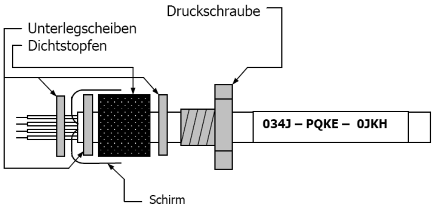


Fig. 10.2: Cable Assembling

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

10.4 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 this, 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.

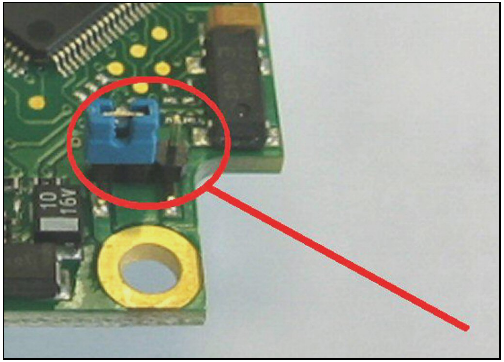


Fig. 10.3: Connector (Jumper)

10.5 Exchange of the Sensor

From factory side the sensor has already been connected to the controller. Inside the model group CTL and inside the model group G an exchange of sensors and controllers is possible.
The sensors and controllers of the models CTLF, M-1L, M-1H, M-2L, M-2H, M-3L, and M-3 H cannot be exchanged.

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

10.5.1 Entering of the Calibration Code

Every sensor has a specific calibration code, which is printed on the sensor. For a correct temperature measurement and functionality of the sensor this calibration code must be stored into the controller.
The calibration code consists of five blocks with 4 characters each.

Example: **EKJ0 – 0OUD – 0A1B – A17U – 93OZ**
block1 block2 block3 block4 block5

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.

Fig. 10.4: Calibration Code

You will find the calibration code on a label fixed on the sensor. Please do not remove this label or make sure the code is noted anywhere. The code is needed if the sensor has to be exchanged.

10.5.2 Exchange of the Sensor Cable

The sensor cable can also be exchanged if necessary. For a dismantling on the sensor side, please open at first the cover plate on the back side of the sensor. Then please remove the terminal block and loose the connections. After the new cable has been installed, please do the same steps in reverse order. Please take care the cable shield is properly connected to the sensor housing.

As exchange cable a cable type with same wire profiles and specification should be used to avoid influences on the accuracy.

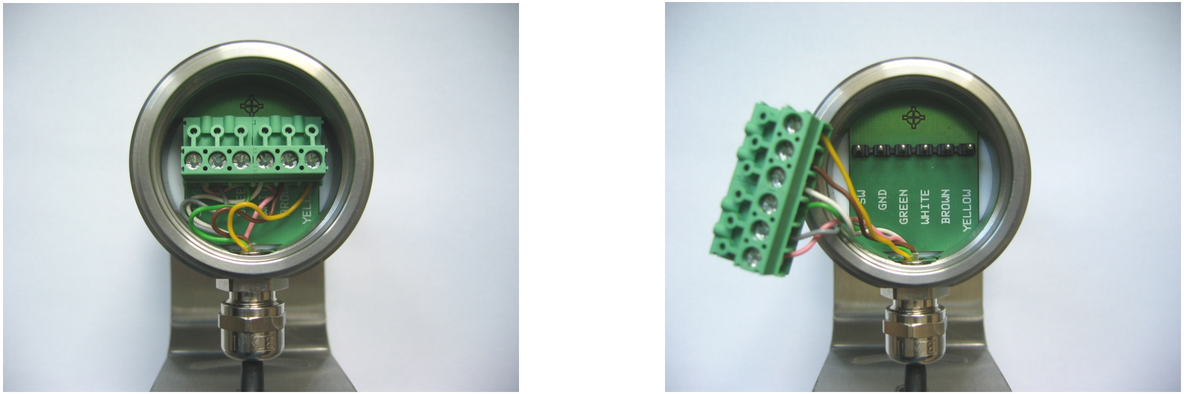


Fig. 10.5: View on terminal block with sensor cables

11 Outputs and Inputs

11.1 Analog Outputs

The CTL has two analog output channels.

11.1.1 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 software allows the programming of output channel 1 as an alarm output.

Output signal	Range	Connection pin on CTL 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 there are different connection pins on the main board (**OUT-mV/mA** or **OUT-TC**).

11.1.2 Output Channel 2 [only for CTL, CTLF, G]

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 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.

11.2 Digital Interfaces

The controller 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 controller. 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.

The Ethernet interface requires at minimum 12 V supply voltage.
Please pay attention to the notes on the according interface manuals.

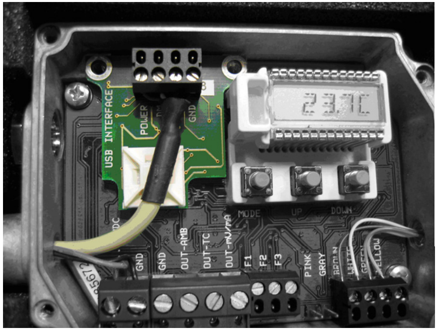


Fig. 11.1: CTL controller with Interface board

11.2.1 USB Interface Kit

11.2.1.1 Scope of Supply

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

11.2.1.2 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 controller. Now press the PCB downwards and fix it using both M3x5 screws. Exchange the blind screw on the controller 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 CTL 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 functionality of the CTL.

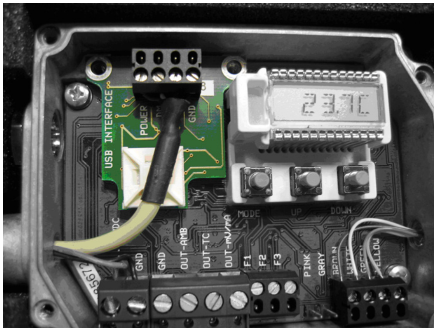


Fig. 11.2: CTL controller with USB Interface

11.2.2 RS232 Interface Kit

11.2.2.1 Scope of Supply

1 pcs.	Package	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

11.2.2.2 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 controller. Now press the RS232 interface down to connect it with the CTL.
- 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 CTL always needs an external power supply for operation.
Please install the software CTL 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 CTL unit (factory default: 9.6 kBaud).

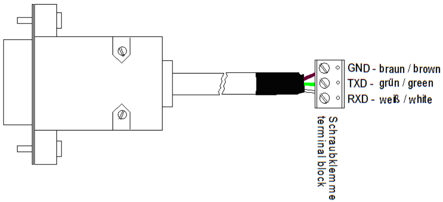


Fig. 11.3: Correct wiring

11.2.3 RS485 Interface Kit

11.2.3.1 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	3 pcs.	Terminal block on the board

11.2.3.2 Installation

- Please connect the RS485-USB-adapter 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 controller.
- Now press the RS485-interface down to connect it with the CTL. Use both M3x5 screws for fixing the board.
- The RS485-USB-adapter TM-RS485USBK-CTL 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 CTL and from there to terminal A of the next CTL and so on (Fig. 2). 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 CTL units on one RS485-USB-adapter. The 120R-switch is to be turned to ON at one of the connected CTL units, only.
- Each CTL unit connected to the RS485 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 CTL connect software. The setting for baud rate in the software must be the same as on the CTL unit (factory default: 9.6 kBaud).

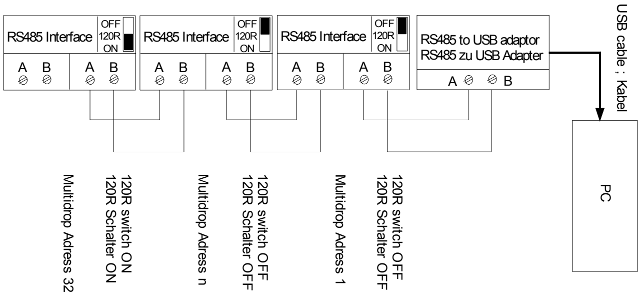
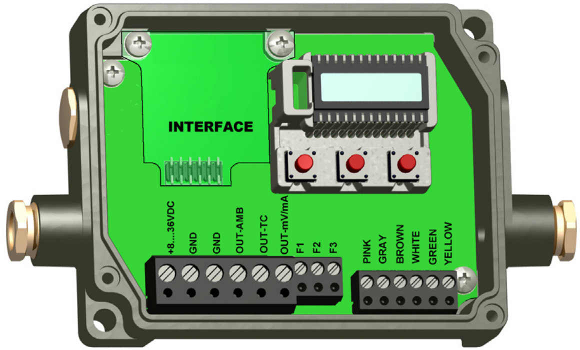


Fig. 11.4: Correct wiring

11.2.4 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

11.2.5 Profibus-Accessory-Kit

11.2.5.1 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.	Screws M3x5
1 pcs.	Profibus-interface cable preassembled		

11.2.5.2 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 (Fig. 2).

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.

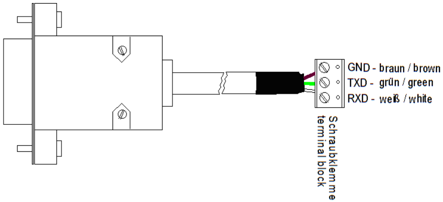
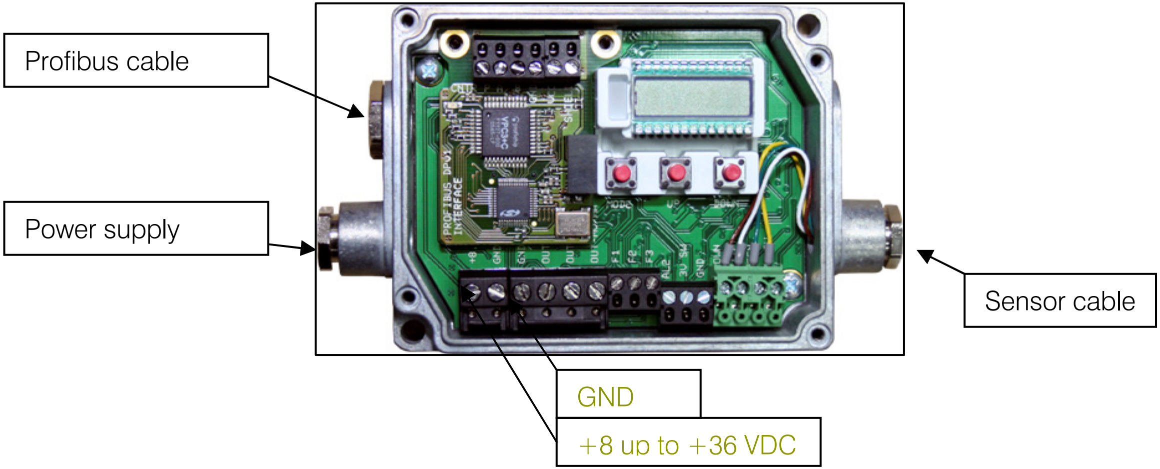


Fig. 11.5: Correct wiring

11.2.5.3 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 SUB-D 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 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 page 8 up to 31.

11.2.6 Ethernet-interface

11.2.6.1 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

11.2.6.2 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 the case that 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.

11.2.6.3 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:

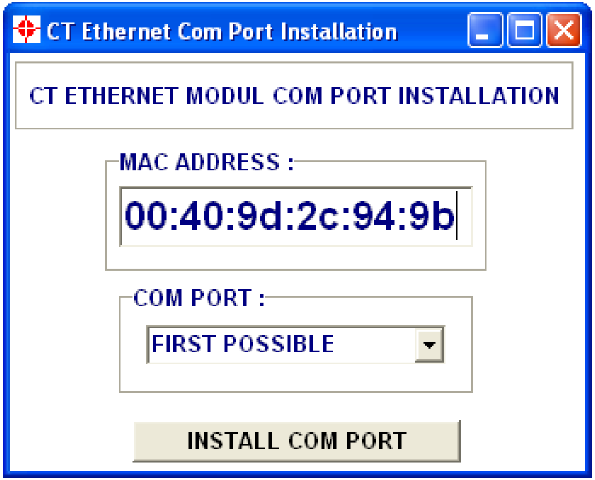
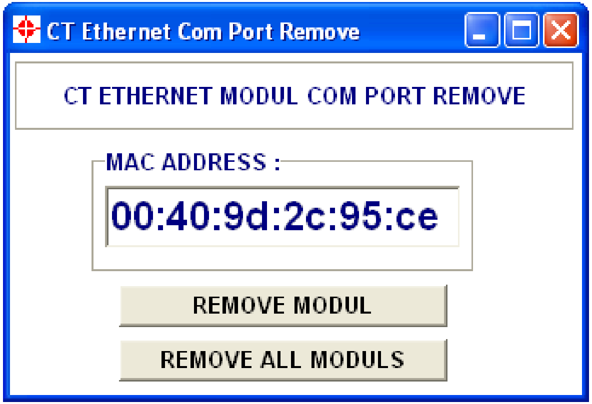


Fig. 11.6: CT Ethernet Com Port Installation

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.

11.2.6.4 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.
The following dialog appears:



The dialog allows you 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.

11.3 Relay Outputs

The CTL 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 alarm values are set according to the ► Factory Default Settings. 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 a digital interface (USB, RS232) and the software is needed.

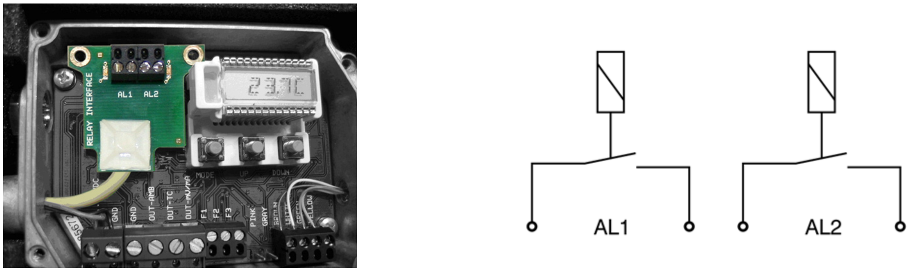


Fig. 11.7: Relais Interface with correct wiring

11.4 Functional Inputs

The three functional inputs F1 – F3 can be programmed with the 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 represents
F1 = high / F2, F3 = low
High-level: ≥ +3 V…+36 V
Low-level: ≤ +0.4 V…–36 V

11.5 Alarms

The CTL has the following Alarm features:

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

11.5.6 Output Channel 1 and 2

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

11.5.7 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 [24V/ 50mA].

From factory side the alarms are defined as follows:

Alarm 1	Norm. closed/ Low-Alarm
Alarm 2	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 is needed.

12 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].

12.1 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).

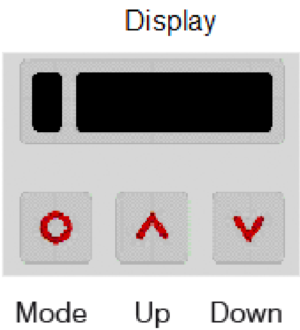


Fig. 12.1: Display and programming keys

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

12.2 Set Factory Defaults

Factory Default Setting: To set the CTL 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
S ON	Laser Sighting [ON]	ON/ OFF
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]	-40.0 … 975.0 °C
|| 100.0	Upper alarm limit [100 °C]	-40.0 … 975.0 °C
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

12.3 Emissivity, Statistic, Prescriptive Limits

S ON Activating (ON) and Deactivating (OFF) of the Sighting Laser. By pressing Up or Down the laser can be switched on and off.

□ MV5 Selection of the Output signal. By pressing Up or Down the different output signals can be selected (see table).

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].

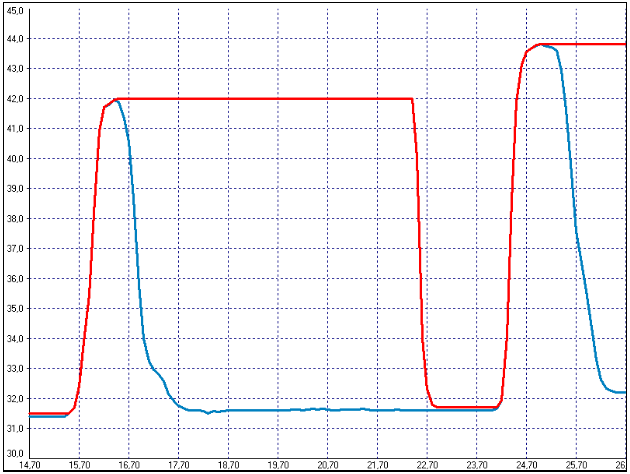
T1.000 Setup of Transmissivity. This function is used if an optical component (protective window, additional optics e.g.) is mounted between sensor and object. The standard setting is 1.000 = 100 % (if no protective window etc. is used).

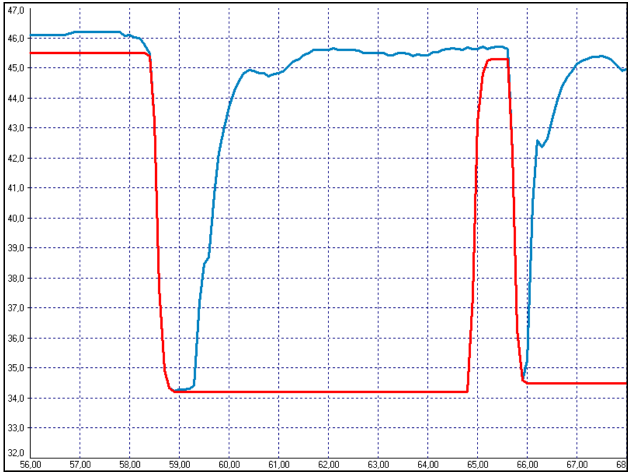
A 0.2 Setup of Average time. If the value is set to 0.0 the display will show --- (function deactivated). In this mode an arithmetic algorithm will be performed to smoothen the signal. The set time is the time constant. This function can be combined with all other post processing functions.

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 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.

12.4 Digital Command Set

The digital communication of the CTL sensors is based on a binary protocol.
You will find a protocol and command description on the software CD in the directory: \Commands.

12.5 Laser Sighting

The CTL has an integrated double laser aiming. Both of the laser beams are marking the exactly location and size of the measurement spot, independent from the distance. At the focus point of the according optics [► Optical Charts] both lasers are crossing and showing as one dot the minimum spot. This enables a perfect alignment of the sensor to the object.

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!

The laser can be activated/ deactivated via the programming keys on the unit or via the software. If the laser is activated a yellow LED will shine (beside temperature display).
At ambient temperatures >50 °C the laser will switch off automatically.

12.6 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

13 Software

13.1 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.
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.

13.2 System Requirements

- Windows XP 2000
- USB interface
- CD-ROM drive
- Al least 128 MByte RAM
- Hard disc with at least 30 MByte free space

13.3 Features

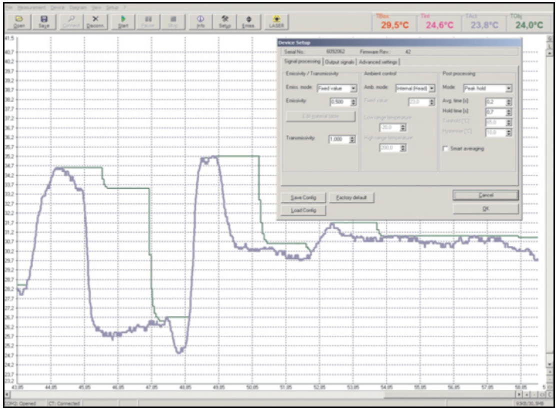


Fig. 13.1: Graphic display

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

14 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 controller transforms the emitted infrared radiation into electrical signals.

15 Emissivity

15.1 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.

15.2 Determination of Unknown Emissivity

- ► 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.

15.3 Characteristic Emissivity

In case none of the methods mentioned above help to determine the emissivity you may use the emissivity table's ►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

Appendix A – Emissivity Table Metals

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

Appendix B – Emissivity Table Non Metals

Material		Typical Emissivity			
Spectral response		1.0 μm	1.6 μm	5.1 μm	8-14 μm
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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