MARATHON MM
SERIES

High-Performance Infrared Thermometer

Operating Instructions

Raytek®
A Fluke Company

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.

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.

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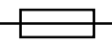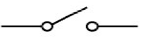
Safety Instructions

Safety Symbols

∿	**AC (Alternating Current)**
⎓	**DC (Direct Current)**
⚠	**Risk of danger. Important information. See manual.**
⚡	**Hazardous voltage. Risk of electrical shock.**
i	**Helpful information regarding the optimal use of the instrument.**
⏚	**Earth ground**
⏛	**Protective ground**
▭	**Fuse**
⊣⊢	**Normally-open (NO) relay**
⊣⊬⊢	**Normally-closed (NC) relay**
⎯o⁄o⎯	**Switch or relay contact**
⊣⊦	**DC power supply**
CE	**Conforms to European Union directive.**
🗑	**Disposal of old instruments should be handled according to professional and environmental regulations as electronic waste.**

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To prevent possible electrical shock, fire, or personal injury follow these guidelines:
- Read all safety Information before you use the product.
- Use the product only as specified, or the protection supplied by the product can be compromised.
- Carefully read all instructions.
- Do not use and disable the product if it is damaged.
- Do not use the product if it operates incorrectly.
- Do not look directly into the laser with optical tools (for example, binoculars, telescopes, microscopes). Optical tools can focus the laser and be dangerous to the eye.
- Do not look into the laser. Do not point laser directly at persons or animals or indirectly off reflective surfaces.
- Do not use laser viewing glasses as laser protection glasses. Laser viewing glasses are used only for better visibility of the laser in bright light.
- Use the product only as specified or hazardous laser radiation exposure can occur.

2 Product Description

The Marathon MM is a multi-purpose, high performance single color infrared pyrometer with an extensive feature set, rugged industrial housing and a high level of functionality. The sensor is available in different spectral responses to accommodate the wide range of industrial applications requiring non-contact temperature measurement. It is intended to be simple to operate, with a user-friendly interface and well suited to a wide variety of industrial applications.

Each sensor has a rugged stainless steel housing, a rear membrane panel with backlit LCD display, and a standard through the lens sighting with optional laser target sighting. Alternative to the laser sighting, a video sighting is offered as an option. The Marathon MM is also available with remotely adjustable precision focus optics. Users can easily adjust the focus of measurement targets, either by push-button on the rear of the instrument, or remotely via the RS232/RS485 connection from a PC.

Each model operates as a temperature measurement subsystem consisting of optical elements, spectral filters, detector, and digital electronics. All components are water-tight NEMA-4 (IP65, IEC529) rated and are built to operate on a 100 percent duty cycle in industrial environments. Simultaneous analog and digital outputs consist of standardized signals commonly available for use with computers, controllers, recorders, alarms, or A/D interfaces.

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3 Technical Data

3.1 Measurement Specifications

Temperature Range

LT	-40 to 800°C (-40 to 1472°F)
G7	300 to 900°C (572 to 1652°F)
G5L	250 to 1650°C (482 to 3002°F)
G5H	450 to 2250°C (842 to 4082°F)
MT	250 to 1100°C (482 to 2012°F)
3M	100 to 600°C (212 to 1112°F)
2ML	300 to 1100°C (572 to 2012°F)
2MH	450 to 2250°C (842 to 4082°F)
1ML	400 to 1740°C (752 to 3164°F)
1MH	540 to 3000°C (1004 to 5432°F)

i **Measurements at the low end of the temperature range for the 1M models can be effected by disturbing day light!**

Spectral Response

LT	8 to 14 μm
G7	7.9 μm
G5	5 μm
MT	3.9 μm
3M	2.1 to 2.5 μm
2M	1.6 μm
1M	1 μm

Response Time (95%)

LT, MT, G7	120 ms
G5	60 ms
3M	20 ms
1M, 2M	2 ms

Exposure Time[1] (95%)

1M, 2M	1 ms

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[1] The exposure time is the minimum time during which the measured object must be present. The output value of the sensor can be delayed. (VDI/VDE 3511)

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Technical Data

System Accuracy[2]

LT	± 1% of reading or ± 1°C for T_{meas} > 0°C (32°F) (whichever is greater)
	± 2°C for T_{meas} < 0°C (32°F)
MT	± 1% of reading for T_{meas} > 350°C (662°F)
	± 2°C or ± 2% for T_{meas} < 350°C (662°F) (whichever is greater)
G5L, G5H, G7	± 1% of reading
3M	± 1% of reading for T_{meas} > 150°C (302°F)
	± 5°C for T_{meas} < 150°C (302°F)
2ML	± (0.3% of reading + 2°C)
2MH	± (0.3% of reading + 1°C)
1ML	± (0.3% of reading + 1°C) for T_{meas} > 450°C (842°F)
	± (2% of reading + 2°C) for T_{meas} < 450°C (842°F)
1MH	± (0.3% of reading + 1°C) for T_{meas} > 650°C (1202°F)
	± (2% of reading + 2°C) for T_{meas} < 650°C (1202°F)

Repeatability[3]

LT, MT, G5, 3M, G7	± 0.5% of reading or ± 0.5°C, whichever is greater
2ML, 2MH	± (0.1% of reading + 1°C)
1ML	± (0.1% of reading + 1°C) for T_{meas} > 450°C (842°F)
	± (1% of reading + 1°C) for T_{meas} < 450°C (842°F)
1MH	± (0.1% of reading + 1°C) for T_{meas} > 650°C (1202°F)
	± (1% of reading + 1°C) for T_{meas} < 650°C (1202°F)

Temperature Resolution (mA output)

2MH, 1MH	0.2 K
all other models	0.1 K

Noise Equivalent Temperature (NETD)

LT	0.1 K at T_{obj} = 23°C (73°F), T_{amb} = 23°C (74°F)
3M	0.1 K at T_{obj} = 200°C (392°F), T_{amb} = 25°C (77°F)
MT, G5, G7	0.5 K at T_{obj} = 10% of full measurement range, T_{amb} = 25°C (77°F)
2M, 1M	0.5 K at T_{obj} = 10% of full measurement range, T_{amb} = 25°C (77°F)
	Response time = Instrument Response time

Emissivity	0.100 to 1.150, in 0.001 increments
Signal Processing	Peak hold, valley hold, averaging, advanced peak hold, advanced valley hold, ambient background temperature compensation

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[2] at 23°C ±5°C (73°F ±9°F), emissivity = 1.0, and time response 1.0 s

[3] at 23°C ±5°C (73°F ±9°F)

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3.2 Optical Specifications

In all cases, make sure the target completely fills the measurement spot, see section 6.1.1 Distance to Object, page 24.

The actual spot size for any distance, when the unit is at focus distance, can be calculated by using the following formula. Divide the distance D by your model's D:S number. For example, for a unit with D:S = 300:1, if the sensor is 2200 mm (86 in.) from the target, divide 2200 by 300 (86 by 300), which gives you a target spot size of approximately 7.3 mm (0.29 in.).

D = Distance
S = Spot size
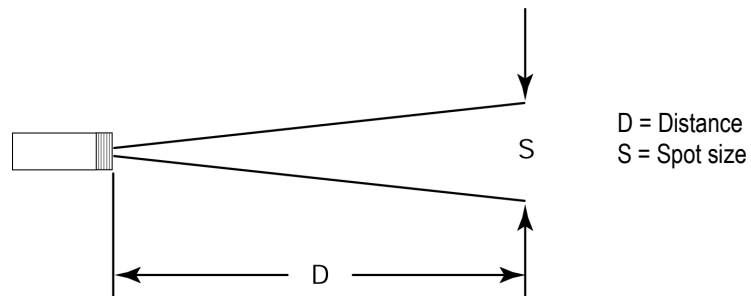
Figure 1: Spot Size Chart

All target spot sizes indicated in the optical diagrams are based on 90% energy.

3.2.1 Variable Focus

Model	Focus	Focus Range	Optical Resolution D:S *	Smallest Spot Size
LT, MT, G5, 3M	VF1	200 mm (7.9 in.) to 2200 mm (86.6 in.)	70:1	2.9 mm @ 200 mm (0.11 in. @ 7.9 in.)
G7	VF1	200 mm (7.9 in.) to 2200 mm (86.6 in.)	100:1	2.9 mm @ 200 mm (0.11 in. @ 7.9 in.)
1ML, 2ML	VF1	300 mm (11.8 in.) to 2200 mm (86.6 in.)	160:1	1.9 mm @ 300 mm (0.07 in. @ 11.8 in.)
1MH, 2MH	VF1	300 mm (11.8 in.) to 2200 mm (86.6 in.)	300:1	1 mm @ 300 mm (0.04 in. @ 11.8 in.)

* Optical Resolution is achieved for each focal point in the focus range

Mean Time Between Failures (MTBF)   10,000 operations (at T_{amb} = 23°C/74°F)

Technical Data

3.2.2 Fixed Focus

Optical Resolution D:S

LT, MT, G5, 3M	70:1
G7	100:1

Available Optics

LT, MT, G5, 3M, G7	SF1, SF2, SF3
LT, 3M	CF1
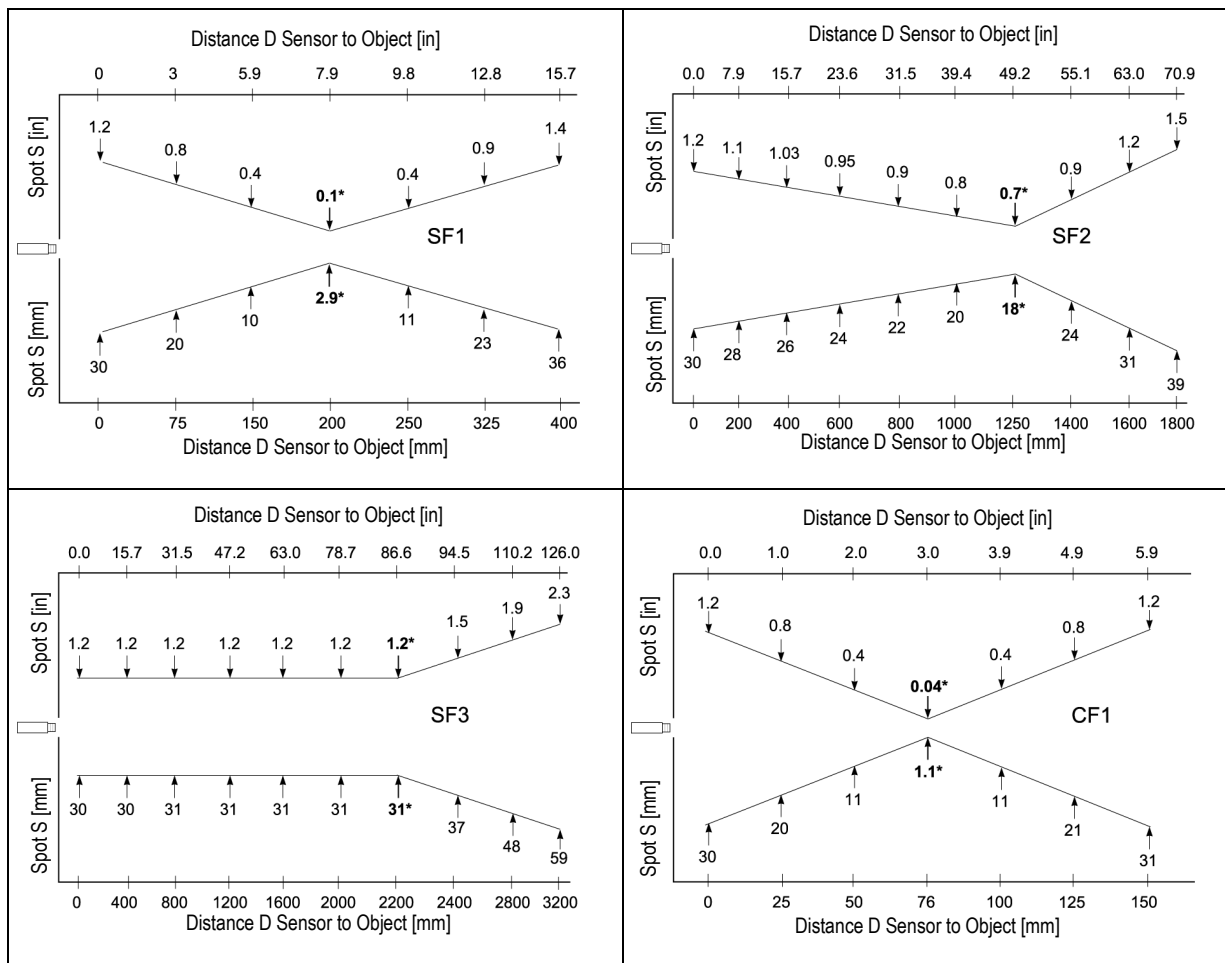
SF … Standard Focus, CF … Close Focus

* specified D:S ratio at focus point only

Table 1: Optical Diagrams for D:S = 70:1

> **ℹ** The focus distance is measured from the front end of the sensor. For units with Air/Water Cooled Housing you have to subtract 34.5 mm (1.358 in) from the focus distance. This is very important especially for sensors with close focus optic!

D:S = 100:1 SF1 — Spot Size [mm] vs Focus Distance [mm]: 28, 2 (at 200), 32 (at 400)

D:S = 100:1 SF1 — Spot Size [in] vs Focus Distance [in]: 1,10, 0,08 (at 8), 1,26 (at 16)

D:S = 100:1 SF2 — Spot Size [mm] vs Focus Distance [mm]: 28, 12,5 (at 1250), 26 (at 1800)

D:S = 100:1 SF2 — Spot Size [in] vs Focus Distance [in]: 1,10, 0,49, 1,02

D:S = 100:1 SF3 — Spot Size [mm] vs Distance [mm]: 28,0, 22,0 (at 2200), 37,0 (at 3200)

D:S = 100:1 SF3 — Spot Size [in] vs Distance [in]: 1,10, 0,87, 1,46
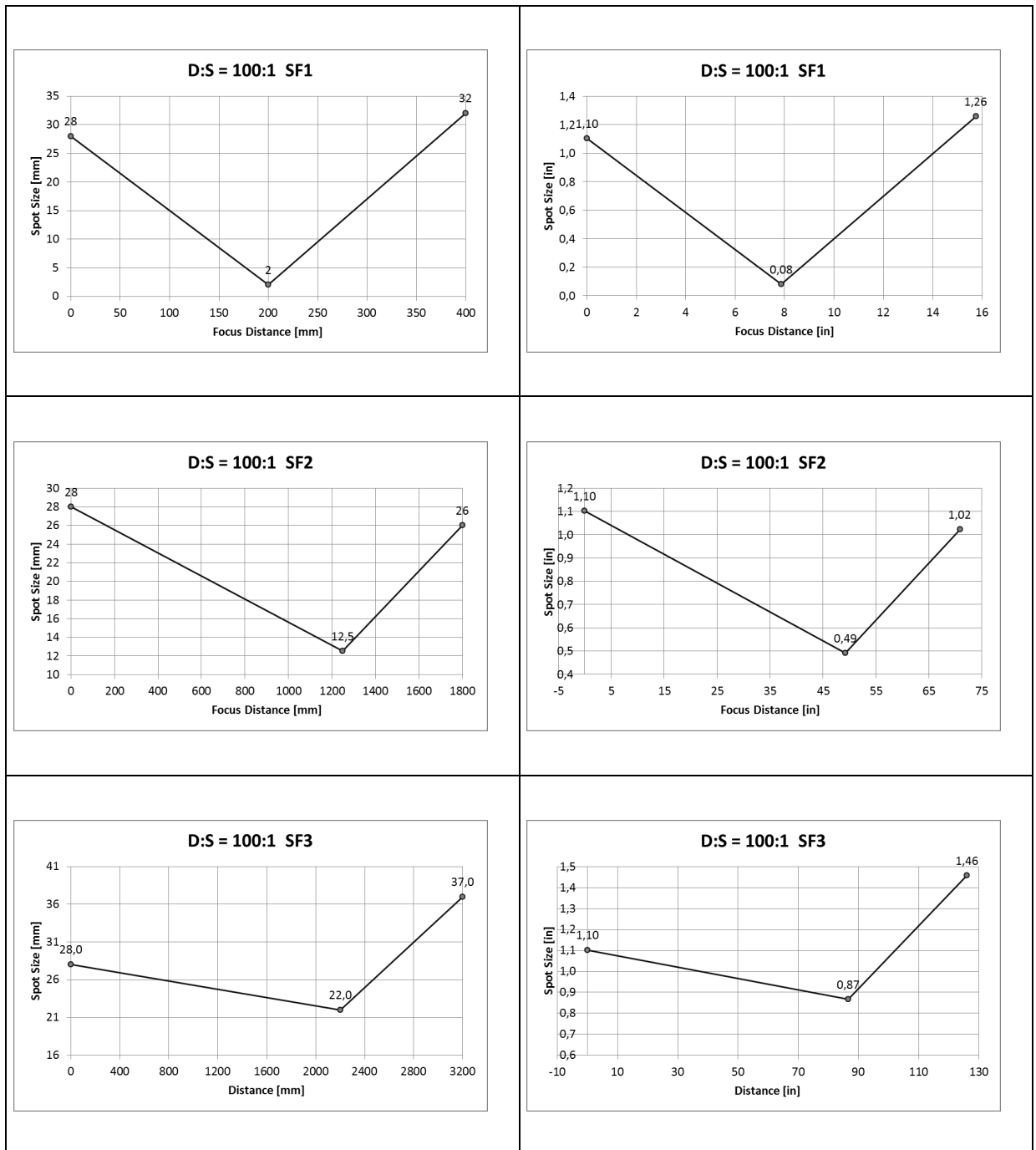
SF … Standard Focus, CF … Close Focus

* D:S = 100:1 at focus point

Table 3: Optical Diagrams for D:S = 100:1

Technical Data
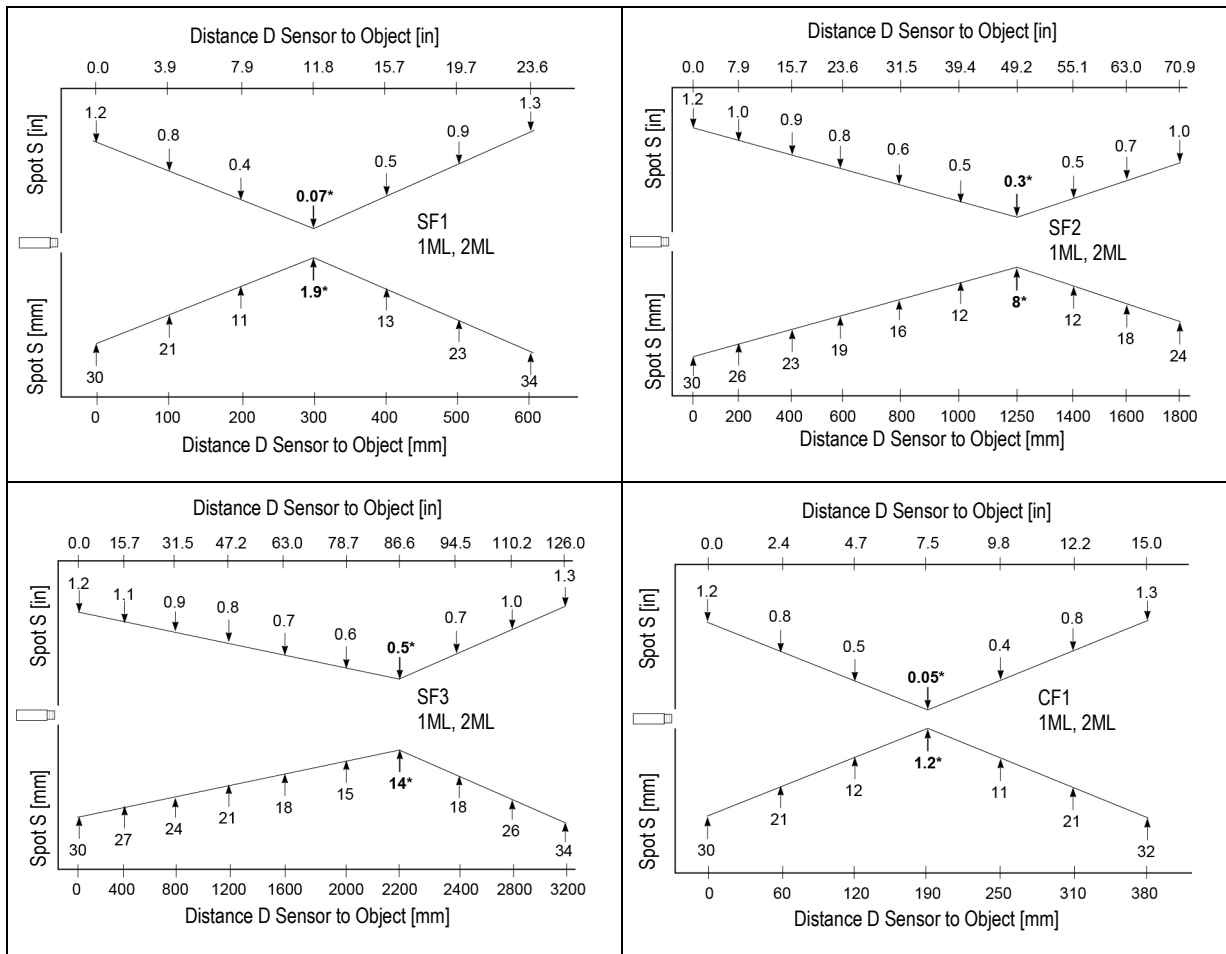
SF … Standard Focus, CF … Close Focus

* D:S = 160:1 at focus point

Table 2: Optical Diagrams for D:S = 160:1

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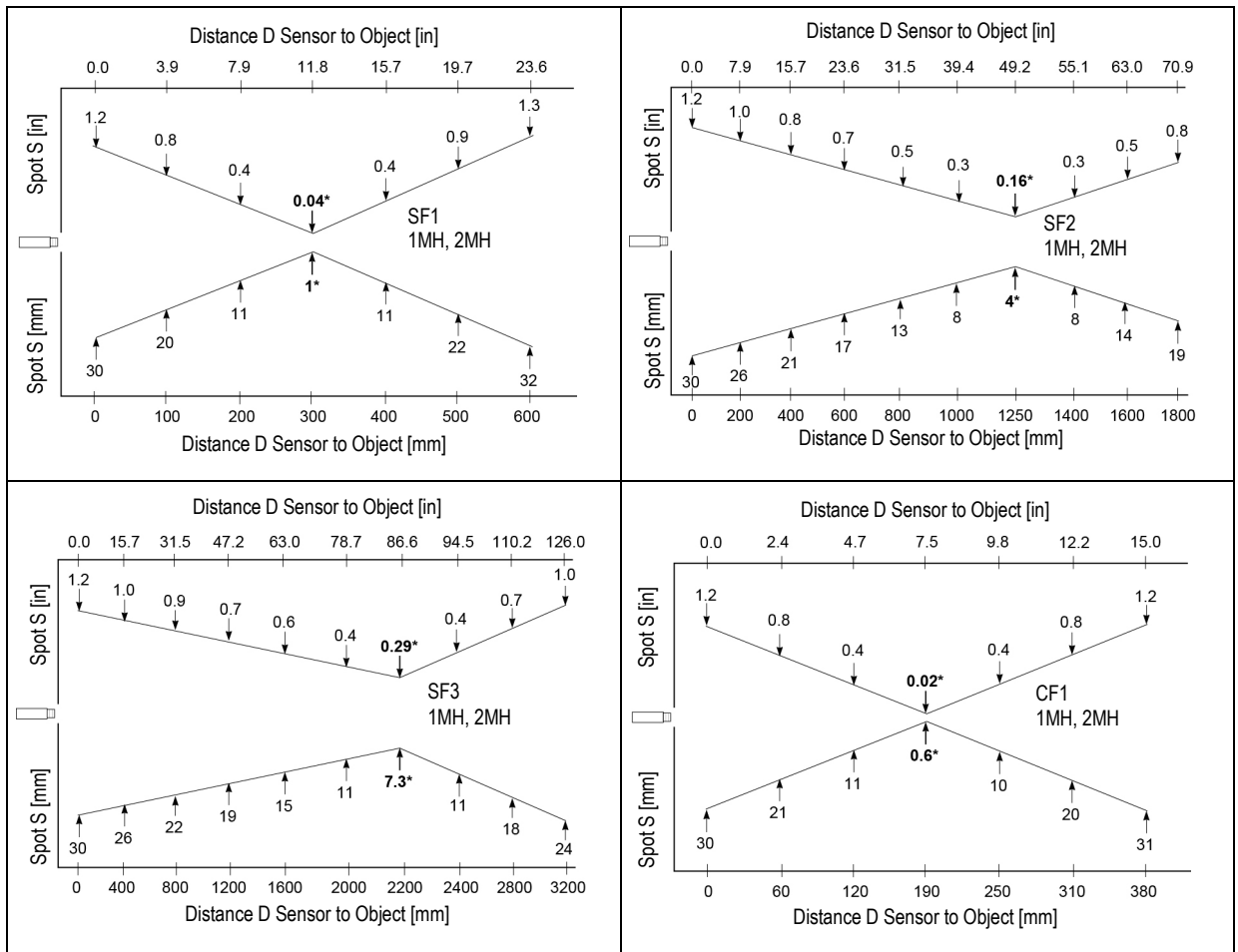
SF … Standard Focus, CF … Close Focus

* D:S = 300:1 at focus point

Table 3: Optical Diagrams for D:S = 300:1

Technical Data

3.3 Electrical Specifications

Power Supply	24 VDC ± 20%, min. 500 mA
Outputs	
Analog	0 - 20 mA, 4 - 20 mA (active)
	14 bit resolution
	max. current loop impedance: 500 Ω
RS485 Interface	networkable to 32 sensors
	Baud rate: 300, 1200, 2400, 9600, 19200, 38400 (default), 57600, 115200
	(max. 38400 Baud in 2-wire mode)
	Data format: 8 bit, no parity, 1 stop bit,
	4-wire mode (full-duplex) or 2-wire mode (half duplex),
	selectable via control panel or software
Relay	Contacts max. 48 V, 300 mA, response time < 2 ms,
	(software programmable)
Display	5 digit backlit LCD display
External Input	
Input Voltage	0 to 5 VDC
	functions: trigger, laser ON/OFF switching, ambient background temperature compensation, or emissivity setting, see section 7.4.3 External Input page 42.

3.4 Environmental Specifications

Environmental rating	NEMA-4 / IEC 529, IP 65 (also with video option)
EMI	CE compliant to IEC 61326
Relative Humidity	10% to 95% non-condensing
Storage Temperature	-20 to 70°C (-4 to 158°F)
Ambient Temperature	5 to 65°C (41 to 149°F) without cooling
with video	5 to 50°C (41 to 122°F) without cooling
with air cooling	10 to 120°C (50 to 250°F)
with water cooling	10 to 175°C (50 to 350°F)
with ThermoJacket	10 to 315°C (50 to 600°F) water cooled
Warm up Period	20 min.
Vibration	MIL-STD-810D (IEC 68-2-6) 2 G, 10 - 150 Hz, 3 axis
Mechanical Shock	MIL-STD-810D (IEC 68-2-27) 5 G, 11 ms duration, 3 axis
Weight	0.7 kg (1.54 lb)

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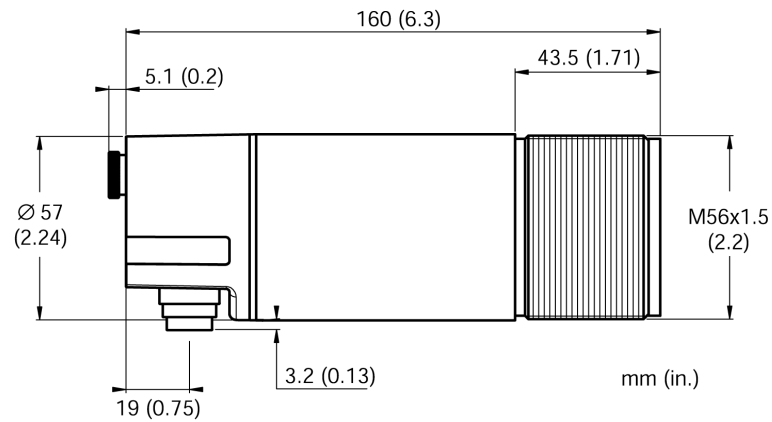
3.5 Dimensions

Figure 2: Dimensions of Sensor

For the dimensional drawing of the Fixed Mounting Bracket, see section 9.2 Fixed Mounting Bracket, page 55.

3.6 Scope of Delivery

The scope of delivery includes the following:
- Sensor with through-the-lens sighting
- Operating Instructions
- DataTemp Multidrop Software
- Mounting nut made from stainless steel (XXXMMACMN)
- Fixed mounting bracket made from stainless steel (XXXMMACFB)

4 Basics

4.1 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 section 12.2 Typical Emissivity Values, page 82.

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 signal. The signal processing electronics analyze the electrical signals and convert it into a temperature measurement. 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 temperature without touching an object. Consequently, surface temperatures of moving or hard to reach objects can easily be measured.

4.2 Emissivity of Target Object

Determine the emissivity of the target object as described in appendix 12.1 Determination of Emissivity, page 82. 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 can be reduced to a minimum if particular care is taken during installation, and the sensing head is shielded from these reflecting radiation sources.

5 Environment

Sensor location depends on the application. Before deciding on a location, you need to be aware of the ambient temperature of the location, the atmospheric quality of the location, and the possible electromagnetic interference in that location, according to the sections described above. If you plan to use air purging, you need to have an air connection available. If you are installing the sensor in a ThermoJacket accessory, you should use the appropriate mounting device. Also, wiring and conduit runs must be considered, including computer wiring and connections, if used.

5.1 Ambient Temperature

The sensor is designed for measurements in ambient temperatures between 5°C and 65°C (41 to 149°F). A water or air cooled housing is available as option to extend the operating range to 120°C (250°F) with air cooling and to 175°C (350°F) with water cooling.
In ambient conditions up to 315°C (600°F), the ThermoJacket housing should be used. When using the ThermoJacket, it is strongly recommended to use the supplied air purge to avoid condensation on the lens.

5.2 Atmospheric Quality

If the lens gets too dirty, it cannot detect enough infrared energy to measure accurately. It is good practice to always keep the lens clean. The air purge helps keep contaminants from building up on the lens. If you use the air purge accessory, make sure a filtered air supply with clean dry air at the correct air pressure is installed before proceeding with the sensor installation.

5.3 Electrical Interference

To minimize measurement errors due to electrical or electromagnetic interference or "noise" be aware of the following:

- Mount the electronics enclosure as far away as possible from potential sources of electrical interference such as motorized equipment producing large step load changes.
- Use shielded wire for all input and output connections.
- Make sure the shield wire from the electronics to terminal block cable is earth grounded.
- For additional protection, use conduit for the external connections. Solid conduit is better than flexible conduit in high noise environments.
- Do not run AC power in the same conduit as the sensor signal wiring.

> **i** **When installing the sensor, check for any high-intensity discharge lamps or heaters that may be in the field of view (either background or reflected on a shiny target). Reflected heat sources can cause a sensor to give erroneous readings.**

6 Installation

6.1 Mechanical Installation

After all preparations are complete, you can install the sensor. How and where you anchor the sensor depends on the type of surface and the type of bracket you are using. You can mount the sensor through a hole, on a bracket of your own design, or on the available bracket accessory.

6.1.1 Distance to Object

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 section 3.2 Optical Specifications, page 15.
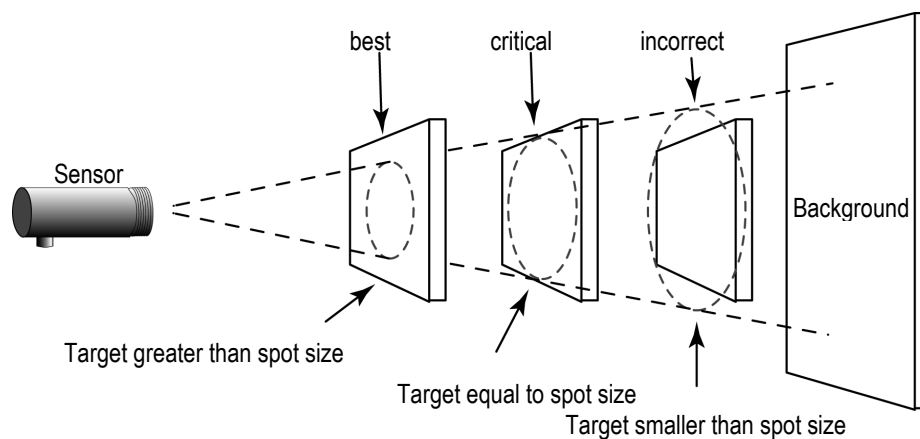
Figure 3: Proper Sensor Placement

6.1.2 Variable Focus

The optional variable focus allows adjustment of the focus length of the sensor optics. Using sensors with this feature requires that the correct focal distance be set on the sensor. To determine the correct focal distance for the sensor, measure the distance in millimeters from the face of the sensor to the target. Set the focal distance to be equal to the measured distance. It is possible to set the focal distance either on the control panel of the sensor or through the DataTemp Multidrop Software.
The factory default focal distance is 600 mm (23.6 in.).

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6.1.3 Viewing Angles

The sensor head can be placed at any angle from the target up to 30°.

Best
90° to target

Acceptable
Angles

Good
30° to 90° to target

Bad
0° to 30° to target
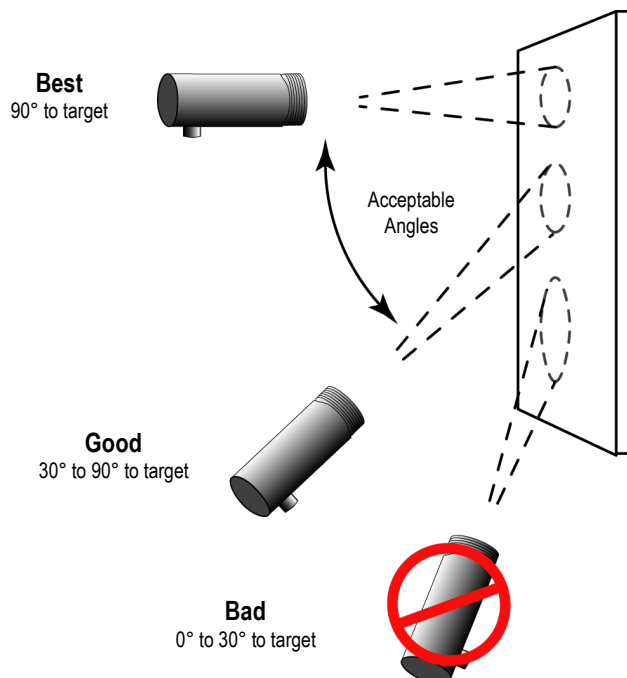
Figure 4: Acceptable Sensor Viewing Angles

Installation

6.2 Electrical Installation

The 12-wire connecting cable is used to wire all inputs and outputs of the sensor. The cable comes in two different temperature versions. For more information, see section see section 9.9 Terminal Box, page 60 and section 9.11 High Temp Cable, page 62.

The following figure shows how to configure the drain wires of the cables before connecting to the sensor. The bare wire with the clear shrink tubing (cable shield) must be connected to the terminal labeled CLEAR.
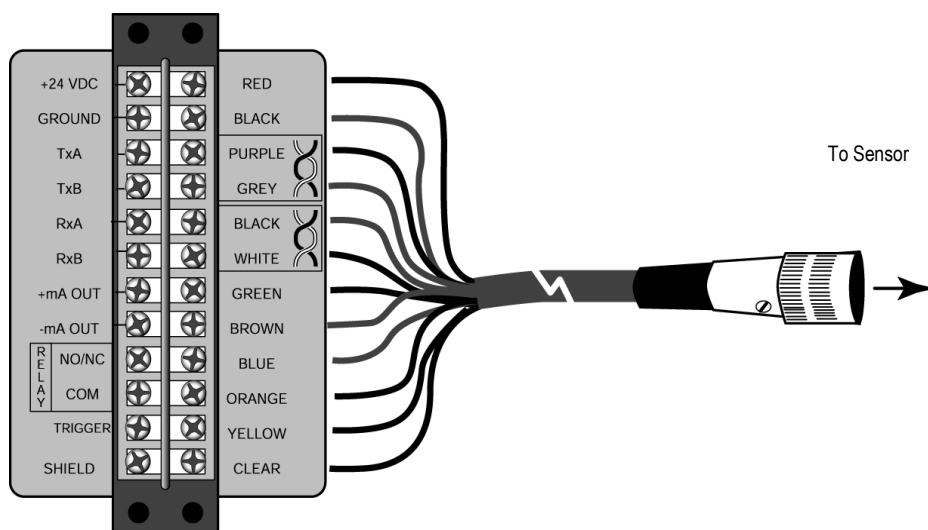
Figure 5: Sensor Connecting Cable with Terminal Block

ℹ **The factory default setting for the Marathon MM is the 4-Wire Mode!**

ℹ **The complete wiring must have only one common earth ground point!**

⚠ **Power supplies based on a IT grid structure could cause an unintended reset of the sensor. To avoid this, consider a sensor mounting isolated from the machinery!**
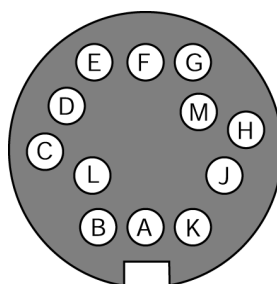
Figure 6: DIN Connector Pin Layout (pin side)

Pin	Cable Color	Description
A	black	RxA*
B	white	RxB*
C	gray	TxB**
D	purple	TxA**
E	white/drain	Shield
F	yellow	Trigger / External Input
G	orange	Relay COM
H	blue	Relay NO/NC
J	green	+ mA out
K	brown	- mA out (analog ground)
L	black	Digital ground
M	red	+24 VDC

*   RxA and RxB are twisted paired
** TxA and TxB are twisted paired

Table 4: DIN Connector Wiring

⚠ **Incorrect wiring can damage the sensor and void the warranty. Before applying power, make sure all connections are correct and secure!**

⚠ **To prevent possible electrical shock, fire, or personal injury make sure that the sensor is grounded before use.**

Installation

6.3 Computer Interfacing

The distance between the sensor and a computer can be up to 1200 m (4000 ft.) via RS485 interface. 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. The USB/RS485 Interface Converter allows you to connect your sensor to computers by using a USB interface.

With auto configuration the converter is able to automatically configure RS485 signals without external switch setting. The converter is equipped with 3000 VDC of isolation and internal surge-protection to protect the host computer and the converter against high voltage spikes, as well as ground potential difference. When the converter is connected the computer gets one virtual COM port.

Technical Data

Power supply	5 VDC direct from USB port
Speed	max. 256 kBit/s
RS485	4 wire (full duplex) and 2 wire (half duplex)
Terminal screwed	accepts 0.05 to 3 mm² (AWG 13 to AWG 30)
USB connector	type B (supplied with type A to type B cable)
Ambient Temperature	0 to 60°C (32 to 140°F), 10-90% relative humidity, non-condensing
Storage Temperature	-20 to 70°C (-4 to 158°F), 10-90% relative humidity, non-condensing
Dimensions (L x W x H)	151 x 75 x 26 mm (5.9 x 2.9 x 1 in)

Figure 7: USB/RS485 Converter (XXXUSB485)

Using the 2-wire communication reduces wiring cost in comparison to the 4-wire communications. The disadvantage is, that because the data transfer can be only in one direction at the same time, 2-wire communications have a maximum baud rate of 38.4 kBaud. 2-wire communications is available for network installations, in situations where other sensors are only able to communicate via 2 wires(e.g. MI3 sensor).

> **i** **The factory default setting for the Marathon MM is the 4-Wire Mode!**
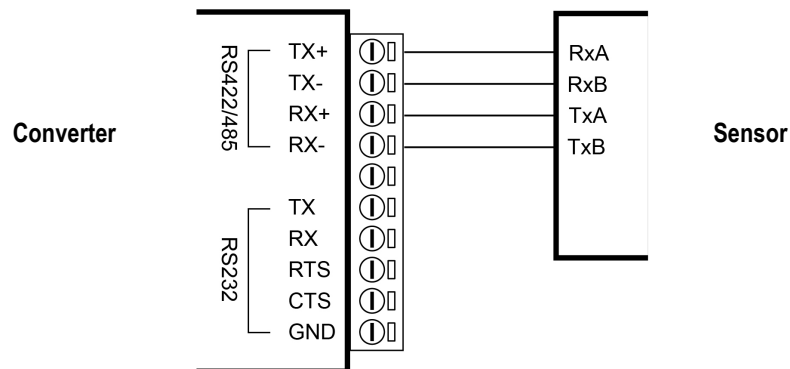
Figure 8: Wiring the Sensor's RS485 Interface with USB/RS485 Converter in 4-Wire Mode (factory default)
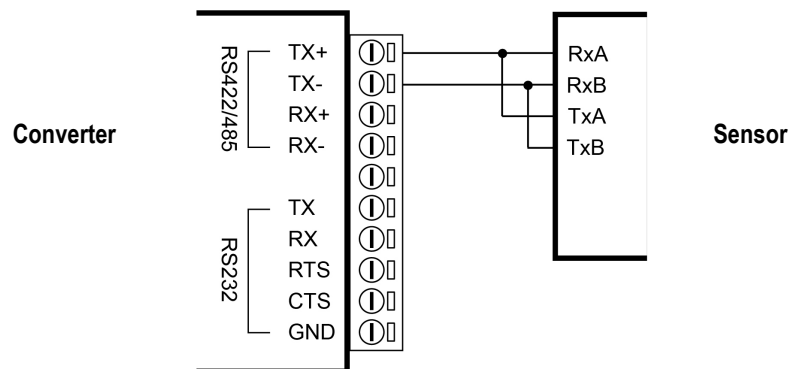
Figure 9: Wiring the Sensor's RS485 Interface with USB/RS485 Converter in 2-Wire Mode

Installation

6.4 Multiple Sensors in a Network

6.4.1 Wiring

For an installation of two or more sensors in a network, each sensor cable is wired to its own terminal block. The RS485 terminals on each terminal block are wired in parallel.
The following figures illustrate the wiring of sensors in a 4-wire and 2-wire multidrop installation.
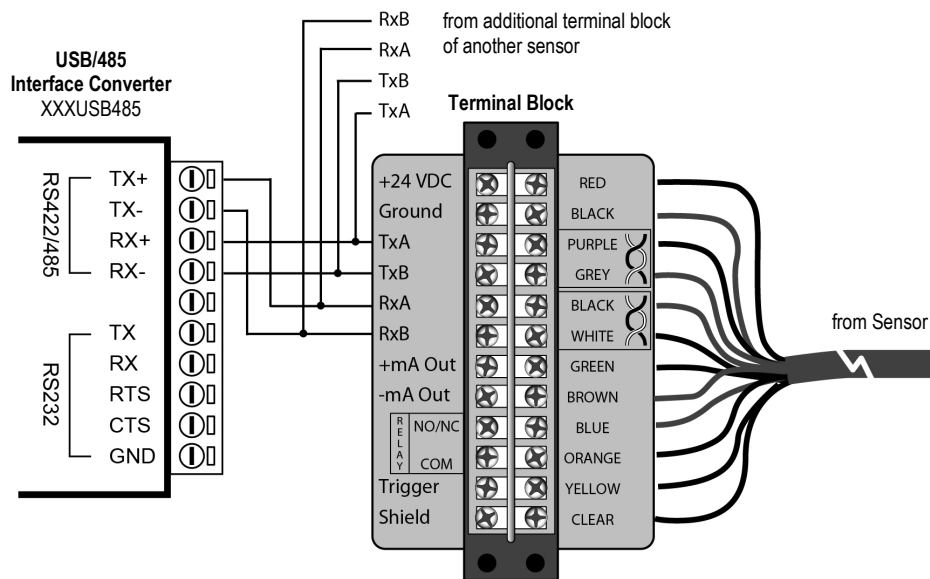
Figure 10: 4-Wire Multidrop Wiring in a Network
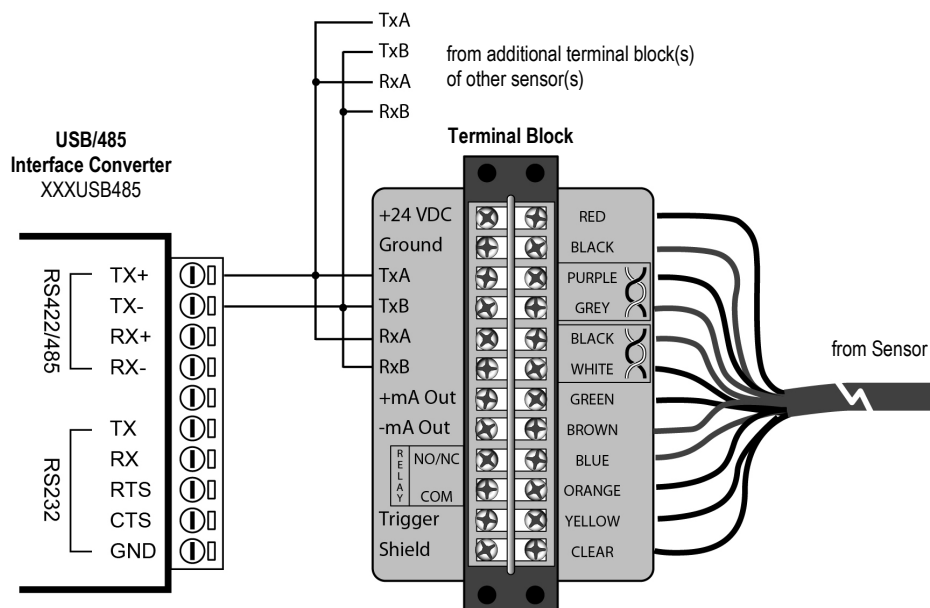
Figure 11: 2-Wire Multidrop Wiring in a Network

6.4.2 Addressing

The addressing of a sensor can be done by means of the Control Panel on the back of the sensor or the DataTemp Multidrop Software (Menu <Sensor Setup>) that came with your sensor. An alternative would be to use the specific interface commands of the sensor in conjunction with a standard terminal program (e.g. Windows HyperTerminal), see section 10.12 Command List, page 76.

If you are installing two or more sensors in a multi-drop configuration, please be aware of the following:

- Each sensor must have a unique address greater zero.
- Each sensor must be set to the same baud rate.

6.4.3 Configuration Procedure

1. Attach each unit individually to the computer.

2. Start the DataTemp Multidrop Software.

3. In the DataTemp Multidrop Startup Wizard, select the correct COM port and ASCII protocol, then <Scan All Baud Rates> for a <Single Sensor>. DataTemp Multidrop should find the single MM unit connected to the computer serial port.

4. Once DataTemp Multidrop is running, go to the <Setup> menu and select <Sensor Setup>.

5. In the <Sensor Setup> menu select the <Advanced Setup> tab. This tab contains the Communications Interface menu. The Interface Menu allows you to set the <Polling Address>, <Baud Rate> and <RS485 Mode>. Each unit needs a unique address, but the same <Baud Rate> and <RS485 Mode> settings.

6. Once all the units are addressed, wire up the units in the either the 2-wire or 4-wire multidrop manner, keeping all TxA's, TxB's, RxA's and RxB's to be common.

7. Now you can run the DataTemp Multidrop Software and by selecting the baud rate that you set, the program will quickly identify all of the units attached on the network and you're up and running.

It is also possible to address each unit without the use of the DataTemp Multidrop Software. Once the unit is powered up, use the enter and mode buttons on the back panel operator interface and toggle to the Multidrop Address field, see section 7.2 Operation Modes, page 32. Use up and down buttons to select a unique address for each unit. The units may now be installed in a multidrop network.

7 Operation

Once you have the sensor positioned and connected properly, the system is ready for continuous operation.

The operation of the sensor can be done by means of the built-in control panel in the sensor's housing or by means of the software that came with your sensor.

7.1 Control Panel

The sensor is equipped with a control panel in the sensor's housing, which has setting/controlling buttons and an LCD display. The panel is used primarily for setting up the instrument and is sealed during operation. The buttons and the display are defined in the following sections.
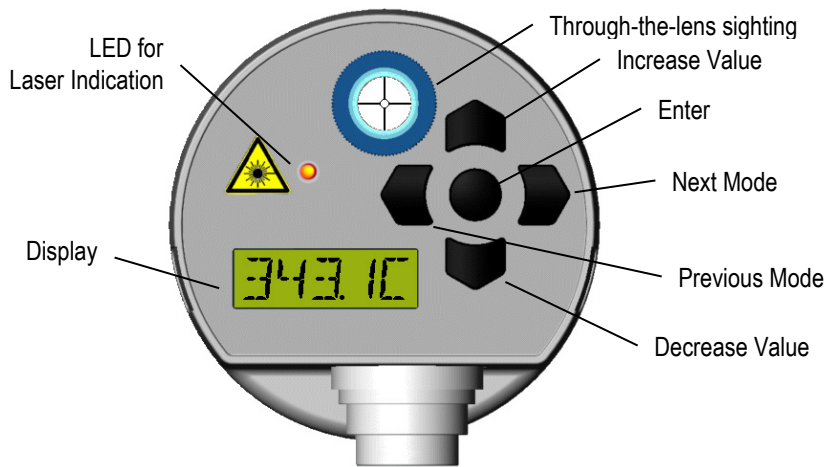
Figure 12: Control Panel

The sensor has a user interface lockout feature that keeps the unit from being accidentally changed from the control panel (locked by default in multidrop mode). This lockout mode denies access to all the adjustable parameters on the control panel. Access to the display modes of the panel while in a locked condition is provided.

7.2 Operation Modes

When you first turn the unit on, the display shows the current temperature. Pushing the keys of the control panel will change the figures on the display as shown in the menu tree below.

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Enter
●

<Object Temp.>

◄ ►

<Ambient Temp.>

◄ ►

ε <Emissivity>   ▲▼ 0.100 to 1.150

◄ ►

τ <Transmission>   ▲▼ 0.100 to 1.000

◄ ►

F <Focus>   ▲▼ 0.2/0.3 - 2.2

◄ ►

L <Laser> / V <Video>   ▲▼ On/Off/TRG

◄ ►

A <Average>   ▲▼ 0.0 to 300.0

◄ ►

Enter
●

P <Peak Hold>   ▲▼ 0.0 to 300.0

◄ ►

Saving of the selected parameter

V <Valley Hold>   ▲▼ 0.0 to 300.0

◄ ►

L <Low mA>   ▲▼ Low to High Temp

no action for 10 sec

H <High mA>   ▲▼ Low to High Temp

Without saving a parameter

◄ ►

M <Multidrop Addr.>   ▲▼ --, 1 to 32

◄ ►

B <Baud Rate>   ▲▼ 0.3, 1.2, 2.4, 9.6, 19.2, 38.4, 57.6, 115.2

◄ ►

U <Temp. Unit>   ▲▼ °C, °F, K

◄ ►

In the event of displaying the object's temperature and pressing the <Enter> button again, the sensor will not run through the complete menu again but directly go to the menu which was last used.

COM <Com Mode>   ▲▼ 2-wire/4-wire

◄ ►

CP <Control Panel>   ▲▼ Lock

◄ ►

Figure 13: Operation Modes

Operation

Object Temp.:	The display shows the current temperature of the measured object.
Ambient Temp.:	The display shows the current internal temperature of the sensor.
Emissivity:	Changes the emissivity value. The emissivity is a calculated ratio of infrared energy emitted by an object to the energy emitted by a blackbody at the same temperature (a perfect radiator has an emissivity of 1.00). For information on determining an unknown emissivity and for sample emissivities, see section 12.2 Typical Emissivity Values, page 82.
Transmission:	Changes the transmission value when using protective windows. For example, if a protective window is used with the sensor, set the transmission to the appropriate value.
Focus:	Changes the focus length of the sensor optics.
Laser/Video:	Switches the laser or the video (if available) on or off. With the setting <TRG> the laser can also be switched on/off via the external input.
Average:	Parameter given in seconds. Once Average is set above 0.0, it automatically activates. Note that other hold functions (like Peak Hold or Valley Hold) cannot be used concurrently. The default value is 0.0. For further information see section 7.3.1 Averaging, page 35.
Peak Hold:	Parameter given in seconds. Once Peak Hold is set above 0.0, it automatically activates. Note that other hold functions (like Valley Hold or Averaging) cannot be used concurrently. The default value is 0.0. For further information see section 7.3.2 Peak Hold, page 36.
Valley Hold:	Parameter given in seconds. Once Valley Hold is set above 0.0, it automatically activates. Note that other hold functions (like Peak Hold or Averaging) cannot be used concurrently. The default value is 0.0. For further information see section 7.3.4 Valley Hold, page 39.
Low mA:	Defines the temperature for the low current output value (0 or 4 mA).
High mA:	Defines the temperature for the high current output value (20 mA).
Multidrop Addr.:	Defines the address of a sensor in a network. Each sensor in a network must have a unique address. "--" means a standalone unit with address 0.
Baud Rate:	Defines the baud rate of a sensor. Each sensor in a multidrop network must be set to the same baud rate.
Temp. Unit:	The temperature display can be set to °C , °K or °F. Note that this setting influences the RS485 output for both object and ambient temperature. The default value is °C.
Com Mode:	Selects the desired digital communication mode for the sensor, either 2-Wire or 4-Wire.

Control Panel: The control panel can be locked to avoid accidentally change of sensor operating parameters. Once locked the control panel must be unlocked by using the control panel as follows:

1. Control Panel is locked.
2. Press the **<●>** button to enter Control Panel menu.
3. Press the following buttons consecutively: **<▲> <▼>**
4. Control Panel is unlocked.

Note that the control panel is locked by default in multidrop mode and can also be unlocked through the DataTemp Multidrop Software or a programming command.

7.3 Signal Processing

Activating and adjusting the parameters for the signal processing is accomplished either through the DataTemp Multidrop Software, or the programming commands, or partially on the control panel.

7.3.1 Averaging

Averaging can be useful when an average temperature over a specific duration is desired, or when a smoothing of fluctuating temperatures is required. The signal is smoothed depending on the defined time basis. In other words, 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. The following figure illustrates an averaging output signal.

This function is set on the control panel, the software or by means of the programming command G.

Figure 14: Averaging

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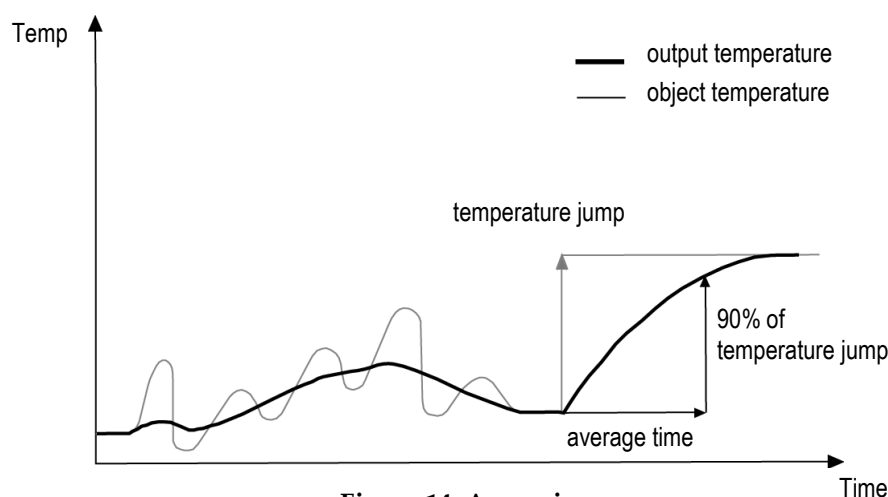
Operation

7.3.2 Peak Hold

With Peak Hold, the respective last peak value is held until the next reset will occur. There are the following possibilities for a reset.

7.3.2.1 Reset

- **Reset by Time**: The peak will be held for a certain hold time. Once the hold time is exceeded the output signal, tracks and output the actual object temperature and the algorithm will start over again. This function is set on the control panel, the software or by means of the programming command <P>.
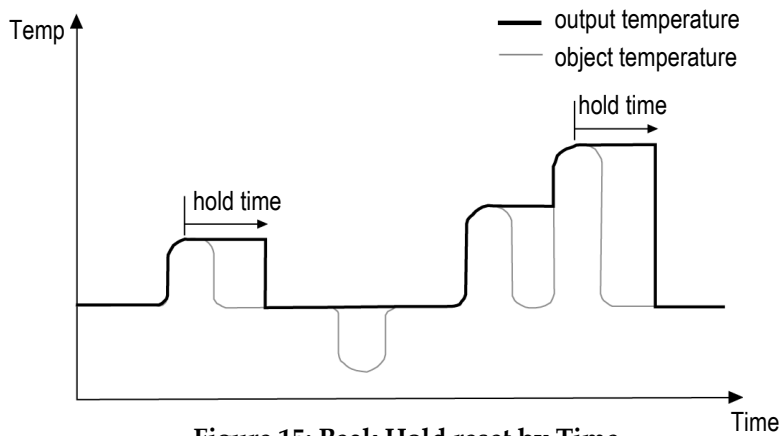
Figure 15: Peak Hold reset by Time

- **Reset by Trigger**: A logical low signal for the trigger will reset the peak hold function. As long as the input is kept at logical low level the actual object temperatures will be transferred toward the output. At the next logical high level, the hold function will be restarted.
  To activate the reset by trigger function, the Peak Hold must be set to 300.0 either through the control panel, or DataTemp Multidrop Software, or the programming commands <P>. For wiring the external trigger, see section 7.4.3.1 Trigger, page 42.
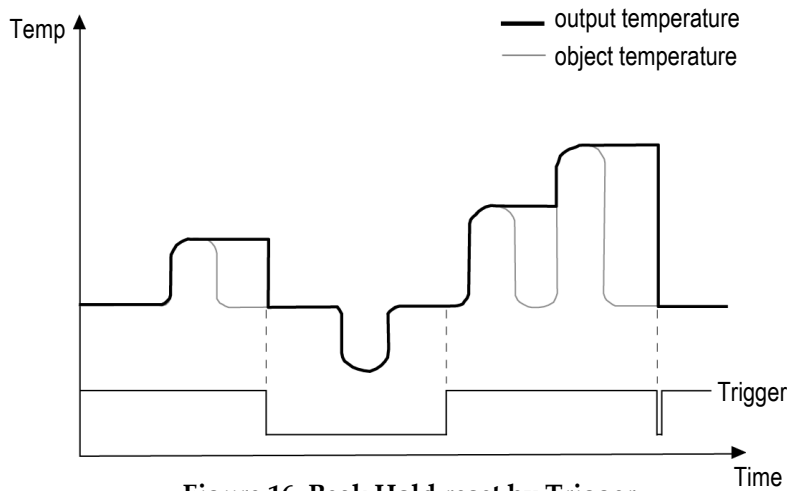
Figure 16: Peak Hold reset by Trigger

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- **Reset by burst string (Burst Peak Hold)**: In burst mode, the peak will be held until a new burst string is being sent via the digital interface, so the effective peak hold time is defined as the time difference between two sent burst strings.

  In the poll mode, there is a dedicated peak hold time set to <BS> + 10 ms whereby <BS> is the parameter for the burst speed.

  This function Burst Peak Hold is activated by means of the programming command <BP=1> and resets the commands <F>, <G>, and <P>.
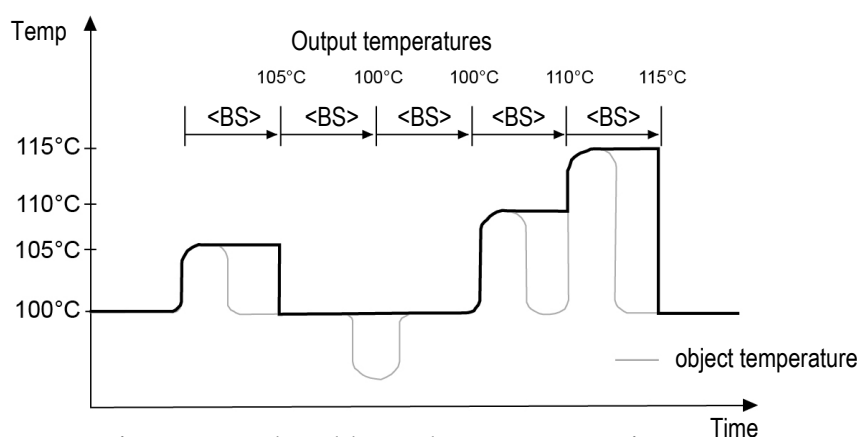
Figure 17: Peak Hold reset by sent Burst String
Peak Hold time equal to burst speed <BS>

7.3.2.2 Signal Slope

Here are the following options to define the lapse for the signal slope in case of a reset.

- Signal slope defined by **perpendicular drop** (default)
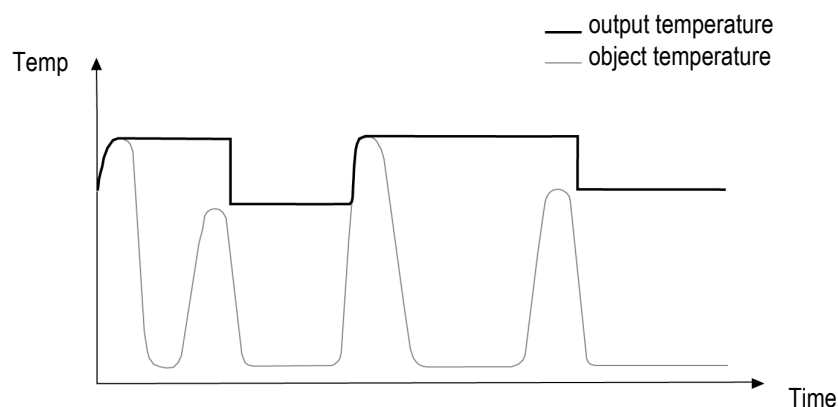
Figure 18: Perpendicular Signal Slope

- Signal slope defined by a **linear decay**: the decay is given in the Kelvin/second. This parameter is set by means of the programming command <XE>.

Operation
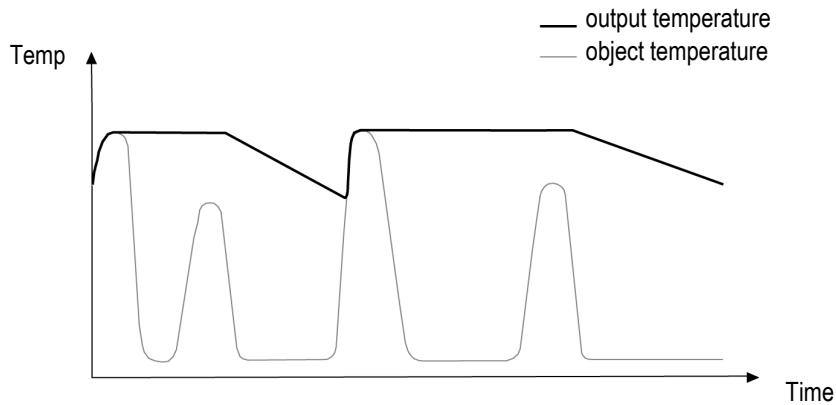
Figure 19: Signal Slope defined by Decay

- Signal slope defined by an **average** time. The average time is the amount of time the output signal needs to reach 90% magnitude compared to a perpendicular drop. This parameter is set by means of the programming command <AA>.
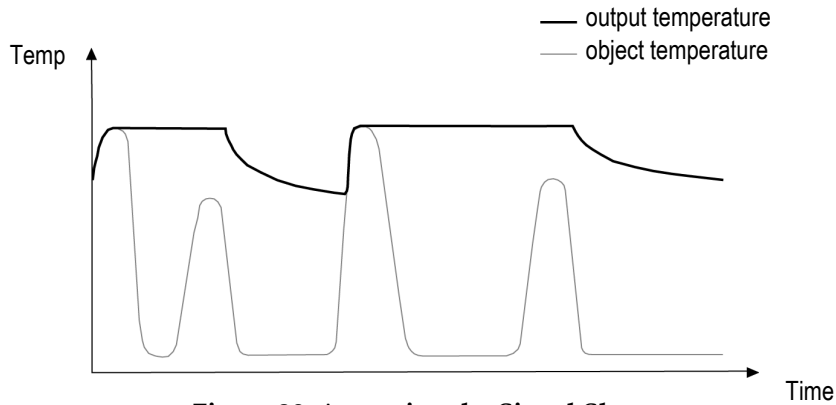
Figure 20: Averaging the Signal Slope

7.3.3 Advanced Peak Hold

This function searches the sensor signal for a local peak and writes this value to the output until a new local peak is found. Before the algorithm restarts searching for a local peak, the object temperature has to drop below a predefined threshold. If the object temperature raises 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 peak while the object temperature is currently below the predefined threshold the output signal jumps to the new maximum temperature of this local peak. Once the actual temperature has passed a peak above a certain magnitude, a new local peak is found. This magnitude is called hysteresis.

The threshold is set by means of the programming command <C>, for hysteresis use the command <XY>.

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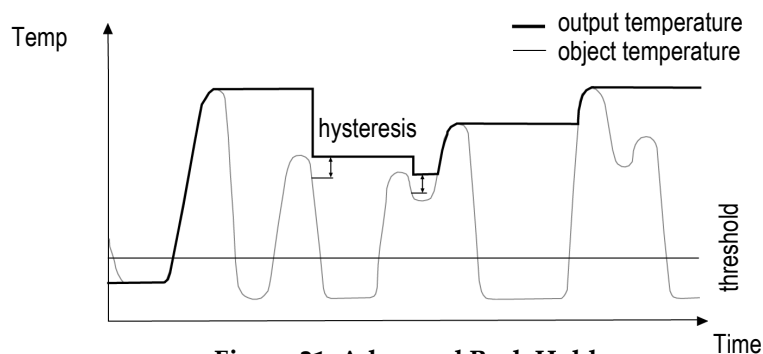
Figure 21: Advanced Peak Hold

For the advanced peak hold function, there are the same settings for reset and signal slope available like for the peak hold function, see sections 7.3.2.1 Reset, page 36 and 7.3.2.2 Signal Slope, page 37.

7.3.4 Valley Hold

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

7.3.5 Advanced Valley Hold

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

Operation

7.4 Inputs and Outputs

7.4.1 Milliamp Output

The milliamp output is an analog output you can connect directly to a recording device (e.g., chart recorder), PLC, or controller. The mA output can be forced to a specific value through the DataTemp Multidrop software or a programming command according to section 10.9.1 Current Output, page 73. This feature is useful for testing or calibrating connected equipment.
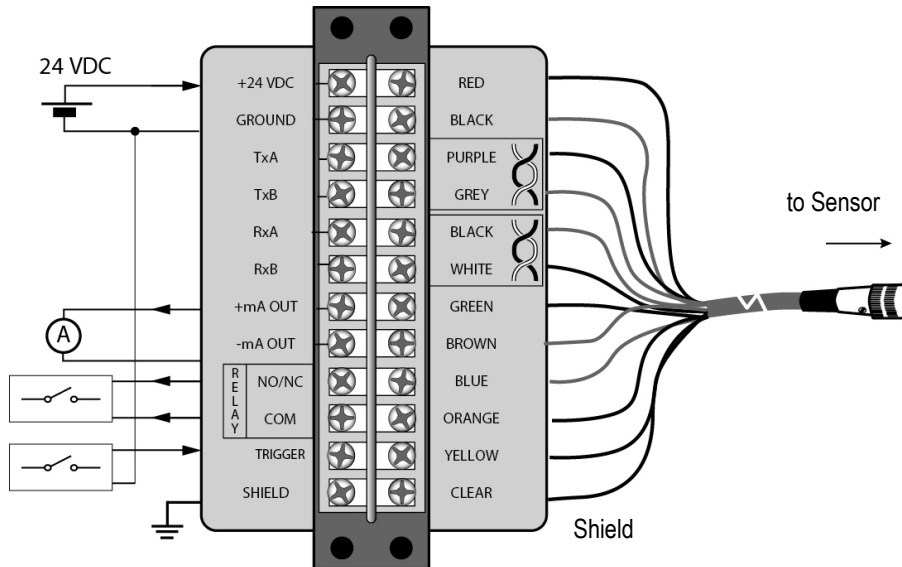
Figure 22: Wiring the Terminal

7.4.2 Relay Output

The relay output is used as an alarm for failsafe conditions, see section 11.2 Fail-Safe Operation, page 80, or as a threshold relay. Relay output relates to the currently displayed temperature on the control panel display. The relay output can be used to indicate an alarm state or to control external actions. The relay contacts can be set either to N.C. (normally closed: relay contacts are closed while in the home position) or N.O. (normally open: relay contacts are open while in the home position). The relay can also be forced on or off for testing connected equipment through the DataTemp Multidrop software or a programming command, see section 10.9.2 Relay Output, page 73.

7.4.2.1 Thresholds

The relay output has two user selectable thresholds. The two thresholds are set by default to the bottom temperature range. Activating and adjusting the threshold value is accomplished through the DataTemp Multidrop Software. Once one or both thresholds are activated the relay changes state as the current measured temperature passes the threshold temperature.
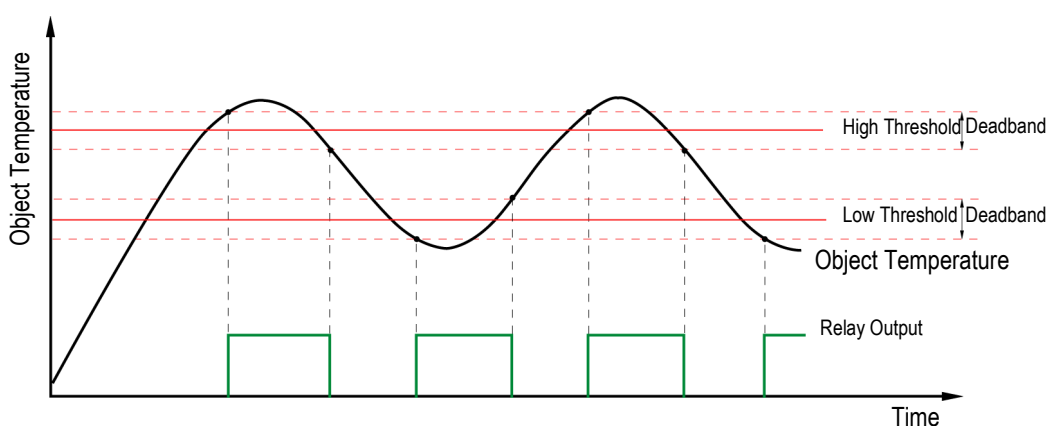
Figure 23: Relay Output Example

7.4.2.2 Deadband

Deadband is a zone of flexibility around the threshold. The alarm does not go abnormal until the temperature exceeds the threshold value by the number of set deadband degrees. Thereafter, it does not go normal until the temperature is below the threshold by the number of set deadband degrees. The deadband is factory preset to ±2 K of threshold value. Adjusting to other values is accomplished through DataTemp Multidrop Software. For information on the sensor's communication protocols, see section 10

Operation

7.4.3 External Input

The external input can be used to provide the following functions:
- digital input for triggering
- digital input for On/Off switching of the laser
- analog input for compensating the ambient background temperature
- analog input for setting the emissivity

> **ℹ** **Only one input function can be active at a given time. Before changing to another input function (e.g. remote emissivity setting) the currently set function (e.g. ambient background compensation) needs to be switched off explicitly!**

See the DataTemp Multidrop Software help for set up instructions, or refer to the required parameter commands in section 10.9.3 External Input, page 74.
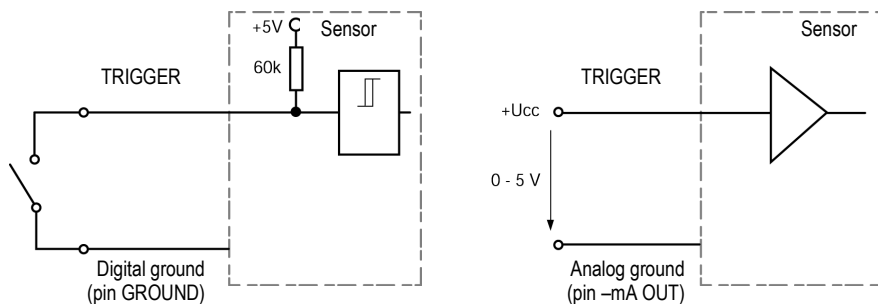
Figure 24: Digital (left) and Analog (right) Using of External Input

7.4.3.1 Trigger

The trigger is activated by shorting the external input to digital ground (pin GROUND on the terminal block) for a minimum duration pulse of 10 ms. That can be done with an external switch, relay, transistor, or TTL gate.

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7.4.3.2 Ambient Background 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 not significantly lower than the target temperature. For instance, the higher temperature of a furnace wall could lead to too-high temperatures being measured especially for lower emissivity targets. A built in ambient background temperature compensation utility compensates for the impact of the reflected radiation in accordance to 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 compensates the final result by subtracting the amount of ambient radiation measured from the sum of thermal radiation the sensor is exposed to.

> **i** **The ambient background temperature compensation should always be activated in case of lower emissivity targets in conjunction with targets cooler than the surrounding environment or heat sources near to the target!**

Three possibilities for ambient background temperature compensation are available:
- The **internal sensor temperature** is utilized for compensation assuming that the ambient background temperature is more or less represented by the internal sensor temperature. This is the default setting.
- If the background ambient temperature is known and constant, the user may input the known ambient temperature as a **constant temperature value**.
- Ambient background temperature compensation from a **second temperature sensor** (infrared or contact sensor) ensures extremely accurate results. An analog voltage signal at the external input (0 to 5 VDC) is utilized for real time compensation. The voltage input signal is wired to the trigger input terminal of the Marathon terminal block. If an infrared temperature sensor is used for background compensation, both sensors must be set on the same temperature range.

Operation

All ambient background temperature compensation functions are enabled through the DataTemp Multidrop software, see the software help for set up instructions, or refer to the required command protocol in section 10.8.6 Ambient Background Temperature Compensation, page 72.
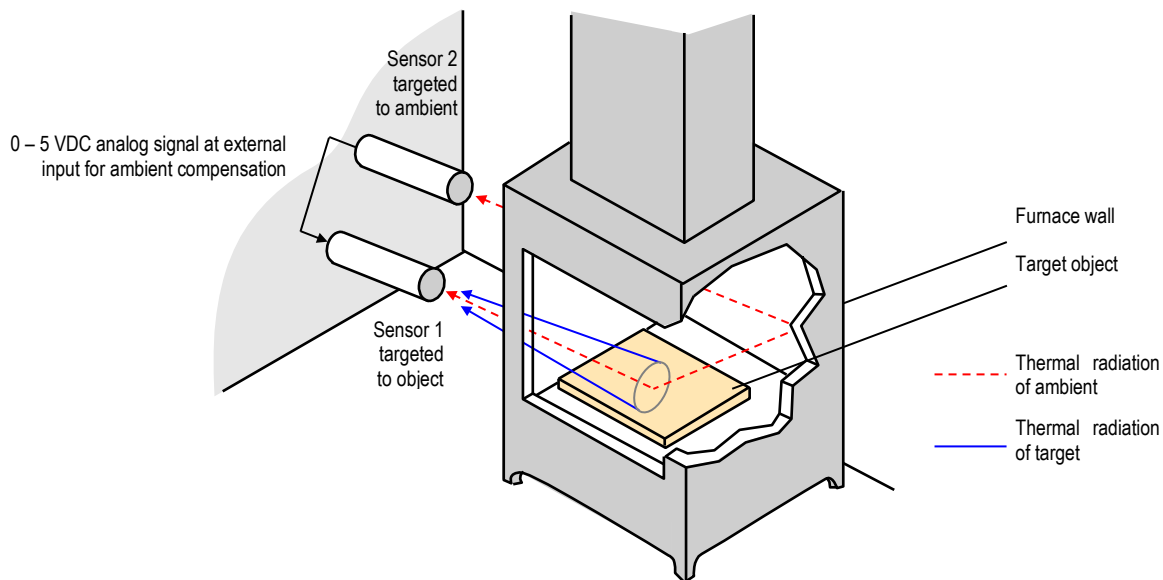
Figure 25: Ambient Background Temperature Compensation with Second Infrared Sensor

7.4.3.3 Emissivity Setting

The external input (trigger input) can be configured to accept an analog voltage signal (0 to 5 VDC) to provide real time emissivity setting. This function is enabled through the DataTemp Multidrop Software, see the software help for set up instructions, or refer to the required command protocol in section 10.8.5 Emissivity Setting, page 72. The following table shows the relationship between input voltage and emissivity.

U in V	0.00	0.24	0.48	0.71	0.95	1.19	1.43	1.67	1.90	2.14	2.38	2.62	2.86	3.10	3.33	3.57	3.81	4.05	4.29	4.52	4.76	5.00
Emissivity	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95	1.00	1.05	1.10	1.15

Table 5: Ratio between Analog Input Voltage and Emissivity
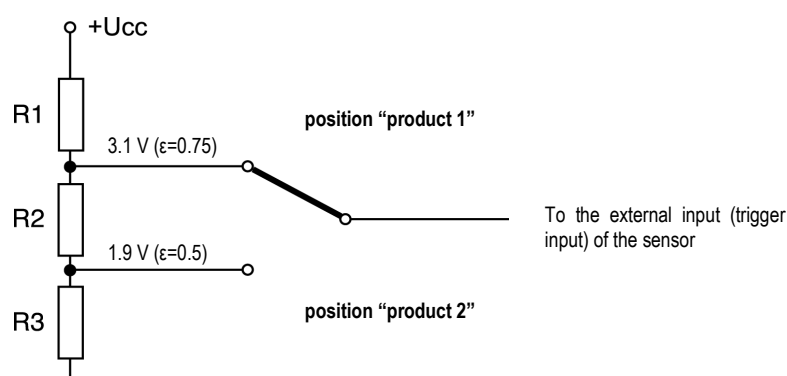
Figure 26: Adjustment of Emissivity at External Input (Example)

Operation

7.5 Factory Defaults

The following table provides the values in case of a factory default. The factory default can only be initiated by using the DataTemp Multidrop Software. The Multidrop address and the baud rate will not change from the last value when factory default is done.

Parameter	Factory defaults
Display mode	°C, TEMP- Display
Emissivity	0.95
Transmission	1.00
Focus	600 mm (23.6 in.)
Laser	Off
Average	000.0 (off)
Peak Hold	000.0 (off)
Valley Hold	000.0 (off)
Low mA (4 mA)	Minimum temperature of range
High mA (20 mA)	Maximum temperature of range
Multidrop Address	not changed (0 with delivery)
Baud Rate	not changed (38400 with delivery)
Temperature Unit	°C
Relay alarm output	controlled by unit
Current Output	4 – 20 mA
Control Panel	unlocked
Serial Communication	4-wire
RS485 Transfer Mode	Poll mode
Output String (RS485)	UTEIEC = temperature unit, target temperature, emissivity, internal temperature, error code

Figure 27: Factory Defaults

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8 Options

Options are items that are factory installed and must be specified at time of order. The following are available:

- Laser Sighting (…L) or Video Sighting (…V)
- Air/Water Cooled Housing including air purge
- Manufacturer's Calibration Certificate based on certified probes traced on national standards, e.g. DAkkS (XXXMMCERT)
- Variable Focus (…VF1), see section 3.2.1 Variable Focus, page 15

8.1 Laser Sighting

The laser sighting allows fast and precise aiming at small, rapidly moving targets, or targets passing at irregular intervals. The laser is specially aligned with the sensor's lens to provide accurate, non-parallax pinpointing of targets. The laser comes as a small, bright red spot indicating the center of the area being measured.
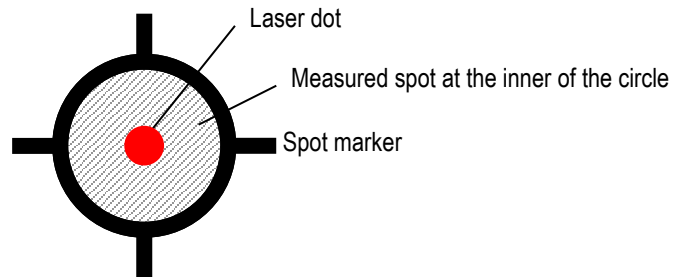
Figure 28: Spot Size Indication

For activating the laser sighting see Figure 13: Operation Modes on page 33.

The laser is a Class II, AlGaInP type laser with an output power less than 1 mW, and an output wavelength of 650 nm. The laser complies with FDA Radiation Performance Standards, 21CFR, subchapter J, and meets IEC 825, Class 2 specifications.

> **i** **To preserve laser longevity, the laser automatically turns off after approximately 10 minutes of constant use!**

WARNING!
Avoid exposure to laser light! Eye damage can result. Use extreme caution when operating! Never point at another person!

LASERLIGHT
Do not stare into beam!
Laser Class 2
EN 60825-1
< 1 mW, 650 nm

Options

8.2 Video Sighting

The Marathon MM unit has optional video sighting. Video sighting is intended as a convenient way to verify correct sighting of the Marathon MM unit. Video sighting also allows for either video or frame capture of the process, enhancing process documentation.

Video Specifications:

Pixels:	510 x 492
Field of View	8°
Focus	equal the focal distance of the IR channel (for units with fixed and variable focus)
Composite Video Output Format:	NTSC (analog)
Signal – Noise Ratio:	40 dB
Fixed Noise:	0.03% V_{PP}
Ambient Temperature Range:	5 to 50°C (41 to 122°F)
Minimum Required Illumination:	5 Lux
Impedance:	75 Ω
Cable Connection Type:	BNC
Maximum Analog Video Cable Run:	100 m (328 ft.)

The video sighting option is integral to the sensor electronics, so no additional installation is required. The unit utilizes an industry-standard BNC connector for the video output.
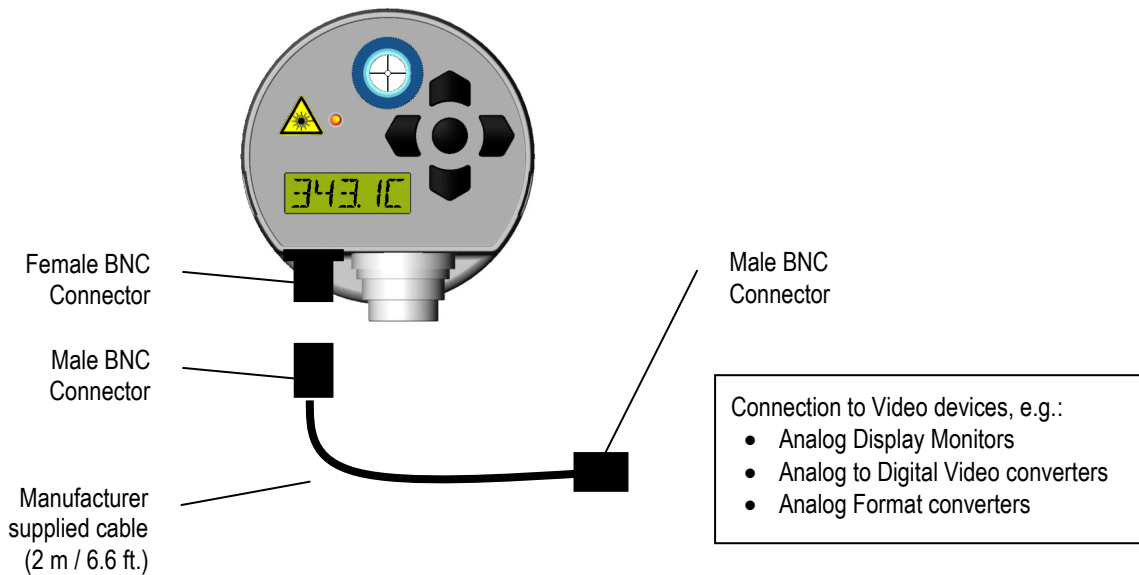
Figure 29: Wiring the Video Output

Analog Display Monitors

The analog NTSC video output can be feed directly to any monitor that accepts this video format. If NTSC video monitors are not locally available, there are commercially available devices that convert NTSC format into PAL or SECAM formats.

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Digital Video

In order to utilize the frame capture functionality of the MultiDrop Software, the analog video signal must be converted into a digital signal imported via a USB port to the MultiDrop Software. An analog to digital video converter is available from the manufacturer (P/N XXXMMACVCON) or can be purchased locally. Consider the operating instructions for the converter! The USB port on the PC must fulfill the USB 2.0 specification!

> **i** **Consider the following sequence for the installation:**
> 1. **Install the driver for the converter on the PC.**
> 2. **Connect the converter to the PC.**

> **i** **In case of installation problems it is recommended to deactivate possible other video devices via the control panel of the PC temporally!**

Once converted and imported to a PC, the Video Icon in the MultiDrop Software's toolbar automatically detects and displays the video stream.
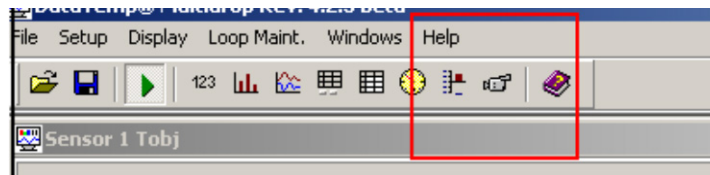
Figure 30: Video Icon in the MultiDrop Software

The video image window can be formatted in the <Setup Video View> window. This window can be opened by right clicking on the default video image window.
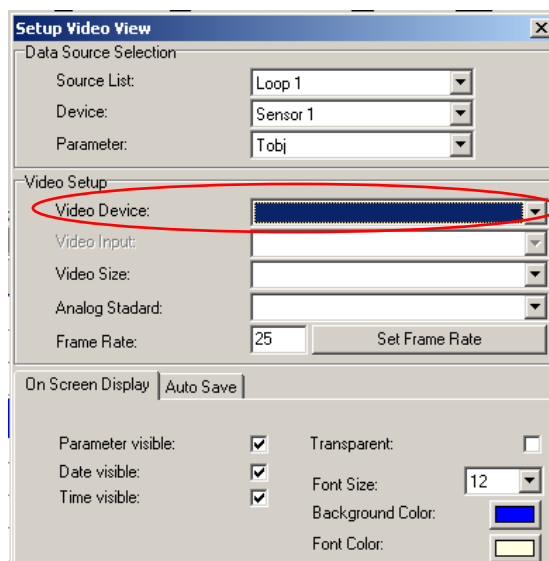
Select the video device XXXMMACVCON:
<Hi-Speed USB DVD Creator>

Attention: You can only see the video device for a PC connected converter!

Figure 31: Formatting the Video Image

Options

The <Auto Save> tab in the <Setup Video View> window is used to define the parameters for video frame capture and file path.
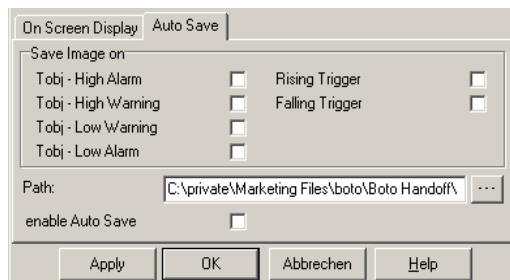
Figure 32: Setting the <Auto Save> function

8.3 Air/Water Cooled Housing

The Air/Water Cooled Housing allows the sensor to be used in ambient temperatures up to 120°C (250°F) with air cooling, and 175°C (350°F) with water cooling. The cooling media should be connected using 1/8" NPT stainless steel fittings requiring 6 mm (0.24 in) inner diameter and 8 mm (0.31 in) outer diameter for the tube.

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). The maximal pressure limit is 5 bar (73 PSI). Chilled water below 10°C (50°F) is not recommended, see section 8.3.1 Avoidance of Condensation, page 52.

> **i** **The Air/Water Cooled Housing is delivered with appropriate fittings.**
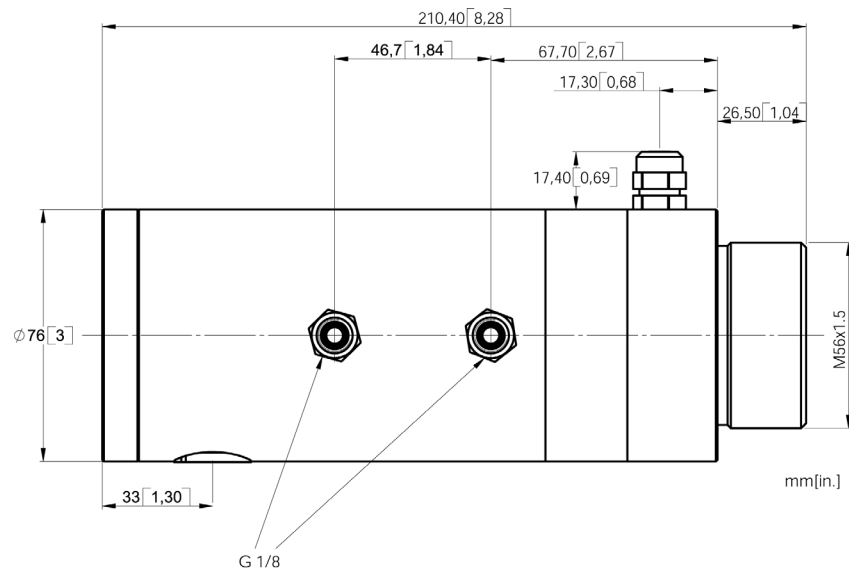
Figure 33: Air/Water Cooled Housing

> **i** **For ambient temperatures exceeding 175°C (350°F), the ThermoJacket can be used. This accessory allows operation at ambient temperatures up to 315°C (600°F)!**

Options

8.3.1 Avoidance of Condensation

If environmental conditions 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 sensor, thereby decreasing the capability of the air to hold water. The relative humidity increases and can reach 100% very quickly. In case of a further cooling, the surplus water vapor will condense out as water. 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.

> **i** **There is no warranty repair possible in case of condensation within the housing!**

To avoid condensation, the temperature of the cooling media and the flow rate must be selected to ensure a **minimum** device temperature. The minimum sensor 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	
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							
90/194	35/95	40/104	50/122	50/122	50/122	60/140	60/140	60/140											
100/212	40/104	50/122	50/122	60/140	60/140														

Tab. 6: Minimum device temperatures [°C/°F]

Example:

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

The use of lower temperatures is at your own risk!

> Temperatures higher than 60°C (140°F) are not recommended due to the temperature limitation of the sensor.

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9 Accessories

9.1 Overview

Accessories include items that may be ordered at any time and added on-site.

- Fixed Mounting Bracket (XXXMMACFB)
- Adjustable Mounting Bracket (XXXMMACAB)
- Air Purge Collar (XXXMMACAP...)
- Sight Tube (XXXTST…)
- Pipe Thread Adapter (XXXMMACPA)
- Right Angle Mirror (XXXMMACRA...)
- USB/RS485 Converter (XXXUSB485) see section 6.3 Computer Interfacing, page 28.
- Industrial Power Supply (XXXSYSPS)
- Terminal Box (RAYMAPB)
- Low Temp Cable with Terminal Block(XXX2CLTCB…)
- High Temp Cable with Terminal Block(XXX2CCB…)
- Terminal Block (XXXMATB)
- Terminal Box with terminal block and power supply (RAYMAPB)
- Protective Window (XXXMMACTW…)
- ThermoJacket (RAYTXXTJ4)
- {reserved}
- {reserved}

Accessories

Figure 34: Accessories

Pipe Adapter
XXXMMACPA

Adjustable Pipe Adapter
XXXTXXAPA

Fixed Mounting Bracket
XXXMMACFB

Pipe Adapter
XXXMMACPA

Sensor

Sight Tube
XXXTST...

Adjustable Mounting Bracket
XXXMMACAB

Right Angle Mirror
XXXMMACRA...

Air Purge Collar
XXXMMACAP...

ThermoJacket
RAYTXXTJ4

Mounting Nut
XXXMMACMN

Protection Window
XXXMMACTW...
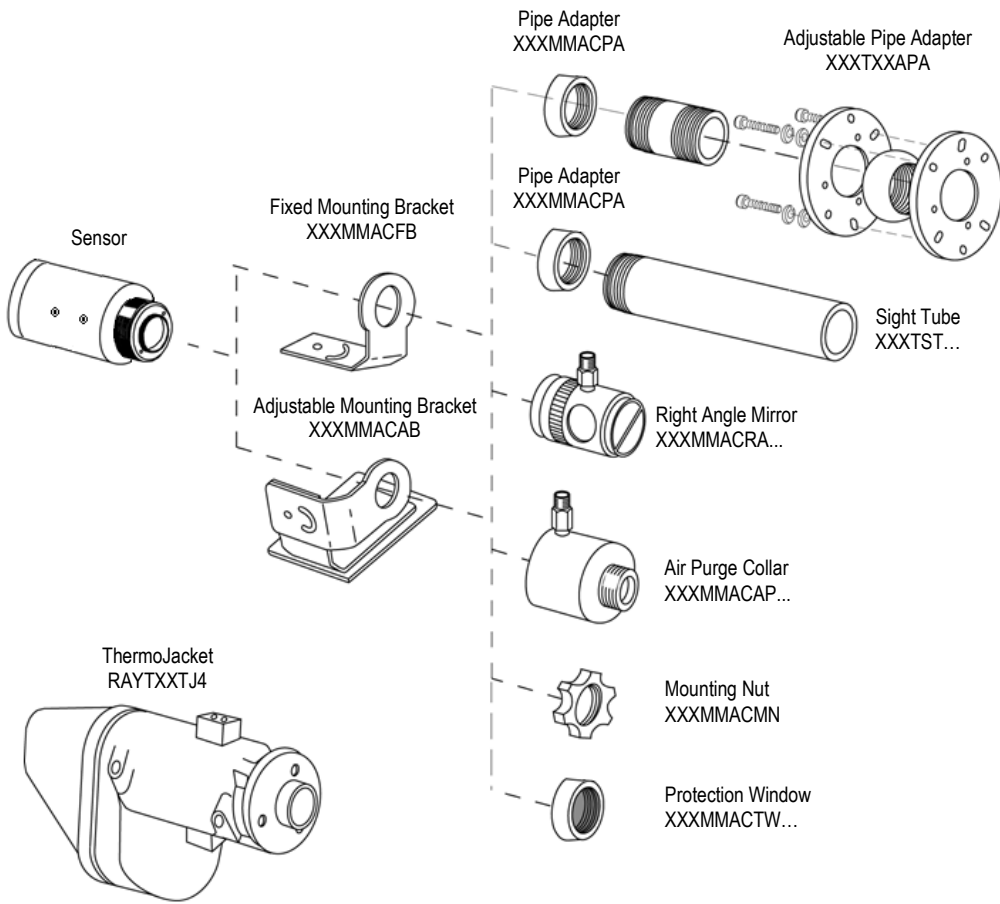
9.2 Fixed Mounting Bracket
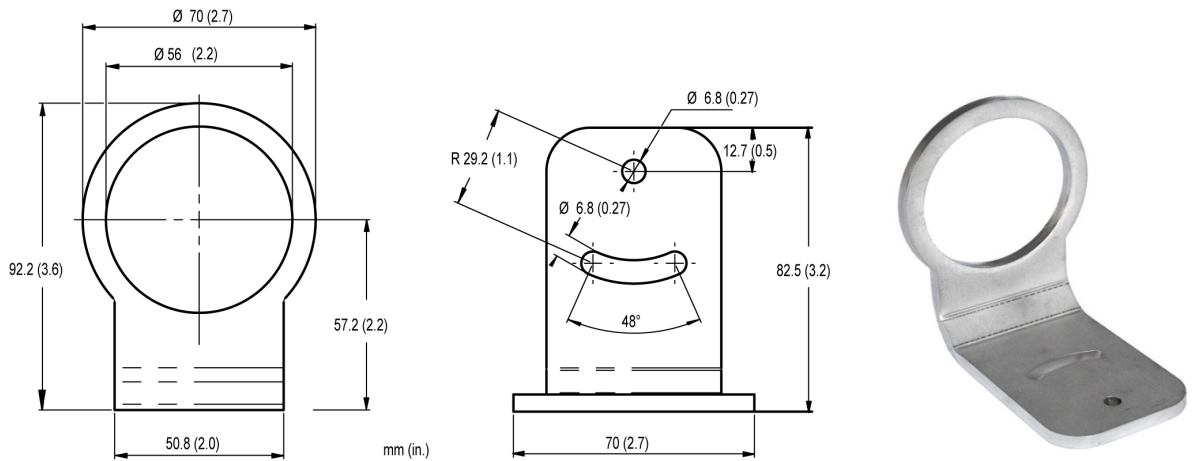
Figure 3: Fixed Mounting Bracket in Stainless Steel (XXXMMACFB)

9.3 Adjustable Mounting Bracket
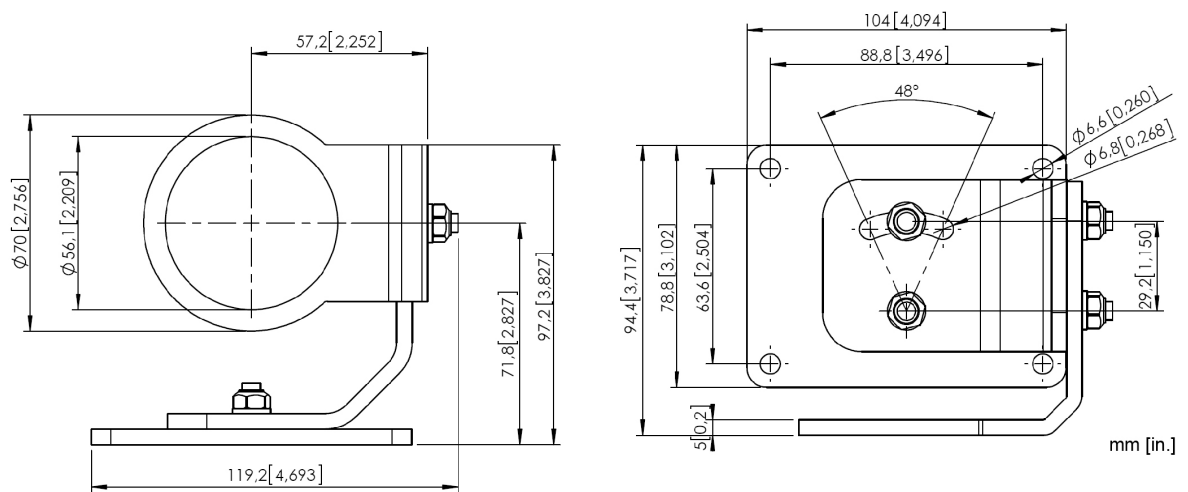
Figure 35: Adjustable Mounting Bracket in Stainless Steel (XXXMMACAB)

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Accessories

9.4 Air Purge Collar

The Air Purge Collar accessory is used to keep dust, moisture, airborne particles, and vapors away from the optical head's lens. It can be installed before or after the bracket. It must be screwed in fully. Air flows into the 1/8" NPT fitting and out the front aperture. Air flow should be a maximum of 0.5 - 1.5 liters/sec (1 - 3 cfm). Clean (filtered) or "instrument" air is recommended to avoid contaminants from settling on the lens. Do not use chilled air below 10°C (50°F).

The air purge collar can only be used either with the sensor alone or with the Air/Water Cooled Housing.

The Air Purge Collar is rotatable in steps of 120°.

The Air Purge Collar is available in Aluminum (XXXMMACAP) or stainless steel (XXXMMACAPS).
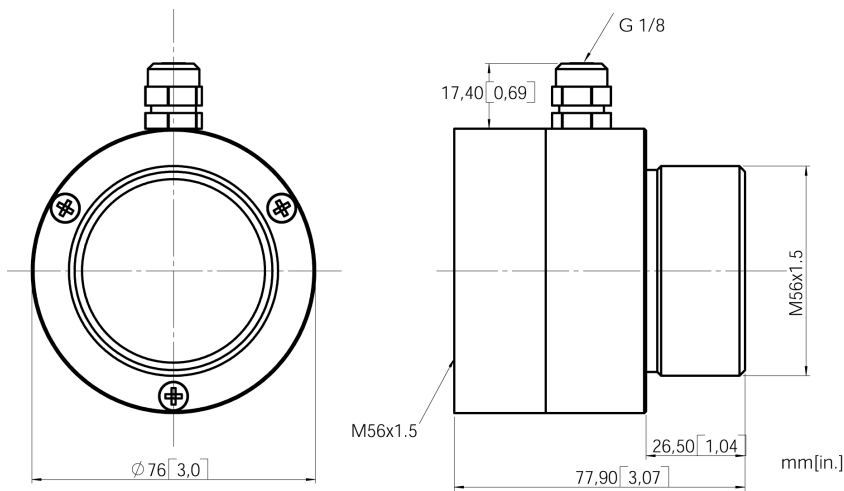
Figure 36: Air Purge Collar

9.5 Sight Tube

Use a protection tube in temperature measurement environments where reflected energy is a problem.
- Stainless Steel Protection Tube up to 800°C (1472°F) (XXXTST12)
- Ceramic (Alumina) Protection Tube up to 1500°C (2732°F) (XXXTSTC12)

> **When using a customer supplied protection tube, use caution in specifying the inside diameter and length. Your sensing head determines what diameter/length combinations are possible without impeding the optical field of view!**
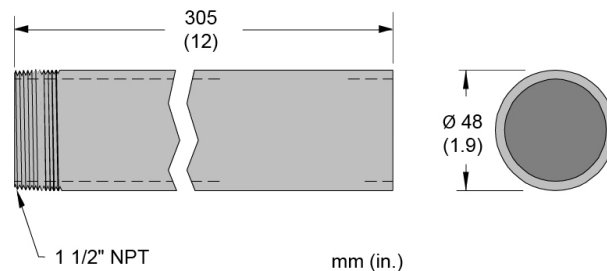
Figure 37: Sight Tube

9.6 Pipe Thread Adapter

The pipe thread adapter must be used to connect the sight tube with the sensor housing. It is made from stainless steel.
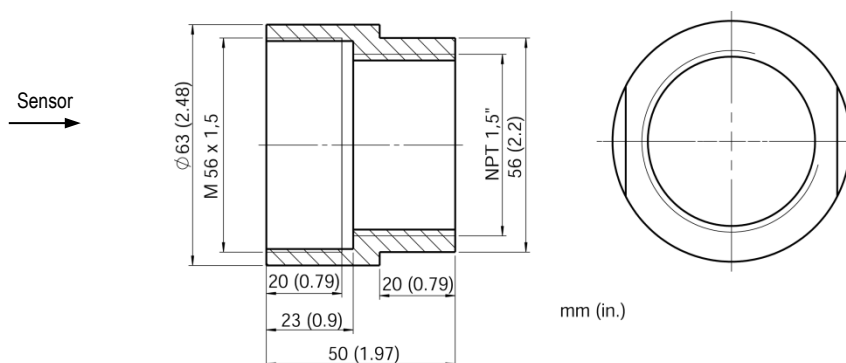
Figure 38: Pipe Adapter (XXXMMACPA)
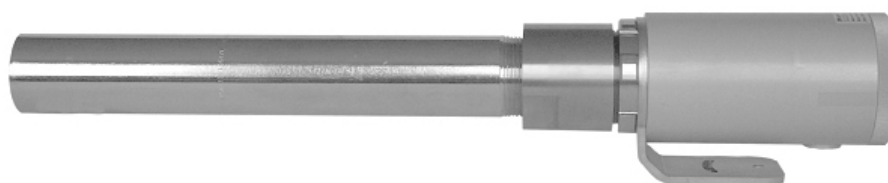
Figure 39: Sensor with Sight Tube (XXXTST…) Pipe Adapter (XXXMMACPA), and Fixed Mounting Bracket (XXXMMACFB)

Accessories

9.7 Right Angle Mirror

The Right Angle Mirror 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. In dusty or contaminated environments, the air purging should be used to keep the mirror surface clean.

The right angle mirror is available in Aluminum (XXXMMACRA) or stainless steel (XXXMMACRAS).
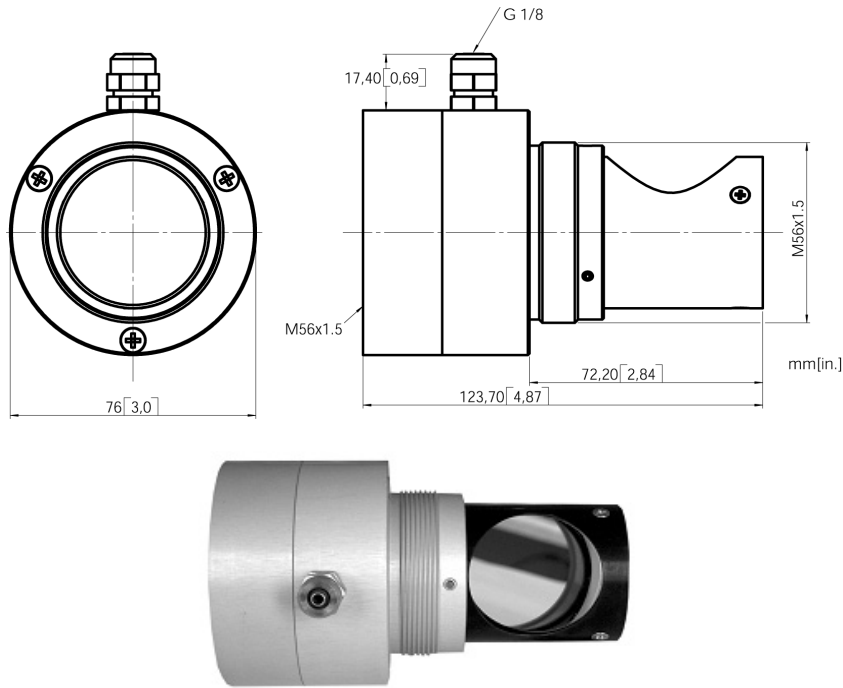
Figure 40: Right Angle Mirror

9.8 Industrial Power Supply

The DIN-rail mount industrial power supply delivers isolated dc power and provides short circuit and overload protection.

⚠️ **To prevent electrical shocks, the power supply must be used in protected environments (cabinets)!**

Technical data:

Protection class	prepared for class II equipment
Environmental protection	IP20
Operating temperature range	-25°C to 55°C (-13°F to 131°F)
AC Input	100 – 240 VAC 44/66 Hz
DC Output	24 VDC / 1.3 A
Cross sections	input/output
	0.08 to 2.5 mm² (AWG 28 to 12)
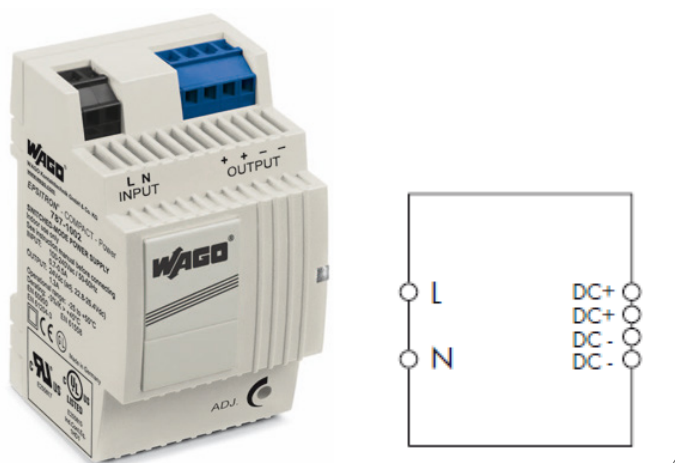
Figure 41: Industrial Power Supply (XXXSYSPS)

[4] Copyright Wago®

Accessories

9.9 Terminal Box

The terminal box is designed to provide IP66 (NEMA-4) protection to the terminal block, see section 6.2 Electrical Installation, page 26, and a power supply for the sensor. The box should be surface mounted using the flanges and holes provided. It should be mounted in such a manner to allow the free flow of air around the unit. Ambient temperatures should be kept within the range of 0 to 50°C (32 to 120°F).

Technical data for the power supply:

AC input	100 – 240 VAC 50/60 Hz
DC output	24 VDC / 1.1 A
Operating temperature	-20 to 60°C (-4 to 140°F)
Humidity	20 to 90%, non-condensing
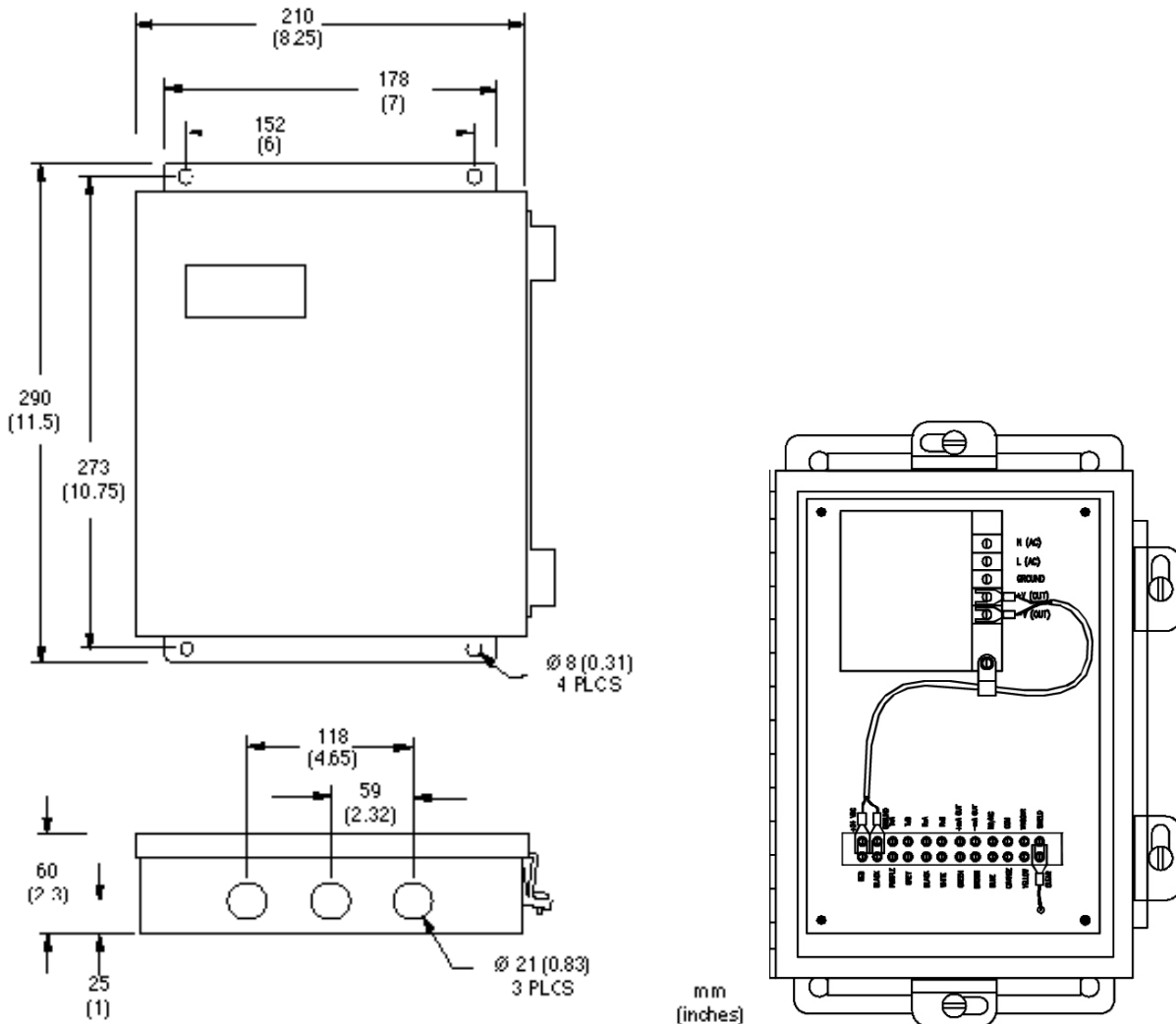
Figure 42: Terminal Box (RAYMAPB)

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9.10 Low Temp Cable

The 12-wire low temp cable (XXX2CLTCB…) is used for wiring the sensor with the 24 VDC power supply, all outputs, and the RS485 interface. The cable is PUR (Polyurethane) coated and withstands ambient temperatures form -40 to 105°C (-40°F to 221°F). PUR coated cables are flexible and have good to excellent resistance to against oil, bases, and acids.

- Temperature: -40 to 105°C (-40°F to 221°F)
- Cable material   PUR- 11Y (Polyurethane), Halogen free, Silicone free
- Cable diameter: 7.2 mm (0.283 in) nominal
- Conductors:

Power supply	2 wires (black/red)	
Conductor:	0.2 mm² (AWG 24), 7x32 tinned copper	
Isolation:	PE- 2YI1	
Shield:	none	
RS485 interface	2 twisted pairs (black/white and purple/gray)	
Conductor:	0,2 mm² (AWG 24), 7x32 tinned copper	
Isolation:	PE- 2YI1	
Shield:	CDV-15, 85% covered	
Outputs and Ground	6 wires (green/brown/blue/orange/yellow/clear)	
Conductor:	0,2 mm² (AWG 24), 7x32 tinned copper	
Isolation:	PE- 2YI1	
Shield:	none	

Further information for wiring the cable can be found in section 6.2 Electrical Installation, page 26.

The low temp cable can be purchased from the manufacturer in the following lengths: 4 m, 8 m, 15 m, 30 m, 60 m (13 ft., 26 ft., 49 ft., 98 ft., 197 ft.)

If you cut the cable to shorten it, notice that both sets of twisted-pair wires have drain wires inside their insulation. These drain wires (and the white wire that is not part of the twisted pair) must be connected to the terminal labeled CLEAR.

If you purchase your own RS485 cable, use wire with the same specifications as those listed above. Maximum RS485 cable length is 1.200 meters (4000 ft).

Accessories

9.11 High Temp Cable

The 12-wire cable (XXX2CCB…) is used for wiring the sensor with the 24 VDC power supply, all outputs, and the RS485 interface. The cable is Teflon coated and withstands ambient temperatures form -80 to 200°C (-112°F to 392°F). Teflon coated temperature cables have good to excellent resistance to oxidation, heat, weather, sun, ozone, flame, water, acid, alkalis, and alcohol, but poor resistance to gasoline, kerosene, and degreaser solvents.

- Power supply   2 wires (black/red)
    - Conductor: 0.3 mm² (AWG 22), 7x30 tinned copper
    - Isolation: FEP 0.15 mm wall (0.006 in)
    - Shield: none
- RS485 interface   2 twisted pairs (black/white and purple/gray)
    - Conductor: 0,22 mm² (AWG 24), 7x32 tinned copper
    - Isolation: FEP 0.15 mm wall (0.006 in)
    - Shield: Aluminized Mylar with drain wire
- Outputs and Ground   6 wires (green/brown/blue/orange/yellow/clear)
    - Conductor: 0,22 mm² (AWG 24), 7x32 tinned copper
    - Isolation: FEP 0.15 mm wall (0.006 in)
    - Shield: none
- Cable diameter: 7 mm (0.275 in) nominal
- Temperature: UL-rated at -80 to 200°C (-112°F to 392°F)

⚠️ **Teflon develops poisonous gasses when it comes into contact with flames!**

Further information for wiring the cable can be found in section 6.2

High temp 12-wire cable can be purchased from the manufacturer in the following lengths: 4 m, 8 m, 15 m, 30 m, 60 m (13 ft., 26 ft., 49 ft., 98 ft., 197 ft.)

If you cut the cable to shorten it, notice that both sets of twisted-pair wires have drain wires inside their insulation. These drain wires (and the white wire that is not part of the twisted pair) must be connected to the terminal labeled CLEAR.

If you purchase your own RS485 cable, use wire with the same specifications as those listed above. Maximum RS485 cable length is 1.200 m (4000 ft).

9.12 Protective Window

Protective windows can be used to protect the sensor's optics against dust and other contamination. The following table provides an overview of the available protective windows recommended for the spectral models. All protective windows have a transmission below 100%.

> ⚠️ **To avoid erroneous readings, ensure that the transmission for the appropriate protective window must be set in the sensor, see section 7.2 Operation Modes, page 32!**

Order number	Identification	Model	Material	Transmission
XXXMMACTWL	no dot	Focus SF/VF: LT, 3M, MT, G5	Zinc Sulphide	0.75 ±0.05
XXXMMACTWLS	no dot	Focus SF/VF: LT, 3M, MT, G5	Zinc Sulphide stainless steel	0.75 ±0.05
XXXMMACTWLCF	1 dot	Close Focus CF: LT, 3M	Zinc Sulphide	0.75 ±0.05
XXXMMACTWLCFS	1 dot	Close Focus CF: LT, 3M	Zinc Sulphide stainless steel	0.75 ±0.05
XXXMMACTWLF1	no dot	LT	Plastic Foil stainless steel	0.75 ±0.05
XXXMMACTWGP	2 dots	1M, 2M	Fused Silica	0.93 ±0.05
XXXMMACTWGPS	2 dots	1M, 2M	Fused Silica stainless steel	0.93 ±0.05

Tab. 7: Protective Windows

For special requirements, please contact your local vendor or representative about our range of special protective windows.
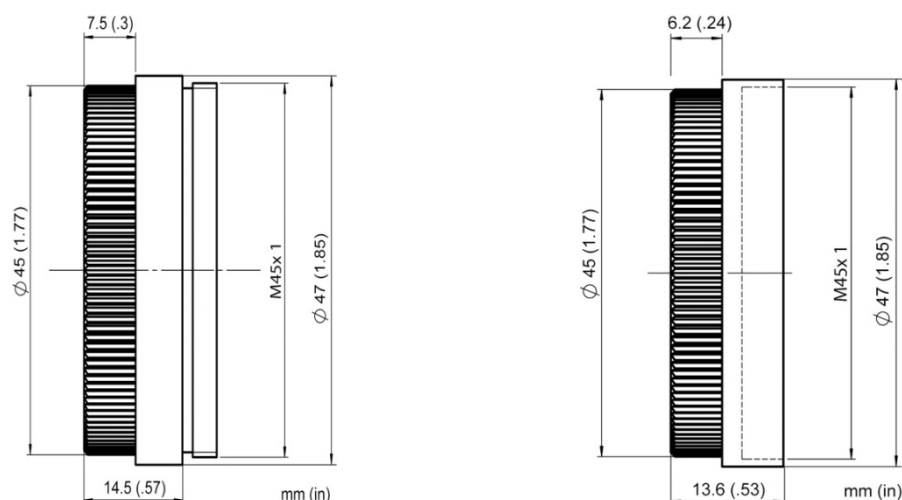
Figure 43: Dimensions for Protective Window(left: SF version, right: CF version)

Accessories

9.13 ThermoJacket

The ThermoJacket gives you the ability to use the sensor in ambient temperatures up 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.
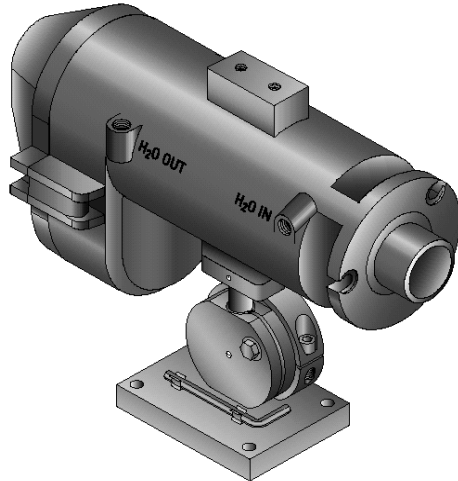
Figure 44: ThermoJacket (RAYTXXTJ4) with Mounting Base (XXXTXXMB)

For more information see the ThermoJacket's manual.

9.14 *{reserved}*

9.15 *{reserved}*

10 Programming Guide

This section explains the sensor's communication protocol. A protocol is the set of commands that define all possible communications with the sensor. The commands are described along with their associated ASCII command characters and related message format information. Use them when writing custom programs for your applications or when communicating with your sensor with a terminal program.

10.1 Serial Interface versus Control Panel

Since the sensor includes a control panel, the possibility exists for the user to make manual changes to parameter settings. To resolve conflicts between manual parameter settings and settings by means of the serial interface, the sensor observes the following rules:

- Command precedence: the most recent parameter change is valid, whether originating from control panel or the serial interface.
- If a manual parameter change on the control panel is made, the sensor will transmit a "notification" string to the host (e.g. a PC). Notification strings are suppressed in multidrop mode.

10.2 Storing of Parameters

All sensor parameters, which are changed via the serial interface, are changed in the sensor internal EEPROM memory. The EEPROM memory will retain all information after powering off the sensor.

10.3 Command Structure

After transmitting one command, it is obligatory to wait for the response from the sensor before sending another. Make sure that a command sent was completely transmitted from the sender before the next command can be sent.

i   **All commands must be entered in upper case (capital) letters!**

10.3.1 Requesting a parameter (Poll Mode)

?E<CR>   "?" is the command for "request"
                        "E" is the parameter requested
                        <CR> carriage return (0Dh) is closing the request

10.3.2 Setting a parameter (Poll Mode)

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 (0Dh) is closing the setting

10.3.3 Sensor response

!E0.975<CR><LF>   "!" is the parameter for "answer"

                    "E" is the parameter

                    "0.975" is the value for the parameter

                    <CR> <LF> (0Dh 0Ah) is closing the answer

For processing the received commands, the device needs up to 500 ms in the normal case. For certain commands, this time can be even longer, see <Time out> parameter given in section 10.12 Command List, page 76.

10.3.4 Sensor notification

With a notification the sensor informs the host, that the sensor or the firmware was reset.

#XI1<CR><LF>   "#" is the parameter for "Notification"

                    "XI1" is the value for the notification (e.g. "XI1" firmware reset)

                    <CR> <LF> (0Dh 0Ah) is closing the notification

To track the sensor's reset, XI remains unequal to zero as long as XI=0 is set manually via the digital interface.

With a notification the sensor also informs the host, that a parameter was set on the control panel manually.

#XL1<CR><LF>   "#" is the parameter for "Notification"

                    "XL1" is the value for the notification (e.g. "XL1" laser switched on)

                    <CR> <LF> (0Dh 0Ah) is closing the notification

10.3.5 Error Messages

An asterisk * will be transmitted back to the host in the event of an "illegal" instruction. An illegal instruction is considered to be one of the following:

- "*Unknown Command" – any non-used or non-allowed character (e.g. lower case characters)
- "*Range Error" – an "out-of-range" parameter value
- "*Syntax Error" – a value entered in an incorrect format
- "*Function impossible" – unit not in correct modus to execute the requested function

10.4 Transfer Modes

There are two possible transfer modes for the serial interface.

Poll Mode: The current value of any individual parameter can be requested by the host. The sensor responds once with the value at the selected baud rate.

Burst Mode: A pre-defined data string, a so called "burst string", will be transferred continuously as long as the burst mode is activated.

V=P   "P" starts the poll mode

V=B   "B" starts the burst mode

$=UTIEECCS   "$" sets the content of the burst string:

                    "U" for temperature unit

                    "T" for target temperature

                    "I" for internal temperature of the sensor

                    "E" for emissivity value

                    "EC" for error code

                    "CS" adds a checksum

| ?$ | gives the burst string parameters while in poll mode, e.g. "UTIE" |
| ?X$ | gives the burst string content while in poll mode, e.g. "UC T0150.3 I0027.1 E0.950" |

Return from burst mode to poll mode

| 4-Wire Communication: | send "V=P" |
| 2-Wire Communication: | send "V=P". It could be necessary to send the command more than one times. |

10.5 Checksum

The destination for the burst string is often a Windows PC. The Windows operating system is non deterministic and known to let the buffer of the serial communication overflow. To test the burst string a checksum can be added to it by writing <CS> to the burst string definition string ($=...).

The <CS> command can also be used in the polling mode. <CS=1> activates the checksum transfer as a 3 digit integer number.

Example:

?CS	//asks for the checksum status
!CS0	//answer: no checksum activated
CS=1	//enable the checksum calculation
!CS1 CS048	//answer: checksum is activated, checksum added, checksum in decimal format

Character Transmission Check

You can check the correctness of transmitted strings by evaluating the block check character (BCC), the checksum. This can be done by taking the exclusive OR (XOR) of the ASCII values of all the characters transmitted from the start character (here: "!") up to the "S" but excluding the checksum value itself (here: 127), carriage return <CR> and line feed <LF>. For example, the shaded characters are included as follows:

| ! | E | 0 | . | 5 | <space> | C | S | 127 | <CR> | <LF> |

Please note, the start character can be one of the following: "!", "?", "*", "#", <multidrop address>, <first character of the burst string>.

You can evaluate the received string easily by converting the ASCII values to Binary and progressively adding the Binary values together, minding the following rules for taking the XOR:

0	1	1	0
0	1	0	1
0	0	1	1

The sent checksum from the exemplary line above needs to be identical to the calculated checksum below.

ASCII	HEX	Binary	Dec	
!	21	0010 0001		
E	45	0100 0101		
0	30	0011 0000		
.	2E	0010 1110		
5	35	0011 0101		
<space>	20	0010 0000		
C	43	0100 0011		
S	53	0101 0011		
	7F	0111 1111	**127**	calculated checksum via XOR operation

Algorithm for a character wise executed XOR operation given in exemplary Basic programming code:

```
Bcc = 0
For I = 1 To Len(String)
     Bcc = Bcc Xor Asc(Mid$(String, I, 1))
Next I
```

10.6 Burst Mode

10.6.1 Speed

The communications of the sensor are capable of operating in either burst mode or poll mode. Poll mode requires that a query be issued by a host PC and the unit will respond to the query. In burst mode the unit transmits a pre-configured burst string at a certain rate.

LT, G5, MT, 3M, and G7 units produce a new temperature read (sample time) every 20 ms.
2M and 1M units produce a new temperature read (sample time) every 1 ms.

However, the communications of the sensor in burst mode are limited by the computer baud rate as well as the length and content of the burst string.

- The **Standard burst mode** cycle time is 50 ms. If the burst string contains characters other than "T", "I", or "XT" then the unit will transmit the string every 50 ms. Example burst programmed so that $=TIXTE produces the string <T0150.3 I0027.1 XT00 E0.950> every 50 ms.

- The burst mode cycle time of the sensor can be reduced by shortening the length of the burst string. A **Faster burst mode** cycle time can be achieved when the burst string is configured to contain no other characters than "T", "I", and "XT".
  Example 1: $=TIXT results in <T0150.3 I0027.1 XT00>
  Example 2: $=TI results in <T0150.3 I0027.1>.
  When the burst string is configured in this way the unit will transmit the string with 20 ms for LT, G5, MT, 3M, and G7 models and 5 ms for 2M and 1M models). Due to this faster rate of data transmission, communications will now be limited by the baud rate of the host. If the host computer does not have a fast enough baud rate then data will be lost and the effective data transmission rate will be slower than the cycle time of the unit.

- Because the required baud rate is a function of the number of characters in the burst string, the **Fastest burst** mode **cycle** time can effectively be achieved by reducing the number of

characters in the burst string. Using this mode automatically sets the burst string to contain only the values for the "T", "I" and "XT" parameters. However, the "T", "I" and "XT" characters are removed from the burst string.. , Issuing the command $=$ sets the unit into the fastest burst and changes the format of the burst string from <T0150.3 I0027.1 XT00> to <0150.3 0027.1 00>. Because of the burst string is now shorter, the required baud rate will be slower and the effective transmission rate will be faster.

10.6.2 Minimum Baud Rate

The minimum required interface baud rate depends on the number of transferred characters and the read cycle time of the burst mode (standard, fast, or fastest). It may be computed as the following:

$$b = \frac{n_{bit} \cdot n_{char}}{t_{cycle}}$$

where:

b = minimum required interface baud rate in [bit/s]

n_{bit} = the number of necessary bits for one transferred character including stop bit, is always 9 (8 data bits and 1 stop bit), given in [bit/char]

n_{char} = the number of characters in the burst string including blanks, <CR>, and <LF>, given in [char]

t_{cycle} = read cycle time given in [s]

Example:

The burst string in the format "$=TIXT" + "$=$" gives the content with 12 characters, e.g. "1234.5 46 0<CR>". What is the minimum required interface baud rate in the very fast burst mode with 1 ms read cycle time?

$$b = \frac{9 bit \cdot 12 char}{char \cdot 1 \cdot 10^{-3} s} = 108000 \frac{bit}{s} \rightarrow \underline{\underline{115200 \frac{bit}{s}}}$$

10.7 Sensor Information

The sensor information is factory installed as read only values.

Command	Description	Answer (example)
?XU	Name of the sensor	"!XUMMLT"
?DS	Additional remark, e.g. for special numbers	"!DSRAY"
?XV	Serial number of the sensor	"!XV2C027"
?XR	Firmware revision number	"!XR2.08"
?XH	Maximum temperature of the sensor	"!XH0800.0"
?XB	Minimum temperature of the sensor	"!XB-040.0"

Table 9: Sensor Information

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10.8 Sensor Setup

10.8.1 General Settings

U=C	sets the physical unit for the temperature value (C or F or K). In case of a changed physical unit all temperature related parameters (e.g., thresholds) are converted automatically.
E=0.950	sets the emissivity according to the setting of "ES" command
A=250	sets the ambient background temperature compensation according to the setting of "AC" command
XG=1.000	sets the transmission
?T	asks for the target temperature
?I	asks for the internal temperature of the sensor
?Q	asks for the energy value of the target temperature

10.8.2 Sample Time

The sample time roughly defines the time between the update of the analog output. On all units this is factory defined to be equal to the stated response time of the unit. However, LT, G5, MT, 3M, and G7 sensors have the capability to update the analog output at rates faster than the stated response time. Reducing the sample time will reduce the time that the AD converter is averaging the detector signal. This reduced averaging can result in considerably more noise in the analog output signal, thus this setting should not be changed under most circumstances. The sample time can be set to the following values:

ST=20000	sets sample time to 20 ms, for complete suppressing of 50 Hz noise
ST=16666	sets sample time to 16.6 ms, for complete suppressing of 60 Hz noise
ST=2000	sets sample time to 2 ms, for fastest possible analog update rate that provides a smooth step response, but with higher noise.

10.8.3 Temperature Pre-Processing

The samples from the AD converter can be processed before or after temperature calculation. The following filters are available for temperature pre-processing:

FF=0 0 0	switches the filter off. This command is for 2M and 1M devices and allows for transient events as short as 900 µs in duration to be captured. This mode greatly increases the amount of noise on the unit's output.
FF=1 <threshold> 0	averages the last 16 samples. Over the <threshold> no averaging is applied. The <threshold> is given in AD counts. Use the command Q for getting AD counts. (default value: <threshold> = 750).
FF=2 0 0	sets the filter to consider the detector response curve for LT, G5, MT, 3M, and G7 devices to allow for transient events as short as 20 ms in duration to be captured. This mode greatly increases the amount of noise on the unit's output.
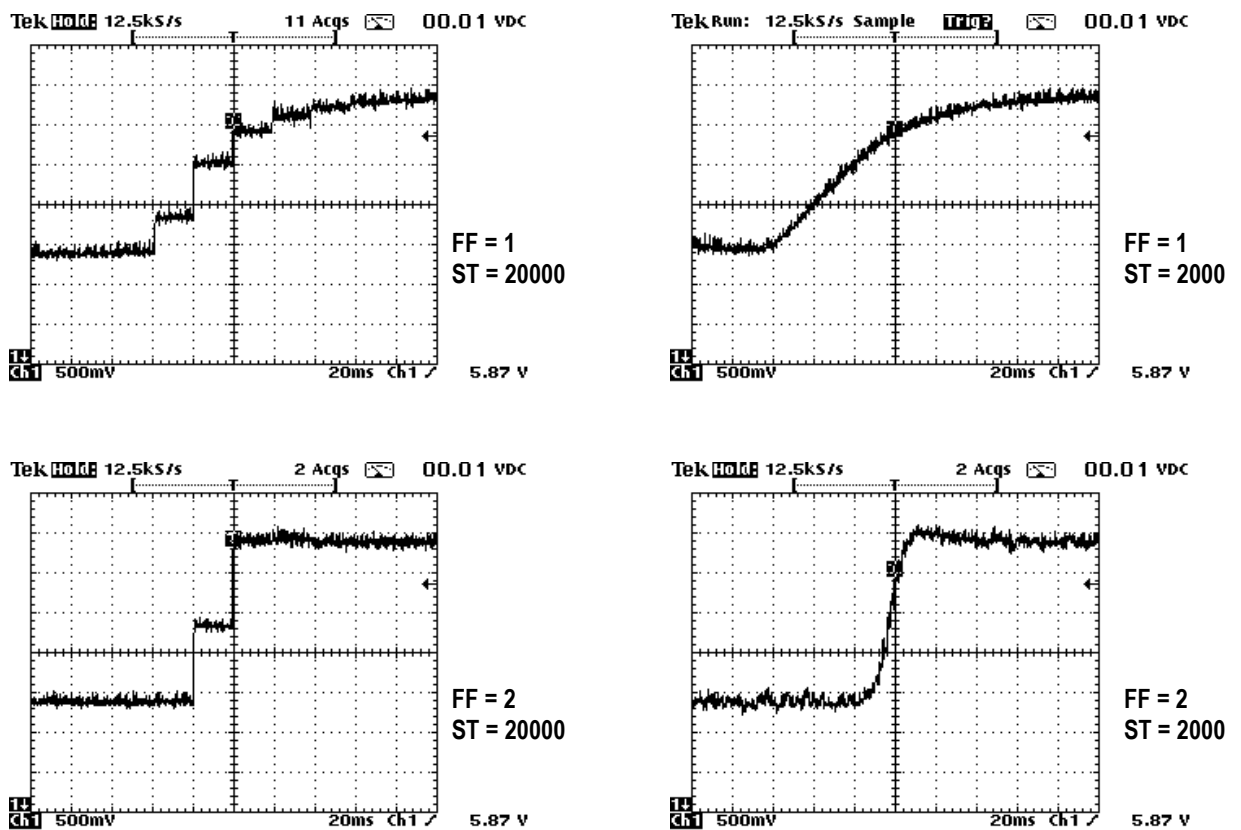
**Figure 49: Typical step responses at the output depending on the setting
of FF and ST (example for LT sensor)**

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10.8.4 Temperature Range

The device has a standard range in which it is calibrated. This range may be extended by the internal reserve.

RT=S   switches to the standard temperature range
RT=E   switches to the extended temperature range

All parameters of the technical specification (e.g. accuracy) are valid only inside the standard temperature range – there is no specification for the extended temperature range!

10.8.5 Emissivity Setting

The emissivity setting is selected by means of the "ES" command.

ES=I   sets emissivity by a constant number
ES=E   sets the emissivity by an analog voltage on the external input. The ambient background temperature compensation will be set off ("AC=0") when it was in external mode before ("AC=2"). For more information see section 7.4.3 External Input, page 42.
?E   asks for the current emissivity value

10.8.6 Ambient Background Temperature Compensation

In case the ambient background temperature is not represented by the internal sensor temperature, you must set the ambient background temperature values as follows:

A=250.0   current ambient background temperature according to the setting of "AC" command
AC=0   no compensation (internal sensor temperature equal to ambient temperature)
AC=1   compensation with a constant temperature value set with command "A"
AC=2   compensation with an analog voltage signal at the external input, 0 – 5 VDC corresponds to a temperature range set by using the commands AL and AH.
         Resulting temperature is read out by command "A". The emissivity setting will be set to internally ("ES=I"). For more information see section 7.4.3 External Input, page 42.

10.8.7 Temperature Hold Functions

The following table lists the various temperature hold functions along with their resets and timing values. Use this table as a guide for programming your sensor and adjusting the hold times.

Please note, the setting of some commands is not possible by using of the control panel, these commands are only available by means of the software. For further information see section 7.3 Signal Processing, page 35.

Hold Function	RESET by	Peak Time	Valley Time	Thresold	Hystersis	Decay Rate
				Protocol code		
		P	F	C	XY	XE
none	none	000.0	000.0	-*	-*	-*
Peak Hold	timer	000.1-299.9	000.0	000.0	-*	000.0
Peak Hold	trigger	300.0**	000.0	000.0	-*	000.0
Peak Hold	sent burst string					
Peak Hold with decay	timer	000.1-299.9	000.0	000.0	-*	0001-3000
Advanced Peak Hold	trigger or threshold	300.0**	000.0	Temp. range	-*	0000
Advanced Peak Hold	timer or threshold	000.1-299.9	000.0	Temp. range	-*	0000

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Advanced Peak Hold with decay	timer or threshold	000.1-299.9	000.0	Temp. range	-*	0001-3000
Valley Hold	timer	000.0	000.1-299.9	000.0	-*	000.0
Valley Hold	trigger	000.0	300.0**	000.0	-*	000.0
Valley Hold with decay	timer	000.0	000.1-299.9	000.0	-*	0001-3000
Advanced Valley Hold	trigger or threshold	000.0	300.0**	Temp. range	-*	0000
Advanced Valley Hold	timer or threshold	000.0	000.1-299.9	Temp. range	-*	0000
Advanced Valley Hold with decay	timer or threshold	000.0	000.1-299.9	Temp. range	-*	0001-3000

* Value does not affect the function type
** Holds infinitely or until triggered

As alternative to the linear decay an averaged decay was implemented. For selection see the following table.

Hold Function	Decay Rate [K/s]	Adv. Average Hold Time [s]
Adv...Hold with Linear Decay	XE = 0001 - 3000	0
Adv...Hold with Averaged Decay	*	AA = 0.1 - 999

Table 10: Decay Functions

Please note the different meanings of the parameters from "XE" and "AA":
- The linear decay rate (XE) is given in K/s
- The averaged decay (AA) gives the time when the signal will have reached 90% of the final temperature.

10.9 Sensor Control

10.9.1 Current Output

The current output corresponds to the target temperature value. The output can be set to 0 – 20 mA or 4 – 20 mA.

XO=4 sets the current output range to 4 – 20 mA

H=500 sets the temperature for the top current output value to 500 (in current scale) e.g., the top current output value of 20 mA shall represent 500°C

L=0 sets the temperature for the bottom current output value to 0 (in current scale) e.g., the bottom current output value of 4 mA shall represent 0°C

The minimum temperature span between "H" and "L" command values is 20 K.

For testing purposes the output can be forced to provide a constant current value.

O=13.57 output of a constant current at 13.57 mA

O=60 switches back to the target temperature controlled output

10.9.2 Relay Output

The relay output (alarm output) can be triggered:
- by target temperature
- by internal sensor temperature
- manually (command controlled)

The alarm output can be set either to N.C. (normally closed: relay contacts are closed while in the home position) or N.O. (normally open: relay contacts are open while in the home position).

K=2 alarm output triggered by target temperature and internal sensor temperature, N.O. normally open

K=3	alarm output triggered by target temperature and internal sensor temperature, N.C. normally closed
K=4	alarm output triggered by internal sensor temperature, N.O. normally open
K=5	alarm output triggered by internal sensor temperature, N.C. normally closed
K=6	alarm output triggered by target temperature, N.O. normally open
K=7	alarm output triggered by target temperature, N.C. normally closed
XS=125.3	sets the alarm threshold to 125.3 in current scale. The alarm threshold is used for the target temperature only (see command XS). If the internal sensor temperature is selected as the trigger source (K=4, K=5), use the command <DA> for defining the alarm threshold.

10.9.3 External Input

The external input is shared by several functions, see section 7.4.3 External Input, page 42. The following commands will change the input type automatically:

P=300, F=300	external input as trigger, resets the (advanced) Peak/Valley Hold function
ES=E	external input as voltage input (0 V – 5 V) for setting the emissivity
AC=2	external input as voltage input (0 V – 5 V) for setting the ambient temperature
XL=T	external input for On/Off switching of the laser

One of the basic rules for the used protocol here does forbid cross dependencies between commands. So the user has to take care not to use two functions the same time. Using more than one function will not destroy the device electrically but may result in malfunction.

?XT	gives the actual trigger state
?TV	gives the measured input voltage

10.9.4 Lock Mode

The access to the sensor is possible via serial interface or via direct user input on the control panel. With a command it is possible to lock the mode buttons. This allows access to the sensor only via serial interface.

J=L	direct user input via mode buttons on control panel denied

10.10 RS485 Communication

The serial RS485 communication can be either in 2-wire or 4-wire mode.

HM=2   sets the sensor into 2-wire communication mode.
HM=4   sets the sensor into 4-wire communication mode

For setting the baud rate, one of the following two commands must be selected.

D=576   sets the baud rate to 57600, baud rate must be given with 3 numbers (003, 012, 024, 096, 192, 384, 576, 115).
BR=57600   sets the baud rate to 57600, baud rate must be given with up to 6 numbers (300, 1200, 2400, 9600, 19200, 38400, 57600, 115200)

In case of using the sensor in 2-wire mode the baud rate is limited to 38400.

10.11 Multidrop Mode

Up to 32 devices can be connected within an RS485 multidrop network, see section 6.4 Multiple Sensors in a Network, page 30. To direct a command to one sensor 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. A unit with the address 000 is a single unit and not in multidrop mode.

XA=024   sets the device to address 24

Changing an address:
(e.g., the address is change from 17 to 24)
command   answer
"017?E"   "017E0.950"   *// asking one sensor on address 17*
"017XA=024"   "017XA024"   *// setting of a new address*
"024?E"   "024E0.950"   *// asking same sensor now on address 24*

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.

command   answer
"024?E"   "024E0.950"
"000E=0.5"   will be executed from all sensors, no answer
"024?E"   "024E0.500"
"012?E"   "012E0.500"

i   **When a sensor has a multidrop address between 001 and 032, its control panel is automatically locked. It can be unlocked with the command "xxxJ=U", where xxx is the multidrop address!**

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10.12 Command List

P ... Poll, B ... Burst, S ... Set, N ... Notification

(1) n = number, X = uppercase letter

Description	Char	Format	P	B	S	N	legal values	factory default	LCD Char
Poll parameter	?	?X/?XX	√				?T		
Set parameter	=	X/XX=...			√		E=0.85		
Multidrop addressing		001?E	√		√		answer: 001!E0.950	000	
Error message	*						*Syntax error		
Acknowledge message	!						!P010		
Burst string format	$		√		√			UTEI	
Ambient radiation correction	A	nnnn.n	√		√		0 – max. range		
Advanced hold averaging time	AA	nnn.n	√		√		0 = no averaging 0.1 … 999.0 s	0	
Ambient compensation control	AC	n	√		√		0 = no compensation, 1 = by command <A> 2 = external input (0V—5V)	0	
Low range for ambient control with external input at 0V	AL	nnnn.n	√		√		min range – max range	min range	
High range for ambient control with external input at 5 V	AH	nnnn.n	√		√		min range – max range	max range	
Burst Peak Hold for 1M/2M models only	BP	n	√		√		0 = off (no Peak Hold) 1 = on Polling: Peak Hold time over <BS> + 10 ms Burst: Peak Hold time over <BS>	0	
Baud rate	BR	nnnnnn	√		√		9600, 19200, 38400, 57600, 115200 Time out: 2000 ms	38400 with delivery, no change with factory default	
Burst speed	BS	integer	√		√		number in milliseconds 50ms ... 20s for 1M/2M models down to 5 ms but sample time guaranteed steps in 5 ms	50	
Advanced hold threshold	C	nnnn.n	√		√		in current scale (°C/°F/°K)	<= min.range --advanced off	min. range
Internal temp. alarm threshold	DA	nn.n	√			√	-10 to 65°C (14 to 149°F)	65°C (149°F)	
Device special	DS	XXX	√		(√)		e.g. !DSRAY	Set at production	
Emissivity internal	E	n.nnn	√	√	√		0.1 - 1.15	0.95	E

Description	Char	Format	P	B	S	N	legal values	factory default	LCD Char
Error code	EC	nnnn	√	√			hex value of ErrCode: BIT0 Object temp. over range BIT1 Object temp. under range BIT2 Internal temp. over range BIT3 Internal temp. under range BIT4 ADC initialisation error BIT5 EEPROM error user space BIT6 EEPROM error calibration BIT7 Device in init phase BIT8 Focus motor error BIT9 Focus zero position lost BITA Focus motor moving BITB mA output over range BITC mA output under range		
Emissivity source	ES	X	√		√		I = Emissivity from Internal (by command) E = Emissivity from External analog input (0V—5V)	I	
Valley hold time	F	Nnn.n	√	√	√	√	0.0 - 299.9s (300 = ∞)	0.0s	V
Focal distance	FC	nnn.n	√		√	√	within the focus range, in meter Time out: 1000 ms (Polling) Time out: 2000 ms (Setting)	0.6	F
Activate pre-calculation Filter	FF	n 0 0	√		√		0 = off 1 = Filter Average 2 = Filter Detector	1	
Average time	G	nnn.n	√	√	√	√	0.0 – 999.0 s	0.0 s	A
Top of mA range	H	nnnn.n	√	√	√	√			H
RS485 mode	HM	n	√		√	√	2 = 2-wire, 4 = 4-wire	4	COM
Sensor internal temp.	I	nnn.n	√	√			in current scale (°C/°F)		
Switch panel lock	J	X	√		√	√	L = locked U = unlocked	unlocked	CP
Relay alarm output control	K	n	√		√		0 = off 1 = on 2 = Target and Internal norm. open 3 = Target and Internal norm. closed 4 = Internal, normal open 5 = Internal, norm. closed 6 = Target, norm. open 7 = Target, norm. closed	2	
Bottom of mA range	L	nnnn.n	√	√	√	√			L
Output current	O	nn.nn	√		√		0.00 – 20.00 current in mA 21 = over range; 60 = controlled by unit	60 After reset = 60	
Peak hold time	P	nnn.n	√	√	√	√	0.0 - 299.9 s (300 = ∞)	0.0 s	P
AD counts	Q	nnnnnnn	√	√					
Reset	RS				√		Reset of the firmware, acknowledged with: !RS[CR][LF] #XI1[CR][LF] Time out: 12000 ms		
Temperature range	RT		√		√		E = Extended range S = Standard range (= <bottomTemp> <topTemp>)	S	-

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Description	Char	Format	P	B	S	N	legal values	factory default	LCD Char
Sample time	ST	X	√		(√)		For LT, G5, MT, 3M it can be set to the following times (in µs): 2000, 10000, 16666, 20000 or 33333	20000	-
Target temperature	T	nnnn.n	√	√			in current scale (°C/°F)		
Thermal shock control	TS	n	√		√		Y / N reserved for special models only	N	
Voltage at trigger pin	TV	float	√				in Volt		
Temperature unit	U	X	√	√	√	√	C / K / F	C	U
Poll/burst mode	V	X	√		√		P=poll B=burst	poll mode	
Handle video control	VI	n	√		√	√	0=OFF, 1=ON N=not installed	0	
UART counter for 1M/2M models only	W	n	√	√			0 = off, 1 = on (for Poll Mode) responds with 4 digit hex code (max x7FFF) Reset to 1 with activating the burst mode V=B Reset to 0 with resetting of firmware or device	0	
Burst string content	X$		√						
Multidrop address	XA	0nn	√		√	√	0 – 32 (0 → single unit mode)	0	
Device bottom range limit	XB	nnnn.n	√		(√)				
Deadband	XD	nn	√		√		1 – 55°C/K; 1-99°F	2	
Decay rate	XE	nnnn	√		√		1-3000K/s	0	
Restore factory defaults	XF				√		Time out: 12000 ms		
Transmission	XG	n.nnn	√	√	√		0.1 - 1.0	1.0	T
Device high range limit	XH	nnnn.n	√		(√)				
Sensor initialisation	XI	n	√	√	√	√	1 after RESET, 2 if the internal watchdog caused the reset, 0 if XI=0		
Laser control	XL	X	√		√	√	0=OFF, 1=ON, N=not installed, Y=installed, T=external input is used to switch the laser	0	
Analog output mode	XO	n	√		√		0 = 0...20mA, 4 = 4...20mA	4	
Second relay threshold	XP	nnnn.n	√		√		XP = bottom range switches the alarm mode off	bottom range	
Firmware revision	XR		√				e.g. 1.01	Set in FW	
Alarm threshold for target temp.	XS	nnnn.n	√		√		XS = bottom range switches the alarm mode off	bottom range	
Trigger	XT	n	√	√		√	0 = inactive, 1 = active	0	
Unit identification	XU		√		(√)		e.g. !XUMM		
Serial number	XV		√		(√)		e.g. 98123		
Advanced hold hysteresis	XY	nnnn	√		√		0 – 3000 K	2	
Timer internal for 1M/2M models only	Z			√			0 – 9999 ms		

11 Maintenance

Our sales representatives and customer service are always at your disposal for questions regarding application assistance, calibration, repair, and solutions to specific problems. Please contact your local sales representative if you need assistance. In many cases, problems can be solved over the telephone. If you need to return equipment for servicing, calibration, or repair, please contact our Service Department before shipping. Phone numbers are listed at the beginning of this document.

To prevent possible electrical shock, fire or personal injury follow these guidelines:

- Have an approved technician repair the product.

11.1 Troubleshooting Minor Problems

Symptom	Probable Cause	Solution
No output	No power to instrument	Check the power supply
Erroneous temperature	Faulty sensor cable	Verify cable continuity
Erroneous temperature	Field of view obstruction	Remove the obstruction
Erroneous temperature	Window lens	Clean the lens
Erroneous temperature	Wrong emissivity	Correct the setting
Temperature fluctuates	Wrong signal processing	Correct Peak/Valley Hold or Average settings

Table 11: Troubleshooting

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Maintenance

11.2 Fail-Safe Operation

The Fail-Safe system is designed to alert the operator and provide a safe output in case of any system failure. Basically, it is designed to shutdown the process in the event of a set-up error, system error, or a failure in the sensor electronics.

⚠️ **The Fail-Safe circuit should never be relied on exclusively to protect critical heating processes. Other safety devices should also be used to supplement this function!**

When an error or failure does occur, the display indicates the possible failure area, and the output circuits automatically adjust to their lowest or highest preset level. The following table shows the values displayed on the control panel and transmitted over the serial interface.

Symptom	Error Code	Priority	0 – 20 mA Output	4 – 20 mA Output
Internal temperature over range	EIHH	1 (high)	21 to 24 mA	21 to 24 mA
Internal temperature under range	EIUU	2	0 mA	3.5 mA
Target temperature under range	EUUU	3	0 mA	3.5 mA
Target temperature over range	EHHH	4 (low)	21 to 24 mA	21 to 24 mA

Table 12: Error Codes and Current Output Values

The relay is controlled by the temperature selected on the display. If any failsafe code appears on the display, the relay changes to the "abnormal" state. This causes the relay to change state, leaving a normal numerical temperature output.

If two errors occur simultaneously, the higher priority error is the one that is presented on the digital and analog outputs. For example, if the internal temperature is too high and the target temperature is over range, the unit outputs EIHH on the display and digital output and 21 mA on the analog output.

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11.3 Cleaning the Lens

Keep the lens clean at all times. Care should be taken when cleaning the lens. To clean the window, do the following:

1. Lightly blow off loose particles with "canned" air (used for cleaning computer equipment) or a small squeeze bellows (used for cleaning camera lenses).
2. Gently brush off any remaining particles with a soft camel hair brush or a soft lens tissue (available from camera supply stores).
3. Clean remaining "dirt" using a cotton swab or soft lens tissue dampened in distilled water. Do not scratch the surface.

For finger prints or other grease, use any of the following:
- Denatured alcohol
- Ethanol
- Kodak lens cleaner

Apply one of the above to the lens. Wipe gently with a soft, clean cloth until you see colors on the surface, then allow to air dry. Do not wipe the surface dry, this may scratch the surface.

If silicones (used in hand creams) get on the window, gently wipe the surface with Hexane. Allow 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!**

Appendix

12 Appendix

12.1 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 (⌀ 38 mm / 1.5 in., XXXRPMACED) 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 is 0.95. Next, measure the temperature of the painted area using an emissivity setting of 0.95. 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.

12.2 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. Transmission (e.g. thin films plastics)

METALS

Material	1 µm	1.6 µm	2.3 µm	3.9 µm	5 µm	7.9 µm	8 – 14 µm
				Emissivity			
Aluminum							
Unoxidized	0.1-0.2	0.02-0.2	0.02-0.2	0.02-0.2	0.02-0.2	0.03-0.15	0.02-0.1
Oxidized	0.4	0.4	0.2-0.4	0.2-0.4	0.2-0.4	0.20-0.55	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	0.03-0.15	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	0.10-0.20	0.02-0.2
Oxidized						0.60-0.85	
Copper							
Polished		0.03	0.03	0.03	0.03	0.03-0.15	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	0.40-0.80	0.4-0.8
Gold	0.3	0.01-0.1	0.01-0.1	0.01-0.1	0.01-0.1	0.02-0.15	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	0.80-0.90	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
polished	0.2-0.5	0.25	0.25	0.15	0.15	0.10-0.25	0.15
Iron							
Oxidized	0.4-0.8	0.5-0.8	0.7-0.9	0.6-0.9	0.6-0.9	0.80-0.95	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	0.10-0.95	0.6-0.95
Unoxidized	0.35	0.3	0.1-0.3	0.25	0.25	0.10-0.15	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	0.10-0.25	0.1

Appendix

Material	Emissivity						
	1 µm	1.6 µm	2.3 µm	3.9 µm	5 µm	7.9 µm	8 – 14 µm
Monel (Ni-Cu)	0.3	0.2-0.6	0.2-0.6	0.1-0.5	0.1-0.5	0.10-0.25	0.1-0.14
Oxidized						0.60-0.85	0.7-0.9
Nickel							
Oxidized	0.8-0.9	0.4-0.7	0.4-0.7	0.3-0.6	0.3-0.6	0.80-0.95	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	0.03-0.15	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	0.10-0.25	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	0.80-0.95	0.7-0.9
Stainless	0.35	0.2-0.9	0.2-0.9	0.15-0.8	0.15-0.8	0.10-0.25	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	0.05-0.20	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	0.15-0.25	0.02

Tab. 13: Typical Emissivity Values

NON-METALS

Material			Emissivity			
	1 µm	1.6 µm	2.3 µm	5 µm	7.9 µm	8 – 14 µm
Asbestos	0.9		0.8	0.9		0.95
Asphalt				0.95	0.95-1.00	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	0.45-0.70	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
Coke	0.95-1.00	0.95-1.00	0.95-1.00	0.95-1.00	0.95-1.00	0.95-1.00
Concrete	0.65		0.9	0.9		0.95
Cloth				0.95		0.95
Glass						
Plate			0.2	0.98	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.)					0.90-1.00	0.9-0.95
Paper (any color)				0.95	0.90-1.00	0.95
Plastic, opaque at 500 µm thickness (20 mils)				0.95		0.95
Rubber				0.9	0.95-1.00	0.95
Sand				0.9		0.9
Snow						0.9
Soil						0.9-0.98
Water						0.93
Wood, Natural				0.9-0.95	0.90-1.00	0.9-0.95

Tab. 14: 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.

13 Traceability of Instrument Calibration

Fluke IR Traceability

National Metrology Institutes

PTB
-50 to 800°C
ITS 90

NIST
800 to 2700°C
ITS 90

Annual NIST Calibration and historical data

Fluke Primary Standards

-20 to 800°C
Low Temp Primary Standard

400 to 800°C
Fluke Medium Temp
Primary Standard

760 to 2700°C
High Temp
Primary Standard

Cross

Fluke Working Standards

-20 to 800°C
Low Temp Secondary
(Working) Standard

400 to 800°C
Medium Temp
Secondary

760 to 2700°C
High Temp Secondary
(Working) Standard

Fluke Calibrated blackbody cavities and

Working cavaties and plates
(black body sources)

Computerized cavity
(black body source)
500 to 2727°C

Daily check at
1000, 1700, and
2500°C

CUSTOMER INFRARED THERMOMETERS

Fluke reserves the right to make changes to this traceability and methodes without notice.

14 Notices