

Infrared - measuring transducer IR-CT 20 LT/ 1M/ 2M/ 3M/ G5

Infrared Sensor



Operators manual

CE-Conformity

The product complies with the following standards:

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



The product accomplishes the requirements of the EMC Directive 89/336/EEC and of the low-voltage directive 73/23/EEC.

Read the manual carefully before the initial start-up. The producer reserves the right to change the herein described specifications in case of technical advance of the product. References to other chapters are marked as [► ...].

Warranty

Each single product passes through a quality process. Nevertheless, if failures occur please contact the customer service at once. The warranty period covers 24 months starting on the delivery date. After the warranty is expired the manufacturer guarantees additional 6 months warranty for all repaired or substituted product components. Warranty does not apply to damages, which result from misuse or neglect. The warranty also expires if you open the product. The manufacturer is not liable for consequential damage. If a failure occurs during the warranty period the product will be replaced, calibrated or repaired without further charges. The freight costs will be paid by the sender. The manufacturer reserves the right to exchange components of the product instead of repairing it. If the failure results from misuse or neglect the user has to pay for the repair. In that case you may ask for a cost estimate beforehand.

Content

	Page		Page
Description	3	Outputs and Inputs	39
Scope of Supply	3	Analog Outputs	39
Maintenance	3	Digital Interfaces	40
Cautions	4	Relay Outputs	40
Model Overview	4	Functional Inputs	41
Factory Default Settings	5	Alarms	42
Technical Data	6	Operating	43
General Specifications	6	Sensor Setup	43
Electrical Specifications	7	Error messages	48
Measurement Specifications [LT models]	8	Software CompactConnect	49
Measurement Specifications [CTfast/ CThot]	9	Installation	49
Measurement Specifications [1M/ 2M models]	10	Communication Settings	50
Measurement Specifications [3M/ G5 models]	11	Basics of Infrared Thermometry	52
Optical Charts	12	Emissivity	53
CF Lens and Protective Window	19	Definition	53
Mechanical Installation	23	Determination of unknown Emissivities	53
Mounting Accessories	25	Characteristic Emissivities	54
Air Purge Collars	26	Appendix A – Emissivity Table Metals	55
Further Accessories	28	Appendix B – Emissivity Table Non Metals	57
Electrical Installation	33		
Cable Connections	33		
Ground Connection	36		
Exchange of the Sensing Head	37		

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 head is made of stainless steel (IP65/ NEMA-4 rating) – the sensor electronics is placed in a separate box made of die casting zinc.

The CT sensing head is a sensitive optical system. Please use only the thread for mechanical installation.

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

Scope of Supply

- CT sensing head with connection cable and electronic box
- Mounting nut
- Operators manual

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).

Cautions

Avoid static electricity. Sensors of the LT and G5 series should not be used close to arc welders, induction heaters or 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.

Model Overview

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

Model	Model codes	Measurement range	spectral response	typical applications
CT LT	LT02/ LT15/ LT20	-50 to 975 °C	8-14 μm	non-metallic surfaces
CT fast	LT10F	-50 to 975 °C	8-14 μm	fast processes
CT hot	LT02H/ LT10H	-40 to 975 °C	8-14 μm	high ambient temperatures (up to 250 °C)
CT 1M	1ML/ 1MH	485 to 1800 °C	1 μm	metals and ceramic surfaces
CT 2M	2ML/ 2MH	250 to 1600 °C	1 μm	metals and ceramic surfaces
CT 3M	3ML/ 3MH	50 to 600 °C	2,3 μm	metals at low object temperatures (from 50 °C)
CT G5	G5L/ G5H	100 to 1650 °C	5,2 μm	measurement of glass

In the following chapters of this manual you will find only the short model codes.

On the 1M, 2M, 3M and G5 models the whole measurement range is split into two sub ranges (L and H).

Factory Default Settings

The unit has the following presetting at time of delivery:

Signal output object temperature	0-5 V
Emissivity	0,970 [LT/ G5] 1,000 [1M/ 2M/ 3M]
Transmissivity	1,000
Averaging (AVG)	0,2 s/ LT10F: 0,1 s inactive [1M/ 2M/ 3M]
Smart Averaging	inactive/ LT10F, 1M, 2M, 3M: active
Peak hold	inactive
Valley hold	inactive

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

	<u>LT</u>	<u>1ML</u>	<u>1MH</u>	<u>2ML</u>	<u>2MH</u>	<u>3ML</u>	<u>3MH</u>	<u>G5L</u>	<u>G5H</u>
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	350
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 (on LT and G5 output at OUT-AMB as 0-5 V signal)	internal head temperature probe								
Baud rate [kBaud]	9,6	115	115	115	115	115	115	9,6	9,6

Technical Data

General Specifications

	Sensing head	Electronic box
Environmental rating	IP65 (NEMA-4)	IP65 (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 CThot	55 mm x 29,5 mm, M18x1 (with massive housing)	
Weight	40 g	420 g
Weight CThot	205 g (with massive housing)	
Cable length	1 m (only LT02, LT15, LT22, LT10F), 3 m, 8 m, 15 m	
Cable diameter	2,8 mm	
Ambient temperature cable	180 °C max. [High temperature cable for CThot: 250 °C]	
Vibration	IEC 68-2-6: 3G, 11 – 200Hz, any axis	
Shock	IEC 68-2-27: 50G, 11ms, any axis	
EMI	89/336/EWG	
Software (optional)	CompactConnect	

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 [LT/ G5 only]	Head temperature [-20...180 °C/ -20...250 °C on LT02H and LT10H] 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 at Pin AL2 [24 V/ 50 mA]
Output impedances	
mA	max. loop resistance 500 Ω (at 8-36 VDC),
mV	min. 100 K Ω 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)

Measurement Specifications [LT models]

	LT02	LT15	LT22
Temperature range (scalable)	-50...600 °C	-50...600 °C	-50...975 °C
Ambient temperature (head)	-20...130 °C	-20...180 °C	-20...180 °C
Storage temperature (head)	-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)}	$\pm 1^\circ\text{C}$ or $\pm 1\%$ ³⁾	$\pm 1^\circ\text{C}$ or $\pm 1\%$ ³⁾	$\pm 1^\circ\text{C}$ or $\pm 1\%$ ³⁾
Repeatability ¹⁾	$\pm 0,5^\circ\text{C}$ or $\pm 0,5\%$ ³⁾	$\pm 0,5^\circ\text{C}$ or $\pm 0,5\%$ ³⁾	$\pm 0,5^\circ\text{C}$ or $\pm 0,5\%$ ³⁾
Temperature resolution (NETD)	0,1 °C ³⁾	0,1 °C ³⁾	0,1 °C ³⁾
Response time (95 % signal)	150 ms	150 ms	150 ms
Warm-up time	10 min	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)		

¹⁾ at ambient temperature $23\pm 5^\circ\text{C}$; whichever is greater

²⁾ Accuracy for thermocouple output: $\pm 2,5^\circ\text{C}$ or $\pm 1\%$

³⁾ at object temperatures $> 0^\circ\text{C}$

On the LT02 models the head cable must not be moved during the measurement.

Measurement Specifications [CTfast/ CThot]

	LT10F	LT02H	LT10H
Temperature range (scalable)	-50...975 °C	-40...975 °C	-40...975 °C
Ambient temperature (head)	-20...120 °C	-20...250 °C	-20...250 °C
Storage temperature (head)	-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)}	$\pm 2^\circ\text{C}$ or $\pm 1\%$ ³⁾	$\pm 1,5^\circ\text{C}$ or $\pm 1\%$ ³⁾	$\pm 1,5^\circ\text{C}$ or $\pm 1\%$ ³⁾
Repeatability ¹⁾	$\pm 0,75^\circ\text{C}$ or $\pm 0,75\%$ ³⁾	$\pm 0,5^\circ\text{C}$ or $\pm 0,5\%$ ³⁾	$\pm 0,5^\circ\text{C}$ or $\pm 0,5\%$ ³⁾
Temperature resolution (NETD)	0,5 °C ³⁾	0,25 °C ³⁾	0,25 °C ³⁾
Response time (90 % signal)	9 ms	100 ms	100 ms
Warm-up time	10 min	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)		

¹⁾ at ambient temperature $23\pm 5^\circ\text{C}$; whichever is greater

²⁾ Accuracy for thermocouple output: $\pm 2,5^\circ\text{C}$ or $\pm 1\%$

³⁾ at object temperatures $\geq 20^\circ\text{C}$

On the CThot models [LT02H/ LT10H] the head cable must not be moved during the measurement.

Measurement Specifications [1M/ 2M models]

	1ML	1MH	2ML	2MH
Temperature range (scalable)	485...1050 °C	650...1800 °C	250...800 °C	385...1600 °C
Ambient temperature (head)	-20...100 °C	-20...100 °C	-20...125 °C	-20...125 °C
Storage temperature (head)	-40...100 °C	-40...100 °C	-40...125 °C	-40...125 °C
Spectral range	1 μm	1 μm	1,6 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⁾	----- ±(0,1 % of reading +1 °C) ³⁾ -----			
Temperature resolution	----- 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)			

¹⁾ at ambient temperature 23±5 °C

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

³⁾ ε = 1/ Response time 1s

⁴⁾ with dynamic adaptation at low signal levels

Measurement Specifications [3M/ G5 models]

	3ML	3MH	G5L	G5H
Temperature range (scalable)	50...375 °C ¹⁾	100...600 °C ¹⁾	100...1200 °C	250...1650 °C
Ambient temperature (head)	-20...85 °C	-20...85 °C	-20...85 °C	-20...85 °C
Storage temperature (head)	-40...125 °C	-40...125 °C	-40...85 °C	-40...85 °C
Spectral range	2,3 μm	2,3 μm	5,2 μm	5,2 μm
Optical resolution	22:1	33:1	10:1	20:1
System accuracy ^{2) 3)}	±(0,3 % of reading +2 °C) ⁴⁾		----- ±2 °C or ±1 % ⁶⁾ -----	
Repeatability ²⁾	±(0,1 % of reading +1 °C) ⁴⁾		----- ±0,5 °C or ±0,5 % ⁶⁾ -----	
Temperature resolution	0,1 °C ⁴⁾	0,1 °C ⁴⁾	0,1 °C	0,2 °C
Exposure time (90 % signal)	1 ms ⁵⁾	1 ms ⁵⁾		
Response time (90 % signal)			120 ms	80 ms
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)			

¹⁾ T_{Object} > T_{Head}+25 °C

²⁾ at ambient temperature 23±5 °C

³⁾ Accuracy for thermocouple output: ±2,5°C or ±1%

⁴⁾ ε = 1/ Response time 1s

⁵⁾ with dynamic adaptation at low signal levels

⁶⁾ whichever is greater

Optical Charts

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

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

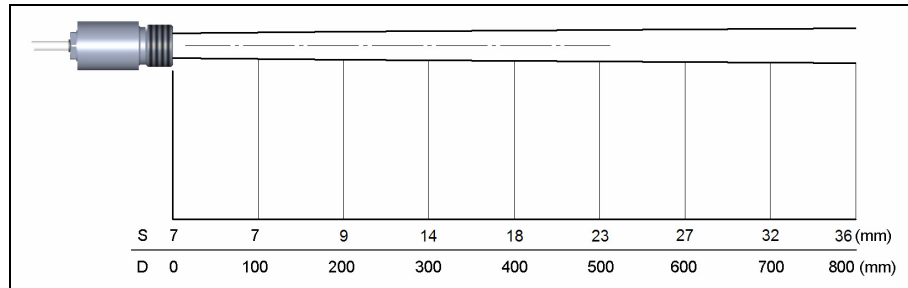
D = Distance from front of the sensing head to the object

S = Spot size

The D:S ratio is valid for the focus point.

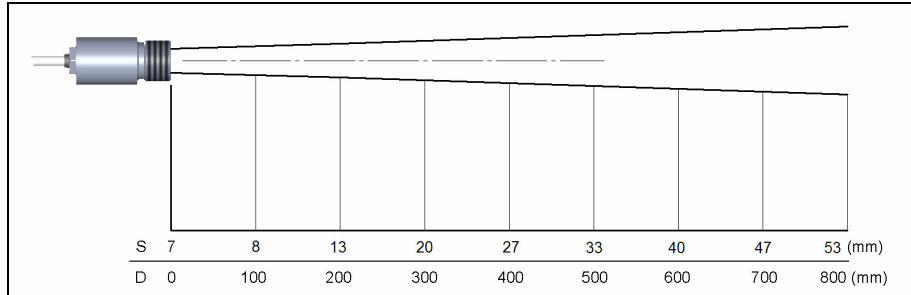
LT22

D:S = 22:1



LT15

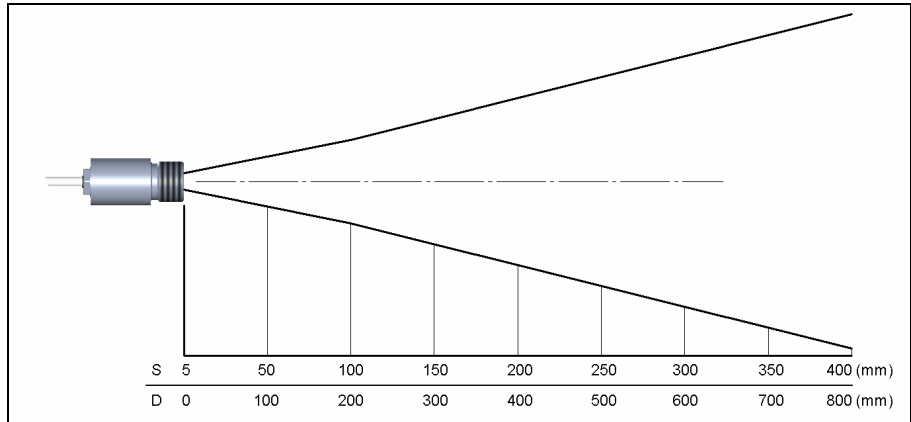
D:S = 15:1



LT02

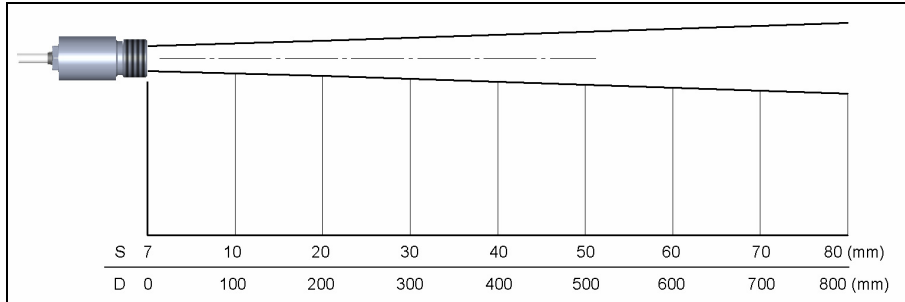
LT02H

D:S = 2:1



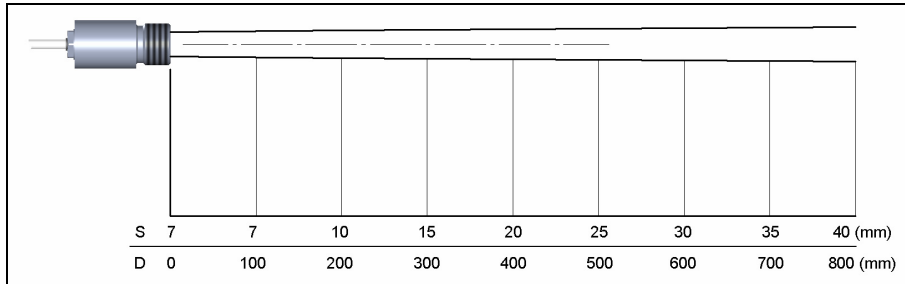
LT10F **LT10H** **G5L**

D:S = 10:1



G5H

D:S = 20:1



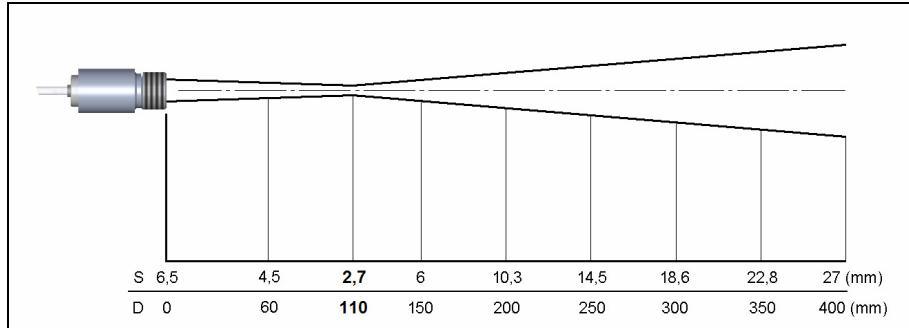
1ML

2ML

Optics: CF

D:S = 40:1/ 2,7mm@ 110mm

D:S (far field) = 12:1

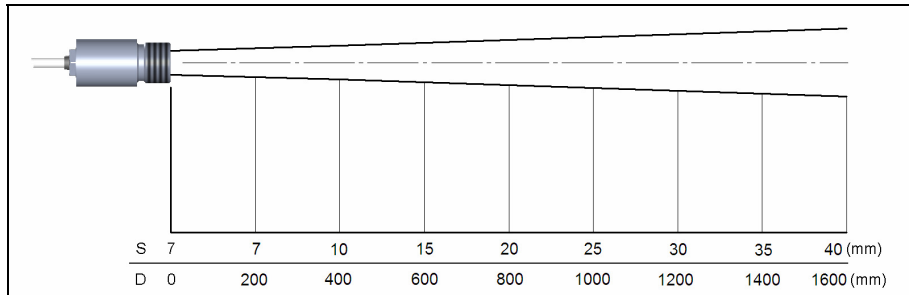


1ML

2ML

Optics: SF

D:S = 40:1

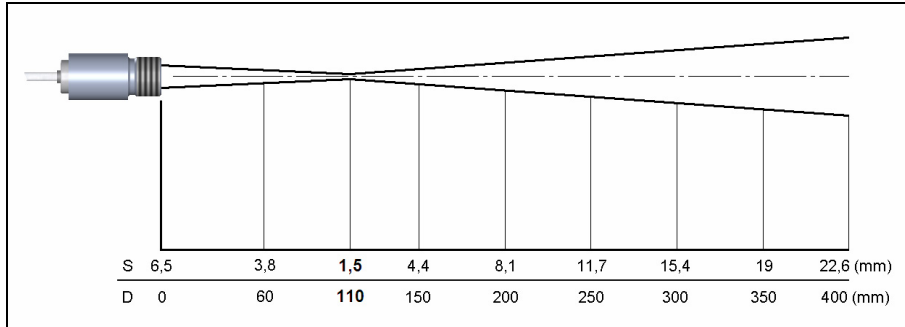


1MH **2MH**

Optics: CF

D:S = 75:1/ 1,5mm@ 110mm

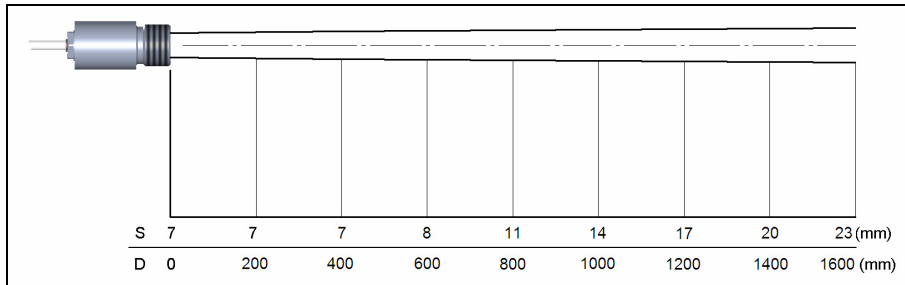
D:S (far field) = 14:1



1MH **2MH**

Optics: SF

D:S = 75:1

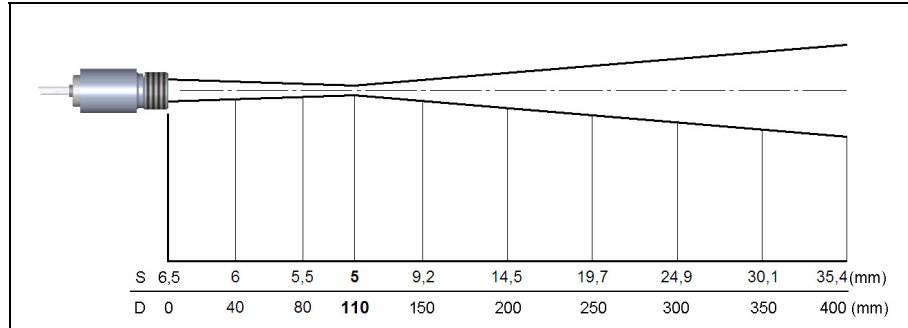


3ML

Optics: CF

D:S = 22:1/ 5mm@ 110mm

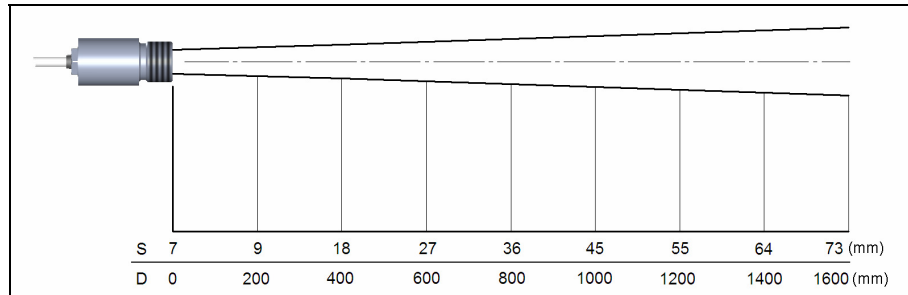
D:S (far field) = 9:1



3ML

Optics: SF

D:S = 22:1

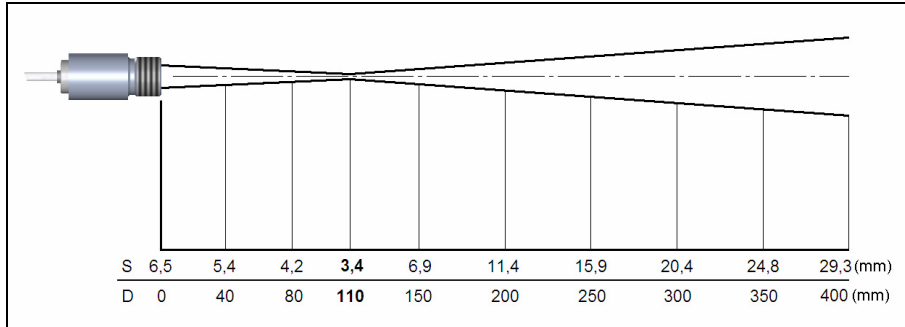


3MH

Optics: CF

D:S = 33:1/ 3,4mm@ 110mm

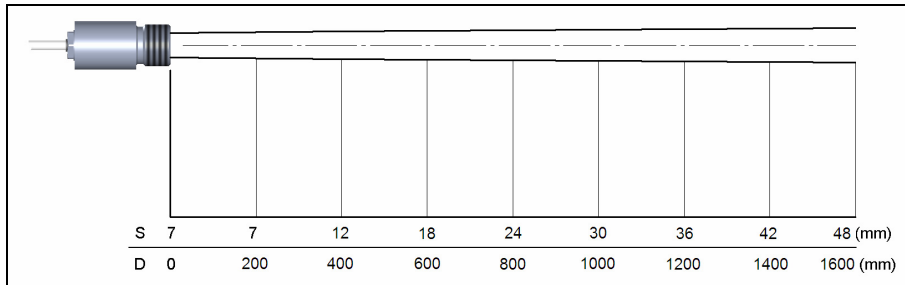
D:S (far field) = 11:1



3MH

Optics: SF

D:S = 33:1



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, 1M, 2M and 3M models. The minimum spot size depends on the used sensing head. The distance is always measured from the front edge of the CF lens holder or laminar air purge collar. The installation on the sensing head will be done by turning the CF lens until end stop. To combine it with the massive housing please use the version with external thread M12x1.

If the CF lens is used, the transmission has to be set to **0,78** [LT].

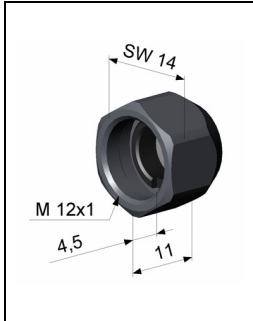
Versions Overview:

ACCTCF	CF lens for installation on sensing head [LT]
ACCTCFHT	CF lens for installation on sensing head [1M/ 2M/ 3M]
ACCTCFE	CF lens with external thread for installation in massive housing [LT]
ACCTCFHTE	CF lens with external thread for installation in massive housing [1M/ 2M/ 3M]

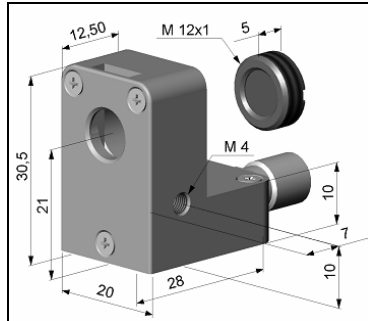
For protection of the sensing head optics a protective window is available. The mechanical dimensions are equal to the CF lens. It is available in the following versions:

ACCTPW	Protective window for installation on sensing head [LT]
ACCTPWHT	Protective window for installation on sensing head [1M/ 2M/ 3M]
ACCTPWE	Protective window with external thread for installation in massive housing [LT]
ACCTPWHT E	Protective window with external thread for installation in massive housing [1M/ 2M/ 3M]

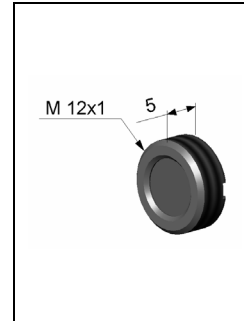
If the protective window is used, the transmission has to be set to **0,83** [LT] or **0,93** [1M/ 2M/ 3M].



CF lens:
ACCTCF/ ACCTCFHT
Protective window:
ACCTPW/ ACCTPWHT



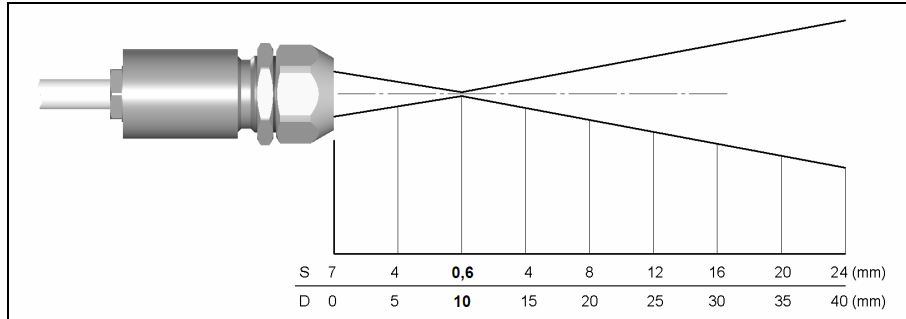
Laminar air purge with integrated
CF lens:
ACCTAPLCF/ ACCTAPLCFHT



CF lens with external thread:
ACCTCFE/ ACCTCFHTE
Protective window with external thread:
ACCTPWE/ ACCTPWHT

LT22 + CF lens

0,6 mm@ 10 mm
0,6 mm@ 8 mm [ACCTAPLCF]
D:S (far field) = 1,5:1

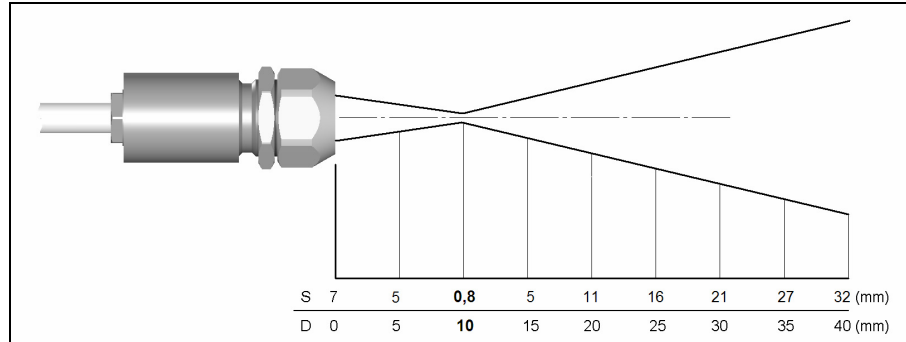


LT15 + CF lens

0,8 mm@ 10 mm

0,8 mm@ 8 mm [ACCTAPLCF]

D:S (far field) = 1,2:1

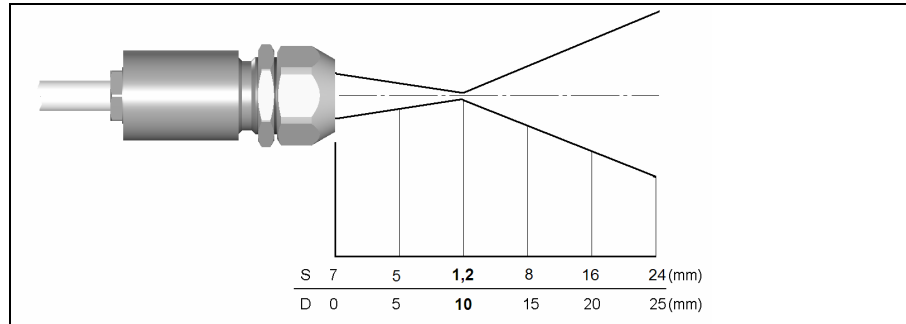


LT10F/ LT10H + CF lens

1,2 mm@ 10 mm

1,2 mm@ 8 mm [ACCTAPLCF]

D:S (far field) = 1,2:1

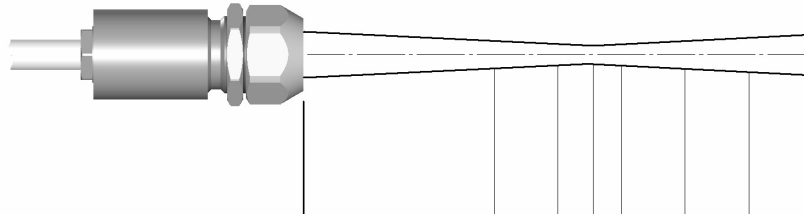


LT02/ LT02H + CF lens

2,5 mm@ 23 mm

2,5 mm@ 21 mm [ACCTAPLCF]

D:S (far field) = 5:1



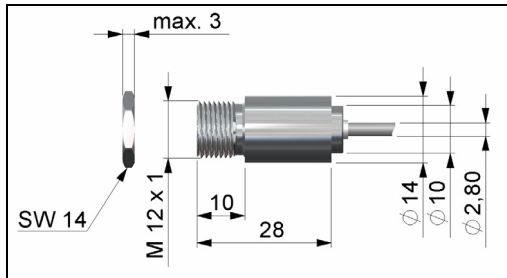
S	7		3	2,6	2,5	2,6	3	4,7	6,3 (mm)
D	0		15	20	23	25	30	35	40 (mm)

Mechanical Installation

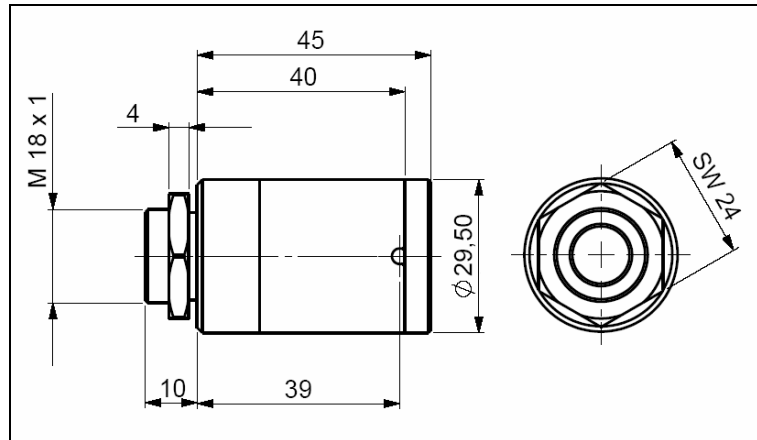
The CT sensing heads are equipped with a metrical M12x1-thread and can be installed either directly via the sensor thread or with help of the hex nut (included in scope of supply) to the mounting bracket available. Various mounting brackets, which make the adjustment of the sensing head easier, can be additionally ordered as accessories.

The CThot 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 [].



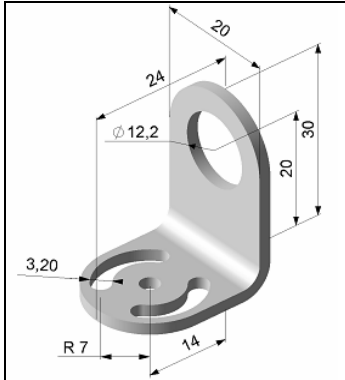
Sensing head



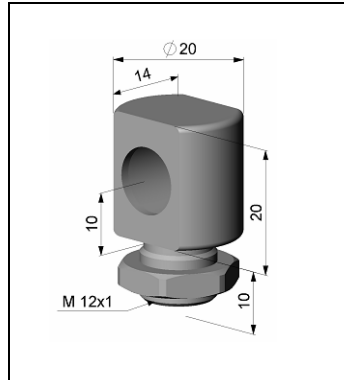
Massive housing (Standard on CThot)

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

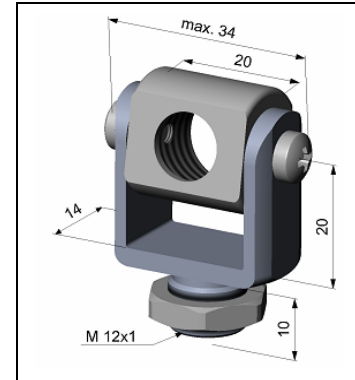
Mounting Accessories



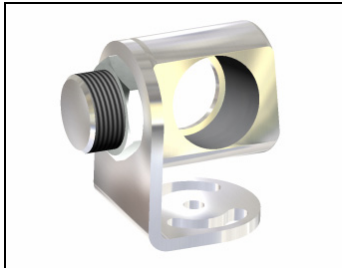
Mounting bracket, adjustable in one axis [ACCTFB]



Mounting bolt with M12x1 thread, adjustable in one axis [ACCTMB]



Mounting fork with M12x1 thread, adjustable in 2 axes [ACCTMG]

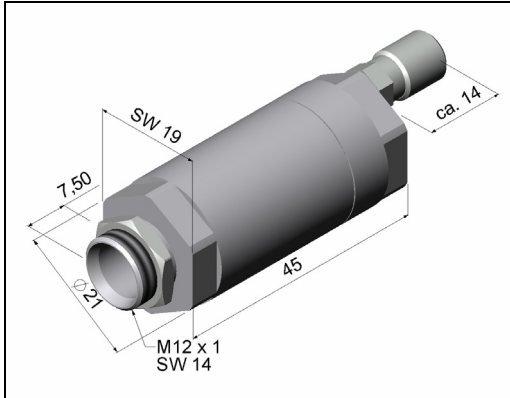


Mounting bracket, adjustable in two axes [ACCTAB]
consisting of: ACCTFB and ACCTMB

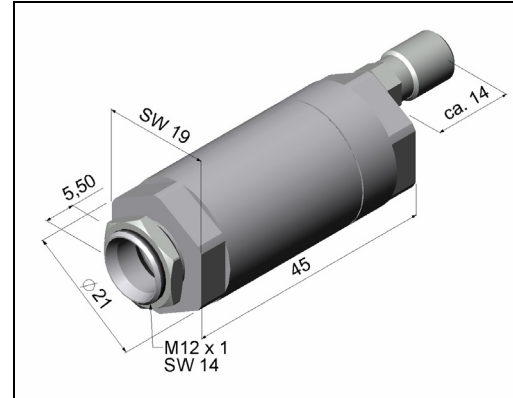
The **Mounting fork** can be combined with the **Mounting bracket [ACCTFB]** using the M12x1 thread.

Air Purge Collars

The lens must be kept clean at all times from dust, smoke, fumes and other contaminants in order to avoid reading errors. These effects can be reduced by using an **air purge collar**. Make sure to use oil-free, technically clean air, only.

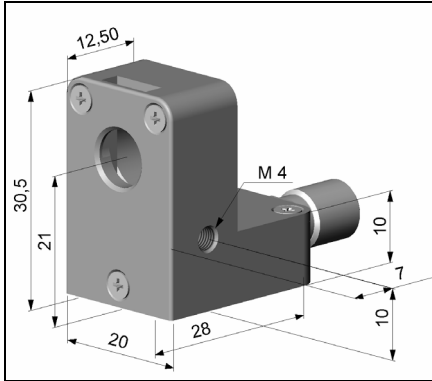


**Standard air purge collar [ACCTAP]
for LT22, LT15, LT10F
fits to the mounting bracket
Hose connection: 3x5 mm
Thread (fitting): M5**



**Standard air purge collar [ACCTAP2]
for LT02
fits to the mounting bracket
Hose connection: 3x5 mm
Thread (fitting): M5**

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

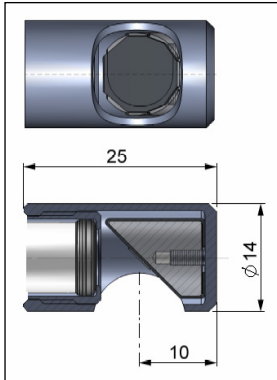


A combination of the **Laminar air purge collar** with the bottom section of the **Mounting fork** allows an adjustment in two axes. [ACCTAPL+ACCTMG]

Laminar air purge collar [ACCTAPL]
The sideward air outlet prevents a cooling down of the object in short distances.
Hose connection: 3x5 mm
Thread (fitting): M5

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

Further Accessories



Right Angle Mirror [ACCTRAM]

for LT22, LT15 and LT10F;

Enables measurements with 90° angle to sensor axis.

The mirror has a reflexion of 96% in combination with a LT22 and LT15 head and 88% with a LT10F head.

If the mirror is used this value has to be multiplied by the emissivity value of the measurement object.

Example: LT22 and object with emissivity = 0,85

$0,85 \times 0,96 = 0,816$

Thus the emissivity in the CT has to be set to the resulting value of 0,816.



Laser-Sightingtool [D08ACCTLST]

battery powered (2x Alkaline AA), for alignment of CT sensing heads. The laser head has the same mechanical dimensions as the CT sensing head.

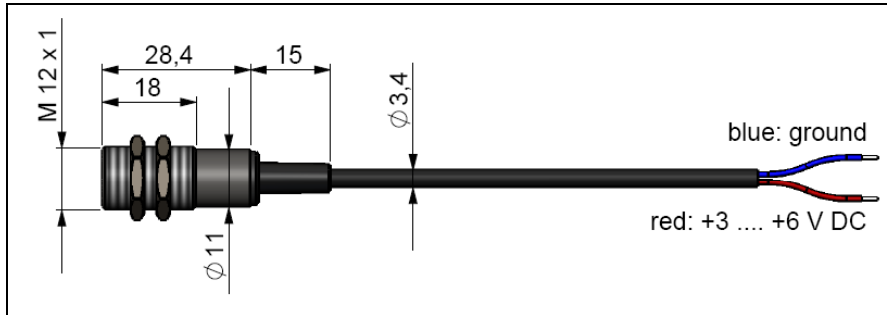
WARNING: Do not point the laser directly at the eyes of persons or animals! Do not stare into the laser beam. Avoid indirect exposure via reflective surfaces!



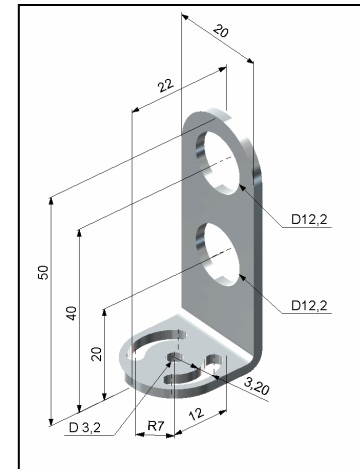
OEM-Laser-Sightingtool

The OEM-Laser-Sightingtool is available with 3,5 m [ACCTOEMLST] and 8 m connection cable [ACCTOEMLSTCB8]. The laser can be connected to the pins **3V SW** and **GND** [► Elektrische Installation] and switched on and off via the programming keys or via the software.

The special double-hole mounting bracket [ACCTFB2] allows a simultaneous mounting of the CT sensing head and the laser head.

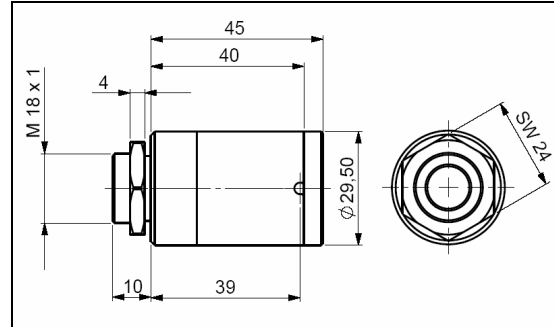


ACCTOEMLST or ACCTOEMLSTCB8

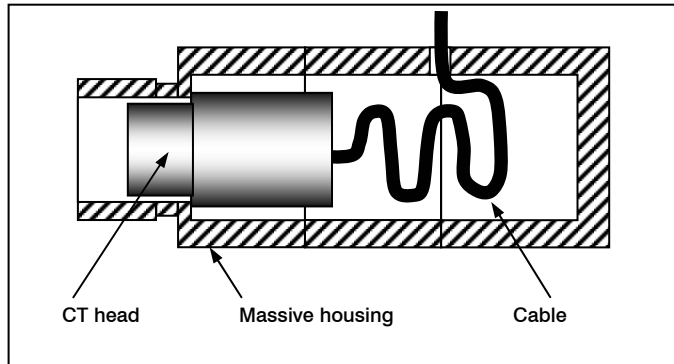


ACCTFB2

Massive Housing



Massive housing, stainless steel [D06ACCTMHS] – also available in aluminum (anodized) or brass



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 [ACCTCFE] or with the protective window [ACCTPWE].

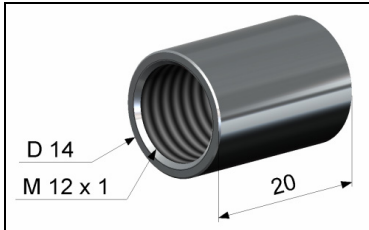
► CF Lens and Protective Window

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

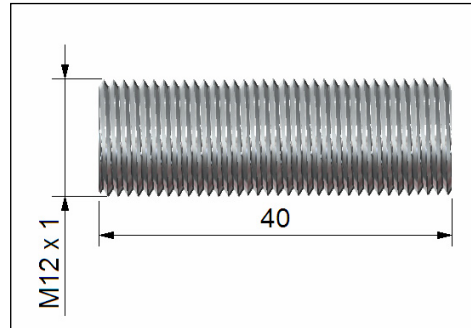
Pipe Adapter and Sighting Tubes

The pipe adapter [**ACCTPA**] allows an assembling of sighting tubes directly on the CT head. The sighting tubes are available in 3 different lengths:

ACCTST20	20 mm
ACCTST40	40 mm
ACCTST88	88 mm



ACCTPA

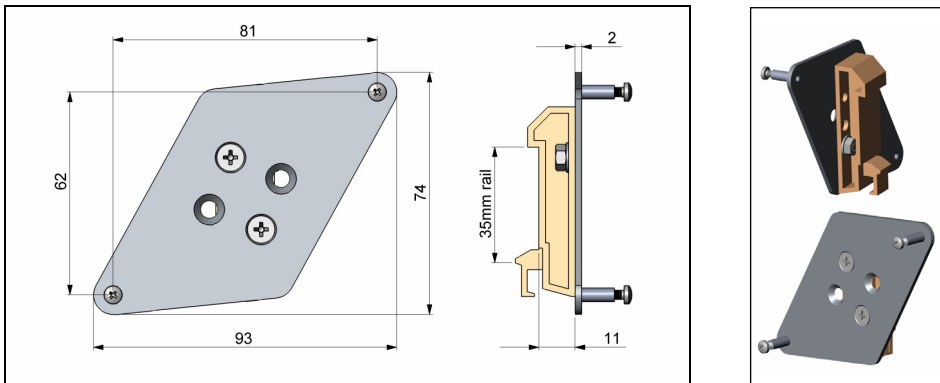


ACCTST40

The sighting tubes can only be used for sensing heads with a distance-to-spot ratio (D:S) of $\geq 15:1$.

Rail Mount Adapter for Electronic box

With the rail mount adapter the CT electronics can be mounted easily on a DIN rail (TS35) according EN50022.



ACCTRAIL

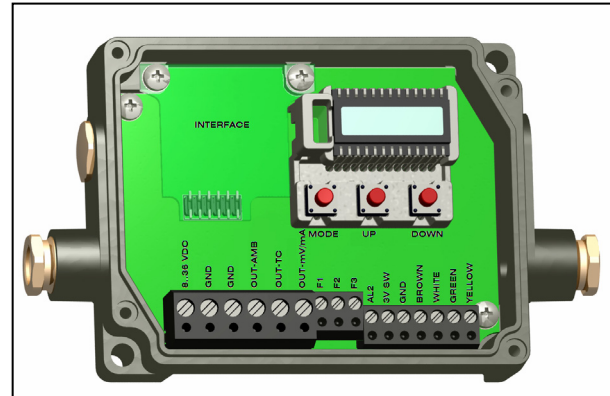
Electrical Installation

Cable Connections

For the electrical installation of the CT 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 LT/ G5]

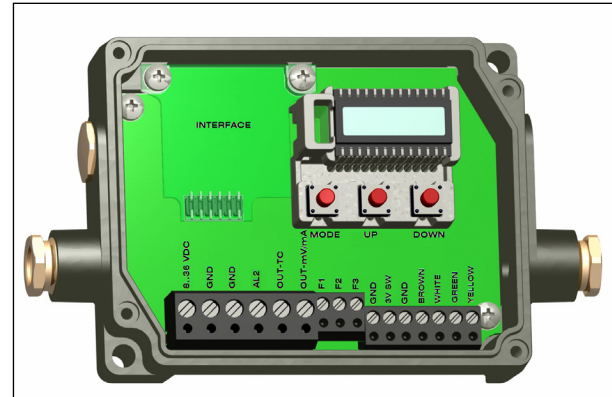
+8..36 VDC	Power supply
GND	Ground (0 V) of power supply
GND	Ground (0 V) of internal in- and outputs
OUT-AMB	Analog output head temperature (mV)
OUT-TC	Analog output thermocouple (J or K)
OUT-mV/mA	Analog output object temperature (mV or mA)
F1-F3	Functional inputs
AL2	Alarm 2 (Open collector output)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



Opened LT/ G5 electronic box
with terminal connections

Designation [models 1M/ 2M/ 3M]

+8...36VDC	Power supply
GND	Ground (0V) of power supply
GND	Ground (0V) 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 (0V)
3V SW	3 VDC, switchable, for laser-sightingtool
GND	Ground (0 V) for laser-sightingtool
BROWN	BROWN/ Temperature probe head (NTC)
WHITE	WHITE/ Head ground
GREEN	GREEN/ Head power
YELLOW	YELLOW/ Detector signal



Opened 1M/ 2M/ 3M electronic box
with terminal connections

Power supply

Please use a power supply unit with an output voltage of **8–36 VDC** which can supply **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!**

Cable Assembling

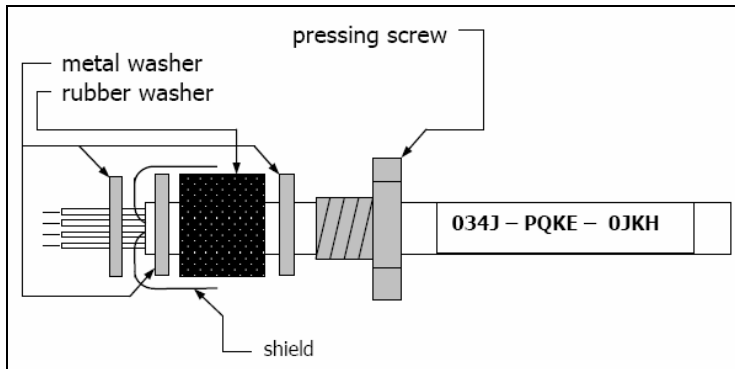
The cable gland M12x1,5 allows the use of cables with a diameter of 3 to 5 mm.

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.



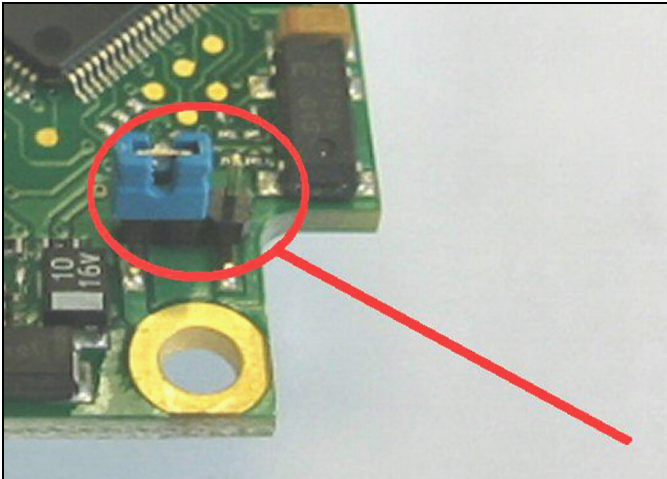
Use shielded cables only. The sensor shield has to be grounded.

Ground Connection

At the bottom side of the mainboard 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 electronics 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.



Exchange of the Sensing Head

From factory side the sensing head has already been connected to the electronics and the calibration code has been entered. Inside the model group **LT22, LT15, LT02, LT10H, LT02H** any exchange of sensing heads and electronics is possible. The sensing heads and electronics of the models **LT10F, 1M, 2M, 3M, G5** cannot be exchanged.

After exchanging a head the calibration code of the new head must be entered into the electronics.

Entering of the Calibration Code

Every head has a specific calibration code, which is printed on the head cable. For a correct temperature measurement and functionality of the sensor this calibration code must be stored into the electronic box. The calibration code consists of **3 blocks** (LT10F, 1ML, 1MH, 2ML, 2MH = 5 blocks) with **4 characters** each.

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



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 head cable (near the electronics). Please do not remove this label or make sure the code is noted anywhere. The code is needed if the electronics has to be exchanged or in case of a necessary recalibration of the sensor.

Sensing Head Cable

On the models **LT22, LT15, LT02, LT10H, LT02H, G5** the sensing head 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 **LT10F, 1M, 2M, 3M** the sensing head cable may not be changed in its length.

On the CT models **LT02, LT02H and LT10H** the head cable must not be moved during the measurement.

Outputs and Inputs

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!

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 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 mainboard are used (**OUT-mV/mA** or **OUT-TC**).

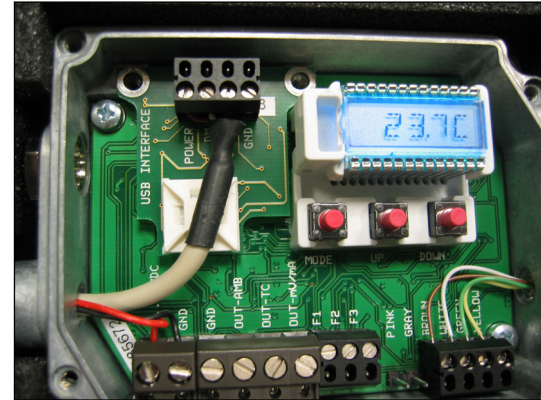
Output channel 2 [LT/ G5 only]

The connection pin OUT-AMB is used for output of the head temperature [-20-180 °C or -20-250 °C (on LT02H and LT10H) 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 head temperature **THead** also the object temperature **TObj** or electronic box temperature **TBox** can be selected as alarm source.

Digital Interfaces

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.



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

Relay 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 alarm values are set according to the ► Factory Default Settings.
To make advanced settings (change of low- and high alarm) a digital interface (USB, RS232) and the software is needed.

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 ► $\epsilon=0,1$; 9 V ► $\epsilon=1$; 10 V ► $\epsilon=1,1$]
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)

A non connected input represents:

F1=High | F2, F3=Low.

[High level: $\geq +3$ V...+36 V | Low level: $\leq +0,4$ V...-36 V]

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 (CThot: 1K)**.

Output channel 1 and 2 [channel 2 on LT/ G5 only]

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

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 mainboard [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

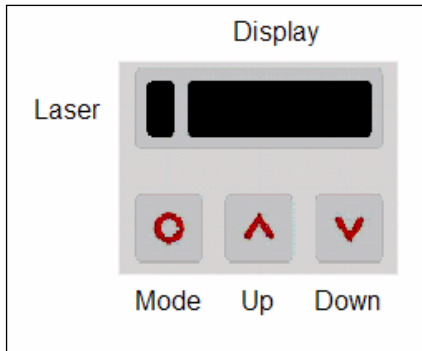
For extended setup like definition as low or high alarm [via change of normally open/ closed], selection of the signal source [TObj, THead, TBox] a digital interface (e.g. USB, RS232) including the software CompactConnect is needed.

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**].

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).



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

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	Head temperature [127 °C]	fixed
25CB	Box temperature [25 °C]	fixed
142CA	Current object temperature [142 °C]	fixed
<input type="checkbox"/> MV5	Signal output channel 1 [0-5 V]	<input type="checkbox"/> 0-20 = 0–20 mA/ <input type="checkbox"/> 4-20 = 4–20 mA/ <input type="checkbox"/> MV5 = 0–5 V/ <input type="checkbox"/> MV10 = 0-10 V/ <input type="checkbox"/> TCJ = thermocouple type J/ <input type="checkbox"/> 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 oo oo oo oo = infinite
V----	Signal output Valley hold [inactive]	V---- = inactive/ 0,1 ... 999,9 s / V oo oo oo oo = infinite
u 0.0	Lower limit temperature range [0 °C]	depending on model / inactive at TCJ- and TCK-output
n 500.0	Upper limit temperature range [500 °C]	depending on model / 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 [head temperature]	XHEAD = head temperature/ -40,0 ... 900,0 °C (for LT) as fixed value for compensation/ returning to XHEAD (head temperature) by pressing Up and Down together
M 01	Multidrop adress [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 Sighting (3 VDC switch to connection pin 3V SW)	ON/ OFF This menu item appears on first position on 1M/ 2M/ 3M models.

□ 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.

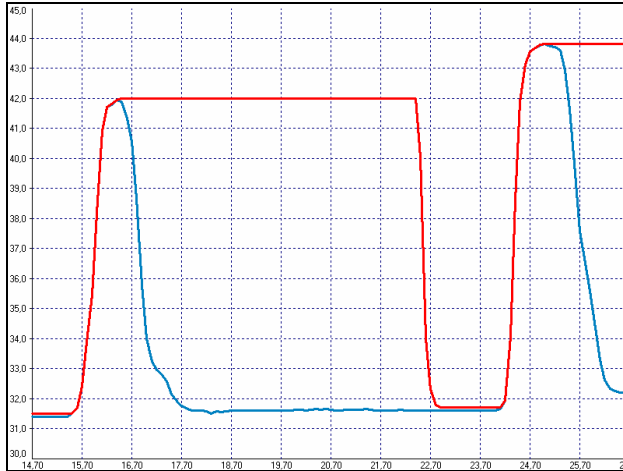
P----

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.

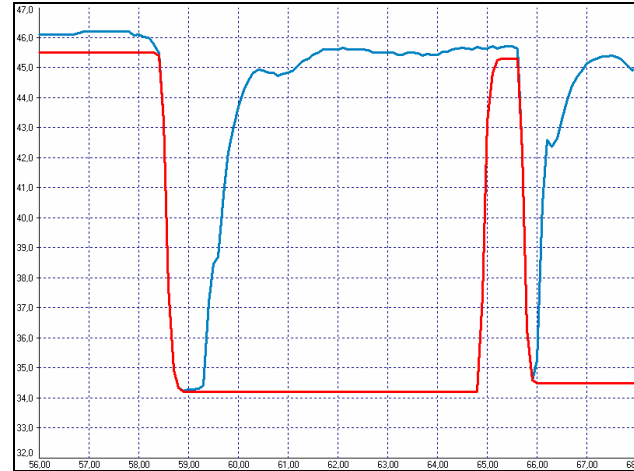
V----

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 \geq 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.

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

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

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.

S ON

Activating (**ON**) and Deactivating (**OFF**) of an optional **Sighting Laser**

[▶ **Further Accessories**]. By pressing **Up** or **Down** a voltage of 3 VDC will be switched to the **3V SW** connection pin on the mainboard.

Error messages

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

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

Software CompactConnect

Installation

Insert the installation CD into the according drive on your computer. If the autorun option is activated the installation wizard will start automatically. Otherwise please start **setup.exe** from the CD-ROM. Follow the instructions of the wizard until the installation is finished.

The installation wizard will place a launch icon on the desktop and in the start menu:

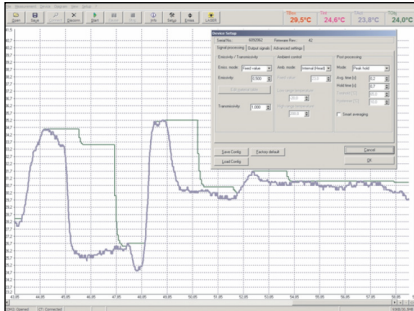
[Start]\Programs\CompactConnect.

If you want to uninstall the software from your system please use the **uninstall icon** in the start menu.

System requirements:

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

You will find a detailed software manual on the CD.



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

Communication Settings

Serial Interface

Baud rate: 9,6...115,2 kBaud (adjustable on the unit or via software)
Data bits: 8
Parity: none
Stop bits: 1
Flow control: off

Protocol

All sensors of the CT series are using a binary protocol. Alternatively they can be switched to an ASCII protocol. To get a fast communication the protocol has no additional overhead with CR, LR or ACK bytes.

ASCII protocol

The models **LT02**, **LT15**, **LT22**, **LT02H** and **LT10H** can be switched to ASCII by changing the first figure of block 3 of the head calibration code. This figure has to be changed from **0 to 4** (always **+4**; that means on the CTeX this figure has to be changed from **1 to 5**).

▶ Exchange of the Sensig Head]

Example:	Binary: A6FG – 22KB – 0 AS0 block1 block2 block3	ASCII: A6FG – 22KB – 4 AS0 block1 block2 block3
-----------------	-------------------------------------------------------------------	------------------------------------------------------------------

Saving of parameter settings

After power on of the CT sensor the flash mode is active. It means, changed parameter settings will be saved in the CT-internal Flash-EEPROM and will be kept also after the sensor is switched off.

In case settings should be changed quite often or continuously the flash mode can be switched off by using the following command:

Decimal: **112**
HEX: **0x70**
Data, Answer: **byte 1**
Result: **1 – Data will not be written into the flash memory**
 2 – Data will be written into the flash memory

If the flash mode is deactivated, all settings will only be kept as long as the unit is powered. If the unit is switched off and powered on again all previous settings are lost.

The command 0x71 will poll the current status.

You will find a detailed protocol and command description on the software CD CompactConnect in the directory: **\Commands**.

Basics of Infrared Thermometry

Depending on the temperature each object emits a certain amount of infrared radiation. A change in the temperature of the object is accompanied by a change in the intensity of the radiation. For the measurement of “thermal radiation” infrared thermometry uses a wave-length ranging between 1μ and $20 \mu\text{m}$.

The intensity of the emitted radiation depends on the material. This material contingent constant is described with the help of the emissivity which is a known value for most materials (see enclosed table emissivity).

Infrared thermometers are optoelectronic sensors. They calculate the surface temperature on the basis of the emitted infrared radiation from an object. The most important feature of infrared thermometers is that they enable the user to measure objects contactless. Consequently, these products help to measure the temperature of inaccessible or moving objects without difficulties. Infrared thermometers basically consist of the following components:

- lens
- spectral filter
- detector
- electronics (amplifier/ linearization/ signal processing)

The specifications of the lens decisively determine the optical path of the infrared thermometer, which is characterized by the ratio **D**istance to **S**pot 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.

Emissivity

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.

Determination of unknown Emissivities

- ▶ First, determine the actual temperature of the measuring object with a thermocouple or contact sensor. Second, measure the temperature with the infrared thermometer and modify the emissivity until the displayed result corresponds to the actual temperature.
- ▶ If you monitor temperatures of up to 380°C you may place a special plastic sticker (emissivity dots – part number: ACLSED) 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.

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- 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.

Characteristic Emissivities

In case none of the methods mentioned above help to determine the emissivity you may use the emissivity tables ► **Appendix A and B**. These are average values, only. The actual emissivity of a material depends on the following factors:

- temperature
- measuring angle
- geometry of the surface
- thickness of the material
- constitution of the surface (polished, oxidized, rough, sandblast)
- spectral range of the measurement
- transmissivity (e.g. with thin films)

Appendix A – Emissivity Table Metals

Material		typical Emissivity			
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			
	1,0 μm	2,2 μm	5,1 μm	8-14 μm
Asbestos	0,9	0,8	0,9	0,95
Asphalt			0,95	0,95
Basalt			0,7	0,7
Carbon	non oxidized graphite	0,8-0,9	0,8-0,9	0,8-0,9
		0,8-0,9	0,7-0,9	0,7-0,8
Carborundum		0,95	0,9	0,9
Ceramic	0,4	0,8-0,95	0,8-0,95	0,95
Concrete	0,65	0,9	0,9	0,95
Glass	plate	0,2	0,98	0,85
	melt	0,4-0,9	0,9	
Grit			0,95	0,95
Gypsum			0,4-0,97	0,8-0,95
Ice				0,98
Limestone			0,4-0,98	0,98
Paint	non alkaline			0,9-0,95
Paper	any color		0,95	0,95
Plastic >50 μm	non transparent		0,95	0,95
Rubber			0,9	0,95
Sand			0,9	0,9
Snow				0,9
Soil				0,9-0,98
Textiles			0,95	0,95
Water				0,93
Wood	natural		0,9-0,95	0,9-0,95