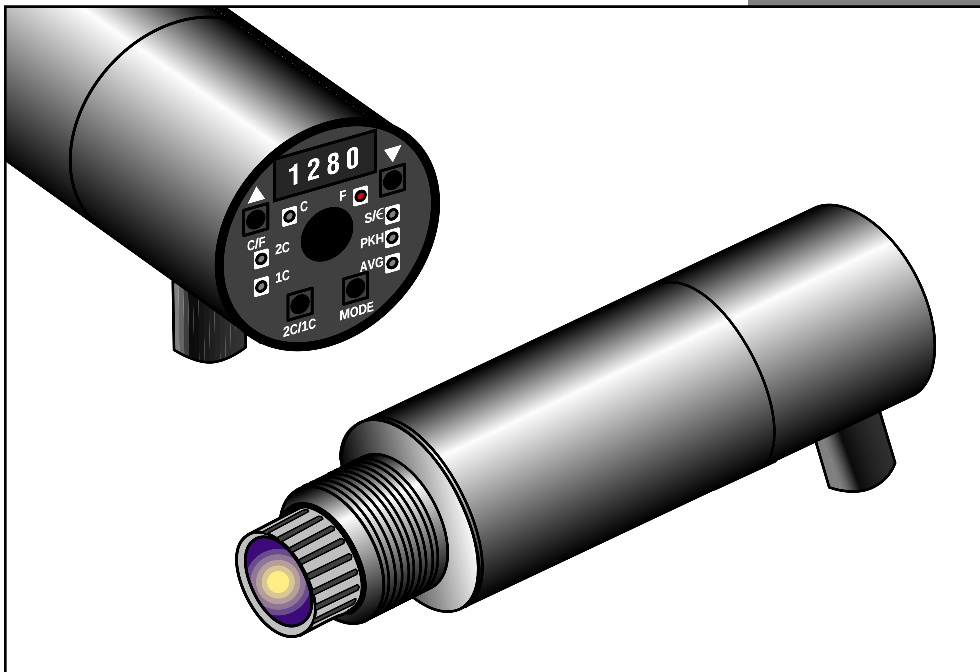
MR1S

MARATHON SERIES



Marathon

High Performance
Integrated Ratio
Infrared Thermometer

Operator’s Manual

Raytek®

Rev. C 10/00
56913-1

ISO 9001 Certified

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APPENDICES

Part 1 Introduction

This section covers manual layout and product information, and it points you in the right direction to install and operate your sensor or sensors in a non-multidrop or multidrop networked environment.

Topics include...

- About this Manual
- Where to Start
- Product Description
- Product Specifications
- Accessories and Options

ABOUT THIS MANUAL

The *Marathon MR1S Operator's Manual* provides detailed information about Marathon Series™ infrared thermometers and supporting software. It is designed to be used as a reference tool in the installation and operation of your sensor or sensors.

This manual is organized according to the type of process environment you are installing into, whether it is a non-multidrop, non-networked installation or a multidrop, networked installation.

- **Part 1** discusses manual usage, product descriptions and specifications, and what section of the manual, either Part 2 or Part 3, to go to for information on installation and operation for your particular environment.
- **Part 2** covers the installation and operation Marathon sensors in a non-multidrop, non-networked process environment. **If you are using Part 2 as an installation and operating guide, you do not need Part 3.**
- **Part 3** explains the installation, communication setup, and operation of one or up to 32 Marathon sensors in a multidrop network. **If you are using Part 3 as a guide, you do not need Part 2.**
- **Part 4** describes how to use the three supplied Marathon utility programs. Two programs can be used in any Marathon sensor environment, one program is for a multidrop network environment only.
- **Appendices** are made up of a Programming Guide, which lists the communications protocols for Marathon sensors; an Emissivity Guide, which shows examples of emissivity settings for various metals and non-metals; a DIN connector wiring chart; information on calibration traceability; and data on CE conformity for the European community.

WHERE TO START

Whether you are planning to install a single sensor, multiple sensors, or an interconnected sensor network, you must first prepare for installation. Use the following guide to go to the section that pertains to your type of installation:

- One Sensor / no Computer–Go to Part 2.
- One Sensor / Computer / non-multidrop–Go to Part 2.
- Each Additional Sensor / Computer / non-multidrop–Go to Part 2.
- One or More Sensors / Computer / future multidrop network–Go to Part 3.
- One or More Sensors / Computer / multidrop network–Go to Part 3.

1.0 PRODUCT DESCRIPTION

The Thermalert Marathon MR1S 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:

- **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.
- **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.

Each model (Table 1-1) operates as an integrated temperature measurement subsystem consisting of optical elements, spectral filters, detector, digital electronics and a NEMA-4 (IEC 529, IP 65) 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.

Table 1-1: Models

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")

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

Note: For the percentage of allowed signal reduction at temperatures below the minimum temperature (95% attenuation) as shown above, refer to Figure 1-3.

1.1 THEORY OF OPERATION

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 and / 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.

1.1.1 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.

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

1.1.2 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.

1.1.3 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.

1.2 ACCESSORIES

A full range of accessories for various applications and industrial environments are available (see Figure 1-1). Accessories include items that may be ordered at any time and added on-site. These include the following:

- Air purge collar
- Fixed bracket
- Adjustable bracket (included with sensor)
- Swivel bracket
- Mounting nut
- Polarizing filter
- Isolated 24 VDC power supply (110 or 220) or switching power supply with universal input (110 / 220)
- RS-485 to RS-232 interface converter (w / 110V or 220V power supply)
- 4, 8, 15, 30, or 60 meter (13, 26, 50, 100, or 200 feet) cable (For cable longer than 60 meters (200 feet), contact your sales representative.)
- Field Calibration Package

Also available is a ThermoJacket™ (see Figure 1-1) and the following accessories:

- Adjustable mounting bracket
- Mounting flange
- Adjustable pipe adapter accessory
- 305 mm (12 in) stainless steel (#300, schedule 40) sighting tube
- 305 mm (12 in) ceramic sighting tube
- Sighting tube mounting flange
- Blast gate accessory
- Focusing tool (to focus unit while in ThermoJacket or if mounted in recess)

Notes: Sensing heads are rated NEMA-4 (IEC 529, IP 65) with conduit adapter accessory and compression fitting (which prevents liquid from entering through the connector).

If you do not have a focusing tool accessory, the sensor must be focused before mounting inside a ThermoJacket or air purge collar.

1.3 OPTIONS

Options are items that are factory installed and must be ordered with base model units. The following are available:

- Air / water-cooled housing (see Figure 1-1)
- NIST certification
- Glass window endcap (easy viewing of LEDs) instead of standard endcap

WARNING

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

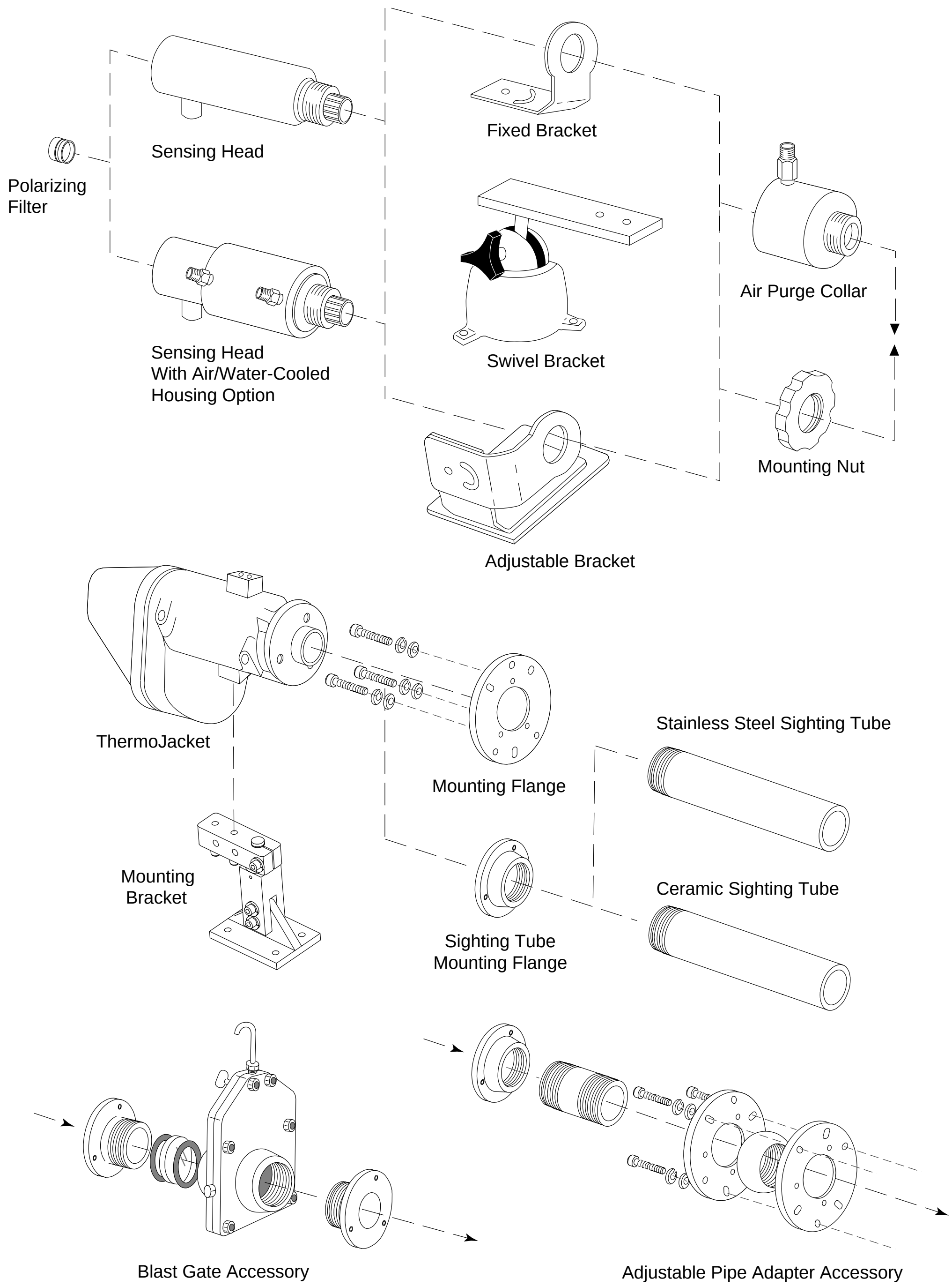

Figure 1-1: Accessories and Options

IMPORTANT

When reading this manual, look into exceptions that may result from customized features. Check with your sales representative whenever a parameter is critical or operation seems abnormal.

1.4 SPECIFICATIONS

The following sections cover optical, thermal, operational, electrical, and physical specifications for each model. (Specifications subject to change without notice.)

1.4.1 Optical

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 1-2.

Divide the distance (D, in Figure 1-2) 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).

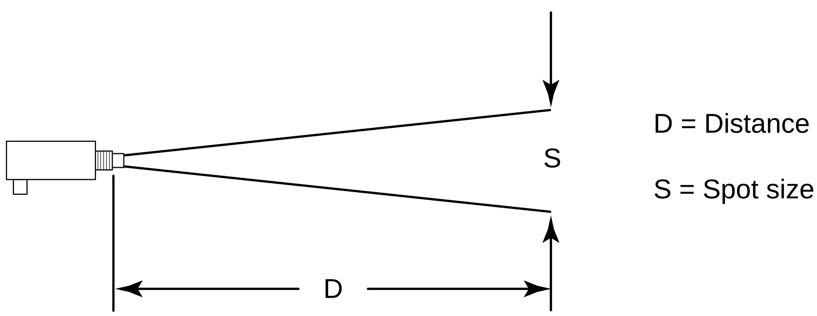

Figure 1-2: Spot Size Chart

Note: D:S is a ratio and applies to either metric or standard measurements.
The nominal spectral response for all models is as follows:

- 1-color band: 0.75 to 1.1 µm
- 2-color bands: 0.75 to 1.1 µm
  0.95 to 1.1 µm

Optical Resolution (D:S)

Model A	44:1
Model B	82:1
Model C	130:1

Optical resolution assumes 95% energy at the focus point.

1.4.2 Thermal

This section lists specifications related to the sensors thermal characteristics. Refer to Table 1-1 for each model's overall temperature measurement range.

System Accuracy

A and B Models	± 0.75% of full scale
C Model	± 0.75% of full scale up to 2900°C (5252°F)
	Note: Unit operates up to 3000°C (5432°F)

System Repeatability

All Models	0.3% of full scale

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

Noise Equivalent Temperature (NET)

All Models	1°C peak to peak, target emissivity of 1.00, unobscured target
	3°C peak to peak, for all specified attenuation conditions

Figures 1-3, 1-4, and 1-5 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 1-1.

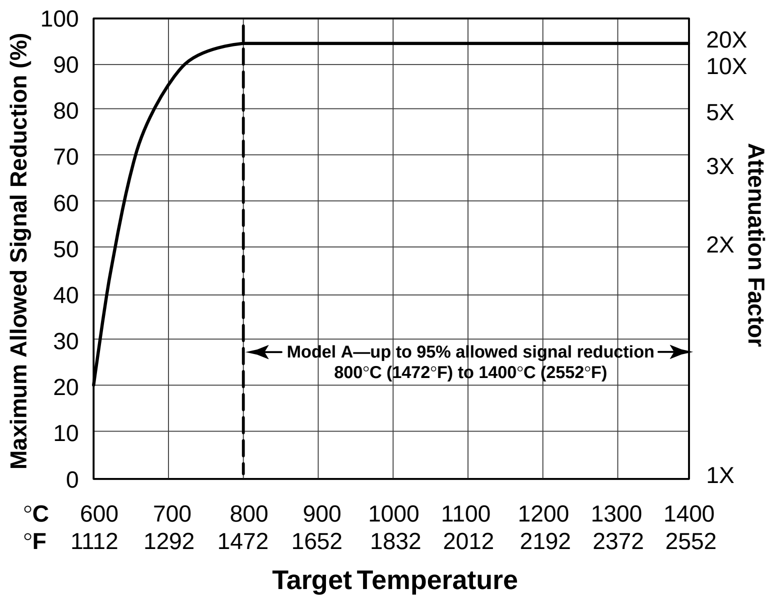

Figure 1-3: Model A Percentage of Allowed Signal Reduction

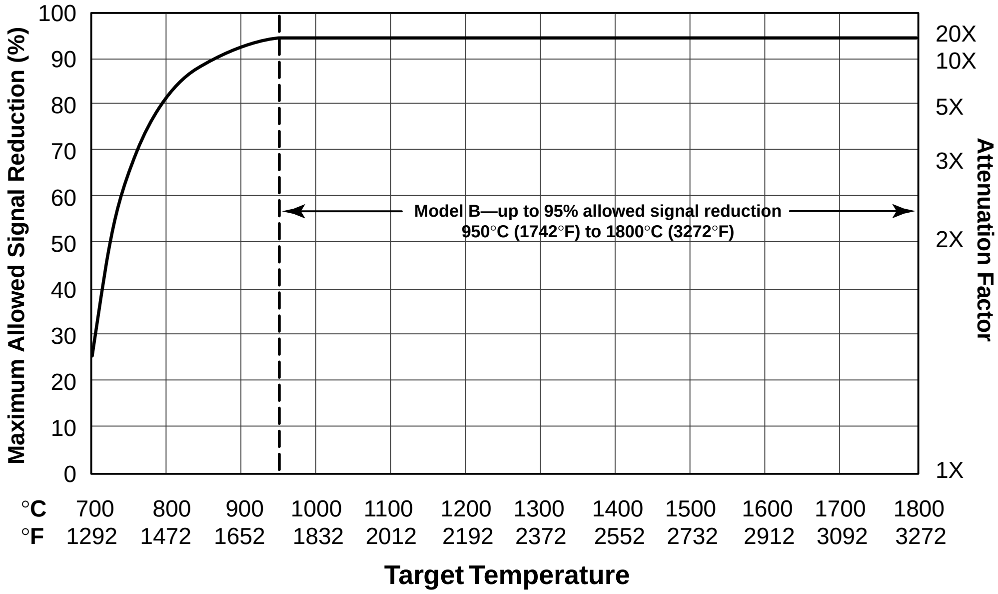

Figure 1-4: Model B Percentage of Allowed Signal Reduction

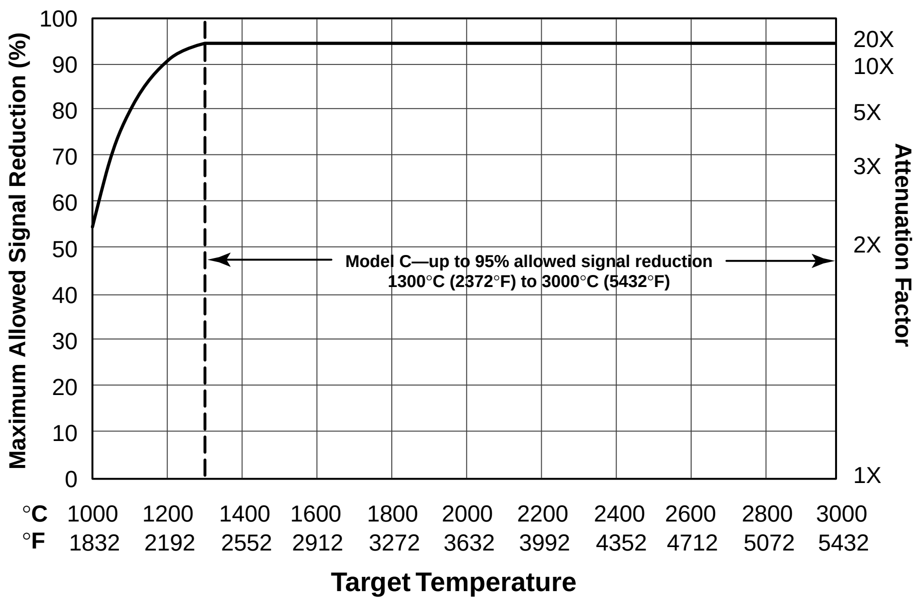

Figure 1-5: Model C Percentage of Allowed Signal Reduction

1.4.3 Operational

Display	7-segment LED display—shows temperature, slope, emissivity, peak hold seconds, average seconds, and failsafe codes. Individual LEDs indicate modes and active functions (e.g., 2C / 1C mode, slope, emissivity, peak hold, and average)
Detector	1-color mode: Si 2-color mode: Si / Si

Temperature Resolution (Display and RS485)

All Models	1°C or 1°F

Analog Output Resolution

Models A and B	1°C or 1°F
Model C	1°C or 2°F

Two-Way RS-485 Output Description

All Models	Baud Rate: 300, 1200, 2400, 9600, 19200, 38400 (default) *Note: Adjustable baud rate only available through 2-way RS-485.* Data Format: 8 bits, no parity, 1 stop bit Software selectable 4-wire, full-duplex non-multidrop, point-to-point or 2-wire half-duplex multidrop.

Emissivity (1-color)	0.10 - 1.00, digitally adjustable in increments of 0.01
Slope (2-color)	0.850 - 1.150, digitally adjustable in increments of 0.001
Peak Hold Range	0 to 300 seconds, digitally adjustable in increments of 0.1 secs.
Averaging Range	0 to 300 seconds, digitally adjustable in increments of 0.1 secs.
Warm Up Period	15 minutes
Fail-Safe	Full or low scale, depending upon system failure (refer to Section 4.2)

1.4.4 Electrical

Power	24 VDC, ± 20%, at 500 mA (Can tolerate up to 100 mV peak to peak of ripple)
Power Consumption	maximum of 12 watts
Outputs	0-20 mA / 4-20 mA, two-way RS485, relay control for failsafe alarm or setpoint
Output Isolation	500 V AC or DC provided by Raytek supplied power supply accessory
Max Current Loop Impedance	500 ohm
Dielectric Withstand Voltage	500 V
Relay Contacts	Type: SPDT contact closure (software programmable to NO or NC) Maximum rating: 48 V, 300 mA AC or DC
External Reset	Trigger input (TTL input–see Figure 1-6)

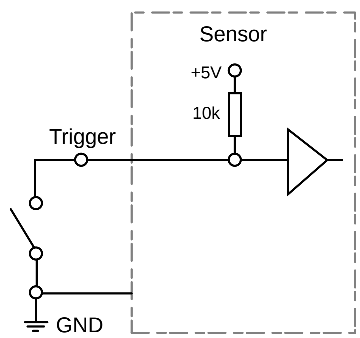

Figure 1-6: External Reset (Trigger Input) Wiring Diagram

1.4.5 Physical

Dimensions

Sensing Head	198mm (7.8 in) L x 57mm (2.2 in) Dia
with air / water-cooled housing	198mm (7.8 in) L x 76mm (3.0 in) Dia
with ThermoJacket	338mm (13.3 in) L x 125mm (4.93 in) W x 158mm (6.2 in) H

Weight

Sensing Head	0.56 kg (19 oz)
with air / water-cooled housing	0.8 kg (28 oz)
ThermoJacket (body only)	3.26 kg (7.2 lbs)

1.4.6 Environmental

Ambient Operating Range	
No Cooling	0 to 50°C (32 to 120°F)
With Air Cooling	0 to 120°C (32 to 250°F)
With Water Cooling	0 to 175°C (32 to 350°F)
With ThermoJacket	0 to 315°C (32 to 600°F)
Vibration	MIL-STD-810D (IEC 68-2-6) 3 Gs, 11 to 200 Hz, any axis
Mechanical Shock	MIL-STD-810D (IEC 68-2-27) 50 Gs, 11 msec duration, any axis
Thermal Shock	None
Relative Humidity	10% to 95% non-condensing at 22°C to 43°C (72°F to 110°F)
Storage Temperature	-20 to 70°C (-4 to 158°F)
Environmental Rating	NEMA-4 (IEC 529, IP 65) rated with conduit adapter and compression fitting (which prevents liquid from entering through the connector)
Electromagnetic Interference	CE certification Emission Standard: EN50081-2 Immunity Standard: EN50082-2

1.5 MECHANICAL

Mechanical specifications include measured drawings for the sensor and its accessories and options.

1.5.1 Sensors

The following illustrations show dimensions of a standard sensor (Figure 1-7), a sensor with the air / water-cooled housing option (Figure 1-8), and the adjustable bracket (supplied–Figure 1-9). Dimensions are listed for your installation convenience.

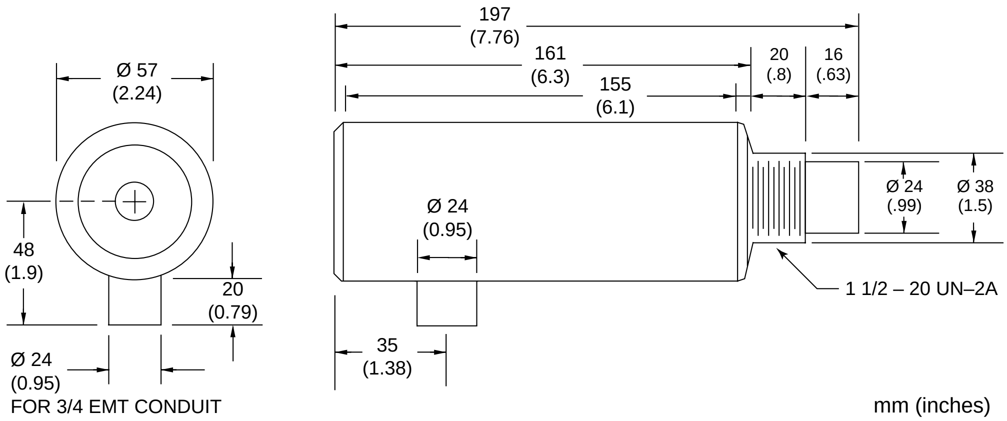

Figure 1-7: Sensing Head

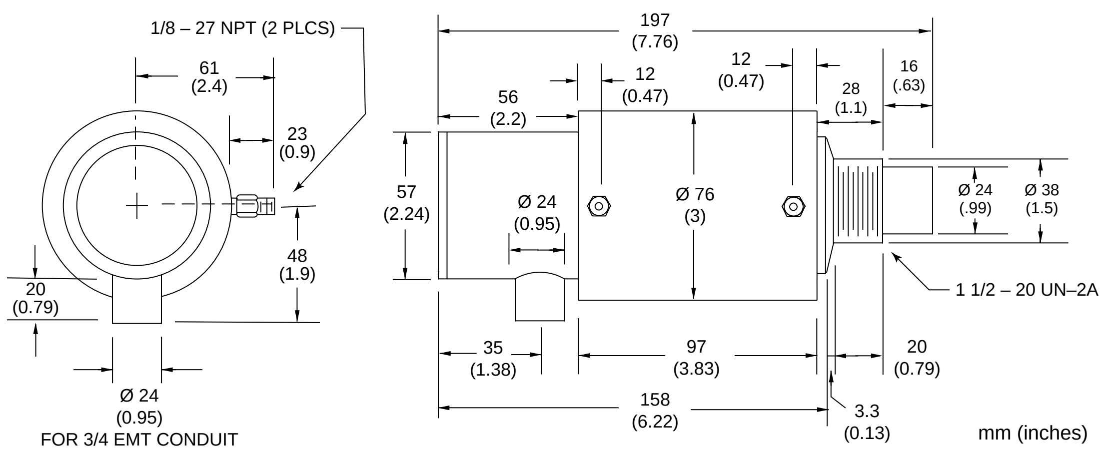

Figure 1-8: Sensing Head with Air / Water-Cooled Housing Option

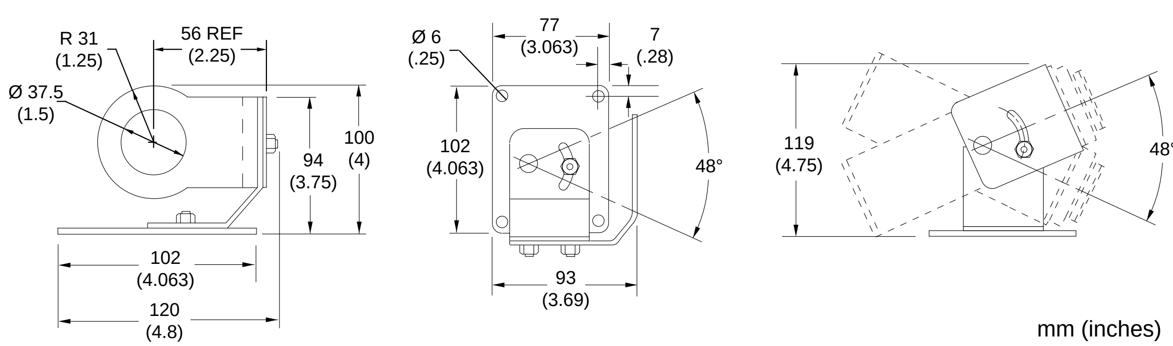

Figure 1-9: Adjustable Bracket

1.5.2 Accessories and Options

This section defines accessories and options, lists installation considerations, and shows the dimensions for each piece. Note that accessories can be purchased at any time and added to the sensor(s). Options must be ordered with the unit(s). For purchasing information, contact your sales representative.

1.5.2.1 Fixed Mounting Bracket

The Fixed Mounting Bracket accessory (Figure 1-10) can be used if the sensor will always remain in a fixed location.

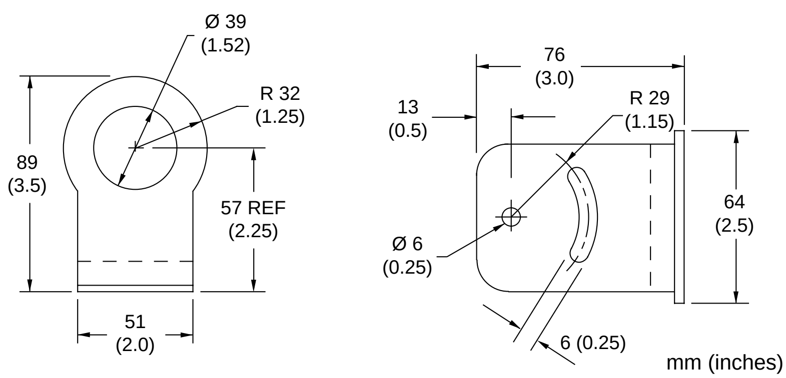

Figure 1-10: Fixed Mounting Bracket

1.5.2.2 Air Purge Collar

The Air Purge Collar accessory (Figure 1-11) is used to keep dust, moisture, airborne particles, and vapors away from the lens. It can be installed before or after the bracket (see Figure 1-1, Accessories Overview). 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).

IMPORTANT

Focus the instrument before attaching the air purge collar.

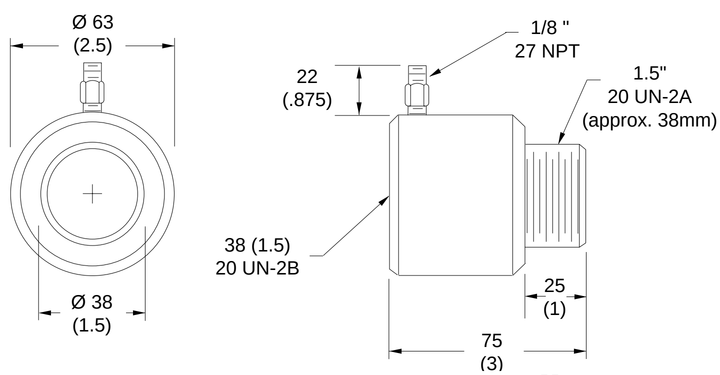

Figure 1-11: Air Purge Collar

1.5.2.3 Polarizing Filter

The Polarizing Filter (Figure 1-12) 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.

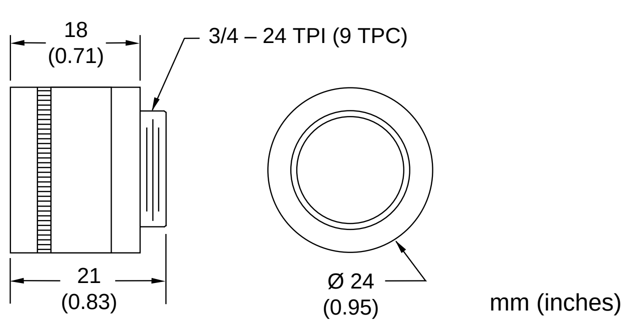

Figure 1-12: Polarizing Filter

1.5.2.4 ThermoJacket and Accessories

The ThermoJacket accessory allows use of sensing heads in ambient temperatures up to 315°C (600°F). The ThermoJacket's rugged cast aluminum housing completely encloses the head and provides water cooling and air purging in one unit. Sensing heads can be easily installed or removed from the ThermoJacket housing in its mounted position. See the *ThermoJacket Operator's Manual* for more information.

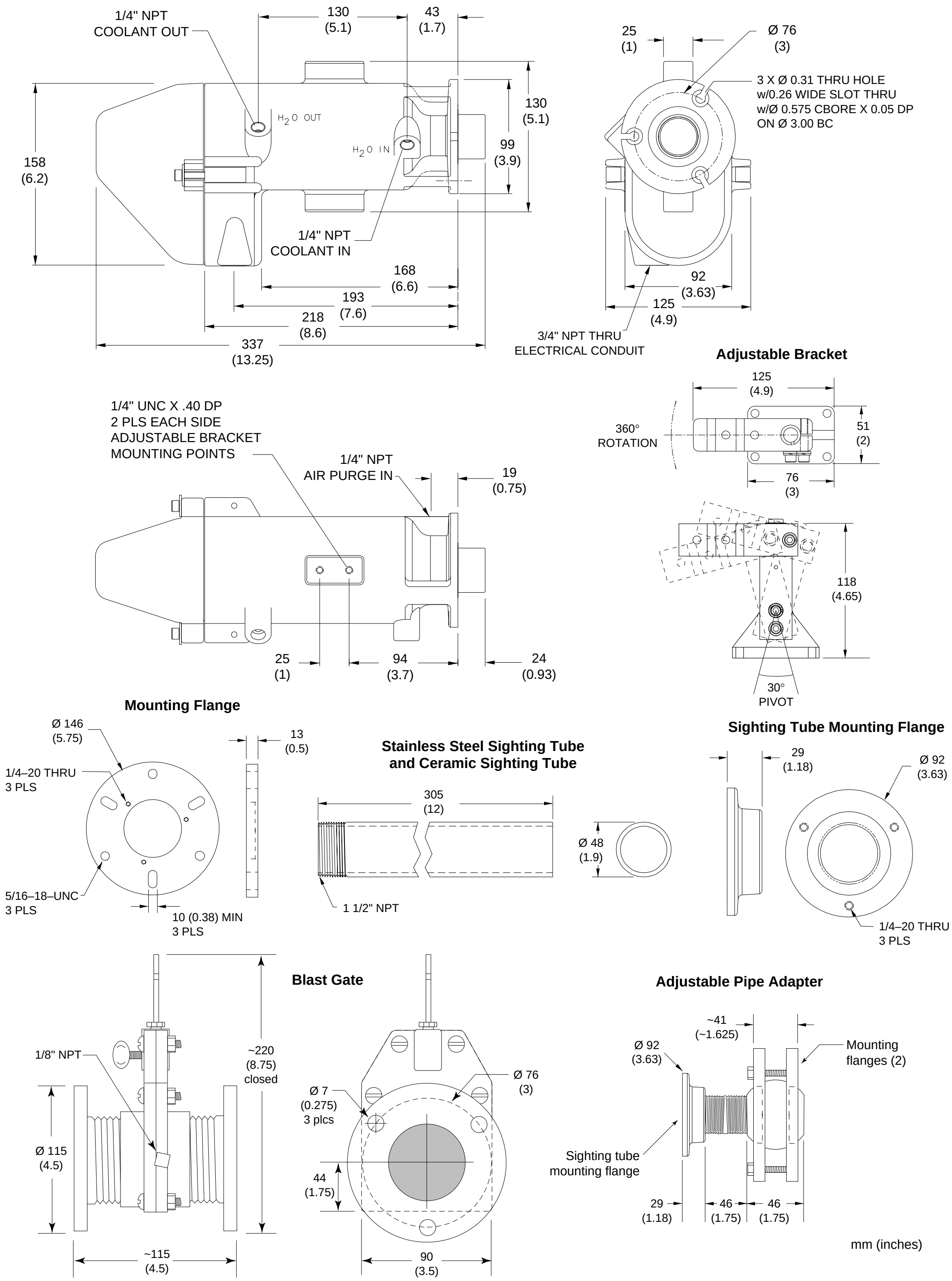

Figure 1-13: ThermoJacket and Accessories

1.5.3 Cables

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

- RS-485—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.

Notes: If you purchase your own RS-485 cable, use wire with the same specifications as those listed above. Maximum RS-485 cable length is 1200 meters (4000 feet).

WARNING

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.

1.6 FACTORY DEFAULT VALUES

Table 1-2 lists the unit's default values as it is shipped from the factory.

Table 1-2: Factory Defaults

PARAMETER	AS SHIPPED FROM FACTORY (DEFAULTS) *
Display	2-color mode, degrees C, TEMP display
Emissivity	1.00
AVG	0.0
PKH	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 ***
RS-485 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 2-way RS-485 command (#XF). Refer to Appendix D for explanations and examples of RS-485 commands.

** These parameters can be adjusted both by a 2-way RS-485 command, which allows you to scale the high and low temperature points to suit your application.

*** Communications Mode and RS-485 Mode, like Baud Rate, are unchanged when the factory defaults are restored.

Part 2 Non-multidrop Installation & Operation

This section explains the installation and operation of a Marathon infrared thermometer in a non-multidrop environment. If you are installing one or more sensors using these directions, you do not need Part 3. However, if your future plans include setting up a multidrop sensor network, consider using Part 3 instead of Part 2 so your initial installation will be multidrop ready.

Topics include...

- Preparation
- Mechanical Installation
- Electrical Installation
- Operation

2.0 INSTALLATION

The installation process consists of the following:

- Preparation
- Mechanical Installation
- Electrical Installation

The most important part in the installation process is preparation. Please read Section 2.1 thoroughly before proceeding with the mechanical and electrical installations.

2.1 PREPARATION

Sensor location, the configuration, and / or the number of sensors depend on the application. Before installing any sensors 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 and / or air or water cooling, you need to have air and water connections available. Also, wiring and conduit runs must be considered, including computer and controller wiring and connections, if used. The following subsections cover topics to consider before you install the sensor.

Note: All sensors, whether standard or with the air/water-cooled housing option, are supplied with an adjustable bracket and mounting nut. If necessary, the sensor can be mounted through a hole, or it can be mounted using a customer-supplied bracket or other accessories. (Refer to Part 1, Section 1.1 and 1.2, for an overview of the available accessories and options.)

2.1.1 Ambient Temperature

The sensing head is designed to operate in ambient temperatures between 0°C (32°F) and 50°C (120°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 (120°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.

2.1.2 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 (see Section 4.2). 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 is installed before proceeding with the sensor installation.

2.1.3 Electrical Interference

To minimize electrical or electromagnetic interference or "noise," be aware of the following:

- Mount the sensor 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 in the sensor 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.

2.1.4 Sensor Location

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. Figure 2-1 shows sensor placement and the various conditions where 2-color temperature measurements can be taken. Note, however, that if the field of view degrades beyond 95%, accuracy also degrades.

IMPORTANT

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 2-color sensor to give erroneous readings.

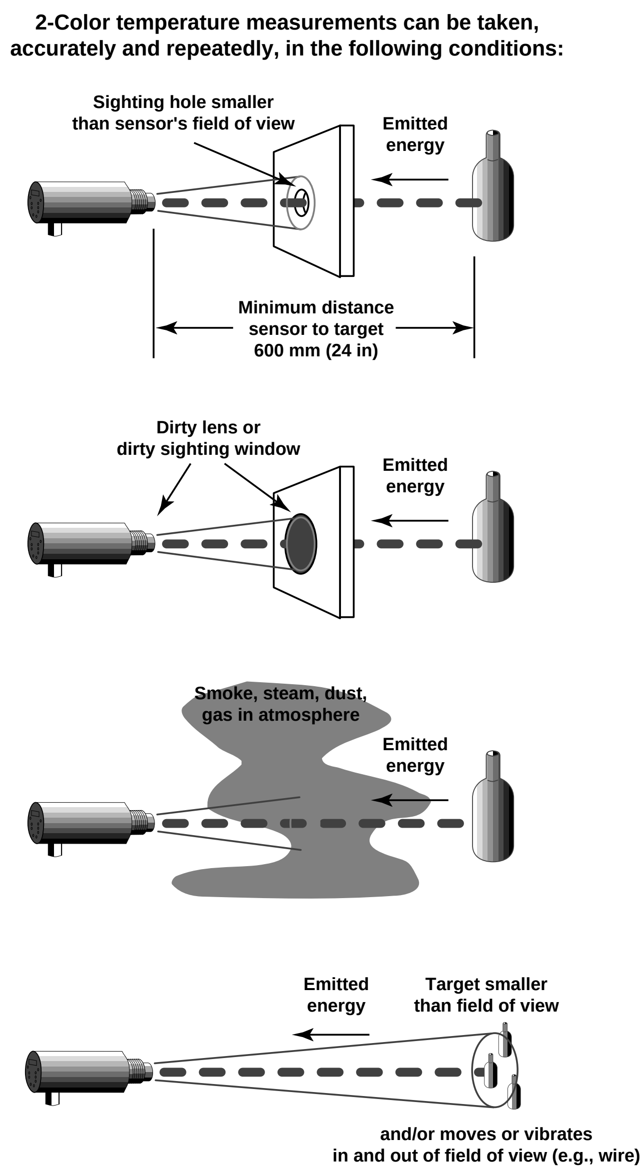

Figure 2-1: 2-Color Sensor Placement

Sensor placement for 1-color temperature measurements is more critical than 2-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. Because you can focus the lens, the distance from the target is not a major considation, as long as the target completely fills the field of view. Figure 2-2 illustrates proper placement when using the 1-color mode.

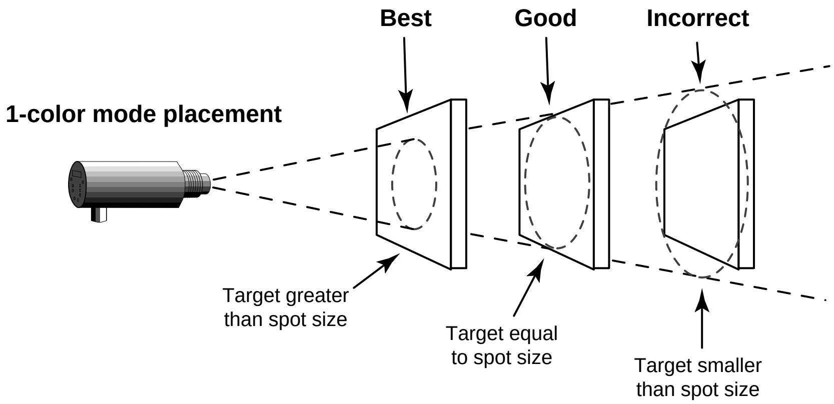

Figure 2-1: Proper Sensor Placement

The sensor can be placed at any angle from the target up to 45°, for 2-color mode, or 30°, for 1-color mode (Figure 2-3).

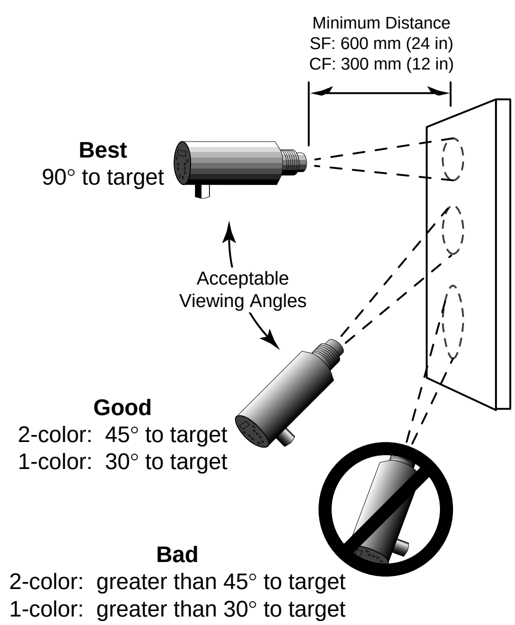

Figure 2-2: Acceptable Sensor Viewing Angles

2.2 MECHANICAL INSTALLATION

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

2.2.1 Mounting 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 (refer to Part 1). If you are installing the sensor in a ThermoJacket accessory, you should use the appropriate mounting device. (Refer to Part 1 for an overview of ThermoJacket accessories.) 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.

NOTICE

If you are installing two or more sensors in a multi-drop configuration, or if you plan to add to or more sensors at a later date, refer to Part 3 for information on multi-drop installations.

2.2.2 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 (Figure 2-11). (Note that the target appears upside down.)

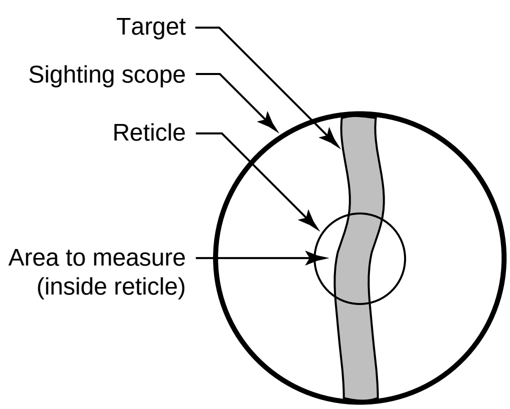

Figure 2-11: Sensor Eyepiece and Reticle

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.

2.3 ELECTRICAL INSTALLATION

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 2-3.

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

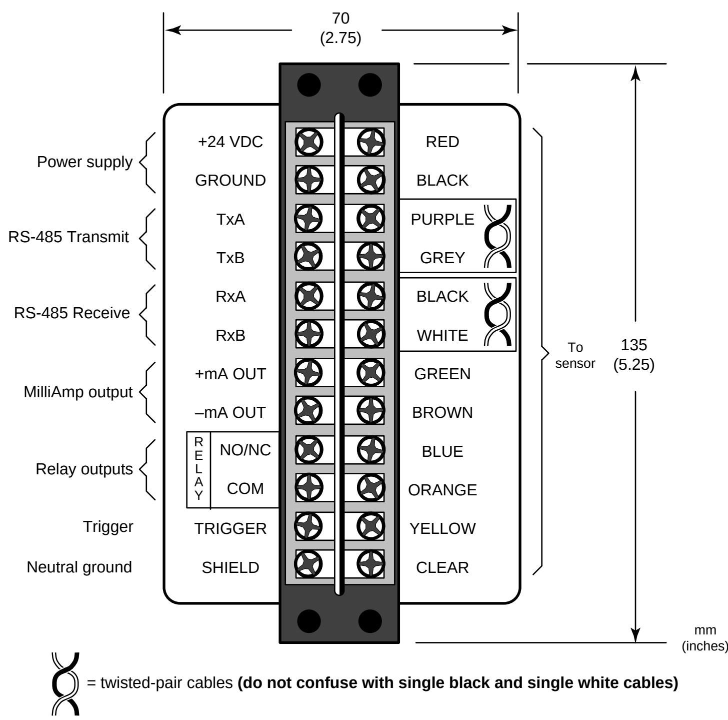

Figure 2-3: Terminal Block

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 2-12 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.)**

WARNING

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

Note: 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, IP 65).

IMPORTANT

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 meters (200 feet) or less. RS-485 cables can be extended up to 1200 meters (4000 feet).

Avoid installing the sensor cable in noisy electrical environments such as around electrical motors, switch gear, or induction heaters. In these environments, it is recommended to install the cable in conduit. Note that the sensor head is designed to fit conduit directly.

2.3.1 Power

Connections from a 24 VDC (250 mA or higher) power supply attach to the first two terminals on the terminal strip (as shown in Figure 2-3).

IMPORTANT

Isolation is provided only when used with the appropriate Raytek supplied power supply accessory.

2.3.2 RS-485 Interface Converter

To connect to a computer's RS-232 port, you need the Interface Converter accessory (Figure 2-4) and the proper RS-232 cable (available from computer parts stores). If your computer has an RS-485 interface card, you can connect directly to its port (using the proper connector) with the sensor cable or with wiring from the terminal block.

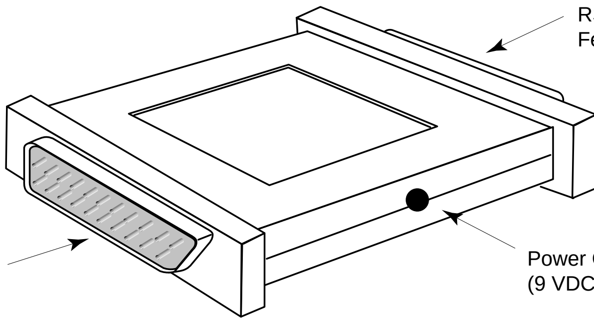

Figure 2-4: RS-485 to RS-232 Interface Converter

The interface converter has a 25-pin male (RS-485) and 25-pin female (RS-232) connector. Figure 2-5 shows the various RS-232 and RS-485 connections.

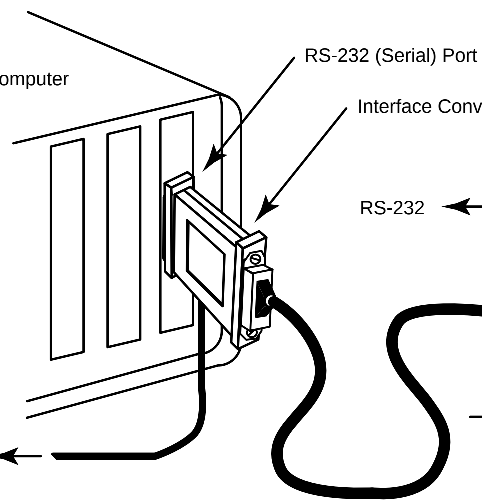

Figure 2-5: RS-485 to RS-232 Conversion and Computer Connection

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NOTICE

You must supply your own cable between the converter and terminal block. Purchase (from any computer parts supply store) a serial cable with a 25-pin female connector on one end and bare wires on the other. Make sure a wiring diagram is included with your purchase.

Note that the cable's RxA and RxB wires connect to the terminal block's TxA and TxB screws, and the cable's TxA and TxB wires connect to the terminal block's RxA and RxB screws.

Note: Personal computers can have up to 4 serial ports (RS-232 connections). These are listed as COM1, COM2, COM3, and COM4. Usually COM1 and COM2 are the only physical connections on the back of the computer.

Connect the interface converter to an available COM port on your computer. If your computer has a 9-pin serial connector, use a 25-pin to 9-pin adapter between the interface converter and the computer.

IMPORTANT

On older computers the COM1 port is used by a pointing device (mouse, trackball, etc.), and sometimes the COM2 port is connected to an external modem or fax/modem (an internal modem can also be set to use COM2). It is possible for two devices to share an interrupt (COM1/COM3 or COM2/COM4); however, they cannot be used at the same time or your system might "crash." You can connect the RS-232 cable to the same port as, for instance, your modem, but you need to make sure the modem is inactive while you use the sensor.

The RS-485 output is as follows:

Baud Rate: 300, 1200, 2400, 9600, 19200, 38400 (default)
Note: Adjustable baud rate only available through 2-way RS-485.
Data Format: 8 bits, no parity, 1 stop bit
Four-wire full duplex, point-to-point

For a full description of the RS-485 output string, see Appendix B.

WARNING

If you are using the converter's optional power adapter, note the following: After connecting the serial cables, attach the adapter plug into the converter BEFORE plugging the AC adapter into an AC outlet.

2.3.3 Milliamp Output

The milliamp output is an analog output you can connect directly to a chart recorder or other recording device.

The analog output resolution for A and B models is 1°C or 1°F, C model is 1 °C or 2°F.

The analog output corresponds to either the 2-color or 1-color readings on the display.

Note: The mA output can be forced to a specific value, underrange, or overrange with a 2-way RS-485 command. See Appendix B for details. This feature is useful for testing or calibrating connected equipment.

2.3.4 Relay Outputs

The relay output is used as an alarm for failsafe conditions only. (Refer to Section 4.2 for failsafe information.) This corresponds to the currently displayed temperature on the LED display (2C or 1C).

Note: Since the way you use the relay outputs depends on the application, check with your sales representative for the best way to use this feature.

Connections can be made to the terminal strip for Normally Open (Relay NO) or Normally Closed (Relay NC). One terminal is common for both (Relay COM).

Note: The relay can be set to either NO (Normally Open) or NC (Normally Closed) with a 2-way RS-485 command depending on compatibility requirements of connected equipment. The relay can be forced on or off via 2-way RS-485 for testing connected equipment. See Appendix B for details.

2.4 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 Graphic Setup and Display program is supplied with your sensor and is covered in Part 4. You can also create custom programs using the communications protocols listed in Appendix B.

IMPORTANT

Make sure air, water, power, and computer connections are secure.

Avoid taking temperature measurements in bright sunlight. Also, be aware targets with low temperatures (below the sensor's range) and low emissivities may not register correctly.

2.4.1 THE 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. Besides displaying the current temperature, the LED can display slope (2-color) or emissivity (1-color), the peak hold setting, and the average temperature.

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 LEDs to be visible, is available as an option. (You cannot use the polarizing filter with this option.)

Figure 3-1 is an overview of the sensor's control panel. It is made up of four button-style switches, seven LEDs, a 4-digit display panel, and a sighting scope. These are defined in the following sections.

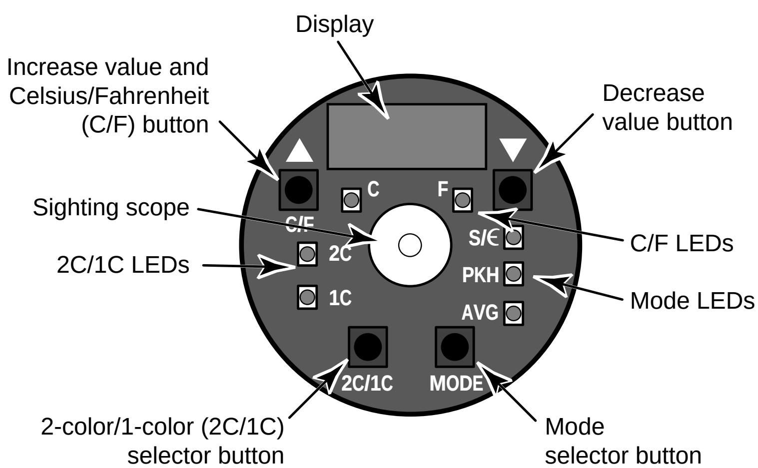

Figure 2-6: Control Panel

2.4.2 SET-UP

To begin setting up the sensor, first make sure all connections are secure, then turn on the power supply. **Allow the sensor to warm up for 15 minutes before making control panel adjustments.** (You can also set up remotely through the 2-way RS-485 connection. Refer to Appendix B.)

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 2-7 illustrates the sequence of operation for the mode selector button when in current temperature mode.

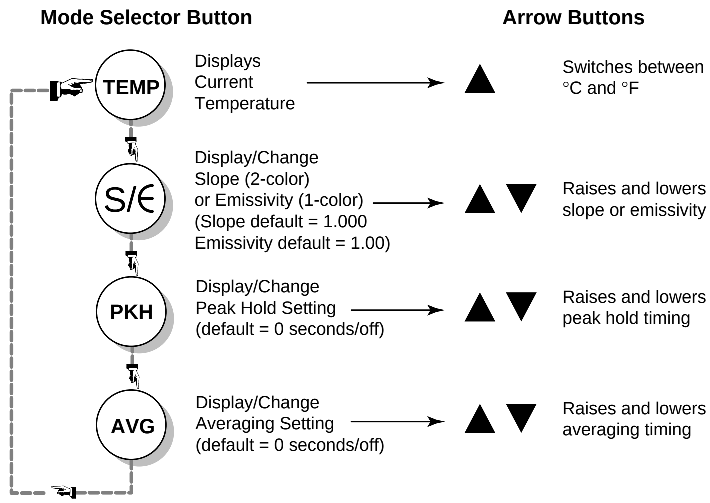

Figure 2-7: Mode Selector Button Sequence

Note: When the PKH mode is active (PKH LED lit), the Mode Selector cycle skips AVG (TEMP to E to PKH back to TEMP). When the AVG mode is active (AVG LED lit), the Mode Selector cycle skips PKH (TEMP to E to AVG back to TEMP).

To change the settings for each mode using the control panel is simple. The following sections define each of the control panel's features and functions and explains sensor setup and use. Section 2.4.2.5 explains how to reset the factory defaults. Note that all modes can be changed from a computer using controlling software such as those listed in Part 4.

WARNING

Do not connect, disconnect, or change wiring while the power is on.

2.4.2.1 2-Color/1-Color Operation

The first setting you need to make is selecting whether to make 2-color or 1-color temperature measurements. Because you purchased this particular unit, you will probably use the 2-color feature. However, if the target completely fills the field of view and there are no obstructions, you can use 1-color temperature measurement. (Refer to Appendix B to estimate the correct emissivity setting.)

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. (Figure 3-1 shows the location of the 2C / 1C selector.)

Note: Switching affects the LED display and analog out but not the RS-485 out. Switching between 1C and 2C can also be done with a 2-way RS-485 command. See Appendix B for details.

Lockout Mode

The sensor has a remote locking feature that keeps the unit from being accidentally changed from the control panel. This lockout mode denies access to all the switches on the control panel. It is available through the RS-485 connection and can be unlocked only by a command from the remote computer. See Appendix B for details.

2.4.2.2 Modes

Pressing the mode selector button (Figure 3-1) cycles you through the four operating modes (as shown in Figure 3-2): temperature display mode, Slope / Emissivity display and adjustment mode, Peak Hold output display and adjustment mode, Average output display and adjustment mode, and back to the temperature display mode.

Temperature

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 RS-485 output for both target and internal temperatures.

Slope/Emissivity

The slope is an adjustment that compensates for the differences in the emissivity of the two spectral ranges. 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 slope is preset at the factory at 1.000, and the emissivity is preset at 1.00. For information on determining an unknown emissivity, and for sample emissivities, refer to Appendix B.

You can set the unit up for either 2-color or 1-color measurements. The 2C / 1C selector button on the control panel switches between the two functions. One of the red LEDs above the button, labeled 2C and 1C, will show what function is active.

For 2-color measurements—You need to set the slope for the material being measured. To set the slope, do the following:

1. **Press the Mode button until the S/∈ LED is lit.**

   The current slope value shows on the display.
2. **Press the ▲ or ▼ (UP or DOWN) button to change the value.**
3. **Press the Mode button several times until the temperature LED indicator is lit.**

   The displayed temperature will now be based on the new slope value.

IMPORTANT

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:

- Cobalt
- Iron
- Stainless Steel
- Steel
- Nickel

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

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

Molten iron also has an approximate slope setting of 1.060.

Unknown Slope—To measure the temperature of objects or materials that are not listed above, you will have to set the slope by doing the following (make sure the 2C LED is lit):

1. **Take the temperature of the target's surface.**

   Use a reliable contact or probe thermometer. If you have to measure several areas on the target, use the average of the temperatures for the following steps.
2. **Aim the unit at the target.**
3. **Press the Mode button until the S/∈ LED is lit.**

   The current slope value shows on the display.
4. **Press the ▲ or ▼ (UP or DOWN) button to change the value.**

5. **Press the Mode button several times until the C or F LED indicator is lit.**

   Compare the displayed temperature to that of the contact or probe thermometer's. If they are not the same, repeat steps 3 through 5 until they are.

Emissivity—When using the 1-color feature you have to set the emissivity, if necessary. The emissivity is preset at the factory at 1.00. If this is acceptable for the type of surface you are measuring, no adjustment is necessary. However, if you are unsure of the target's emissivity, refer to Appendix B, which lists the emissivities of many metals and non-metals. If the material you want to measure is not listed, Appendix B also shows how to determine an unknown emissivity.

To change the unit's emissivity setting, complete the following (make sure the 1C LED is lit):

1. **Press the Mode button until the S/∈ LED is lit.**

   The current emissivity value shows on the display.

2. **Press the ▲ or ▼ (UP or DOWN) button to change the value.**
3. **Press the Mode button several times until the temperature LED is lit.**

   The displayed temperature will now be based on the new emissivity value.

Note: Slope and emissivity can also be adjusted with a 2-way RS-485 command. See Appendix A for details.

Peak Hold (PKH)

Peak Hold can be useful when a peak temperature reading is desired. For example, use Peak Hold when the background temperature between discrete targets is less than that of the target. Figure 2-8 illustrates the Peak Hold output signal.

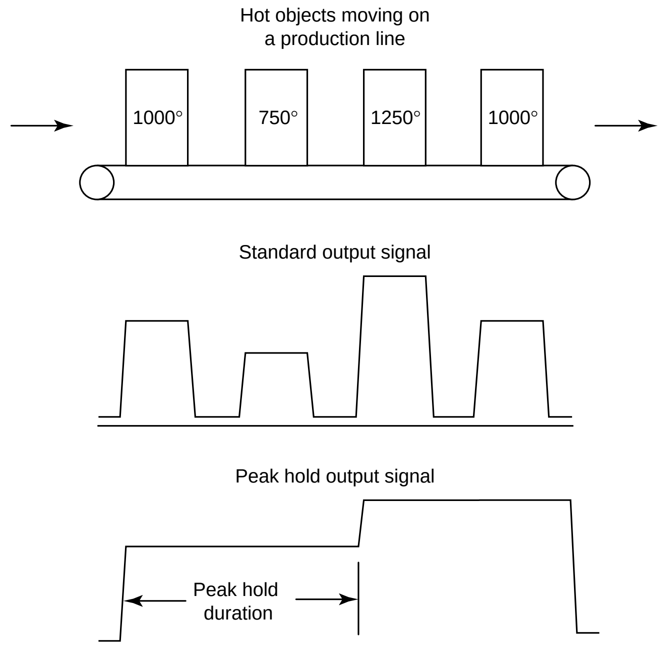

Figure 2-8: Peak Hold Output Signal Example

When you activate Peak Hold, the instrument monitors the maximum temperature seen over a predetermined time interval (duration). Should the unit measure a temperature higher than the one it is presently displaying, it immediately updates the display and starts a new time interval. On the other hand, should it see no temperature above the one presently displayed, it will hold this value until the duration expires, at which time it will update to a new value equal to the highest temperature seen at the time the interval expired. If the unit measures an intermediate temperature before measuring ambient, and if the last object has passed, the unit will display and output the intermediate value for one more duration before ambient is finally displayed. Figure 2-8 illustrates this function. This algorithm prevents large changes in output, a desirable feature for controller applications.

To set and activate Peak Hold, do the following:

1. **Press the Mode button until the PKH LED is lit.**
2. **Press the ▲ (UP) button to both set and activate.**

   The display reads in 0.1 seconds. Set Peak Hold from 0 to 299.9 seconds. If Peak Hold is set to 300.0 seconds, a hardware reset is needed to trigger another reading.
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. Note that Averaging (AVG) cannot be used concurrently. To deactivate Peak Hold, push the MODE button until only the PKH LED indicator is lit and reset to 0 by pushing the ▼ (DOWN) button.

Note: Peak Hold can also be adjusted with a 2-way RS-485 command. See Appendix B for details.

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. Figure 2-9 illustrates the Averaging output signal.

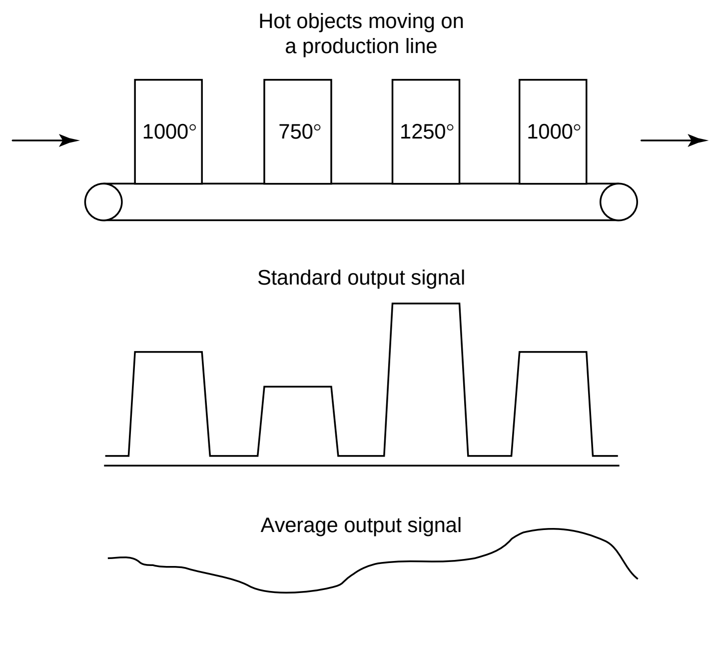

Figure 2-9: Averaging Output Signal Example

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

To set and activate Average, do the following:

1. **Press the Mode button until the AVG LED is lit.**
2. **Press the ▲ (UP) button to both set and activate.**

   The display reads in 0.1 seconds. Set Average anywhere from 0 to 300 seconds (to set the time constant of the first order, low-pass filtering).
3. **Press the Mode button until the C or F LED is lit.**

   If Average has been activated, the Average LED will stay lit.

Once Average is set above 0, it is automatically activated. Peak hold cannot be used concurrently. To deactivate Average, push the MODE button until only the Average LED indicator is lit and reset to 0 by pushing the ▼ (DOWN) button.

Note: Average can also be adjusted with a 2-way RS-485 command (only works in Setup mode). See Appendix B for details.

2.4.2.3 Setpoint

The Setpoint is deactivated by default (alarm mode). Activating and adjusting the Setpoint is accomplished through software. Refer to Appendix B for information on the sensor's communication protocols.

Once the Setpoint is activated the relay changes state as the current temperature passes the setpoint temperature.

2.4.2.4 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 (±4° F) of Setpoint value. Adjusting to other values is accomplished through software. Refer to Appendix B for information on the sensor's communication protocols. Figure 2-10 is an example of the Deadband around a Setpoint temperature of 960°C (1760°F).

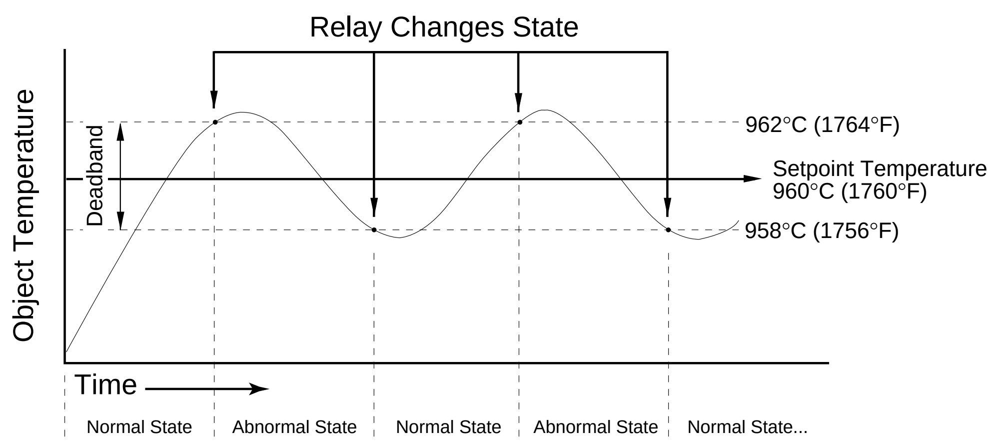

Figure 2-10: Deadband Example

2.4.2.5 Resetting Factory Defaults

To globally reset the unit to its factory default settings, make sure the unit is in Setup mode (SET LED is lit) and press the ▲ and ▼ buttons (up and down arrows) at the same time for approximately 2 seconds.

The factory defaults are listed in Part 1, Section 1.5.

Note: Resetting Factory Defaults can also be done with a 2-way RS-485 command. See Appendix B for details.

Part 3 Multidrop Installation & Operation

This section explains the installation and operation of one or more Marathon infrared thermometers in a multidrop sensor-network environment.

Topics include...

- Preparation
- Network Communication Setup
- Mechanical Installation
- Electrical Installation
- Operation

3.0 MULTI-DROP SENSOR INSTALLATION

The multi-drop sensor installation consists of the following:

- Preparation
- Communication Setup
- Mechanical Installation
- Electrical Installation

The most important part of the installation process is preparation. An additional preparation required for multidrop installations is the Network Communication Setup. Preparation and communications setup must be completed before proceeding to the mechanical installation.

3.1 MULTI-DROP PREPARATION

Sensor location, sensor configuration, and / or the number of sensors depend on the application. Before installing your sensors, 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. If you plan to use air purging and / or air or water cooling, you need to have air and water connections available. Also, wiring and conduit runs must be considered, including computer and controller wiring and connections, if used. The following subsections cover topics to consider before you install the sensor.

Note: All sensors, whether standard or with the air/water-cooled housing option, are supplied with an adjustable bracket and mounting nut. If necessary, the sensor can be mounted through a hole, or it can be mounted using a customer-supplied bracket or other accessories. (Refer to Part 1, Section 1.1 and 1.2 for an overview of the available accessories and options.)

3.1.1 Ambient Temperature

The sensing head is designed to operate in ambient temperatures between 0°C (32°F) and 50°C (120°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 (120°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.

3.1.2 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 (see Section 4.2). 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 is installed before proceeding with the sensor installation.

3.1.3 Electrical Interference

To minimize electrical or electromagnetic interference or “noise,” be aware of the following:

- Mount the sensor 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 in the sensor 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.

3.1.4 Sensor Location

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. Figure 2-1 shows sensor placement and the various conditions where 2-color temperature measurements can be taken. Note, however, that if the field of view degrades beyond 95%, accuracy also degrades.

IMPORTANT

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 2-color sensor to give erroneous readings.

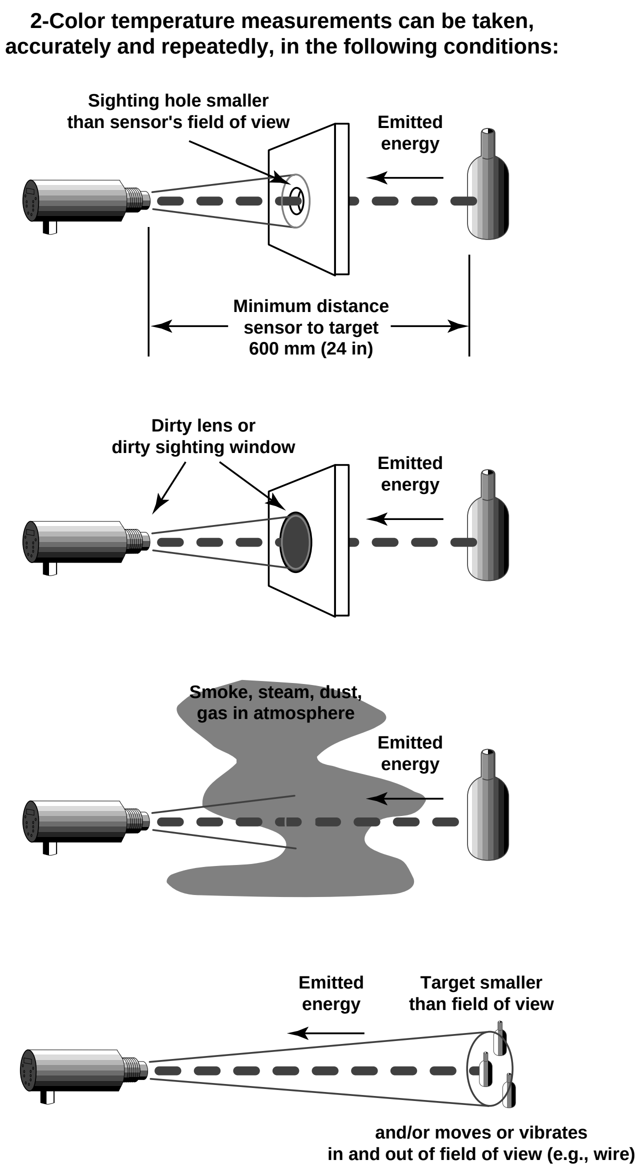

Figure 2-1: 2-Color Sensor Placement

Sensor placement for 1-color temperature measurements is more critical than 2-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. Because you can focus the lens, the distance from the target is not a major considation, as long as the target completely fills the field of view. Figure 2-2 illustrates proper placement when using the 1-color mode.

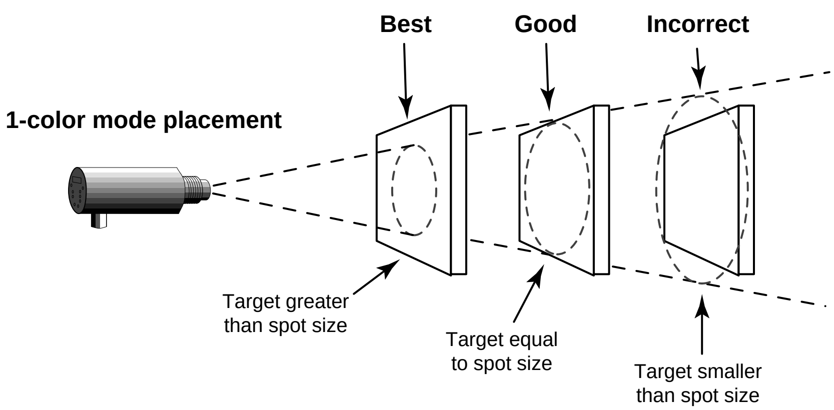

Figure 3-1: Proper Sensor Placement

The sensor can be placed at any angle from the target up to 45°, for 2-color mode, or 30°, for 1-color mode (Figure 2-3).

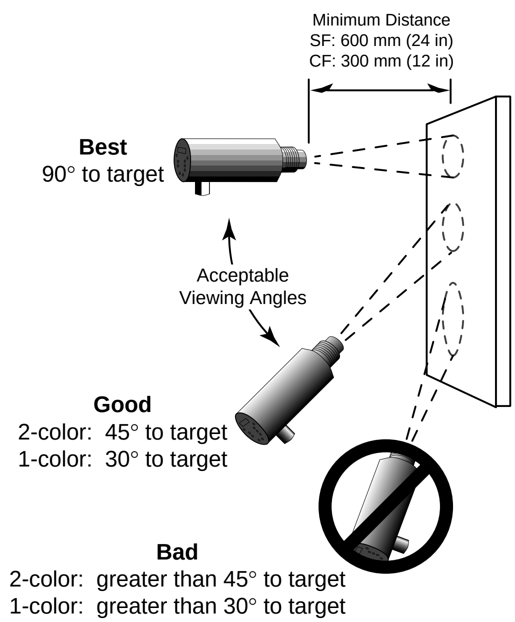

Figure 3-2: Acceptable Sensor Viewing Angles

3.1.5 Multi-drop Considerations

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

- Each Marathon sensor must have a unique "address."
- Sensor setup and addressing must be done before mounting sensor in permanent location.
- Each sensor must be set to the same baud rate.
- A 200 MHz or faster Pentium-class personal computer is suggested.
- If your computer does not have RS-485 communication capabilities, you will need to attach the RS-485 to RS-232 Converter accessory.

IMPORTANT

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 erroneous readings.

3.2 NETWORK COMMUNICATION SETUP

The following sections cover software installation, preparing your sensors, and how to use the software to give each sensor a unique address. These steps should be completed before installing the sensors in their permanent location.

3.2.1 Software Installation

The software that came with your Marathon sensor(s) consists of four separate programs. These include the Network Communications Setup (covered in this section), the Graphic Setup and Display, the Sensor Network Setup and Display (displays temperatures and alarms for up to 32 sensors), and the Chat program (direct communications between the user and the sensor). These programs are covered in Part 4.

Note: You can create your own programs customized to your application by using the communications protocols listed in Appendix B.

To install the software on a personal computer running Windows 95, Windows 98, or Windows NT 4.0 (Service Pack 3), complete the following steps:

1. Put Disk 1 in your floppy drive.
2. Click on the Start Button and select Run.
3. Type A:\Install and press the Return/Enter key.
4. Follow the installation instructions.

All necessary programs are installed in the Raytek program group.

3.2.2 Preparing the Sensors for a 4-Wire Multidrop Installation

Before mounting the sensors in their permanent location, each one must be initialized with a unique address so communication to and from the sensors and the computer can occur without problems. To set up your computer to initialize the sensors, complete the following steps (use Figure 3-3 as a guide):

1. Turn off your computer.
2. Wire a sensor cable to the right side of a terminal block (supplied with each cable), and attach the appropriate power supply and RS-485 cables to the other side. (Refer to Section 2.3, Electrical Installation, for terminal block information.)
3. Plug the RS-485 to RS-232 converter into your computer's serial port, and plug in the AC power supply cable if used. (Use the supplied 25-pin to 9-pin adapter if necessary.)

   Note: This step is not necessary if your computer is equipped with an RS-485 interface card
4. Before turning on the computer, make sure the sensor and RS-485 to RS-232 adapter power supplies are plugged in.
5. Turn on your computer.

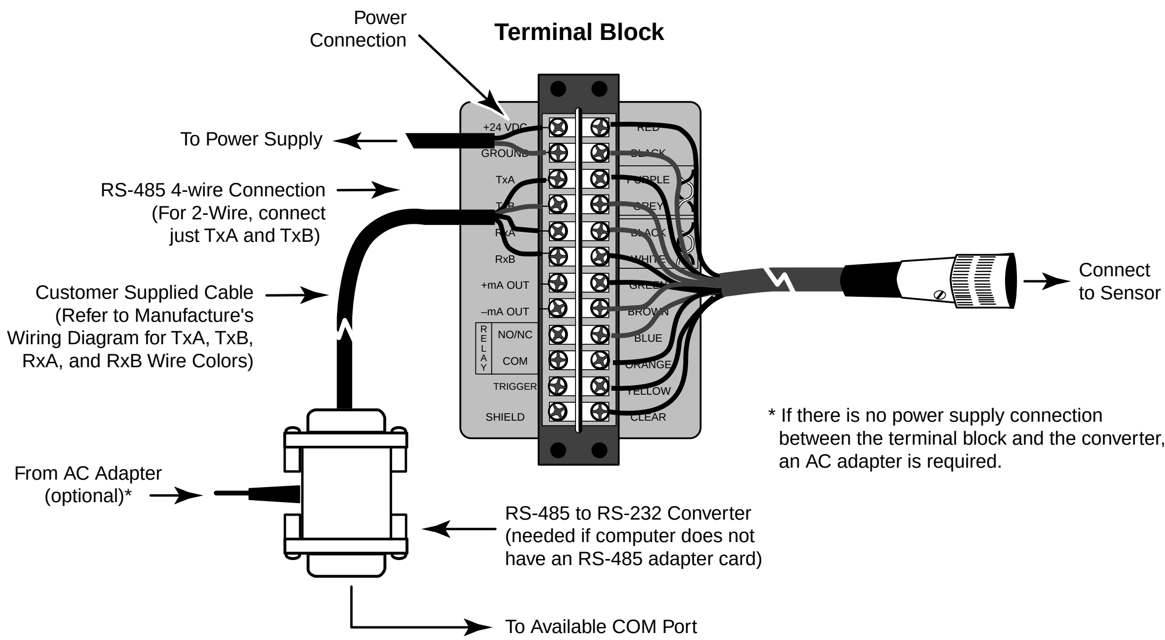

Figure 3-3: Wiring for 2-Wire Sensor Setup

VERY IMPORTANT

You must supply your own cable between the converter and terminal block. Purchase (from any computer parts supply store) a serial cable with a 25-pin female connector on one end and bare wires on the other. Make sure a wiring diagram is included with your purchase.

Note that the cable's RxA and RxB wires connect to the terminal block's TxA and TxB screws, and the cable's TxA and TxB wires connect to the terminal block's RxA and RxB screws.

After setting up your computer, complete the following steps to initialize and give each sensor a unique address:

1. Connect a sensor to the sensor cable.
2. Start the Network Communication Setup program. Click the Start button, select Programs, Raytek, and select Network Communication Setup. A screen similar to Figure 3-4 displays.

   Note: For demonstration or training purposes, this program can be run without sensors connected. To do so, start the program by clicking the Start button, select Run, and type the path and file name for the program along with the word, Demo. For example, if the program file is at C:\Programs, type on the command line, C:\Programs\Octopus.exe demo.

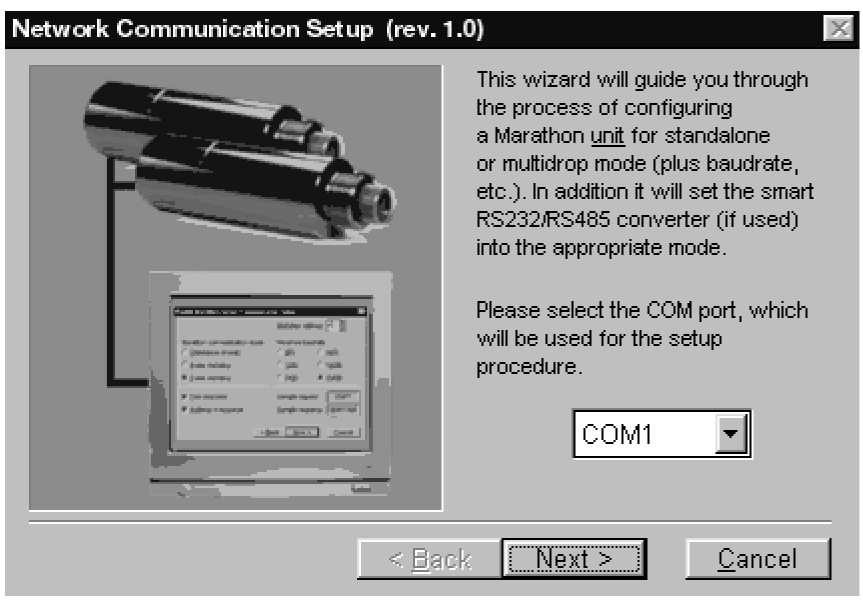

Figure 3-4: Communication Setup Screen

Select the appropriate COM port and click the Next button. The following screen displays (Figure 3-5).

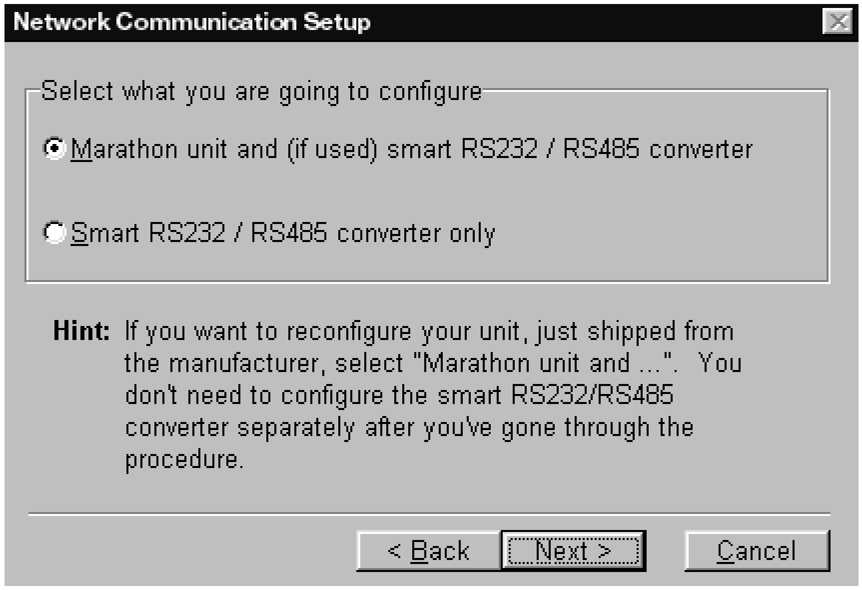

Figure 3-5: Communication Setup Screen 2

3. If you have a Marathon sensor attached, and you want to configure or reconfigure the unit, select “Marathon unit and (if used) smart RS-232 / RS-485 converter.” Click the Next button and a screen like Figure 3-6 displays.

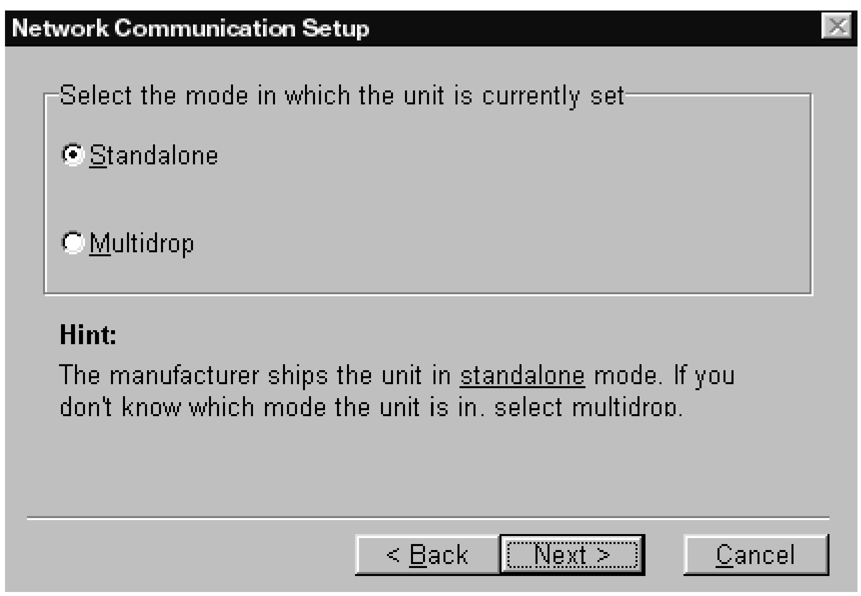

Figure 3-6: Standalone or Multidrop Selection Screen

If no sensor is connected and you have a smart RS-232 / RS-485 converter attached, and you want to configure the connection, select “Smart RS-232 / RS-485 converter only.” (After you click the Next button, follow the onscreen instructions to complete the configuration.)

As the “Hint” mentions, all units are shipped in Standalone mode.

4. For Multidrop installations, select Multidrop and click the Next button. A screen similar to Figure 3-7 displays.

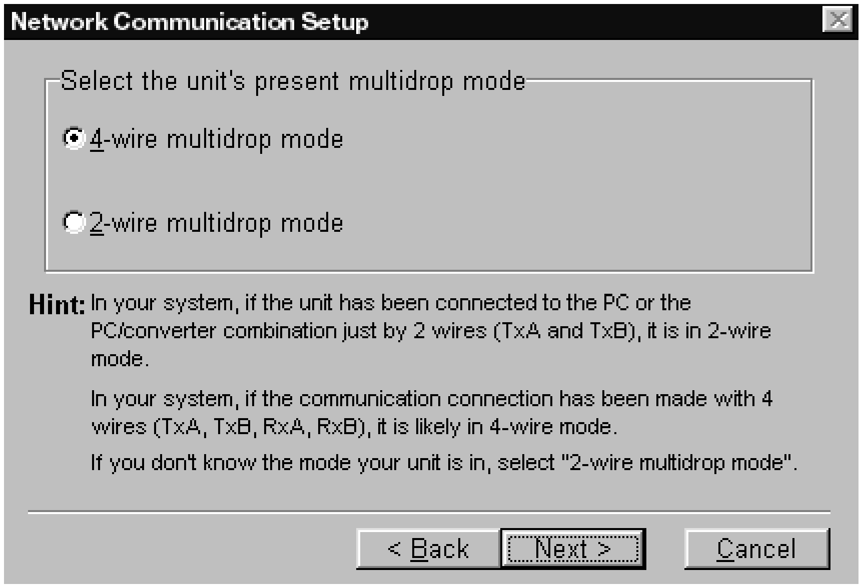

Figure 3-7: Multidrop Mode Screen

Sensors are shipped in 4-wire mode. If you are connecting the units to the computer using 4-wires, select “4-wire mulitidrop mode.” If you are using 2-wires, select “2-wire multidrop mode.” (To continue with a 2-wire multidrop installation, go to Section 3.2.3.) After you make your selection, click the Next button.

Note: Sensors in a 2-wire multidrop environment cannot be put in burst mode.

5. If you selected “4-wire multidrop mode,” you are shown a wiring diagram to verify the attached sensor is wired correctly (Figure 3-8). If this is correct, click Next.

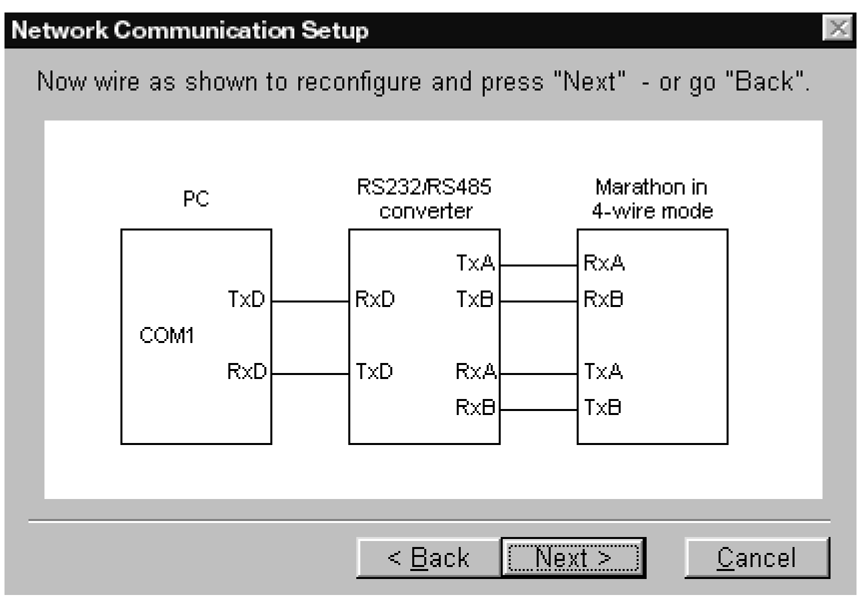

Figure 3-8: 4-Wire Wiring Diagram

6. On the sensor's back panel is a switch that is labeled "S" and "A." The next screen (Figure 3-9), prompts you to make sure the switch is in the "A" position, and to check once more that power and all connections are secure. If everything is correct, click the Next button.

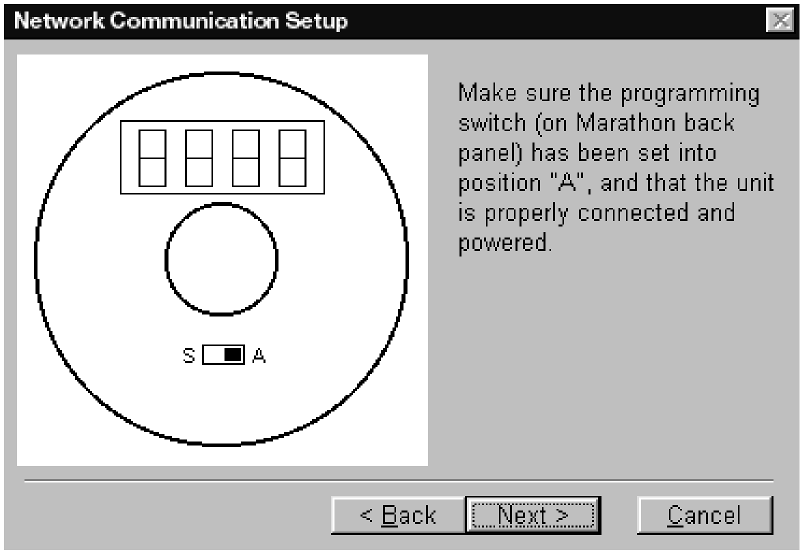

Figure 3-9: Switch Selection / Verification Screen

7. Now you can set the attached sensor's address (Figure 3-10). Select a number, making sure it is not one used by another sensor on the multidrop network. Select the desired communication mode, the desired baud rate, and if you want the multidrop address in the response. Click the Next button.

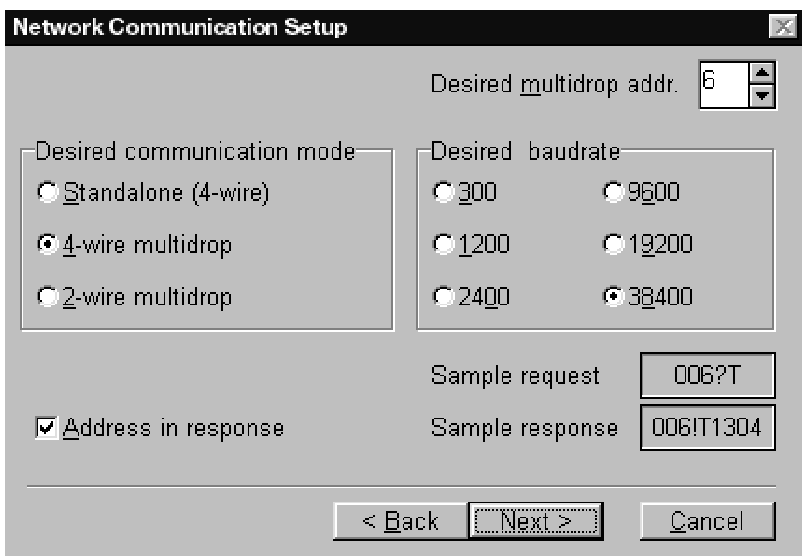

Figure 3-10: Address Selection Screen

Notes: If you check "Address in response," the sensor's multidrop address will be included in the data stream (see Sample response, above). This allows for easy checking of data in printouts or on the monitor when using custom monitoring programs..
Setting a sensor's multidrop address to 0 returns it to a non-multidrop (standalone) mode.

8. This complete the 4-wire multidrop setup procedure. If you have more sensors to configure, disconnect the sensor you just set up and connect the next one, then click on the Repeat button, as shown in Figure 3-11. Repeat the process in the order that displays.

Figure 3-11: Repeat or Exit Screen

3.2.3 Preparing the Sensors for a 2-Wire Multidrop Installation

If you chose “2-wire multidrop mode” in step 4 of Section 3.2.2, continue with the following instructions:

1. After you click on the Next button a screen similar to Figure 3-12 displays.

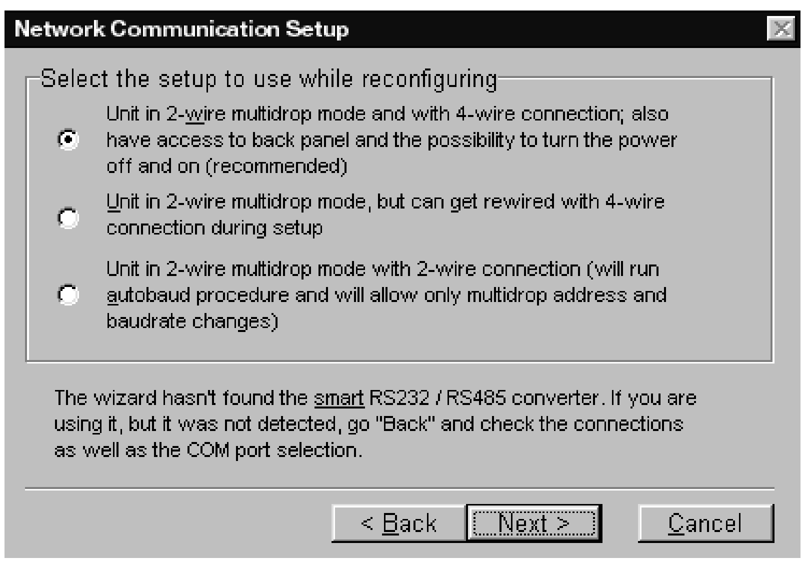

Figure 3-12: 2-Wire Setup Screen

Make a selection based on your current communication wiring setup and click the Next button.

2. Depending on the selection you make, a screen showing how the wiring should be displays (similar to Figure 3-13). Follow the directions and click the Next button.

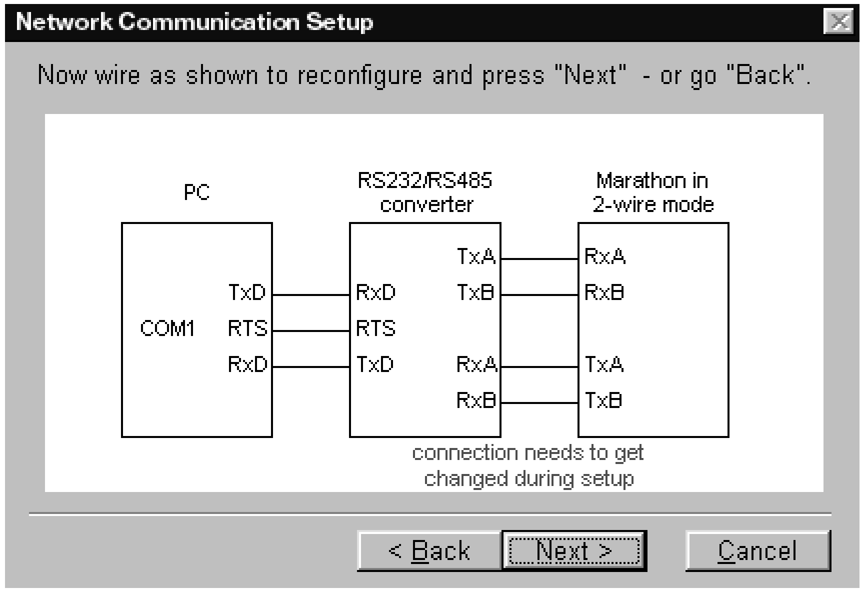

Figure 3-13: 2-Wire Setup Wiring Diagram Screen

3. The remaining steps are similar to those listed in Section 3.2.2 (steps 6 through 8), and you will be returned to the “Repeat or Exit” screen (Figure 3-11).

   Some additional steps may display if you selected “Unit in 2-wire multidrop mode with 2-wire connection.” The screens are self-explanatory. Complete those steps to return to the “Repeat or Exit” screen.

3.3 MULTIDROP MECHANICAL INSTALLATION

After all preparations are complete and each sensor is properly set up, mechanical installation can proceed. Be sure all appropriate communication, electrical, water, and air connections to each sensor are in place.

3.3.1 Mounting 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 (refer to Part 1). If you are installing the sensor in a ThermoJacket accessory, you should use the appropriate mounting device. (Refer to Part 1 for an overview of ThermoJacket accessories.) 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.

NOTICE

If you are installing two or more sensors in a multi-drop configuration, or if you plan to add to or more sensors at a later date, refer to Part 3 for information on multi-drop installations.

3.3.2 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 (Figure 2-11). (Note that the target appears upside down.)

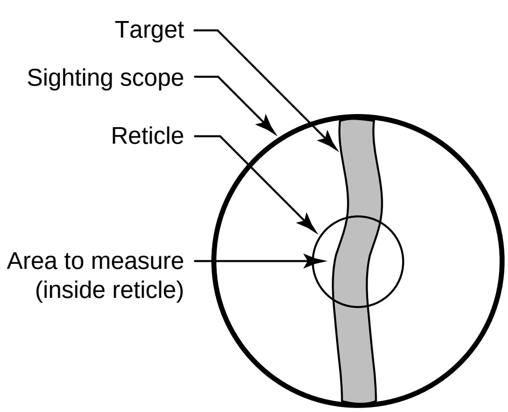

Figure 2-11: Sensor Eyepiece and Reticle

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.

3.4 MULTIDROP ELECTRICAL INSTALLATION

The following sections explain the terminal block, RS-232 / RS-485 connections, power, communications, and sensor wiring for 2-wire and 4-wire multidrop installations.

IMPORTANT

Each sensor must have its own cable, terminal block (supplied with sensor cables), and power supply. Only one RS-485 cable is necessary from the computer to the first 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 3-14

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

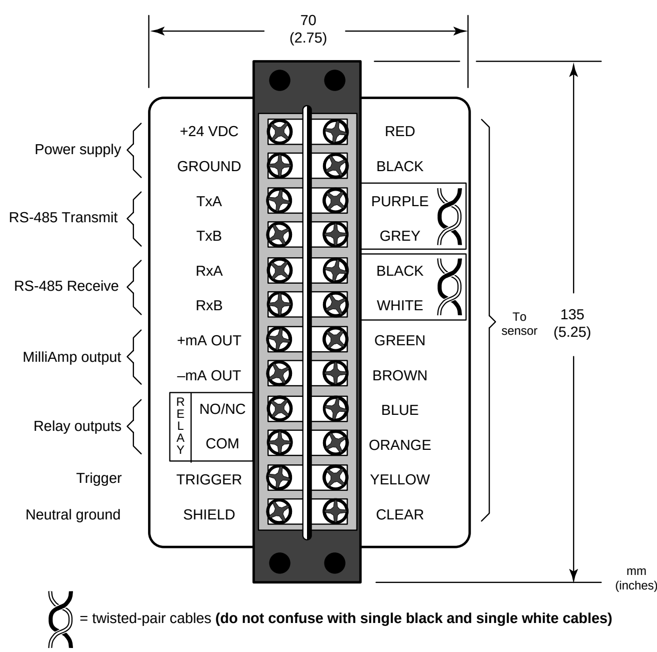

Figure 3-14: Terminal Block

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 2-12 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.)**

WARNING

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

Note: 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, IP 65).

IMPORTANT

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 meters (200 feet) or less. RS-485 cables can be extended up to 1200 meters (4000 feet).

Avoid installing the sensor cable in noisy electrical environments such as around electrical motors, switch gear, or induction heaters. In these environments, it is recommended to install the cable in conduit. Note that the sensor head is designed to fit conduit directly.

3.4.1 Power

Connections from a 24 VDC (250 mA or higher) power supply attach to the first two terminals on the terminal strip (as shown in Figure 2-3).

IMPORTANT

Isolation is provided only when used with the appropriate Raytek supplied power supply accessory.

3.4.2 RS-485 Interface Converter

To connect to a computer's RS-232 port, you need the Interface Converter accessory (Figure 3-15) and the proper RS-232 cable. If your computer has an RS-485 interface card, you can connect directly to its port (using the proper connector) with the sensor cable or with wiring from the terminal block.

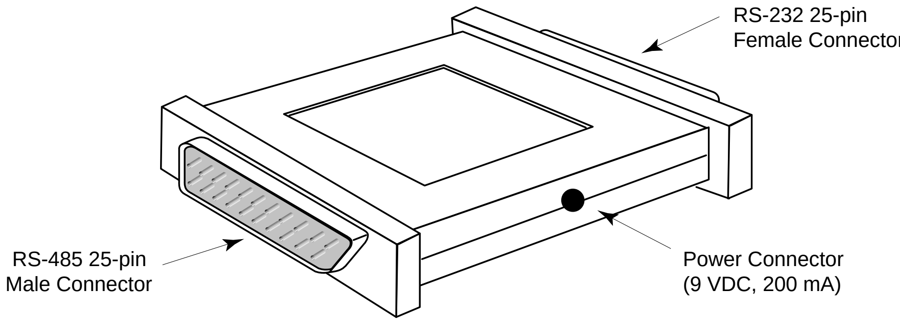

Figure 2-4: RS-485 to RS-232 Interface Converter

The interface converter has a 25-pin male (RS-485) and 25-pin female (RS-232) connector. Figure 3-16 shows the various RS-232 and RS-485 connections.

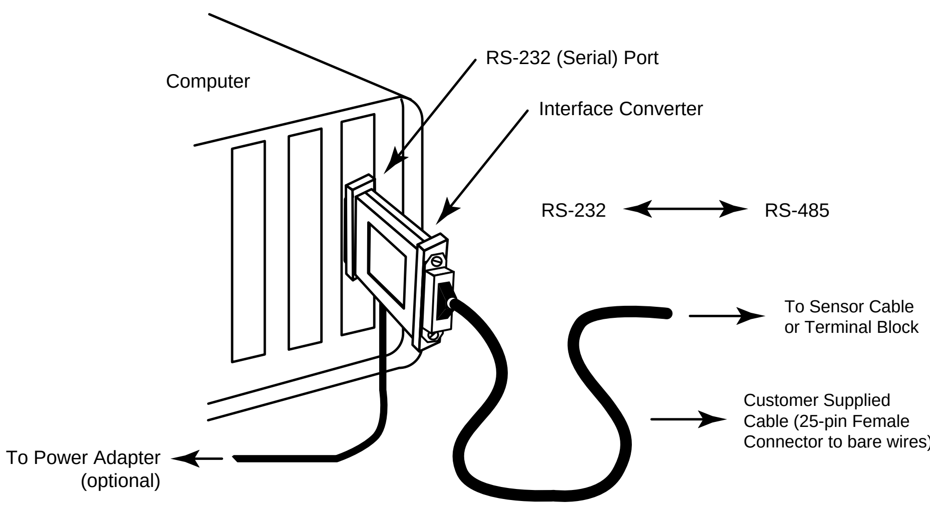

Figure 2-5: RS-485 to RS-232 Conversion and Computer Connection

NOTICE

You must supply your own cable between the converter and terminal block. Purchase (from any computer parts supply store) a serial cable with a 25-pin female connector on one end and bare wires on the other. Make sure a wiring diagram is included with your purchase.

Note that the cable's RxA and RxB wires connect to the terminal block's TxA and TxB screws, and the cable's TxA and TxB wires connect to the terminal block's RxA and RxB screws.

Note: Personal computers can have up to 4 serial ports (RS-232 connections). These are listed as COM1, COM2, COM3, and COM4. Usually COM1 and COM2 are the only physical connections on the back of the computer.

Connect the interface converter to an available COM port on your computer. If your computer has a 9-pin serial connector, use a 25-pin to 9-pin adapter between the interface converter and the computer.

IMPORTANT

On older computers the COM1 port is used by a pointing device (mouse, trackball, etc.), and sometimes the COM2 port is connected to an external modem or fax/modem (an internal modem can also be set to use COM2). It is possible for two devices to share an interrupt (COM1/COM3 or COM2/COM4); however, they cannot be used at the same time or your system might "crash." You can connect the RS-232 cable to the same port as, for instance, your modem, but you need to make sure the modem is inactive while you use the sensor.

The RS-485 output is as follows:

Baud Rate: 300, 1200, 2400, 9600, 19200, 38400 (default)
Note: Adjustable baud rate only available through 2-way RS-485.
Data Format: 8 bits, no parity, 1 stop bit
Two-wire half-duplex or four-wire full duplex, point-to-point

For a full description of the RS-485 output string, see Appendix B.

WARNING

If you are using the converter's optional power adapter, note the following: After connecting the serial cables, attach the adapter plug into the converter BEFORE plugging the AC adapter into an AC outlet.

3.4.3 Milliamp Output

The milliamp output is an analog output you can connect directly to a chart recorder or other recording device.

The analog output resolution for A and B models is 1°C or 1°F, C model is 1 °C or 2°F.

The analog output corresponds to either the 2-color or 1-color readings on the display.

Note: The mA output can be forced to a specific value, underrange, or overrange with a 2-way RS-485 command. See Appendix B for details. This feature is useful for testing or calibrating connected equipment.

3.4.4 Relay Outputs

The relay output is used as an alarm for failsafe conditions or as a setpoint relay. (Refer to Section 4.2 for failsafe information.) Relay outputs relate to the currently displayed temperatue on the LED display.

Note: Since the way you use the relay outputs depends on the application, check with your sales representative for the best way to use this feature.

The relay can be set to either NO (Normally Open) or NC (Normally Closed) with a 2-way RS-485 command depending on compatibility requirements of connected equipment. The relay can be forced on or off via 2-way RS-485 for testing connected equipment. See Appendix B for details.

3.4.5 2-Wire Electrical Installation

Each sensor cable is wired to its own terminal block. For multidrop installations,the RS-485 terminals on each terminal block are wired together in parallel as shown in Figure 3-17, below.

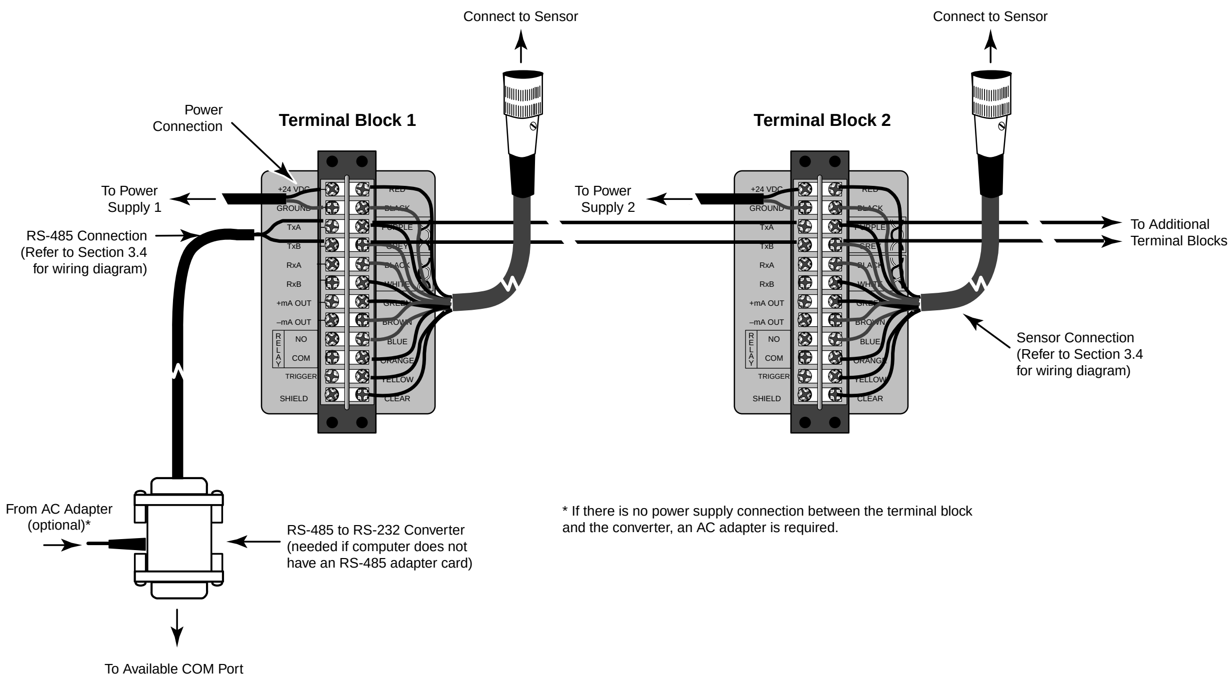

Figure 3-17: 2-Wire Multidrop Wiring

NOTICE

Be aware that you, the user, must supply your own RS-485 cable from the terminal block to the RS-485 to RS-232 converter.

Be sure to connect the correct wires to the terminal block's TxA and TxB screw terminals. (Make sure the cable you purchase includes a wiring diagram.)

3.4.6 4-Wire Electrical Installation

For a 4-wire multidrop installation, each sensor cable is wired to its own terminal block. The RS-485 terminals on each terminal block are wired in parallel as shown in Figure 3-18, below.

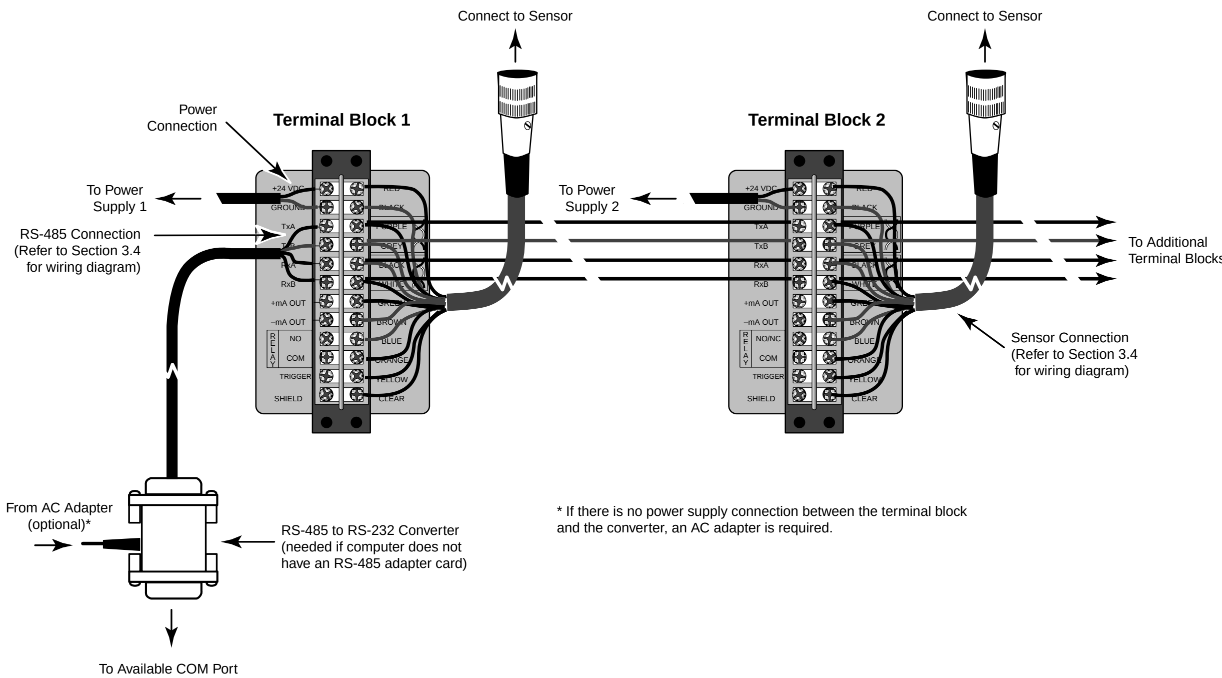

Figure 3-18: 4-Wire Multidrop Wiring

For setting up milliamp and relay outputs, refer to Sections 3.3.4 and 3.3.5.

The software you received with your sensor, besides the Network Communication Setup program described earlier in this section, includes a Sensor Network Setup and Display program (for monitoring temperatures of up to 32 sensors), a Graphic Setup and Display program (for configuring sensor parameters and monitoring processes for one or two sensors), a Chat program (for communicating directly to a sensor from your computer terminal), and a Field Calibration program. All but the Field Calibration program are described in Part 4 (Field Calibration is explained in Appendix D).

3.5 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 Graphic Setup and Display program is supplied with your sensor and is covered in Part 4. You can also create custom programs using the communications protocols listed in Appendix B.

IMPORTANT

Make sure air, water, power, and computer connections are secure.

Avoid taking temperature measurements in bright sunlight. Also, be aware targets with low temperatures (below the sensor's range) and low emissivities may not register correctly.

3.5.1 The Control Panel

The control panel is normally locked in multidrop mode but may be unlocked through software. (Refer to Appendix B for software protocols.)

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. Besides displaying the current temperature, the LED can display slope (2-color) or emissivity (1-color), the peak hold setting, and the average temperature.

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 LEDs to be visible, is available as an option. (You cannot use the polarizing filter with this option.)

Figure 3-1 is an overview of the sensor's control panel. It is made up of four button-style switches, seven LEDs, a 4-digit display panel, and a sighting scope. These are defined in the following sections.

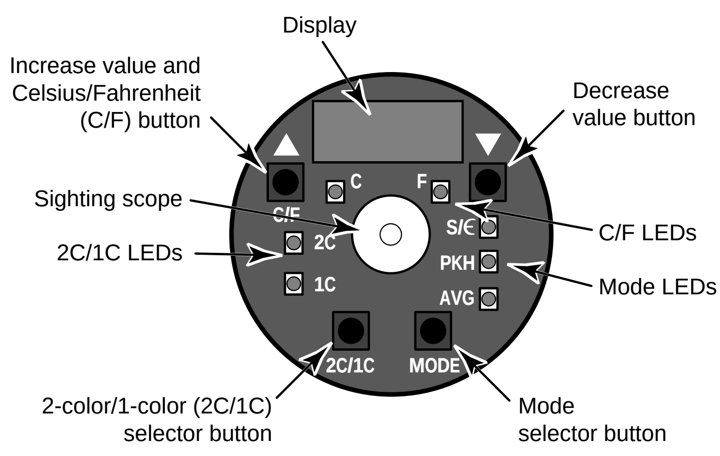

Figure 2-6: Control Panel

3.5.2 Set-Up

To begin setting up the sensor, first make sure all connections are secure, then turn on the power supply. **Allow the sensor to warm up for 15 minutes before making control panel adjustments.** (You can also set up remotely through the 2-way RS-485 connection. Refer to Appendix B.)

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 2-7 illustrates the sequence of operation for the mode selector button when in current temperature mode.

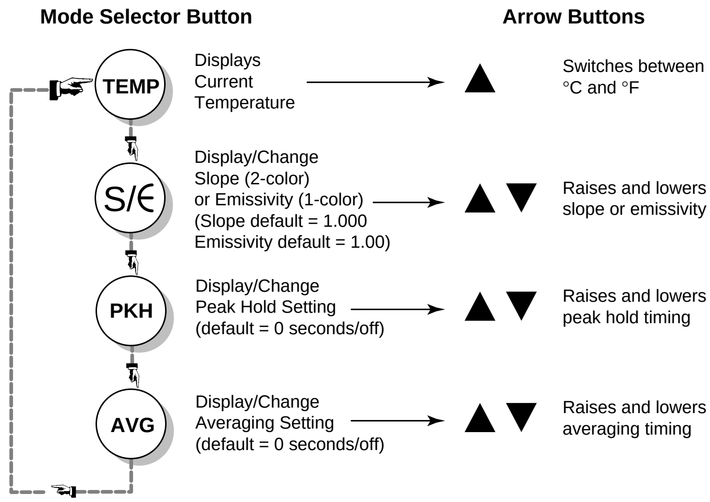

Figure 2-7: Mode Selector Button Sequence

Note: *When the PKH mode is active (PKH LED lit), the Mode Selector cycle skips AVG (TEMP to E to PKH back to TEMP). When the AVG mode is active (AVG LED lit), the Mode Selector cycle skips PKH (TEMP to E to AVG back to TEMP).*

To change the settings for each mode using the control panel is simple. The following sections define each of the control panel's features and functions and explains sensor setup and use. Section 2.4.2.5 explains how to reset the factory defaults. Note that all modes can be changed from a computer using controlling software such as the supplied Utilities program.

WARNING

Do not connect, disconnect, or change wiring while the power is on.

3.5.2.1 2-Color/1-Color Operation

The first setting you need to make is selecting whether to make 2-color or 1-color temperature measurements. Because you purchased this particular unit, you will probably use the 2-color feature. However, if the target completely fills the field of view and there are no obstructions, you can use 1-color temperature measurement. (Refer to Appendix B to estimate the correct emissivity setting.)

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. (Figure 3-1 shows the location of the 2C / 1C selector.)

Note: Switching affects the LED display and analog out but not the RS-485 out. Switching between 1C and 2C can also be done with a 2-way RS-485 command. See Appendix A for details.

Lockout Mode

The sensor has a remote locking feature that keeps the unit from being accidentally changed from the control panel. (Lockout is the default when in multidrop mode.) This lockout mode denies access to all the switches on the control panel. It is available through the RS-485 connection and can be unlocked only by a command from the remote computer. See Appendix B for details.

3.5.2.2 Modes

Pressing the mode selector button (Figure 3-1) cycles you through the four operating modes (as shown in Figure 3-2): temperature display mode, Slope / Emissivity display and adjustment mode, Peak Hold output display and adjustment mode, Average output display and adjustment mode, and back to the temperature display mode.

Temperature

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 RS-485 output for both target and internal temperatures.

Slope/Emissivity

The slope is an adjustment that compensates for the differences in the emissivity of the two spectral ranges. 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 slope is preset at the factory at 1.000, and the emissivity is preset at 1.00. For information on determining an unknown emissivity, and for sample emissivities, refer to Appendix B.

You can set the unit up for either 2-color or 1-color measurements. The 2C / 1C selector button on the control panel switches between the two functions. One of the red LEDs above the button, labeled 2C and 1C, will show what function is active.

For 2-color measurements—You need to set the slope for the material being measured. To set the slope, do the following:

1. **Press the Mode button until the S/∈ LED is lit.**

   The current slope value shows on the display.
2. **Press the ▲ or ▼ (UP or DOWN) button to change the value.**
3. **Press the Mode button several times until the temperature LED indicator is lit.**

   The displayed temperature will now be based on the new slope value.

IMPORTANT

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:

- Cobalt
- Iron
- Stainless Steel
- Steel
- Nickel

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

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

Molten iron also has an approximate slope setting of 1.060.

Unknown Slope—To measure the temperature of objects or materials that are not listed above, you will have to set the slope by doing the following (make sure the 2C LED is lit):

1. **Take the temperature of the target's surface.**

   Use a reliable contact or probe thermometer. If you have to measure several areas on the target, use the average of the temperatures for the following steps.
2. **Aim the unit at the target.**
3. **Press the Mode button until the S/∈ LED is lit.**

   The current slope value shows on the display.
4. **Press the ▲ or ▼ (UP or DOWN) button to change the value.**
5. **Press the Mode button several times until the C or F LED indicator is lit.**

   Compare the displayed temperature to that of the contact or probe thermometer's. If they are not the same, repeat steps 3 through 5 until they are.

Emissivity—When using the 1-color feature you have to set the emissivity, if necessary. The emissivity is preset at the factory at 1.00. If this is acceptable for the type of surface you are measuring, no adjustment is necessary. However, if you are unsure of the target's emissivity, refer to Appendix B, which lists the emissivities of many metals and non-metals. If the material you want to measure is not listed, Appendix B also shows how to determine an unknown emissivity.

To change the unit's emissivity setting, complete the following (make sure the 1C LED is lit):

1. **Press the Mode button until the S/∈ LED is lit.**

   The current emissivity value shows on the display.

2. **Press the ▲ or ▼ (UP or DOWN) button to change the value.**
3. **Press the Mode button several times until the temperature LED is lit.**

   The displayed temperature will now be based on the new emissivity value.

Note: Slope and emissivity can also be adjusted with a 2-way RS-485 command. See Appendix A for details.

Peak Hold (PKH)

Peak Hold can be useful when a peak temperature reading is desired. For example, use Peak Hold when the background temperature between discrete targets is less than that of the target. Figure 3-21 illustrates the Peak Hold output signal.

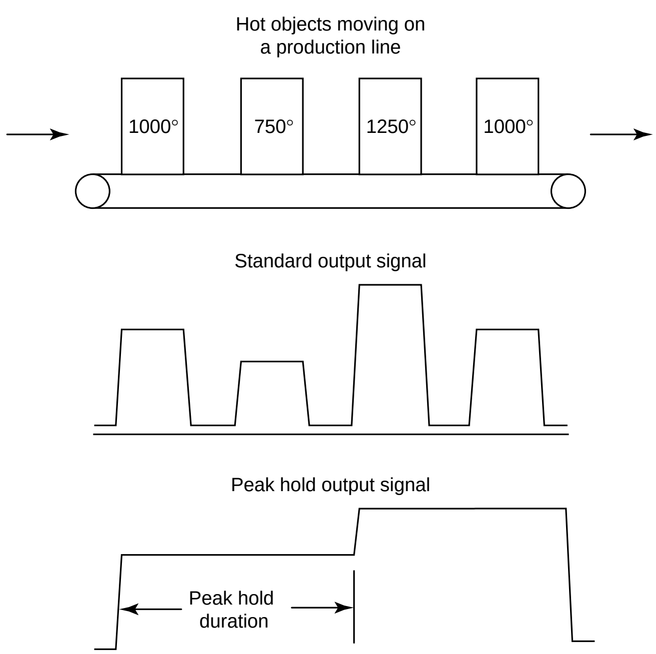

Figure 3-21: Peak Hold Output Signal Example

When you activate Peak Hold, the instrument monitors the maximum temperature seen over a predetermined time interval (duration). Should the unit measure a temperature higher than the one it is presently displaying, it immediately updates the display and starts a new time interval. On the other hand, should it see no temperature above the one presently displayed, it will hold this value until the duration expires, at which time it will update to a new value equal to the highest temperature seen at the time the interval expired. If the unit measures an intermediate temperature before measuring ambient, and if the last object has passed, the unit will display and output the intermediate value for one more duration before ambient is finally displayed. Figure 3-21 illustrates this function. This algorithm prevents large changes in output, a desirable feature for controller applications.

To set and activate Peak Hold, do the following:

1. **Press the Mode button until the PKH LED is lit.**
2. **Press the ▲ (UP) button to both set and activate.**

   The display reads in 0.1 seconds. Set Peak Hold from 0 to 299.9 seconds. If Peak Hold is set to 300.0 seconds, a hardware reset is needed to trigger another reading.
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. Note that Averaging (AVG) cannot be used concurrently. To deactivate Peak Hold, push the MODE button until only the PKH LED indicator is lit and reset to 0 by pushing the ▼ (DOWN) button.

Note: Peak Hold can also be adjusted with a 2-way RS-485 command. See Appendix B for details.

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. Figure 3-22 illustrates the Averaging output signal.

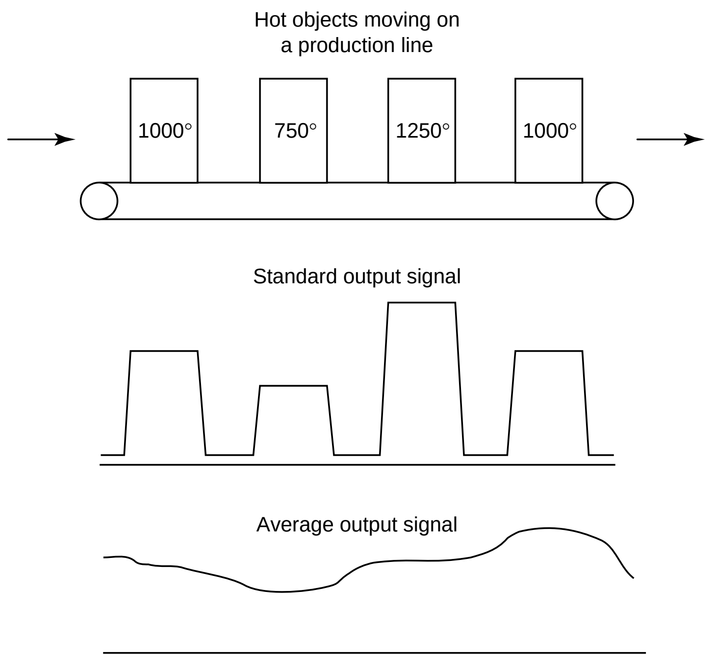

Figure 3-22: Averaging Output Signal Example

The averaging algorithm simulates a first order low pass RC filter whose time constant can be adjusted to match the user’s averaging needs.

To set and activate Average, do the following:

1. **Press the Mode button until the AVG LED is lit.**
2. **Press the ▲ (UP) button to both set and activate.**

   The display reads in 0.1 seconds. Set Average anywhere from 0 to 300 seconds (to set the time constant of the first order, low-pass filtering).
3. **Press the Mode button until the C or F LED is lit.**

   If Average has been activated, the Average LED will stay lit.

Once Average is set above 0, it is automatically activated. Peak hold cannot be used concurrently. To deactivate Average, push the MODE button until only the Average LED indicator is lit and reset to 0 by pushing the ▼ (DOWN) button.

Notes: Average can also be adjusted with a 2-way RS-485 command (only works in Setup mode). See Appendix B for details.

Average is not available in Fast (FST) Mode.

3.5.2.3 Setpoint

The Setpoint is deactivated by default (alarm mode). Activating and adjusting the Setpoint is accomplished through software. Refer to Appendix B for information on the sensor's communication protocols.

Once the Setpoint is activated the corresponding relays change state as the current temperature passes the setpoint temperature.

3.5.2.4 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. Refer to Appendix D for information on the sensor's communication protocols. Figure 3-23 is an example of the Deadband around a Setpoint temperature of 960°C (1760°F).

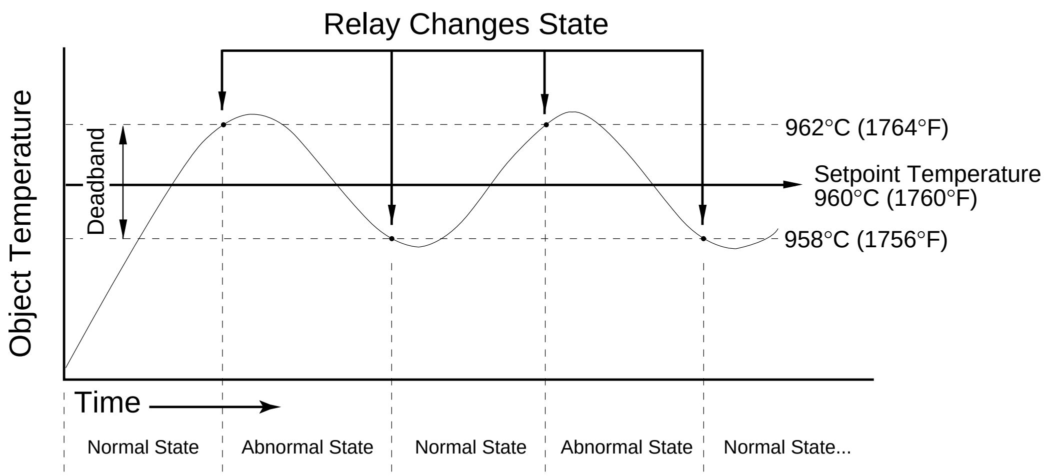

Figure 3-23: Deadband Example

3.5.2.5 Resetting Factory Defaults

To globally reset the unit to its factory default settings, make sure the unit is in Setup mode (SET LED is lit) and press the ▲ and ▼ buttons (up and down arrows) at the same time for approximately 2 seconds.

The factory defaults are listed in Part 1, Section 1.5.

Note: Resetting Factory Defaults can also be done with a 2-way RS-485 command. See Appendix B for details.

Part 4 Marathon Support Software Installation & User Guides

This section explains the installation and operation of the Marathon Support Software included with your sensors. The Graphic Setup and Display, Sensor Network Setup and Display, and Chat programs can be used in multidrop sensor environments. The Graphic Setup and Display and Marathon Chat programs can be used in non-multidrop environments.

Topics include...

- Installation
- Graphic Setup and Display User Guide
- Sensor Network Setup and Display User Guide
- Marathon Chat Program User Guide

SOFTWARE INSTALLATION

The software that came with your Marathon sensor(s) consists of five separate programs. These include the Network Communications Setup (multidrop only–covered in Part 3), the Graphic Setup and Display, the Sensor Network Setup and Display (displays temperatures and alarms for up to 32 sensors), the Chat program (direct communications between the user and the sensor), and the Field Calibration program (covered in Appendix D).

Note: You can also create your own custom programs for your application by using the communications protocols listed in Appendix B.

IMPORTANT

If you installed your sensors in a multidrop environment using Part 3 as a guide, you have already installed all necessary software. Skip the following steps.

To install the software on a personal computer running Windows 95, Windows 98, or Windows NT 4.0 (Service Pack 3), complete the following steps:

1. Put Disk 1 in your floppy drive.
2. Click on the Start Button and select Run.
3. Type A:\Install and press the Return/Enter key.
4. Follow the installation instructions.

All necessary programs are installed in the Raytek program group.

4.0 MARATHON SUPPORT SOFTWARE PROGRAMS

The following sections explain how to use the Graphic Setup and Display, Sensor Network Setup and Display, and Marathon Chat programs that are included in the software that came with your sensor. These programs are installed along with the Network Communication Setup program described in Part 3.

Note: For demonstration or training purposes, the Graphic Setup and Display and the Sensor Network Setup and Display programs can be run without sensors connected. This is described in the following sections.

4.1 GRAPHIC SETUP AND DISPLAY PROGRAM

The Graphic Setup and Display program allows you to change parameter values and to monitor, both digitally and graphically, one or two Marathon sensors.

To start the program, Click the Start menu, select Programs and the Raytek Program Group, then select Graphic Setup and Display from the list of files. When the program starts you first see a screen similar to Figure 4-1.

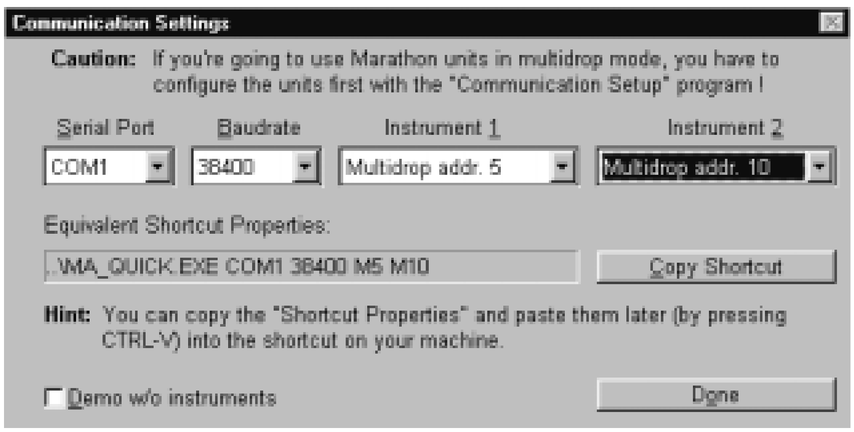

Figure 4-1: Communication Settings Screen

Choose the appropriate Serial Port and Baud rate, then select any one or two instruments attached to the sensor network. As the cautionary note states, using the sensors in multidrop mode requires them to have been preconfigured with the Network Communication Setup program as described in Part 3 (multidrop installations only).

For demonstration or training purposes when no sensors are attached, you can select the check box, Demo w/o instruments.

Click on the Done button when ready.

Note: If you don't plan to change settings, you can create a shortcut that will load the set configuration and proceed directly to the main screen (Figure 4-2). This will bypass the communication setup screen (Figure 4-1) and start the program faster. Use the Copy Shortcut button, then Paste the shortcut properties into the Graphdsp.exe file's properties (shortcut tab).

The main screen can display the parameters of one or two sensors (as shown in Figure 4-2). Any Marathon 1-color standard or 2-color ratio thermometer can be displayed concurrently as long as they are on the same sensor network. For example, Figure 4-2 shows an MR1F 2-color fiber optic ratio thermometer on the left and an MA2S 1-color instrument on the right.

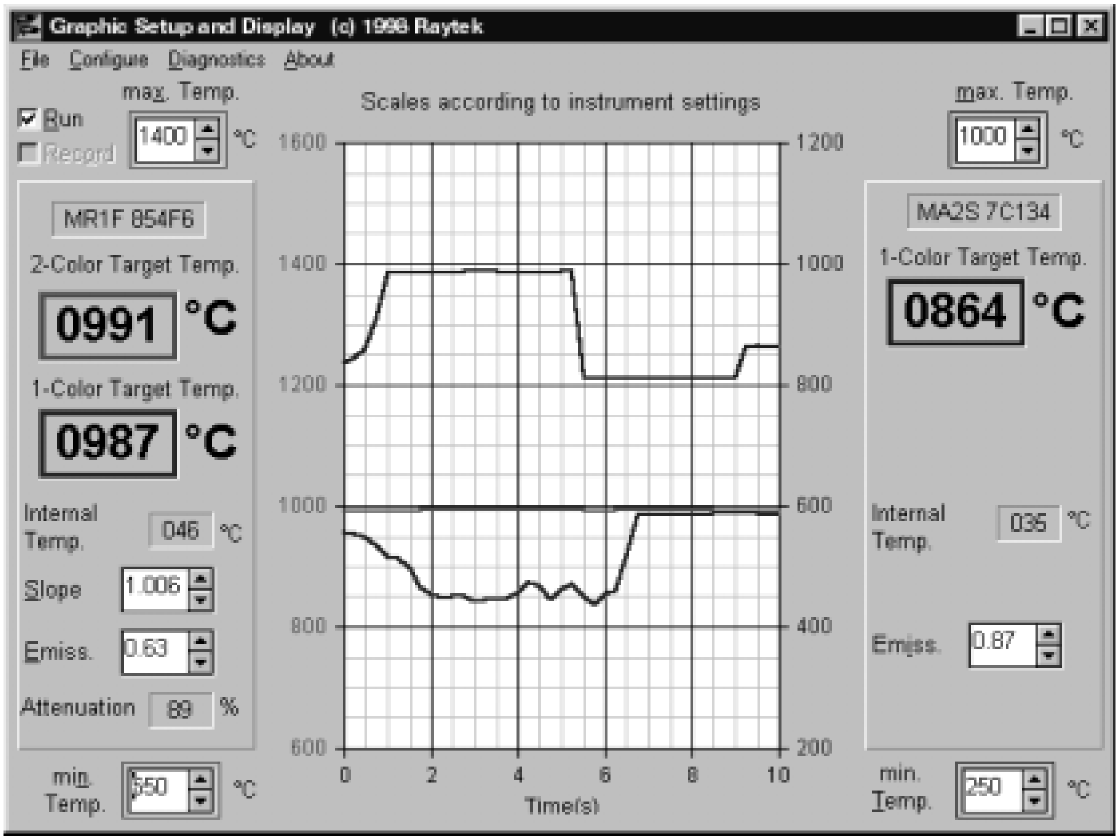

Figure 4-2: The Graphic Setup and Display Main Screen

Parameters you can change from the main screen include the maximum and minimum displayed temperatures and the emissivity and / or slope of each instrument.

The colored squares show the currently measured temperature, and the graph displays temperatures over a period of time.

The menus at the top of the screen include File, Configure, and Diagnostics, as shown in Figure 4-3, and About.

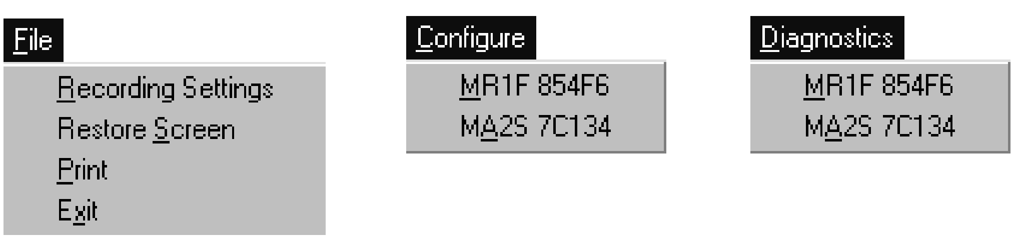

Figure 4-3: The Menus

The File menu is made up of the following:

Recording Settings–allows you to record the incoming data stream at an interval you select (Figure 4-4). Double clicking the large square or clicking the button brings up a standard Windows file menu listing where you can name a file to record to. When you have completed the necessary tasks, click on the Done button.

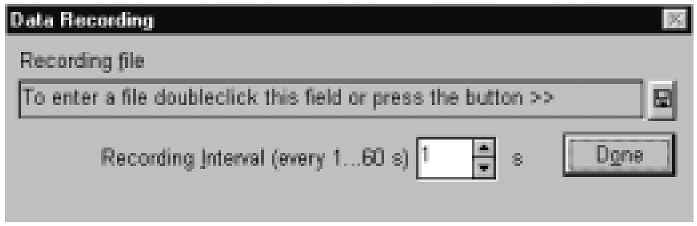

Figure 4-4: Data Recording

Restore Screen–lets you restore the screen to its original appearance after resizing.

Print–allows you to make a hardcopy printout of the display. The printouts can be used as records of parameter settings and / or temperature displays.

Exit–exits the program.

CONFIGURE

When you pull down the Configure menu, you will see one or two selections showing the sensor(s) being monitored by the Quick Start program. If you select one of the sensors, a screen similar to Figure 4-5 displays. Current sensor settings display on the right side of the screen.

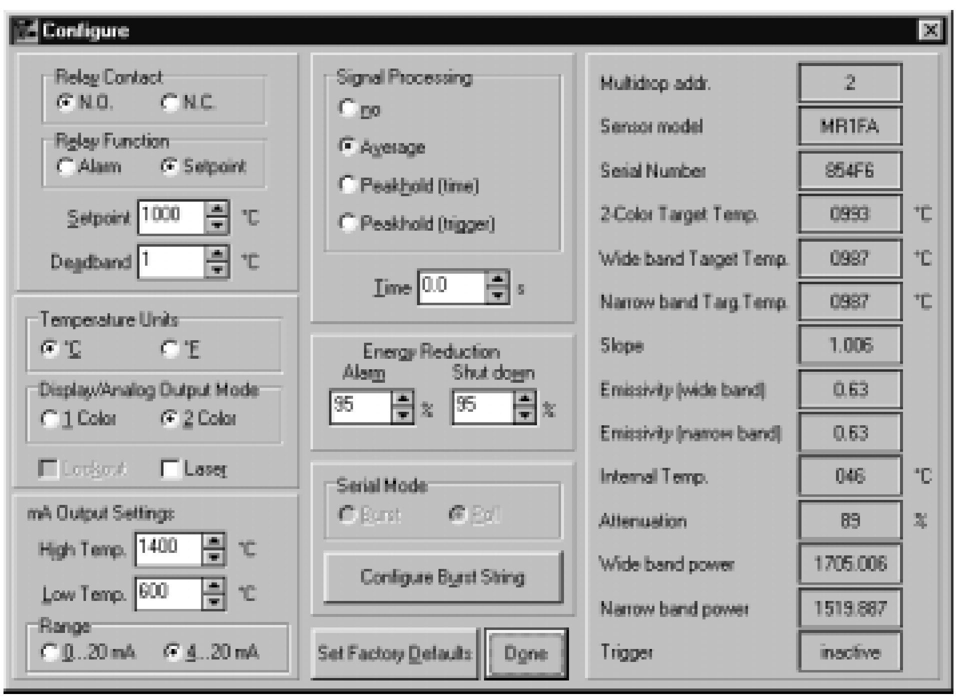

Figure 4-5: Sensor Configuration Screen

Relay Contact–You can set the relay contact to N.O. (Normally Open) or N.C. (Normally Closed). If it is set to N.O., when the relay is triggered (as with an alarm or setpoint), it will close. The opposite is true when set to N.C.

Relay Function–can be set to Alarm or Setpoint. With an alarm you can have an alarm alert you when the temperature goes above or below the maximum or minimum temperatures or for any other failsafe condition (as explained in Appendix A). When you select Setpoint two additional selection windows open where you can choose a setpoint temperature and a deadband range. The setpoint can be your optimum process temperature, and the deadbanc can be the allowable temperature range above and below the setpoint. If the temperature goes beyond a deadband value, the sensor can trip an external function and / or notify you through an external alarm. For more information on Setpoint and Deadband, refer to the appropriate sections in Part 2 or Part 3.

Temperature Units–allows you to set the unit and software to display °C or °F.

Display/Analog Output Mode–You only have this choice when using Marathon 2-color ratio thermometers, which can be switched between 1-color and 2-color temperature measurement modes. Use 1-color mode only if the sensor has an unobstructed view of a target and only if the target completely fills the field of view. Also, if using 1-color mode, the sensor should not be in an area where the lens can get contaminated with dirt, steam, smoke, or moisture. Only when the sensor is in 2-color mode can accurate temperature measurements be taken in these circumstances.

Lockout–Select this box if you need to disable (lockout) the buttons on the sensor's control panel. With this selected, the sensor cannot be changed except through software. This makes sure no accidental changes are made to the sensor and that there is no chance of tampering while the instrument is on the process line. Sensors set up in a multidrop network are automatically locked. (It is recommended that you do not unlock multidropped sensors.) Note that this program doesn't allow you to unlock multidrop sensors. If you need to unlock them, use the CHAT program.

mA Output Settings–You can set the High Temp. (20 mA output) and / or Low Temp. (0 or 4 mA), if necessary, to temperatures appropriate for your process.

Range–allows you the choice of setting the sensor's mA output to select a range from 0 to 20 mA or 4 to 20 mA.

Signal Processing–lets you select no signal processing, averaging (which is timed), peak hold with a timer, or peak hold that is triggered. If you select Average or Peak hold (time) a time number box displays where you can set the averaging time constant or how long peak hold should be held. If you select Peak hold (trigger), an external trigger connected to the sensor is used to cut off peak hold. Note that the averaging time constant controls how fast the sensor responds to a fast change in target temperature.

Energy Reduction–Marathon sensors are unique in that they will send an alarm, or completely shut down, if the infrared signal to their detectors drops below 95% (default setting). With this program you can change the Alarm and Shut down percentage to a figure better suited to your process.

Serial Mode–The interface has two modes of operation: Poll and Burst. These are defined in Appendix B, Section B.2.1 If you select Burst mode, you also have the ability to select sensor output parameters to display and / or record by clicking the Configure Burst String button. If you click the button, a screen similar to Figure 4-6 displays. Note that this screen's contents vary depending on the sensor model.

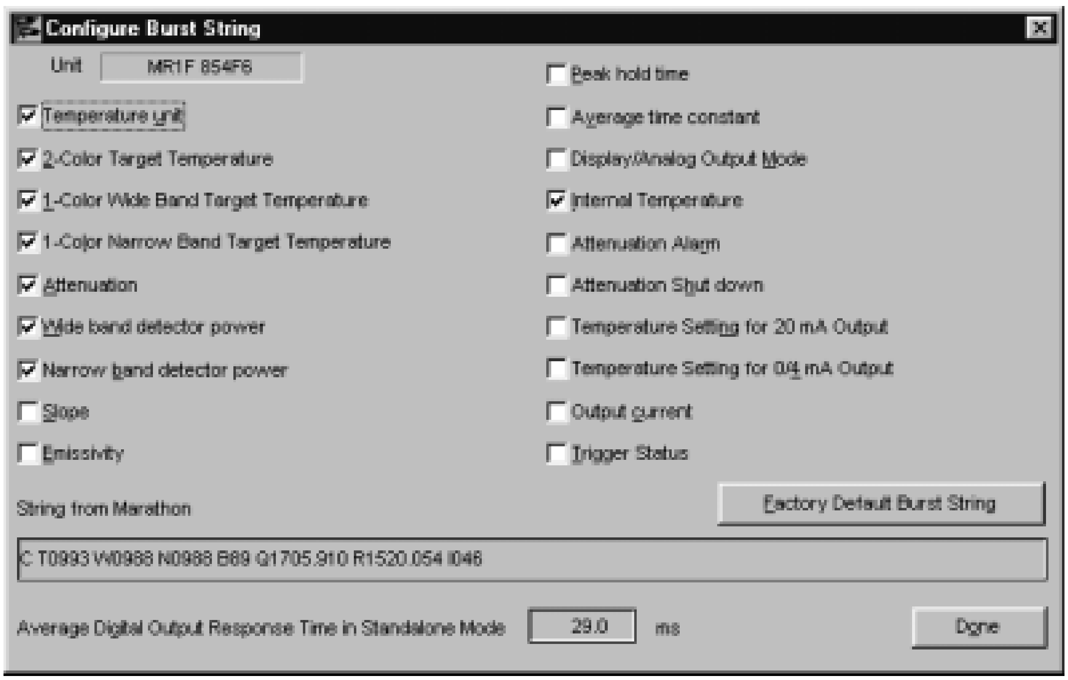

Figure 4-6: Configure Burst String Window

Each checked item adds to the burst string and displays in the space at the bottom of the window. Also displayed is the millisecond average response time of the digital output signal (in standalone mode). This figure is an estimate and will vary depending on the baud rate.

After you make your selections, click on the Done button, and you will be returned to the Sensor Configuration Screen. To return to the factory settings, click the Factory Default Burst String button.

Set Factory Defaults–Any changes you have made to the Configure screen can be returned to the factory settings by clicking on the Set Factory Defaults button.

Done–After making changes, click on the Done button. You will be returned to the Main screen.

DIAGNOSTICS

When you pull down the Diagnostics menu, you will see one or two selections showing the sensor(s) being monitored by the Graphic Setup and Display program. If you select one of the sensors, a screen similar to Figure 4-7 displays. The diagnostics functions allow you to perform simple checks on the sensor's output and relay.

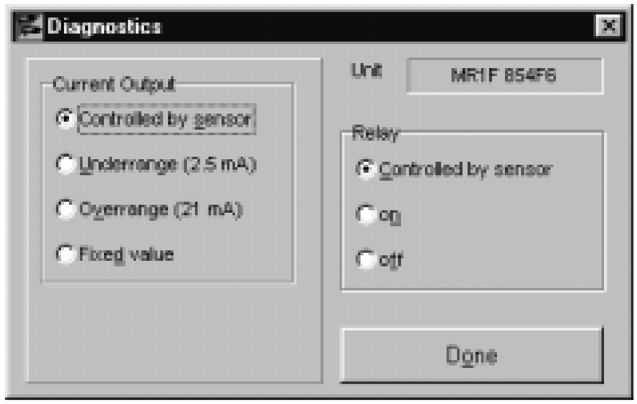

Figure 4-7: Diagnostics Window

4.2 SENSOR NETWORK SETUP AND DISPLAY PROGRAM

The Multidisplay program gives you the ability to setup and/or monitor up to 32 sensors, 16 to a screen. The program can be run two ways: supervisor mode and operator mode. Supervisor mode allows setup changes and operator mode allows only monitoring capabilities.

To start the program, Click the Start menu, select Programs and the Raytek Program Group, then select either Sensor Network Setup and Display (supervisor mode) or Sensor Network Display (operator mode) from the list of files. When the program starts you first see a communication setup screen similar to Figure 4-8.

Figure 4-8: Sensor Network Communication Setup

Select the appropriate com port and baudrate, and, if setting up for demonstration or training purposes, select Demo w/o inst, and click the Done button. A screen similar to Figure 4-9 displays (steel mill example).

Note that you can create a shortcut that will preload the connection parameters and proceed directly to the main screen, or you can run this program from the Start/Run command line. This will bypass the Sensor Network Setup and Display screen and start the program faster. Valid parameters are COM1, COM2, 300, 1200, 2400, 9600, 19200, or 38400, SETUP, and DEMO. For example, GRAPH.DSP COM1 19200 starts the program using COM 1 at 19200 baud. If you add SETUP on the command line, the program will run the initial setup screen. If you enter GRAPH.DSP DEMO, the program runs in demo mode (no sensors attached).

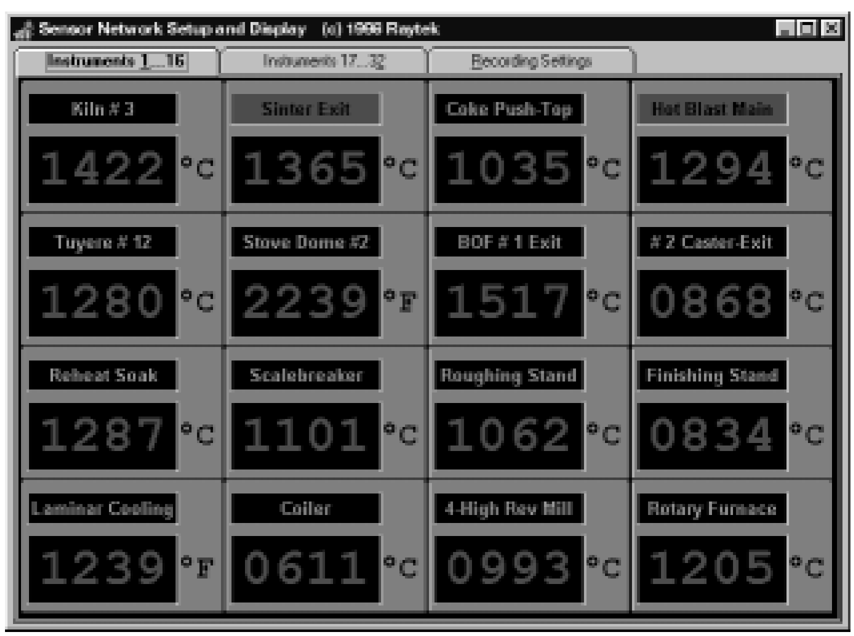

Figure 4-9: Sensor Network Setup and Display Main Screen

At the top of the 16 temperature displays are three tabs. By clicking on a tab, the screen associated with that tab displays. The first two tabs are for temperature displays, as shown in Figure 4-9 on the previous page, with up to 16 sensors on each page. The third tab is for recording settings. If you click on the Recording Settings tab, a screen similar to Figure 4-10 displays.

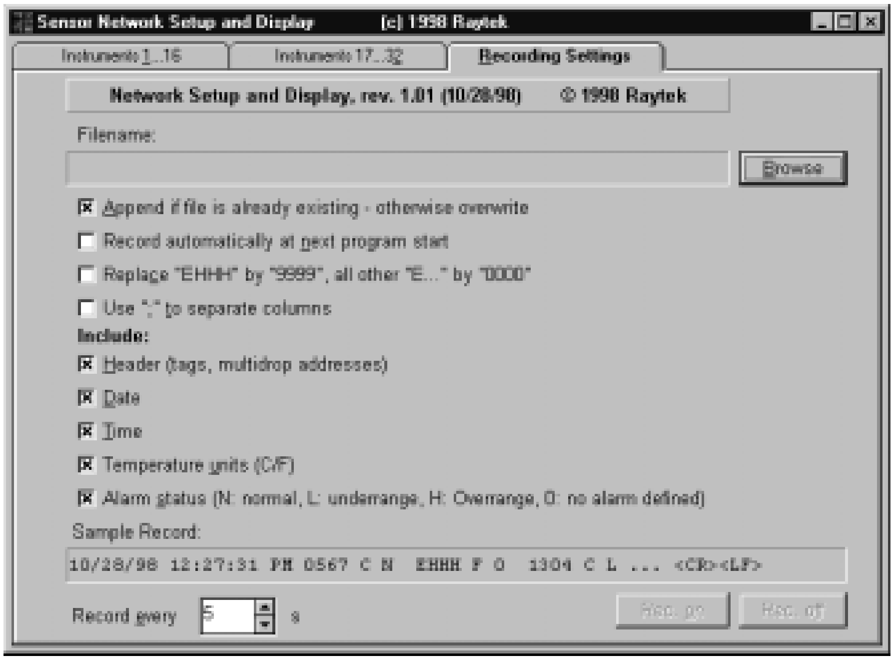

Figure 4-10: Recording Settings Screen

The program will automatically record all temperatures displayed on the first two screens. You may omit or include explanatory information (header, date and time, C or F, or alarm status) by clicking the appropriate check boxes. Use the Browse button to name the file and select a location to store it, and click on the Rec. on button to start recording. The recording function creates a standard ASCII text file that can be printed as is, using the Windows Notepad or another text editor, or you can import the text file into a spreadsheet program such as Excel™.

A sample text file, using the checked selections in Figure 4-10, would display like Figure 4-11.

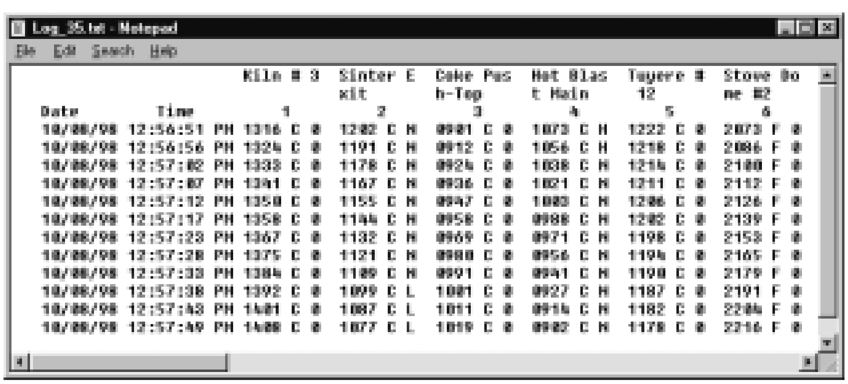

Figure 4-11: Recording Example

Any of the sensor displays under the Instruments tabs can be clicked on to open a Configure screen similar to Figure 4-12.

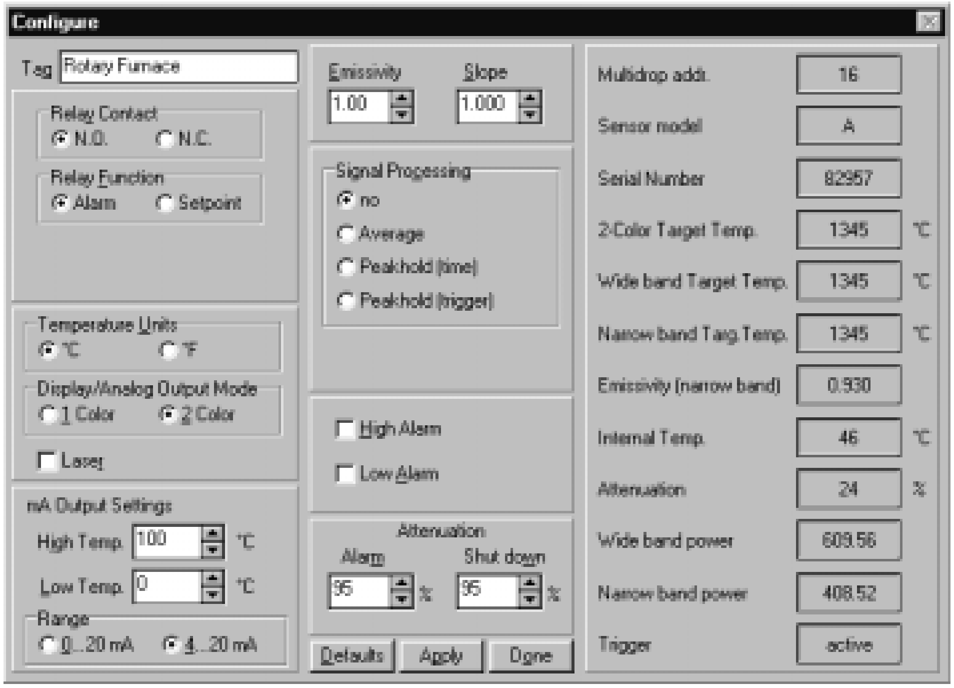

Figure 4-12: Configure Screen

Each sensor display shows only temperature, temperature unit, and, if alarms are set, they'll blink red or green to show if they are above or below the alarm ("soft" alarm, not a relay function). The Configure screen is made up of the following:

Tag–The tag is an area where you can name each sensor to help identify it. This is helpful if you have a number of sensors spread out through a plant or at different areas of a process.

Relay Contact–You can set the relay contact to N.O. (Normally Open) or N.C. (Normally Closed). If it is set to N.O., when the relay is triggered (as with an alarm or setpoint), it will close. The opposite is true when set to N.C.

Relay Function–can be set to Alarm or Setpoint. With an alarm you can have an alarm alert you when the temperature goes above or below the maximum or minimum temperatures or for any other failsafe condition (as explained in Appendix A). When you select Setpoint two additional selection windows open where you can choose a setpoint temperature and a deadband range. The setpoint can be your optimum process temperature, and the deadbanc can be the allowable temperature range above and below the setpoint. If the temperature goes beyond a deadband value, the sensor can trip an external function and / or notify you through an external alarm. For more information on Setpoint and Deadband, refer to the appropriate sections in Part 2 or Part 3.

Temperature Units–allows you to set the unit to display °C or °F.

Display/Analog Output Mode–You only have this choice when using Marathon 2-color ratio thermometers, which can be switched between 1-color and 2-color temperature measurement modes. Use 1-color mode only if the sensor has an unobstructed view of a target and only if the target completely fills the field of view. Also, if using 1-color mode, the sensor should not be in an area where the lens can get contaminated with dirt, steam, smoke, or moisture. Only when the sensor is in 2-color mode can accurate temperature measurements be taken in these circumstances.

mA Output Settings–You can set the High Temp. (20 mA output) and / or Low Temp. (0 or 4 mA), if necessary, to temperatures appropriate for your process.

Range–allows you the choice of setting the sensor's mA output to cover a range from 0 to 20 mA or 4 to 20 mA.

Emissivity/Slope–You can change the emissivity and / or slope of an instrument by clicking on the up and down arrows or by entering a new number in the box. Changing these values are necessary only if the target being measured requires it. Refer to Appendix E for sample emissivities for metals and non-metals. Note that Slope is only available for 2-color ratio instruments.

Signal Processing–lets you select no signal processing, averaging (which is timed), peak hold with a timer, or peak hold that is triggered. If you select Average or Peak hold (time) a time number box displays where you can set the averaging time constant or how long peak hold should be held. If you select Peak hold (trigger), an external trigger connected to the sensor is used to cut off peak hold. Note that the averaging time constant controls how fast the sensor responds to a fast change in target temperature.

High Alarm/Low Alarm–Selecting one or both of these check boxes allows visual monitoring of each unit if it goes above or below an alarm level. When you select a check box, a numeric control pops up allowing you to set the alarm level. This is independent of relay. The name (tag) on a temperature display will blink either red or green depending on the condition. If there is an alarm condition on the second page of sensors, an alert (independent of relay alarm) pops up in the middle of the first page screen allowing you to immediately go the second page.

Attenuation–Marathon sensors are unique in that they will send an alarm, or completely shut down, if the infrared signal to their detectors drops below 95% (default setting). With this program you can change the Alarm and Shut down percentage to a figure better suited to your process.

After you make any configuration changes, click on the Apply or Done button. To switch the sensor back to its factory settings, click on the Default button.

DISPLAY INFORMATION

You can change the text and background colors for each temperature window, and the colors for the titles over each window (normal and flashing alarms) by clicking the right mouse button over the temperature display or text window.

4.3 MARATHON CHAT PROGRAM

The Chat program lets you control sensors through a command-line interface from your computer. You can enter data to change parameters for custom applications, and you can retrieve information for data analysis

To start the Chat program, Click the Start menu, select Programs and the Raytek Program Group, then select Marathon Chat from the list of files. When the program starts a screen similar to Figure 4-13 displays.

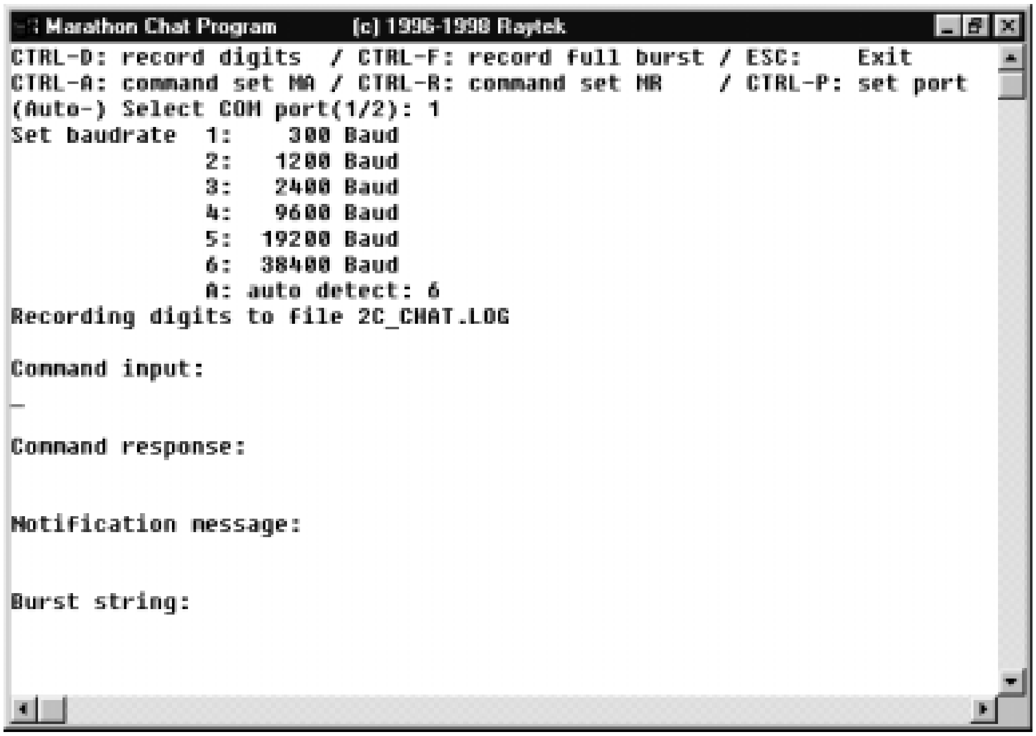

Figure 4-13: Chat Program Display

At the command line you can enter data to change the sensor's parameters. For a description and examples of the character set for command line entries, refer to Appendix B. You can also get a help screen listing of the character set by holding down the control key and typing A or R. The A gives you the character set for the Marathon MA series 2-way command set. The R gives you the character set for the Marathon MR series 2-way command set.

This program can also log incoming data from the sensor. This data is stored as text in a .log file. The log text is space delimited and can be imported into a spreadsheet program for graphing and analysis. To start recording of digits (temperature data), hold down the control key and press D. To stop recording, do the same. To record the sensor's full burst (all data), hold down the control key and press F. To stop recording, do the same.

The program logs everything it receives, but will only display command responses, reports of pushbutton activity, and lines containing transmission errors.

Appendices

The appendices consist of additional information to help you maintain and operate your Marathon infrared thermometer.

Topics include...

- Troubleshooting and Maintenance
- Programming Guide
- Object Emissivity
- DIN Connector Wiring
- Traceability of Instrument Calibration
- CE Conformity for European Community

APPENDIX A: TROUBLESHOOTING AND 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 on the Warranty / Copyright page at the beginning of this manual.

A.1 TROUBLESHOOTING MINOR PROBLEMS

Table A-1 lists common symptoms, their causes, and possible solutions. If you are experiencing a problem that is not listed below, please call our Service Department.

Table A-1: Troubleshooting

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 dirty	Clean the window (see Section 4.3)
Erroneous temperature	Wrong slope or emissivity	Correct the setting
Temperature fluctuates	Wrong signal processing	Correct Peak Hold or Average settings

A.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.

IMPORTANT

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. Table A-2 shows the values displayed on the LED display and transmitted over the 2-way interface.

Table A-2: Fail-safe Error Codes

CONDITION	2-COLOR	1-COLOR (WIDE BAND)	1-COLOR* (NARROW BAND)
Two-color temperature over range	EHHH	<temperature>	<temperature>
Wide band temperature over range	<temperature>	EHHH	<temperature>
Narrow band temperature over range	<temperature>	<temperature>	EHHH
Wide band detector failure	EHHH	EHHH	<temperature>
Narrow band detector failure	EHHH	<temperature>	EHHH
Two-color temperature under range	EUUU	<temperature>	<temperature>
Wide band temperature under range	<temperature>	EUUU	<temperature>
Narrow band temperature under range	<temperature>	<temperature>	EUUU
Energy too low	EUUU	<temperature>	<temperature>
Internal temperature over range	EIHH	EIHH	EIHH
Internal temperature under range	EIUU	EIUU	EIUU
Heater control temperature over range	ECHH	ECHH	ECHH
Heater control temperature under range	ECUU	ECUU	ECUU
Attenuation >95% ("dirty window")** (1)	<temperature>	<temperature>	<temperature>
Attenuation too high (>95%) (1)	EAAA	<temperature>	<temperature>

* Only available through RS-485
** Relay will go to "alarm" state
(1) Note that the activation levels for these conditions may be set to different values. (e.g., "dirty window" at 95%, EAAA at 98%)

When internal ambient temperature is requested, it is always transmitted, even if it is out of range. The analog output always corrensponds to the selected temperature displayed on the LEDs, as shown in Table 4-3.

Table A-3: Analog Outputs

SELECTED TEMPERATURE	0-20 mA ANALOG OUTPUT	4-20 mA ANALOG OUTPUT
Normal	Scaled to temperature	Scaled to temperature
EHHH	21 to 24 mA	21 to 24 mA
EUUU	0	2 to 3 mA
EIHH	21 to 24 mA	21 to 24 mA
EIUU	0	2 to 3 mA
ECHH	21 to 24 mA	21 to 24 mA
ECUU	0	2 to 3 mA
EAAA	0	2 to 3 mA

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. The dirty window is detected in either 1-color or 2-color mode.

Following are the priorities of the possible failsafe conditions:

1. Heater control temperature over range
2. Heater control temperature under range
3. Internal temperature over range
4. Internal temperature under range
5. Wide band detector failure
6. Narrow band detector failure
7. Energy too low
8. Attenuation too high (>95%)
9. Attenuation >95% ("dirty window")
10. Two-color temperature under range
11. Two-color temperature over range
12. Wide band temperature under range
13. Wide band temperature over range
14. Narrow band temperature under range
15. Narrow band temperature over range

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 LEDs 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 RS-485, their over and under range conditions are independent.

Examples of failsafe conditions:

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

   Outputs:

   LEDs: EUUU
   RS485:C T0999
   Analog: 2 to 3 mA
   Relay: Abnormal state

2. Two-color temperature is selected for display on LEDs. 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:

   LEDs: 1021
   RS485:C T1021 W0703 N0685
   Analog: Scaled to temperature, between 4 and 20 mA
   Relay: Abnormal state

A.3 CLEANING THE WINDOW

A moderately dirty window will generally not affect the sensor's accuracy in 2-color mode. However, dirt on the window will affect the 1-color reading. Also, if the window gets too dirty, the sensor cannot detect enough infrared energy to take an accurage reading, and it will enter a failsafe state. Therefore, regular cleaning of the sensor window is recommended.

Care should be taken when cleaning the window. To clean the window, do the following:

1. Lightly blow off loose particles.
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 window. 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.

A.4 CHANGING THE WINDOW

Sometimes extremely harsh environments can cause damage to the window. Replacement windows are available from the manufacturer. To order replacement windows, contact your local sales representative or distributor.

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.

WARNING

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

---

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.

APPENDIX B: PROGRAMMING GUIDE

This appendix explains the sensor's communication protocols. Use them when writing custom programs for your applications or when communicating with your sensor(s) with the Chat program.

B.1 INTRODUCTION

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. See Table B-1 for details.

Note: If the unit is in multidrop mode and you have checked the "Address in Response," the 3-digit address will be sent out before the exclamation mark.

For a change in the setting of a parameter (number 2, above), 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.

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
- An "out-of-range" parameter value
- A value entered in the incorrect format (see Table B-1)
- Lower case character(s) entered (all characters must be upper case)

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 (see the end of this appendix for information on Poll and Burst modes). The response is faster at higher baud rates. Contact your sales representative if you need further details for higher baud rates.

IMPORTANT

All commands must be entered in upper case (capital) letters. Also note that leading and trailing zeros are necessary. Examples: send E=0.90, not E=0.9; send P=001.2, not P=1.2.

B.2 PROTOCOLS DESCRIPTION

Table B-1 describes the commands available for 2-way communications.

Table B-1: Protocols

DESCRIPTION	CHAR	MR	MA	FORMAT (2)	P (1)	B (1)	S (1)	N (1)	LEGAL VALUES	MR FACTORY DEFAULT	MA FACTORY DEFAULT
Burst string format	$	√	√	(3)	√		√		(3)	UTSI	UTEI
Show list of commands	?	√	√		√						
Soft jumper		√	√		√		√			off	off
Measured attenuation	B	√	√	nn	√	√			00 to 99		
Baud rate (5)	D	√	√	nnn	√		√		003=300 baud 012=1200 baud 024=2400 baud 096=9600 baud 192=19200 baud 384=38400 baud	38400	38400
Emissivity	E	√	√	n.nn	√	√	√		0.10–1.00	1.00	1.00
Average time (4)	G	√	√	nnn.n	√	√	√	√	000.0–300.0 sec	000.0	000.0
Top of mA range	H	√	√	nnnn	√	√	√	√	0000-9999 (°C or °F)	High end of sensor range	High end of sensor range
Sensor internal ambient	I	√	√	nnn	√	√					
Switch panel lock	J	√	√	X	√		√		L=Locked U=Unlocked	Unlocked	Unlocked
Relay alarm output control	K	√	√	n	√		√		0=off 1=on 2=Normally Open 3=Normally Closed	2	2
Bottom of mA range	L	√	√	nnnn	√	√	√		0000-9999 (°C or °F)	Low end of sensor range	Low end of sensor range
Mode–MR series	M	√		n	√	√	√	√	1=1-color 2=2-color	2	
Mode–MA series	M		√	X	√	√	√	√	S=Setup mode F=Fast mode		S
Target temp–1-color narrow	N	√		nnnn	√	√					
Output current	O	√	√	nn		√	√		00=controlled by unit 02=under range 21=over range 00–20=current in mA	00	00

Notes:
(1) Commands may appear as **P**olled for (queried), **B**urst string item, **S**et command, or **N**otification.
(2) n = number, X = uppercase letter.
(3) See Section B.2.2.
(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 B-1 (continued): Protocols

DESCRIPTION	CHAR	MR	MA	FORMAT (2)	P (1)	B (1)	S (1)	N (1)	LEGAL VALUES	MR FACTORY DEFAULT	MA FACTORY DEFAULT
Peak hold time (3)	P	√	√	nnn.n	√	√	√	√	000.0–300.0 sec	0000.0	0000.0
Power MR series: wide power MA series: power	Q	√	√	nnnn.nnn	√	√			0000.000–9999.999		
Narrow power	R	√		nnnn.nnn	√	√			0000.000–9999.999		
Slope	S	√		n.nnn	√	√	√	√	0.850–1.150	1.000	
Target Temperature MR series: 2-color MA series: 1-color	T	√	√	nnnn	√	√			(4)		
Temperature units (scale)	U	√	√	X	√	√	√	√	C or F	Foreign: C US: F	Foreign: C US: F
Poll/burst mode	V	√	√	X			√		P+Polled B=Burst	Burst	Burst
Target temp: 1-color wide	W	√		nnnn	√	√			(4)		
Burst string contents (5)	X$	√	√		√						
Multidrop address	XA	√	√	nnn	√	√	√		000 to 032	000	000
Low temperature limit	XB	√	√	nnnn	√				0000–9999 (4)	Set at factory calibration	Set at factory calibration
Deadband (6)	XD	√	√	nn	√		√		01–55 in °C 01–99 in °F	02	02
Restore factory defaults	XF	√	√				√	√			
High temperature limit	XH	√	√	nnnn	√				0000–9999 (4)	Set at factory calibration	Set at factory calibration
Sensor initialization	XI	√	√	n	√	√	√	√	0=flag reset 1=flag set or nothing	1	1
Laser	XL		√	X	√		√	√	0=off (7) 1=on H=overheat (off) N=no laser built in		0
Sensor model type	XM	√	√	X	√				A, B, C	Set at factory calibration	Set at factory calibration

Notes:
(1) Commands may appear as **P**olled for (queried), **B**urst string item, **S**et command, or **N**otification.
(2) n = number, X = uppercase letter.
(3) Setting Peak Hold cancels Average, and vice-versa. 300.0 means reset an external trigger.
(4) In current scale, °C or °F.
(5) See Section B.2.2.
(6) No effect if relay in alarm mode.

Table B-1 (continued): Protocols

DESCRIPTION	CHAR	MR	MA	FORMAT (2)	P (1)	B (1)	S (1)	N (1)	LEGAL VALUES	MR FACTORY DEFAULT	MA FACTORY DEFAULT
0-20 mA or 4-20 mA analog output	XO	√	√	n	√		√		0=0–20 mA 4=4–20 mA	4	4
Sensor revision	XR	√	√	Xn	√					Set at factory calibration	Set at factory calibration
Setpoint/Relay function	XS	√	√	nnnn	√		√		0000 to 5432 (3)	0000	0000
Trigger	XT	√	√	n	√	√		√	XT0=inactive XT1=active		
Identify unit	XU	√	√	varies	√					!XUMR1S !XUMR1F	!XUMA1S !XUMA2S
Sensor serial number	XV	√	√	Xnnnnnn	√					Set at factory calibration	Set at factory calibration
Attenuation to activate relay (4)	Y	√		nn	√	√	√		0 to 95% energy reduction	95%	
Attenuation for failsafe	Z	√		nn	√	√	√		0 to 99% energy reduction	95%	

Notes:
(1) Commands may appear as **P**olled for (queried), **B**urst string item, **S**et command, or **N**otification.
(2) n = number, X = uppercase letter
(3) 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.
(4) Relay goes to abnormal, display and analog out continue to provide temperature. See Appendix A.

Table B-2: Command Examples

DESCRIPTION	EXAMPLES FROM HOST		EXAMPLES FROM UNIT		WHERE USED (1)			
	QUERY	SET	RESPONSE	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		001D=384	001!D384				√	
Emissivity	001?E	001E=0.95	001!E0.95	001#E0.95	√	√	√	√
Average time	001?G	001G=001.2	001!G001.2	001#G001.2	√	√	√	√
Top of mA range	001?H	001H=2000	001!H2000		√	√	√	
Sensor internal ambient	001?I		001!I028		√	√		
Switch panel lock	001?J	001J=L	001!JL		√		√	
Relay alarm output control		001K=0	001!K0		√		√	
Bottom of mA range	001?L	001L=1200	001!L1200		√	√	√	
Mode–MR series	001?M	001M=1	001!M1	001#M1	√	√	√	√
Mode–MA series	001?M	001M=F	001!MF	001#MF	√	√	√	√
Target temp–1-color narrow	001?N		001!N1158		√	√		
Output current		001O=10	001!O10		√	√	√	
Peak Hold time	001?P	001P=005.6	001!P005.6	001#P005.6	√	√	√	√
Power	001?Q		001!Q0036.102		√	√		
Narrow Power	001?R		001!R0002.890		√	√		
Slope	001?S	001S=0.850	001!S0.850	001#!S0.850	√	√	√	√
Target Temperature MR series: 2–color MA series: 1-color	001?T		001!T1225		√	√		
Temperature units	001?U	001U=C	001!UC	001#UC	√	√	√	√
Poll/Burst mode		001V=P	001!VP				√	
Target Temp: 1–color wide	001?W		001!W1210		√	√		
Burst string contents	001?X$				√			
Multidrop address	001?XA	001XA=013	001!XA013		√	√	√	
Low temperature limit	001?XB		001!XB0300		√			
Deadband	001?XD	001XD=12	001!XD12		√		√	
Restore factory defaults		XF	001!XF	001#!XF			√	√
High temperature limit	001?XH		001!XH1400		√			
Sensor initialization	001?XI	001XI=0	001!XI0	001#XI	√	√	√	√
Laser	001?XL	001XL=1	001!XL1	001#XL1	√		√	√
Sensor Model Type	001?XM		001!XMA		√			
0-20 mA or 4-20 mA analog output	001?XO	001XO=4	001!XO4		√		√	
Sensor revision	001?XR		001!XRF1		√			
Setpoint/Relay function	001?XS	001XS=1234	001!XS1234		√		√	
Trigger	001?XT		001!XT0	001#XT0	√	√		√
Identify unit	001?XU		001!XUMA1S		√			
Sensor serial number	001?XV		001!XVA099901		√			
Attenuation to activate relay	001?Y	001Y=95	001!Y95		√	√	√	
Attenuation for failsave	001?Z	001Z=99	oo1!Z99		√	√	√	

Note:
(1) Commands may appear as **P**olled for (queried), **B**urst string item, **S**et command, or **N**otification.

B.2.1 Poll Versus Burst Modes

The interface has two modes of operation: Poll and Burst. Either mode can be selected by the host.

Poll: 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.

Burst: The unit transmits the user-defined output string (continuously, at the selected baud rate), which may contain all of the parameters except for those noted in Section B.2.2. Parameters may also be polled for while the instrument is in burst mode. The poll string will be inserted in the burst-mode stream.

B.2.2 The Burst Mode

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 (scale)
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 / 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
- Setpoint
- Deadband
- Current Output Mode (0–20 mA / 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>:

C T1250 Q0400.023 E1.00 G005.5 H1400 <CR><LF>

The default string is as follows: C T1234 E1.00 I025 <CR><LF>

The string for fast mode is as follows: 1234 <CR><LF> (where 1234 is the displayed temperature)

B.3 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 supplressed in multidrop mode.) (See examples in Table B-2.)

- A manual lockout command is available in the protocols set so the host can render the user interface “display only,” if desired.

All parameters, except for Relay Control and Set Current Output, set via the 2-way interface are retained in the sensor’s nonvolatile memory.

Note: When a unit is placed in multidrop mode its manual user interface is automatically locked.

B.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 RS-485 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:

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

where

t = average digital 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, emissivity, and ambient (20 characters), the average digital response time would be the following:

$$t = 9.9 + \frac{20 \text{ X } 15000}{38400}$$

$$= 17.7 \text{ ms}$$

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

APPENDIX C: SLOPE AND EMISSIVITY

Slope is the ratio of 1-color wideband emissivity to 1-color narrow emissivity and is used in the calculation of 2-color temperature. Since there is no way to adjust 1-color narrow emissivity in the instrument, the temperature algorithm derives it by dividing 1-color wide emissivity by slope.

Therefore, if the user needs to look at the narrowband temperature, care should be taken in adjusting slope and wideband emissivity in such a way that narrow band emissivity is calculated to be greater than 1.00 (or less than 0.10).

Emissivity is the measure of an object's ability to emit infrared energy. It can be a value from 0 (shiny mirror) to 1.0 (blackbody). If a higher than actual emissivity value is set, the sensor's output will read low. For example, if 0.95 is set, and the actual emissivity is 0.9, the reading will show lower than the true temperature.

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.

HOW TO DETERMINE EMISSIVITY

If you cannot find the emissivity of a material in Table B-1, it can be determined by one of the following methods, in order of preference:

1. Determine the actual temperature of the material using a sensor such as an RTD, thermocouple or other suitable method. Adjust the emissivity setting until the sensor's temperature reading is the same as the actual temperature reading. This is the correct emissivity for the measured material.
2. If a portion of the surface of the object can be coated, use a flat black paint (not semi-gloss or gloss), which will have an emissivity of about 0.98. Next, measure the painted area using an emissivity setting of 0.98. Finally, measure 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.

TYPICAL EMISSIVITY VALUES

Table B-1 is a reference for determining the emissivity of various metals. Table B-2 is a reference for non-metals. Emissivity values shown in the table are only approximate, since several parameters may affect the emissivity of an object. These include temperature, angle of measurement, geometry (plane, concave, convex, etc.), thickness, surface quality (polished, rough, oxidized, sandblasted), spectral region of measurement, and transmissivity (i.e., thin film plastics).

Table B-1: Typical Emissivity Values for Metals

MATERIAL	EMISSIVITY	MATERIAL	EMISSIVITY
	1.0µm		1.0µm
Aluminum		Lead	
Unoxidized	0.1-0.2	Polished	0.35
Oxidized	0.4	Rough	0.65
Roughened	0.2-0.8	Magnesium	0.3-0.8
Polished	0.1-0.2	Molybdenum	
Brass		Oxidized	0.5-0.9
Polished	0.1-0.3	Unoxidized	0.25-0.35
Oxidized	0.6	Monel (Ni-Cu)	0.3
Chromium	0.4	Nickel	
Copper		Oxidized	0.8-0.9
Polished	0.05	Electrolytic	0.2-0.4
Roughened	0.05-0.2	Silver	0.04
Oxidized	0.2-0.8	Steel	
Gold	0.3	Cold-Rolled	0.8-0.9
Haynes		Polished Sheet	0.35
Alloy	0.5-0.9	Molten	0.35
Inconel		Oxidized	0.8-0.9
Oxidized	0.4-0.9	Stainless	0.35
Sandblasted	0.3-0.4	Tin (Unoxidized)	0.25
Electropolished	0.2-0.5	Titanium	
Iron		Polished	0.5-0.75
Oxidized	0.4-0.8	Tungsten	
Unoxidized	0.35	Polished	0.35-0.4
Molten	0.35	Zinc	
Iron, Cast		Oxidized	0.6
Oxidized	0.7-0.9	Polished	0.5
Unoxidized	0.35		
Molten	0.35		
Iron, Wrought			
Dull	0.9		

Table B-2: Typical Emissivity Values for Non-Metals

MATERIAL	EMISSIVITY
	1.0µm
Asbestos	0.9
Carbon	
Unoxidized	0.8-0.95
Graphite	0.8-0.9
Ceramic	0.4
Concrete	0.65

To optimize surface temperature measurements consider the following guidelines:

1. Determine the object emissivity using the instrument used for the measurement.
2. Avoid reflections. Shield the object from surrounding high temperature sources.
3. For higher temperature objects, use shorter wavelength instruments whenever overlap occurs.
4. For semi-transparent materials such as glass, make sure that the background is uniform and lower in temperature than the object.
5. Mount the sensor perpendicular to the target surface whenever emissivity is less than 0.9. Note that in all cases, do not mount the sensor at angles exceeding 45 degrees from perpendicular.

APPENDIX D: 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.

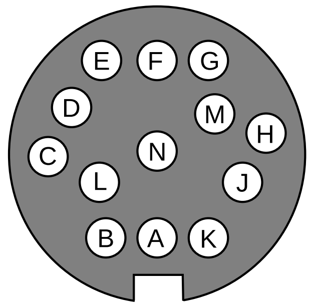

Figure D-1: DIN Connector Pin Layout (Pin Side)

Table D-1: DIN Connector Wiring

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	Relay NC
G	Orange	Relay COM
H	Blue	Relay NO
J	Green	+ mA Out
K	Brown	– mA Out
L	Black	Power Ground
M	Red	+ 24 VDC
N	No Connection	N/A

* Note: Twisted Pairs — Black & White
— Grey & Purple

APPENDIX E: TRACEABILITY OF INSTRUMENT CALIBRATION

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

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

NIST certificates are available as an option (must be ordered with the instrument). Contact the manufacturer (not NIST) to order this option.

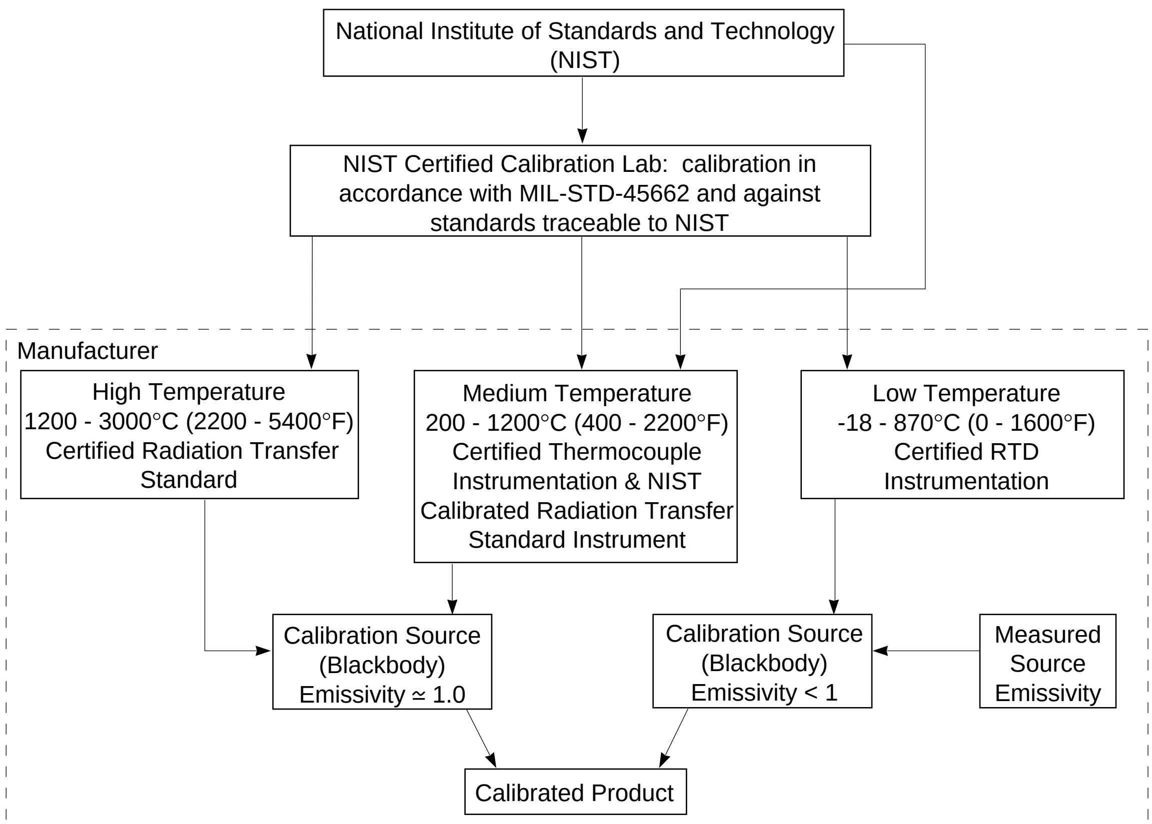

Figure E-1: Traceability of Temperature Instrumentation Calibration

Note: NIST certificates are currently only available for Si detector models.

APPENDIX F: CE CONFORMITY FOR THE EUROPEAN COMMUNITY

This instrument conforms to the following standards:

- EN50081-2 Emission Standard
- EN50082-2 Immunity Standard

Glossary Of Terms

This glossary of terms defines vocabulary and nomenclature commonly used within Raytek manuals and literature and is a part of every online product manual. Raytek encourages feedback on items contained within the glossary. Please feel free to offer suggestions on additions, clarification, and/or deletions to this document.

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 (TAMB)	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 Planckís Radiation Law. [Refs. 2,3]
Calibration Procedure	A 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]

Carnot Cycle	An ideal heat engine that converts thermal energy to mechanical work with the greatest efficiency that can be achieved.
Celsius or C	The temperature scale in which the temperature in Celsius (T_C) is related to the temperature in Kelvin (T_K) by the formula; $T_C = T_K - 273.15$. 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 (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 (DOI)	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.
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.
IEEE-488	A standard developed by Hewlett-Packard Corporation and adopted by the IEEE for digital interface between programmable instrumentation. It uses a 16-bit bus to interconnect up to 15 instruments. The standard comprises hardware and protocol options. It is also called the Hewlett-Packard Interface Bus (HPIB) or General Purpose Interface Bus (HPIB) or General Purpose Interface Bus (GPIB). The present standard is ANSI / IEEE-4881-1987.
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 therefrom. 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 (M) as the ratio of an applied electrical potential divided by the flow of electrical current resulting therefrom.

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 3-5µm and 8-14µm regions of the spectrum and require TE cooling in the 3-5 µm region and cryogenic cooling in the 8-14µm 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 — See NETD.

NETD (or NE³T) — 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 therefrom. 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.

RS-232 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-RS-232-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.

RS-422 A recommended standard developed by EIA that defines a balanced interface and is an expansion of RS-423 that increases the data rate to 10 Mbps. see RS-423

RS-423 A recommended standard developed by EIA that defines an unbalanced interface and is an expansion of RS-232 and provides improvements included increased connecting cable lengths, increased data rates, and use of multiple receivers on line.

RS-485 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 resonances 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 occurances: 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.

Thermocouple — A set of two junctions of two dissimilar metals used to measure temperature by means of the Peltier effect, whereby heat is liberated or absorbed by the flow of electrical current through a junction of two dissimilar metals such that an electrical potential develops between two such junctions in proportion to the difference in temperature of the junctions. A variety of types exist including:

J (Fe / constantan)	K (chromel / alumel)
T (Cu / constantan)	E (chromel / constantan)
R (Pt / Pt - 30% Rh)	S (Pt / Pt -10% Rh)
B (Pt - 6% Rh / Pt - 30% Rh)	G (W / W - 26% Re)
C (W - 5% Re / W - 26% Re)	D (W - 3% Re / W - 25% Re)

Thermoelectric (TE) 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]

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