MARATHON MM SERIES

High-Performance Infrared Thermometer

Operating Instructions

Raytek®

Noncontact Temperature Measurement

Rev. B1 01/2006
58201

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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, less than 100% compatible DOS-compatible systems, or with 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.

Declaration of Conformity for the European Community

This instrument conforms to the following standards:

EMC:	EN61326-1,
Safety:	EN61010-1:1993 / A2:1995
Laser:	EN 60825-1

TABLE OF CONTENTS

1 Safety Instructions

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

Acceptable Operation

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

Unacceptable Operation

The instrument should not be used for medical diagnosis.

Replacement Parts and Accessories

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

Instrument Disposal

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

Operating Instructions

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

Helpful information regarding the optimal use of the instrument.

Warnings concerning operation to avoid instrument damage.

Warnings concerning operation to avoid personal injury.

Pay particular attention to the following **safety instructions.**

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

Use in 110 / 230 V electrical systems can result in electrical hazards and personal injury if not properly protected. All instrument parts supplied by electricity must be covered to prevent physical contact and other hazards at all times.

2 Product Description

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 Marathon MM is available in 5 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. A laser target sighting or video sighting are offered as an option. The 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.

Model	Temperature range	Optical Resolution	Spectral Response	Time Response	Description
MMLT	-40 to 800°C (-40 to 1472°F)	70:1	8 - 14 µm	120 ms	for common low temperature applications such as plastics processing; extrusion, thermoforming, molding, welding and sealing, textile drying, food processing and packaging.
MMG5L	250 to 1650°C (482 to 3002°F)	70:1	5 µm	60 ms	Glass surface temperature measurements, bending, forming, tempering, annealing, sealing and lamination
MMG5H	450 to 2250°C (842 to 4082°F)	70:1	5 µm	60 ms	
MMMT	250 to 1100°C (482 to 2012°F)	70:1	3.9 µm	120 ms	for lower and medium temperature metals processing applications, combustion fired ovens, furnaces boilers and kilns.
MM2ML	300 to 1100°C (572 to 2012°F)	160:1	1.6 µm	1 ms*	high temperature applications, steel and metals processing; heat treating & annealing, industrial furnaces, kilns and ovens, foundry & casting, forging, laser welding, hot strip mills, hot metal detection
MM2MH	450 to 2250°C (842 to 4082°F)	300:1	1.6 µm	1 ms*	
MM1ML	450 to 1740°C (842 to 3164°F)	160:1	1 µm	1 ms*	
MM1MH	650 to 3000°C (1202 to 5432°F)	300:1	1 µm	1 ms*	

** Exposure time according to VDI/VDE 3511*

Table 1: Models

3 Technical Data

3.1 Measurement Specifications

Temperature Range

LT	-40 to 800°C (-40 to 1472°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)
2ML	300 to 1100°C (572 to 2012°F)
2MH	450 to 2250°C (842 to 4082°F)
1ML	450 to 1740°C (842 to 3164°F)
1MH	650 to 3000°C (1202 to 5432°F)

Spectral Response

LT	8 to 14 μm
G5	5 μm
MT	3.9 μm
2M	1.6 μm
1M	1 μm

Response Time (95%)

LT, MT	120 ms
G5	60 ms
1M, 2M	2 ms

Exposure Time[1] (95%)

1M, 2M	1 ms

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	± 1% of reading
2ML	± (0.3% of reading + 2°C)
2MH, 1ML, 1MH	± (0.3% of reading + 1°C)

Repeatability[3]

LT, MT, G5	± 0.5% of reading or ± 0.5°C, whichever is greater
2ML, 2MH, 1ML, 1MH	± (0.1% of reading + 1°C)

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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)

[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)

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, T_{amb} = 23°C (74°F)
MT, G5	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

3.2 Optical Specifications

In all cases, make sure the target completely fills the measurement spot, see section 6.1.1 Distance to Object, on page 13.

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.).

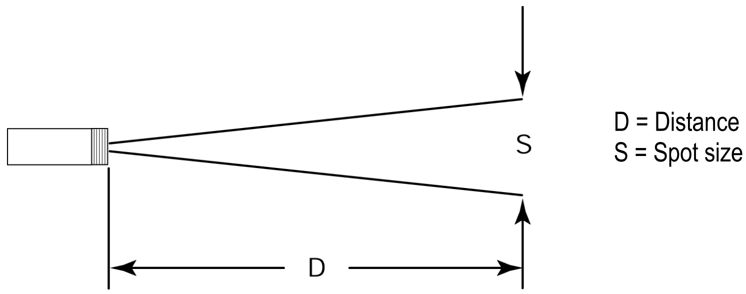
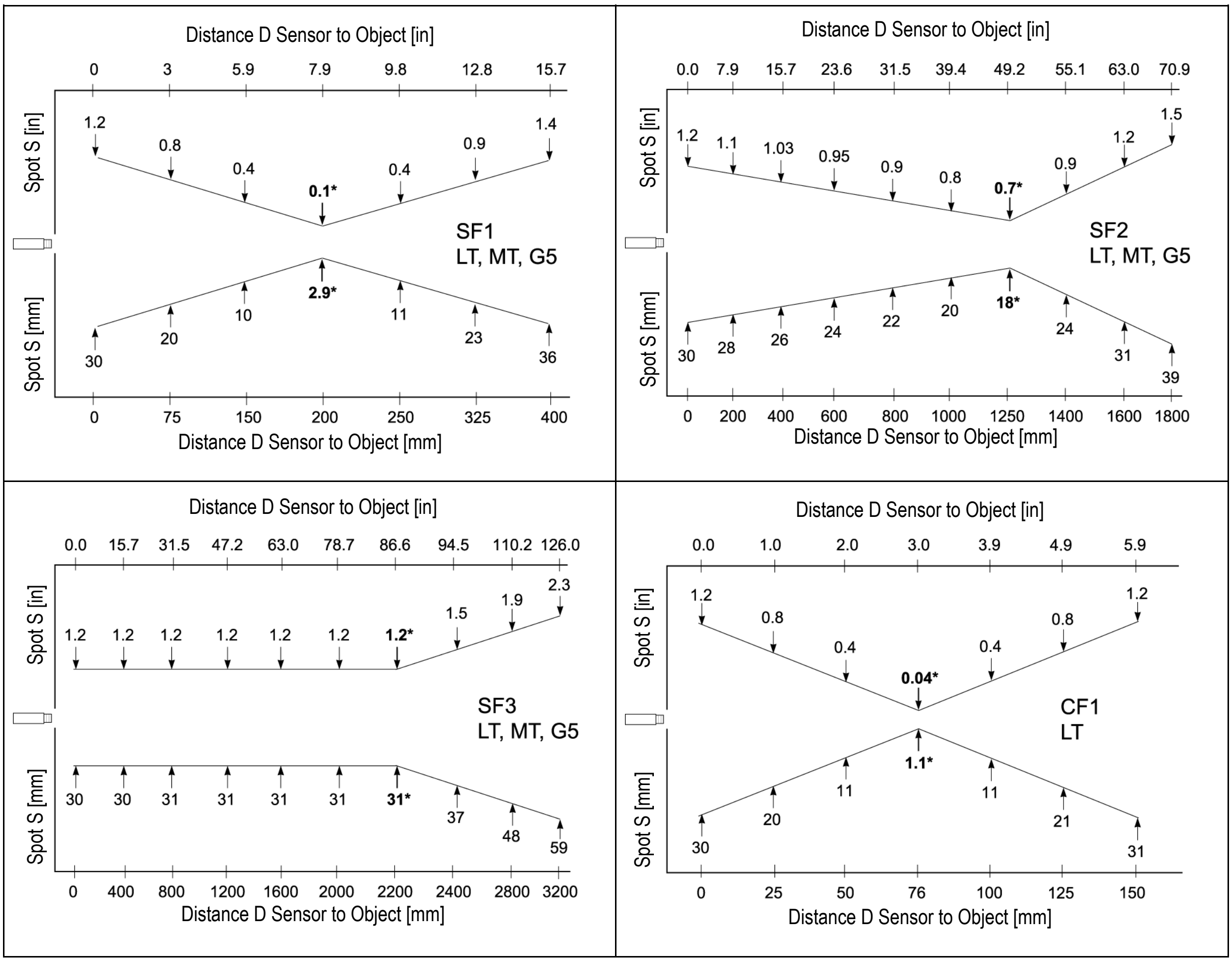


Figure 1: Spot Size Chart

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

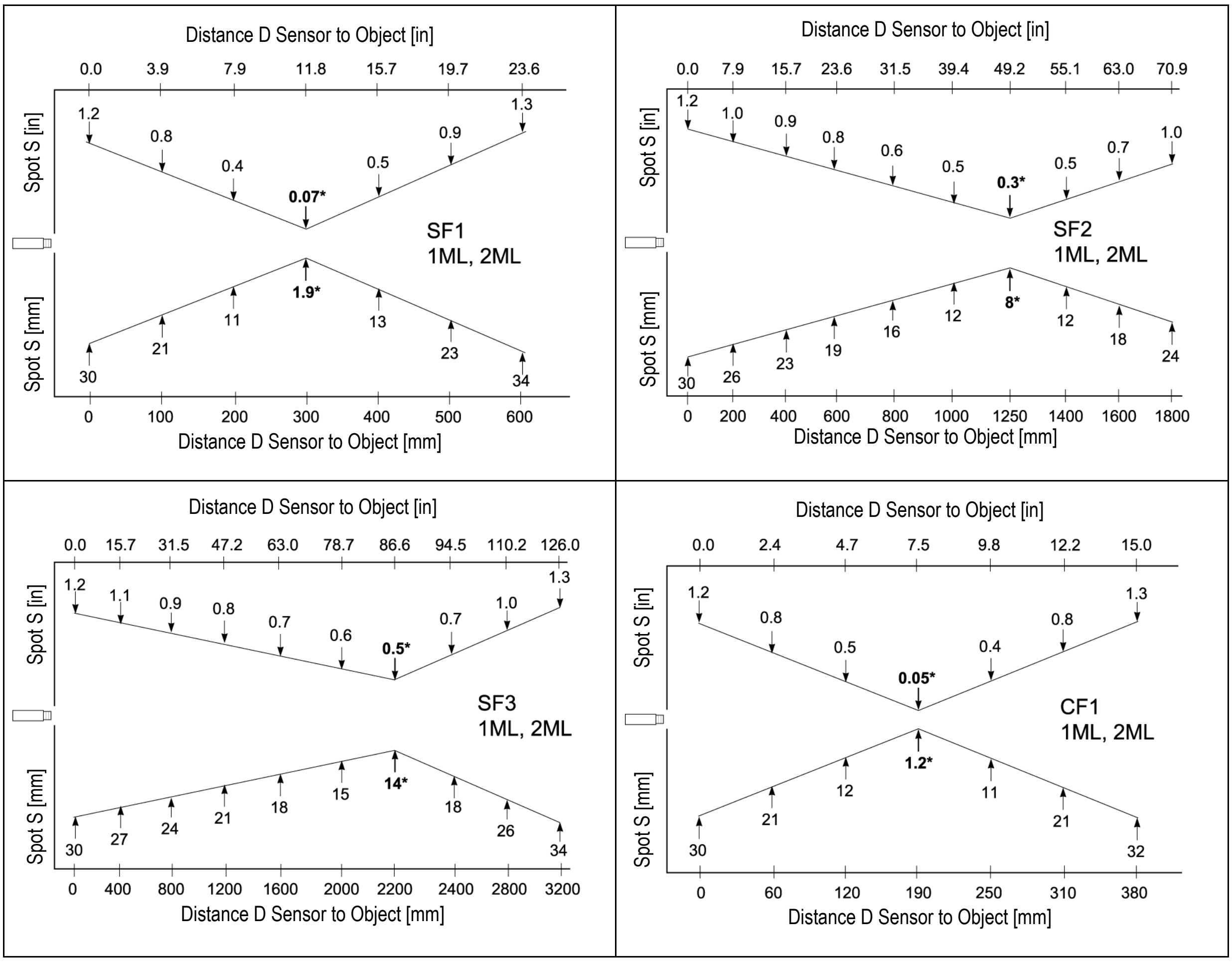
3.2.1 Fixed Focus Optical Specifications



SF … Standard Focus, CF … Close Focus

* Focus Point D:S = 70:1

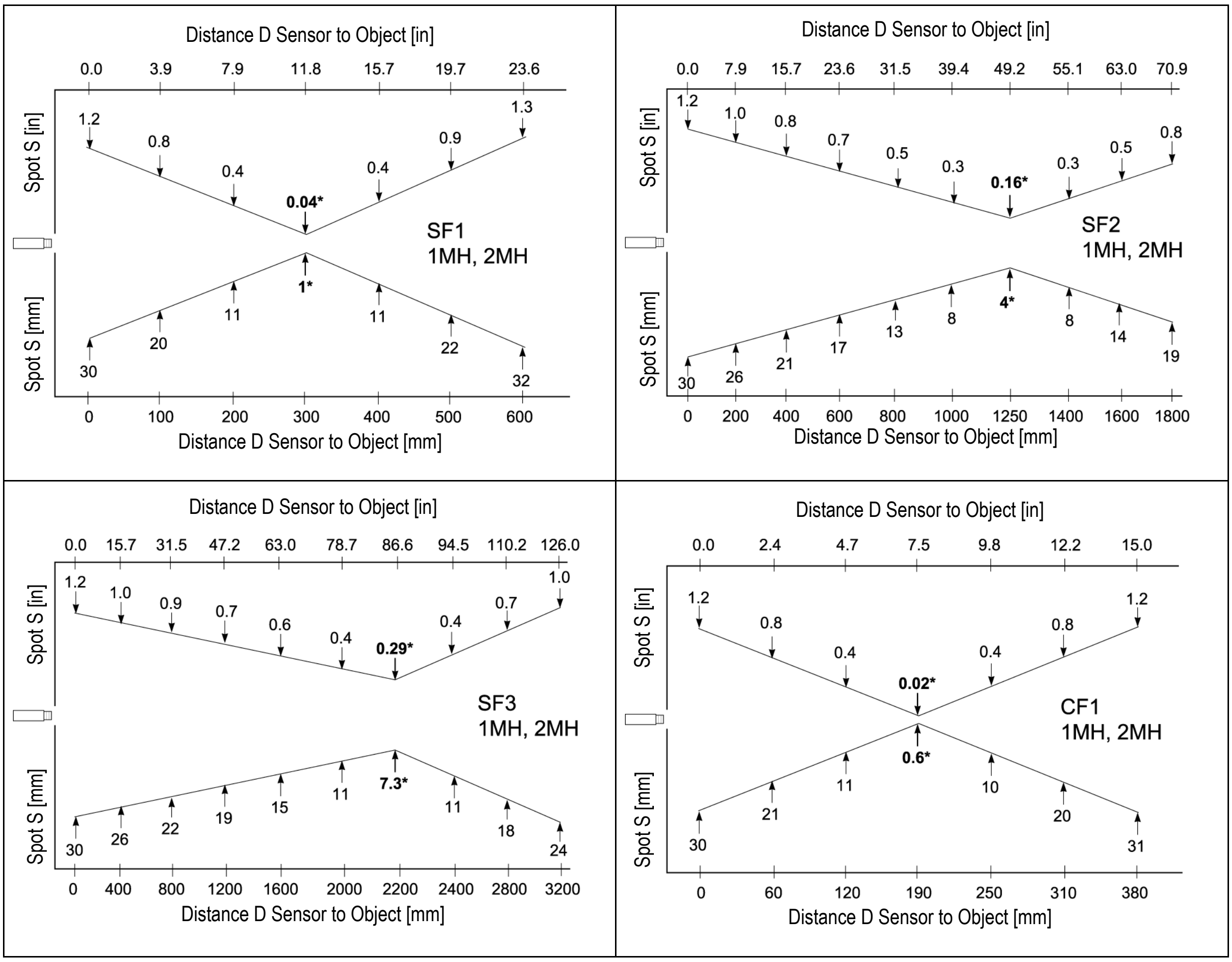
Table 2: Optical Diagrams for LT, MT, G5 Sensors



SF … Standard Focus, CF … Close Focus

* Focus Point D:S = 160:1

Table 3: Optical Diagrams for 1ML, 2ML Sensors



SF … Standard Focus, CF … Close Focus

* Focus Point D:S = 300:1

Table 4: Optical Diagrams for 1MH, 2MH Sensors

3.2.2 Variable Focus Optical Specifications

Model	Focus	Focus Range	Optical Resolution D:S *	Smallest Spot Size
LT, G5, MT	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.)
2ML, 1ML	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.)
2MH, 1MH	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)

3.3 Electrical Specifications

Power Supply	24 VDC ± 20%, min. 500 mA
Outputs	
Analog	0 - 20 mA, 4 - 20 mA, 14 bit resolution max. current loop impedance: 500 Ω
RS485 Interface	networkable to 32 sensors Baud rate: 300, 1200, 2400, 9600, 19200, 38400, 57600 (default), 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, ambient background temperature compensation, or emissivity setting, see section 7.4.3 External Input on page 30.

3.4 Environmental Specifications

Environmental rating	NEMA-4 (IEC 529, IP 65)
EMI	CE compliant to IEC 61326, performance criteria B
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 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) 3 G, 11 - 200 Hz, any axis
Mechanical Shock	MIL-STD-810D (IEC 68-2-27) 50 G, 11 ms duration, any axis
Weight	0.7 kg (1.54 lb)

3.5 Dimensions

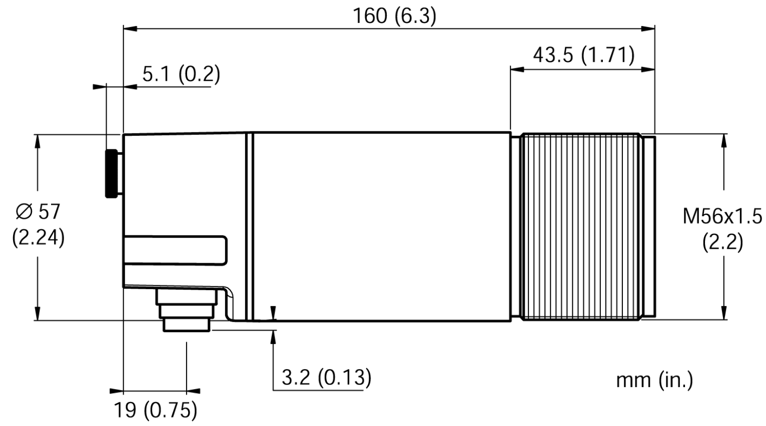


Figure 2: Dimensions of Sensor

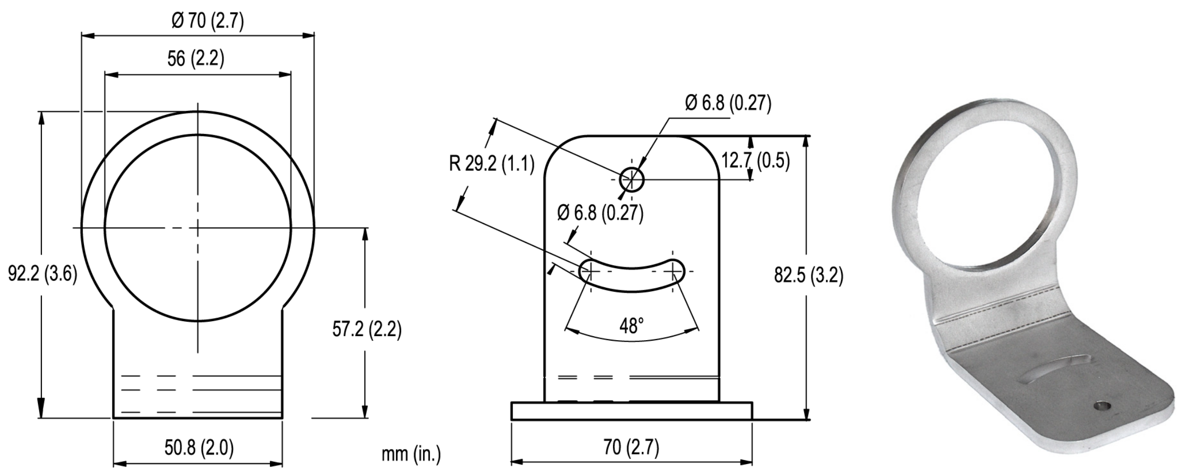


Figure 3: Fixed Mounting Bracket

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 appendix see section 12.2 Typical Emissivity Values, on page 64.
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 on page 64. 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 Sensor Location

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). In ambient conditions above 65°C (149°F), a water or air cooled housing is available 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 water-cooled housing, it is strongly recommended to use the supplied air purge collar 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, and the instrument will indicate a failure. It is good practice to always keep the lens clean. The Air Purge Collar helps keep contaminants from building up on the lens. If you use air purging, 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 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 for other equipment in the same conduit as the sensor signal wiring.

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, on page 4.

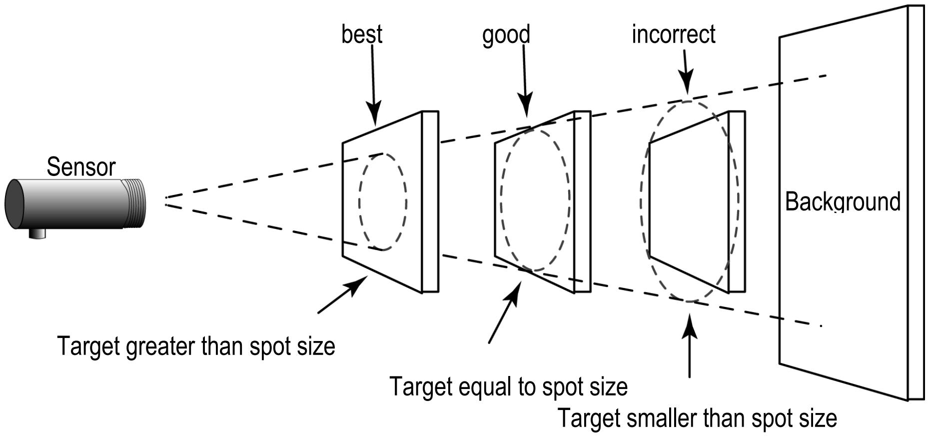


Figure 4: Proper Sensor Placement

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.).

6.1.3 Viewing Angles

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

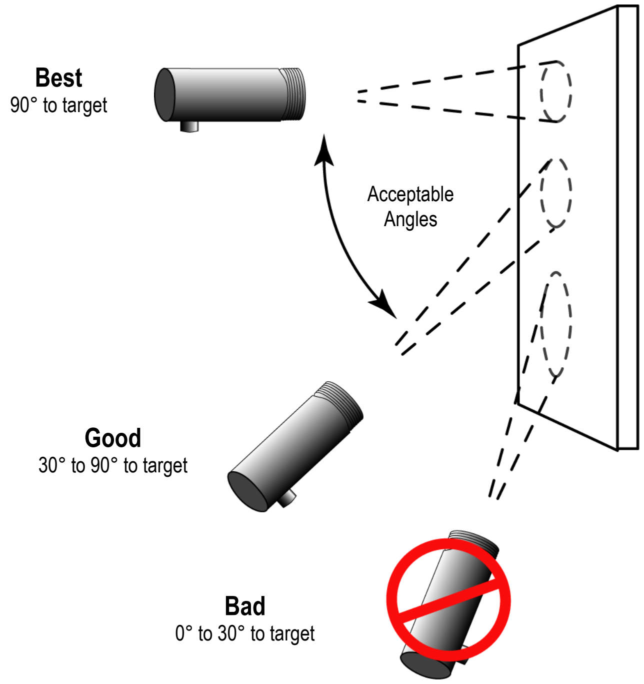


Figure 5: Acceptable Sensor Viewing Angles

6.2 Electrical Installation

The distance between the sensor and a computer (via RS485 cable) can be up to 1200 m (4000 feet). This allows ample distance from the harsh environment where the sensing head is mounted to a control room or pulpit where the computer is located.

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 9.9 Low Temp Cable, on page 46 and section 9.10 High Temp Cable, on page 47.

The following figure shows how to configure the drain wires of the cables before connecting to the sensor and RS232/485 converter. The bare wire with the clear shrink tubing (cable shield) must be connected to the terminal labeled CLEAR.

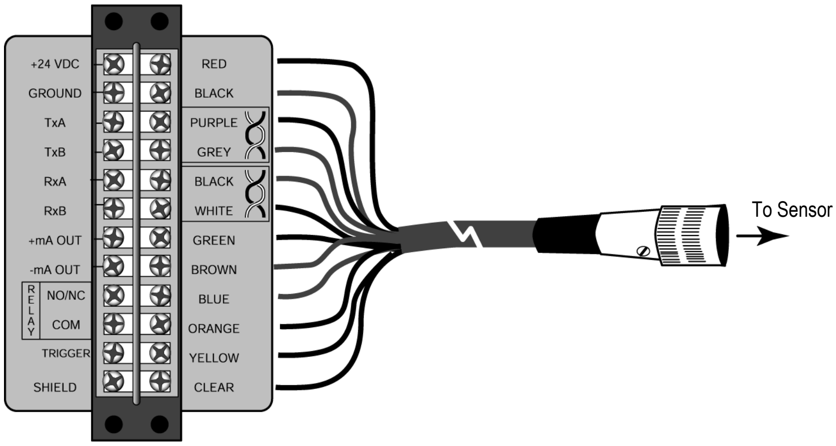


Figure 6: Sensor Connecting Cable with Terminal Block

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

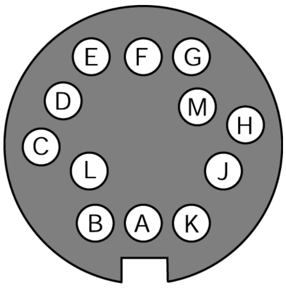


Figure 7: DIN Connector Pin Layout (pin side)

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 5: DIN Connector Wiring

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

6.3 Power Supply

Connect a 24 VDC (500 mA or higher) power supply to the appropriate terminals on the sensor's terminal strip.

Isolation is provided only when used with the appropriate manufacturer supplied power supply accessory!

6.4 RS232/485 Interface Converter

To connect to a computer's RS232 port, you need one of the interface converter accessories (similar to the following figure) and the proper RS232 cable. If your computer has an RS485 interface card, you can connect the sensor directly to its port (using the proper connector) with wiring from the terminal block.
Connect the interface converter to an available COM port on your computer, either directly or with an appropriate serial cable (available from computer supply stores). If your computer has a 9-pin serial connector, use the 25-pin to 9-pin cable between the interface converter or cable and the computer.
For appropriate interface converters, see section 9.8 Industrial Power Supply, on page 45.

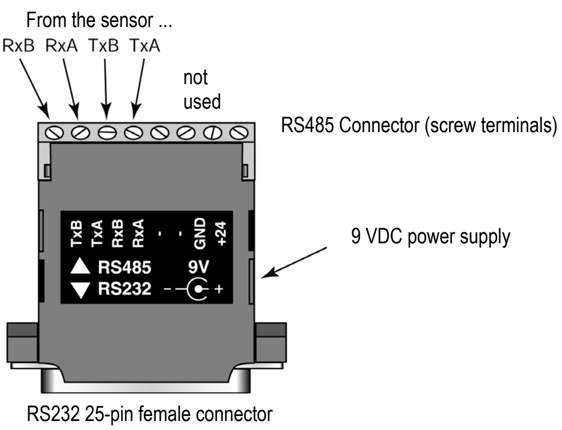


Figure 8: RS232/485 Interface Converter with terminal XXX485CVT

The RS485 output is as follows:
  Baud rate: 300, 1200, 2400, 9600, 19200, 38400, 57600 (default), 115200
  Data format: 8 bit, no parity, 1 stop bit
  4-wire mode (full-duplex)

6.5 Connecting to a PC

To set up your computer to initialize the sensors, complete the following steps:

1. Turn off your computer.
2. Plug in one end of the appropriate cable into the sensor's connector.
3. Attach the power and digital communication wires on the other end of the cable to the appropriate terminals on the RS485/RS232 converter. Note that the RxA and RxB wires from the sensor connect to the TxA and TxB converter terminals, and the TxA and TxB wires from the sensor connect to the RxA and RxB converter terminals.
4. Plug the RS485/RS232 converter into your computer's serial port, or attach it to a serial cable if a longer run to the computer is needed, and plug the AC power supply cable into the converter. (You may need to use the supplied 25-pin to 9-pin cable to connect to the computer.)
5. Before turning on the computer, make sure the sensor and RS485 to RS232 adapter power supplies are plugged in.
6. Turn on your computer.

You need to make sure another serial device (e.g. an internal modem) is not using the identical COM-port at the same time!

If the PC has only got an USB- instead of a COM port, please use the RS232/USB converter (XXXUSBCV) which is available from the manufacturer!

Always power up the interface converter before the sensor. Also, never change RS485 or power connections while the instrument is powered. Doing so will damage the interface converter and void the warranty!

6.5.1 4-Wire Communication

In 4-wire communication the data can be transferred in both directions, from sensor to PC and reverse. 4-wire communication should be preferred compared to 2-wire communication (for 2-wire communication see appendix 12.3 2-Wire Communication, on page 68).

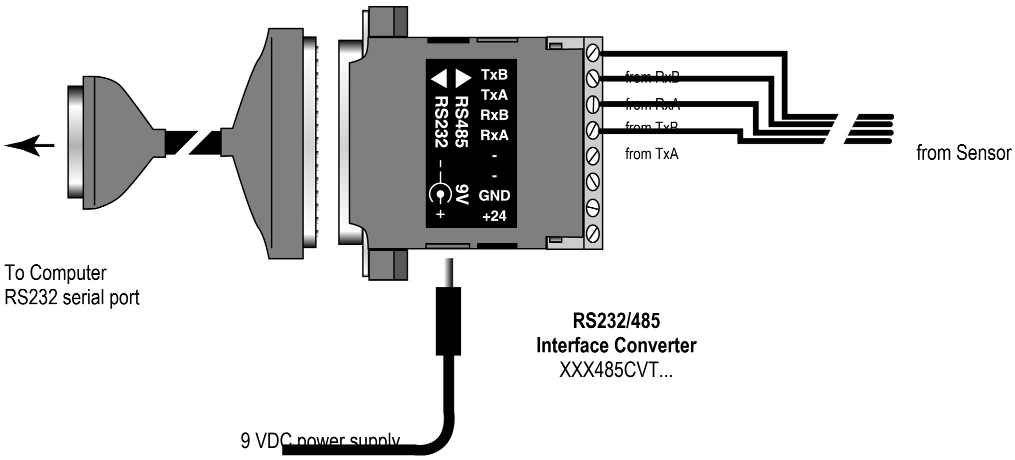


Figure 9: 4-Wire Sensor Communication

6.5.2 Connecting to Terminal Block

If you need to extend the wiring or to have a complete wiring of all inputs/outputs, use the Terminal Block accessory. Make sure you connect the color-coded wires correctly.

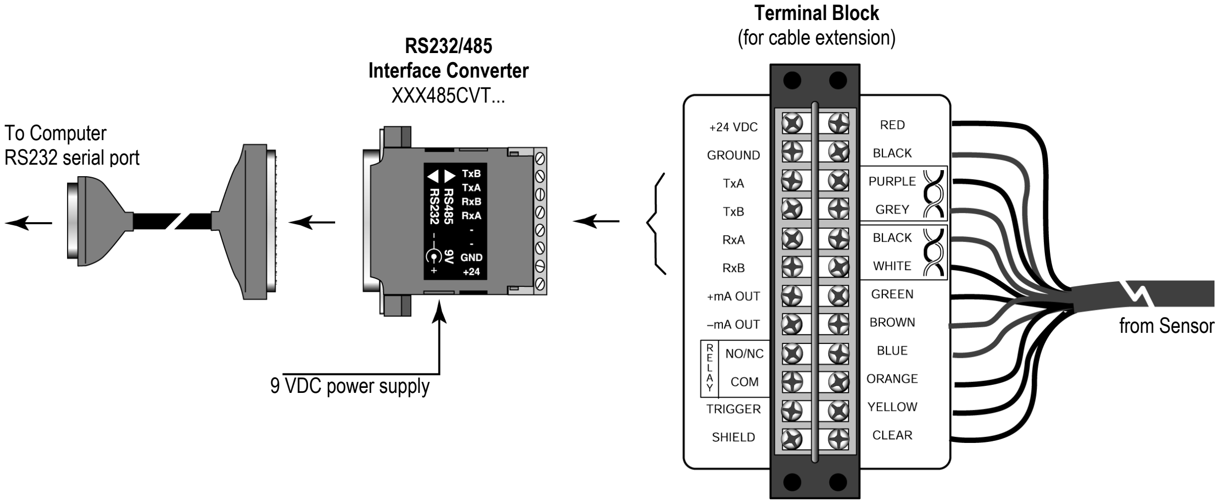


Figure 10: Connections from Sensor to Computer with the Terminal Block

6.6 Installing of Multiple Sensors in a Network

6.6.1 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 figure illustrates the wiring of sensors in a 4-wire multidrop installation. A network as a 2-wire multidrop installation is shown in Figure 43, page 68.

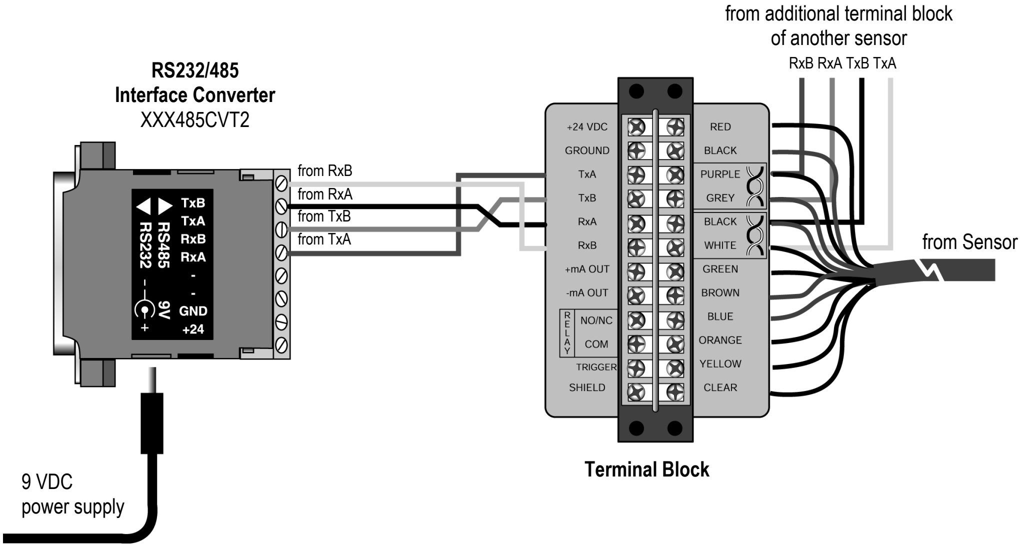


Figure 11: 4-Wire Multidrop Wiring in a Network

6.6.2 Addressing

The addressing of a sensor can be done by means of the Control Panel on the back of the sensor or the 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 58.
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.

6.6.3 Configuration Procedure

1. Attach each unit individually in 4-wire mode 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 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 DataTemp Multidrop. 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, on page 21. 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.

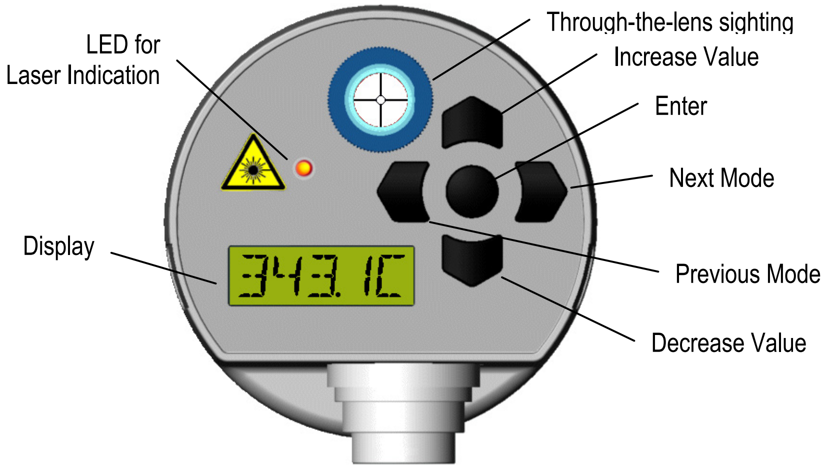
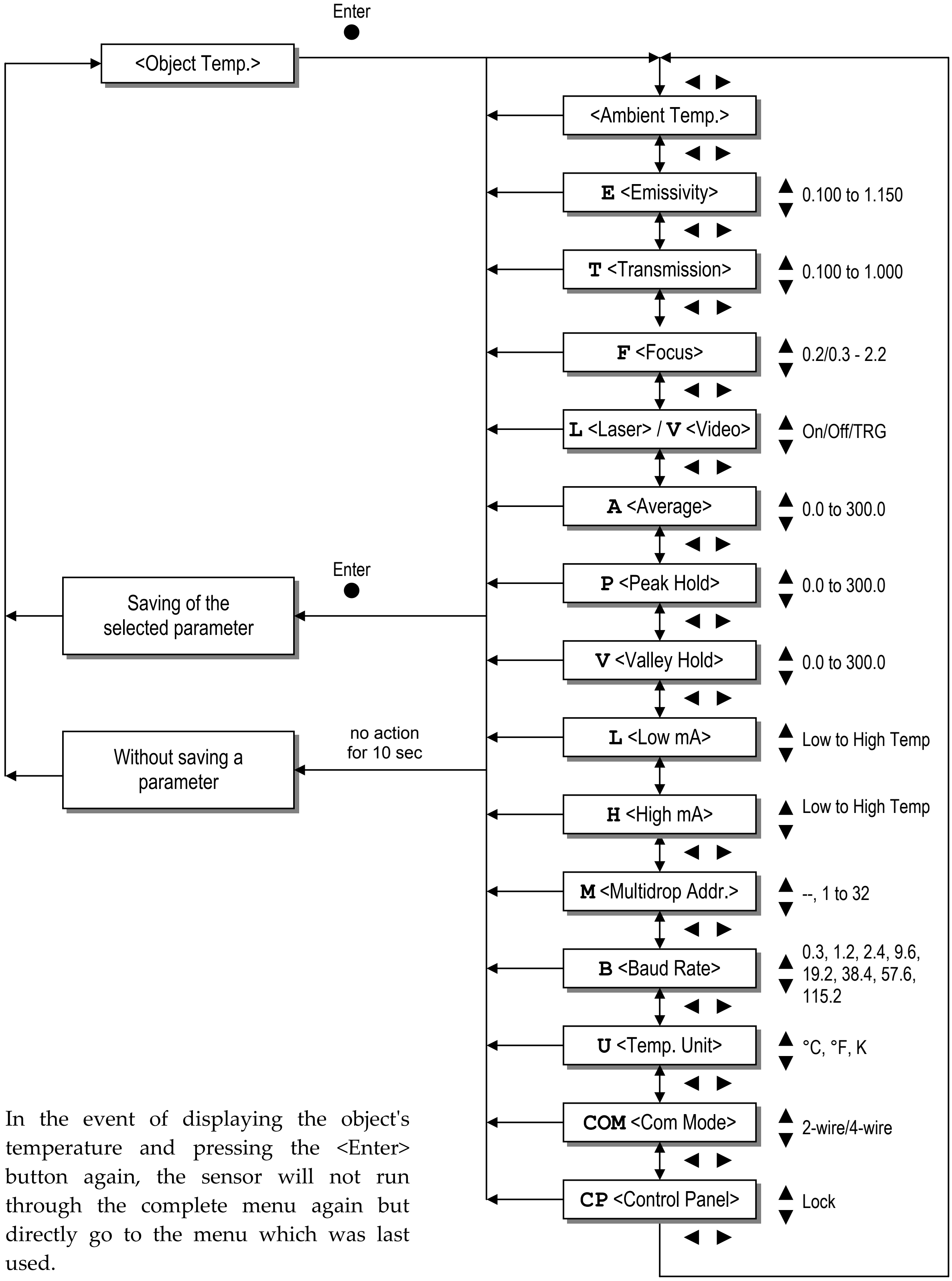


Figure 12: Control Panel

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.



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.

Figure 13: Operation Modes

Object Temp.:	The display shows the current temperature of the measured object.
Ambient Temp.:	The displays 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, on page 64.
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, on page 24.
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, on page 25.
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, on page 27.
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.For wiring instructions, see section 6.5 Connecting to a PC on page 17 including applicable subsections.

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 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.

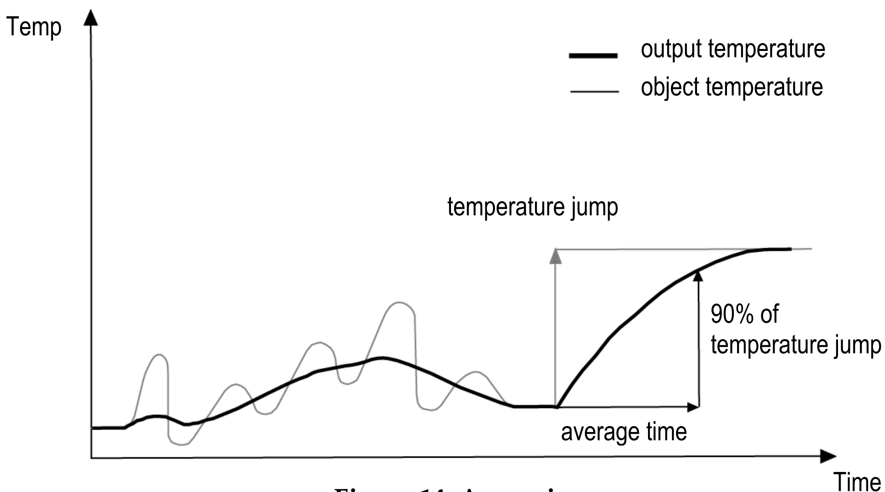


Figure 14: Averaging

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.

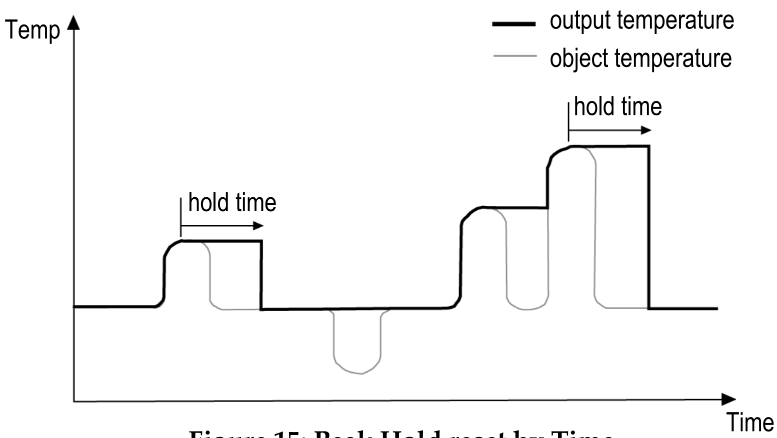


Figure 15: Peak Hold reset by Time

- **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 software, or the programming commands P. For wiring the external trigger, see section 7.4.3.1 Trigger, on page 30.

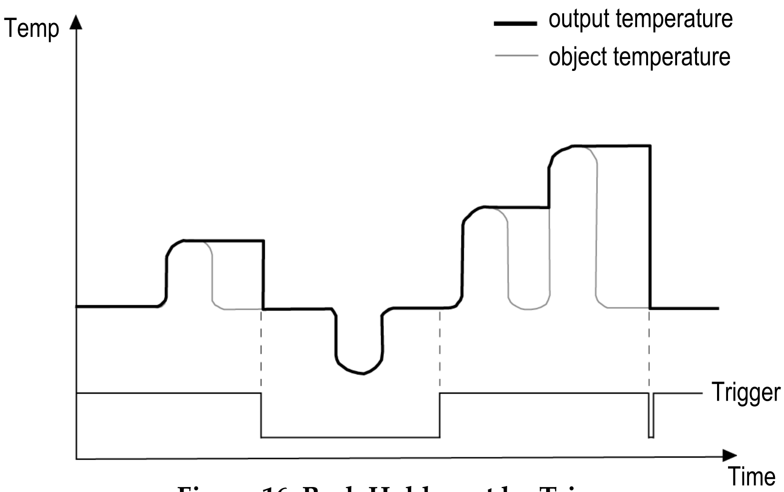


Figure 16: Peak Hold reset by Trigger

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)

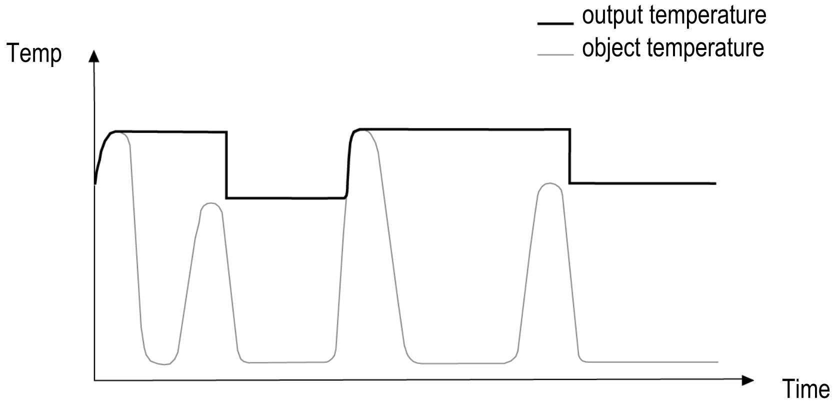


Figure 17: Perpendicular Signal Slope

- 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.

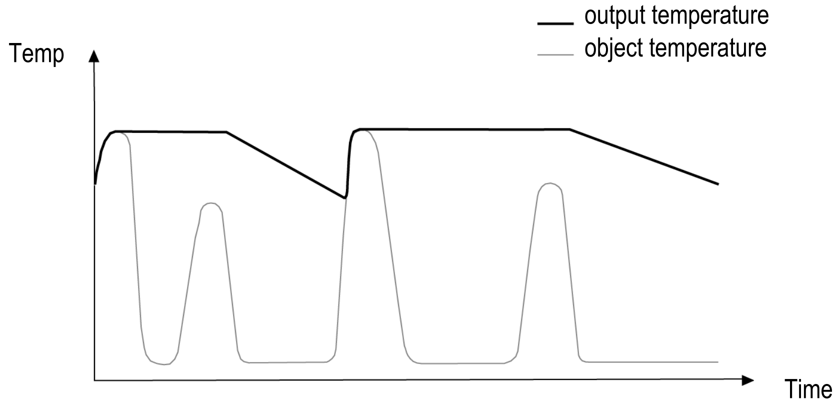


Figure 18: Signal Slope defined by Decay

- 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.

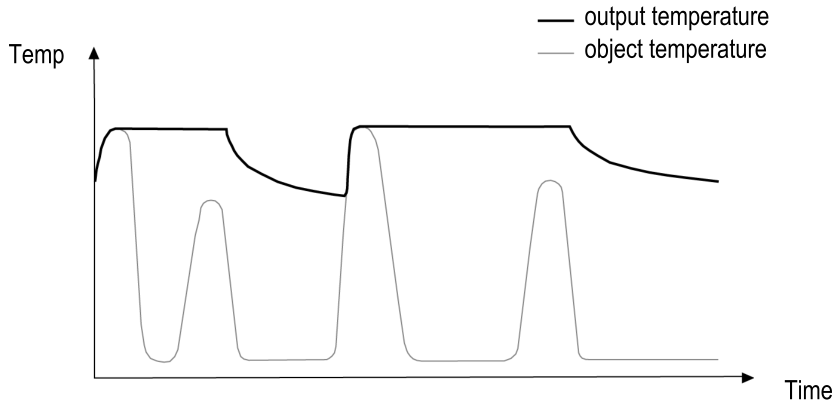


Figure 19: Averaging the Signal Slope

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.

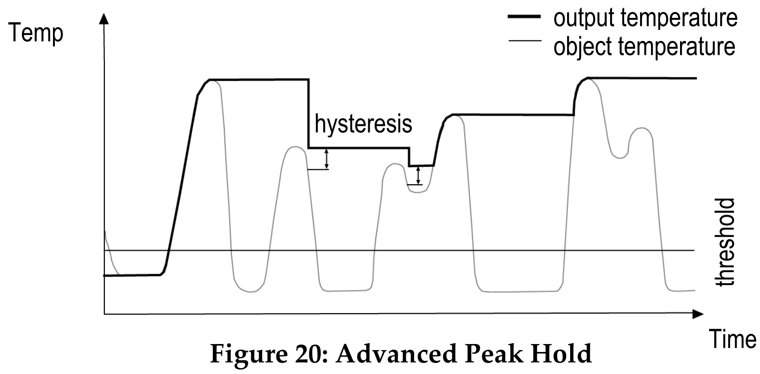


Figure 20: Advanced Peak Hold

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, on page 25 and 7.3.2.2 Signal Slope, on page 26.

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.

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 software or a programming command according to section 10.9.1 Current Output on page 55. This feature is useful for testing or calibrating connected equipment.

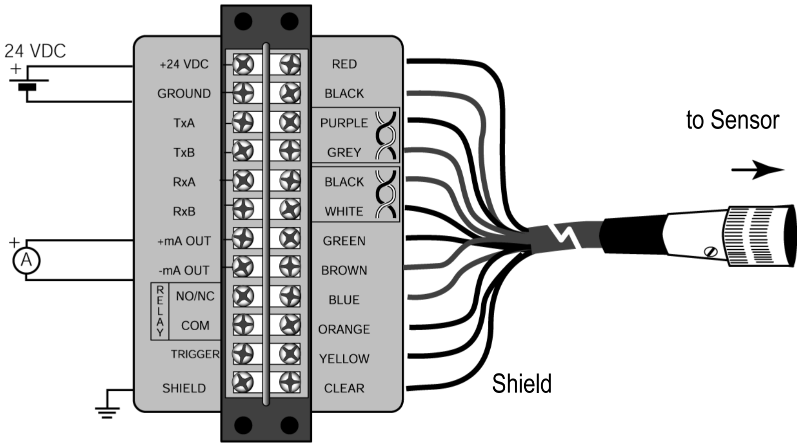


Figure 21: Wiring the mA Output

7.4.2 Relay Output

The relay output is used as an alarm for failsafe conditions, see section 11.2 Fail-Safe Operation, page 62, or as a setpoint 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 software or a programming command, see section 10.9.2 Relay Output on page 55.

7.4.2.1 Setpoints

The relay output has two user selectable setpoints. The two setpoints are deactivated by default (alarm mode). Activating and adjusting the setpoint value is accomplished through the DataTemp software. Once one or both setpoints are activated the relay changes state as the current measured temperature passes the setpoint temperature.

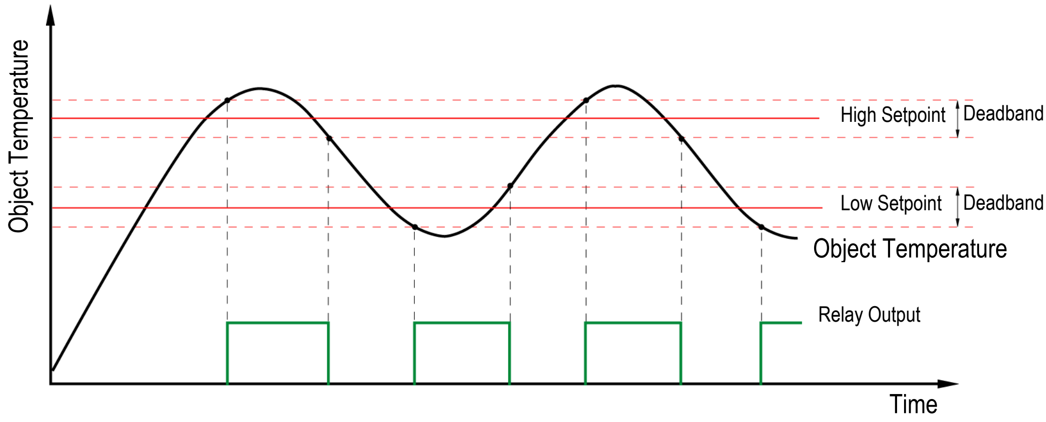


Figure 22: Relay Output Example

7.4.2.2 Deadband

Deadband is a zone of flexibility around the setpoint. The alarm does not go abnormal until the temperature exceeds the setpoint value by the number of set deadband degrees. Thereafter, it does not go normal until the temperature is below the setpoint by the number of set deadband degrees. The deadband is factory preset to ±2 K of setpoint value. Adjusting to other values is accomplished through DataTemp software. For information on the sensor's communication protocols, see section 10 Programming Guide on page 49.

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

Please note that only one input function can be active at a given time.
See the DataTemp Multidrop software help for set up instructions, or refer to the required parameter commands in section 10.9.3 External Input, on page 56.

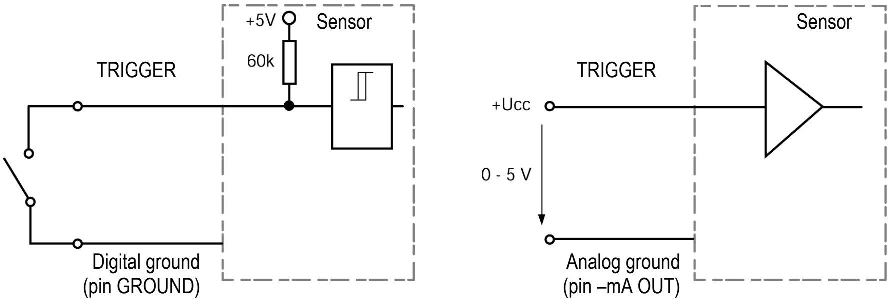


Figure 23: Digital (left) and Analog (right) Using of External Input

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.

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.

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.

All ambient background temperature compensation functions are enabled through the DataTemp 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, on page 54.

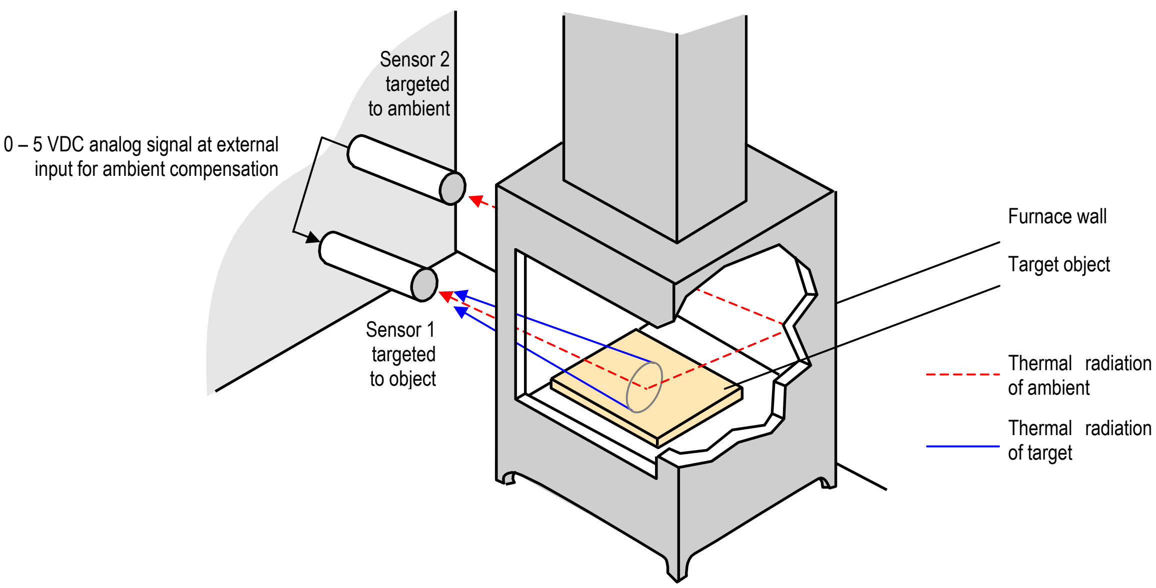


Figure 24: Ambient Background Temperature Compensation with Second Infrared Sensor

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 software, see the software help for set up instructions, or refer to the required command protocol in section 10.8.5 Emissivity Setting, on page 54. 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 6: Ratio between Analog Input Voltage and Emissivity

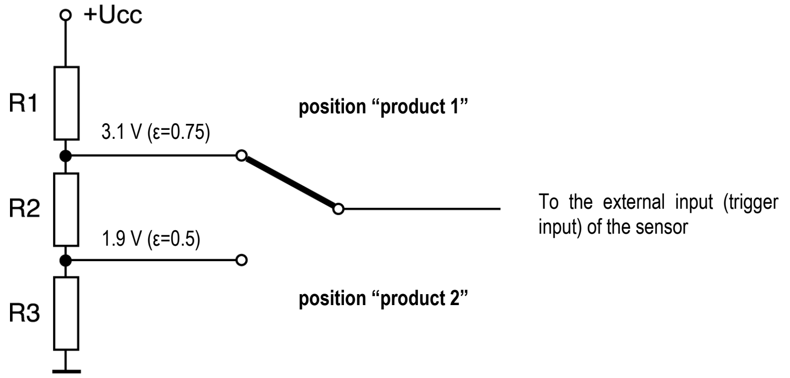


Figure 25: Adjustment of Emissivity at External Input (Example)

7.5 Factory Defaults

To globally reset the unit to its factory default settings, press the ▲ and ▼ buttons at the same time for approximately 2 seconds. The parameter reset via the control panel is possible only with an unlocked control panel. Multidrop address and baud rate will not change from the last value when this 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 (57600 with delivery)
Temperature Unit	°C
Relay alarm output	controlled by unit
Current Output	4 – 20 mA
Control Panel	unlocked
Serial Communication	4-wire (full duplex)
RS485 Transfer Mode	Poll mode
Output String (RS485)	UTEIEC = temperature unit, target temperature, emissivity, internal temperature, error code

Figure 26: Factory Defaults

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 (...W) including air purge
- Variable Focus (…VF1), see section 3.2.2 Variable Focus Optical Specifications, on page 8.
- ISO Calibration Certificate, based on NIST/DKD certified probes (XXXMMCERT)

8.1 Laser Sighting

The laser sighting option 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.

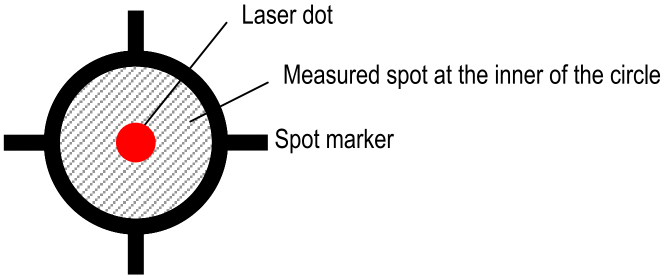


Figure 27: Spot Size Indication

For activating the laser sighting see Figure 13: Operation Modes on page 22.

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.

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!

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°
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.

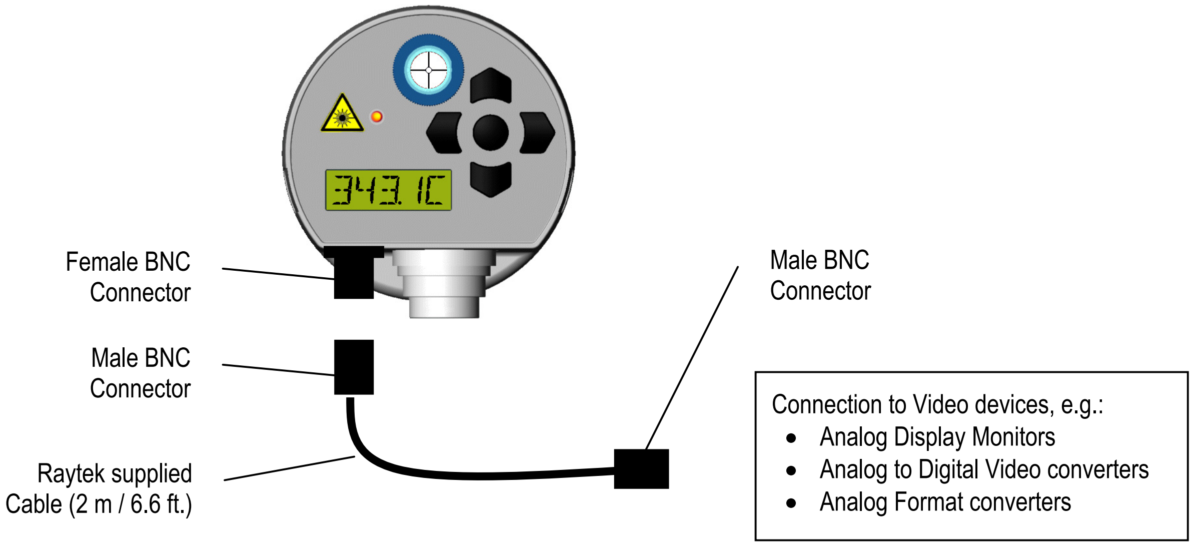


Figure 28: Wiring the Video Output

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.

Digital Video

In order to utilize the frame capture functionality of the DataTemp MultiDrop Software, the analog video signal must be converted into a digital signal imported via a USB port to the DataTemp MultiDrop Software. An analog to digital video converter is available from Raytek (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!

Consider the following sequence for the installation:

1. **Install the driver for the converter on the PC.**
2. **Connect the converter to the PC.**

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 DataTemp MultiDrop Software's toolbar automatically detects and displays the video stream.

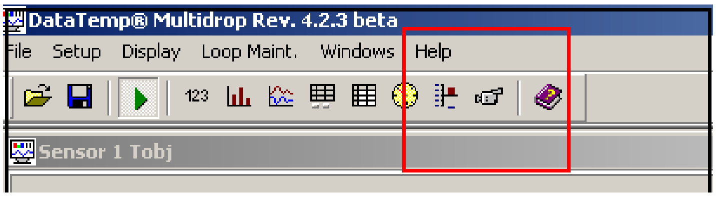


Figure 29: Video Icon in the DataTemp MultiDrop Software

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.

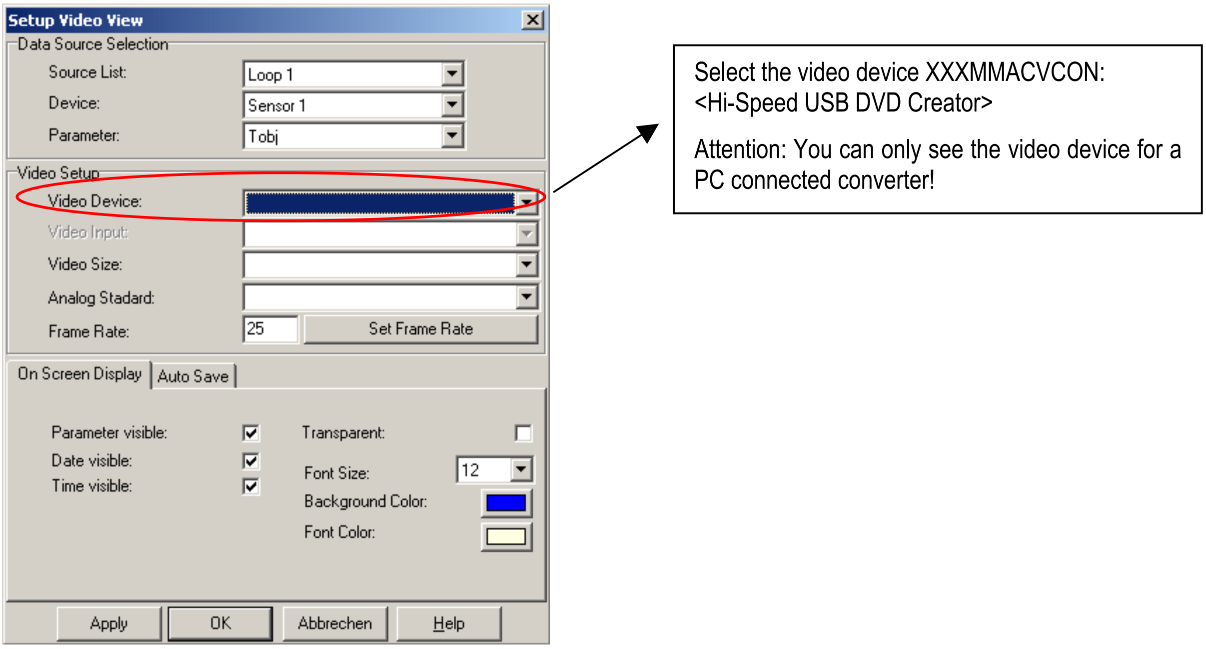


Figure 30: Formatting the Video Image

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

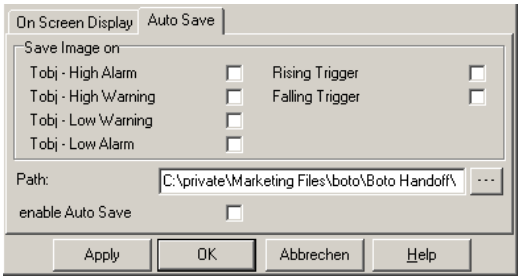
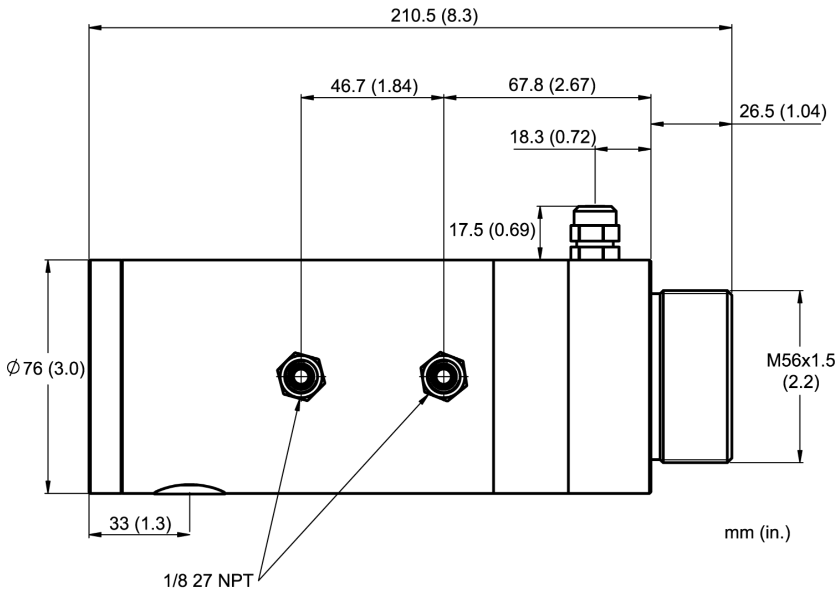


Figure 31: Setting the <Auto Save> function

8.3 Air/Water Cooled Housing

The Air/Water Cooled Housing option 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. Air flow should be 1.4 to 2.5 l/sec at 25°C (77°F). Water flow should be approximately 1.0 to 2.0 l/min (water temperature between 10 and 27°C / 50 to 80.6°F). Chilled water below 10°C (50°F) is not recommended, see section 8.3.1 Avoidance of Condensation on page 39.



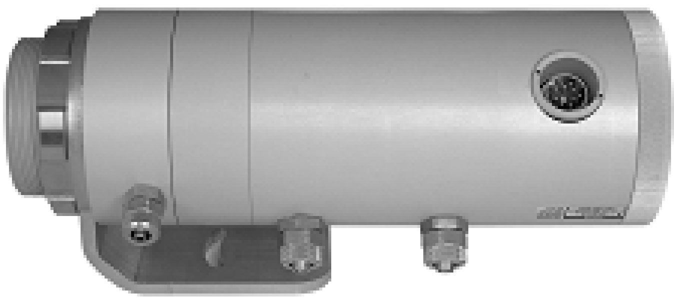


Figure 32: Air/Water Cooled Housing

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)!

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.

Ambient Temperature [°C/°F] \ Relative Humidity [%]	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. 7: 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.

9 Accessories

9.1 Overview

A full range of accessories for various applications and industrial environments are available. Accessories include items that may be ordered at any time and added on-site.

- Adjustable Mounting Bracket (XXXMMACAB)
- Air Purge Collar (XXXMMACAP)
- Sight Tube (XXXTST…)
- Pipe Thread Adapter (XXXMMACPA)
- Right Angle Mirror (XXXMMACRA)
- RS232/485 Interface Converter (XXX485CV…)
- RS232/USB Converter (XXXUSBCV)
- Industrial Power Supply (XXX2CDCPSS)
- Low Temp Cable (XXX2CLTCB…) with Terminal Block
- High Temp Cable (XXX2CCB…) with Terminal Block
- Terminal Block (XXXMATB)
- Terminal Block including 24 VDC power supply (110 / 230 VAC input) and IP 65 (NEMA-4) rated housing (RAYMAPB)
- Protective Window (XXXMMACTW…)
- ThermoJacket (RAYTXXTJ4)

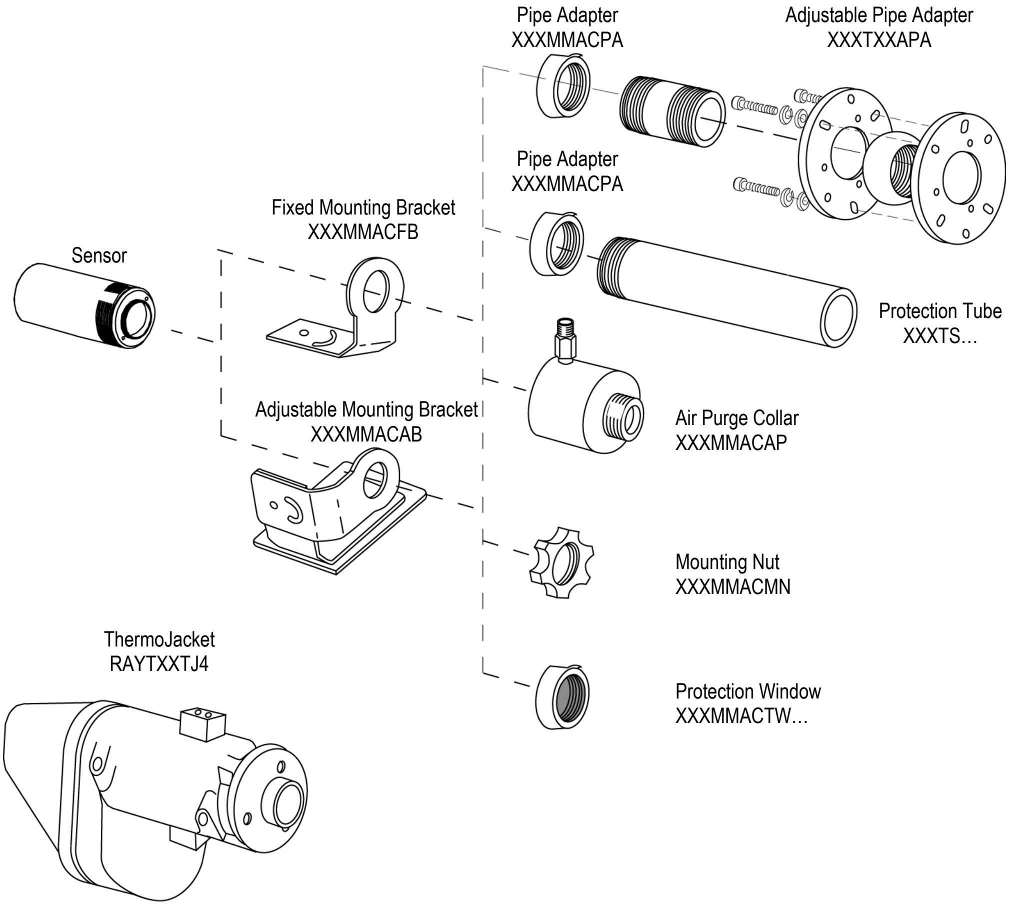


Figure 33: Accessories

9.2 Adjustable Mounting Bracket

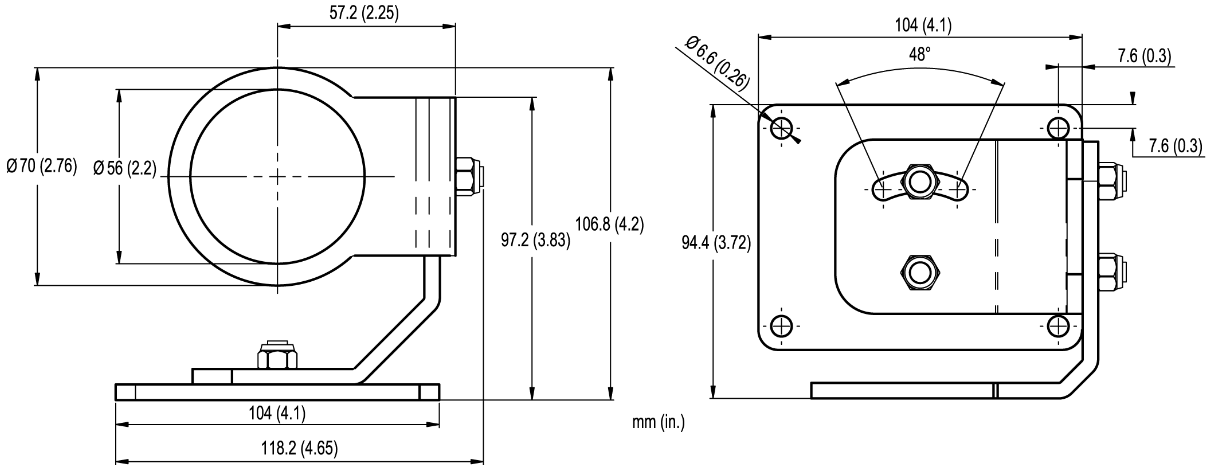


Figure 34: Adjustable Mounting Bracket (Stainless Steel) XXXMMACAB

9.3 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 be used either with the sensor alone or with the Air/Water Cooled Housing.
The Air Purge Collar is rotatable in steps of 120°.

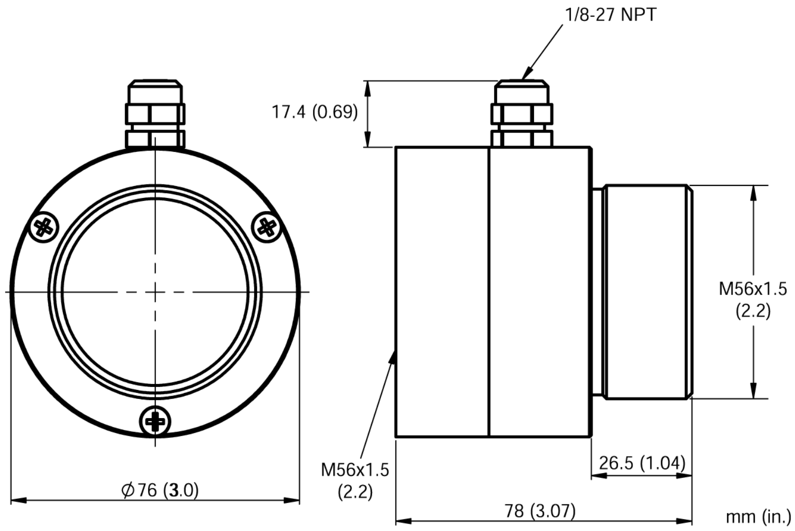


Figure 35: Air Purge Collar XXXMMACAP

9.4 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 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!

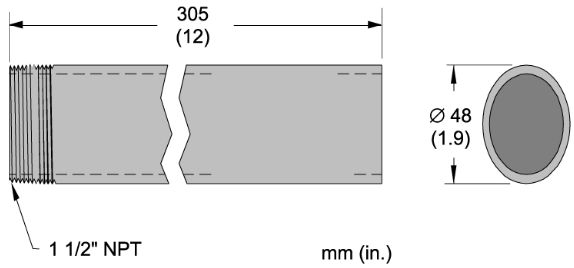


Figure 36: Sight Tube

9.5 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.

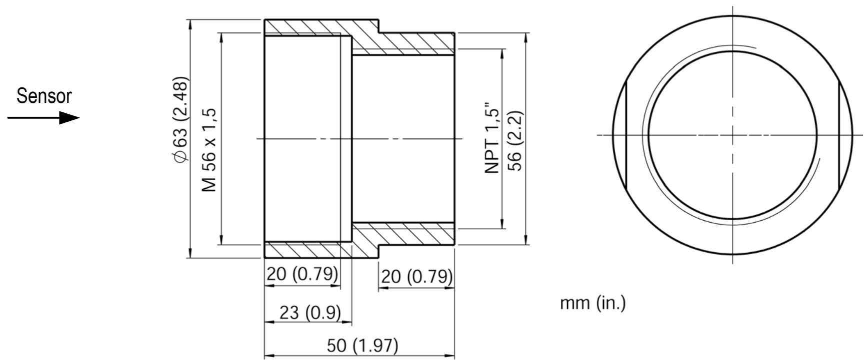


Figure 37: Pipe Adapter XXXMMACPA

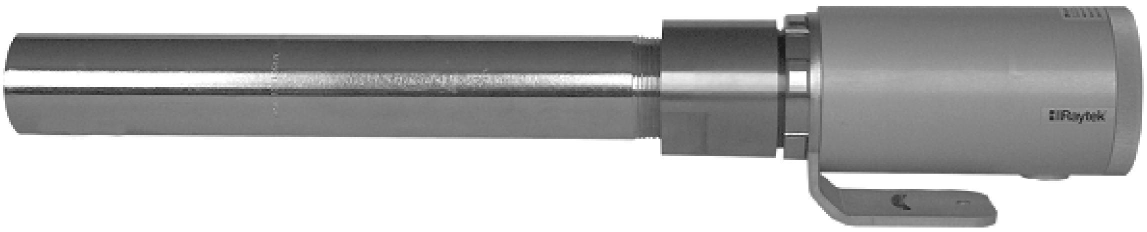


Figure 38: Sensor with Sight Tube (XXXTST…), Pipe Adapter (XXXMMACPA), and Fixed Mounting Bracket (XXXMMACFB)

9.6 Right Angle Mirror

The Right Angle Mirror (XXXMMACRA) 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.

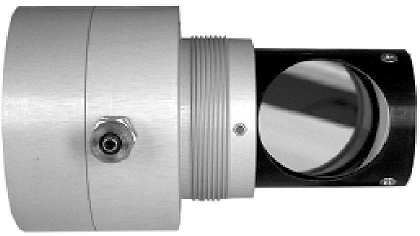


Figure 39: Right Angle Mirror XXXMMACRA

9.7 RS232/485 Interface Converter

The RS232/485 interface converters have built-in smart switching and have been designed to be fast, allowing for use in either 2-wire or 4-wire mode, in either multi-drop or stand-alone mode. The RS232/485 interface converter is required for multi-drop communications.

Do not use other commercially available converters, as they do not have the necessary features!

Order number	Model
XXX485CVT1	25 pin to terminal strip interface converter with 110 VAC power adapter
XXX485CVT2	25 pin to terminal strip interface converter with 230 VAC power adapter

Tab. 8: Available RS232/485 Interface Converters

For more information regarding the wiring of the RS232/485 interface converter, see section 6.4 RS232/485 Interface Converter, on page 16 and section 6.5 Connecting to a PC, on page 17.

9.8 Industrial Power Supply

The industrial power supply (type TXL 025-24S) transforms an input voltage of 100 – 240 VAC (50 / 60Hz) into an output voltage of 24 VDC / 1.1 A. Do not twist the mounting screws deeper than **2 mm (0.08 in.)** into the mounting threads.

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

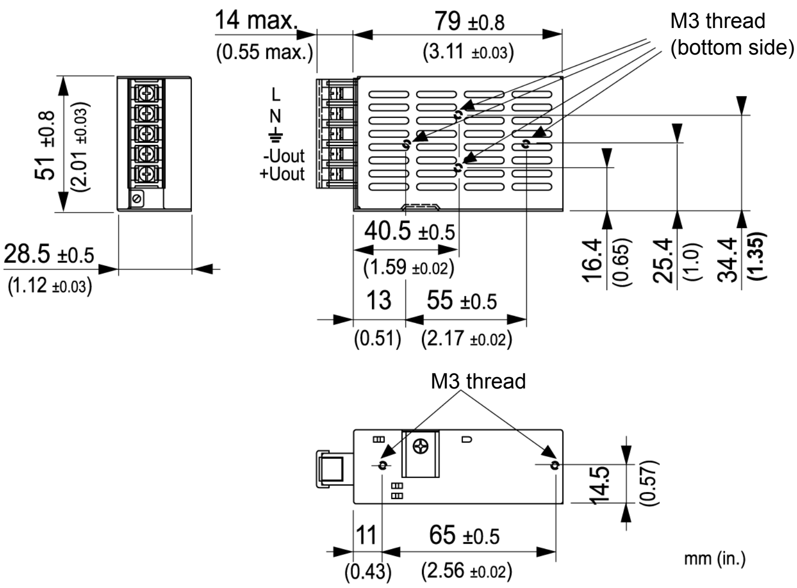


Figure 40: Dimensions and picture of Industrial Power Supply XXX2CDCPSS

9.9 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), 7 x 20 mm, tinned copper
	Isolation:	PE- 2YI1
	Shield:	none
RS485 interface		2 twisted pairs (black/white and purple/gray)
	Conductor:	0,2 mm² (AWG 24), 7 x 20 mm, 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), 7 x 20 mm, tinned copper
	Isolation:	PE- 2YI1
	Shield:	none

Further information for wiring the cable can be found in section 6.2 Electrical Installation, on page 14.

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).

9.10 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 mm^2 (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 mm^2 (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 mm^2 (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 Electrical Installation, on page 14.

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 meters (4000 feet).

9.11 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 a LT, MT, and G5 model. 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 on page 21!

Order number	Model	Material	Transmission
XXXMMACTWL	LT, MT, G5	Zinc Sulphide	0.75 ±0.05
XXXMMACTWGP	1M, 2M	Fused Silica	0.93 ±0.05

Tab. 9: Protective Windows

For special requirements, please contact your local vendor or representative about our range of special protective windows.

9.12 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.

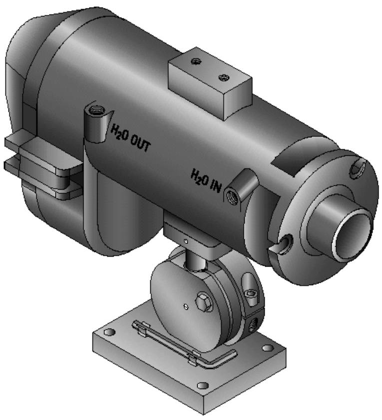


Figure 41: ThermoJacket (XXXTXXTJ4) with Mounting Base

For more information see the ThermoJacket's manual.

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 recommended to wait for the response from the sensor before sending another.

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

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

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

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

Sensor notification

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

#XI<CR><LF>	"#" is the parameter for "Notification"
	"XI" is the value for the notification (e.g. "XI" devices switches to "ON")
	<CR> <LF> (0Dh 0Ah) is closing the notification

10.4 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

10.5 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"

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 ($=...).

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.

10.6 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, MT, and G5 units produce a new temperature read (sample time) every 20 ms.
1M and 2M 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 just "T", "I", and "XT", thus $=TIXT and the unit produces the string <T0150.3 I0027.1 XT00>.
  When the burst string is configured in this way the unit will attempt to transmit the string at the cycle time of the unit. (20 ms for LT, MT, and G5; 1 ms for 1M and 2M). 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?

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

10.7 Sensor Information

The sensor information is factory installed as read only values.

Command	Description	Answer (example)
?XU	Name of the sensor	"!XUMMLTDCL2"
?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 10: Sensor Information

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, MT and G5 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 1M and 2M 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, and MT 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.

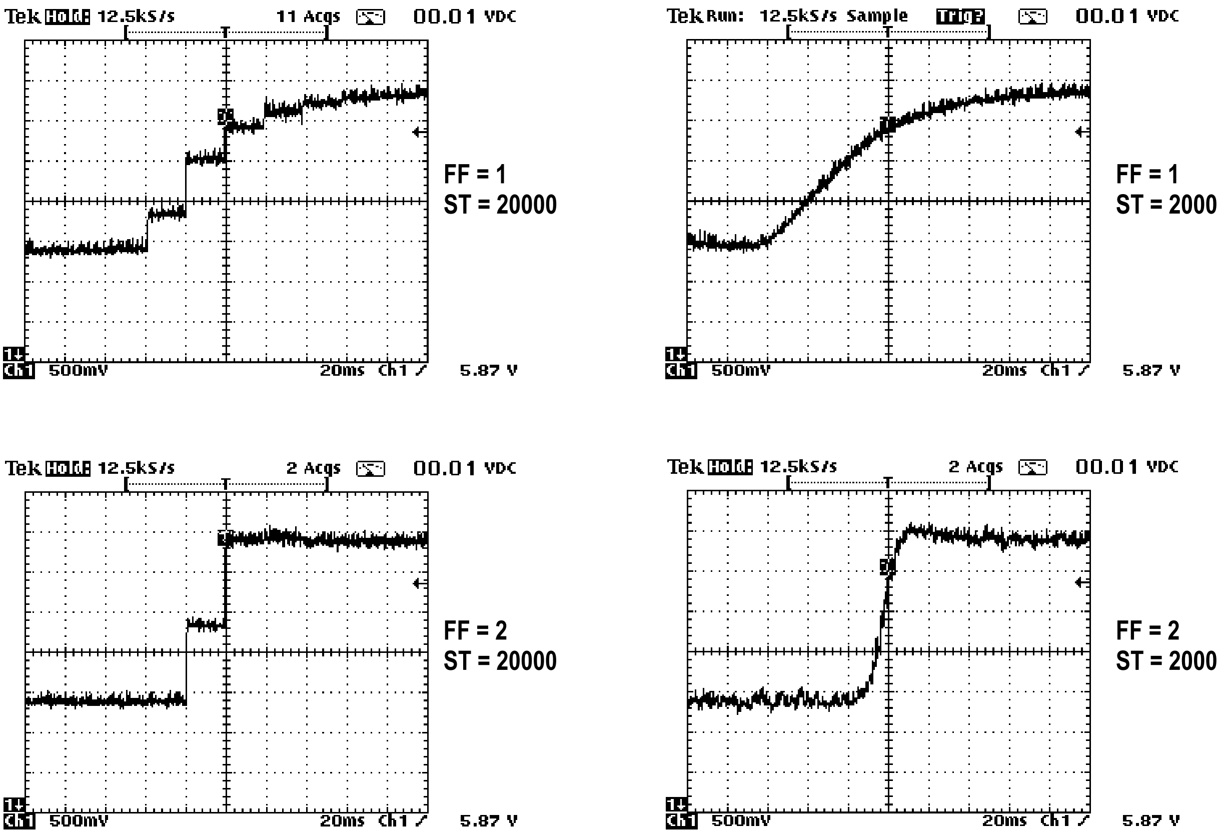


Figure 42: Typical step responses at the output depending on the setting of FF and ST (example for LT sensor)

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. Automatically, the command "ES=E" sets "XN=0" (trigger mode: off). 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 on page 30.
?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". Automatically, the command "AC=2" sets "XN=0" (trigger mode: off). The emissivity setting will be set to internally ("ES=I"). For more information see section 7.4.3 External Input on page 30.

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, on page 24.

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 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

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 11: 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, N.O. normally open
K=3 alarm output triggered by target 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
XS=125.3	sets the alarm threshold to 125.3 in current scale. The alarm threshold is used for both possible trigger sources, the target temperature and the internal sensor temperature. If the internal sensor temperature is selected as the trigger source (K=4, K=5), the alarm threshold is limited to the maximum and minimum allowed internal sensor temperature automatically.

10.9.3 External Input

The external input is shared by several functions, see section 7.4.3 External Input, on page 30. 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). Command format compatible to Marathon Series.
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 Raytek RS232/RS485 converter in 2-wire mode then the baud rate is limited to 38400. The baud rate of the device must be set to this or a lower value before switching to the 2-wire mode!

10.11 Multidrop Mode

Up to 32 devices can be connected within an RS485 multidrop network, see section 6.6 Installing of Multiple Sensors in a Network on page 19. 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 24 to 17)

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"

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!

10.12 Command List

Description	Char	Format (1)	P	B	S	N	legal values	factory default	LCD Char
Poll parameter	?	?X/?XX	√				?T		
Set parameter	=	X/XX=...			√		E=0.85		
Set parameter without EEPROM storage	#	X/XX#…			√		E#0.85		
Multidrop addressing		001?E	√		√		answer: 001!E0.950	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 = with comp. by command, 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	
Baud rate	BR	nnnnnn	√		√		9600, 19200, 38400, 57600, 115200	57600	
Burst speed	BS	integer	√		√		number in milliseconds 50ms ... 20s	50	
Advanced hold threshold	C	nnnn.n	√		√		in current scale (°C/°F/°K)	<= min.range --advanced off	min. range
CheckSum	CS			√			Only valid inside of the burst string.		
Baud rate (like Marathon)	D	nnn	√		√		096, 192, 384, 574, 115	576	
Device special	DS	XXX	√		(√)		e.g. !DSRAY	Set at production	
Emissivity internal	E	n.nnn	√	√	√		0.1 - 1.15	0.95	E
Error code	EC	nnnn	√	√			hex value of ErrCode (2)		
Emissivity source	ES	X	√		√		I = Emissivity from Internal (by command) E = Emissivity from External analog input (0V—5V)	I	
Pre-sel. emissivity value	EV	n.nnn	√				0.1 – 1.1 not implemented		
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	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/mV range	H	nnnn.n	√	√	√	√		(8)	H
RS485 mode	HM	n	√		√	√	2 = 2-wire, 4 = 4-wire	4	COM

Description	Char	Format (1)	P	B	S	N	legal values	factory default	LCD Char
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 Intern norm. open 3 = Target and Intern norm. closed 4 = Intern normal open 5 = Intern norm. closed	2	
Bottom of mA/mV range	L	nnnn.n	√	√	√	√		(9)	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	nnnnn	√	√					
Temperature range	RT		√		√		E = Extended range S = Standard range (= <bottomTemp> <topTemp>)	S	-
Sample time	ST	X	√		(√)		For LT, G5, MT 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	N	
Voltage at trigger pin	TV	float	√						
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	0	
Burst string contents	X$		√						
Multidrop address	XA	0nn	√		√	√	0 – 32 (0 → single unit mode)	0	
Device bottom range limit	XB	nnnn.n	√		(√)				
Deadband (5)	XD	nn	√		√		1 – 55°C/K; 1-99°F	2	
Decay rate	XE	nnnn	√		√		1-3000K/s	0	
Restore factory defaults	XF				√				
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 setpoint	XP	nnnn.n	√		√		Bottom range switches the second setpoint off.	bottom range	
Firmware revision	XR		√				e.g. 1.01	Set in FW	
Setpoint relay function	XS	nnnn.n	√		√		Bottom range places the unit in alarm mode.	bottom range	

Description	Char	Format (1)	P	B	S	N	legal values	factory default	LCD Char
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	

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

(1) n = number, X = uppercase letter

(2) Error Codes:

Object temperature over range	*BIT0*
Object temperature under range	*BIT1*
Internal temperature over range	*BIT2*
Internal temperature under range	*BIT3*
ADC initialisation error	*BIT4*
EEPROM error user space	*BIT5*
EEPROM error calibration space	*BIT6*
Device in init phase	*BIT7*
Focus motor error	*BIT8*
Focus zero position lost	*BIT9*

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.

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 12: Troubleshooting

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	2 to 3 mA
Target temperature under range	EUUU	3	0 mA	2 to 3 mA
Target temperature over range	EHHH	4 (low)	21 to 24 mA	21 to 24 mA

Table 13: 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.

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!

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)

Material	METALS Emissivity				
	1 µm	1.6 µm	3.9 µm	5 µm	8 – 14 µm
Aluminum					
Unoxidized	0.1-0.2	0.02-0.2	0.02-0.2	0.02-0.2	0.02-0.1
Oxidized	0.4	0.4	0.2-0.4	0.2-0.4	0.2-0.4
Alloy A3003, Oxidized		0.4	0.4	0.4	0.3
Roughened	0.2-0.8	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
Brass					
Polished	0.1-0.3	0.01-0.05	0.01-0.05	0.01-0.05	0.01-0.05
Burnished			0.3	0.3	0.3
Oxidized	0.6	0.6	0.5	0.5	0.5
Chromium	0.4	0.4	0.03-0.3	0.03-0.3	0.02-0.2
Copper					
Polished		0.03	0.03	0.03	0.03
Roughened		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	0.5-0.8	0.5-0.8	0.4-0.8
Gold	0.3	0.01-0.1	0.01-0.1	0.01-0.1	0.01-0.1
Haynes					
Alloy	0.5-0.9	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	0.7-0.95
Sandblasted	0.3-0.4	0.3-0.6	0.3-0.6	0.3-0.6	0.3-0.6
Electropolished	0.2-0.5	0.25	0.15	0.15	0.15
Iron					
Oxidized	0.4-0.8	0.5-0.8	0.6-0.9	0.6-0.9	0.5-0.9
Unoxidized	0.35	0.1-0.3	0.05-0.25	0.05-0.25	0.05-0.2
Rusted		0.6-0.9	0.5-0.8	0.5-0.8	0.5-0.7
Molten	0.35	0.4-0.6	—	—	—
Iron, Cast					
Oxidized	0.7-0.9	0.7-0.9	0.65-0.95	0.65-0.95	0.6-0.95
Unoxidized	0.35	0.3	0.25	0.25	0.2
Molten	0.35	0.3-0.4	0.2-0.3	0.2-0.3	0.2-0.3
Iron, Wrought					
Dull	0.9	0.9	0.9	0.9	0.9

Tab. 14: Typical Emissivity Values

Material	METALS Emissivity				
	1 µm	1.6 µm	3.9 µm	5 µm	8 – 14 µm
Lead					
Polished	0.35	0.05-0.2	0.05-0.2	0.05-0.2	0.05-0.1
Rough	0.65	0.6	0.4	0.4	0.4
Oxidized		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	0.03-0.15	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
Molybdenum					
Oxidized	0.5-0.9	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	0.1-0.15	0.1-0.15	0.1
Monel (Ni-Cu)	0.3	0.2-0.6	0.1-0.5	0.1-0.5	0.1-0.14
Nickel					
Oxidized	0.8-0.9	0.4-0.7	0.3-0.6	0.3-0.6	0.2-0.5
Electrolytic	0.2-0.4	0.1-0.3	0.1-0.15	0.1-0.15	0.05-0.15
Platinum					
Black		0.95	0.9	0.9	0.9
Silver		0.02	0.02	0.02	0.02
Steel					
Cold-Rolled	0.8-0.9	0.8-0.9	0.8-0.9	0.8-0.9	0.7-0.9
Ground Sheet			0.5-0.7	0.5-0.7	0.4-0.6
Polished Sheet	0.35	0.25	0.1	0.1	0.1
Molten	0.35	0.25-0.4	0.1-0.2	0.1-0.2	—
Oxidized	0.8-0.9	0.8-0.9	0.7-0.9	0.7-0.9	0.7-0.9
Stainless	0.35	0.2-0.9	0.15-0.8	0.15-0.8	0.1-0.8
Tin (Unoxidized)	0.25	0.1-0.3	0.05	0.05	0.05
Titanium					
Polished	0.5-0.75	0.3-0.5	0.1-0.3	0.1-0.3	0.05-0.2
Oxidized		0.6-0.8	0.5-0.7	0.5-0.7	0.5-0.6
Tungsten			0.05-0.5	0.05-0.5	0.03
Polished	0.35-0.4	0.1-0.3	0.05-0.25	0.05-0.25	0.03-0.1
Zinc					
Oxidized	0.6	0.15	0.1	0.1	0.1
Polished	0.5	0.05	0.03	0.03	0.02

Tab. 15: Typical Emissivity Values

Material	NON-METALS Emissivity				
	1 µm	1.6 µm	3.9 µm	5 µm	8 – 14 µm
Asbestos	0.9			0.9	0.95
Asphalt				0.95	0.95
Basalt				0.7	0.7
Carbon					
Unoxidized	0.8-0.95			0.8-0.9	0.8-0.9
Graphite	0.8-0.9			0.7-0.9	0.7-0.8
Carborundum				0.9	0.9
Ceramic	0.4			0.8-0.95	0.95
Clay				0.85-0.95	0.95
Concrete	0.65			0.9	0.95
Cloth				0.95	0.95
Glass					
Plate				0.98	0.85
“Gob”				0.9	—
Gravel				0.95	0.95
Gypsum				0.4-0.97	0.8-0.95
Ice				—	0.98
Limestone				0.4-0.98	0.98
Paint (non-al.)				—	0.9-0.95
Paper (any color)				0.95	0.95
Plastic, opaque at 500 µm thickness (20 mils)				0.95	0.95
Rubber				0.9	0.95
Sand				0.9	0.9
Snow				—	0.9
Soil				—	0.9-0.98
Water				—	0.93
Wood, Natural				0.9-0.95	0.9-0.95

Tab. 16: 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.

12.3 2-Wire Communication

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. Raytek MI sensor). For setting the Interface Converter into the 2-wire communication mode, use the Network Communication Setup Software, found on the software CD.

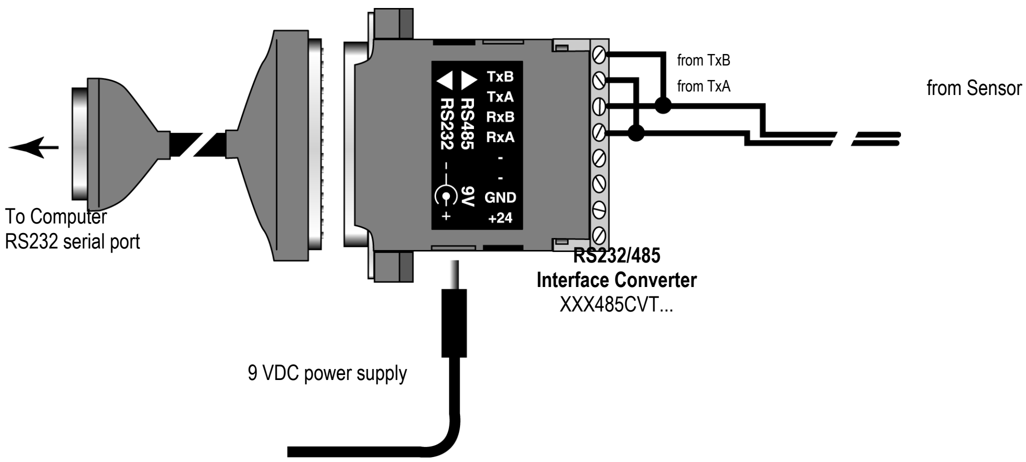


Figure 43: 2-Wire Sensor Communication

13 Traceability of Instrument Calibration

The temperature sources (blackbodies) used to calibrate this instrument are traceable to the German National Institute of Standards and Technology (PTB).

The calibration sources for this instrument were certified by a PTB certified calibration laboratory and are traceable to PTB primary standards. The certificate describes the equipment used for calibration and any corresponding PTB report numbers. In addition, the certificate lists test accuracy data.

An ISO Calibration Certificate from the manufacturer, based on certified probes (XXXMMCERT) can be ordered as an option.

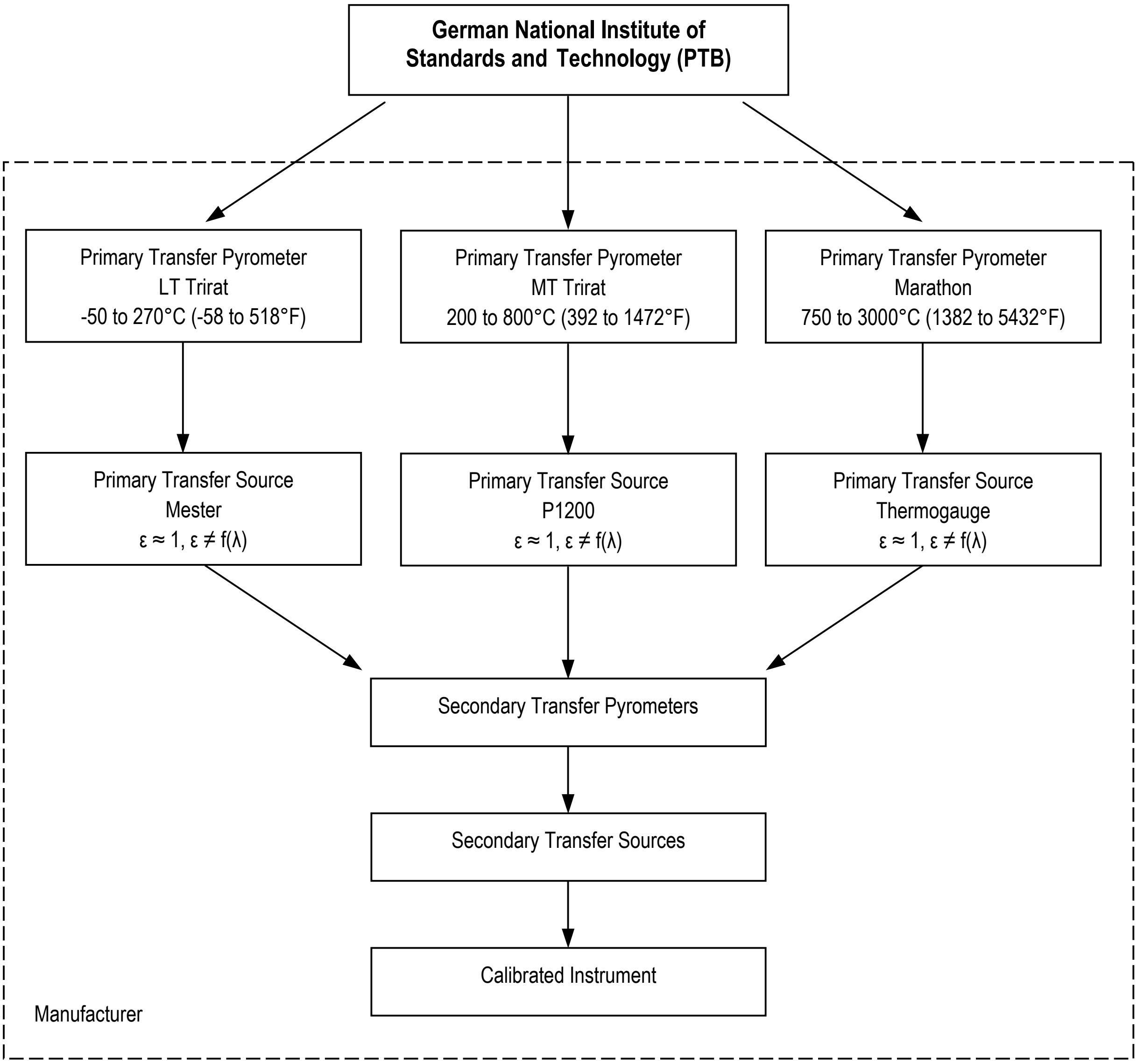


Figure 44: Traceability of Temperature Instrumentation Calibration

14 Glossary of Terms

Absolute Zero The temperature of –273.16°C, –459.69°F, or 0°K; thought to be the temperature at which molecular motion vanishes and a body would have no heat energy. [Ref.1]

Accuracy The maximum deviation in a set of measurements between the temperature indicated by a radiation thermometer and the known temperature of a reference source, including the uncertainty of the reference temperature source. [Ref. 3] The accuracy can be expressed in a variety of ways including temperature, percentage of temperature reading, or percentage of full scale temperature of an instrument.

Ambient Derating Derating or decrease in accuracy of an instrument due to changes in its ambient temperature from that at which it was calibrated. See also Temperature Coefficient.

Ambient Operating Range Range in the ambient temperature over which the instrument is designed to operate.

Ambient Temperature The temperature of the instrument. Can also refer to the temperature that gives rise to the background. See Background Radiation.

Ambient Temperature Compensation (T_{AMB}) See Reflected Energy Compensation.

ASTM American Society for Testing and Materials.

ASTM E 1256 ASTM E1256 - 88, Standard Test Methods for Radiation Thermometers (Single Waveband Type). A standard by which Raytek products are tested and calibrated for accuracy, repeatability, resolution, target size, response time, warm-up time, and long-term drift.

Atmospheric Windows The spectral bands in which the atmosphere least affects the transmission of radiant energy. The spectral bands are 0.4 to 1.8, 2 to 2.5, 3 to 5, and 8 to 14 micrometers.

Background Radiation Radiation that enters an instrument from sources other than the intended target. Background radiation can enter due to reflections from the target or scattering within the instrument.

Blackbody An ideal thermal radiator that absorbs all of the radiation incident thereon, and the radiant emission from which is quantified by Planck's Radiation Law. [Refs. 2,3]

Calibration Procedure procedure that is performed to determine and set the parameters affecting an instrument's performance in order to ensure its designed function within prescribed limits.

Calibration Source A source for which the radiance temperature can be calibrated to within a known level of uncertainty in relation to some other parameter, and in which this relationship is sufficiently constant to enable it to be used for a reasonable period without calibration. [Ref. 4]

Celsius or C The temperature scale in which the temperature in Celsius (TC) is related to the temperature in Kelvin (TK) by the formula; TC = TK –273.15. The freezing point of water at standard atmospheric pressure is very nearly 0°C, and the corresponding boiling point is very nearly 100°C. Formerly known as centigrade temperature scale. [Ref. 1]

Color Temperature The temperature of a black body from which the radiant energy has the same spectral distribution as that from a surface.

Colored Body or Non Gray Body A source of thermal emission for which the emissivity depends on wavelength and is not constant.

Comparison Pyrometry Method of radiation thermometry wherein the temperature of a calibrated source is changed until the radiation received from the source is the same as that from the target to determine the temperature of the target.

Current-Loop A form of communications wherein a pair of wires is used to transmit the signal as a current. Levels of 4 to 20 mA are often used to indicate the minimum and maximum signal level, respectively. Sometimes, for digital applications, various magnitudes of mA current are used to indicate a logical 1 and 0 mA. The current loop is often characterized by a maximum impedance of the device that is connected to the loop.

D:S Optical resolution expressed as a ratio of the distance to the resolution spot divided by the diameter of the spot.

Deadband Temperature band (±) about the set point, wherein an alarm output or relay cannot change state, thus providing hysteresis.

Detector Transducer which produces a voltage or current proportional to the electromagnetic energy incident upon it. See also Thermopile, MCT, Thermoelectric Cooled, Pyroelectric, and Lead Selenide and Si detectors.

Dielectric Withstand Voltage or Breakdown Voltage, the maximum voltage an insulator of electricity can endure without electrical conduction through the material.

Digital Data Bus A pair of electrical conductors connecting several transmitters and receivers of digital data.

Digital Image Processing Converting an image to digital form and changing the image to enhance it or prepare it for analysis by computer or human vision. In the case of an infrared image or thermogram, this could include temperature scaling, spot temperature measurements, thermal profiles, image addition, subtraction, averaging, filtering, and storage.

Digital Output Interval The time interval between transmission of packets of digital data containing temperature and system status information.

DIN Deutsches Institut für Normung. The German standard for many instrumentation products.

Drift The change in instrument indication over a period of time not caused by external influences on the device. [Ref. 3]

EMI/RFI Electro-Magnetic Interference/Radio Frequency Interference, which affects the performance of electronic equipment.

Glossary of Terms

Emissivity	At a given wavelength the ratio of infrared energy radiated by an object at a given temperature to that emitted by a blackbody at the same temperature. The emissivity of a blackbody is unity at all wavelengths.
Environmental Rating	A rating given (usually by agencies and regulatory bodies) to indicate the severity of the environment in which the unit will function reliably.
External Reset (Trigger)	Initialization of an instrument to its state at power up including signal conditioning features (Peak Hold, Valley Hold, Sample Hold, Average, 1-way RS232, etc.) via the external reset input.
Fahrenheit or F	Temperature measurement scale where, at standard atmospheric pressure, the freezing point of water is 32°F and the vaporization point of water is 212°F. To convert from Celsius, use F = (C x 1.8) + 32.
Fail-Safe Operation	A feature designed to alert the operator via display, and to bring a process to a safe shutdown via output, in the event of a particular control system or process failure.
Far Field	A measurement distance sufficiently large (typically greater than 10 times the focal distance) whereby the spot size of an instrument is growing in direct proportion to the distance from the instrument, and the field of view is constant.
Field of View (FOV)	The area or solid angle viewed through an optical or infrared instrument. Typically expressed by giving the spot diameter of an instrument and the distance to that spot. Also expressed as the angular size of the spot at the focal point. See Optical or Infrared Resolution.
Focal Point or Distance	The point or distance from the instrument at which the object is focused onto the detector within the instrument. The focal point is the place or distance at which the optical or infrared resolution is greatest.
Full Scale Accuracy	The temperature measurement accuracy expressed as a percentage of the maximum possible reading of an instrument.
Gray Body	A source of radiant emissions for which the emissivity is less than 1 but constant and, therefore, independent of wavelength.
IEC	International Electrotechnical Commission. A European organization that coordinates and sets related standards among the European Community.
IFOV	Instantaneous Field of View, Instantaneous Field of View is the angular resolution of an imaging instrument that is determined by the size of the detector and the lens. For a point instrument the IFOV and FOV are the same.
Image Processing	Converting an image to a digital form and further enhancing the image to prepare it for computer or visual analysis. In the case of an infrared image or thermogram, this could include temperature scaling, spot temperature measurements, and thermal profiles, as well as image addition, subtraction, averaging, filtering, and storage.

Indium Antimonide (InSb) A material used to construct photon detectors that are sensitive in the spectral region from 2.0 to 5.5 µm and used in infrared scanners and imagers. These detectors require cryogenic cooling.

Infrared Radiation (IR) Radiation within the portion of the electromagnetic spectrum which extends from 0.75 to 1000 µm.

Infrared or Optical Filter See Spectral Filter or Neutral Density Filter.

Infrared Thermometer An instrument that determines the temperature of an object by means of detecting and quantifying the infrared radiation emitted there from. Types include total power, wide band, narrow band, and multiple wavelengths.

Insulation Resistance The property of a material to resist the flow of electrical current and expressed in Megohms (MΩ) as the ratio of an applied electrical potential divided by the flow of electrical current resulting there from.

Interchangeability … of heads. The ability for a head sensor to be interchanged with another of the same type without the need to recalibrate the system (also referred to as Universal Electronics). Some monitors support the interchangeability of different types of heads.

Intrinsically Safe A standard for preventing explosions in hazardous areas by limiting the electrical energy available to levels that are insufficient to cause ignition of explosive atmospheres during normal operation of an instrument.

IP Designation Grades of intrinsic safety protection pertaining to enclosures per the British Standard 4752. The type of protection is defined by two digits, the first relating to accessibility and the second to environmental protection. The two numbers are preceded by the letters IP. [Ref. 6]

Isolated Inputs … Outputs or Power Supplies. Inputs, outputs and power supply lines that are electrically insulated from each other, whereby arbitrary grounding of these lines cannot affect the performance of the instrument such as generate ground-loops or short out internal resistors.

Isotherm A continuous line (not necessarily straight or smooth) on a surface (or chart) comprising points of equal or constant temperature.

JIS Japanese Industrial Standard. A technical governing body that sets standards for determining or establishing the accuracy of IR thermometers.

Kelvin or K A temperature scale that is directly related to the heat energy within a body. Formally, a temperature scale in which the ratio of the temperatures of two reservoirs is equal to the ratio of the amount of heat absorbed from one of the them by a heat engine operating in a Carnot Cycle to the amount of heat rejected by this engine to the other reservoir. The temperature of the triple point of water (in this scale) is defined as 273.16° K. [Ref. 1] To convert from Celsius, K=C+273.16.

Lead Selenide (PbSe) A material used to make photon detectors that are sensitive in the 3 to 5 µm spectral band. These detectors require thermoelectric cooling and are used in IR thermometers, scanners, and imagers.

Maximum Current Loop Impedance Describes the size of a load that can be driven by an instrument with a mA output. For example a 500 Ohm maximum loop impedance means that the instrument can supply 10 Volts at 20 mA into this load.

MCT (Mercury Cadmium Telluride) or HgCdTe. A ternary alloy material used to build photon detectors that are sensitive in the 3 – 5 μm and 8 – 14 μm regions of the spectrum and require TE cooling in the 3 - 5 μm region and cryogenic cooling in the 8 – 14 μm region.

Minimum spot size The diameter of the smallest object for which an instrument can meet its performance specifications.

NEMA National Electrical Manufacturer's Association. Among its activities, sets US standards for housing enclosures, similar to IEC IP.

NET or NETD Noise Equivalent Temperature Difference or the change in temperature of a blackbody target that fills the radiometer FOV which results in a change in the radiometer signal equal to the rms noise of the instrument.

Neutral Density Filter An optical or infrared filter for which the transmission is constant and not a function or wavelength.

NIST Traceability Calibration in accordance with and against standards traceable to NIST (National Institute of Standards and Technology, USA). Traceability to NIST is a means of ensuring that reference standards remain valid and their calibration remains current.

Optical or Infrared Resolution The ratio of the distance to the target divided by the diameter of the circular area (or spot) for which the energy received by the thermometer is a specified percentage of the total energy that would be collected by an instrument viewing a calibration source at the same temperature. The distance to the target is generally the focal distance of the instrument. The percentage energy is generally 90% to 95%.

Optical Pyrometer A system that, by comparing a source whose temperature is to be measured to a standardized source of illumination (usually compared to the human eye), determines the temperature of the former source.

Output Impedance Describes the impedance of the thermometer that is experienced by any device connected thereto. To achieve accurate readings, the input impedance of a device connected to the thermometer must be much greater than the output impedance of the thermometer.

Peak Hold Output of the maximum temperature measurement indicated by an instrument during the time duration for which this display mode has been active.

Photondetector or Quantum Detector A type of detector in which the photons or quanta of energy interact directly with the detector to generate a signal.

Pyroelectric Detector Thermal detector that has a signal generated by means of the pyroelectric effect wherein changes in temperature of the detector generates an electrical signal.

Pyrometer A broad class of temperature measuring devices. They were originally designed to measure high temperature, but some are now used in any temperature range. Includes radiation pyrometers, thermocouples, resistance pyrometers, and thermistors.

Radiance Temperature The temperature of a black body which has a radiance equal to the radiance of the object at a particular wavelength or wavelength band. [Ref. 5]

Radiant Energy The electromagnetic energy emitted by an object due to its temperature.

Radiation Thermometer A device used to measure the temperature of an object by quantification of the electromagnetic radiation emitted there from. Also, a radiometer calibrated to indicate a blackbody's temperature. [Ref. 3]

Rankine or R The absolute temperature scale related to Fahrenheit in the equivalent manner Kelvin is to Celsius. R = 1.8 x K, or also R = F + 459.67.

Reference Junction or Cold Junction. Refers to the thermocouple junction that must be known in order to infer the temperature of the other or thermocouple measurement junction.

Reflectance The ratio of the radiant energy reflected from a surface to that incident on the surface.

Reflected Energy Compensation Feature used to achieve greater accuracy by compensating for background IR energy that is reflected off the target into the instrument. If the temperature of the background is known, the instrument reading can be corrected by using this feature.

Relative Humidity The dimensionless ratio of the actual vapor pressure of the air to the saturation vapor pressure (abbreviated RH). Percent relative humidity is expressed as the product of RH and 100. For example an RH of 0.30 is a percent relative humidity of 30%. [Ref. 1]

Repeatability The degree to which a single instrument gives the same reading on the same object over successive measures under the same ambient and target conditions. The ASTM standard E 1256 defines it as the sample standard deviation of twelve measurements of temperature at the center of the span of the instrument. Generally expressed as a temperature difference or a percent of full scale value, or both. [Ref. 3]

Resolution See Temperature Resolution, Optical Resolution, or Spatial Resolution.

Response Time The time for an instrument's output to change to 95% of its final value when subjected to an instantaneous change in target temperature corresponding to the maximum temperature the instrument can measure (per ASTM E 1256). The average time required for software computation within the processor is also included in this specification for Raytek products.

RS232 Recommended Standard (RS) 232 is a standard developed by the Electronic Industries Association (EIA) that governs the serial communications interface between data processing and data communications equipment and is widely used to connect microcomputers to peripheral devices. [Ref. 1] The present revision is EIA-RS232-D, which defines the interface between Data Terminal Equipment (DTE) and Data Communications Equipment (DCE)

	employing serial binary data interchange. The standard does not define the protocol or format of the binary stream. The standard comprises three parts: electrical characteristics, interface mechanical characteristics, and functional description of the interchange circuits. The equivalent international standard is Comite Consultatif International Telegraphique et Telephonique (CCITT) V.24.
RS485	A recommended standard developed by EIA that is an improvement over RS-422 in that it allows an increase in the number of receivers and transmitters permitted on the line.
RTD	Resistance Temperature Device. A contact measurement device whose resistance varies with temperature.
Sample Hold	A temperature taken from a target and displayed or held for a set period of time or until the next external reset occurs.
Scatter	Radiant energy reaching the detector of an instrument from the background other than that which is reflected from the target.
Set Point	Process or measurement variable setting which when crossed by the measured value will trigger an event and/or cause a relay to change state.
Shock Test	An impact test where an object or test unit is subjected to an impulsive force which is capable of exciting mechanical resonance's of vibration.
Signal Processing	Manipulation of temperature data for purposes of enhancing the data. Examples of signal processing functions include Peak Hold, Valley Hold, and Averaging.
Silicon (Si) Detector	A photon detector used in measurement of high temperatures.
Size-of-Source Effect	The effect by which the energy collected by, and temperature reading of, an instrument continues to increase as the size of a target increases beyond the field-of-view of the instrument. It is caused by two occurrences: the remaining energy above the percentage used to define location and scattering of radiation as it enters the instrument such that energy from outside the FOV of the instrument enters it. The existence of this effect means that the accuracy of the instrument may be affected by targets that are too large as well as two small. This effect is also called Target Size Effect. [ASTM STP 895]
Slope	The ratio of the emissivities for the two spectral bands of a 2-color radiometer. The emissivity of the shorter wavelength band is divided by the emissivity of the longer wavelength band. Slope can be greater than, equal to, or less than unity. Slope accounts for materials where emissivity varies with wavelength.
Spectral Filter	An optical or infrared element used to spectrally limit the transmission of radiant energy reaching an instrument's detector.
Spectral Response	The wavelength region in which the IR Thermometer is sensitive.
Spot	The diameter of the area on the target where the temperature determination is made. The spot is defined by the circular aperture at the target which

allows typically 90% of the IR energy from the target to be collected by the instrument. See also Size-of-Source Effect.

Stare or Lag A saturation effect whereby the signal from an instrument endures beyond the response time after the target has been removed from the field of view. Can be caused by exposing the sensor to a target of high temperature for an extended period. The effect is expressed as the increase in response time required for the sensor to return to within 5% of the correct reading.

Storage Temperature Range The ambient temperature range an instrument can survive in a non-operating mode and perform within specifications when operated.

Target The object upon which the temperature is determined.

Target Size Effect See Size-of-Source Effect.

Temperature A property of an object which determines the direction of heat flow when the object is placed in thermal contact with another object (i.e., heat flows from a region of higher temperature to one of lower temperature). [Ref. 1]

Temperature Coefficient The change in accuracy of an instrument with changes in ambient temperature from that at which the instrument was calibrated. Usually expressed as the percent change in accuracy (or additional error in degrees) per change in ambient temperature. For a rapid change in ambient conditions, refer to Thermal Shock.

Temperature Resolution The minimum simulated or actual change in target temperature that gives a usable change in output and/or indication. [Ref. 3]

Temporal Drift The change in accuracy of an instrument over time. This effect may be due to aging of the instrument's components or calibration changes.

Thermal Detector Detector in which the photons of incident radiation are converted to heat and then into a signal from the detector. Thermal detectors include pyroelectric, bolometer, and thermopile types.

Thermal Drift See Temperature Coefficient.

Thermal Radiator An object that emits electromagnetic energy due to its temperature.

Thermal Shock An error due to a rapid change in the ambient temperature of an instrument. Expressed as a maximum error and the time required for performance to return to prescribed specifications.

Thermistor A semiconductor material whose resistivity changes with temperature.

Thermoelectric Cooling Cooling based on the Peltier effect. An electrical current is sent through two junctions of two dissimilar metals. One junction will grow hot while the other will grow cold. Heat from the hot junction is dissipated to the environment, and the cold from the other junction is used to cool. [Ref. 1]

Thermogram A thermal photograph generated by scanning an object or scene. [Ref. 1]

Thermopile A number of similar thermocouples connected in series, arranged so that alternate junctions are at the reference temperature and at the measured temperature, to increase the output for a given temperature difference between reference and measuring junctions. [Ref. 2]

Time Constant The time it takes for a sensing element to respond to 63.2% of a step change at the target.

Transfer Standard A precision radiometric measurement instrument with NIST traceable calibration in the USA (with other recognized standards available for international customers), used to calibrate radiation reference sources.

Transmittance The ratio of IR radiant energy incident on an object to that exiting the object.

Triple Point The condition of temperature and pressure under which the gaseous, liquid, and solid phases of a substance can exist in equilibrium. For water at atmospheric pressure, this is typically referred to as its freezing point.

Two-Color Thermometry A technique that measures the energy in two different wavelength bands (colors) in order to determine temperature. The 2 color technique has been shown to be effective for correcting errors due to partial blockage of the target caused by dust particles.

Valley Hold Output of the minimum temperature measurement indicated by an instrument during the time duration for which this display mode has been active.

Verification Confirmation of a design with regard to performance within all prescribed specifications.

Vibration Test A test where oscillatory or repetitive motion is induced in an object (as per MIL-STD-810 or IEC 68-2-6), which is specified as an acceleration in g's and power spectral density (PSD), after which the unit is tested for proper operation.

Warm-Up Time Time, after turn on, until the instrument will function within specified repeatability. [Ref. 3]

15 References

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