XR

Infrared Sensor

Operating Instructions

Rev. B1 10/2013
57301

WARRANTY

The manufacturer warrants this instrument to be free from defects in material and workmanship under normal use and service for the period of two years from date of purchase. This warranty extends only to the original purchaser. This warranty shall not apply to fuses, batteries, or any product which has been subject to misuse, neglect, accident, or abnormal conditions of operation.

In the event of failure of a product covered by this warranty, the manufacturer will repair the instrument when it is returned by the purchaser, freight prepaid, to an authorized Service Facility within the applicable warranty period, provided manufacturer's examination discloses to its satisfaction that the product was defective. The manufacturer may, at its option, replace the product in lieu of repair. With regard to any covered product returned within the applicable warranty period, repairs or replacement will be made without charge and with return freight paid by the manufacturer, unless the failure was caused by misuse, neglect, accident, or abnormal conditions of operation or storage, in which case repairs will be billed at a reasonable cost. In such a case, an estimate will be submitted before work is started, if requested.

THE FOREGOING WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTY OF MERCHANTABILITY, FITNESS, OR ADEQUACY FOR ANY PARTICULAR PURPOSE OR USE. THE MANUFACTURER SHALL NOT BE LIABLE FOR ANY SPECIAL, INCIDENTAL OR CONSEQUENTIAL DAMAGES, WHETHER IN CONTRACT, TORT, OR OTHERWISE.

SOFTWARE WARRANTY

The manufacturer does not warrant that the software described herein will function properly in every hardware and software environment. This software may not work in combination with modified or emulated versions of Windows operating environments, memory-resident software, or on computers with inadequate memory. The manufacturer warrants that the program disk is free from defects in material and workmanship, assuming normal use, for a period of one year. Except for this warranty, the manufacturer makes no warranty or representation, either expressed or implied, with respect to this software or documentation, including its quality, performance, merchantability, or fitness for a particular purpose. As a result, this software and documentation are licensed "as is," and the licensee (i.e., the User) assumes the entire risk as to its quality and performance. The liability of the manufacturer under this warranty shall be limited to the amount paid by the User. In no event shall the manufacturer be liable for any costs including but not limited to those incurred as a result of lost profits or revenue, loss of use of the computer software, loss of data, the cost of substitute software, claims by third parties, or for other similar costs. The manufacturer's software and documentation are copyrighted with all rights reserved. It is illegal to make copies for another person.

Specifications subject to change without notice.

The device complies with the requirements of the European Directives.

EC – Directive 2004/108/EC (EMC)

Content

1 Safety Instructions

This document contains important information, which should be kept at all times with the instrument during its operational life. Other users of this instrument should be given these instructions with the instrument. Eventual updates to this information must be added to the original document. The instrument can only be operated by trained personnel in accordance with these instructions and local safety regulations.

Acceptable Operation

This instrument is intended only for the measurement of temperature. The instrument is appropriate for continuous use. The instrument operates reliably in demanding conditions, such as in high environmental temperatures, as long as the documented technical specifications for all instrument components are adhered to. Compliance with the operating instructions is necessary to ensure the expected results.

Unacceptable Operation

The instrument should not be used for medical diagnosis.

Replacement Parts and Accessories

Use only original parts and accessories approved by the manufacturer. The use of other products can compromise the operation safety and functionality of the instrument.

Instrument Disposal

Disposal of old instruments should be handled according to professional and environmental regulations as electronic waste.

Operating Instructions

The following symbols are used to highlight essential safety information in the operation instructions:

Helpful information regarding the optimal use of the instrument.

Warnings concerning operation to avoid instrument damage and personal injury.

The instrument is equipped with a Class 2 laser. Class 2 lasers shine only within the visible spectrum at an intensity of 1 mW. Looking directly into the laser beam can produce a slight, temporary blinding effect, but does not result in physical injury or damage to the eyes, even when the beam is magnified by optical aids. At any rate, closing the eye lids is encouraged when eye contact is made with the laser beam. Pay attention to possible reflections of the laser beam. The laser functions only to locate and mark surface measurement targets. Do not aim the laser at people or animals.

Incorrect use of 110 / 230 V electrical systems can result in electrical hazards and personal injury. All instrument parts supplied with electricity must be covered to prevent physical contact and other hazards at all times.

2 Technical Data

2.1 Models

	LT
Temperature range	-40 to 600°C (-40 to 1112°F)
Optical resolution* (90% energy, at focal distance)	33 : 1
Spectral response	8 to 14 µm
Focus Options	SF, CF1, CF2

	LTH
Temperature range	-40 to 600°C (-40 to 1112°F)
Optical resolution* (90% energy, at focal distance)	50 : 1
Spectral response	8 to 14 µm
Focus Options	SF, CF2

	MT
Temperature range	250 to 1200°C (482 to 2192°F)
Optical resolution* (90% energy, at focal distance)	30 : 1
Spectral response	3.9 µm
Focus Options	SF, CF2

	G5
Temperature range	250 to 1650°C (482 to 3002°F)
Optical resolution* (90% energy, at focal distance)	33 : 1
Spectral response	4.8 to 5.2 µm
Focus Options	SF, CF2

	P7
Temperature range	10 to 350°C (50 to 662°F)
Optical resolution* (90% energy, at focal distance)	30 : 1
Spectral response	7.9 µm
Focus Options	SF

Measurement Parameters

Accuracy[1]	± 1 % or ± 1°C (± 2°F) of reading, whichever is greater
	± 2°C (± 3.6°F) for temperatures < 10°C (50°F)
	± 2°C (± 3.6°F) for temperatures < 90°C (194°F) for P7 models
	± 1.2% or ± 1.2°C (± 2.2°F), for thermocouple
Repeatability	± 0.5 % or ± 0.5°C (± 1°F) of reading, whichever is greater
Response time (95 %)	150 ms
Temperature resolution (analog)	0.5°C
Temperature resolution (digital)	0.1°C
Emissivity	0.100 … 1.100 (adjustable)
Transmissivity	0.100 … 1.000 (adjustable)

Electrical Parameters

Output (OUT)	0 - 20 mA or
	4 - 20 mA or
	0 - 5 V
	J Thermocouple (only on terminal block connector versions)
	K Thermocouple (only on terminal block connector versions)
Alarm output	Opto-coupled contact closure for head ambient temperature, switches if internal sensor temperature exceed 70°C (158°F) or output for alarm relay (software controlled)
Power	22 - 26 VDC, 100 mA

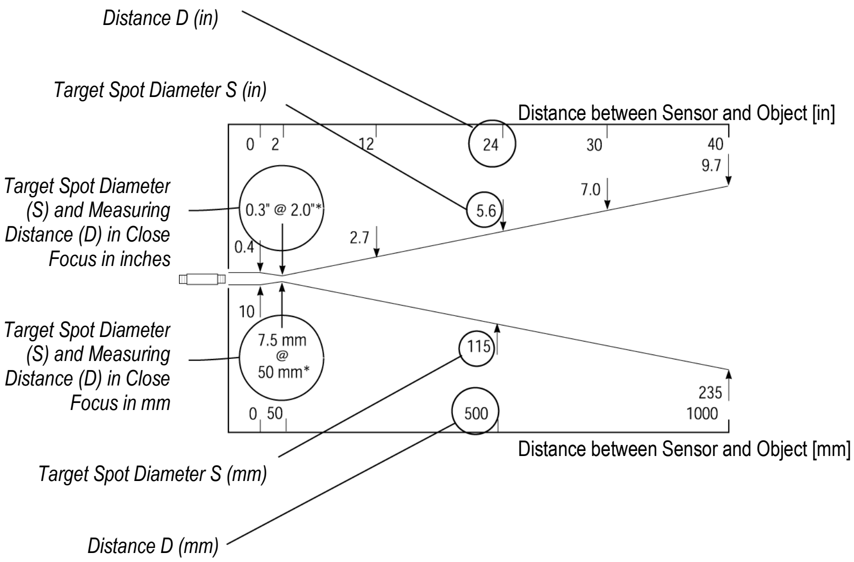
General Parameter

Environmental rating	IP65
Bore-Sight tolerance	1° (at focal distance)
Ambient operating range	0 to 70°C (32 to 158°F)
with air cooling	120°C (248°F)
with water cooling	175°C (347°F)
with ThermoJacket	315°C (599°F)
with Laser	0 to 40°C (-4 to 104°F)
Storage temperature	-20 to 70°C (-4 to 158°F)
Vibration	IEC 68-2-6 (MIL STD 810D), 3 axis, 11 bis 200 Hz, 3 G
Shock	IEC 68-2-27 (MIL STD 810D), 3 axis, 11 ms, 50 G
Dimensions	L: max. 192 mm (7.6 in); Ø: 42 mm (1.7 in)
Weight	585 g (21 oz)
Housing	A model: Aluminum
	S model: 316L stainless steel

[1] at ambient temperature 23°C ± 5°C (73°F ± 9°F)

2.2 Optical Diagrams

The optical diagrams indicate the target spot diameter at any given distance between the target object and the sensing head.
All target spot sizes indicated in the optical diagrams are based on 90% energy.



Close Focus D : S = *Proportion between Distance (D) to Target Spot and Target Spot Diameter (S) in Close Focus*

Far Field D : S = *Proportion with Distances 10 times greater than the Close Focus Distance*

Figure 1: How to read the optical diagrams

Calculating the Target Spot Size

To calculate the target spot size from two known points within an optical diagram the following formula can be used:

$$S_x = S_n + \left[\frac{(D_x - D_n)}{(D_f - D_n)} \cdot (S_f - S_n) \right]$$

S_x = *unknown diameter of target spot*
S_n = *smallest known diameter of target spot*
S_f = *greatest known diameter of target spot*
D_x = *distance to unknown target spot*
D_n = *distance to smaller known target spot*
D_f = *distance to greater known target spot*

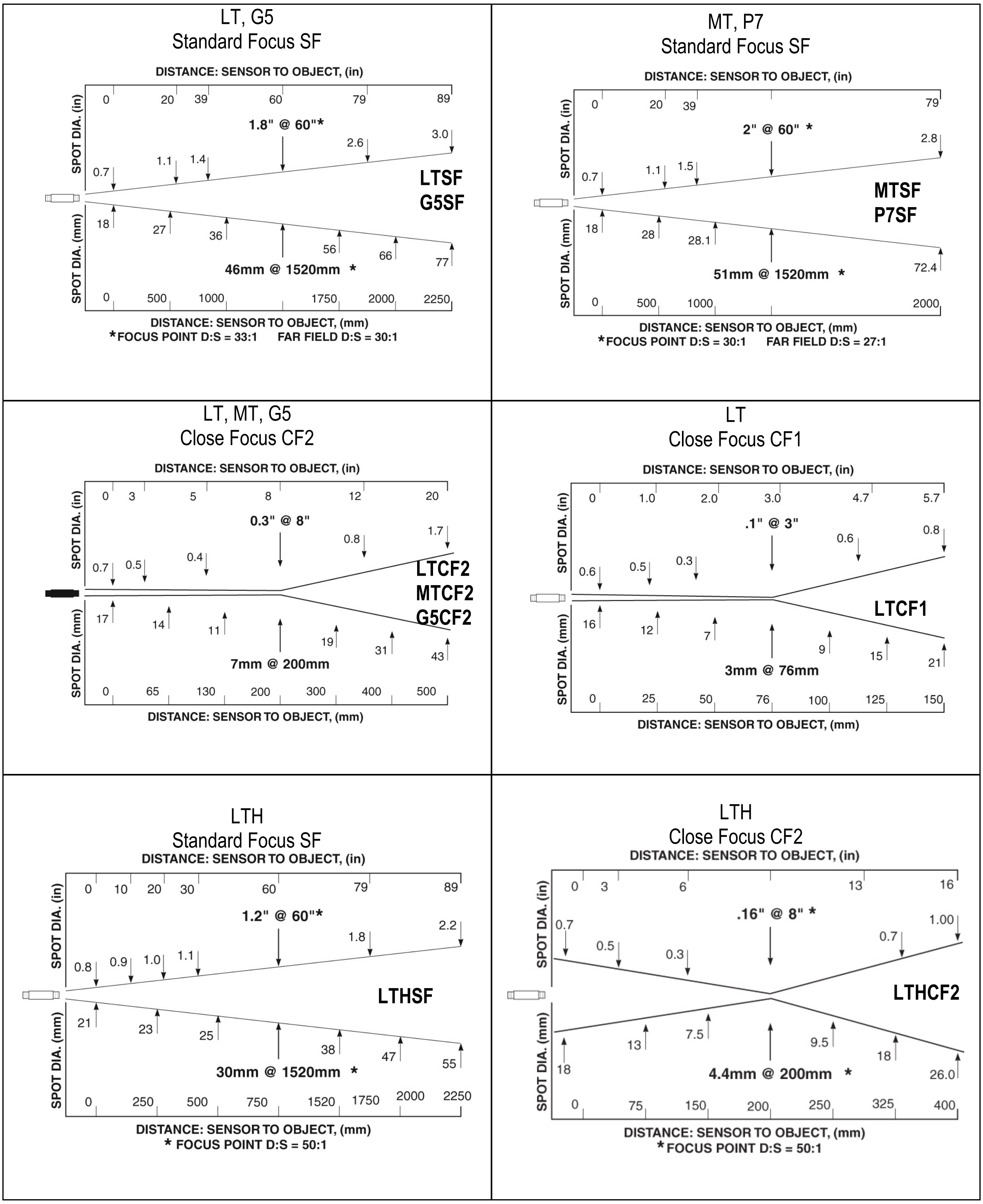


Figure 2: Optical Diagrams

2.3 Dimensions of Sensor

All sensors are supplied with a fixed bracket and mounting nut. Alternatively, the sensor may also be mounted using customer-supplied accessories.

All sensors and accessories are supplied with 1.5“ 20 UN 2 threads.

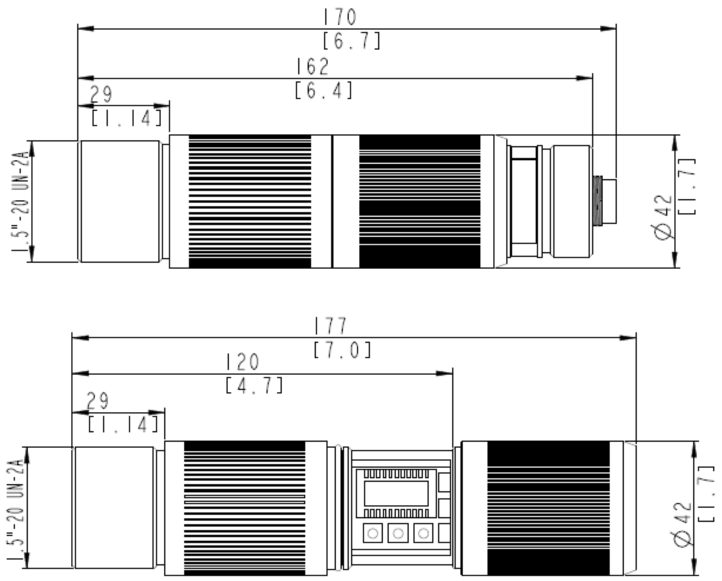


Figure 3: Dimensions of the Sensor with DIN Connection

Figure 4: Dimensions of the Sensor with Terminal Connection

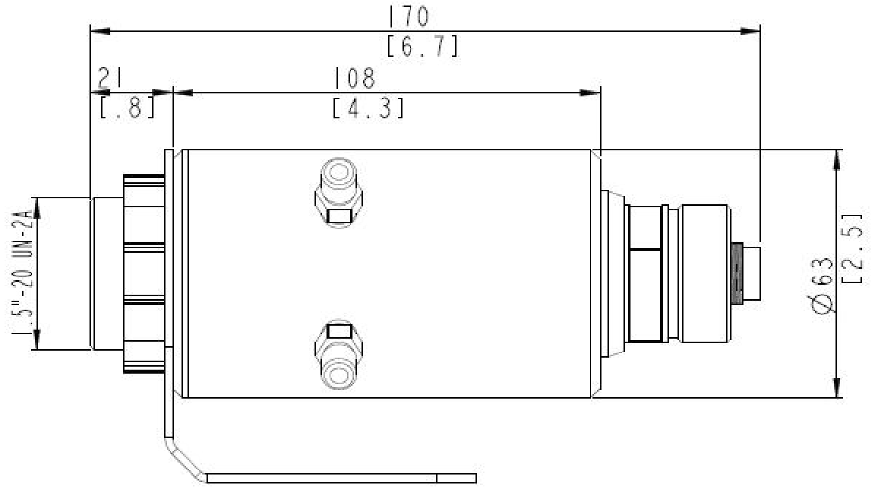


Figure 5: Dimensions of the Sensor with DIN Connectors and Water-cooled housing

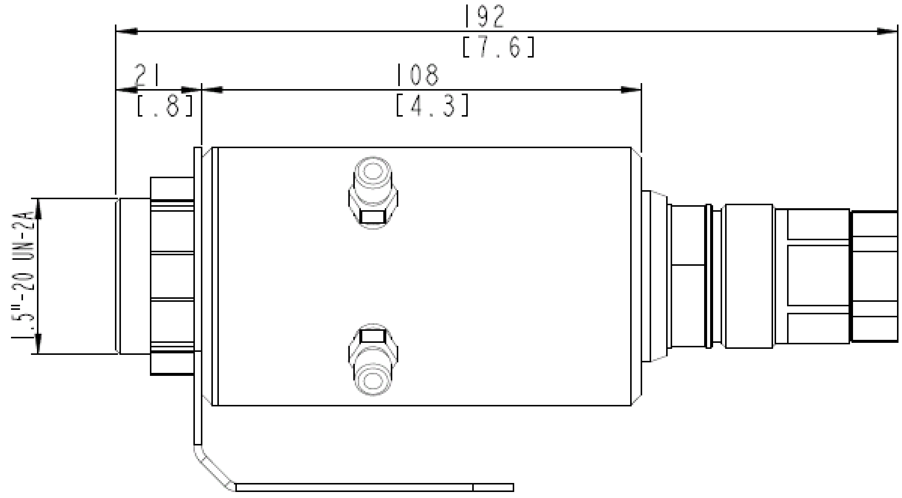


Figure 6: Dimensions of the Sensor with Terminal Connections and Water-cooled housing

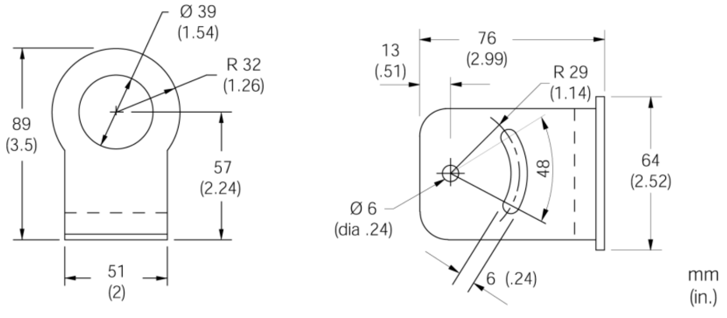


Figure 7: Dimensions of the fixed bracket (XXXTXXACFB)

2.4 Scope of Delivery

All models are provided with:

- Operator's manual
- Fixed bracket
- Mounting nut
- Support software CD
- Laser (only with LTHSF or LTHCF2)

3 Basics

3.1 Measurement of Infrared Temperature

Everything emits an amount of infrared radiation according to its surface temperature. The intensity of the infrared radiation changes according to the temperature of the object. Depending on the material and surface properties, the emitted radiation lies in a wavelength spectrum of approximately 1 to 20 μm. The intensity of the infrared radiation (”heat radiation”) is dependent on the material. For many substances this material-dependent constant is known. It is referred to as ”emissivity value”, see appendix, see section .9.2 Typical Emissivity Values, page 55.
Infrared thermometers are optical-electronic sensors. These sensors are able to detect ”radiation of heat”. Infrared thermometers are made up of a lens, a spectral filter, a sensor, and an electronic signal-processing unit. The task of the spectral filter is to select the wavelength spectrum of interest. The sensor converts the infrared radiation into an electrical parameter. The connected electronics generate electrical signals for further analysis. As the intensity of the emitted infrared radiation is dependent on the material, the required emissivity can be selected on the sensor.
The biggest advantage of the infrared thermometer is its ability to measure in the absence of contact. Consequently, surface temperatures of moving or hard to reach objects can easily be measured.

3.2 Distance and Spot Size

The desired spot size on the target will determine the maximum measurement distance and the necessary focus length of the optical module. To avoid erroneous readings the target spot size must contain the entire field of view of the sensor. Consequently, the sensor must be positioned so the field of view is the same as or smaller than the desired target size. For a list indicating the available focus models and their parameters see Figure 2: Optical Diagrams page 11.

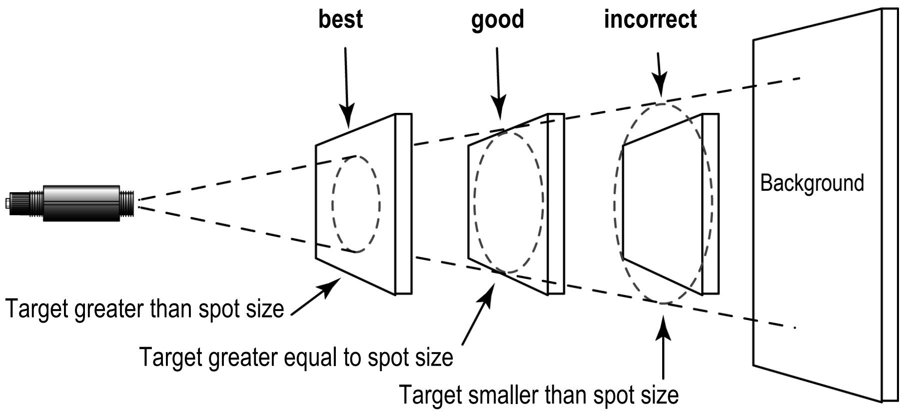


Figure 8: Proper Sensor Placement

3.3 Ambient Temperature

The sensing head is designed for measurements in ambient temperatures between 0 and 70°C (32 to 158°F).

3.4 Atmospheric Quality

In order to prevent damage to the lens and erroneous readings, the lens should always be protected from dust, smoke, fumes, and other contaminants. For this purpose an air purge collar is available. You should only use oil free, clean "instrument" air.

3.5 Electrical Interference

To minimize electrical or electromagnetic interference, follow these precautions:

- Mount the sensor as far away as possible from possible sources of interference such as motorized equipment producing large step load changes.
- Ensure a fully insulated installation of the sensor (Avoid ground loops!).
- Make sure the shield wire in the sensor cable is earth grounded at one location.

3.6 Emissivity of Target Object

Determine the emissivity of the target object as described in appendix 9.1 Determination of Emissivity page 55. If emissivity is low, measured results could be falsified by interfering infrared radiation from background objects (such as heating systems, flames, fireclay bricks, etc. close beside or behind the target object). This type of problem can occur when measuring reflecting surfaces and very thin materials such as plastic films and glass.
This measuring error when measuring objects with low emissivity can be reduced to a minimum if particular care is taken during installation, and the sensing head is shielded from these reflecting radiation sources.

4 Operation

4.1 DIN Quick Connection

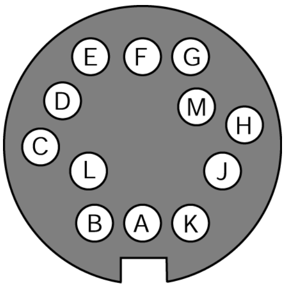


Figure 9: Plug (Connection side, not the solder side)

Pin	Designation	Conductor
M	24 VDC	red
L	GND	black
A	FTC1	black
B	FTC2	white
D	RS485-A	purple
C	RS485-B	grey
F	FTC3	yellow
E	Shield	clear
J	Output +	green
K	Output –	brown
H	Relay NO/NC	blue
G	Relay COM	orange

Table 1: Connections

Terminal Block

Sensor cables can be ordered in several lengths. They come with a 12-pin DIN plug on one end and bare wires on the other. There are two temperature versions available: up to 200°C/392°F (XXX2CCB…) and up to 105°C/221°F (XXX2CLTCB…).
An external terminal block is included with each sensor cable and is labeled as shown in the figure below.

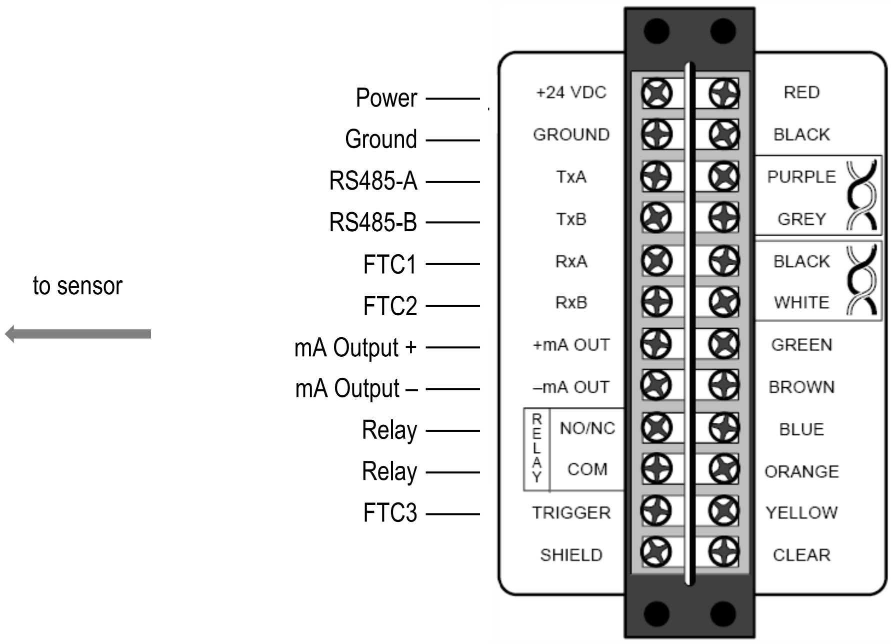
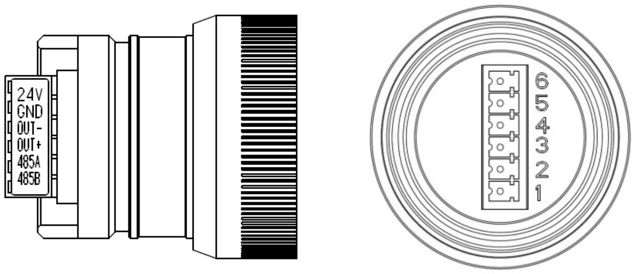


Figure 10: Terminal Block

4.2 Terminal Strip Connection



Pin	Designation	Conductor
1	U_{in} (24 VDC)	red
2	GND In	purple
3	Output –	yellow
4	Output +	green
5	RS485-A	blue
6	RS485-B	orange

Figure 11: Plug

Figure 12: Connection

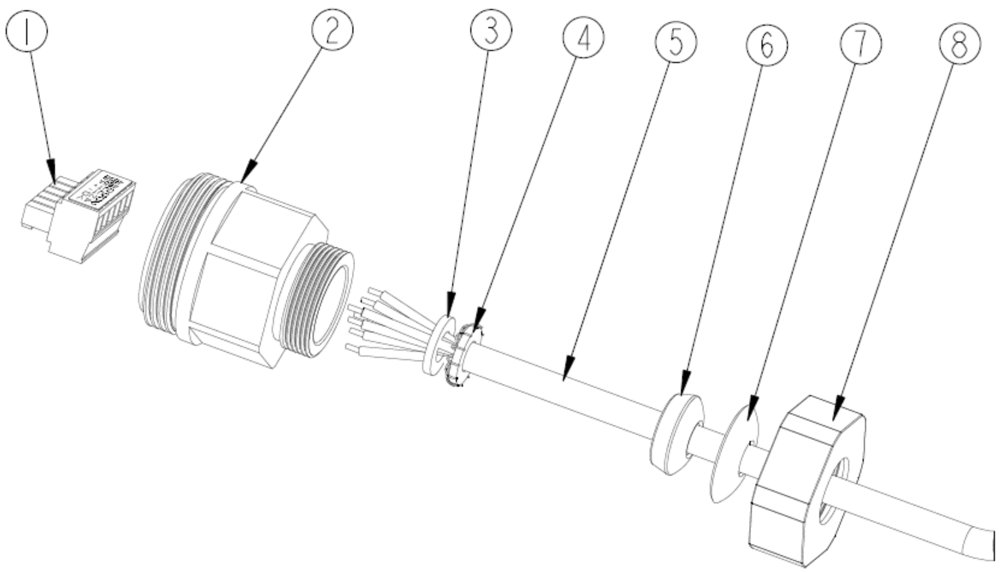
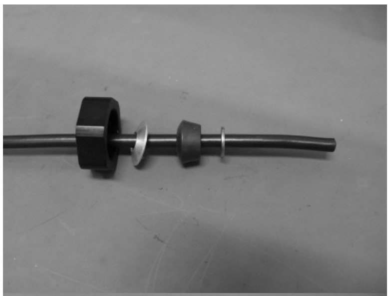


Figure 13: Cable Connection

1. Terminal connector **2**. Seal-cap **3. 4.** washer **5.** 6-cores cable **6.** relief bushing **7.** arc-plate **8.** End nut

Sensor cables can be ordered in several lengths (XXXXRLTCB…). The cable withstands up to 85°C (185°F).
By using your ones, use only cable with outside diameter from 5.2 to 6.5 mm (AWG 24).

The cable must include shielded wires. It should not be used as a strain relief!

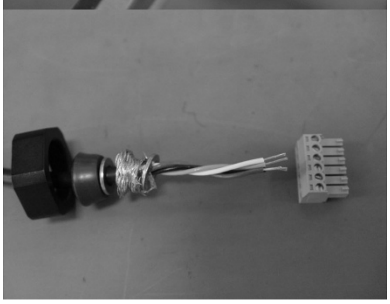


Put the following on the cable: the one of metal washers (4), the relief bushing (6), the arc-plate (7) and the end nut (8).

Cut about 60 mm (2.3 in) of the cable sheath from the end of the cable. Caution! Be careful! Do not cut into the shield!

Use another metal washer (3) to put the cable shield spread into the two washers.

Clip the shield to fit the size of washers.



Strip 5 mm (.15 in) of insulation from the wires (6).

Operation

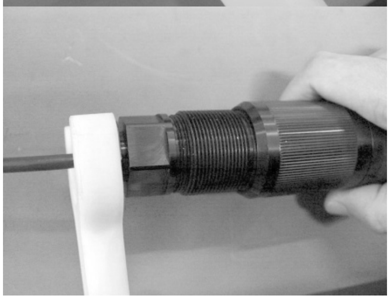
Put the seal-cap (2) on the cable. Screw the end nut (8) and seal-cap (2) together, not too tight. Keep the cable revolve freely.

Connect the wires to terminal connector (1).

Plug the connector (1) in unit.

Hold the cable tightly. Screw the seal-cap (2) to the unit. Keep the cable don’t revolve with the seal-cap (2).

Screw up the seal cap (2) by spanner or by hand.



Screw up the end nut (8) by spanner or by hand.

4.3 Operation Modes

Opening the Sensor

To open the sensor, screw the cab on the right side and then push it further to the right until it hold from the second thread.

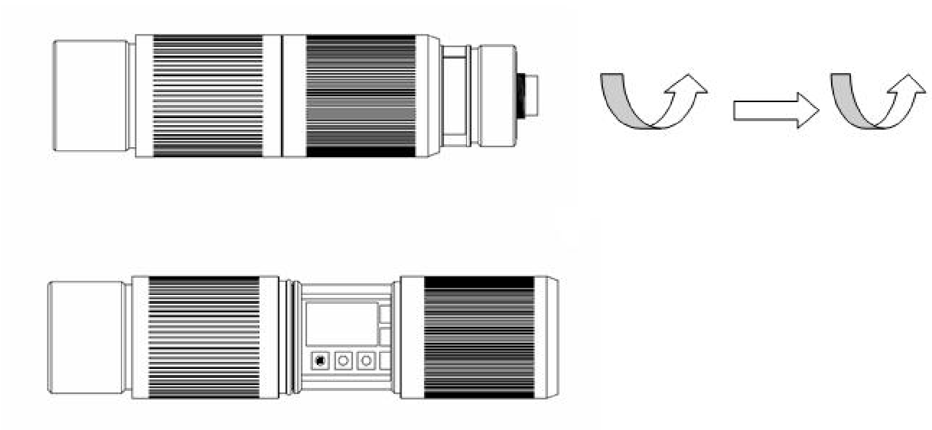


Figure 14: Opening the Sensor

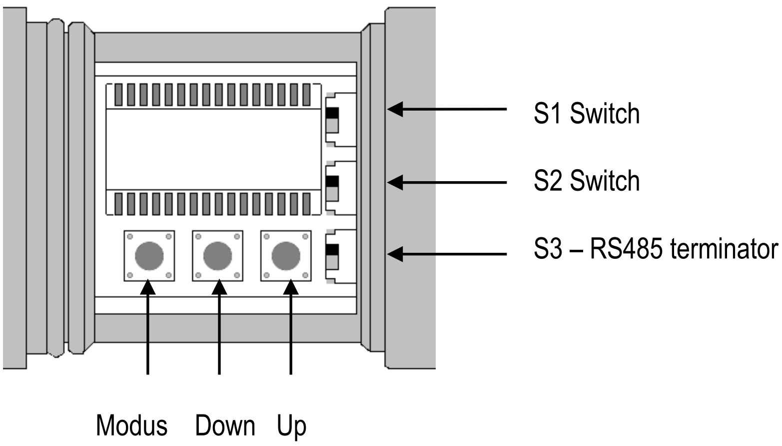


Figure 15: Operating Elements

Operation

User Interface and Sensor Programming

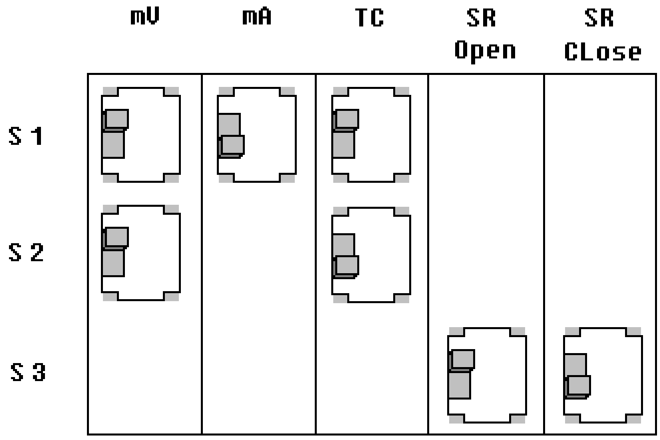
You can easily make adjustments inside the electronic housing. The actual function mode is shown on the display. Use the Mode button to choose a parameter. Change the value using the <Up> and <Down> buttons.

Display	Mode	Range (to modify: Up- and Down buttons)
T	Actual Target Temperature (processed)	Not adjustable
C	Actual Target Temperature (not processed)	Not adjustable
A	Messkopftemperatur	Not adjustable
	Output Mode	mV mV output setting (default) 4 - 20 4 - 20 mA current loop 0 - 20 0 - 20 mA current loop TCJ J Thermocouple**** TCK K Thermocouple****
E	Emissivity	0.100 ... 1.000 (default: 0.950)
T	Transmissivity	0.100 ... 1.000 (default: 1.000)
A	Signal Output Mode: Average*	0.100 ... 999.0
P	Signal Output Mode: Peak Hold*	0.100 ... 998.9 999 = infinite (P ∞)
V	Signal Output Mode: Valley Hold*	0.100 ... 998.9 999 = infinite (V ∞)
L	Low end of range	L = -40 ... 600 (default: depends on model)
H	High end of range	H = -40 ... 600 (default: depends on model)
U	Unit	°C oder °F (default: C)
M	Multidrop address	1 ... 32, --- means 0 (single unit)
R	Relay Output Mode**	0 Open 1 Close 2 NO Target Temperature high 3 NC Target Temperature high 4 NO Internal Sensor Temperature high 5 NC Internal Sensor Temperature high
X	Low Scale output*	0 Off 1 On
Y	High Scale output*	0 Off 1 On
S	Laser Switch***	0 Off 1 On 2 Controlled by FTC3**

* not simultaneously
** only available with DIN Quick connection (12 pin)
*** only available on LT sensors with laser
**** only available with Terminal Strip connection (6 pin)

Table 2: Settung of a mode

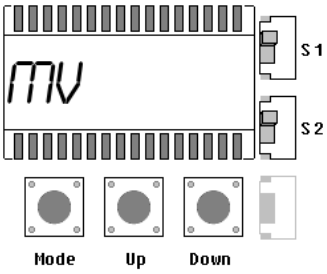
Switch functions:



SR: Shunt Resistor (RS485 terminator)

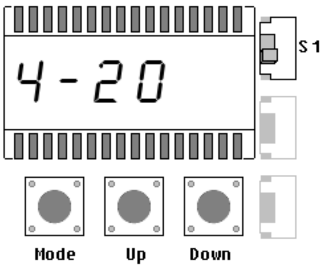
0-5V Output Mode (default)

Set the S1 and S2 to <mV> position. Use the <Down> button, until <mV> appears. Press <Mode> button.



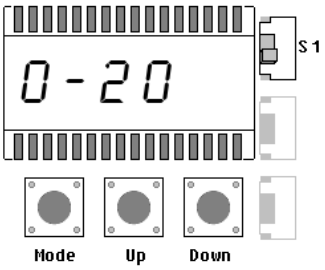
4-20 mA Output Mode

Set the S1 to <mA> position. Use the <Down> button, until <4-20> appears. Press <Mode> button.



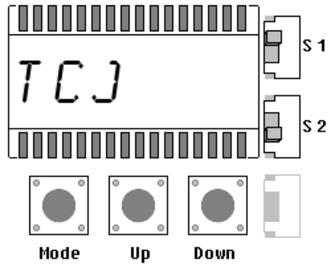
0-20 mA Output Mode

Set the S1 to <mA> position. Use the <Down> button, until <0-20> appears. Press <Mode> button.



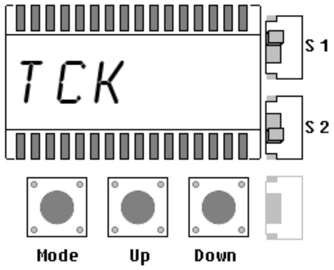
J Thermocouple Output Mode

Set the S1 and S2 to <TC> position. Use the <Down> button, until <TCJ> appears. Press <Mode> button.
Thermocouple output available only with terminal block connections.



K Thermocouple Output Mode

Set the S1 and S2 to <TC> position. Use the <Down> button, until <TCK> appears. Press <Mode> button.
Thermocouple output available only with terminal block connections.



4.4 Post Processing

4.4.1 Averaging

Averaging is used to smooth the output signal. The signal is smoothed depending on the defined time basis. The output signal tracks the detector signal with significant time delay but noise and short peaks are damped. Use a longer average time for more accurate damping behavior. The average time is the amount of time the output signal needs to reach 90% magnitude of an object temperature jump.
Attention: The disadvantage of averaging is the time delay of the output signal. If the temperature jumps at the input (hot object), the output signal reaches only 90% magnitude of the actual object temperature after the defined average time.

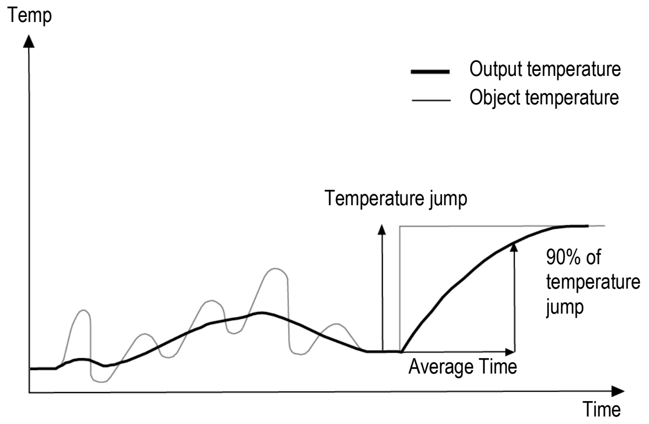


Figure 16: Averaging

A low level input (GND) at external input FTC3 will promptly interrupt the averaging and will start the calculation again.

4.4.2 Peak Hold

The output signal follows the object temperature until a maximum is reached. The output will „hold" the maximum value for the selected duration of the hold time. Once the hold time is exceeded, the peak hold function will reset and the output will resume tracking the object temperature until a new peak is reached. The range for the hold time is 0.1 to 998.9 s.

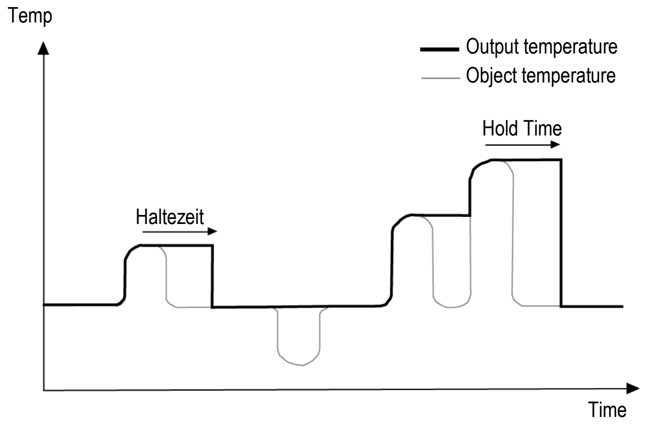


Figure 17: Peak Hold

A defined hold time of 999 s (symbol "∞" in the display) will put the device into continuous peak detection mode.
A low level input (GND) at external input FTC3 will promptly interrupt the hold time and will start the maximum detection again.

4.4.3 Valley Hold

The output signal follows the object temperature until a minimum is reached. The output will „hold" the minimum value for the selected duration of the hold time. Once the hold time is exceeded, the valley hold function will reset and the output will resume tracking the object temperature until a new valley is reached. The range for the hold time is 0.1 to 998.9 s

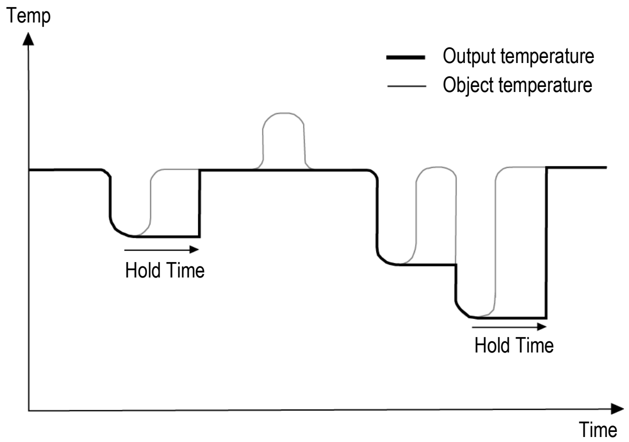


Figure 18: Valley Hold

A defined hold time of 999 s (symbol "∞" in the display) will put the device into continuous valley detection mode.
A low level input (GND) at external input FTC3 will promptly interrupt the hold time and will start the minimum detection again.

4.4.4 Advanced Peak Hold

This function searches the sensor signal for a local maximum (peak) and writes this value to the output until a new local maximum is found. Before the algorithm restarts its search for a local maximum, the object temperature has to drop below a predefined threshold. If the object temperature rises above the held value, which has been written to the output so far, the output signal follows the object temperature again. If the algorithm detects a local maximum while the object temperature is currently below the predefined threshold, the output signal jumps to the new maximum temperature of this local maximum. Once the actual temperature has passed a maximum above a certain magnitude, a new local maximum is found. This magnitude is called hysteresis.

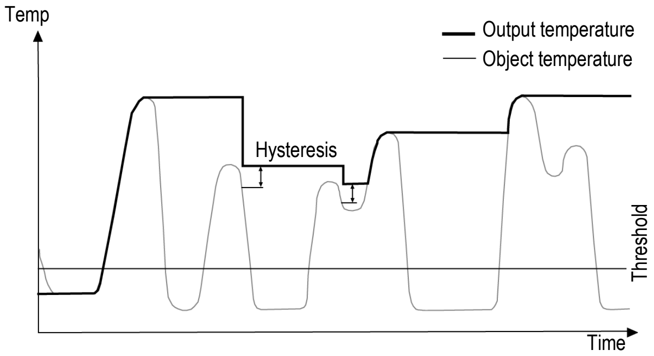


Figure 19: Advanced Peak Hold

The advanced peak hold function is only adjustable by means of the DataTemp Multidrop Software.

4.4.5 Advanced Valley Hold

This function works similar to the advanced peak hold function, except that it will search the signal for a local minimum.

4.4.6 Advanced Peak Hold with Averaging

The output signal delivered by the advanced peak hold functions tends to jump up and down. This is due to the fact, that only maximum points of the otherwise homogenous trace will be shown. The user may combine the functionality of the peak hold function with the averaging function by choosing an average time, thus, smoothing the output signal for convenient tracing.

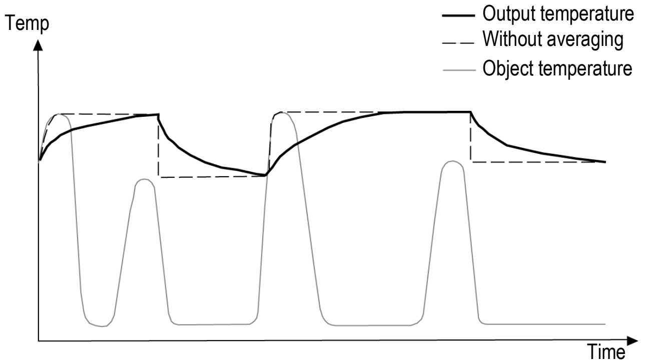


Figure 20: Advanced Peak Hold with Averaging

The advanced peak hold function with averaging is only adjustable by means of the DataTemp Multidrop Software.

4.4.7 Advanced Valley Hold with Averaging

This function works similar to the advanced peak hold function with averaging, except it will search the signal for a local minimum.

4.5 Inputs FTC

The three inputs FTC1, FTC2, and FTC3 are used for the external control of the unit.

The inputs FTC1, FTC2, and FTC3 are controllable via the DataTemp Multidrop Software!

	FTC1	FTC2	FTC3
Emissivity value (analog input)	x		
Emissivity value (digital input)	x	x	x
Ambient Temperature Compensation		x	
Trigger/Hold/Laser			x

Table 1: Use of the external inputs

4.5.1 Emissivity Setting (analog)

The FTC1 input can be configured to accept an analog voltage signal (0 to 5 VDC) to provide real time emissivity setting. Each input can support one head. The following table shows the relationship between input voltage and emissivity:

U in V	0.0	0.5	...	4.5	5.0
Emissivity	0.1	0.2	...	1.0	1.1

Table 2: Ratio between Analog Input Voltage and Emissivity

Example:
This process requires setting the emissivity:
- for product 1: 0.90
- for product 2: 0.40

Following the example below, the operator needs only to switch to position "product 1" or "product 2".

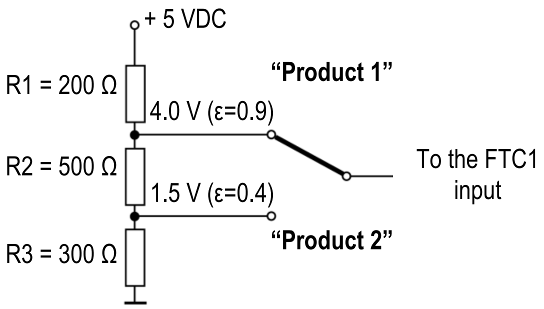


Figure 21: Adjustment of Emissivity at FTC Input (Example)

4.5.2 Emissivity Setting (digital)

The electronics of the sensors contains a table with 8 pre-installed settings for emissivity. To activate these emissivity settings, you need to have the inputs FTC1, FTC2, and FTC3 connected. According to the voltage level on the FTC inputs, one of the table entries will be activated.

0 = Low signal (input at 0 V)
1 = High signal (input at 5 V)

A non-wired input is considered as High signal!

Table Entry	Emissivity (Example)	FTC3	FTC2	FTC1
0	1.100	0	0	0
1	0.500	0	0	1
2	0.600	0	1	0
3	0.700	0	1	1
4	0.800	1	0	0
5	0.970	1	0	1
6	1.000	1	1	0
7	0.950	1	1	1

Figure 22: Digital Selection of Emissivity with FTC Inputs

The values in the table are controllable via the DataTemp Multidrop software only.

(01943) 602001 @ sales@issltd.co.uk www.issltd.co.uk

4.5.3 Ambient Temperature Compensation

The sensor is capable of improving the accuracy of target temperature measurements by taking into account the ambient or background temperature. This feature is useful when the target emissivity is below 1.0 and the background temperature is significantly hotter than the target temperature. For instance, the higher temperature of a furnace wall could lead to hotter temperatures being measured especially for low emissivity targets.
Ambient background temperature compensation allows for the impact of reflected radiation in accordance with the reflective behavior of the target. Due to the surface structure of the target, some amount of ambient radiation will be reflected and therefore, added to the thermal radiation that is collected by the sensor. The ambient background temperature compensation adjusts the final result by subtracting the amount of ambient radiation measured from the sum of thermal radiation the sensor is exposed to.

The ambient background temperature compensation should always be activated in case of low emissivity targets measured in hot environments or when heat sources are near the target!

Three possibilities for ambient background temperature compensation are available:

- The **internal sensing head temperature** is utilized for compensation assuming that the ambient background temperature is more or less represented by the internal sensing head temperature. This is the default setting.
- If the background ambient temperature is known and constant, the user may give the known ambient temperature as a **constant temperature value**.
- Ambient background temperature compensation from a **second temperature sensor** (infrared or contact temperature sensor) ensures extremely accurate results. For example, a second IR sensor, configured to provide a 0 to 5 volt output scaled for the same temperature range as the target can be connected to input FTC2 to provide real-time ambient background compensation.

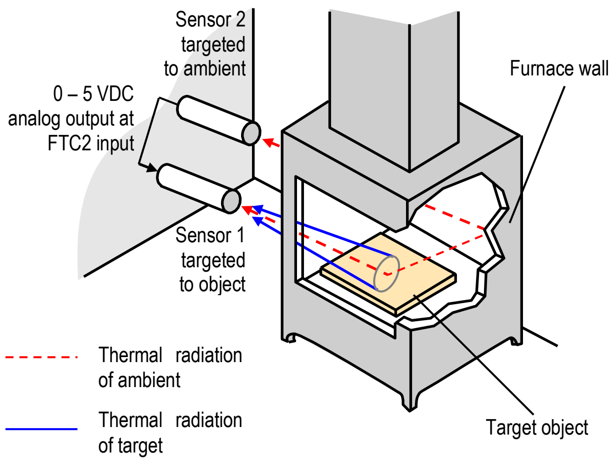


Figure 23: Principle of Ambient Background Temperature Compensation

4.5.4 Trigger/Hold/Laser

The external FTC3 input can be used either as Trigger or Hold or as Laser switch.

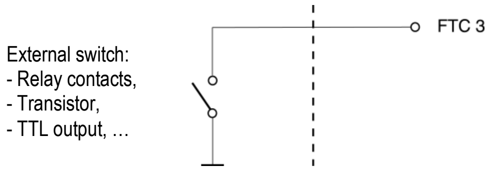


Figure 24: Wiring the FTC3 Input

Trigger: A logical low signal at the input FTC3 will reset the peak or valley hold function. As long as the input is kept at logical low level, the software will transfer the actual object temperatures toward the output. At the next logical high level, the hold function will be restarted.

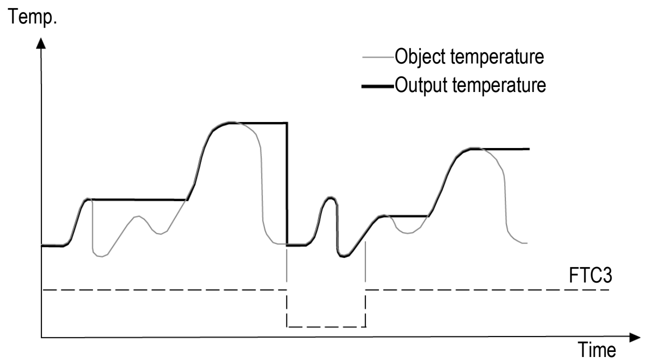


Figure 25: FTC3 for Resetting the Peak Hold Function

Hold: This mode acts as an externally generated hold function. A transition at the input FTC3 from logical high level toward logical low level will transfer the current temperature toward the output. This temperature will be written to the output until a new transition from high to low occurs at the input FTC3.

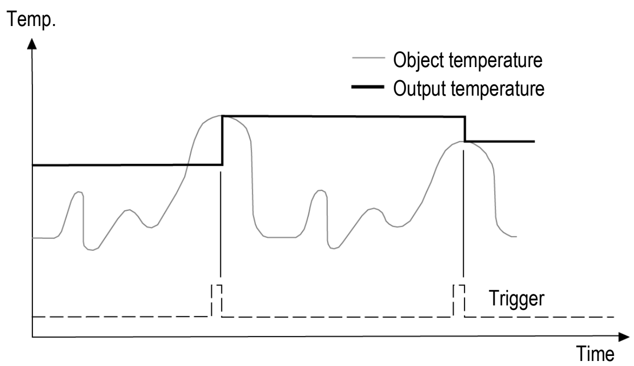


Figure 26: FTC3 for Holding the Output Temperature

Laser: This mode acts as external triggered laser switch. A logical high signal applied at the input FTC3 will activate the laser.

4.6 RS485 Communication

The RS485 serial interface is used for networked sensors or for long distances up to 1200 m (4000 ft). This allows ample distance from the harsh environment where the sensing system is mounted to a control room or pulpit where the computer is located.

4.6.1 PC Connection via USB/RS485 Converter

The USB/RS485 converter is self-powering via the USB connection.

Figure 27: USB/RS485 Converter (XXXUSB485)

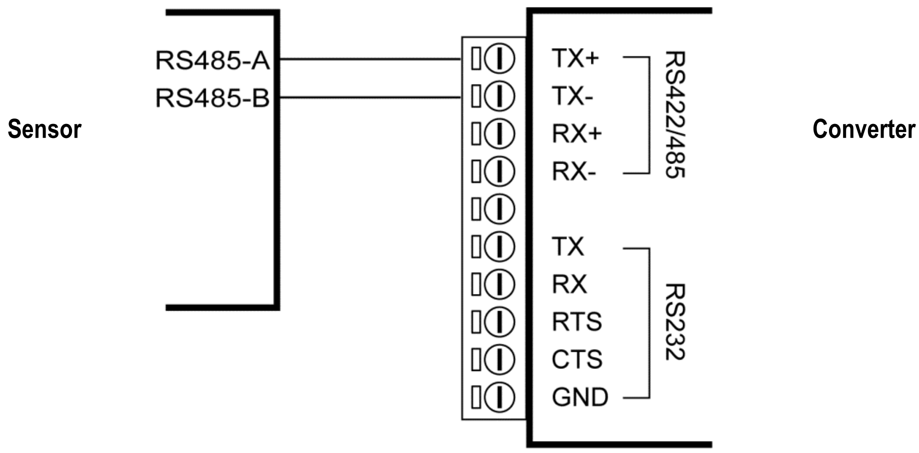
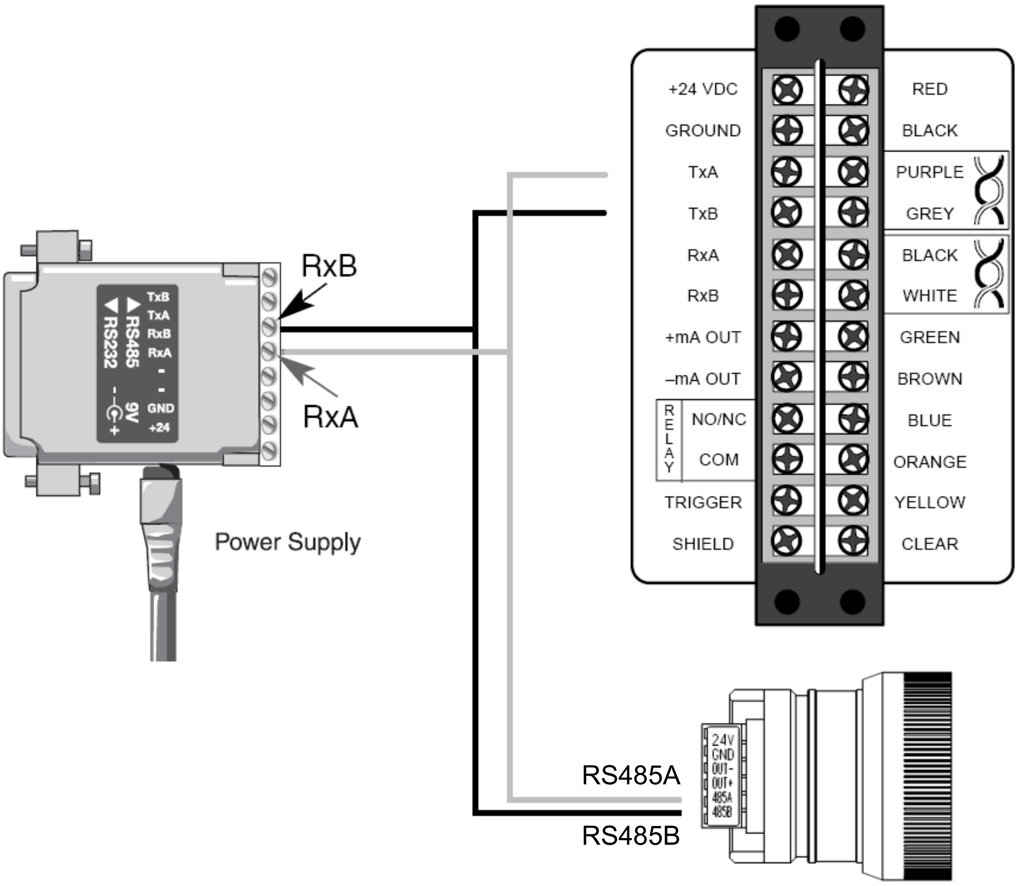


Figure 28: Wiring the Sensor's RS485 Interface (left) with USB/RS485 Converter (right)

4.6.2 PC Connection via RS232/485 Converter

The RS232/485 adapter comes with a power supply:

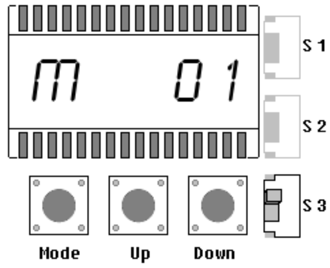
RAYMINCONV2	for 230 VAC
RAYMINCONV1	for 110 VAC



4.6.3 Multiple Sensor Installation

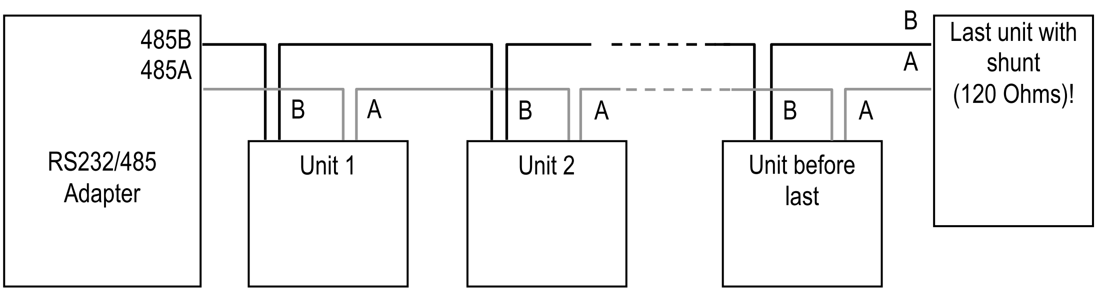
You may connect up to 32 units as shown below. Before units are in a loop the multidrop address needs to be defined. Use only one power supply for all boxes in the network to avoid ground loops!

Multidrop Address
Press <Mode> button until <M> appears. Use <Up> and <Down> to select address number. Press <Mode> again to confirm.



Alternatively you may also use the DataTemp Multidrop Software, see section 6.3.1 Sensor Setup, page 44.

Make sure to deactivate the preset shunt resistor for all units except for the last one. To deactivate the shunt resistor the S3 must be at position <open>.



4.7 Factory Defaults

Hold <Down> button and press <Mode> button twice to restore factory defaults.

5 Accessories

5.1 Overview

For all models:

- Mounting Nut XXXTXXACMN
- Fixed Mounting Bracket XXXTXXACFB
- Adjustable Bracket XXXRXXACAB
- Air Purge Collar XXXRXXACAP
- Right Angle Mirror XXXRXXACRA
- Sighting Viewer XXXRXXACSV
- Adjustable Pipe Adapter XXXRXXAPA
- Protective Window for lens protection XXXTXACTW…
- Air/Water-Cooled Housing XXXXRACWC…
- ThermoJacket RAYTXXTJ5
- USB/RS485 Adapter XXXUSB485

  see section 4.6.1 PC Connection via USB/RS485 Converter, page 32.

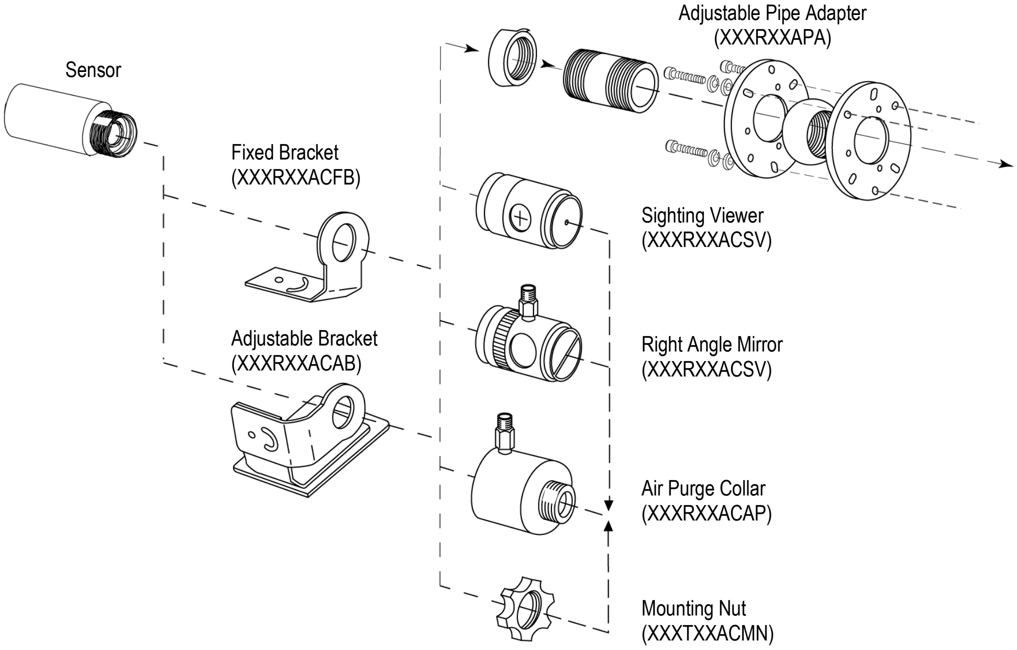


Figure 29: Overview to the available accessories

5.2 Adjustable Bracket

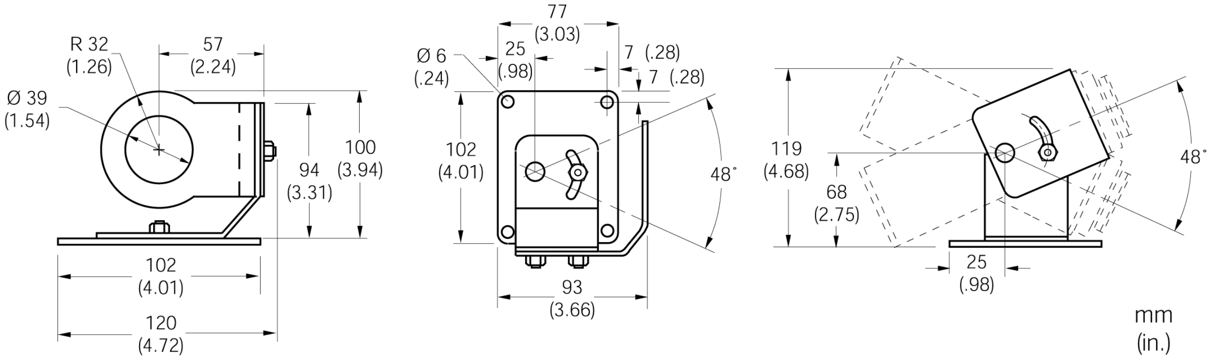


Figure 30: Adjustable Bracket (XXXTXXACAB)

5.3 Air Purge Collar

The Air Purge Collar (XXXTXXACAP) is used to keep dust, moisture, airborne particles, and vapors away from the lens. It can be mounted before or after the bracket. The airflow is passed through 1/8" NPT stainless steel fitting onto the front aperture. Airflow should be a maximum of 0.5 to 1.5 l/s (0.13 to 0.4 gallons/s). Clean, oil free air is recommended.

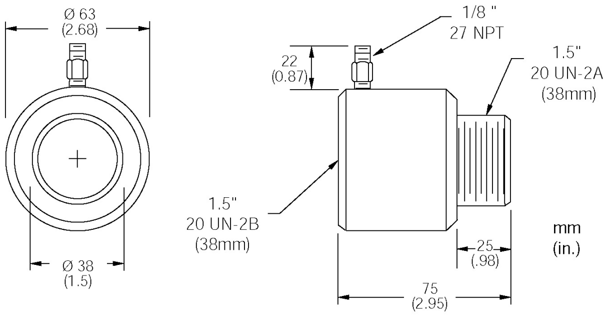


Figure 31: Dimension of Air Purge Collar

5.4 Right Angle Mirror

The Right Angle Mirror (XXXTXXACRA) is used to turn the field of view by 90° against the sensor axis. It is recommended when space limitations or excessive radiation do not allow to directly align the sensor to the target. The mirror must be installed after the bracket and after the Air Purge Collar and screwed in fully. In dusty or contaminated environments, air purging is required to keep the mirror surface clean.

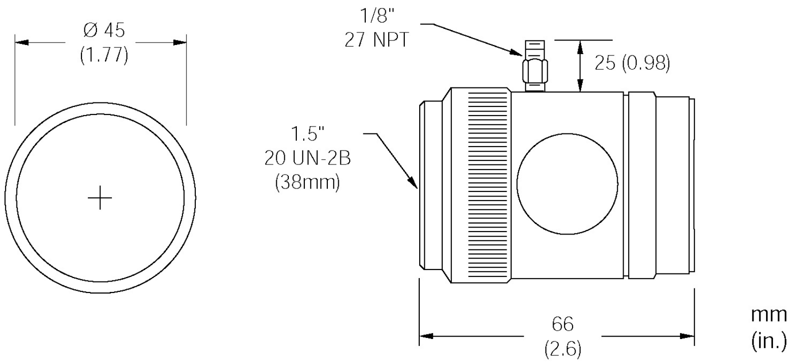


Figure 32: Right Angle Mirror

When using the Right Angle Mirror, adjust the emissivity settings downward by 5%. For example, for an object with an emissivity of 0.65, you adjust the value down to 0.62. This correction accounts for energy losses in the mirror.

5.5 Sighting Viewer

The Sighting Viewer (XXXTXXACSV) is used to aid in the alignment of the standard sensor. It is used when the object is small and far from the sensor as well as when it is difficult to obtain a direct in-line sighting. It can be used both with and without the Air Purge Collar, but not with the Right Angle Mirror. First secure the sensor to the bracket using the mounting nut or the Air Purge Collar. Next screw on the Sighting Viewer Tool fully. Now, position and secure the bracket. When the alignment is complete, do not forget to remove the Sighting Viewer Tool.
The Sighting Viewer Tool has the same dimensions as the Right Angle Mirror.

5.6 Adjustable Pipe Adapter

The adjustable pipe adapter (XXXTXXACPA) is available to connect a sighting tube or conduit to a sensor with or without water/air cooled housing.

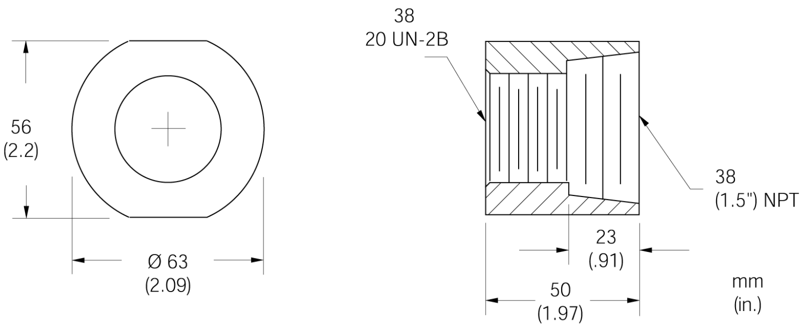


Figure 33: Adjustable Pipe Adapter

5.7 Protective Window

Protective windows can be used to protect the sensor's optic against dust and other contaminations. For sensors with plastic lenses the use of a protective window combined with the air purge is strongly recommended.
The following table provides an overview of the available protective windows. All protective windows have a transmission below 100%.

Order number	For model	Designation	Material	Transmissivity	Use
XXXTXACTWX	LT	none	Zinc Sulfide	0.75 ±0.05	for LT sensors with laser
XXXTXACTWXS	LT	none (stainless steel)	Zinc Sulfide	0.75 ±0.05	for LT sensors with laser
XXXTXACTWL	LT	none	Amtir	0.65 ±0.05	max. 300°C (572°F)
XXXTXACTWLF1	LT	none (stainless steel)	Polyethylene foil	0.75 ±0.05	for food applications, non-poisonous, non-fragile
XXXTXACTWM	MT	4 red dots	Sapphire	0.88 ±0.05	max. 1800°C (3272°F)
XXXTXACTWGP	P7, G5	2 red dots	Calcium Fluoride	0.93 ±0.05	max. 600°C (1112°F)

Table 3: Protective Windows

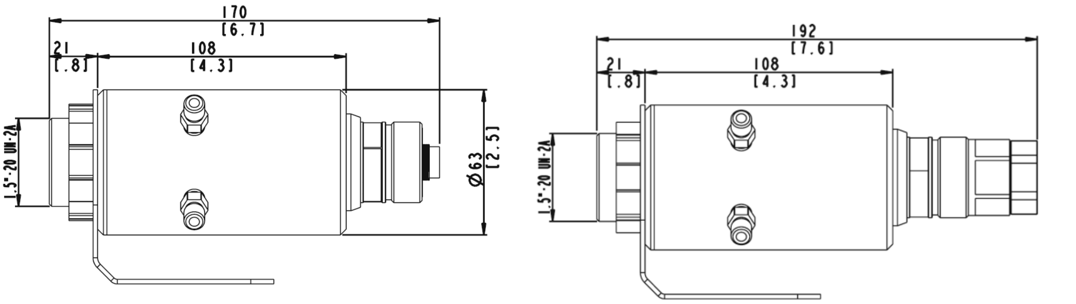
Determination of transmissivity of an unknown protective window:
If transmissivity of the measuring screen is not indicated on the data sheet, you can also determine the transmissivity yourself. Please proceed as follows:

1. Measure the temperature of the target object with the sensing head, without using the protective window. Note correct setting of emissivity.
2. Insert the protective window in the sensing head.
3. Adjust the transmissivity in the software until the same temperature is displayed, as it was determined without the protective window.

For more information regarding the mounting of a protective window, see section 8.5 Replacing a Protective Window, page 54.

5.8 Air/Water-Cooled Housing

The Air/Water-Cooled Housing accessory allows the sensor to be used in ambient temperatures up to 120°C (250°F) with air-cooling, and 180°C (356°F) with water-cooling. The cooling media should be connected using 1/8″ NPT fittings. Air flow should be 1.4 to 2.5 l/sec at 25°C (77°F). Water flow should be approximately 1.0 to 2.0 l/min (water temperature between 10 and 27°C (50 to 80.6°F). Chilled water below 10°C (50°F) is not recommended, see section 5.8.1 Connecting, page 40.
The Air/Water-Cooled Housing is available in stainless steel (…S) and aluminum (...A) and includes the air purge collar.



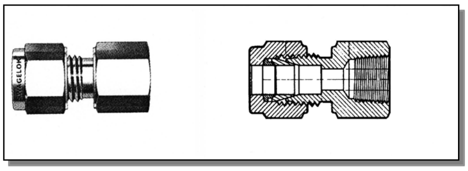
Sensor with DIN quick connector Sensor with terminal strip connection mm [in]

Figure 34: Air/Water-Cooled Housing

5.8.1 Connecting

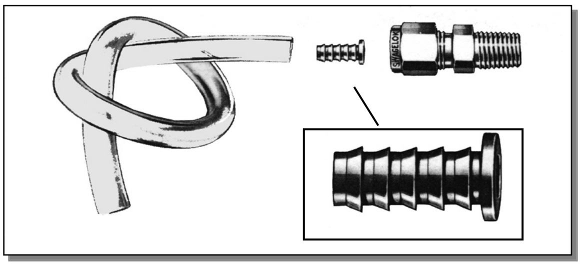
As a standard the cooled housing is supplied with fittings and non-metric 1/8″ NPT threads. If you intend to supply the cooling media through pipes or hoses, consider the following information.

- Thread Adapter - metric pipe to NPT inside thread
- Thread Adapter - inch-type pipe to NPT inside thread



Inner Thread NPT (in.)	Pipe Outer Ø
1/8	4 mm (0.16 in)
1/8	6 mm (0.24 in)
1/8	8 mm (0.31 in)
Inner Thread NPT (in.)	**DIN-ISO-Outer Thread**
1/8	4 mm (0.16 in)

- Supporting tube for PVC or Tygon hoses



Schlauchaußen Ø	Schlauchinnen Ø
6 mm	4 mm
8 mm	6 mm

5.8.2 Avoidance of Condensation

If environmental condition makes water cooling necessary, it is strictly recommended to check whether condensation will be a real problem or not.
Water cooling also causes a cooling of the air in the inner part of the device. Thereby the capability of the air to store water decreases. The relative humidity increases and can reach 100% very quickly. In case of a further cooling, the surplus water steam will come out as water (condensation). The water will condense on the lenses and the electronics resulting in possible damage to the sensor. Condensation can even happen on an IP65 sealed housing.

There is no warranty repair possible in case of condensed water within the housing!

To avoid condensation, the temperature of the cooling media and the flow rate have to ensure a **minimum** device temperature. The minimum device temperature depends on the ambient temperature and the relative humidity, please consider the following table.

Relative Humidity [%]

Ambient Temperature [°C/°F]	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
0/32	0/32	0/32	0/32	0/32	0/32	0/32	0/32	0/32	0/32	0/32	0/32	0/32	0/32	0/32	0/32	0/32	0/32	0/32	0/32
5/41	0/32	0/32	0/32	0/32	0/32	0/32	0/32	0/32	0/32	0/32	0/32	0/32	0/32	0/32	0/32	0/32	0/32	0/32	5/41
10/50	0/32	0/32	0/32	0/32	0/32	0/32	0/32	0/32	0/32	0/32	0/32	0/32	0/32	5/41	5/41	5/41	5/41	5/41	10/50
15/59	0/32	0/32	0/32	0/32	0/32	0/32	0/32	0/32	0/32	5/41	5/41	5/41	5/41	10/50	10/50	10/50	10/50	10/50	15/59
20/68	0/32	0/32	0/32	0/32	0/32	0/32	5/41	5/41	5/41	10/50	10/50	10/50	10/50	15/59	15/59	15/59	15/59	15/59	20/68
25/77	0/32	0/32	0/32	0/32	5/41	5/41	10/50	10/50	10/50	10/50	15/59	15/59	15/59	20/68	20/68	20/68	20/68	20/68	25/77
30/86	0/32	0/32	0/32	5/41	5/41	10/50	10/50	15/59	15/59	15/59	20/68	20/68	20/68	20/68	25/77	25/77	25/77	25/77	30/86
35/95	0/32	0/32	5/41	10/50	10/50	15/59	15/59	20/68	20/68	20/68	25/77	25/77	25/77	25/77	30/86	30/86	30/86	30/86	35/95
40/104	0/32	5/41	10/50	10/50	15/59	20/68	20/68	20/68	25/77	25/77	25/77	30/86	30/86	30/86	35/95	35/95	35/95	35/95	40/104
45/113	0/32	10/50	15/59	15/59	20/68	25/77	25/77	25/77	30/86	30/86	35/95	35/95	35/95	35/95	40/104	40/104	40/104	40/104	45/113
50/122	5/41	10/50	15/59	20/68	25/77	25/77	30/86	30/86	35/95	35/95	35/95	40/104	40/104	40/104	45/113	45/113	45/113	45/113	50/122
60/140	15/59	20/68	25/77	30/86	30/86	35/95	40/104	40/104	40/104	45/113	45/113	50/122	50/122	50/122	50/122	50/122	50/122	50/122	60/140
70/158	20/68	25/77	35/95	35/95	40/104	45/113	45/113	50/122	50/122	50/122	50/122	50/122	60/140	60/140	60/140	60/140	60/140	60/140	70/158
80/176	25/77	35/95	40/104	45/113	50/122	50/122	50/122	60/140	60/140	60/140	60/140	60/140	70/158	70/158	70/158	70/158	70/158	70/158	80/176
90/194	35/95	40/104	50/122	50/122	50/122	60/140	60/140	60/140	70/158	70/158	70/158	70/158	80/176	80/176	80/176	80/176	80/176	80/176	90/194
100/212	40/104	50/122	50/122	60/140	60/140	70/158	70/158	70/158	80/176	80/176	80/176	80/176	80/176	90/194	90/194	90/194	90/194	90/194	100/212

Tab. 4: Minimum device temperatures [°C/°F]

Temperatures higher than 60°C / 140°F are not recommended due to the temperature limitation of the device.

Example:

Ambient temperature = 50 °C
Relative humidity = 40 %
Minimum device temperature = 30 °C

The use of lower temperatures is at your own risk!

5.9 ThermoJacket

The ThermoJacket gives you the ability to use the sensor in ambient temperaturesup to 315°C (600°F). The ThermoJacket's rugged cast aluminum housing completely encloses the sensor and provides water and/or air cooling and air purging in one unit. The sensor can be installed or removed from the ThermoJacket housing in its mounted position.

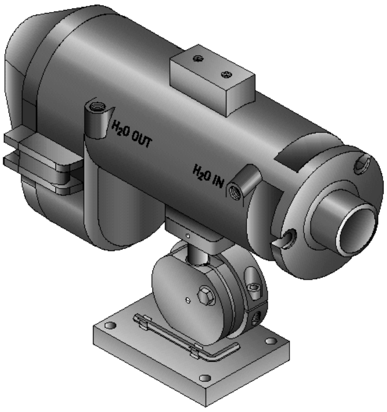


Figure 35: ThermoJacket with Mounting Base

For more information see the ThermoJacket's manual.

6 Software

6.1 Requirements

- PC with Windows 2000/XP/Vista/Win7, 64 MB RAM minimal memory
- about 10 MB free memory on the hard disc for program files

6.2 Software Installation

Make sure any sensor or sensors are turned on before running the program. The Startup Wizard runs the first time you use the program.

Software Start

1. The Startup Wizard runs the first time you use the program. After the first saving your settings, the program starts at the Main screen.
2. The <Open an Existing Configuration> button opens a dialog for selecting an already existing configuration file. Clicking on the <Create a New Configuration> button will call up the Startup Wizard.
3. Choose the appropriate communications COM port. Note that only available ports are active. Select the <**ASCII protocol**> from the drop-down list.
4. Click the <Continue> button and follow the instructions!

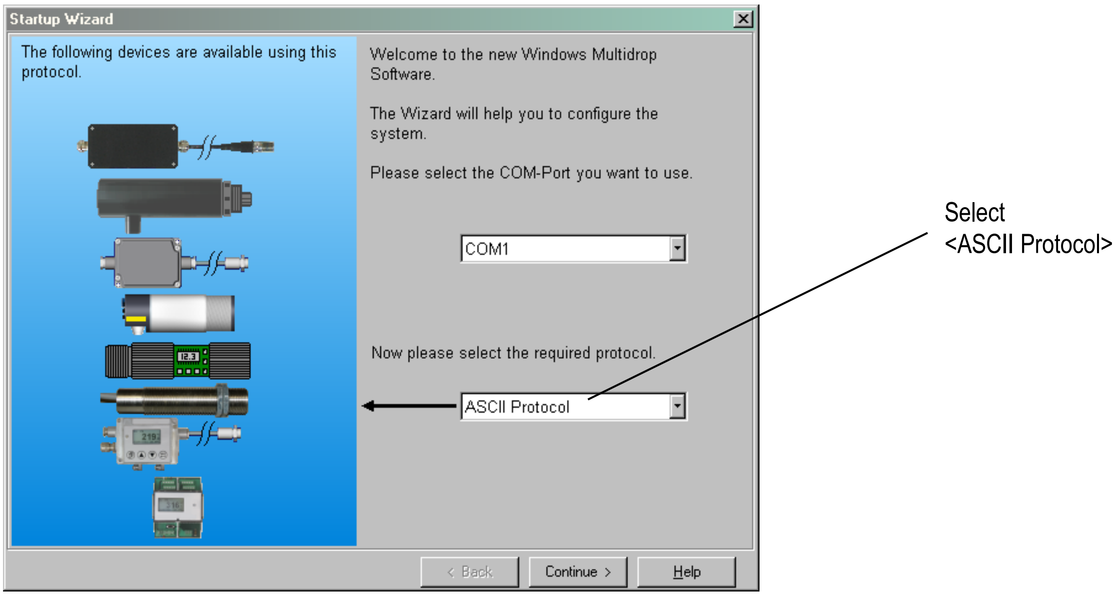


Figure 36: Selection of Communication Protocol

After communication with the devices (real or simulated) is established, a screen showing, how many devices are attached as well as their identification numbers and types of devices. Check here to make sure all installed devices are connected properly

Note: If you notice that not all devices were found, click on the Back button to return to the previous screen, then go check your sensor connections. After checking, click on the <Continue> button so the software rescans for connected devices.

6.3 Setup Menu

6.3.1 Sensor Setup

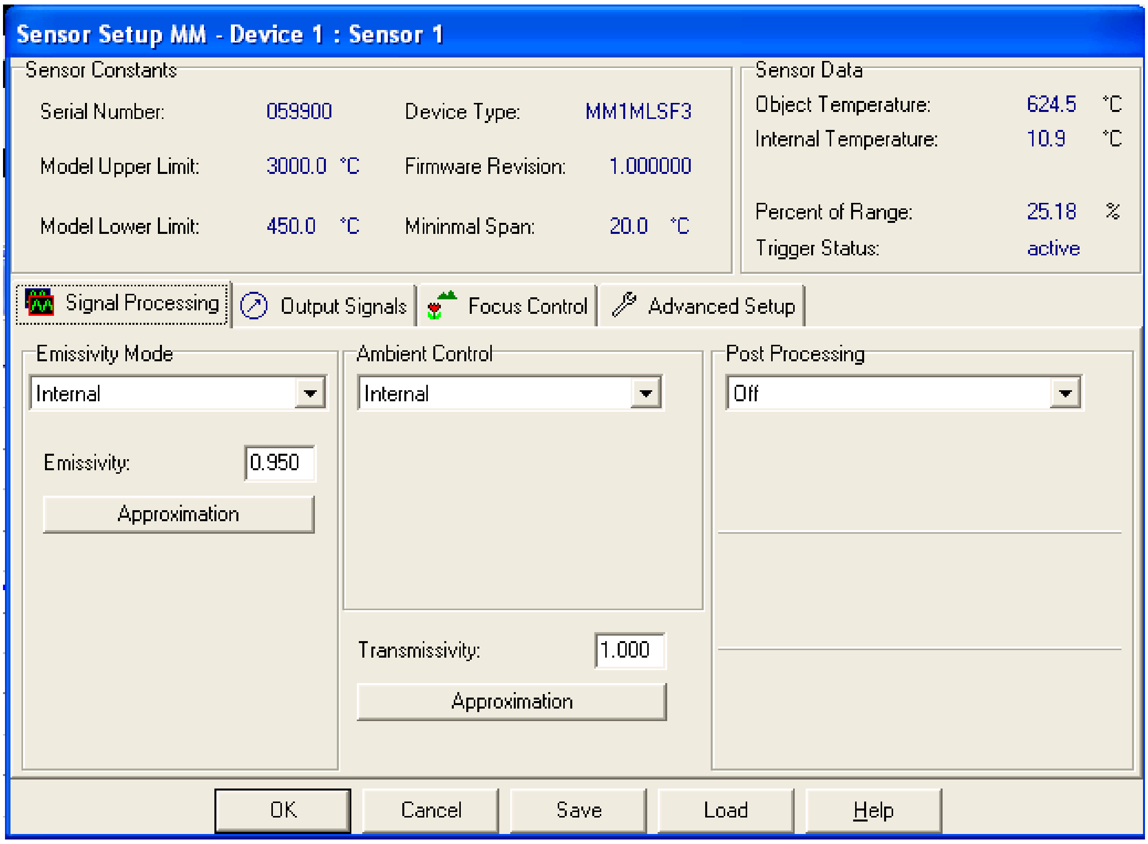


Figure 37: Sensor Setup

Under that dialog you can set up the sensor (emissivity, ambient temperature compensation, signal processing), the outputs (0/4 - 20 mA, alarm relay) and other advanced settings.

Further information you can find under the software online help.

7 Programming

7.1 Transfer Modes

The unit's serial interface is RS485.

Settings: transfer rate: 9.6 kBaud, 8 data bits, 1 stop bit, no parity, flow control: none (half duplex mode).

There are two possible transfer modes for the serial interface:
Poll Mode: By user interface control, a parameter will be set or requested.
Burst Mode: A pre-defined data string ("burst string") will be transferred as fast as possible as long as the burst mode is activated. The data will be transferred in one direction only, from the unit to the user interface.

V=P "P" starts the Poll mode (allows to request or to set parameters)
V=B "B" starts the Burst mode (data will be transferred as fast as possible; necessary: data string definition – "Burst string")
$=UTIE "$" sets the parameter combination ("burst string")
"U" unit (°C or °F)
"T" temperature value
"I" internal temperature of the terminal block connector (terminal block type) or electronics housing (circular type)
"E" emissivity
?X$ gives the burst string parameters while in poll mode

Return from the burst mode to the poll mode:
If the poll mode shall be activated while the burst mode is still active, send a character and within the following 3 seconds the command V=P.

7.2 General Command Structure

Requesting a parameter (Poll Mode)
?E<CR> "?" is the command for "Request"
"E" is the parameter requested
<CR> (carriage return, $0D_h$) is closing the request
It is possible to close with <CR> <LF> ($0D_h$ $0A_h$) but not necessary.

Setting a parameter (Poll Mode)
The parameter will be stored into the device EEPROM.
E=0.975<CR> "E" is the parameter to be set
"=" is the command for "set a parameter"
"0.975" is the value for the parameter
<CR> (carriage return, $0D_h$) is closing the request
It is possible to close with <CR> <LF> ($0D_h$ $0A_h$) but not necessary.

Setting a parameter without writing it into the device EEPROM (Poll Mode)

This function is for test purposes only.

E#0.975<CR> "E" is the parameter to be set
"#" is the command for "set parameter without writing it into the EEPROM"
"0.975" is the value for the parameter
<CR> <LF> ($0D_h$ $0A_h$) is closing the request
It is possible to close with <CR> <LF> ($0D_h$ $0A_h$) but not necessary.

Device response format:

!E0.975<CR><LF> "!" is the parameter for "Answer"
"E" is the Parameter
"0.975" is the value for the parameter
<CR> <LF> ($0D_h$ $0A_h$) is closing the request

After switching the power to "ON", the device is sending a notification:

#XI<CR><LF> "#" is the parameter for "Notification"
"XI" is the value for the notification (here "XI"; unit switches to "ON")
<CR> <LF> ($0D_h$ $0A_h$) is closing the notification.

Error message

Syntax Error "" is the character for "Error"

7.3 Device Setup

7.3.1 Temperature Calculation

U=C Physical Unit for the temperature value
E=0.950 Emissivity setting (Caution: according to the settings for the ES command).
XG=1.000 Setting for transmission

For the calculation of the temperature value, it is possible to set an offset (relative number to be added to the temperature value), and a gain value.

DG=1.0000 Gain adjustment for the temperature signal
DO=0 Offset adjustment for the temperature signal

In case the ambient temperature is not requested by the internal head temperature, you must set the ambient temperature values as follows:

A=250.0 Ambient temperature (example)
AC=1 Choice of compensation temperature value source

7.3.2 Selection of Emissivity and Alarm Outputs

The device allows three choices for the emissivity setting and two for the alarm output setting.

ES Selection of the emissivity setting.
ES=I Emissivity set by a constant number according to the "E" command
ES=E Emissivity set by a voltage on FTC1 (analog input)

ES=D Emissivity set by the entries in a table (selected by digital inputs FTC1 – FTC3), see section 4.5.2 Emissivity Setting (digital), page 28.

?CE asks for the emissivity value that is used for temperature calculation

There are eight entries possible for emissivity setting (1) and a related threshold value (2). To be able to write or read these values, use the following commands:

EP=2 set pointer to line 2 (range: 0 to 7, "table entry") (3)

EV=0.600 set the emissivity value for line 2 to 0.600 (4)

SV=220.0 set the threshold value for line 2 to 220.0 (5)

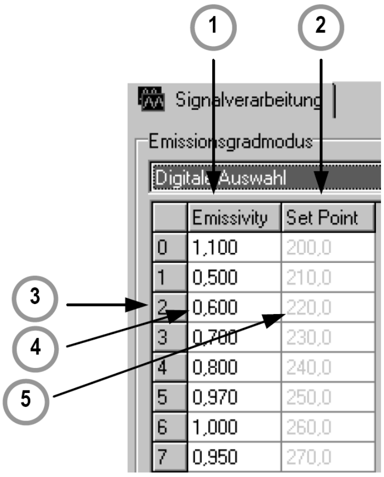


Figure 38: Table Entries for Emissivities and Alarm Thresholds

To activate these emissivity settings, you need to have the 3 external inputs FTC connected. According to the voltage level on the FTC wires, one of the table entries will be activated. See below.

0 = Low signal (active, 0 V)

1 = High signal (5 V)

A not connected input is interpreted as High signal

Table Entry	Emissivity (Example)	FTC3	FTC2	FTC1
0	1.100	0	0	0
1	0.500	0	0	1
2	0.600	0	1	0
3	0.700	0	1	1
4	0.800	1	0	0
5	0.970	1	0	1
6	1.000	1	1	0
7	0.950	1	1	1

Figure 39: Recall of the table entry

The table entries are controllable via the DataTemp Multidrop Software only.

7.3.3 Post Processing

The following parameters can be set to determine the post-processing mode.

P=5	maximum hold, hold time: 5 s
F=12.5	minimum hold, hold time: 12.5 s
G=10	averaging, average time (90%): 10 s
XY=3	advanced maximum hold, hysteresis: 3 K
XY=-2	advanced minimum hold, hysteresis: 2 K
	Advanced Peak/Valley Hold with Averaging:
C=250	advanced hold threshold: 250°C
AA=15	advanced hold with averaging and averaging time (90%): 15 s

7.4 Dynamic Data

The infrared temperature is calculated 50 times a second. To request the dynamic data, following commands are available:

?T	infrared temperature
?I	sensor ambient temperature
?XJ	internal temperature of connector (terminal type) or sensor ambient temperature (circular type)
?Q	energy value of the infra-red temperature
?XT	trigger set point value for the FTC3 analog input

To check for resets (e.g. power shut down) use the command XI. Notice, after a reset the unit is new initialized.

?XI	asks for the reset status
!XI0	no reset occurred
!XI1	a reset occurred, new initialization of the unit
XI=0	sets the reset status back to 0

7.5 Device Control

7.5.1 Controlling the output for the target temperature

The signal output can be set to 4 – 20 mA, 0 – 20 mA or mV. The output can provide a predefined value of full analog range:

XO=4	output mode to 4 – 20 mA
O=25	output of a constant current at 8 mA (25% of 4-20 mA)
O=255	switches back to the temperature controlled output

7.5.2 Analog output, scaling

According to the temperature range of the model, it is possible to set the maximum voltage/current value according to a temperature value (e.g., the maximum current (20 mA) shall represent 200°C). The same setting is possible for the minimum value.

H=500	the maximum current/voltage value is set to 500°C
L=0	the minimum current/voltage value is set to 0°C

Note: You cannot set these values for thermocouple output. The minimum span between the maximum / minimum settings is 20 K.

7.5.3 Alarm output

The opto-coupled alarm output can be function and trigger from various temperature variables:
- Internal sensing head temperature (normally open N.O. or normally closed N.C.)
- Target temperature, to be set to N.C. (relay contacts are closed while home position) or N.O. (relay contacts are open while home position)

K=0	alarm output open
K=4	Sensor head ambient temperature trigger, relay N.O.
K= 2, XS=125.3	Target temperature trigger, relay N.O., threshold setting to 125.3°C (if U=C is set)

7.5.4 Factory default values

It is possible to reset the unit to the default values.

XF	factory default values will be set

7.5.5 Lock mode

The access to the unit is possible via serial interface (software) and via the direct user input (mode buttons, LCD display). It is possible to lock the buttons. This allows the unit to be accessed only via software.

J=L	direct user input via mode buttons denied

7.5.6 Mode Setting for the digital input FTC 3

The digital input FTC3 can used as follows:

XN=T	FTC3 as trigger
XN=H	FTC3 with hold function
XN=L	FTC3 with laser control function

7.5.7 Ambient Temperature Compensation

In case of compensating the background ambient temperature, the following modes are available:

AC=0	no compensation
AC=1	compensation with a constant temperature value set with command A.

AC=2	compensation with an external voltage signal at the analog input FTC2 (0V – 5V corresponds to low end and high end of temperature range), current ambient temperature is readable with command A. **Note: The mode AC = 2 does not function in case of setting the command ES = D!**

7.6 Multiple Units in a Network (Multidrop Mode)

Up to 32 units can be connected within a RS485 two-wire loop, see section 4.6 RS485 Communication, page 32. To direct a command to one unit among the 32 possible, it is necessary to „address“ a command. Therefore, a 3-digit number is set prior the command. The 3-digit number is determined between 001 and 032.

XA=024 will set address to 24 (unit must not be in multidrop mode)

Changing an address:
(e.g. the address is change from 17 to 24)

Command	Answer
„017?E“	„017E0.950“
„017XA=024“	“017XA024” setting of a new address
„024?E“	„024E0.950“

Exception: Broadcast command. If a command is transferred, starting with the 3-digit number 000, all units (with addresses from 001 to 032) connected will get this command – without to send an answer. A unit with the address 000 is a single unit and not in multidrop mode.

Command	Answer
“024?E”	“024E0.950”
“000E=0.5”	executed by all devices, no answer sent
“024?E”	“024E0.500”
“012?E”	“012E0.500”

7.7 Laser

Set laser on or off (available on LTH model)

XL=1	turn on laser
XL=0	turn off laser

Request laser status:

?XL	
XL= H	Current unit under overheat status
?XL	
XL= N	No laser build in current model

8 Maintenance

Our customer service representatives are always at your disposal for any questions you might have. This service includes any support regarding the proper application of your infrared measuring system, calibration or the solution to customer-specific solutions as well as repair.
In many cases your problems will be applications-specific and can possibly be solved over the telephone. So, if you need to return equipment to us, please contact our Service Department before doing so, see phone and fax numbers at the beginning of this document.

8.1 Troubleshooting Minor Problems

Symptom	Possible Cause	Solution
No Output	Cable Disconnected	Check Cable Connections
Erroneous Temperature	Field of View Obstructed	Remove the Obstruction
Erroneous Temperature	Lens Dirty	Clean the Lens
Erroneous Temperature	Wrong Emissivity Setting	Correct the Setting
Temperature Fluctuates	Wrong Signal Processing	Correct Peak, Valley, or Average Settings

Table 5: Troubleshooting

8.2 Error Codes

Display	Description
OVER	Temperature over range
UNDER	Temperature under range
	LCD test, after reset (2 seconds)

Table 6: Error Codes via LCD display

Display	Description
T>>>>>>	Temperature over range
T<<<<<<	Temperature under range

Table 7: Error Codes via RS485

8.3 Automatic Error Indication

The automatic error indication (alarm output) shall warn the user and guarantee a secure output in the event of a system error. In the first place, however, its task is to switch the system off in case of a faulty setup or a defect in the sensing head or in the electronic circuits.

Never rely exclusively on the automatic error indication when monitoring critical heating processes. It is strongly recommended to take additional safety measures!

8.4 Cleaning the Lens

Care should be taken to keep the lens clean. Any foreign matter on the lens will affect the accuracy of the measurements. Be sure to take care when cleaning the lens. Please observe the following:

1. Blow off lose particles with clean air.
2. Gently brush off remaining particles with a soft camel hairbrush.
3. To remove any more severe contamination use a clean, soft cloth dampened with distilled water. In any case, do not scratch the lens surface!

For fingerprints or other grease, use any of the following:

- Denaturized alcohol
- Ethanol
- Kodak lens cleaner

Apply any of the above to the lens. Wipe gently with a clean, soft cloth until you see colors on the lens surface, then allow to air dry. Never wipe the surface dry, this may scratch the surface. If the lens is contaminated with silicones (e.g. from hand creams), clean it carefully using Hexane. Allow the lens to air dry.

Do not use any ammonia or any cleaners containing ammonia to clean the lens. This may result in permanent damage to the lens' surface!

8.5 Replacing a Protective Window

The models contain a thread allowing an easier protective window exchange.
The window material is placed in a metal ring with a thread with an inner rubber gasket. This rubber gasket hermetically seals the sensor against atmospheric contaminants.
Replace the protective window using the special tool supplied with the spare window. Put the tools nozzles into the wholes on the window's mounting ring. Now gently unscrew the protective window from its mount by turning to the left. Take care to screw in the new protective window as tight as possible, but do not over tighten!

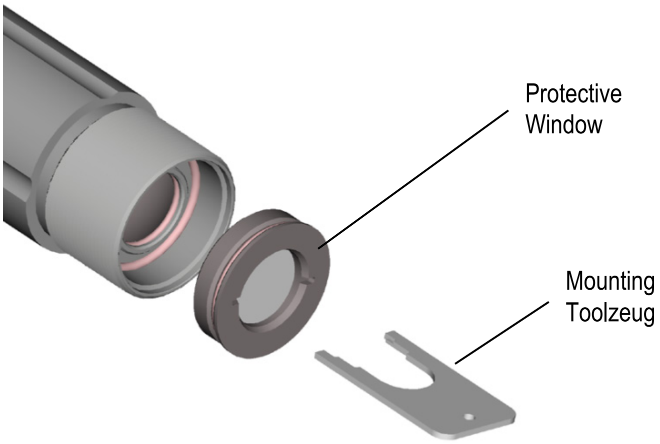


Figure 1: Replacing a Protective Window

9 Appendix

9.1 Determination of Emissivity

Emissivity is a measure of an object's ability to absorb and emit infrared energy. It can have a value between 0 and 1.0. For example a mirror has an emissivity of 0.1, while the so-called "Blackbody" reaches an emissivity value of 1.0. If a higher than actual emissivity value is set, the output will read low, provided the target temperature is above its ambient temperature. For example, if you have set 0.95 and the actual emissivity is 0.9, the temperature reading will be lower than the true temperature.
An object's emissivity can be determined by one of the following methods:

1. Determine the actual temperature of the material using an RTD (PT100), a thermocouple, or any other suitable method. Next, measure the object's temperature and adjust emissivity setting until the correct temperature value is reached. This is the correct emissivity for the measured material.
2. For relatively low temperatures (up to 260°C / 500°F) place a plastic sticker on the object to be measured. This sticker should be large enough to cover the target spot. Next, measure the sticker's temperature using an emissivity setting of 0.95. Finally, measure the temperature of an adjacent area on the object and adjust the emissivity setting until the same temperature is reached. This is the correct emissivity for the measured material.
3. If possible, apply flat black paint to a portion of the surface of the object. The emissivity of the paint must be above 0.98. Next, measure the temperature of the painted area using an emissivity setting of 0.98. Finally, measure the temperature of an adjacent area on the object and adjust the emissivity until the same temperature is reached. This is the correct emissivity for the measured material.

9.2 Typical Emissivity Values

The following table provides a brief reference guide for determining emissivity and can be used when one of the above methods is not practical. Emissivity values shown in the table are only approximate, since several parameters may affect the emissivity of a material. These include the following:

1. Temperature
2. Angle of measurement
3. Geometry (plane, concave, convex)
4. Thickness
5. Surface quality (polished, rough, oxidized, sandblasted)
6. Spectral range of measurement
7. Transmissivity (e.g. thin films plastics)

METALS

Material	Emissivity					
	1 µm	1.6 µm	2.3 µm	3.9 µm	5 µm	8 – 14 µm
Aluminum						
Unoxidized	0.1-0.2	0.02-0.2	0.02-0.2	0.02-0.2	0.02-0.2	0.02-0.1
Oxidized	0.4	0.4	0.2-0.4	0.2-0.4	0.2-0.4	0.2-0.4
Alloy A3003, Oxidized		0.4	0.4	0.4	0.4	0.3
Roughened	0.2-0.8	0.2-0.6	0.2-0.6	0.1-0.4	0.1-0.4	0.1-0.3
Polished	0.1-0.2	0.02-0.1	0.02-0.1	0.02-0.1	0.02-0.1	0.02-0.1
Brass						
Polished	0.1-0.3	0.01-0.05	0.01-0.05	0.01-0.05	0.01-0.05	0.01-0.05
Burnished			0.4	0.3	0.3	0.3
Oxidized	0.6	0.6	0.6	0.5	0.5	0.5
Chromium	0.4	0.4	0.05-0.3	0.03-0.3	0.03-0.3	0.02-0.2
Copper						
Polished		0.03	0.03	0.03	0.03	0.03
Roughened		0.05-0.2	0.05-0.2	0.05-0.15	0.05-0.15	0.05-0.1
Oxidized	0.2-0.8	0.2-0.9	0.7-0.9	0.5-0.8	0.5-0.8	0.4-0.8
Gold	0.3	0.01-0.1	0.01-0.1	0.01-0.1	0.01-0.1	0.01-0.1
Haynes						
Alloy	0.5-0.9	0.6-0.9	0.6-0.9	0.3-0.8	0.3-0.8	0.3-0.8
Inconel						
Oxidized	0.4-0.9	0.6-0.9	0.6-0.9	0.6-0.9	0.6-0.9	0.7-0.95
Sandblasted	0.3-0.4	0.3-0.6	0.3-0.6	0.3-0.6	0.3-0.6	0.3-0.6
Electropolished	0.2-0.5	0.25	0.25	0.15	0.15	0.15
Iron						
Oxidized	0.4-0.8	0.5-0.8	0.7-0.9	0.6-0.9	0.6-0.9	0.5-0.9
Unoxidized	0.35	0.1-0.3	0.1-0.3	0.05-0.25	0.05-0.25	0.05-0.2
Rusted		0.6-0.9	0.6-0.9	0.5-0.8	0.5-0.8	0.5-0.7
Molten	0.35	0.4-0.6	0.4-0.6			
Iron, Cast						
Oxidized	0.7-0.9	0.7-0.9	0.7-0.9	0.65-0.95	0.65-0.95	0.6-0.95
Unoxidized	0.35	0.3	0.1-0.3	0.25	0.25	0.2
Molten	0.35	0.3-0.4	0.3-0.4	0.2-0.3	0.2-0.3	0.2-0.3
Iron, Wrought						
Dull	0.9	0.9	0.95	0.9	0.9	0.9
Lead						
Polished	0.35	0.05-0.2	0.05-0.2	0.05-0.2	0.05-0.2	0.05-0.1
Rough	0.65	0.6	0.5	0.4	0.4	0.4
Oxidized		0.3-0.7	0.3-0.7	0.2-0.7	0.2-0.7	0.2-0.6
Magnesium	0.3-0.8	0.05-0.3	0.05-0.2	0.03-0.15	0.03-0.15	0.02-0.1
Mercury		0.05-0.15	0.05-0.15	0.05-0.15	0.05-0.15	0.05-0.15
Molybdenum						
Oxidized	0.5-0.9	0.4-0.9	0.4-0.9	0.3-0.7	0.3-0.7	0.2-0.6
Unoxidized	0.25-0.35	0.1-0.35	0.1-0.3	0.1-0.15	0.1-0.15	0.1
Monel (Ni-Cu)	0.3	0.2-0.6	0.2-0.6	0.1-0.5	0.1-0.5	0.1-0.14

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METALS

Material	Emissivity					
	1 µm	1.6 µm	2.3 µm	3.9 µm	5 µm	8 – 14 µm
Nickel						
Oxidized	0.8-0.9	0.4-0.7	0.4-0.7	0.3-0.6	0.3-0.6	0.2-0.5
Electrolytic	0.2-0.4	0.1-0.3	0.1-0.2	0.1-0.15	0.1-0.15	0.05-0.15
Platinum						
Black		0.95	0.95	0.9	0.9	0.9
Silver		0.02	0.02	0.02	0.02	0.02
Steel						
Cold-Rolled	0.8-0.9	0.8-0.9		0.8-0.9	0.8-0.9	0.7-0.9
Ground Sheet			0.6-0.7	0.5-0.7	0.5-0.7	0.4-0.6
Polished Sheet	0.35	0.25	0.2	0.1	0.1	0.1
Molten	0.35	0.25-0.4	0.25-0.4	0.1-0.2	0.1-0.2	
Oxidized	0.8-0.9	0.8-0.9	0.8-0.9	0.7-0.9	0.7-0.9	0.7-0.9
Stainless	0.35	0.2-0.9	0.2-0.9	0.15-0.8	0.15-0.8	0.1-0.8
Tin (Unoxidized)	0.25	0.1-0.3	0.1-0.3	0.05	0.05	0.05
Titanium						
Polished	0.5-0.75	0.3-0.5	0.2-0.5	0.1-0.3	0.1-0.3	0.05-0.2
Oxidized		0.6-0.8	0.6-0.8	0.5-0.7	0.5-0.7	0.5-0.6
Tungsten			0.1-0.6	0.05-0.5	0.05-0.5	0.03
Polished	0.35-0.4	0.1-0.3	0.1-0.3	0.05-0.25	0.05-0.25	0.03-0.1
Zinc						
Oxidized	0.6	0.15	0.15	0.1	0.1	0.1
Polished	0.5	0.05	0.05	0.03	0.03	0.02

Tab. 3: Typical Emissivity Values

Material	NON-METALS Emissivity				
	1 µm	1.6 µm	2.3 µm	5 µm	8 – 14 µm
Asbestos	0.9		0.8	0.9	0.95
Asphalt				0.95	0.95
Basalt				0.7	0.7
Carbon					
Unoxidized	0.8-0.95		0,8-0,9	0.8-0.9	0.8-0.9
Graphite	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
Clay			0.8-0.95	0.85-0.95	0.95
Concrete	0.65		0.9	0.9	0.95
Cloth				0.95	0.95
Glass					
Plate			0.2	0.98	0.85
"Gob"			0.4-0.9	0.9	
Gravel				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-al.)					0.9-0.95
Paper (any color)				0.95	0.95
Plastic, opaque at 500 µm thickness (20 mils)				0.95	0.95
Rubber				0.9	0.95
Sand				0.9	0.9
Snow					0.9
Soil					0.9-0.98
Water					0.93
Wood, Natural				0.9-0.95	0.9-0.95

Tab. 4: Typical Emissivity Values

To optimize surface temperature measurements, consider the following guidelines:

- Determine the object emissivity using the instrument which is also to be used for the measurements.
- Avoid reflections by shielding the object from surrounding temperature sources.
- For higher temperature objects use instruments with the shortest wavelength possible.
- For translucent materials such as plastic foils or glass, assure that the background is uniform and lower in temperature than the object.

9.3 Command List

Description	Char	Format	Poll	Burst	Set	Legal values	Factory default	LCD
Poll Parameter	?	?X/?XX	*			?T		
Set Parameter	=	X/XX=...			*	E=0.85		
Set Parameter without EEPROM storage	#	X/XX#			*	E#0.85		
Multidrop addressing		001?E	*		*	answer: 001!E0.95		
Error message	*					*Syntax error		
Acknowledge message	!					!P010		
Burst string Format	$		*		*	(2)	UTEI	
Ambient radiation correction	A	nnnn.n	*		*	(1)	(4)	
Advanced hold averaging time	AA	nnn.n	*		*	0 = no averaging 0.1 … 999.9 secs	0	
Control ambient compensation	AC	n	*		*	0 = no averaging, 1 = with compensation, 2 = external input	0	
Advanced hold threshold	C	nnnn.n	*		*	In current scale(C / F)	100(C)	
Currently calculated emissivity	CE	n.nnn	*					
Current calculation Setpoint / relay function	CS	nnnn.n	*			In current scale (C / F)		
Device adjustment gain	DG	n.nnnn	*		*	0.8000 1.2000	1.0000	
Device adjustment offset	DO	nnn	*		*	-200 +200	0	
Device special	DS	XXX	*			z.B. !DSRAY		
Emissivity internal (7)	E	n.nnn	*	*	*	0.100 – 1.100	0.950	E
Error Code	EC	nnnn	*			Hex value of ErrCode		
Presel. Emissivity pointer (7)	EP	n	*		*	0 – 7	7	
Source: Emissivity / Setpoint / Relay function	ES	X	*		*	I=constant number (E=0.950) E=external analogous input FTC1 D= E/XS digital selected FTC1-3	I	
Presel. Emissivity value	EV	n.nnn	*		*	0.100 - 1.100		
Valley hold time(3)	F	nnn.n	*	*	*	0.000 - 998.9 secs (999 = infinite)	000.0 secs	V
Average time	G	nnn.n	*	*	*	000.0 – 998.9 secs	000.0 secs	A
Top of mA/mV range	H	nnnn.n	*	*	*	(1)	(5)	H
Sensor ambient	I	nnn.n	*	*		In current scale(°C/°F)		
Switch panel lock	J	X	*		*	L=locked U=unlocked	unlocked	
Relay alarm output control	K	X	*		*	0=Open 1=Close 2=Target norm. open 3=norm. closed 4=Head normal open 5=norm. closed N=no relay built in	0	
Bottom of mA/mV range	L	nnnn.n	*	*	*	(1)	(6)	L
Output voltage/current	O	nnn	*		*	0-100=% of full range 255=controlled by unit	255	
Peak hold time (3)	P	nnn.n	*	*	*	000.0 998.9 secs (999 = infinite)	000.0 secs	P

Description	Char	Format	Poll	Burst	Set	Legal values	Factory default	LCD
Power	Q	nnnnn	*	*				
Presel. Setpoint / Relay function	SV	nnn.n				(1)		
Target temperature	T	nnnn.n	*	*		In current scale (°C / °F)		
Temperature unit	U	X	*	*	*	C / F	C	U
Poll / Burst Mode	V	X	*		*	P = poll B = burst	Poll Mode	
Burst string, contents	X$		*					
Multidrop address	XA	nnn	*		*	000 032; 000 = single unit mode	000	
Device buttom range limit	XB	nnnn.n	*					
Restore factory defaults	XF				*			
Transmission	XG	n.nnn	*	*	*	0.100 - 1.000	1.000	T
Device high range limit	XH	nnnn.n	*					
Sensor initialisation	XI	n	*	*	*	1 after RESET, 0 if XI = 0		
Box temperature/Sensor ambient	XJ	nnn.n	*	*		In current scale(°C / °F)		
Laser	XL	X	*		*	0 = off 1 = on H = overheat(off) N = no laser build in		
FTC 3 trigger / hold / Laser	XN	X	*		*	N = No function ON T = trigger H = hold L = Laser	T	
Analog output mode	XO	n	*		*	0 = 0 – 20 mA, 4 = 4 – 20 mA, 9 = mV	9	
Firmware revision	XR		*			e.g. 1.01		
Setpoint / Relay function (7)	XS	nnnn.n	*		*	(1)	(8)	
Trigger	XT	n	*	*		0 = inaktive, 1 = aktive	0	
Unit identification	XU		*			e.g. !XRTLTSF		
Serial number	XV		*			e.g. 98123		
Advance hold hysterese (3)	XY	nnn.n	*		*			

(1) LT: -40 ... 600°C (-40 ... 1112°F) LTH: -40 ... 600°C (-40 ... 1112°F) MT: 250 ... 1200°C (482 ... 2192°F) G5: 250 ... 1650°C (482 ... 3002°F) P7: 10 ... 350°C (50 ... 662°F)
(2) $ = U T Q E P G I H L XT XI XJ CE CS
(3) setting average / peak / valley / advanced hold cancels all other hold modes
(4) 23°C (73°F)
(5) LT: 600°C(1112°F), LTH: 600°C(1112°F), MT: 1200°C(2192°F), G5: 1650°C(3002°F), P7: 350°C (662°F)
(6) LT: -40°C(-40°F), LTH: -40°C(-40°F), MT: 250°C(482°F), G5: 250°C(482°F), P7: 10°C (50°F)
(7) E0 = 1.100, E1 = 0.500, E2 = 0.600, E3 = 0.700, E4 = 0.800, E5 = 0.970, E6 = 1.000, E7 = 0.950 XS0 = 200, XS1 = 210, XS2 = 220, XS3 = 230, XS4 = 240, XS5 = 250, XS6 = 260, XS7 = 270 En / XSn set via command EP = n (n = 0 … 7)
(8) LT: 597.2°C(1107°F), LTH : 597.2°C(1107°F), MT: 1197.2°C(2187°F), G5: 1647.2°C(2997°F), P7: 347.2°C (657°F)

Table 8: Command set

Notes