# MARATHON MR

2-Color Infrared Thermometer


## Operating Instructions

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56913

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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 that has been subject to misuse, neglect, accident, or abnormal conditions of operation.

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

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

# SOFTWARE WARRANTY

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

**Specifications subject to change without notice.**

The device complies with the requirements of the European Directives.

EC – Directive 2004/108/EC (EMC)

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# 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**

Do not dispose of this product as unsorted municipal waste. Go to Fluke's website for recycling information.

**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.

Risk of danger. Important information!

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

# 2 Product Description

The Marathon MR Series of instruments are 2-color infrared noncontact temperature measurement systems with variable focus, through-the-lens sighting, and parallax-free optics. They are energy transducers designed to measure accurately and repeatedly the amount of heat energy emitted from an object, and then convert that energy into a measurable electrical signal. Temperature measurements can be taken using either of the following modes:

- **1-color mode** – for standard temperature measurements. The 1-color mode is best for measuring the temperature of targets in areas where no sighting obstructions, either solid or gaseous, exist. The 1-color mode is also best where the target completely fills the measurement spot and where the background or foreground are higher in temperature than the target.

- **2-color mode** – temperatures are determined from the ratio of two separate and overlapping infrared bands. The 2-color mode is best for measuring the temperature of targets that are partially obscured (either intermittently or permanently) by other objects, openings, screens, or viewing windows that reduce energy, and by dirt, smoke, or steam in the atmosphere. The 2-color mode can also be used on targets that do not completely fill the measurement spot, provided the background is much cooler than the target.

Each model operates as an integrated temperature measurement subsystem consisting of optical elements, spectral filters, detector, digital electronics and a NEMA-4 (IEC 529, IP65) housing. Each is built to operate on a 100 percent duty cycle in industrial environments. Outputs consist of standardized current signals commonly available for use with computers, controllers, recorders, alarms, or A/D interfaces.

| Model | Temperature Range | Minimum Temperature (95% Attenuation) | Optical Resolution (Nominal) |
|---|---|---|---|
| Standard Focus | | | |
| MR1SASF | 600 to 1400°C (1112 to 2552°F) | 800°C (1472°F) | 44:1 |
| MR1SBSF | 700 to 1800°C (1292 to 3272°F) | 950°C (1742°F) | 82:1 |
| MR1SCSF | 1000 to 3000°C (1832 to 5432°F) | 1300°C (2372°F) | 130:1 |
| Close Focus | | | |
| MR1SACF | 600 to 1400°C (1112 to 2552°F) | 800°C (1472°F) | 44:1 |
| MR1SBCF | 700 to 1800°C (1292 to 3272°F) | 950°C (1742°F) | 82:1 |
| MR1SCCF | 1000 to 3000°C (1832 to 5432°F) | 1300°C (2372°F) | 130:1 |

Focal Range SF = Standard Focus 600 mm to ∞ (24" to ∞)
CF = Close Focus 300 mm to 600 mm (12" to 24")

**Table 1: Models**

All Marathon sensors are addressable and can be used in multidrop environments. Setup, utility, and operating/monitoring software is included with your sensor(s).

**For the percentage of allowed signal reduction at temperatures below the minimum temperature (95% attenuation) as shown above, refer to Figure 1.**

## 2.1 Theory of Operation for 2-Color Sensors

Two-color ratio technology makes possible accurate and repeatable temperature measurements that are free from dependence on absolute radiated energy values. In use, a 2-color sensor determines temperature from the ratio of the radiated energies in two separate wavelength bands (colors).

The benefits of 2-color sensors are that accurate measurements can be made under the following conditions:

- When the field of view to the target is partially blocked or obscured.
- When the target is smaller than the sensor's field of view.
- When target emissivities are low or changing by the same factor in both wavelength bands.

Another benefit is that 2-color sensors measure closer to the highest temperature within the measured spot (spatial peak picking) instead of an average temperature. A 2-color sensor can be mounted farther away, even if the target does not fill the resulting spot size. The convenience is that you are not forced to install the sensor at some specific distance based upon target size and the sensor's optical resolution.

### 2.1.1 Partially Obscured Targets

The radiated energy from a target is, in most cases, equally reduced when objects or atmospheric materials block some portion of the optical field of view. It follows that the ratio of the energies is unaffected, and thus the measured temperatures remain accurate. A 2-color sensor is better than a 1-color sensor in the following conditions:

- Sighting paths are partially blocked (either intermittently or permanently).
- Dirt, smoke, or steam is in the atmosphere between the sensor and target.
- Measurements are made through items or areas that reduce emitted energy, such as grills, screens, small openings, or channels.
- Measurements are made through a viewing window that has unpredictable and changing infrared transmission due to accumulating dirt and/or moisture on the window surface.
- The sensor itself is subject to dirt and/or moisture accumulating on the lens surface.

**1-color sensors see polluted atmosphere and dirty windows and lenses as a reduction in energy and give much lower than actual temperature readings!**

### 2.1.2 Targets Smaller Than Field of View

When a target is not large enough to fill the field of view, or if the target is moving within the field of view, radiated energies are equally reduced, but the ratio of the energies is unaffected and measured temperatures remain accurate. This remains true as long as the background temperature is much lower than the target's. The following examples show where 2-color sensors can be used when targets are smaller than the field of view:

- Measuring wire or rod — often too narrow for field of view or moving or vibrating unpredictably. It is much easier to obtain accurate results because sighting is less critical with two-color sensors.
- Measuring molten glass streams — often narrow and difficult to sight consistently with single-wavelength sensors.

### 2.1.3 Low or Changing Emissivities

If the emissivities in both wavelengths (colors) were the same, as they would be for any blackbody (emissivity = 1.0) or greybody (emissivity < 1.0 but constant), then their ratio would be 1, and target emissivity would not be an influence. However, in nature there is no such thing as a greybody. The emissivity of all real objects changes with wavelength and temperature, at varying degrees, depending on the material.

When emissivity is uncertain or changing, a 2-color sensor can be more accurate than a 1-color instrument as long as the emissivity changes by the same factor in both wavelength bands. Note, however, that accurate measurement results are dependent on the application and the type of material being measured. To determine how to use 2-color sensors with your application when uncertain or changing emissivities are a factor, please contact your sales representative.

# 3 Technical Data

## 3.1 Measurement Specifications

| | |
|---|---|
| **Temperature Range** | |
| MR1SA | 600 to 1400°C (1112°F to 2552°F) |
| MR1SB | 700 to 1800°C (1292°F to 3272°F) |
| MR1SC | 1000 to 3000°C (1832°F to 5432°F) |
| **Spectral Nominal Response** | 1.0 µm nominal (Si/Si layered detector) |
| **Spectral Band Response** | |
| 1-color band | 0.75 to 1.1 µm |
| 2-color band | 0.75 to 1.1 µm, 0.95 to 1.1 µm |
| **System Accuracy** | ±(0.5% $T_{meas}$ + 2°C), $T_{meas}$ in °C with no attenuation |
| **Repeatability** | ±0.3% full scale |
| **Temperature Resolution** | ±1°C (±2°F) for display and RS485 interface |
| **Analog Output Resolution** | |
| MR1SA, MR1SB | 1°C or 1°F |
| MR1SC | 1°C or 2°F |
| **Response Time** (95% Response) | all models 10 ms for signal to reach 95% of final temperature |
| **Temperature Coefficient** | All models 0.03% full scale change per 1°C change in ambient temperature |
| **Emissivity (1-color)** | 0.10 to 1.00, digitally adjustable in increments of 0.01 |
| **Slope (2-color)** | 0.850 to 1.150, digitally adjustable in increments of 0.001 |
| **Signal Processing** | Peak hold, averaging |
| **Noise Equivalent Temperature (NET)** | all models 1°C peak to peak, target emissivity of 1.00, unobscured target<br>3°C peak to peak, for all specified attenuation conditions |
| **Peak Hold Range** | 0.1 to 299.9 s (300 s = ∞) |
| **Averaging Range** | 0.1 to 299.9 s (300 s = ∞) |
| **Warm Up Period** | 15 minutes |

Figure 1, Figure 2, and Figure 3 show each sensor model's percentage of allowed signal reduction at all temperatures. Refer to these graphs to estimate what percentage of target area must be visible to the sensor at temperatures below the minimum temperature (95% attenuation) as shown in Table 1.

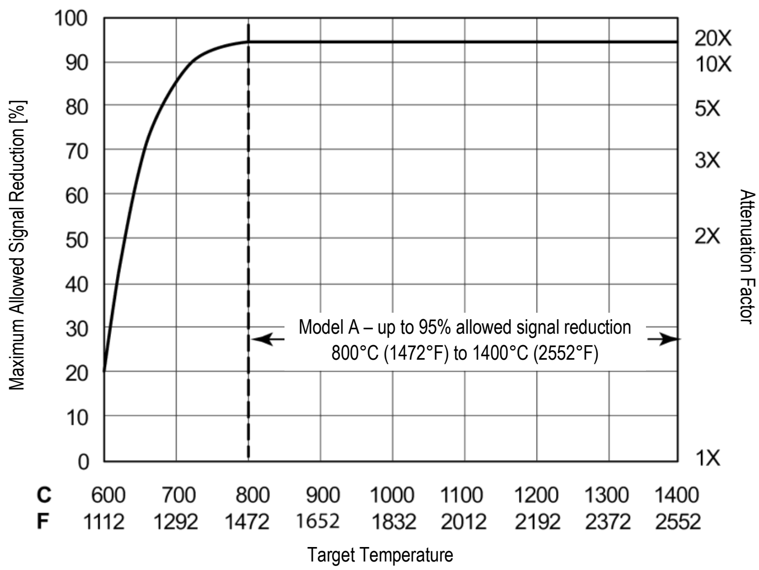


**Figure 1: Model A Percentage of Allowed Signal Reduction**

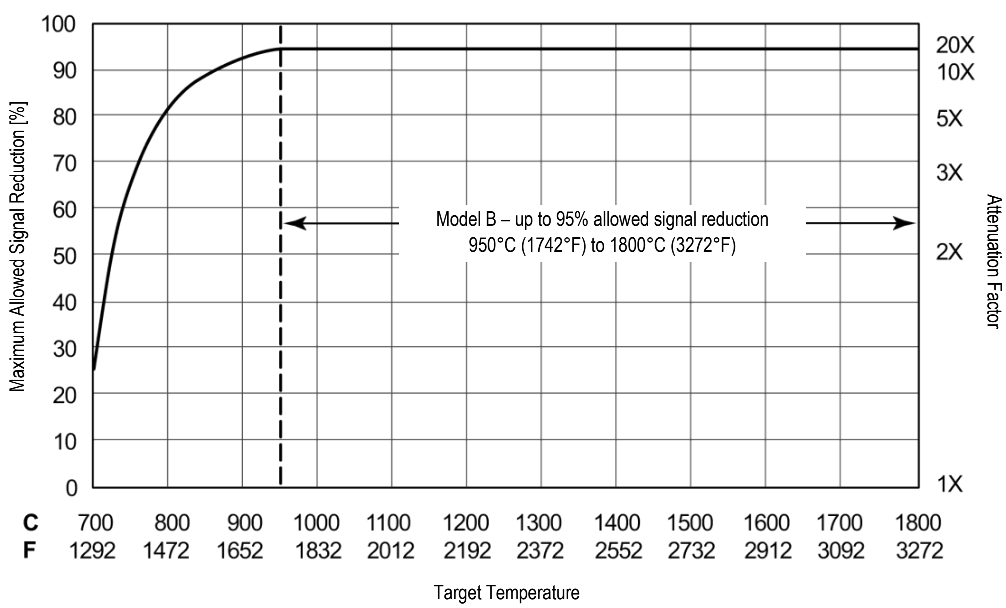


**Figure 2: Model B Percentage of Allowed Signal Reduction**

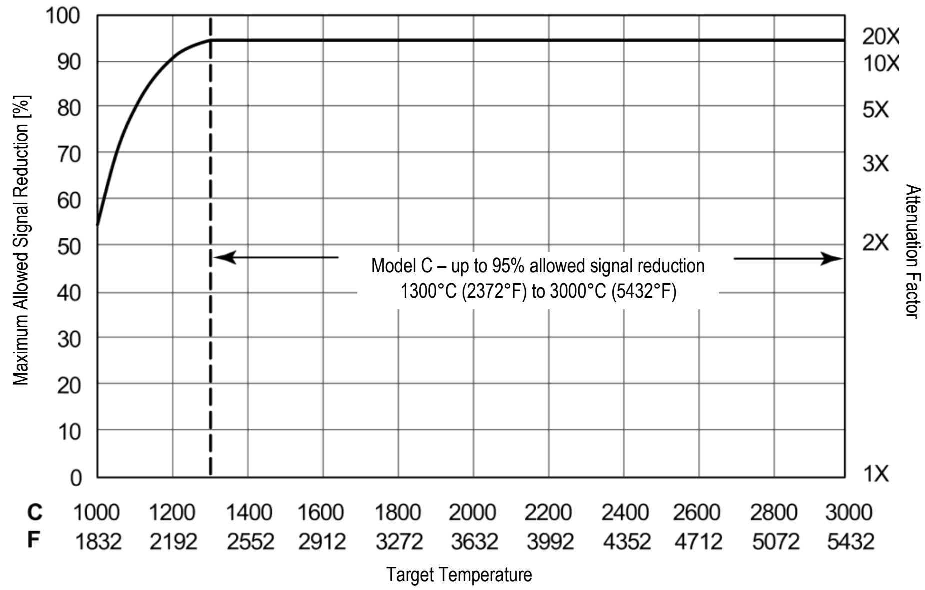


**Figure 3: Model C Percentage of Allowed Signal Reduction**

## 3.2 General Specifications

| | |
|---|---|
| **Display** | 7-segment LED display—shows temperature, slope, emissivity, peak hold seconds, average seconds, and failsafe codes. Individual LED's indicate modes and active functions (e.g., 2C/1C mode, slope, emissivity, peak hold, and average) |
| **Environmental Rating** | IP65 (IEC 529, NEMA-4) |
| **Ambient Temperature** | |
| without cooling | 0 to 50°C (32°F to 122°F) |
| with air cooling | 0 to 120°C (32°F to 250°F) |
| with water cooling | 0 to 175°C (32°F to 350°F) |
| with ThermoJacket | 0 to 315°C (32°F to 600°F) |
| **Storage Temperature** | |
| Electronics Housing | -20 to 70°C (-4°F to 158°F) |
| **Relative Humidity** | 10 to 95%, not condensing at 22°C to 43°C (72°F to 110°F) |
| **Electromagnetic Interference** | CE Emission Standard: EN50081-2<br>CE Immunity Standard: EN50082-2 |
| **Mechanical Shock** | |
| Electronics Housing | MIL-STD-810D (IEC 68-2-27), 50 G, 11 msec duration, 3 axis |
| **Vibrations** | |
| Electronics Housing | MIL-STD-810D (IEC 68-2-6), 3 G, 11 to 200 Hz 3 axis |
| **Thermal Shock** | none |
| **Warm up Period** | 15 minutes |
| **Weight** | |
| sensor | 480 g (17 oz) |

| | |
|---|---|
| with air/water-cooled housing | 800 g (28 oz) |
| **Fail-Safe** | Full or low scale, depending upon system failure, see section 10.2 Fail-Safe Operation, Seite 50. |

## 3.3 Electrical Specifications

| | |
|---|---|
| **Power Supply** | 24 VDC ±20%, 500 mA (max 100 mV peak to peak of ripple) |
| **Power Consumption** | max. 12 W |
| **Outputs** | |
| Analog | 0 - 20 mA, 4 - 20 mA, active output, 16 bit resolution<br>max current loop impedance: 500 Ω |
| Digital RS485 | networkable to 32 sensors<br>Baud rate: 300, 1200, 2400, 9600, 19200, 38400 (default)<br>Data format: 8 bit, no parity, 1 stop bit,<br>Software selectable 4-wire, full-duplex non-multidrop, point-to-point or 2-wire half duplex multidrop |
| Relay Contacts | max. 48 V, 300 mA, response time < 2 ms, (software programmable)<br>Relay Contacts Type: SPDT contact closure |
| **Input** | |
| External Reset | TTL input, trigger for resetting peak hold |

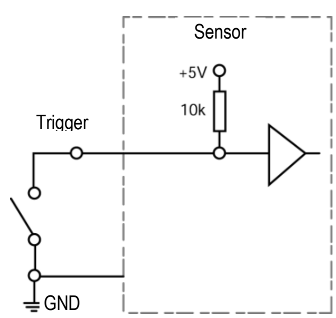


**Figure 4: External Reset Wiring Diagram**

## 3.4 Dimensions

The following illustrations show dimensions of a standard sensor, see Figure 5, a sensor with the air/water-cooled housing option, see Figure 6, and the adjustable bracket.

Dimensions are listed for your installation convenience.

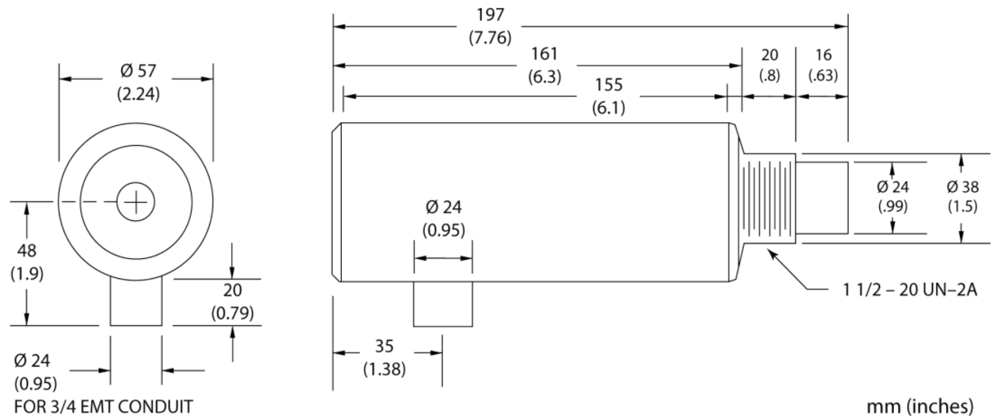


**Figure 5: Dimensions of Sensing Head**

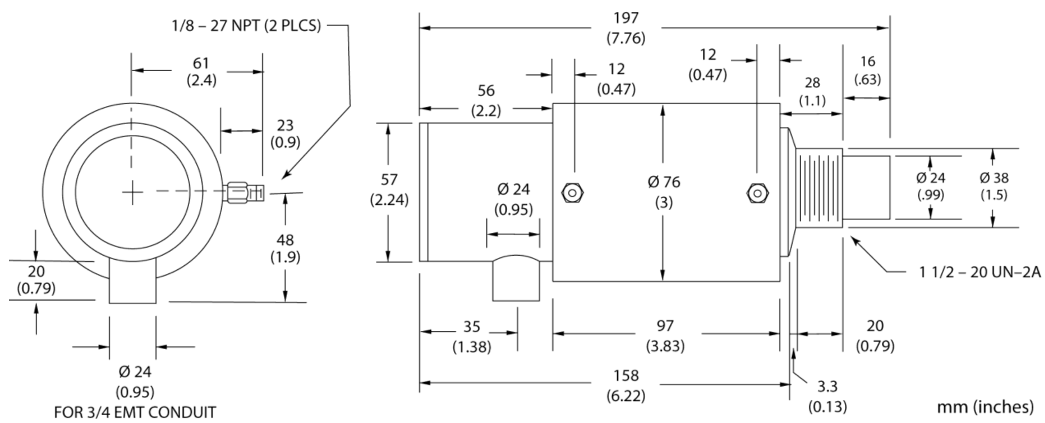


**Figure 6: Sensing Head with Air/Water-Cooled Housing Option**

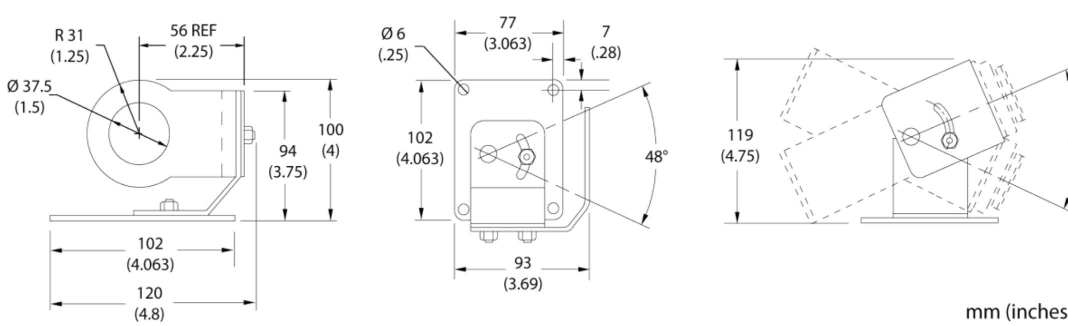


**Figure 7: Adjustable Bracket**

## 3.5 Optical Specifications

**Optical Resolution D:S** (assumes 95% energy at the focus point)

| | |
|---|---|
| MR1SA | 44:1 |
| MR1SB | 82:1 |
| MR1SC | 130:1 |

Because the sensor has variable focus, through-the-lens sighting, and parallax-free optics, it can be mounted almost anywhere. SF (Standard Focus) models can be focused from 600 mm (24 in) to infinity, and CF (Close Focus) models can be focused from 300 mm (12 in) to 600 mm (24 in). For 1-color temperature measurements make sure the target completely fills the measurement spot. The spot size for any distance, when the unit is properly focused, can be figured by using the following formula and Figure 8.

Divide the distance (D, in Figure 8) by your model's D:S number. For example, if a model C unit (D:S = 130:1) is 2000 millimeters (80 inches) from the target, divide 2000 by 130 (80 by 130), which gives you a target spot size of 15 mm (0.6 in). A model A unit (D:S = 44:1) at 2000 mm (80 in) would measure a target spot of 45 mm (1.8 in). Divide 2000 by 44 (80 by 44).

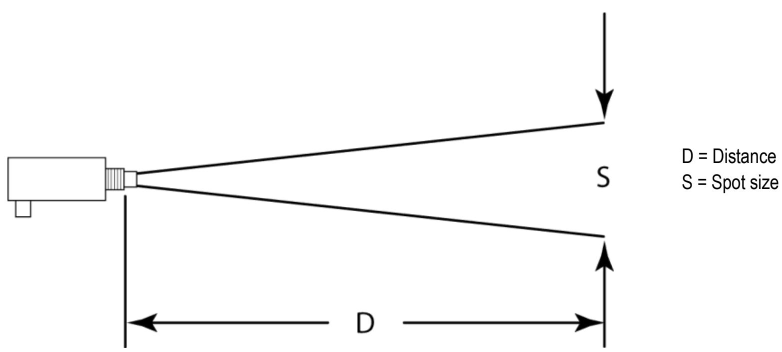


**Figure 8: Spot Size Chart**

**D:S is a ratio and applies to either metric or non-metric measurements!**

## 3.6 Scope of Delivery

The scope of delivery includes the following:

- Marathon MR Documentation and Support CD
- Adjustable mounting bracket (XXXTXXACAB) with mounting nut
- End cap for display

**The cable with the terminal block needs to be ordered separately!**

# 4 Environment

Sensor location and configuration 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 (especially for 1-color temperature measurements), and the possible electromagnetic interference in that location. If you plan to use air purging, you need to have an air connection available. Also, wiring and conduit runs must be considered, including computer wiring and connections, if used. The following subsections cover topics to consider before you install the sensor.

## 4.1 Ambient Temperature

The sensing head is designed to operate in ambient temperatures between 0°C (32°F) and 50°C (122°F). The internal ambient temperature can vary from 10°C (50°F) to 68°C (154°F). Internal temperatures outside this range will cause a failsafe error. In ambient conditions above 50°C (122°F), an optional air/water-cooled housing is available to extend the operating range to 120°C (250°F) with air cooling, or 175°C (350°F) with water cooling. When using the water cooled housing, it is strongly recommended to also use the air purge collar to avoid condensation on the lens. In ambient conditions up to 315°C (600°F), the ThermoJacket accessory should be used.

When using air or water cooling and air purging, make sure air and water supplies are installed before proceeding with the sensor installation.

Water and air temperatures for cooling should be 15-30°C (60-86°F) for best performance. Chilled water or air below 10°C (50°F) is not recommended. For air purging or air cooling, clean (filtered) or "instrument" air is recommended.

## 4.2 Atmospheric Quality

Smoke, fumes, dust, and other contaminants in the air, as well as a dirty lens are generally not a problem when using the 2-color mode (as long as the attenuation is equal in both spectral bands). However, 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 an air supply with the correct air pressure is installed before proceeding with the sensor installation.

## 4.3 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.

# 5 Installation

## 5.1 Mechanical Installation

After all preparations are complete, you can install the sensor.

How you anchor the sensor depends on the type of surface and the type of bracket you are using. As noted before, all sensors, whether standard or with the air/water-cooled housing option, are supplied with an adjustable bracket and mounting nut. You can also mount the sensor through a hole, on a bracket of your own design, or on one of the other available mounting accessories, see section 8 Accessories, Seite 39. If you are installing the sensor in a ThermoJacket accessory, you should use the appropriate mounting device. (Refer to the ThermoJacket manual for further details.) If you do not have the focusing tool accessory, the sensor must be focused before mounting inside a ThermoJacket or before attaching an air purge collar.

### 5.1.1 Distance to Object

The Standard Focus sensor can be focused from 600 mm (24 in) to infinity, and the Close Focus sensor can be focused from 300 mm (12 in) to 600 mm (24 in), so sensor placement can be varied to suit the application. The following sections show sensor placement and the various conditions where 2-color temperature measurements can be taken.

**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.**

### 5.1.2 Sensor Placement (1-Color Mode)

Sensor placement for one-color temperature measurements is more critical than two-color measurements. The sensor must have a clear view of the target. There can be no obstructions on the lens, window, or in the atmosphere. The distance from the target can be anywhere beyond the minimum requirements, as long as the target completely fills the field of view. The following figure illustrates proper placement when using the one-color mode.

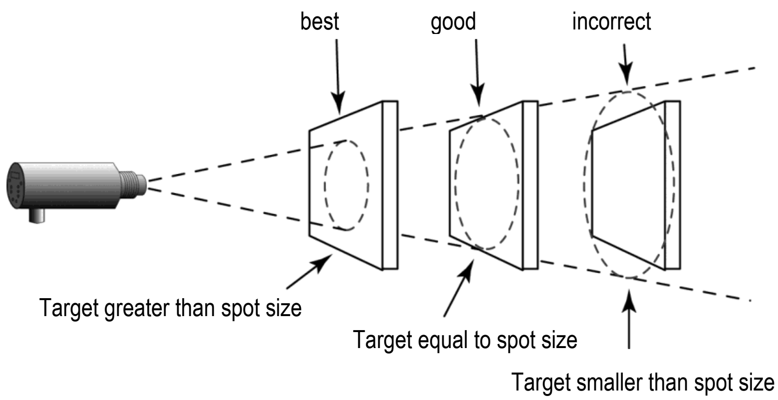


**Figure 9: Proper Sensor Placement in 1-Color Mode**

### 5.1.3 Sensor Placement (2-Color Mode)

The following figure shows head placement under various conditions where two-color temperature measurements can be taken. Note, however, that if the sensor signal is reduced more than 95% (including emissivity and obscuration of the target), the sensor accuracy also degrades.

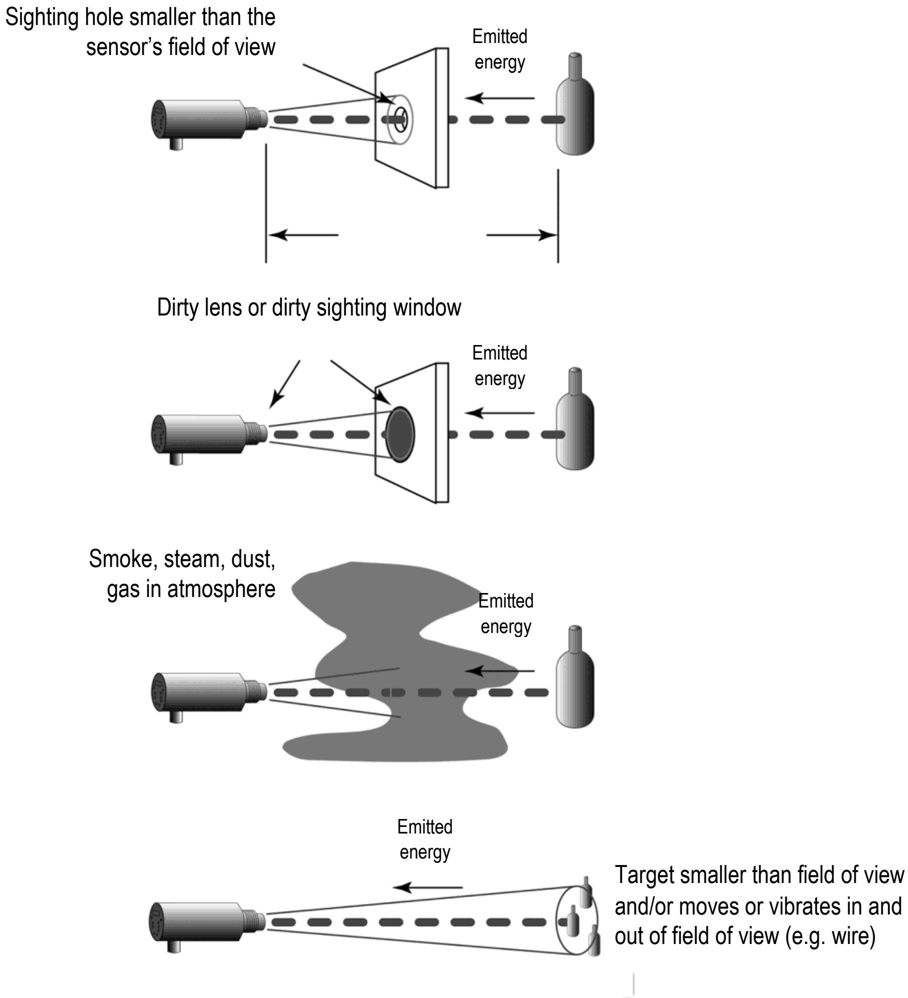


**Figure 10: Sensor Placement in 2-Color Mode**

### 5.1.4 Viewing Angles

The sensor can be placed at any angle from the target up to 30° for one-color mode, or 45° for two-color mode.

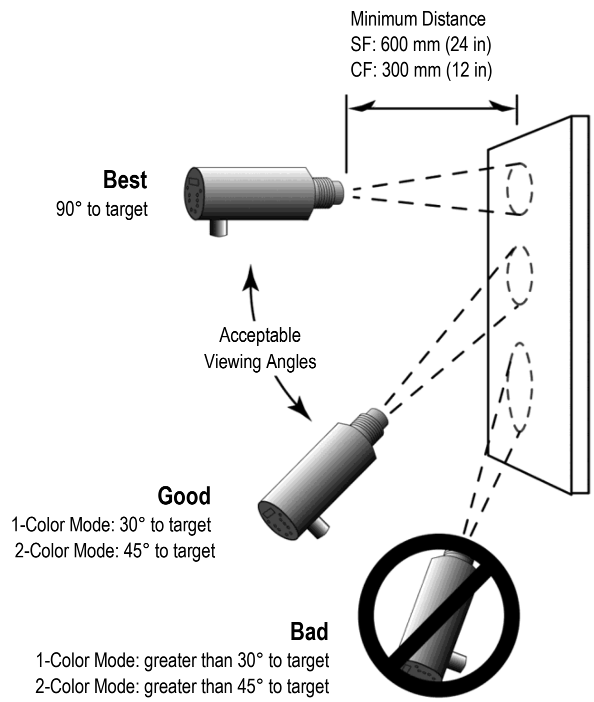


**Figure 11: Acceptable Sensor Viewing Angles**

### 5.1.5 Aiming and Focusing

Once you have the sensor in place, you need to aim and focus it on the target. To aim and focus the sensor, complete the following:

1. Loosen the nuts or bolts of the mounting base. (This can be either a factory-supplied accessory or customer-supplied base.)
2. Look through the eyepiece and position the sensor so the target is centered as much as possible in the middle of the reticle, see Figure 12. (Note that the target appears upside down.)
3. Turn the lens holder clockwise or counter-clockwise until the target is in focus. You can tell the lens is focused correctly by moving your eye from side to side while looking through the eyepiece. The target should not move with respect to the reticle. If it does, keep adjusting the focus until no apparent motion is observed.
4. Check once more to make sure the target is still centered, and secure the mounting base. Focusing is complete.

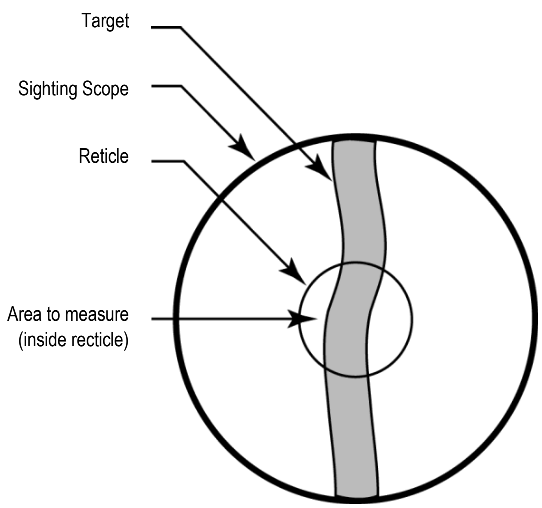


**Figure 12: Sensor Eyepiece and Reticle**

## 5.2 Electrical Installation

### 5.2.1 DIN Connector Wiring

If you need to wire a new DIN connector or rewire the supplied connector, refer to the following illustration and table for the wiring layout.

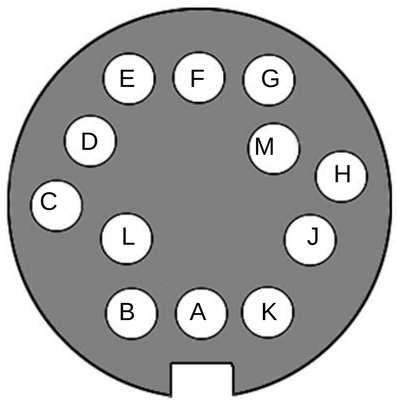


**Figure 13: DIN Connector Pin Layout (Pin Side)**

| Pin | Color | Description |
|---|---|---|
| A | Black* | Rx A |
| B | White* | Rx B |
| C | Grey* | Tx B |
| D | Purple* | Tx A |
| E | White/Drain | Shield |
| F | Yellow | Trigger |
| G | Orange | Relay COM |
| H | Blue | Relay NO/NC |
| J | Green | + mA Out |
| K | Brown | – mA Out |
| L | Black | Power Ground |
| M | Red | + 24 VDC |

Note: Twisted Pairs – Black & White
– Grey & Purple

**Figure 14: DIN Connector Wiring**

### 5.2.2 Cables and Terminal Block

Sensor cables can be ordered in several lengths. They come with a 12-pin DIN plug on one end and bare wires on the other. An external terminal block is included with each sensor cable and is labeled as shown in Figure 15.

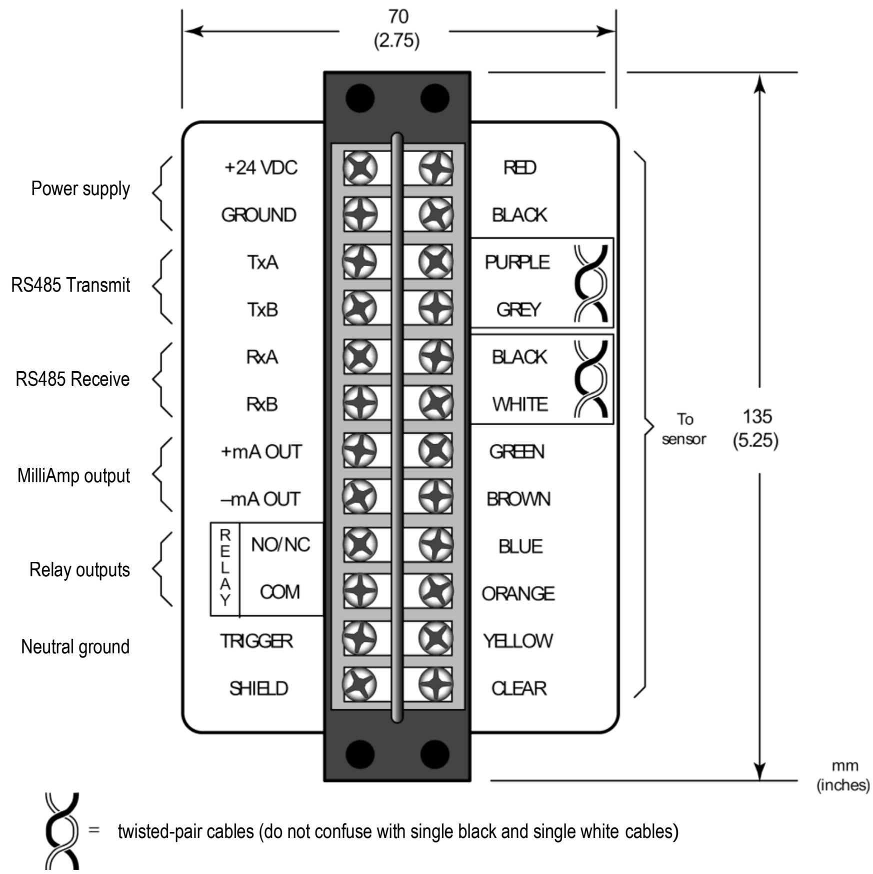


**Figure 15: Terminal Block**

**The terminal block is susceptible to electrostatic discharge. You should mount it in a protective case.**

To connect the bare wires to the terminal block, attach the sensor cable wires to the color coded side of the terminal block. Match the wire's colors to the appropriately labeled terminals. If necessary, use Figure 15 as a guide. The connections on the opposite side of the terminal are discussed in the following subsections. **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. (Only necessary if you cut the cable.)**

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

**When using conduit for the cable, and when it has a compression fitting installed on the conduit connection, the sensor head is rated NEMA-4 (IEC 529, IP65).**

**The sensor cable may be shortened but not lengthened without the appropriate terminal block accessory. Longer cables are available from the factory. Limit power cables to 60 m (200 ft) or less. RS485 cables can be extended up to 1200 m (4000 ft).**

**Avoid installing the sensor cable in noisy electrical environments such as around electrical motors, switch gear, or induction heaters.**

### 5.2.3 Power Supply

Connections from a 24 VDC (500 mA or higher) power supply attach to the appropriate terminals on the electronic enclosure's terminal strip.

**Isolated power is required, and this is provided by the appropriate manufacturer supplied power supply accessory. Beware of use of other power supplies which may not provide the necessary isolation and could cause instrument malfunction or damage!**

### 5.2.4 PC Connection via USB/RS485 Converter

To connect to a computer's USB port, you need one of the USB/RS485 Converter accessories (similar to the following figure) and the proper USB cable.
The distance between the sensor and a computer can be up to 1200 m (4000 ft.) via RS485 interface. This allows ample distance from the harsh environment where the sensing system is mounted to a control room or pulpit where the computer is located. The USB/RS485 converter is self-powering via the USB connection.

**Figure 16: USB/RS485 Converter (XXXUSB485)**

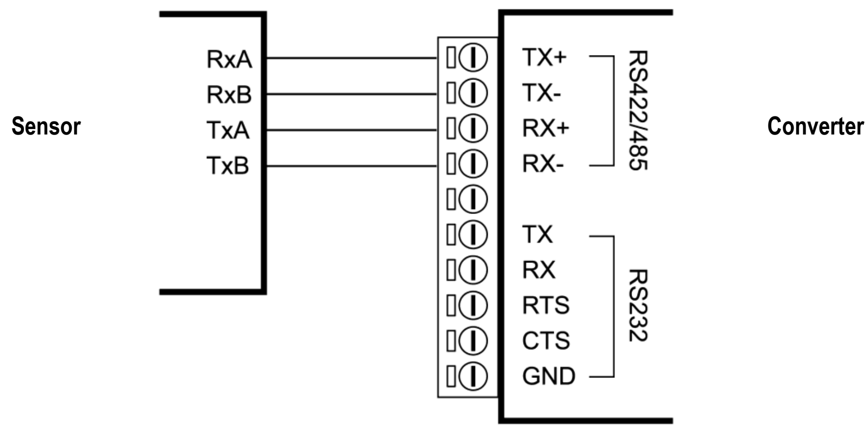


**Figure 17: Wiring the Sensor's RS485 Interface (left) with USB/RS485 Converter (right)**

### 5.2.5 PC Connection via RS232/485 Converter

To connect to a computer's RS232 port, you need one of the Interface Converter accessories (see table below) 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 electronic enclosure's terminal block.

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

| Order number | Model |
|---|---|
| XXX485CVT | 25 pin to terminal strip interface converter, recommended for direct wiring between a serial interface and the terminal block |
| XXX485CVT1 | XXX485CVT with 110 VAC power adapter |
| XXX485CVT2 | XXX485CVT with 230 VAC power adapter |
| XXX485CV | 25 pin to 25 pin interface converter |
| XXX485CV1 | XXX485CV with 110 VAC power adapter |
| XXX485CV2 | XXX485CV with 230 VAC power adapter |

**Table 2: Available RS232/485 Interface Converters**

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 supplied 25-pin to 9-pin cable between the interface converter or cable and the computer.

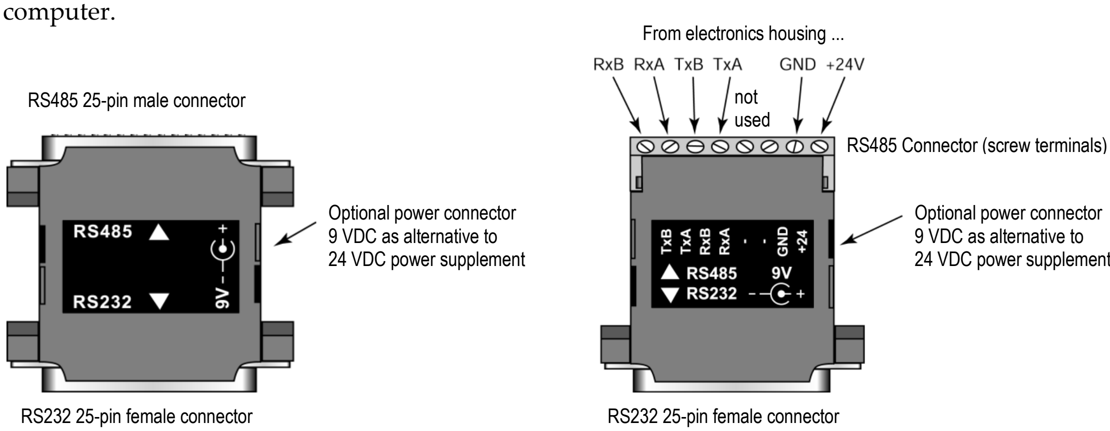


**Figure 18: RS232/485 Interface Converter, with pins (left, XXX485CV…) or terminal (right, XXX485CVT…)**

The RS485 output is as follows:

Baud rate: 300, 1200, 2400, 9600, 19200, 38400 (default)
Data format: 8 bit, no parity, 1 stop bit
4-wire, full duplex, point-to-point

**Adjustable baud rate only available through 2-way RS485.**

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

1. Remove power from the MR sensor!
2. Install all electronics wiring!
3. Plug the RS232/485 interface converter into your computer's serial port, or attach it to a serial cable connected to the computer! Use 9 pin to 25 pin converter if necessary!
4. If the 9 VDC power supply is used, apply power to the RS232/485 converter!
5. Apply power to the MR sensor!
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!**

**Always make all electrical connections before applying power to the MR sensor! Do not change RS485 or power connections on the RS232/485 converter while the MR sensor has power applied, as this may cause damage to the Interface converter!**

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 11.4 2-Wire Communication, Seite 57).
For an installation of two or more sensors in a network, each sensor cable is wired to its own terminal block. The RS485 terminal lines on each terminal block are wired in parallel.

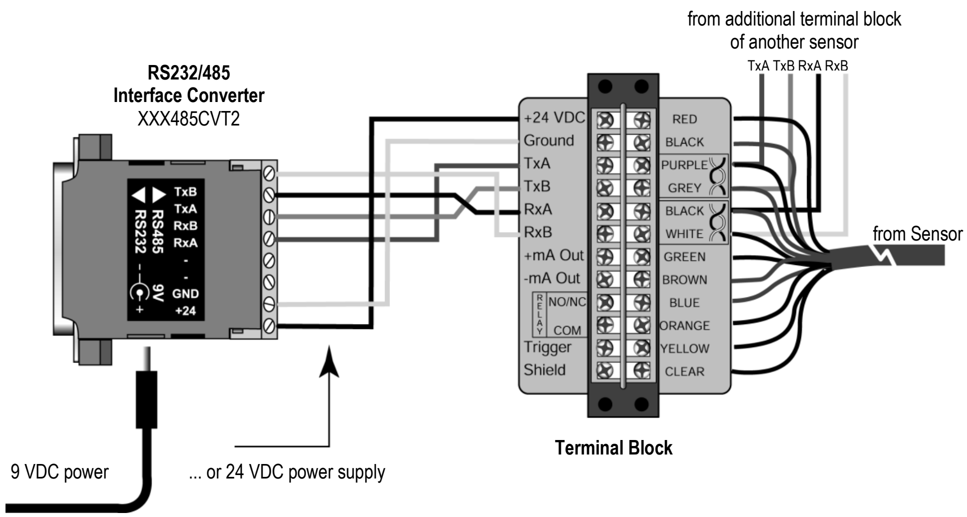


**Figure 19: 4-Wire Multidrop Wiring in a Network**

### 5.2.6 Addressing

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.

The addressing of a sensor can be done by means of 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 9.5 Command List, page 47.

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

- Attach each sensor individually in 4-wire mode to the computer.
- Start the DataTemp Multidrop software.
- 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 MR unit connected to the computer serial port.
- Once DataTemp Multidrop is running, go to the <Setup> menu and select <Sensor Setup>.
- 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.
- 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.
- 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.

# 6 Operation

Once you have your sensor(s) positioned and connected properly, the system is ready for continuous operation. Operation is accomplished either through the back panel or through controlling software. A setup and configuration program is supplied with your sensor. You can also create custom programs using the communications protocols listed in Section 9 Programming Guide on page 44.

## 6.1 Control Panel

The sensor is equipped with a control panel, which has setting/controlling buttons and an LED display. The panel is used primarily for setting up the instrument and is covered over during normal use.

The control panel is protected by the supplied end cap. The sighting hole in the end cap is threaded to accept the polarizing filter accessory (used for sighting/focusing on very bright targets). An end cap with a larger window, which allows all control panel LED's to be visible, is available as an option. (You cannot use the polarizing filter with this option.)

You can configure sensor settings with the control panel or with a computer. The panel is used primarily for setting up the instrument. The buttons and LED's are defined in the following sections.

**Allow the electronics to warm up for 15 minutes before making control panel adjustments!**

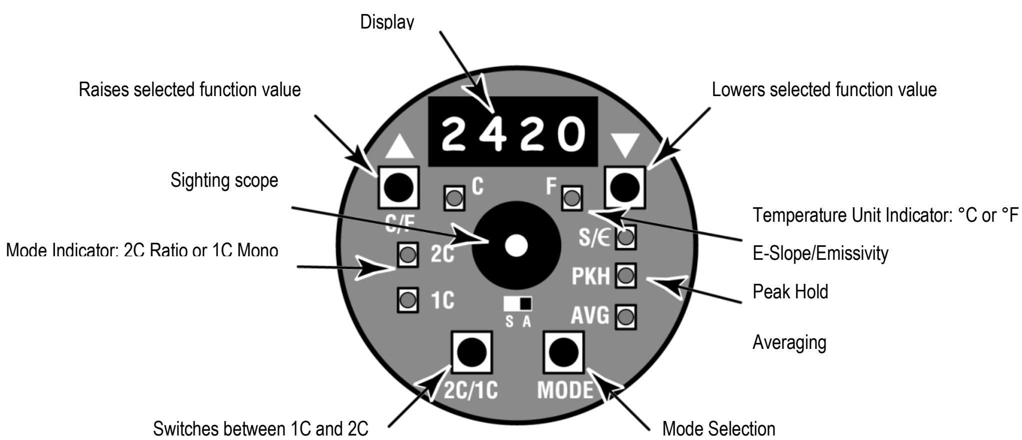


**Figure 20: Control Panel**

The sensor has a remote locking 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 switches on the control panel. It is available through the RS485 connection and can be unlocked only by a command from the remote computer.

On the sensor's back panel is a switch that is labeled "S" and "A." Make sure the switch is always in the "A" position, the "S" position is for servicing only.

## 6.2 Operation Modes

When you first turn the unit on, the display shows the current temperature. Pushing the mode selector button will change the figures on the display to the current setting for each particular mode. Figure 21 illustrates the sequence of operation for the mode selector button when in current temperature mode.

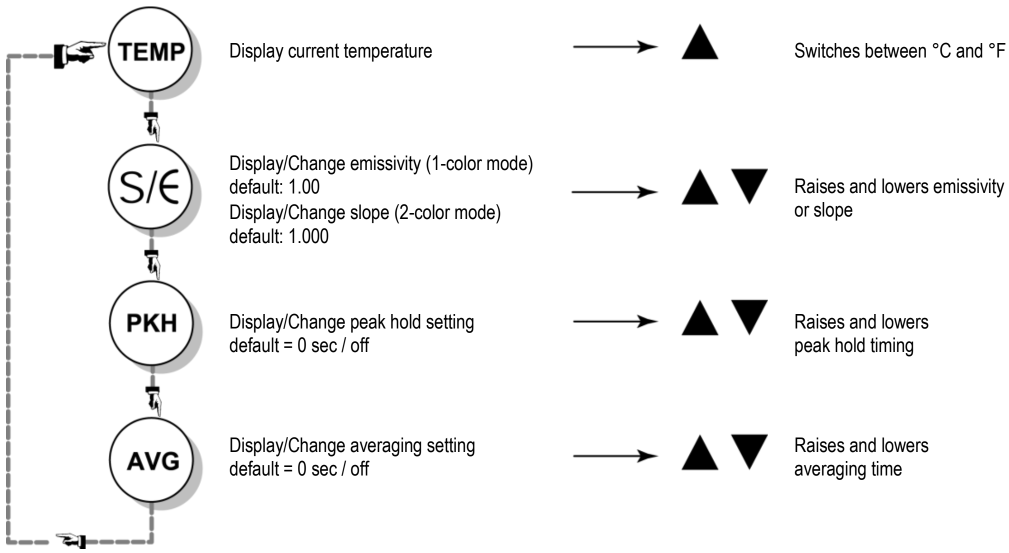


**Figure 21: Mode Selector Button Sequence**

### 6.2.1 Temperature Display

The temperature display can be set for either °C or °F by pressing the C/F selector button (▲ – up arrow), which also doubles as the Increase Value button for the other modes. The Decrease Value (▼ – down arrow) button is inactive in this mode. A lit LED shows you whether the measured temperature is in °C or °F. Note that this setting influences the RS485 output for both target and internal temperatures.

### 6.2.2 Emissivity (1-Color)

You can set the unit up for either 1-color or 2-color measurements. The **1C/2C** selector button on the control panel switches between the two functions. One of the red LEDs, labeled 1C and 2C, will show what function is active.
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). The emissivity is preset at 1.00. For information on determining an unknown emissivity, and for sample emissivities, refer to section 11.1 Determination of Emissivity and 11.2 Typical Emissivity Values, p. 54f.

To change the unit's emissivity setting, complete the following:

1. Make sure the **1C** LED is lit.
2. Press the Mode button until the **Є** LED is lit. The current emissivity value shows on the display.
3. Press the ▲ or ▼ button to change the value.
4. Press the Mode button several times until the **C** or **F** LED is lit. The displayed temperature will now be based on the new emissivity value.

### 6.2.3 Slope (2-Color)

The slope is the quotient of the emissivities based on the narrow and the wide spectral range (first and second wavelength). The slope is preset at the factory at 1.000.

**The slope is the deciding parameter for measurements in 2-color mode! The emissivity affects only measurements in 1-color mode.**

For information on determining an unknown slope, and for sample slopes, refer to section 11.3 Typical Slopes, p. 56.

To change the unit's slope setting, complete the following:

1. Make sure the **2C** LED is lit.
2. Press the Mode button until the **Є** LED is lit. The current slope value shows on the display.
3. Press the ▲ or ▼ button to change the value.
4. Press the Mode button several times until the **C** or **F** LED is lit. The displayed temperature will now be based on the new slope value.

### 6.2.4 2C/1C Switch

To switch between 2-color and 1-color temperature measurement push the 2C/1C selector button. A lit LED indicates the active measurement method. Switching affects the LED display and analog out but not the RS485 out.

#### 6.2.4.1 Peak Hold (PKH)

With Peak Hold, the respective last peak value is held for the duration of Hold Time.
To set and activate Peak Hold, do the following:

1. Press the Mode button until the **PKH** LED is lit.
2. Press the▲ button to both set and activate. The display reads in 0.1 seconds. Set Peak Hold from 0.1 to 299.9 seconds. If Peak Hold is set to 300.0 seconds, a hardware reset is needed to trigger another reading. If Peak Hold is set to 0.0 seconds, the function is deactivated.
3. Press the Mode button until the **C** or **F** LED is lit. If Peak Hold has been activated, the Peak LED will stay lit.

Once Peak Hold is set above 0, it automatically activates. The output signal remains the same until one of two things happens:

- The peak hold time runs out. In this case, the signal reverts to actual temperature.
- The actual temperature goes above the hold temperature. In this case, starts holding new peak.

Note that other hold functions (like Averaging) cannot be used concurrently. By means of the software other hold functions are adjustable (e.g. Advanced Peak Hold).

#### 6.2.4.2 Averaging (AVG)

Averaging can be useful when an average temperature over a specific duration is desired, or when a smoothing of fluctuating temperatures is required.

The averaging algorithm simulates a first order low pass RC filter whose time constant can be adjusted to match the user's averaging needs. The following figure illustrates an averaging output signal.

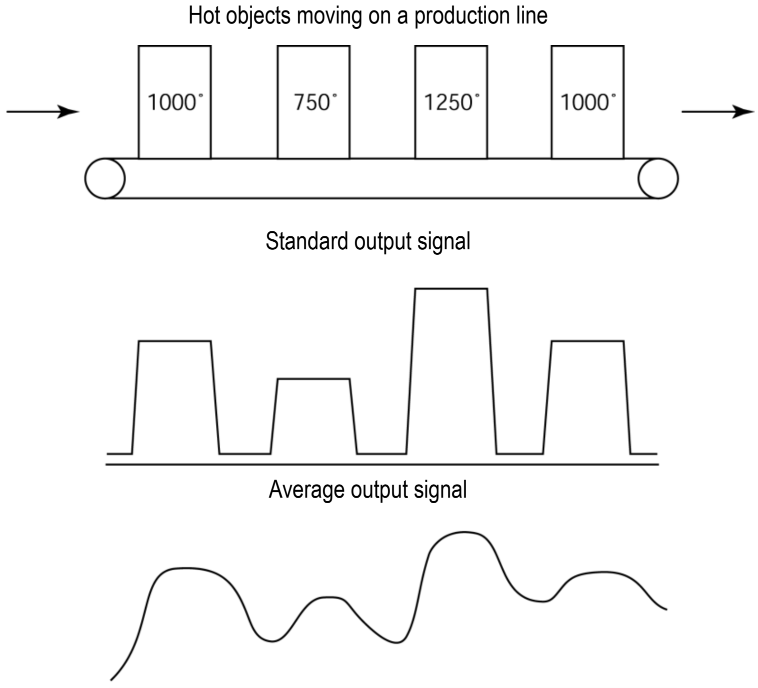


**Figure 22: Averaging Example**

To set and activate Averaging, do the following:

1. Press the Mode button until the **AVG** LED is lit.
2. Press the ▲ button to both set and activate. The display reads in 0.1 seconds. Set Average anywhere from 0.1 to 300.0 seconds. If Average is set to 0.0 seconds, the function is deactivated.
3. Press the Mode button until the **C** or **F** LED is lit. If Average has been activated, the **AVG** LED will stay lit.

Once Averaging is set above 0, it automatically activates. Note that other hold functions (like Peak Hold) cannot be used concurrently.

### 6.2.5 Overview to Hold Functions

The following table lists the various 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.

| Hold Function | RESET by | Peak Time | Valley Time | Threshold | Hysteresis | 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 | -* | 0001-9999 |
| Advanced Peak Hold | trigger or threshold | 300.0 | 000.0 | 0250-3000 | -* | 0000 |
| Advanced Peak Hold | timer or threshold | 000.1-299.9 | 000.0 | 0250-3000 | -* | 0000 |
| Advanced Peak Hold with decay | timer or threshold | 000.1-299.9 | 000.0 | 0250-3000 | -* | 0001-9999 |

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

**Table 3: Hold Functions**

### 6.2.6 Setpoints

The two Setpoints are deactivated by default (alarm mode). Activating and adjusting the Setpoints is accomplished through software. Once one or both Setpoints are activated the relay changes state as the current temperature passes the setpoint temperature.

### 6.2.7 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° C or F of Setpoint value. Adjusting to other values is accomplished through software. For information on the sensor's communication protocols, see Section 9 Programming Guide Seite 44. The following figure is an example of the Deadband around a Setpoint temperature of 960°C (1760°F).

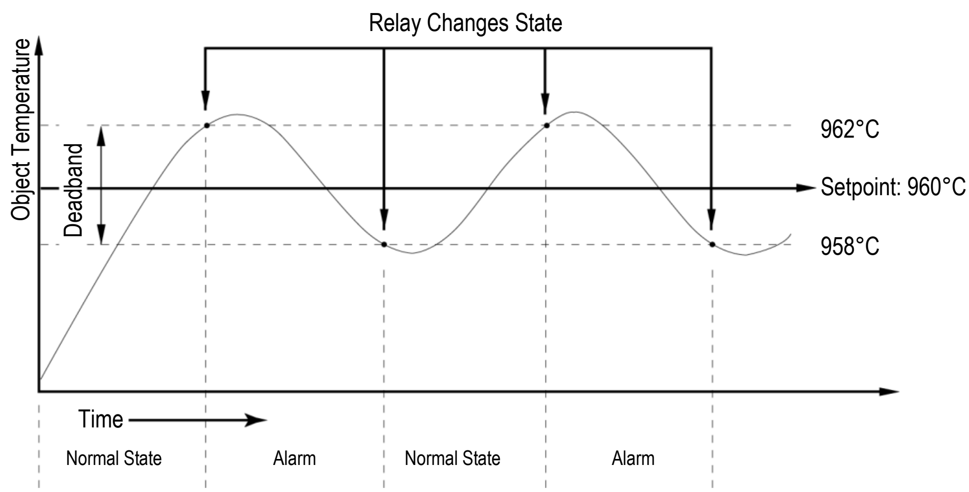


**Figure 23: Deadband Example**

## 6.3 Inputs and Outputs

### 6.3.1 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 analog output resolution for all models is 0.5°C or 1°F. The mA output can be forced to a specific value, underrange, or overrange with a RS485 command. This feature is useful for testing or calibrating connected equipment.

### 6.3.2 Relay Outputs

The relay output is used as an alarm for failsafe conditions or as a setpoint relay, refer to Section 10.2 Fail-Safe Operation, on page. 50. Relay outputs relate to the currently displayed temperature on the LED display. The relay output can be used to indicate an alarm state or to control external actions. The relay can be set to either NO (Normally Open) or NC (Normally Closed) with a 2- way RS485 command (depending on the compatibility requirements of connected equipment). The relay can be forced on or off via the 2-way for testing connected equipment.

### 6.3.3 Trigger

Peak Hold can be Reset by shorting the Trigger input (labeled TRIG) to Ground (labeled GND) for a minimum of 10 msec. This can be done either with a momentary switch or a relay. Peak Hold has to be set to 300.0 seconds to recognize this Reset. The Reset signal will cause the peak reading that the sensor is holding to change immediately to the current target temperature.

## 6.4 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 baud rate will not change from the last value when this is done.

| Parameter | As shipped from Factory (Defaults) |
|---|---|
| Display mode | 2-color mode, degrees C, TEMP display |
| Emissivity | 1.00 |
| PKH | 0.0 |
| AVG | 0.0 |
| Baud rate | 38400 baud * |
| Temperature Setting for 4 mA | Low end of sensor temperature range ** |
| Temperature Setting for 20 mA | High end of sensor temperature range ** |
| Serial Output Transmission Mode | Burst mode, Default string = UTSI |
| Relay Output Control | Controlled by unit, NO function (indicates failsafe alarms) |
| Set Output Current | Controlled by unit, 4-20 mA |
| Lockout Switch Panel Access | Unlocked |
| Communications Mode | Standalone *** |
| RS485 Mode | 4-wire *** |

* Note that the default values can be loaded into the sensor by pressing the ▲ (up) and ▼ (down) buttons together for about 2 seconds or by 2-way instructions. The baud rate will not change from the last value when this is done. Factory defaults can be installed with a RS485 command (#XF).

** These parameters can be adjusted both by a RS485 command, which allows you to scale the high and low temperature points to suit your application.

*** Communications Mode and RS485 Mode, like Baud Rate, are unchanged when the factory defaults are restored

**Table 4: Factory Defaults**

# 7 Options

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

- ISO Calibration Certificate, based on NIST/DKD certified probes (XXXMRCERT)
- Water-Cooled Housing, incl. Air Purge Collar (…W)

## 7.1 Water Cooled Housing including Air Purge Collar

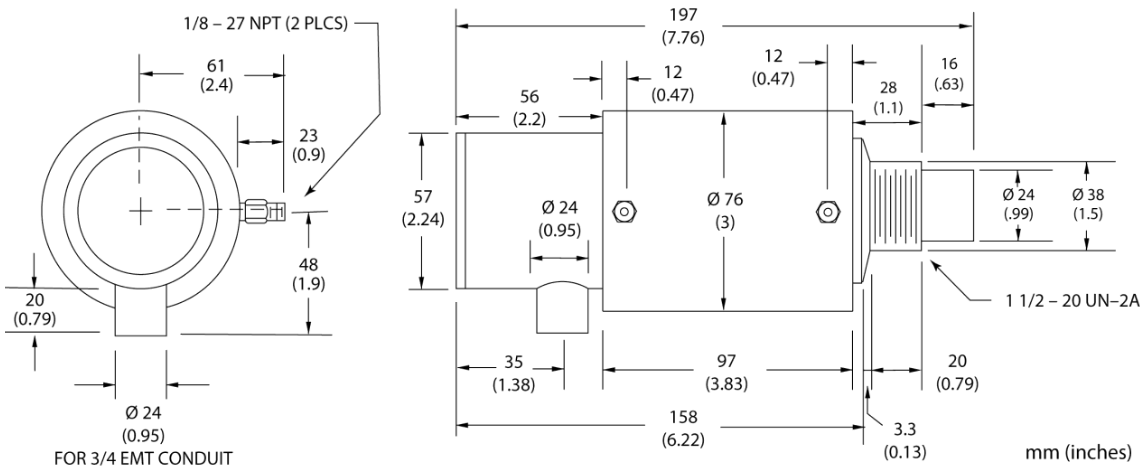


**Figure 24: Sensing Head with Air/Water-Cooled Housing Option**

# 8 Accessories

## 8.1 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. These include the following:

- Fixed Mounting Bracket (XXXTXXACFB)
- Air Purge Collar (XXXTXXACAP)
- Polarizing Filter End Cup (XXXTPFEC)
- Industrial Power Supply (XXXSYSPS)
- USB/RS485 Converter (XXXUSB485), see section 5.2.4, page 26
- RS232/485 Interface Converter (XXX485CV…), see section 5.2.5, page 27
- Cables in the following lengths: 4, 8, 15, 30, or 60 m (13, 26, 50, 100, or 200 ft.) (XXX2CCB…)
- Replacement Window (XXX2CPW)
- ThermoJacket enclosure for ambient temperatures to 315°C (599°F) (RAYTXXTJ1M), see also ThermoJacket documentation

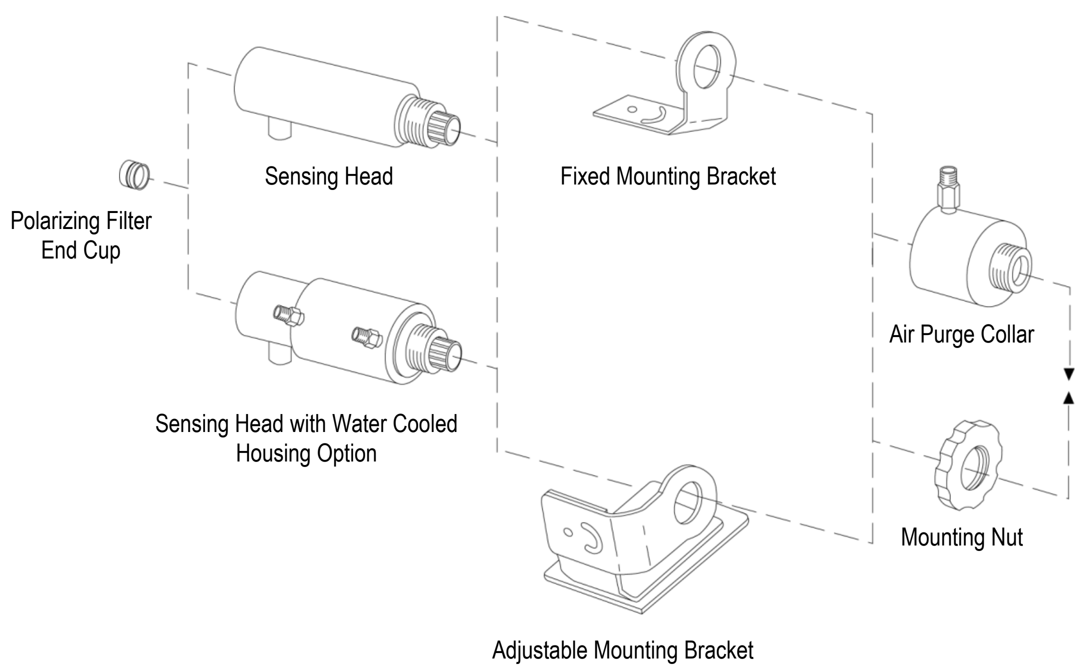


**Figure 25: Sensing Head with Air/Water-Cooled Housing Option**

## 8.2 Fixed Mounting Bracket

The Fixed Mounting Bracket accessory can be used if the sensor will always remain in a fixed location.

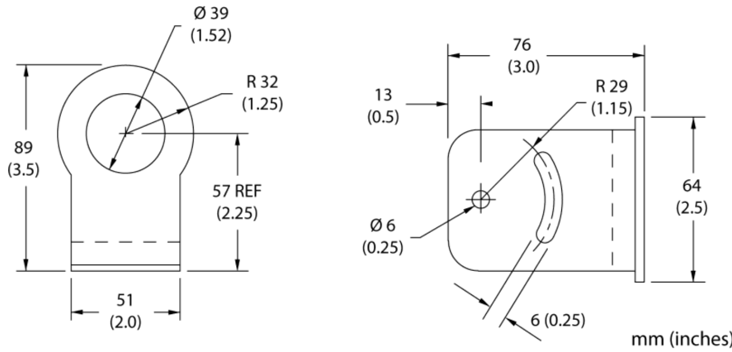


**Figure 26: Fixed Mounting Bracket**

## 8.3 Air Purge Collar

The Air Purge Collar accessory is used to keep dust, moisture, airborne particles, and vapors away from the 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 to 1.5 liters/sec or 0.13 to 0.4 gallon/sec). **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).

**Focus the instrument before attaching the air purge collar.**

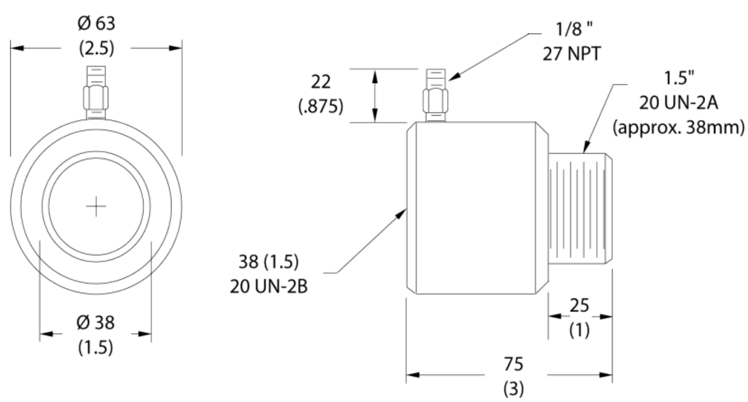


**Figure 27:Air Purge Collar**

## 8.4 Polarizing Filter End Cup

The Polarizing Filter can be screwed into the viewing port to provide eye protection when sighting on bright, high temperature targets. The filter does not affect measured energy. It is solely for viewing comfort. Rotate the outer portion of the filter until you achieve the desired visual attenuation.

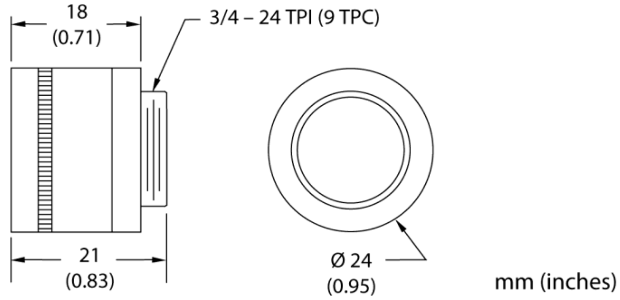


**Figure 28 Polarizing Filter**

**Polarizing filter will not fit in glass window end cap. Do not look through the lens at extremely bright objects with your eyes unprotected. Eye damage could occur.**

## 8.5 Cables

The cable comes with terminal block. The cable is 2 twisted pairs and 8 separate wires. The overall shield is aluminized mylar and 85% braided tinned copper. The following are descriptions of the 12 wires:

- Power—2 wires (Black/Red)
  Conductor: AWG 22/7x30 tinned copper
  Insulation: FEP .006" wall
  Shield: None

- RS485—2 twisted pairs (Black/White and Purple/Gray)
  Conductor: AWG 24/7x32 tinned copper
  Insulation: FEP .006" wall
  Shield: Aluminized mylar with drain wire

- Outputs and Ground—6 wires (Green/Brown/Blue/Orange/Yellow/Clear)
  Conductor: AWG 24/7x32 tinned copper
  Insulation: FEP .006" wall
  Shield: None

Cable Diameter: 7 mm (0.256 in) nominal

Temperature: UL rated at –80°C to 200°C (-112°F to 390°F)

High 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.

**If you purchase your own RS485 cable, use wire with the same specifications as those listed above. Maximum RS485 cable length is 1200 meters (4000 feet).**

**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. (Only necessary if you cut the cable.) Refer to Section 2.3 for terminal block wiring diagram.**

## 8.6 Industrial Power Supply

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

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

**Technical data:**

| | |
|---|---|
| Protection class | class II as per IEC/EN 61140 |
| Environmental protection | IP20 |
| Operating temperature range | -25°C to 70°C (-13°F to 158°F) |
| AC Input | 100 – 240 VAC 50/60 Hz [L/N] |
| wire size | 0.5 to 2 mm² (AWG 24 to 12) |
| DC Output | 24 VDC / 1.25 A [+/–] |
| wire size | 0.5 to 2 mm² (AWG 24 to 12) |

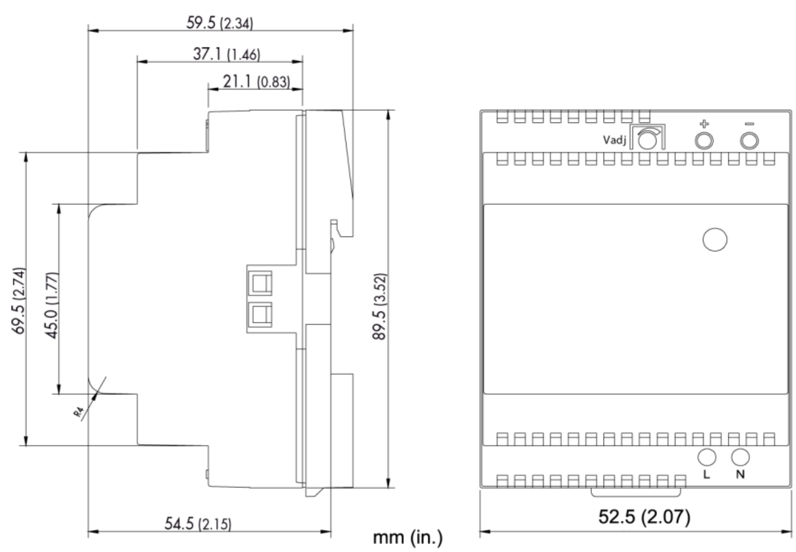


**Figure 29: Dimension of Industrial Power Supply**

# 9 Programming Guide

This section explains the sensor's communication protocol. Use them when writing custom programs for your applications or when communicating with your sensor with a terminal program.

## 9.1 Remote versus Manual Considerations

Since the sensor includes a local user interface, the possibility exists for a person to make manual changes to parameter settings. To resolve conflicts between inputs to the sensor, it observes the following rules:

- Command precedence: the most recent parameter change is valid, whether originating from manual or remote.
- If a manual parameter change is made, the sensor will transmit a "notification" string to the host. (Notification strings are suppressed in multidrop mode.)
- A manual lockout command is available in the protocols set so the host can render the user interface "display only," if desired.

All parameters set via the 2-way interface are retained in the sensor's nonvolatile memory.

**When a unit is placed in multidrop mode its manual user interface is automatically locked! It can be unlocked with the command XXXJ=U <CR>, where XXX is the multidrop address.**

## 9.2 Command Structure

Protocols are the set of commands that define all possible communications with the sensor. The commands are described in the following sections along with their associated ASCII command characters and related message format information. Types of commands include the following:

1. A request for the current value of a parameter
2. A change in the setting of a parameter
3. Defining the information contents of a string (either continuously output or periodically polled at the option of the user)

The sensor will respond to every command with either an "acknowledge" or a "not acknowledge" string. Acknowledge strings begin with the exclamation mark **!** and are either verification of a set command or a parameter value. If the unit is in multidrop mode the 3-digit address can be sent out before the exclamation mark.

For a change in the setting of a parameter, the range of possible setting values is defined, and, if the host inputs a value outside the allowed range, an appropriate "error" response character shall be transmitted back by the sensor.

**All commands must be entered in upper case (capital) letters. Also note that leading and trailing zeros are necessary!**

*Example: Send E=0.90 instead of E=0.9; send P=001.2 instead of P=1.2*

After transmitting one command, the host has to wait for the response from the unit before sending another. A response from the sensor is guaranteed within 4 seconds in Poll mode and 8 seconds in Burst mode at 300 baud. The response is faster at higher baud rates.

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:

- Any non-used or non-allowed character (unknown command)
- An "out-of-range" parameter value
- A value entered in the incorrect format (syntax error)
- Lower case character(s) entered (all characters must be upper case)

## 9.3 Transfer Modes

The protocol allows the use of two different modes: the Poll Mode and the Burst Mode

### 9.3.1 Poll Mode

The current value of any individual parameter can be requested by the host. The unit responds once with the value at the selected baud rate. Additionally, the user-defined output string can be polled.

### 9.3.2 Burst Mode

The unit transmits the user-defined output string (continuously, at the selected baud rate), which may contain all of the parameters. Parameters may also be polled for while the instrument is in burst mode. The poll string will be inserted in the burst-mode stream.

The sensor transmits the parameters in a fixed order, regardless of the order in which they are specified. This order is as follows:

1. Temperature unit
2. Target temperature
3. Power
4. Emissivity
5. Peak hold time
6. Average time
7. Mode (Setup/Fast)
8. Internal temperature
9. Temperature setting for 20 mA
10. Temperature setting for 0 mA / 4 mA
11. Output current (specified values, in mA, or controlled by sensor)
12. Multidrop address
13. Trigger status
14. Multidrop address
15. Initialization flag

The following items cannot be placed in the burst output string:

- Poll/Burst Mode
- Baud rate
- Manual Lockout/Unlock
- Sensor Model Type
- Sensor Serial Number

- Relay Control
- Laser status
- Setpoints
- Deadband
- Current Output Mode (0 - 20 mA or 4 - 20 mA)

The following items cannot be polled:

- Poll/Burst Mode
- Baud rate
- Relay control
- Set current output

*An example string for command $=UTQEGH<CR>*
*The default string is as follows: C T1250 Q0400.023 E1.00 G005.5 H1400 <CR><LF>*

## 9.4 Response Time in Setup Mode

The analog output response time is not guaranteed while a parameter value is being changed or if there is a continuous stream of commands from the host.

The digital response time specifies how quickly the unit can report a temperature change via RS485 in burst mode. (Digital response time is not defined for polled mode.) The digital response time is defined as the time that elapses between a change in target temperature and the transmission of a burst string reporting the new temperature. Actual digital response time can vary from one reading to the next, so the digital response time is defined as the "average digital response time."

The average digital response time depends on the number of characters requested in the output string and with the baud rate. It may be computed as the following:

$$t = 9.9 + \frac{n \cdot 15000}{b}$$

where:

t = average response time in ms
n = the number of characters in the string including <CR> and <LF>
b = the baud rate

Example:
With a baud rate of 38400, and an output string containing temperature units, 2-color temperature and ambient (20 characters), the average digital response time would be the following:

$$t = 9.9 + \frac{20 \cdot 15000}{38400} = 17.7ms$$

Note that the analog output response time is not affected by baud rate or the number of characters transmitted in the burst string.

## 9.5 Command List

Table describes the commands available for 2-way communications.

| Description | Char | Format (2) | P (1) | B (1) | S (1) | N (1) | Legal Values | Factory Default |
|---|---|---|---|---|---|---|---|---|
| Burst string format | $ | (3) | √ | | √ | | (3) | UTSI |
| Show list of commands | ? | | √ | | | | | |
| Measured attenuation | B | nn | √ | √ | | | 00 to 99 | |
| Baud rate (5) | D | nnn | √ | | √ | | 003=300 baud<br>012=1200 baud<br>024=2400 baud<br>096=9600 baud<br>192=19200 baud<br>384=38400baud | 38400 |
| Emissivity | E | n.nn | √ | √ | √ | | 0.10–1.00 | 1.00 |
| Average time (4) | G | nnn.n | √ | √ | √ | √ | 000.0–299.9 sec<br>(300 s = ∞) | 000.0 |
| Top of mA range | H | nnnn | √ | √ | √ | | 0000-9999(°C or °F) | High end of sensor range |
| Sensor internal ambient | I | nnn | √ | √ | | | | |
| Switch panel lock | J | X | | | √ | | L=Locked<br>U=Unlocked | Unlocked |
| Relay alarm output control | K | n | √ | | √ | | 0=off<br>1=on<br>2=Normally Open<br>3=Normally Closed | 2 |
| Bottom of mA range | L | nnnn | √ | √ | √ | | 0000-9999 (°C or °F) | Low end of sensor range |
| Mode–MR series | M | n | | √ | √<br>√ | | 1=1- color<br>2=2- color | 2 |
| | | | | | √ | | F=Fast mode | |
| Target temp – 1-color narrow | N | nnnn | | √ | | | | |
| Output current | O | nn | | √ | √ | | 00=controlled by unit<br>02=under range<br>21=over range<br>00–20=current in mA | 00 |
| Peak hold time (4) | P | nnn.n | √ | √ | v | √ | 000.0–299.9 sec<br>(300 s = ∞) | 0000.0 |
| Wide Power | Q | nnnn.nnn | √ | v | | | 0000.000–9999.999 | |
| Narrow power | R | nnnn.nnn | √ | √ | | | 0000.000–9999.999 | |

Notes:
(1) Commands may appear as Polled for (queried), Burst string item, Set command, or Notification.
(2) n = number, X = uppercase letter.
(3) see section 9.3.2 Burst Mode, Seite 45
(4) Setting Peak Hold cancels Average, and vice-versa.
(5) The sensor restarts after a baud rate change. (Command is not allowed in broadcast mode.)

**Table 5 Command List**

| Description | Char | MR | Format (2) | P (1) | B (1) | S (1) | N (1) | Legal Values | Factory Default |
|---|---|---|---|---|---|---|---|---|---|
| Slope | S | √ | n.nnn | √ | √ | √ | √ | 0.850–1.150 | 1.000 |
| Target Temperature 2-color | T | √ | nnnn | √ | √ | | | (4) | |
| Temperature units (scale) | U | √ | X | √ | √ | √ | √ | C or F | non-US: C US: F |
| Poll/burst mode | V | √ | X | | | √ | | P=Polled B=Burst | Burst |
| Target temp: 1-color wide | W | √ | nnnn | √ | √ | | | (4) | |
| Burst string contents (5) | X$ | √ | | √ | | | | | |
| Multidrop address | XA | √ | nnn | √ | √ | √ | | 000 to 032 | 000 |
| Low temperature limit | XB | √ | nnnn | √ | | | | 0000–9999 (4) | Set at factory calibration |
| Deadband (6) | XD | √ | nn | √ | | √ | | 01–55 in °C<br>01–99 in °F | 02 |
| Restore factory defaults | XF | √ | | | | √ | √ | | |
| High temperature limit | XH | √ | nnnn | √ | | | | 0000–9999 (4) | Set at factory calibration |
| Sensor initialization | XI | √ | n | √ | √ | √ | √ | 0=flag reset<br>1=flag set<br>or nothing | 1 |
| Sensor model type | XM | | X | | | | | A, B, C | Set at factory calibration |
| 0-20 mA or 4-20 mA analog output | XO | √ | n | √ | | √ | | 0=0-20 mA<br>4=4-20 mA | 4 |
| Sensor revision | XR | √ | Xn | √ | | | | | Set a factory calibration |
| Setpoint/Relay function | XS | √ | nnnn | √ | | √ | | 0000 to 5432 (8) | 0000 |
| Trigger | XT | √ | N | √ | √ | | √ | XT0=inactive<br>XT1=active | |
| Identify unit | XU | √ | Varies | √ | | | | | !XUMR1S |
| Sensor serial number | XV | √ | Xnnnnnn | V | | | | | Set a factory calibration |
| Attenuation to activate relay (8) | Y | √ | nn | √ | √ | √ | | 0 to 95% energy | 95% |
| Attenuation for failsafe | Z | √ | nn | √ | √ | √ | | 0 to 99% energy reduction | 95% |

(1) Commands may appear as Polled for (queried), Burst string item, Set command, or Notification.
(2) n = number, X = uppercase letter.
(3) Setting Peak Hold cancels Average, and vice-versa.
(4) In current scale °C or °F
(5) see section 9.3.2 Burst Mode, Seite 45
(6) No effect if relay in alarm mode.
(7) Relay goes to abnormal, display and analog out continue to provide temperature.
(8) 0000 places unit in alarm mode. Non-zero setpoint value puts unit in setpoint mode. Setpoint is in current scale. °C or °F. Must be within unit's temperature range.

**Table 6: Command List (continued)**

## 9.6 Command Examples

| | HOST | SENSOR | HOST | SENSOR | WHERE USED (1) | | | |
|---|---|---|---|---|---|---|---|---|
| Description | Query → | Answer | Set → | Notification | P | B | S | N |
| Burst string format | 001?$ | 001!$UTSI | 001$=UTSI | | √ | | √ | |
| Show list of commands | 001? | | | | √ | | | |
| Measured attenuation | 001?B | 001!B12 | | | √ | √ | | |
| Baud rate | | 001!D384 | 001D=384 | | | | √ | |
| Emissivity | 001?E | 001!E0.95 | 001E=0.95 | 001#E0.95 | √ | √ | √ | √ |
| Average time | 001?G | 001!G001.2 | 001G=001.2 | 001#G001.2 | √ | √ | √ | √ |
| Top of mA range | 001?H | 001!H2000 | 001H=2000 | 001#H2000 | √ | √ | √ | |
| Sensor internal ambient | 001?I | 001!I028 | | | √ | √ | | |
| Switch panel lock | 001?J | 001!JL | 001J=L | | √ | | √ | |
| Relay alarm output control | | 001!K0 | 001K=0 | | √ | | √ | |
| Bottom of mA range | 001?L | 001!L1200 | 001L=1200 | | √ | √ | √ | |
| Mode – MR series | 001?M | 001!M1 | 001M=1 | 001#M1 | √ | √ | √ | √ |
| Target temperature, 1-color narrow | 001?N | 001!N1158 | | | | √ | | |
| Output current | | 001!O10 | 001O=10 | | √ | √ | √ | |
| Peak hold time | 001?P | 001!P005.6 | 001P=005.6 | 001#P005.6 | √ | √ | √ | √ |
| Power | 001?Q | 001!Q0036.102 | | | √ | √ | | |
| Narrow Power | 001?R | 001!R0002.890 | | | √ | √ | | |
| Slope | 001?S | 001!S0.850 | 001S=0.850 | 001#S0.850 | √ | √ | √ | √ |
| Target temperature,<br>MR series 2-color | 001?T | 001!T1225 | | | √ | √ | | |
| Temperature units | 001?U | 001!UC | 001U=C | 001#UC | √ | √ | √ | √ |
| Poll/Burst mode | | 001!VP | 001V=P | | | | √ | |
| Target temperature, 1-color wide | 001?W | 001!W1210 | | | √ | √ | | |
| Burst string contents | 001?X$ | | | | √ | | | |
| Multidrop address | 001?XA | 001!XA013 | 001XA=013 | | √ | √ | √ | |
| Low temperature limit | 001?XB | 001!XB | | | √ | | | |
| Deadband | 001?XD | 001!XD12 | 001XD=12 | | √ | | √ | |
| Restore factory defaults | | 001!XF | XF | 001#XF | | | √ | √ |
| High temperature limit | 001?XH | 001!XH1400 | | | √ | | | |
| Sensor initialization | 001?XI | 001!XI0 | 001XI=0 | 001#XI | √ | √ | √ | √ |
| Laser | 001?XL | 001!XL1 | 001XL=1 | 001#XL1 | √ | | √ | √ |
| Sensor model type | 001?XM | 001!XR | | | √ | | | |
| 0-20 mA or 4 - 20 mA analog output | 001?XO | 001!XO4 | 001XO=4 | | √ | | √ | |
| Sensor revision | 001?XR | 001!XRF1 | | | √ | | | |
| Setpoint / relay function | 001?XS | 001!XS1234 | 001XS=1234 | | √ | | √ | |
| Trigger | 001?XT | 001!XT0 | | 001#XT0 | √ | √ | | √ |
| Identify unit | 001?XU | 001!XUMR1 | | | √ | | | |
| Sensor serial number | 001?XV | 001!XVA099901 | | | √ | | | |
| Attenuation to activate relay | 001?Y | 001!Y95 | 001Y=95 | | √ | √ | √ | |
| Attenuation for failsafe | 001?Z | 001!Z99 | 001Z=99 | | √ | √ | √ | |

**Table 7: Command Examples**

(1) P = Poll Mode (Request for a parameters), B = Burst Mode (continuous sending of parameters in the burst string), S = Set (Command for setting a parameters), N = Notification (Acknowledgment for setting a parameter)

**The given examples are related to a unit in a network addressed with address 001. Stand-alone units are requested without having an address information in the command.**

# 10 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.

## 10.1 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 slope or emissivity | Correct the setting |
| Temperature fluctuates | Wrong signal processing | Correct Peak Hold or Average settings |

**Table 8: Troubleshooting**

## 10.2 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 LED display and transmitted over the 2-way interface.

| Condition | 2-Color | 1-Color (wide band)** | 1-Color* (narrow band)** |
|---|---|---|---|
| Heater control temperature over range | ECHH | ECHH | ECHH |
| Heater control temperature under range | ECUU | ECUU | ECUU |
| Internal temperature over range | EIHH | EIHH | EIHH |
| Internal temperature under range | EIUU | EIUU | EIUU |
| Wide band detector failure | EHHH | EHHH | <temperature> |
| Narrow band detector failure | EHHH | <temperature> | EHHH |
| Energy too low | EUUU | <temperature> | <temperature> |
| Attenuation too high (>95%) | EAAA | <temperature> | <temperature> |
| Attenuation too high >95%<br>("dirty lens", relay will go to "alarm" state) | <temperature> | <temperature> | <temperature> |
| 2-color temperature under range | EUUU | <temperature> | <temperature> |
| 2-color temperature over range | EHHH | <temperature> | <temperature> |
| Wide band temperature under range | <temperature> | EUUU | <temperature> |
| Wide band temperature over range | <temperature> | EHHH | <temperature> |
| Narrow band temperature under range | <temperature> | <temperature> | EUUU |
| Narrow band temperature over range | <temperature> | <temperature> | EHHH |

* only available through RS485
** Wide and narrow band stands for the first and the second wavelength in 2-color mode
*** Note that the activation levels for these conditions may be set to different values. (e.g., "dirty lens" at 95%, EAAA at 98%)

**Table 9: Fail-safe Error Codes**

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. The exception is the "dirty window" condition. This causes the relay to change state, leaving a normal numerical temperature output.

| Error Code | 0 – 20 mA Output | 4 – 20 mA Output |
|---|---|---|
| no error | according to temperature | according to temperature |
| ECHH | 21 to 24 mA | 21 to 24 mA |
| ECUU | 0 mA | 2 to 3 mA |
| EIHH | 21 to 24 mA | 21 to 24 mA |
| EIUU | 0 mA | 2 to 3 mA |
| EUUU | 0 mA | 2 to 3 mA |
| EHHH | 21 to 24 mA | 21 to 24 mA |
| EAAA | 0 mA | 2 to 3 mA |

**Table 10: Current Output Values in accordance to an Error**

If two errors occur simultaneously, the higher priority error is the one that is presented on the LED's digital and analog outputs. For example, in 2-color mode, if the internal ambient is too high and the attenuation is too high, the unit outputs EIHH on the LED's and digital output and 21 mA on the analog output. However, since 2-color wide band and narrow band temperatures may all be presented simultaneously through RS485, their over and under range conditions are independent.

**Examples of failsafe conditions:**

1. One-color temperature is selected for display on the LED's. Two-color temperature is transmitted in burst mode. Wide band temperature is under range. Two-color temperature is 999°C.

   Outputs:
   Display: EUUU
   RS485: C T0999
   Analog: 2 to 3 mA
   Relay: abnormal state

2. Two-color temperature is selected for display on LED's. All three temperatures are transmitted in burst mode. Two-color temperature is 1021°C. Wide band temperature is 703°C. Narrow band temperature is 685°C. Attenuation is above 95%, the "dirty window" threshold.

   Outputs:
   Display: 1021
   RS485: C T1021 W0703 N0685
   Analog: scaled to temperature, between 4 and 20 mA
   Relay: abnormal state

## 10.3 Cleaning the Lens

Keep the lens clean at all times. Any foreign matter on the window will affect 1-color measurement accuracy and may affect two-color accuracy. However, 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

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!**

## 10.4 Changing the Window

Sometimes extremely harsh environments can cause damage to the window.

A replacement window (XXX2CPW) is available from the manufacturer.

To replace the sensor’s window, complete the following:

1. With a very small flat-bladed screw driver (e.g., a jeweler’s screwdriver), pry out the rubberized Buna-N 70 durometer O-ring. The O-ring is set in a groove in front of the window.
2. Turn the sensor face down (window pointing down), and the window should fall out.
3. Turn the sensor face up and insert the new window. (Make sure both sides of the window are clean.)
4. Replace the O-ring.

**If you use a fine-bladed knife to remove the O-ring, be careful not to cut or sever the ring.**

# 11 Appendix

## 11.1 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. If possible, apply flat black paint to a portion of the surface of the object. The emissivity of the paint must be above 0.98. Next, measure the temperature of the painted area using an emissivity setting of 0.98. Finally, measure the temperature of an adjacent area on the object and adjust the emissivity until the same temperature is reached. This is the correct emissivity for the measured material.

## 11.2 Typical Emissivity Values

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

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

| EMISSIVITY AT 1 μM FOR METALS | |
|---|---|
| **Material** | **Emissivity** |
| Aluminum | |
| unoxidized | 0.1-0.2 |
| oxidized | 0.4 |
| roughened | 0.2-0.8 |
| polished | 0.1-0.2 |
| Brass | |
| polished | 0.1-0.3 |
| Burnished | 0.6 |
| Chromium | 0.4 |
| Copper | |
| polished | 0.05 |
| roughened | 0.05-0.2 |
| oxidized | 0.2-0.8 |
| Gold | 0.3 |
| Haynes | |
| Alloy | 0.5-0.9 |
| Inconel | |
| oxidized | 0.4-0.9 |
| sandblasted | 0.3-0.4 |
| electropolished | 0.2-0.5 |
| Iron | |
| oxidized | 0.4-0.8 |
| unoxidized | 0.35 |
| molten | 0.35 |
| | |

| EMISSIVITY AT 1 μM FOR METALS | |
|---|---|
| **Material** | **Emissivity** |
| Iron, cast | |
| oxidized | 0.7-0.9 |
| unoxidized | 0.35 |
| molten | 0.35 |
| Magnesium | 0.3-0.8 |
| Molybdenum | |
| oxidized | 0.5-0.9 |
| unoxidized | 0.25-0.35 |
| Monel (Ni-Cu) | 0.3 |
| Nickel | |
| oxidized | 0.8-0.9 |
| electrolytic | 0.2-0.4 |
| Silver | 0.04 |
| Steel | |
| cold rolled | 0.8-0.9 |
| polished sheet | 0.35 |
| molten | 0.35 |
| oxidized | 0.8-0.9 |
| stainless | 0.35 |
| Tin (unoxidized) | 0.25 |
| Titanium | |
| polished | 0.5-0.75 |
| Zinc | |
| oxidized | 0.6 |
| polished | 0.5 |

**Table 11: Typical Emissivity Values (Metals)**

| EMISSIVITY AT 1 μM FOR NON-METALS | |
|---|---|
| **Material** | **Emissivity** |
| Asbestos | 0.9 |
| Ceramic | 0.4 |
| Concrete | 0.65 |
| Carbon | |
| unoxidized | 0.8-0.95 |
| Graphite | 0.8-0.9 |

**Table 12: Typical Emissivity Values (Non-Metals)**

## 11.3 Typical Slopes

The following slope settings are approximate and will vary depending on the metal alloy and surface finish, as well as the application. These are supplied here as examples.

Set the slope to approximately **1.000** for measuring the following metals with oxidized surfaces:

- Stainless Steel
- Iron
- Cobalt
- Nickel
- Steel

Set the slope to approximately **1.060** for measuring the following metals with smooth, clean, unoxidized surfaces:

- Iron
- Stainless Steel
- Cobalt
- Molybdenum
- Nickel
- Rhodium
- Steel
- Platinum
- Tantalum
- Tungsten

Molten iron also has an approximate slope setting of 1.060.

**How to determine slope?**

The most effective way to determine and adjust the slope is to take the temperature of the material using a probe sensor such as an RTD, thermocouple, or other suitable method. Once you determine the actual temperature, adjust the slope setting until the sensor's temperature reads the same as the actual temperature reading. This is the correct slope for the measured material.

## 11.4 2-Wire Communication

Using the 2-wire communication reduces wiring cost in comparison to the 4-wire communications.
2-wire communications is available for network installations, in situations where other sensors are only able to communicate via 2 wires (e.g. MI sensor). For setting the Interface Converter into the 2-wire communication mode, use the Network Communication Setup Software, found on the software CD.

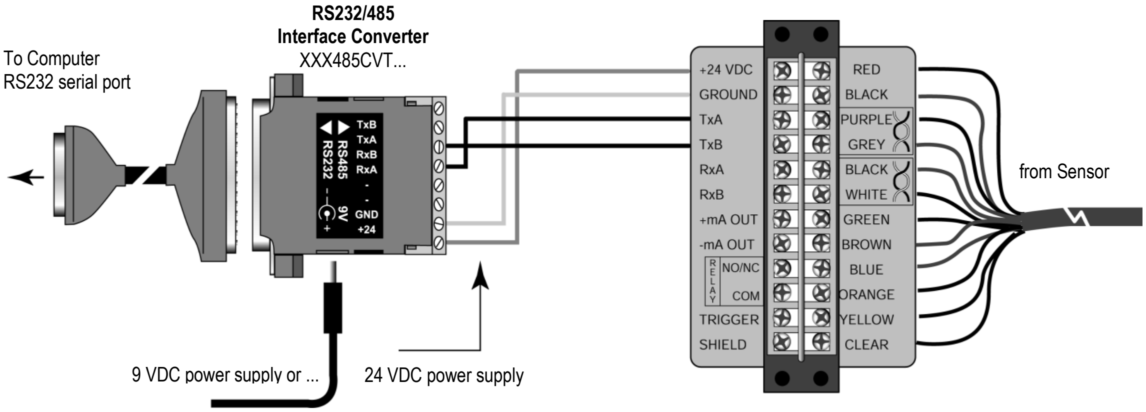


**Figure 30: 2-Wire Sensor Communication**

## 11.5 Traceability of Instrument Calibration