Endurance® Series

Innovative High Temperature Infrared Pyrometers

Users Manual

PN 4979744, English, Rev. 2.0, May 2020

Warranty

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

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

The foregoing warranty is in lieu of all other warranties, expressed or implied, including but not limited to any implied warranty of merchantability, fitness, or adequacy for any particular purpose or use. The manufacturer shall not be liable for any special, incidental or consequential damages, whether in contract, tort, or otherwise.

Software Warranty

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

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Compliance Statement

The device complies with the requirements of the European Directives:

EC – Directive 2014/30/EU – EMC

EC – Directive 2011/65/EU – RoHS II

EN 61326-1: 2013	Electrical measurement, control and laboratory devices - Electromagnetic susceptibility (EMC)
EN 50581: 2012	Technical documentation for the evaluation of electrical products with respect to restriction of hazardous substances (RoHS)

Electromagnetic Compatibility Applies to use in Korea only. Class A Equipment (Industrial Broadcasting & Communication Equipment)
This product meets requirements for industrial (Class A) electromagnetic wave equipment and the seller or user should take notice of it. This equipment is intended for use in business environments and is not to be used in homes.

Safety Information

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

Acceptable Operation

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

Unacceptable Operation

The instrument should not be used for medical diagnosis.

Replacement Parts and Accessories

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

Safety Symbol	Description
	Read all safety information before in the handbook
	Hazardous voltage. Risk of electrical shock.
	Warning. Risk of danger. Important information. See manual.
	Laser warning
	Earth (ground) terminal
	Protective conductor terminal
	Switch or relay contact
	DC power supply
	Conforms to European Union directive.
	Disposal of old instruments should be handled according to professional and environmental regulations as electronic waste.
	Conforms to relevant South Korean EMC Standards.
IP65	International Ingress Protection Marking
	China RoHS

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

- Read all safety information before you use the product.
- Use the product only as specified, or the protection supplied by the product can be compromised.
- Do not use the product around explosive gases, vapor, or in damp or wet environments.
- Carefully read all instructions.
- Do not use and disable the product if it is damaged.
- Do not use the product if it operates incorrectly.
- Do not apply more than the rated voltage between the terminals or each terminal and earth ground.
- Do not look directly into the laser with optical tools (for example, binoculars, telescopes, microscopes). Optical tools can focus the laser and be dangerous to the eye.
- Do not look into the laser. Do not point laser directly at persons or animals or indirectly off reflective surfaces.
- Do not use laser viewing glasses as laser protection glasses. Laser viewing glasses are used only for better visibility of the laser in bright light.
- Use the product only as specified or hazardous laser radiation exposure can occur.
- Incorrect wiring can damage the sensor and void the warranty. Before applying power, make sure all connections are correct and secure!
- To prevent possible electrical shock, fire, or personal injury make sure that the sensor is grounded before use.
- Have an approved technician repair the product.
- The metallic enclosure of the sensor is not necessarily earthed by installation. At least one of the following safety measures must be met to minimize the danger of electrostatic charges:
  - Earth grounding of the cable shield
  - Installing the unit's metallic enclosure on an earth grounded mounting bracket or on any other grounded bases
  - Protect the operator from electrostatic discharge

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For more information, contact your local office.

www.flukeprocessinstruments.com

1 Description

Endurance fiber optical pyrometers are infrared noncontact temperature measurement systems. Such devices have a fixed focus, a laser beam pointing capability through the lens to the target, and fiber optic cables for specific infrared wavelengths. The Endurance devices come in an industrial aluminum die-cast electronics enclosure. A ruggedized fiber optic cable for the external sensor head attachment to the electronics enclosure is protected by a flexible stainless-steel sheath. The external attached sensor head on the one hand and the electronics enclosure on the other hand, allow the installation of the electronics enclosure away from a hot, hostile environment. 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.

Each model operates as an integrated temperature measurement subsystem consisting of optical elements, spectral filters, detectors, digital electronics in a sealed housing. Each is built to operate on a 100 percent duty cycle in industrial environments. Various output types are offered for easy integration into industrial monitoring and control environments.

Monochrome models (1-color) for standard temperature measurement applications

The 1-color mode is best for measuring the temperature of targets in areas where no sighting obstructions, either solid or gaseous, exist. Such 1-color mode is also best where the target completely fills the measurement spot.

Ratio models (2-color) for specific temperature measurement applications

Ratio pyrometers determine the object temperature by 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. Ratio pyrometers can measure and determine the object temperature in either one of both modes (1-color / 2-color), in which always 2 infrared detectors are active.

Table 1-1: Model Overview

Model	Description
EF1M	1-color sensor in spectral range of 1.0 µm for different temperature ranges
EF2M	1-color sensor in spectral range of 1.6 µm for different temperature ranges
EF1R	2-color ratio sensor in spectral range of 1.0 µm for different temperature ranges
EF2R	2-color ratio sensor in spectral range of 1.6 µm for different temperature ranges

The following Endurance model variants are available:

EF	1	R	L	– F0	– 1	– 0	– 0	– 01BL
Series:	Spectral:	Type:	Temperature:	Focus:	Sighting:	Electronics Box:	Communication:	Head Cable:
Endurance Fiber	1 = 1 µm 2 = 1.6µm	M = 1-color monochrome R = 2-color ratio	L = low temp M = mid temp H = high temp	F0 F1 F2	0 = no 1 = laser	0 = M16 connector 1 = inside terminal connection	0 = Ethernet 1 = PROFINET 2 = EthernNet/IP	01B = 1 m (3 ft) 03B = 3 m (10 ft) 06B = 6 m (20 ft) 10B = 10 m (33 ft) 22B = 22 m (72 ft) L = low temp H = high temp

Example: EF1RL-F0-1-0-0-01BL

2 Technical Data

2.1 Measurement Specification

Temperature Range

EF1ML	475 to 900°C (887 to 1652°F)
EF1MM	800 to 1900°C (1472 to 3452°F)
EF1MH	1200 to 3000°C (2192 to 5432°F)
EF2ML	250 to 800°C (482 to 1472°F)
EF2MH	400 to 1700°C (752 to 3092°F)
EF1RL	500 to 1100°C (932 to 2012°F)
EF1RM	700 to 1500°C (1292 to 2732°F)
EF1RH	1000 to 3200°C (1832 to 5792°F)
EF2RL	275 to 1300°C (527 to 2372°F)
EF2RH	350 to 1300°C (662 to 2372°F)

Spectral Response

EF1ML	1 µm
EF1MM	1 µm
EF1MH	1 µm
EF2ML	1.6 µm
EF2MH	1.6 µm
EF1RL	1 µm
EF1RM	1 µm
EF1RH	1 µm
EF2RL	1.6 µm
EF2RH	1.6 µm

Response Time[1]

EF1ML	2 ms
EF1MM	2 ms
EF1MH	2 ms
EF2ML	2 ms
EF2MH	2 ms
EF1RL	10 ms
EF1RM	10 ms
EF1RH	10 ms
EF2RL	20 ms
EF2RH	20 ms

[1] 95% value

Accuracy[2]

EF1ML	± (0.3% + 2°C) for T_{meas} ≥ 475°C (887°F)
EF1MM	± (0.3% + 2°C) for T_{meas} ≥ 800°C (1472°F)
EF1MH	± (0.3% + 2°C) for T_{meas} ≥ 1200°C (2192°F)
EF2ML	± (0.3% + 2°C) for T_{meas} ≥ 250°C (482°F)
EF2MH	± (0.3% + 2°C) for T_{meas} ≥ 400°C (752°F)
EF1RL	± (0.3% + 2°C) for T_{meas} ≥ 500°C (932°F), no attenuation
EF1RM	± (0.3% + 2°C) for T_{meas} ≥ 700°C (1292°F), no attenuation
EF1RH	± (0.3% + 2°C) for T_{meas} ≥ 1000°C (1832°F), no attenuation
EF2RL	± (0.5% + 2°C) for T_{meas} ≥ 275°C (527°F), no attenuation
EF2RH	± (0.5% + 2°C) for T_{meas} ≥ 350°C (662°F), no attenuation

Repeatability[3]

EF1ML	± 1°C (± 2°F) for T_{meas} ≥ 475°C (887°F)
EF1MM	± 1°C (± 2°F) for T_{meas} ≥ 800°C (1472°F)
EF1MH	± 1°C (± 2°F) for T_{meas} ≥ 1200°C (2192°F)
EF2ML	± 1°C (± 2°F) for T_{meas} ≥ 250°C (482°F)
EF2MH	± 1°C (± 2°F) for T_{meas} ≥ 400°C (752°F)
EF1RL	± 1°C (± 2°F) for T_{meas} ≥ 500°C (932°F), no attenuation
EF1RM	± 1°C (± 2°F) for T_{meas} ≥ 700°C (1292°F), no attenuation
EF1RH	± 1°C (± 2°F) for T_{meas} ≥ 1000°C (1832°F), no attenuation
EF2RL	± (0.3% + 1°C) for T_{meas} ≥ 275°C (527°F), no attenuation
EF2RH	± (0.3% + 1°C) for T_{meas} ≥ 350°C (662°F), no attenuation

Temperature Resolution

Display	1°C (2°F)
Analog output	0.1°C (0.2°F), 16 bit
Digital output	0.1°C (0.2°F)

Noise Equivalent Temperature (NET)

all models	1°C peak to peak (target emissivity of 1.00, no attenuation) 3°C peak to peak (for all specified attenuation conditions)

Temperature Coefficient

all models	0.03% full scale, change per 1°C change in ambient temperature

Emissivity

all models	0.100 to 1.100, in 0.001 increments

Slope

all 2C models	0.850 to 1.150, in 0.001 increments

Signal Processing

All models	Averaging, peak hold, valley hold, advanced peak hold, advanced valley hold, ambient background temperature compensation

[2] at ambient temperature 23°C ± 5°C (73°F ± 9°F), emissivity = 1.0 and calibration geometry, T_{meas} in °C
[3] at ambient temperature 23°C ± 5°C (73°F ± 9°F), emissivity = 1.0 and calibration geometry, T_{meas} in °C

2.2 Optical Specifications

Optical Resolution	**D:S**[4]
EF1ML	20:1 (95% energy)
EF1MM	100:1 (95% energy)
EF1MH	100:1(95% energy)
EF2ML	20:1 (95% energy)
EF2MH	40:1 (95% energy)
EF1RL	20:1 (95% energy)
EF1RM	40:1 (95% energy)
EF1RH	65:1 (95% energy)
EF2RL	20:1 (90% energy)
EF2RH	40:1 (90% energy)

Fixed Focus

F0	100 mm (3.9 in)
F1	300 mm (12 in)
F2	infinity (∞)

For exemplary optical charts, see section 15.1 Optical Diagrams, page 121.

Sighting

Laser	green

[4] specified D:S ratio at focus point only

2.3 Electrical Specifications

Power	20 to 48 VDC, max. 12 W Power over Ethernet (IEEE 802.3af, pinout mode A, mixed DC & data)
Outputs	
Analog	0 to 20 mA (active), or 4 to 20 mA (active) current loop impedance: max. 500 Ω short circuit resistant electrically isolated
Alarm	48 V / 300 mA 1 potential-free relay output with wear-free contacts (solid state relay), electrically isolated
Inputs	
Analog	0 to 20 mA or 4 to 20 mA loop impedance max. 220 Ω electrically isolated emissivity setting, slope setting or background temperature compensation
Digital	trigger input (closing contact, active with low status) electrically isolated signal processing control sighting control on/off
RS485	
	2-wire communications (half duplex) 4-wire communications (full duplex), see section 5.6.1 Electronics Housing – Options, page 34. networkable to 32 sensors baud rate: 1200, 2400, 9600, 19200, 38400, 57600, 115200 Bit/s (default: 38400 Bit/s) data format: 8 bit, no parity, 1 stop bit electrically isolated
Ethernet	
Connection	M12 socket, 4 wires (full duplex) 100 MBit/s, 100BASE-TX / IEEE 802.3u, Auto-Negotiation electrically isolated
Addressing	DHCP or fixed IP address
Defaults	IP address: 192.168.42.132 subnet mask: 255.255.255.0 gateway: 192.168.42.1
Protocols	UDP, port 36363 (fixed) TCP/IP version 4, default port 6363, range: 1 to 65535 http web server (port 80) PROFINET IO, see section 9 PROFINET IO, page 68 EthernNet/IP, see section 10 EthernNet/IP, page 72.

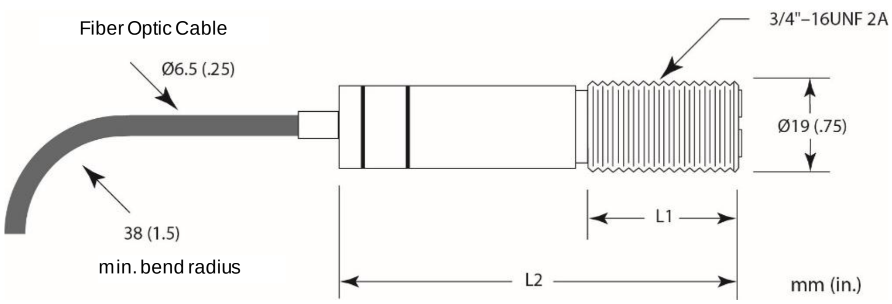
2.4 Environmental Specifications

Ingress Protection	IP65 (IEC529) / NEMA 4
Operating ambient temperature	
Head / fiber cable	0 to 200°C (32 to 392°F) Fiber cable in NEMA-4 (IP65), stainless steel armor, PTFE coated sleeve
Head / fiber cable	0 to 315°C (32 to 600°F) as option no ingress protection, stainless steel armor, no coated sleeve
Electronics housing	0 to 60°C (32 to 140°F) – without cooling 0 to 150°C (32 to 302°F) – with water cooling, see section 12.2.5 Cooling Platform (E-CP), page 100.
Storage temperature	
Electronics housing	-20 to 70°C (-4 to 158°F)
Shock	IEC 68-2-27 (5 G, 11 ms duration, 3 axes)
Vibration	IEC 68-2-6 (2 G, 10 to 150 Hz, 3 axes)
Humidity	10% to 95% @ 22 to 43°C (72 to 109°F), non-condensing
EMC	EN 61326-1:2013 industrial
Warm up Period	15 min.
Material	
Head	stainless steel
Electronics housing	Aluminum diecast
Weight	
Head	100 g (3.5 oz)
Electronics housing	710 g (25 oz)

2.5 Dimensions

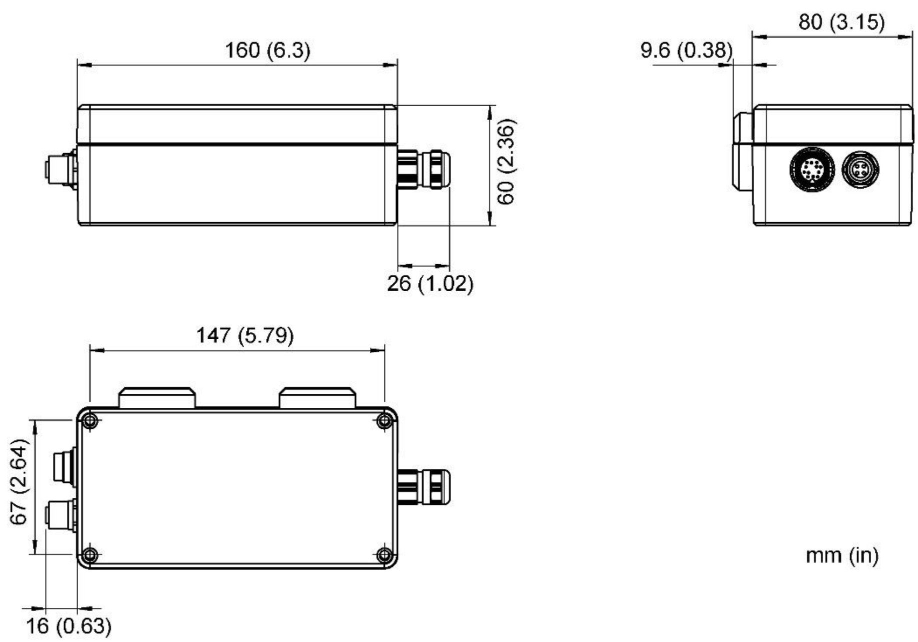
The drawing below illustrates the dimensions of the optical heads and the electronics housing.

Figure 2-1: Dimensions of the Optical Heads



Model	L1	L2
EF1ML, EF1MM, EF1MH, EF2ML, EF2MH	25 mm (1.0 in)	62 mm (2.46 in)
EF1RL, EF2RL, EF2RH	28 mm (1.1 in)	69 mm (2.7 in)
EF1RM, EF1RH	36 mm (1.4 in)	79 mm (3.1 in)

Figure 2-2: Dimensions of the Electronics Housing



2.6 Scope of Delivery

The scope of delivery includes the following:

- Optical head attached to the electronics housing
- 2 mounting nuts
- Adjustable mounting bracket (spare: E-FOMB)
- Data carrier with Multidrop Software and operating instructions
- Quickstart guide, printed

3 Basics

3.1 Measurement of Infrared Temperature

All surfaces emit infrared radiation. The intensity of this infrared radiation changes according to the temperature of the object. Depending on the material and surface properties, the emitted radiation lies in a wavelength spectrum of approximately 1 to 20 µm. The intensity of the infrared radiation (heat radiation) is dependent on the material. For many substances, this material-dependent constant is known. This constant is referred to as the *emissivity value*.

Infrared thermometers are optical-electronic sensors. These sensors are sensitive to the emitted radiation. Infrared thermometers are made up of a lens, a spectral filter, a sensor, and an electronic signal processing unit. The task of the spectral filter is to select the wavelength spectrum of interest. The sensor converts the infrared radiation into an electrical signal. The signal processing electronics analyze the electrical signal and convert it into a temperature measurement. As the intensity of the emitted infrared radiation is dependent on the material, the required emissivity can be selected on the sensor.

The biggest advantage of the infrared thermometer is its ability to measure temperature without touching an object. Consequently, surface temperatures of moving or hard to reach objects can easily be measured.

3.2 Emissivity for 1-Color Measurements

Emissivity is a calculated ratio of infrared energy emitted by an object to the energy emitted by a blackbody at the same temperature (a perfect radiator has an emissivity of 1.00). The emissivity is preset at 1.00. For information on determining an unknown emissivity and for sample emissivities, see section 15.4 Typical Emissivity Values, page 132.

If emissivity is low, measured results could be falsified by interfering infrared radiation from background objects (such as heating systems, flames, fireclay bricks, etc. located close beside or behind the target object). This type of problem can occur when measuring reflective surfaces and very thin materials, such as plastic film and glass.

This measurement error can be reduced to a minimum, if care is taken during installation and the sensing head is shielded from these reflecting radiation sources.

3.3 Theory for 2-Color Measurements

The 2-color ratio technology allows accurate and repeatable temperature measurements, which don't depend 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 the target emissivity is low or changing by the same factor in both wavelength bands.

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

3.3.1 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 graybody (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 graybody. 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 if 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.

Note
Any dirt (dust, fingerprints) on the optical lens or vision window with unknown spectral characteristics can influence the measurement result in 2-color mode. Unpredictable temperature readings may result in such a case!

3.3.2 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!

Note
For accurate temperature readings in the 2 color mode, an attenuation in the sighting path must be equal in both spectral bands!

3.3.3 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 if the background temperature is much lower than the target. 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.

3.3.4 Slope

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

For information on determining an unknown slope, and for sample slopes, refer to section 15.5 Determination of Slope, page 136.

Note
The slope is the most important parameter for measurements in 2-color mode! The emissivity affects only measurements in 1-color mode.

3.3.5 Attenuation

The Attenuation parameter indicates the degree of reduction of the input signal. Attenuation is applicable for sensors in 2-color mode only. Three causes may contribute to a loss of infrared signal from the target:

- Low target emissivity
- Target is too small to fill the measured spot size
- The optical path is partially obstructed – as with smoke, steam, dust, a dirty window, or solid obstructions

The total reduction in signal is the sum of the losses from all three causes. The specified attenuation is how much reduction in signal the instrument can handle and still achieve an accurate temperature measurement.

Example: An instrument has a specification of 95% for the signal attenuation.

Assume a target with Emissivity = 0.45 equivalent to 45% signal and corresponding to 55% signal loss (100% - 45% = 55%)

Transmissivity = 0.0

→ Another 40% maximum can be lost due to an unresolved target or obstructions in the field of view.

4 Environment

4.1 Ambient Temperature

The optical head with the cable is suited for a maximal operating temperature, see section 2.4 Environmental Specifications, page 22. A high temperature version for the cable is available optionally, see section 11.1 Fiber Optic Cable, page 76.

The operating temperature for the electronics housing can be extended by using the cooling platform, see section 12.2.5 Cooling Platform (E-CP), page 100.

4.2 Atmospheric Quality

If the lens gets dirty, infrared energy will be blocked and the sensor will not measure accurately. It is good practice to always keep the lens clean. The air purge collar accessory helps keep contaminants from building up on the lens, see section 12.2.2 Air Purge Collar (E-FOHAPA), page 96. If you use air purging, make sure a filtered air supply with clean, dry air at the correct air pressure is installed before proceeding with the sensor installation.

4.3 Electrical Interference

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

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

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

5 Installation

Risk of Personal Injury

When this instrument is being used in a critical process that could cause property damage and personal injury, the user should provide a redundant device or system that will initiate a safe process shutdown in the event that this instrument should fail.

5.1 Positioning

Sensor location depends on the application. Before deciding on a location, you need to be aware of the ambient temperature of the location, the atmospheric quality of the location, and the possible electromagnetic interference in that location. Please keep in mind, that pure optical sensor heads are totally immune against electromagnetic interference, unlike the electronics enclosure with its integrated electronic parts. If you plan to use air purging, you need to have an air connection available. Wiring and conduit runs must be considered, including computer wiring and connections, if used.

5.2 Distance to Object

The optimal distance to the measuring object depends on the selected optical lens focus (F0, F1, F2) of the sensor and the needed measurement spot size. The correct sensor placement may vary to suit specific applications. The following sections demonstrate the sensor placement under various conditions, where 1- or 2-color temperature measurements deliver reasonable readings.

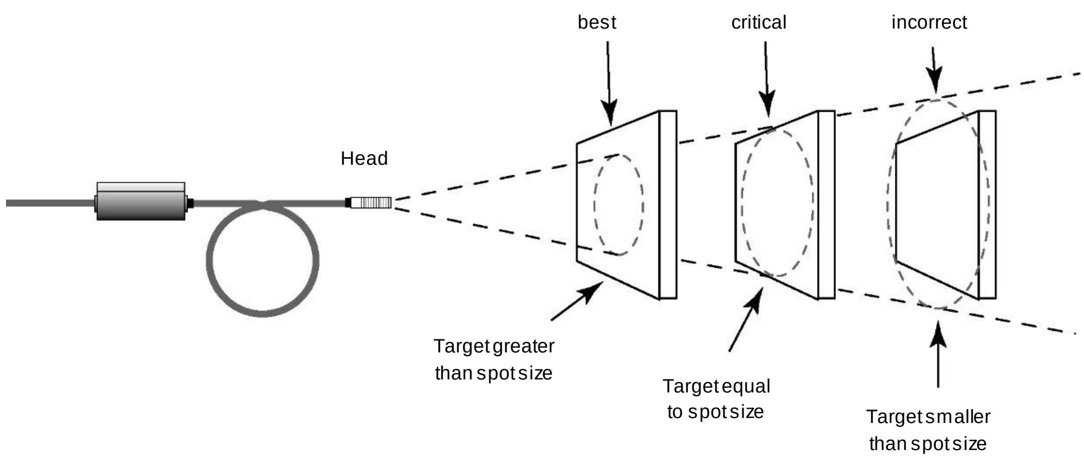
5.2.1 Sensor Placement in 1 Color Mode

The desired spot size on the target will determine the maximum measurement distance. To avoid erroneous readings, the target spot size must completely fill the entire field of view of the sensor. Consequently, the sensor must be positioned so the field of view is the same as or smaller than the desired target size.

For a list indicating the available optics, see section 2.2 Optical Specifications, page 20.

The manufacturer provides a tool for calculating spot sizes, see section 15.2 Spot Size Calculator, page 131.

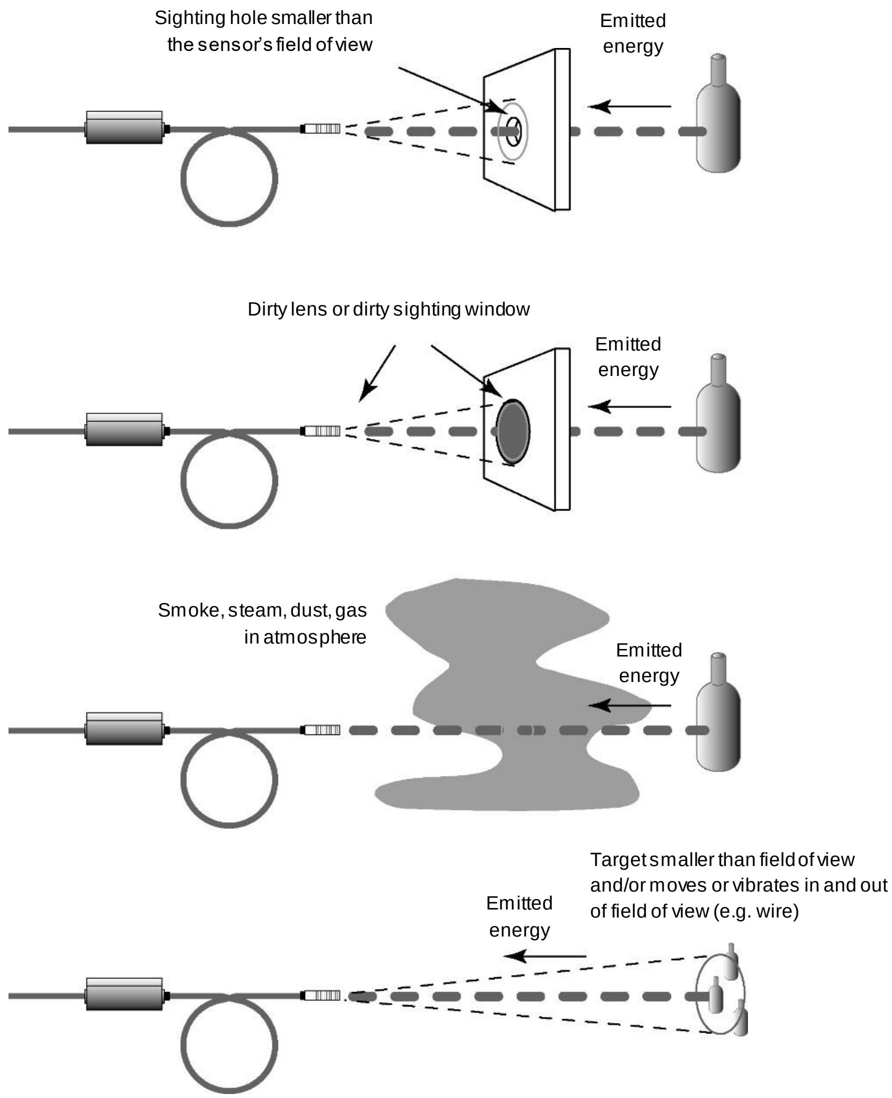
Figure 5-1: Sensor Placement in 1 Color Mode



5.2.2 Sensor Placement in 2 Color Mode

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

Figure 5-2: Sensor Placement in 2 Color Mode



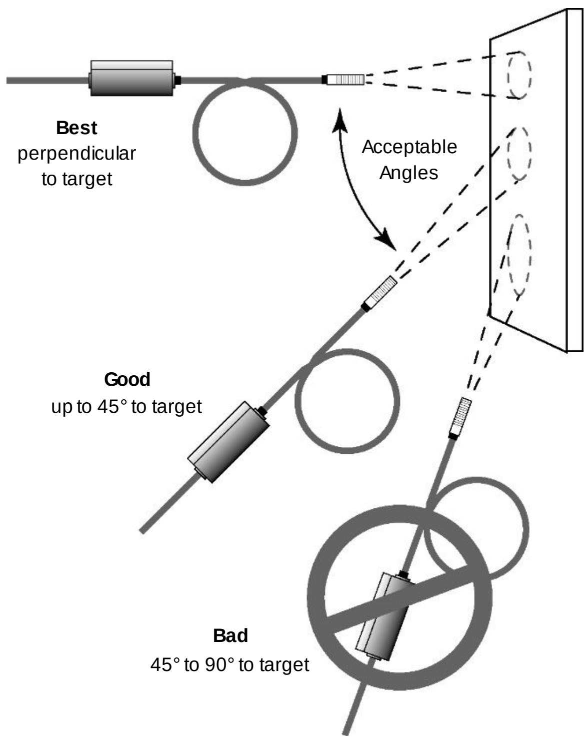
Note

For accurate temperature readings in the 2 color mode, an attenuation in the sighting path must be equal in both spectral bands!

5.3 Viewing Angles

The sensor head can be placed at any angle from the target less than 45°.

Figure 5-3: Acceptable Sensor Viewing Angles



5.4 Aiming

An effective aiming technique is to adjust the sensor head until the highest reading is observed on the internal display. When the highest reading is reached, hold the unit in place and secure the mounting base.

Note

In 1-color measurements, the target measurement area has to fill the complete measurement spot size.

Another aiming can be done by means of the optional laser sighting, see section 11.2 Laser Sighting, page 77 or the battery powered aiming light, see section 12.1.11 Aiming Light (E-FAFAL), page 93.

5.5 Mechanical Installation

How and where to anchor the optical head and electronics enclosure depends on the type of surface and the type of bracket you are using. You can mount the optical head through a hole, on a bracket of your own design, or on the available adjustable bracket accessory.

5.5.1 Fiber Optic Cable

Fiber optic cables and optical heads can withstand hot ambient temperatures up to 200°C (392°F), optional even up to 315°C (599°F). They can also operate in areas of high electromagnetic fields, which would render conventional instruments useless. Longer fiber optic cables allow the electronics enclosure to be well away from hostile environments. The small optical head can be mounted in cramped locations. The fiber optic cable has a small bend radius of 38 mm (1.5 in) minimum and can be “snaked” around and through machinery, walls, and other obstacles. The cable can be disconnected from the electronics box for aiming or threading through conduit during installation.

If the cable needs to be changed, it could be field replaceable. For detailed instructions to remove and attach the fiber optic cable, see section 13.4 Replacing the Fiber Optic Cable, page 105.

The fiber optic cable is a sealed, stainless-steel armor sheath covering the fiber optic bundle.

Bend radius of fiber bundle:	38 mm (1.5 in) minimum
Cable outer diameter:	6.5 mm (0.25 in)
Ambient temperature:	0 to 200°C (32°F to 392°F), optional up to 315°C (599°F)
Environmental rating:	Water tightness as per NEMA-4 (IEC 529, IP65) hose down test, rated attached and with protective sleeves, which prevents liquid from entering through the connectors. The given environmental rating is not valid for the 315°C (599°F) cables!

Ensure fiber optic cable is connected before turning on the laser!

5.6 Electrical Installation

5.6.1 Electronics Housing – Options

The electronics housing is available in two different connector variants:

- Electronics housing with outside 12-pin connector (option -0) – limited to half-duplex RS485 communication, see section 5.6.5 Housing with 12-pin Connector, page 35.
- Electronics housing with cable gland for inside terminal connection (option -1) – supports full-duplex RS485 communication, see section 5.6.6 Housing with Cable Gland, page 36.

Figure 5-4: Electronics Housing with Outside 12-pin Connector

12-pin Connector

Ethernet Connector

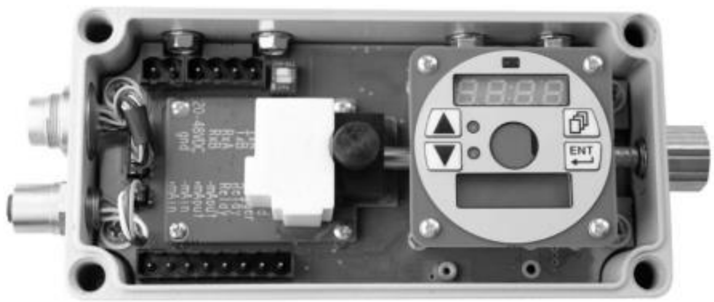


Figure 5-5: Electronics Housing with Cable Gland

Cable Gland

Ethernet Connector

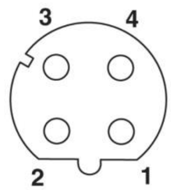
5.6.2 Power Supply

For the power supply, isolated power is required. The manufacturer supplies an appropriate power supply as accessory, see section 12.1.6 Power Supply DIN Rail (E-SYSPS), page 87. Beware of use of other power supplies, which may not provide the necessary isolation and could cause instrument malfunction or damage!

5.6.3 Ethernet Connector

The Ethernet connector is a M12 4-socket connector type, D-coded, and a screw retention feature.

Figure 5-6: Ethernet Connector Socket and Pin Assignment



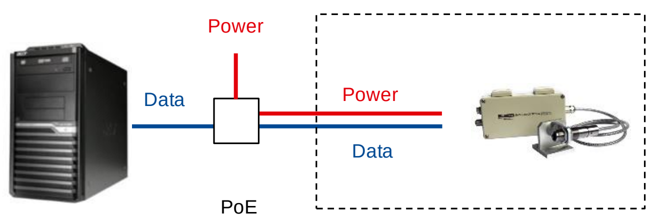
Pin	
1	TX+
2	RX+
3	TX-
4	RX-

For available Ethernet cables, see section 12.1.3 Ethernet PoE Cable (E-ETHxTCBxx), page 84.

5.6.4 Power over Ethernet (PoE)

The sensor is supplied with power via the PoE standard (Power over Ethernet). PoE allows a single cable to provide both data connection and electric power to the sensor. The following figure shows exemplarily the connection to a PC.

Figure 5-7: Sensor Connection to a PC using PoE



5.6.5 Housing with 12-pin Connector

The 12-pin connector comes in M16 metric thread and supports the RS485 interface, trigger input, relay contact, current input, current output and the power supply line. Refer to the following figures below for the wiring layout.

Figure 5-8: 12-pin Connector Pin Layout (pin side)

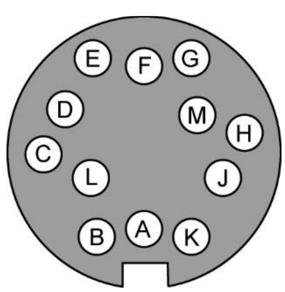


Table 5-1: Pin Assignment for 12-pin Connector

Pin	Description
A	RS485-A
B	RS485-B
C	- mA In
D	+ mA In
E	Shield
F	Trigger
G	Relay (alarm)
H	Relay (alarm)
J	+ mA Out
K	- mA Out
L	Ground (power)
M	+ 24 VDC

For available cables, see section 12.1.1 High Temp 12-Wire Cable (E-2CCBxx), page 80 and section 12.1.2 Low Temp 12-Wire Cable (E-2CLTCBxx), page 82.

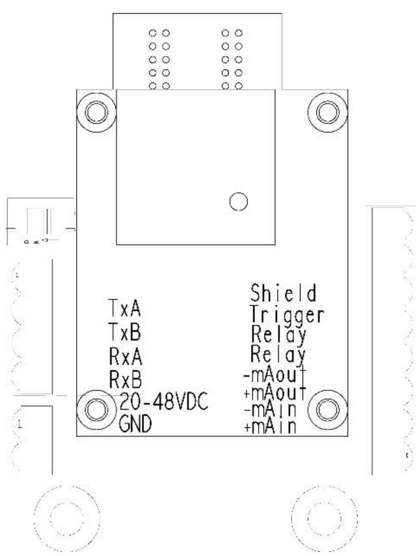
5.6.6 Housing with Cable Gland

The electronics housing with cable gland allows to run the device in full duplex RS485 communication requiring a shielded cable with 14 single wires. The pin assignment is printed on the inside wiring board.

To preserve the ingress protection class for the squeezed cable through the cable gland, the outer cable diameter must be in the range of 6.5 to 9.0 mm (0.26 to 0.35 in).

Three individual snap-on connectors (2-, 4-, 8-wires) come with the delivery to connect the customer specific process cable inside the electronics housing.

Figure 5-9: Pin Assignment



5.7 Inputs

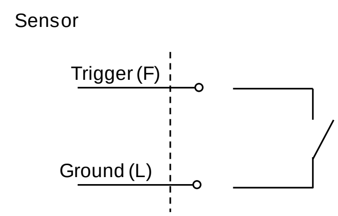
5.7.1 Trigger

The trigger input can be used as switch to initiate one of the following:

- Restarting the signal processing, see section 6.3 Post Processing, page 55.
- Toggling the laser sighting between on/off, see ASCII command XL

The trigger function is activated by shorting the external input to digital ground (pin L). The shorting can be done with an external switch, relay, transistor, or TTL gate.

Figure 5-10: Wiring the Trigger Input

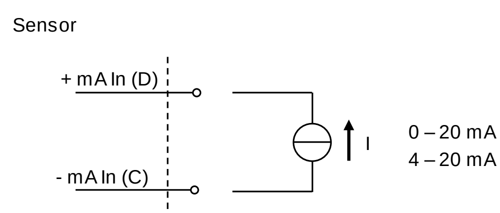


5.7.2 Analog Input

The analog input is galvanically isolated and processes currents in the range of 0 to 20 mA or 4 to 20 mA. The following functions can be executed via the analog input:

- Setting the emissivity value (preferential for sensors in 1-color mode)
- Setting the slope value (for sensors in 2-color mode)
- Setting the temperature for the background temperature compensation
- Reading the current from an external device using the ASCII command <IN>

Figure 5-11: Wiring the Analog Input



5.7.2.1 Emissivity/Slope Setting

The analog input can be configured to accept an analog current to provide real time emissivity setting for sensors in 1-color mode (or slope for sensors in 2-color mode). The following table shows the relationship between input current and emissivity:

Table 5-2: Ratio between Analog Input Current and Emissivity (Example)

I in mA	0.0	2.0	…	18.0	20.0
Emissivity	0.1	0.2	…	1.0	1.1

Use the adequate ASCII commands to configure the analog input, see section 14.5.2 Emissivity Setting, page 113 and section 14.5.3 Background Temperature Compensation, page 113.

5.7.2.2 Background Temperature Compensation

The sensor can improve the accuracy of target temperature measurements by considering the ambient or background temperature. This feature is useful when the target emissivity is below 1.0 and the background temperature is significantly hotter than the target temperature. For instance, the higher temperature of a furnace wall could lead to hotter temperatures being measured, especially for low emissivity targets.

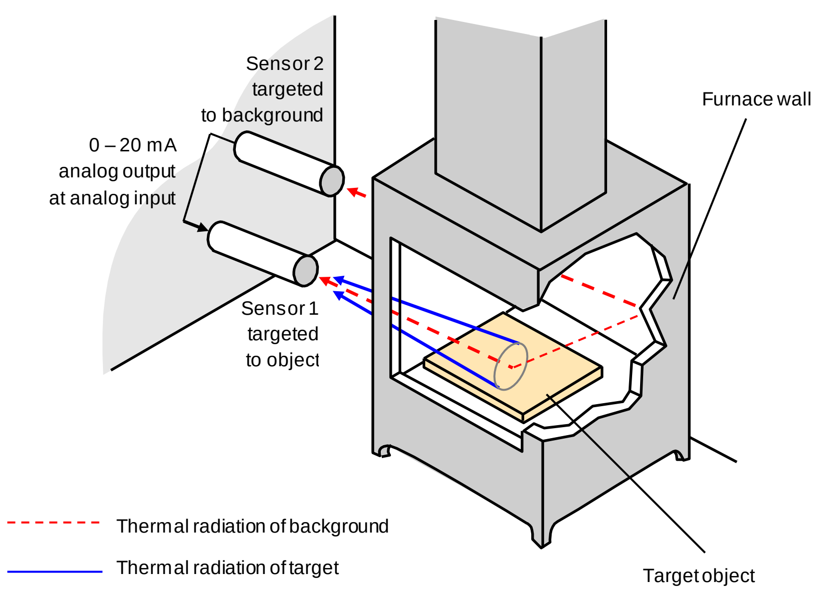
Background temperature compensation allows for the impact of reflected radiation in accordance with the reflective behavior of the target. Due to the surface structure of the target, some amount of ambient radiation will be reflected and therefore, added to the thermal radiation collected by the sensor. The ambient background temperature compensation adjusts the result by subtracting the amount of ambient radiation measured from the sum of thermal radiation the sensor is exposed to.

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

Three possibilities for ambient background temperature compensation are available:

- The **internal sensing head temperature** is utilized for compensation if the background temperature is more or less represented by the internal sensing head temperature. This is the default setting.
- If the background temperature is known and constant, the user may give the known background temperature as a **constant temperature value**.
- Background temperature compensation from a **second temperature sensor** (infrared or contact temperature sensor) ensures extremely accurate results. For example, a second infrared sensor, configured to provide a 0 to 20 mA output scaled for the same temperature range as the first sensor can be connected to the analog input to provide real-time background temperature compensation.

Figure 5-12: Principle of Background Temperature Compensation



Use ASCII commands to configure the analog input, see section 14.5.3 Background Temperature Compensation, page 113.

5.8 Outputs

5.8.1 Relay

The relay output is used as an alarm for failsafe conditions or as a setpoint relay. The relay output can be used to indicate an alarm state or to control external actions. The relay functionality can either be set to:

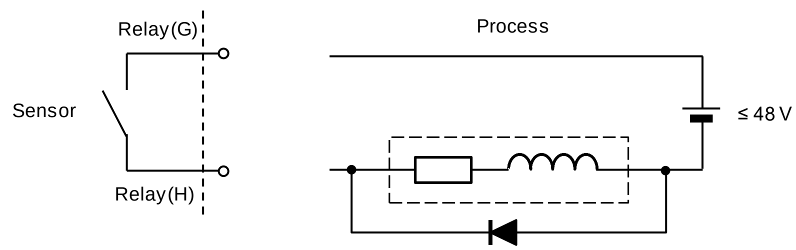
- NO (normally open), NC (normally closed)
- PO (permanently open), PC (permanently closed)

by the appropriate ASCII command. The relay PO and PC state can be used to detect wiring problems between the sensor and the process environment.

The alarm output can be controlled by the target object temperature or the internal case temperature of the sensor. In case of an alarm, the output switches the potential free contacts from a solid-state relay. The maximum load for this output is 48 V / 300 mA.

If a spike voltage exceeding the absolute maximum rated value is generated between the output terminals, insert a clamping diode in parallel to the inductive load as shown in the following circuit diagram to limit the spike voltage.

Figure 5-13: Spike Voltage Limitation for the Alarm Relay



5.8.1.1 Setpoint

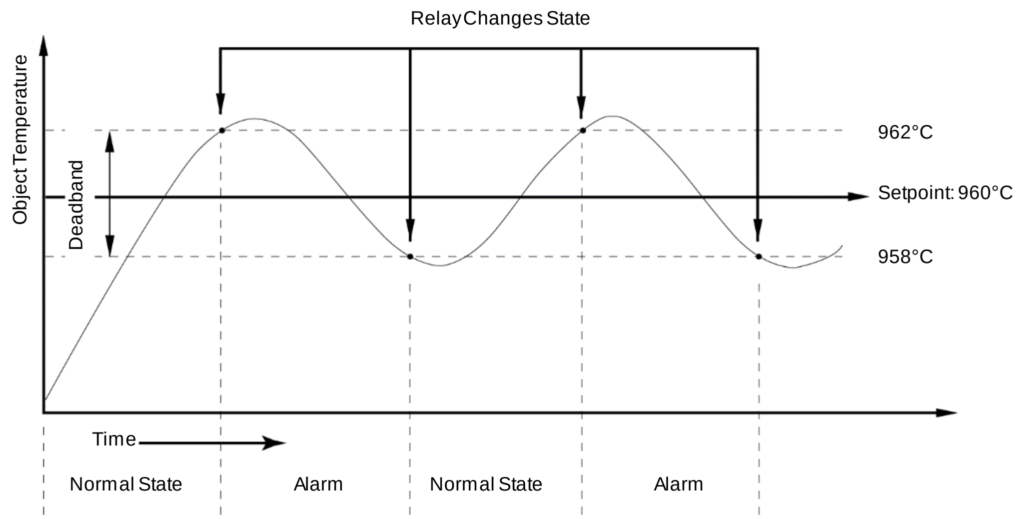
The setpoint function is a temperature alarm mechanism defining a maximum supervising value for the measured temperature. If the setpoint value is exceeded, an alarm state will be signaled by the relay output.

A zero entry as setpoint value deactivates the alarm functionality (alarm mode off). To activate the alarm functionality, set the setpoint entry to a value between the lowest and the highest measurable target temperature.

5.8.1.2 Deadband

Deadband is a zone of flexibility around the setpoint. The alarm does not go abnormal until the temperature exceeds the setpoint value by the number of set deadband degrees. Thereafter, it does not go normal until the temperature is below the setpoint by the number of set deadband degrees. The deadband is factory preset to ± 2° (C or F). Adjusting the deadband entry is accomplished through the control panel or ASCII command.

Figure 5-14: Deadband around the Setpoint (Example)

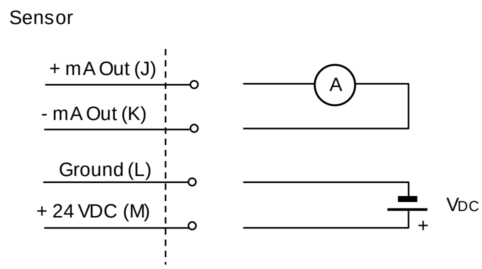


5.8.2 Analog Output

The analog output can be set to 0-20 mA or 4-20 mA current range. Direct connection to a recording device (e.g., chart recorder, PLC, or controller) is possible. The total analog output circuit impedance is limited to 500 Ω.

For the principle wiring, use the installation scheme below.

Figure 5-15: Wiring the Analog Output



A specific feature for the testing or calibrating of connected equipment allows the current loop output to be set to specific values, under range or over range using a dedicated ASCII command. Via such functionality, you can force the instrument, operating in the 4-20 mA mode, to transmit an output current less than 4 mA (e.g., 3.5 mA) or above 20 mA (e.g., 21.0 mA).

Current Calculation

The sensor converts each measured temperature to a current equivalent. By default, the current equivalent corresponds to the measuring range of the sensor. However, the current output can also be scaled to a subrange defined by the user.

The following formula demonstrates the output current calculation regarding the given measurement subrange.

T_{Up} – upper temperature of subrange, e.g. 2000°C
T_{Lo} – lower temperature of subrange, e.g. 1000°C
I_{Up} – upper current of current output range, e.g. 20 mA
I_{Lo} – lower current of current output range, e.g. 4 mA
T_{Meas} – actual measured temperature, e.g. 1500°C
I_{Meas} – actual calculated and output current

$$I_{Meas} = I_{Lo} + \frac{I_{Up} - I_{Lo}}{T_{Up} - T_{Lo}} \cdot (T_{Meas} - T_{Lo}) = 4mA + \frac{20mA - 4mA}{2000°C - 1000°C} \cdot (1500°C - 1000°C) = 12mA$$

6 Operation

Once the sensor is positioned and connected properly, the system is ready for continuous operation. Nonstop operation of the Endurance device is achieved either by back panel operation or through software control via the RS485, the LAN/Ethernet or PROFINET IO communication interface. The Multidrop Software, a MS-Windows based setup and configuration program is supplied with the sensor. You can also create custom programs using the communication protocols listed in section 14 ASCII Programming, page 111.

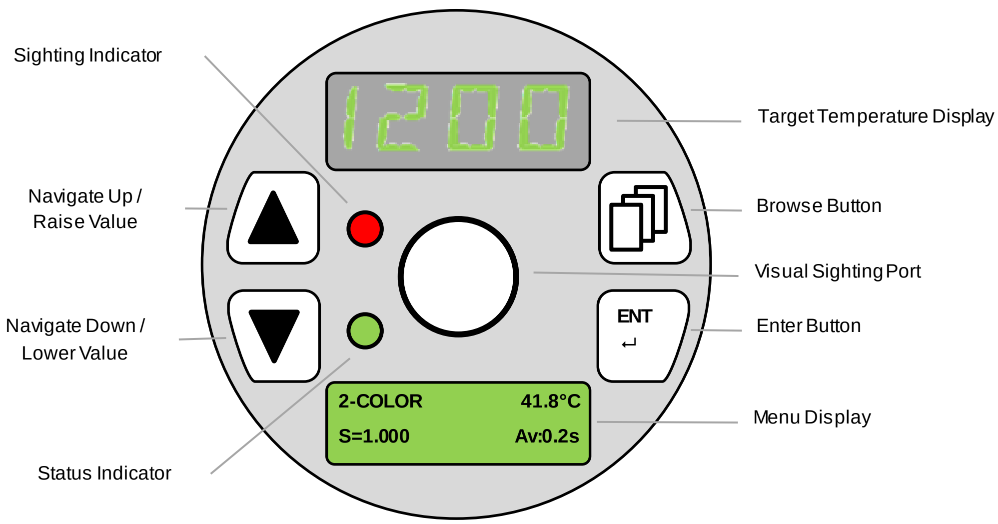
6.1 Control Panel

The Endurance sensor is equipped with a control panel, which is the manually operated user interface and consists of two display types, a sighting and status indicator, and several control buttons, as shown in the figure below.

The panel is primarily for setting up the instrument prior to nonstop operation. A screw able end cap with a sealed glass window protects the user interface during nonstop operation.

The sensor has a remote locking feature to protect the unit from accidental interaction over the control panel. This lockout mode denies access to the submenu functions of the control panel. Via a specific key command over the control panel or the digital communication the device can be unlocked.

Figure 6-1: Control Panel



Do not look through the visual sighting port at extremely bright objects with your eyes unprotected. Eye damage could occur.

6.1.1 Target Temperature Display

The Target Temperature Display fulfills two tasks to inform the operator:

- In normal operation after warming phase, it displays the current measured target temperature, including any signal processing like "Averaging Hold", "Peak Hold" or "Valley Hold". The displayed temperature depends on the preset measurement unit (°C or °F).
- In abnormal operation, during warming phase, or in failure case discovered through the failsafe-circuit, it displays an error code (e.g. EUUU, EAAA), see section 13.2 Fail-Safe Operation, page 101.

6.1.2 Menu Display

The Menu Display is the central user interface display, which shows all selected menus, their submenus and parameters. The background color of the display alternates in accordance to the following conditions:

- Green background – normal functionality, no alarm indication
- Red background – alarm state, alarm threshold violated (e.g. measured target temperature exceeds setpoint)

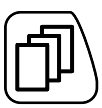
6.1.3 Sighting Indicator

The Sighting Indicator indicates the status of the integrated sighting device (laser). An activation is shown with the sighting indicator set to red.

6.1.4 Status Indicator

The Status Indicator shows a steady green light after warming period to indicate an error free function of the sensor.

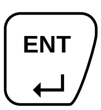
6.1.5 Control Buttons



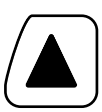
The **Browse** button serves as a selector for one of the available submenus. A specific submenu selection can be done in the following ways:

- Pressing the Browser button several times in series to toggle between the submenus.
- Holding the Browser button pressed, toggles between the submenus about every 2 s.

Stop to press the Browser button if you've reached the preferred submenu, displayed on the menu display. The first menu entry of the selected submenu will be displayed as default.



The **Enter** button confirms the selection of a submenu or a specific submenu entry. After walking through the listed submenu entries by using the Navigate buttons, the selection done by the Enter button initiates a blinking of the modifiable entry. To store updated entries a final press of the Enter button is required.

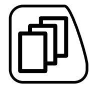


The **Navigate Up** button enables you to walk through the list of integrated entries per submenu, increases marked numerical values or toggles the specific entry.

The **Navigate Down** button enables you to walk through the list of integrated entries per submenu, decreases marked numerical values or toggles the specific entry.

6.2 Menu Structure

Consecutive pushes on the Browse button navigates through the sub-menus as shown below. A selection must be made with the Enter button.



INFORMATION MENU → CONFIGURATION MENU → UNIT SETUP MENU → INTERFACE MENU → ANALOG MENU →

Use the ▲ ▼ keys to toggle between the given settings.

6.2.1 Information Menu

The INFORMATION MENU consists of the following subentries which are not user modifiable and for information purpose only. All items marked in red are exemplary entries.

INFORMATION (1-color mode)	INFORMATION (2-color mode)
1-Color 43.5°C E=1.000 Av:0.2s	2-Color 43.5°C S=1.000 Av:0.2s
INTERNAL TEMP. 23.5°C	INTERNAL TEMP. 23.5°C
	ATTENUATION 100%
LOW LIMIT 400°C	LOW LIMIT 400°C
HIGH LIMIT 1800°C	HIGH LIMIT 1800°C
SENSOR IDENT E1ML-F2-V-0-0	SENSOR IDENT E1RL-F2-V-0-0
SENSOR REVISION 2.02.28	SENSOR REVISION 2.02.28
SERIAL NUMBER 37560001	SERIAL NUMBER 37560001
MAC ADDRESS 001d8d200364	MAC ADDRESS 001d8d200364

INFO FIELD

shows essential information for the sensor such as:

- Operation mode: 1-color or 2-color
- Internal temperature in °C or °F
- Emissivity setting (1-color mode) or Slope setting (2-color mode)
- Signal processing function – Av: average, Ph: peak hold, Vh: valley

INTERNAL TEMP.

displays the internal device temperature in °C or °F (e.g. 39.8°C)

ATTENUATION

The subentry is only available for sensors in 2-color mode. A percentage value of the measured attenuation will be displayed (e.g. 10%).

LOW LIMIT

displays the low limit temperature of the measurement range in °C or °F (e.g. 400.0°C)

HIGH LIMIT

displays the high limit temperature of the measurement range in °C or °F (e.g. 400.0°C)

SENSOR IDENT

displays the sensor's identification number as a combination of spectral model, focus option, sighting option, cooling option, and communication option (e.g. EF1ML-F2-1-0-0-10BL)

SENSOR REVISION

displays the firmware revision number (e.g. 2.02.28)

SENSOR NUMBER

displays the sensor serial number (e.g. 37560001)

MAC ADDRESS

displays the unique MAC address used for network communications (e.g. 001d8d200364)

6.2.2 Configuration Menu

CONFIGURATION (1-color mode)	CONFIGURATION (2-color mode)
	MODE 2-COLOR
TEMP. UNITS °C	TEMP. UNITS °C
RELAY MODE NORMALLY OPEN	RELAY MODE NORMALLY OPEN
	ATTENUATION RELAY 95%
	ATTENUATION FAILSAFE 95%
LASER ON	LASER ON
FACTORY DEFAULT NO	FACTORY DEFAULT NO
KEY -ENTER- UNLOCKED	KEY -ENTER- UNLOCKED

MODE

The subentry is available for 2-color sensors only. It allows to force the device to operate either in 1-color or in 2-color mode.

TEMP. UNITS

toggles between the temperature units °C or °F.

RELAY MODE

toggles between the relay modes for the potential free relay contact:

- NORMALLY OPEN
- PERMANENT CLOSED
- PERMANENTLY OPEN
- NORMALLY CLOSED

ATTENUATION RELAY

allows to set the attenuation threshold to switch the relay. Range is from 0 to 95% of attenuation.

ATTENUATION FAILSAFE

allows to set the attenuation threshold for the failsafe warning EAAA. Range is from 0 to 95% of attenuation.

LASER

For the laser sighting you can toggle between the following modes:

- ON – switches the laser permanently to ON
- OFF – switches the laser permanently to OFF
- TRIGGER LEVEL – switches the laser based on the signal level on the trigger input
- TRIGGER EDGE – switches the laser based on the signal edge on the trigger input
- FLASH – the laser flashes

FACTORY DEFAULT

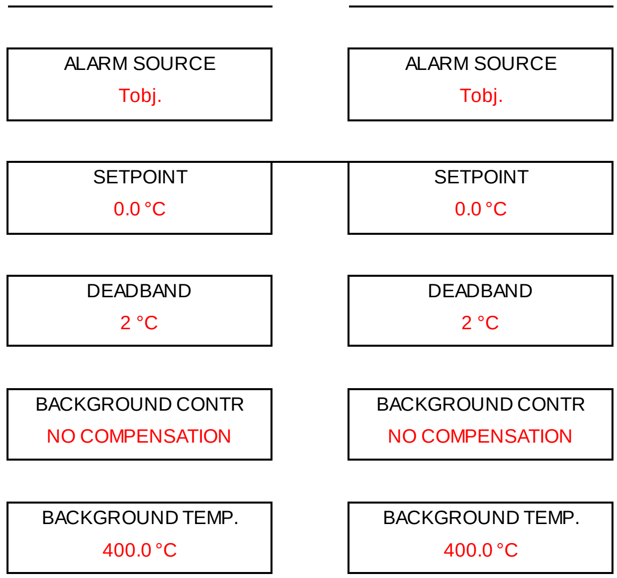
parameters of the sensor back to factory default values, see section 14.9 Command List, page 116.

KEY -ENTER-

shows the LOCKED / UNLOCKED status to avoid unintended user control interactions if the sensor communicates digitally.

6.2.3 Unit Setup Menu

UNIT SETUP (1-color mode)	UNIT SETUP (2-color mode)
	SLOPE 1.000
	SLOPE SOURCE INTERNAL
EMISSIVITY 1.000	EMISSIVITY 1.000
EMISSIV. SOURCE INTERNAL	EMISSIV. SOURCE INTERNAL
TRANMISSIVITY 1.000	TRANMISSIVITY 1.000
SENSOR GAIN 1.000000	SENSOR GAIN 1.000000
SENSOR OFFSET 0.0 °C	SENSOR OFFSET 0.0 °C
	TOPSENSOR GAIN 1.000000
	TOPSENSOR OFFSET 0.0 °C
MATCH 350.0°C E=1.0000	MATCH 350.0°C S=1.0000
AVERAGE 2.0 sec.	AVERAGE 2.0 sec.
PEAK HOLD 0.0 sec.	PEAK HOLD 0.0 sec.
VALLEY HOLD 0.0 sec.	VALLEY HOLD 0.0 sec.
DECAY RATE 0 °C/s	DECAY RATE 0 °C/s



SLOPE

The subentry is only available for sensors in 2-color mode. It allows to correct the temperature reading by an adaptation of the slope value. With the ▲ ▼ keys, you can toggle between slope values from 0.850 to 1.150

SLOPE SOURCE

The subentry is only available for sensors in 2-color mode. It allows to assign the input source for the slope value:

- INTERNAL – the slope value is taken from the value set under the SLOPE subentry
- EXTERNAL mA IN – the slope value is taken from the external current loop analog input

EMISSIVITY

allows to correct the temperature reading by an adaptation of the emissivity value in a range from 0.100 to 1.100

EMISSIVITY SOURCE

allows to assign the input source for the emissivity value:

- INTERNAL – the emissivity value is taken from the value set under the EMISSIVITY subentry
- EXTERNAL mA IN – the emissivity value is taken from the external current loop analog input

TRANSMISSIVITY

allows to correct the temperature reading by an adaptation of the transmissivity value in a range from 0.10 to 1.10. For example, if a protective window is used with the sensor, set the transmission to the appropriate value.

SENSOR GAIN

allows to correct the temperature reading by a gain multiplicator in a range from 0.800000 to 1.200000. The standard value is 1.000000.

SENSOR OFFSET

allows to correct the temperature reading by the addition of an offset value in a range from -200.0 to 200.0°C. The standard value is 0.0°C.

TOPSENSOR GAIN

The subentry is only available for sensors in 2-color mode. It allows to correct the wide band temperature reading by a gain multiplicator in a range from 0.800000 to 1.200000. The standard value is 1.000000.

TOPSENSOR OFFSET

The subentry is only available for sensors in 2-color mode. It allows to correct the wide band temperature reading by the addition of an offset value in a range from -200.0 to 200.0°C. The standard value is 0.0°C.

MATCH

adapts the temperature reading to the expected real object temperature. You can affect the current temperature reading by overriding it with the real, alternatively measured, object temperature. In 1-color mode, the match confirmation corrects the object emissivity value to match the current temperature reading. The match confirmation in 2-color mode adapts the slope value to match the current temperature reading. With the ▲ ▼ keys, you can toggle between temperature match values from "LOW LIMIT" to "HIGH LIMIT" of the temperature range.

AVERAGE

defines the parameter for the signal post processing, see section 6.3.1 Averaging, page 55.

PEAK HOLD

defines the parameter for the signal post processing, see section 6.3.2 Peak Hold, page 55.

VALUE HOLD

defines the parameter for the signal post processing, see section 6.3.4 Valley Hold, page 58.

DECAY RATE

defines the linear signal decay for a given time span. The unit for the decay is in °C/s or °F/s, see Signal Drop: Linear in section 6.3.2.3 Signal Drop with Reset, page 57.

ALARM SOURCE

sets the source for an alarm:

- T_{obj} – the object temperature is the alarm source
- T_{int} – the internal temperature of the sensor is the alarm source

SETPOINT

Once the setpoint is activated by providing a non-zero value, the relay changes state as the current temperature passes the setpoint temperature. With the ▲ ▼ keys, you can toggle between setpoint values from "LOW LIMIT" to "HIGH LIMIT" (e.g. 400.0 °C to 1800.0 °C).

For more information, see section 5.8.1.1 Setpoint, page 39.

DEADBAND

defines the deadband, see section 5.8.1.2 Deadband, page 39.

BACKGROUND CONTR

refers to the compensation source for the background temperature, see section 5.7.2.2 Background Temperature Compensation, page 38.

- NO COMPENSATION – background temperature compensation is switched off
- EXTERNAL mA IN – temperature value for background compensation is taken from the external current loop analog input
- TEMP. VALUE – temperature value for background compensation is taken from subentry BACKGROUND TEMP.

BACKGROUND TEMP.

provides the temperature value for the background compensation. With the ▲ ▼ keys, you can toggle between values between "LOW LIMIT" to "HIGH LIMIT" of the temperature measurement range.

6.2.4 Interface Menu

INTERFACE
RS485 BAUD RATE 115200 bps
MULTIDROP ADDR. 000
RS485 MODE TWO WIRE
TERMIN. RESISTOR OFF
DHCP/BOOTP OFF
ETHERNET IP 192.168.42.132
ETHERNET NM 255.255.255.0
ETHERNET GW 192.168.42.1
ETHERNET PORT 6363
WEB SERVER ON

RS485 BAUD RATE

sets the baud rate for the RS485 communication:
1200, 2400, 9600, 19200, 38400 (default), 57600, 115200 bps

MULTIDROP ADDR.

sets the multidrop address to the sensor. A unique address is mandatory for each sensor in a RS485 network. The valid address range is from 000 to 032
For more information, see section 7 RS485, page 60.

RS485 MODE

defines the RS485 communication mode with TWO WIRE (half-duplex). For Endurance compact sensors are no other settings possible.

TERMIN. RESISTOR

activates/deactivates the sensor internal shunt resistor for the physically last unit in the RS485 network, see section 7.2 Installation, page 60.

DHCP/BOOTP

refers to a network mechanism to obtain a dynamic Ethernet address for the sensor:

- OFF – no dynamic address assignment, the defined ETHERNET IP address is a fixed address
- DHCP ON – dynamic address assignment using DHCP
- BOOTP ON – dynamic address assignment using BOOTP (by means of the correct MAC address)

ETHERNET IP

sets a fixed network address for the sensor, see section 8.1 Addressing, page 64.

ETHERNET NM

sets the network mask to integrate the sensor in an existing subnet domain, see section 8.1 Addressing, page 64.

ETHERNET GW

sets the network gateway address.

ETHERNET PORT

sets the Ethernet port, see section 8.1 Addressing, page 64.

WEB SERVER

activates/deactivates the internal web server provided by the sensor.

6.2.5 Analog Menu

ANALOG

ANALOG OUT MODE
4 – 20 mA

OUT Lo LIMIT
400.0 °C

OUT Hi LIMIT
3000.0 °C

ANALOG IN MODE
4 – 20 mA

IN Lo LIMIT
400.0 °C

IN Hi LIMIT
3000.0 °C

ANALOG OUT MODE

toggles the analog output mode between 0 – 20 mA and 4 – 20 mA.

OUT Lo LIMIT

defines the temperature for the low end of the analog output range (scaling). Valid numbers between 0.0 to 9999.0°C

OUT Hi LIMIT

defines the temperature for the high end of the analog output range (scaling). Valid numbers between 0.0 to 9999.0°C

ANALOG IN MODE

toggles the analog input mode between 0 – 20 mA and 4 – 20 mA.

IN Lo LIMIT

defines the temperature for the low end of the analog input range (scaling). Valid numbers are within the temperature range of the sensor.

IN Hi LIMIT

defines the temperature for the high end of the analog input range (scaling). Valid numbers are within the temperature range of the sensor.

6.3 Post Processing

The activation and modification of post processing functions and their associated parameters is possible via the PC based Multidrop Software, Ethernet or RS485 programming commands, or over the control panel.

Note that only one signal processing function can be active.

6.3.1 Averaging

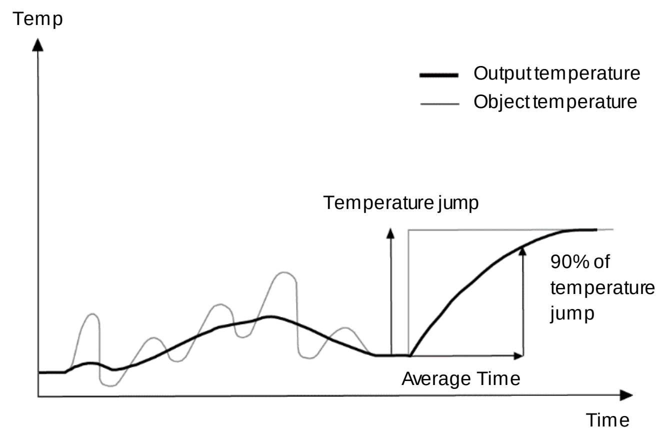
Averaging is used to smooth the output signal. The signal is smoothed depending on the defined time basis. The output signal tracks the detector signal with significant time delay, but noise and short peaks are damped. Use a longer average time for more accurate damping behavior. The average time is the amount of time the output signal needs to reach 90% magnitude of an object temperature jump.

The range for the average time can be set from 0.1 to 300.0 s, whereas just 0.1 - 299.9 s will be interpreted as averaging duration. Once Averaging is set above 0, it automatically activates. A value of 300.0 s indicates that averaging post processing depends on an external trigger signal. A low-level input signal (pull to GND) at the external input (Trigger) will promptly interrupt the averaging and will restart the average calculation with the current temperature reading.

Note

The disadvantage of averaging is the time delay of the output signal. If the temperature jumps at the input (hot object), the output signal reaches only 90% magnitude of the actual object temperature after the defined average time.

Figure 6-2: Averaging



6.3.2 Peak Hold

The output signal follows the object temperature up to the point, where a new maximum is detected. The output will hold the maximum temperature value for the preset duration of the peak hold time. Once the peak hold time expires, the peak hold function will reset, and the output will resume tracking the object temperature until a new peak is reached.

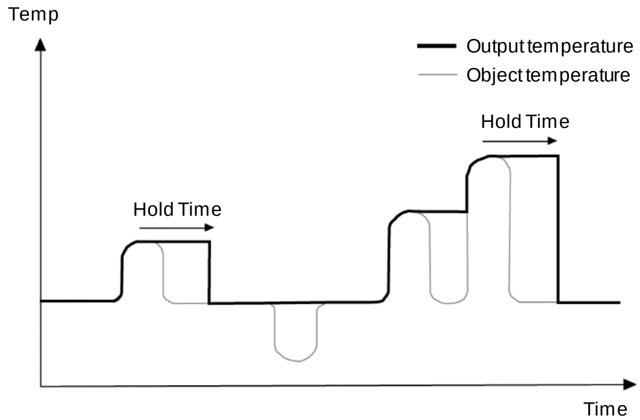
The range for the peak hold time can be set from 0.1 to 300.0 s, whereas just 0.1 - 299.9 s will be interpreted as peak hold duration. A value of 300.0 s indicates that peak hold post processing depends on an external trigger signal. A low-level input signal (pull to GND) at the external input (Trigger) will promptly interrupt the peak hold function and restarts the peak holding with the current temperature reading.

6.3.2.1 Reset by Time

Once the Peak Hold Time is set between 0.1 until 299.9 s, it automatically activates. The post-processed peak hold value stays the same up to the following happens:

- The Peak Hold Time is expired after holding the last peak value. In this case, the signal reverts to the current object temperature reading and restarts the peak holding process with the given hold time.
- The current object temperature reading exceeds the last temperature peak value. In this case, a new peak reading starts with holding the new peak object temperature.

Figure 6-3: Peak Hold and Reset by Time

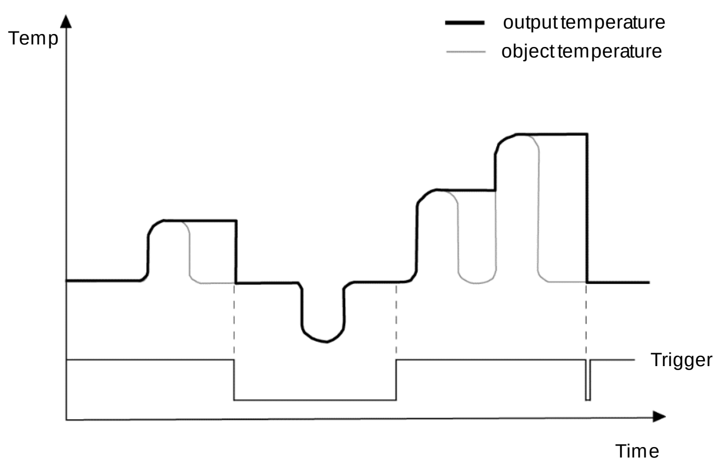


6.3.2.2 Reset by Trigger

Once the Peak Hold Time is set to 300 s, the peak holding process will be activated by an external trigger input signal (Trigger → high). The post-processed peak hold value stays the same up to the following happens:

- The external trigger input signal is pulled down (Trigger → GND). In this case, the signal reverts to the current object temperature reading and deactivates the peak hold function if the external trigger signal stays pulled to GND.
- The current temperature reading exceeds the peak hold temperature. In this case, a new peak reading starts with holding the new peak. No time limit is active for holding the last peak temperature.

Figure 6-4: Peak Hold and Reset by Trigger



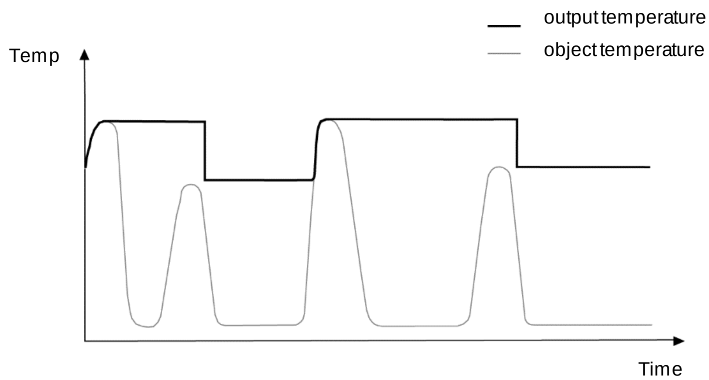
6.3.2.3 Signal Drop with Reset

The following three signal drop (decay) functionalities are implemented:

Signal Drop: Perpendicular

The perpendicular signal drop (default mode) is activated, if both relevant signal decay values (linear & averaging drop) are set to zero (0.0 Kelvin / s).

Figure 6-5: Signal Drop: Perpendicular

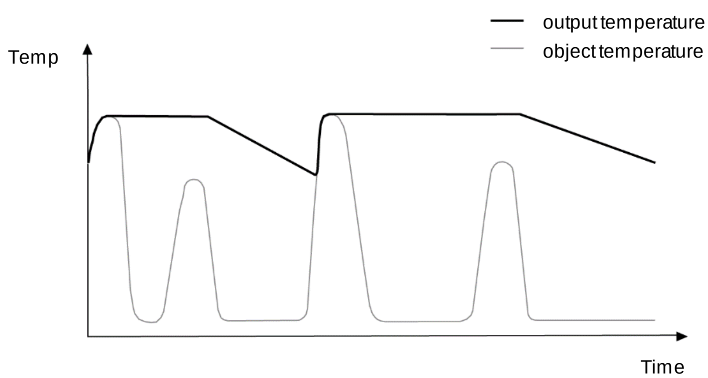


Signal Drop: Linear

The signal drop follows a linear decay function, where the decay value is given in Kelvin / s.

ASCII command: <XE>

Figure 6-6: Signal Drop: Linear

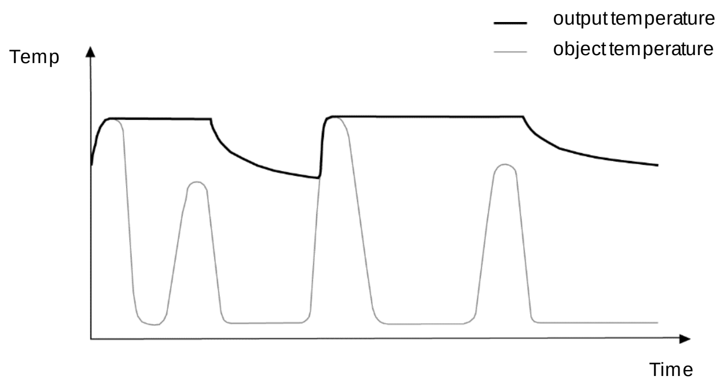


Signal Drop: Averaging

The signal drop follows an averaging function. The average time is the amount of time the output signal needs to reach 90% magnitude compared to a perpendicular drop.

ASCII command: <AA>

Figure 6-7: Signal Drop: Averaging

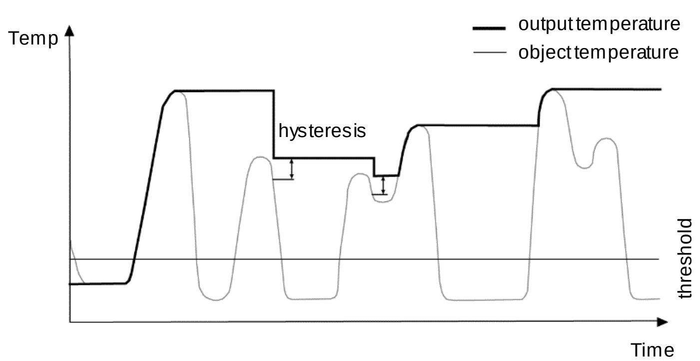


6.3.3 Advanced Peak Hold

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

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

Figure 6-8: Advanced Peak Hold

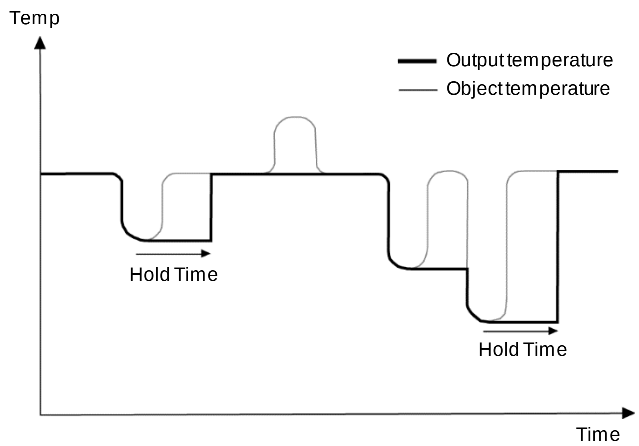


6.3.4 Valley Hold

This function works like the peak hold function, except it will search the signal for a minimum. The output signal follows the object temperature until a minimum is reached. The output will hold the minimum temperature value for the selected duration of the valley hold time. Once the hold time is expired, the valley hold function will reset and the output will resume tracking the object temperature until a new valley is reached.

The range for the valley hold time can be set from 0.1 to 300.0 s, whereas just 0.1 - 299.9 s will be interpreted as valley hold duration. Once Valley Hold is set above 0, it automatically activates. A value of 300.0 s indicates that valley hold post processing depends on an external trigger signal. A low level input (GND) at external input (Trigger) will promptly interrupt the valley hold function and restarts the valley holding with the current temperature reading.

Figure 6-9: Valley Hold



The output signal remains the same until one of two things happens:

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

6.3.5 Advanced Valley Hold

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

7 RS485

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

To connect the RS485 interface to a standard computer you should use a dedicated converter, see section 12.1.8 USB/RS485 Converter, page 90. The RS485 interface allows communication either via the standard Software or directly via dedicated ASCII commands, see section 14 ASCII Programming, page 111.

7.1 Specification

Technical Data:

Physical layer:	RS485, electrically isolated electronics housing (option -0): 2-wire, half-duplex electronics housing (option -1): 4-wire, full-duplex
Baud rate:	1200, 2400, 9600, 19200, 38400 (default), 57600, 115200 Bit/s
Settings:	8 data bits, 1 stop bit, no parity, no flow control
Address range:	1 to 32 0 for stand-alone unit or broadcast transmission

7.2 Installation

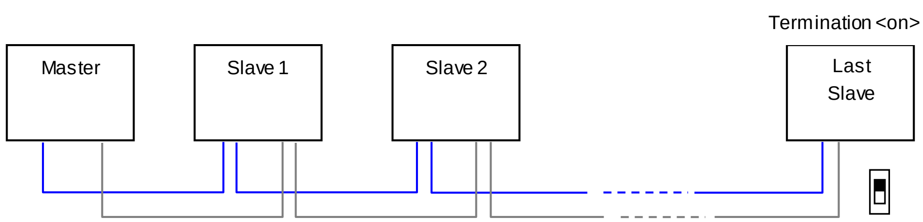
Note
A simultaneous communication via USB and fieldbus (e.g., RS485) is not allowed!

Note
Each slave in the network must have a unique nonzero address and must run at the same baud rate!

The recommended way to add more instruments into a network is connecting each instrument in series to the next in a linear topology (daisy chain). Use only one power supply for all instruments in the network to avoid ground loops!

Note
It is strongly recommended to use shielded and pair twisted cables (e.g. CAT.5)!

Figure 7-1: Network in Linear Topology (daisy chain)



For implementing the termination, you must activate the sensor internal shunt resistor for the physically last unit in the network. The activation can be done via the control panel of the sensor.

7.3 Wiring

Figure 7-2: RS485 Communication, 2-Wire

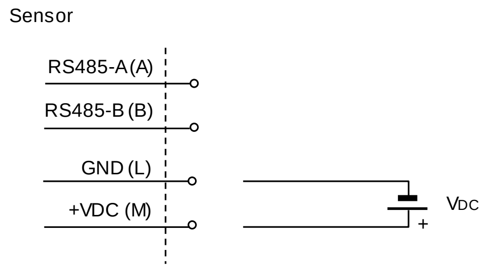
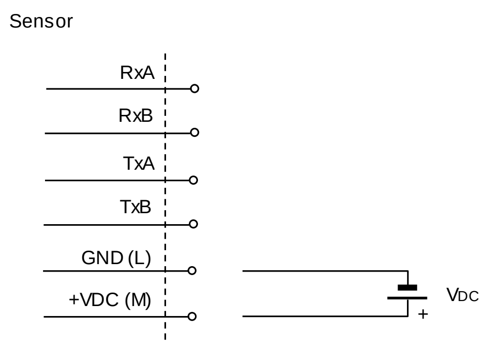
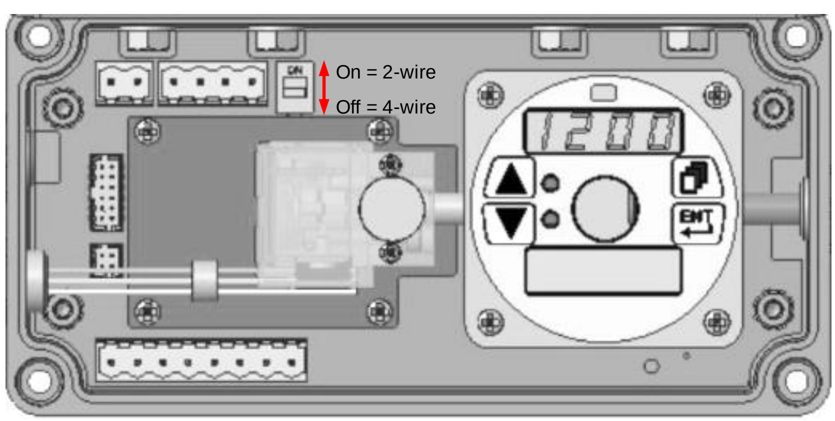


Figure 7-3: RS485 Communication, 4-Wire



The electronics housing with outside 12-pin connector (option -0) supports 2-wire mode only which is equivalent to half-duplex RS485 communication. The electronics housing with cable gland for inside terminal connection (option -1) supports 2-wire or 4-wire mode whereby the latter one corresponds to full-duplex RS485 communication. To enable the 4-wire mode, the housing internal DIP switch on the electronic board must be set to 'Off', see the figure below.

Figure 7-4: Toggling 2-Wire/4-Wire Mode



7.4 Computer Interfacing

The USB/RS485 Interface Converter (E-USB485) allows you to connect your sensor to computers by using a USB interface.

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

Note
In serial RS485 communication, the Endurance sensor supports the 2-wire / half duplex mode only!

Figure 7-5: Wiring the Sensor's RS485 Interface with USB/RS485 Converter, 2-Wire

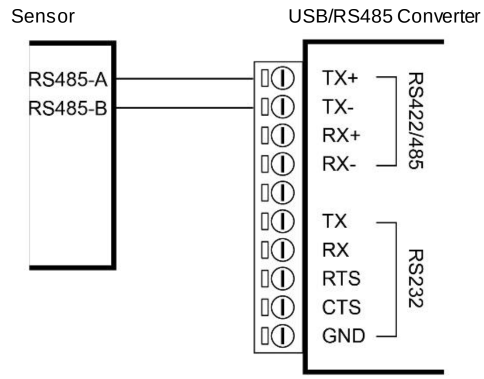
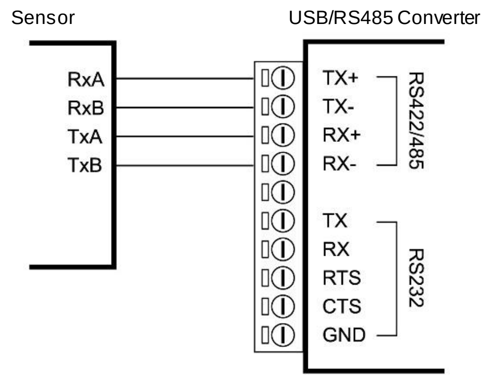


Figure 7-6: Wiring the Sensor's RS485 Interface with USB/RS485 Converter, 4-Wire



7.5 Multiple Sensors

For an installation of two or more sensors in a RS485 network, each sensor needs its specific RS485 network address (1 – 32) set via the control panel or alternatively via an ASCII command. Once all the units are addressed, wire up the units in the 2-wire multidrop manner, whereas all A and B signals must be connected to common lines. The common A signals must be routed to the TX+ and the common B signals to TX- terminal at the USB/RS485 converter as shown above.

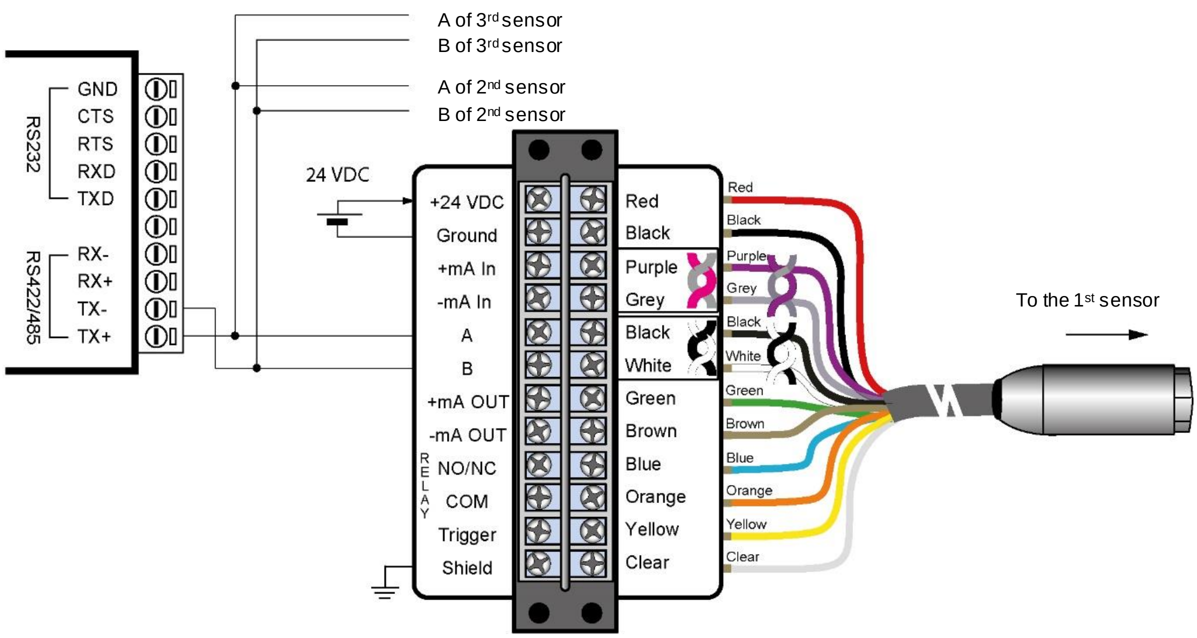
The same approach basically applies to devices running in 4-wire mode. All RS485 pins of one sensor are wired in parallel to the corresponding RS485 pins of the other sensor.

Addressing

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

- Each sensor must have a unique address greater zero (1 – 32).
- Each sensor must be set to the same baud rate (default is 38.4 kBaud).
- Once all the units are addressed, wire up the units in the 2-wire multidrop manner, keeping all A & B to be common. Same approach applies to 4-wire sensors.
- Now you can run the supplied software, as well as written communication software or an individual terminal program to access the sensor for issuing commands and receive the responses.

Figure 7-7: Wiring Multiple Sensors via RS485 Interface with USB/RS485 Converter, 2-Wire



8 Ethernet

8.1 Addressing

The factory default IP address for the sensor is 192.168.42.132

The IP address for the sensor is not free of choice: It must be unique in the network meaning that no other device in the network including the PC network adapter may run at the same IP address. The IP address for the sensor can be set directly via the control panel.

Note
Ask your IT administrator for a free IP address to be used!

8.1.1 Advanced Address Settings

Subnet Mask:

The Subnet Mask defines the interpretation of the IP address. The factory default setting is 255.255.255.0

Port:

In the case that the default port 6363 for the sensor should conflict with something else (it could be blocked by the firewall for example).

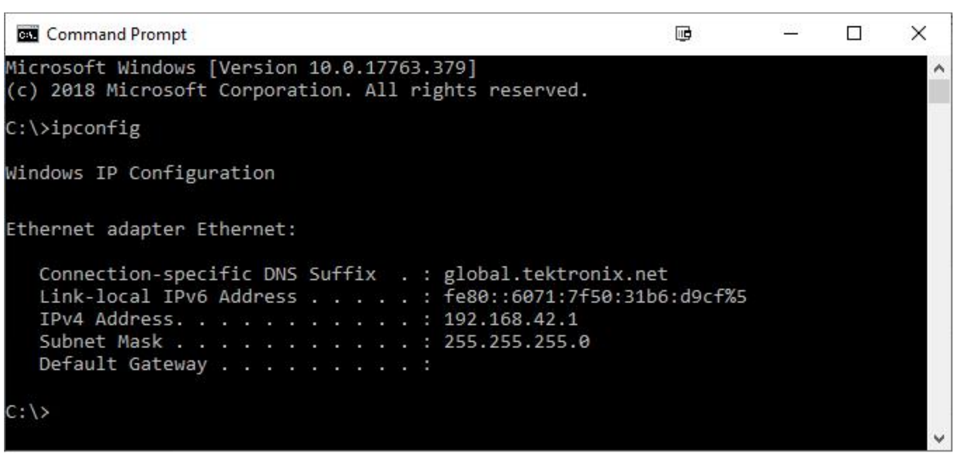
Gateway:

A gateway connects two subnets (which have a different subnet address).

Note
To establish the Ethernet communication, the subnet addresses for both the sensor and the PC need to match! Appropriate changes can be applied either on the sensor side or on the PC network adapter!

Note
The current settings for the IP address and the netmask of the PC can be asked with the command <ipconfig> in a Command Prompt window!

Figure 8-1: Command Prompt Window

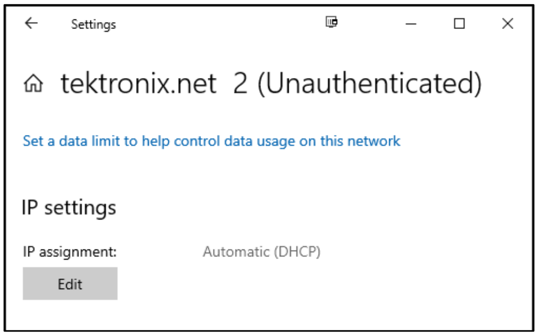


For the example above, the IP address of the PC is 192.168.42.1. The subnet address is 192.168.42, the host address is 1. The subnet address for the sensor must be 192.168.42 as well. The host address of the sensor must be in the range from 2 to 254 (address 1 is already used for the PC).

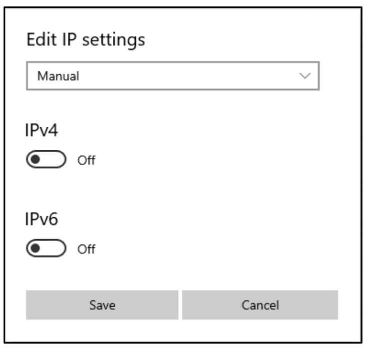
8.2 PC Network Adapter

The network adapter on the PC side can be configured as following:

1. Go to <Start> <Settings> <Network & Internet> <Status> <Change Connection Properties>
2. Under <IP Settings> <IP assignment> click on <Edit>

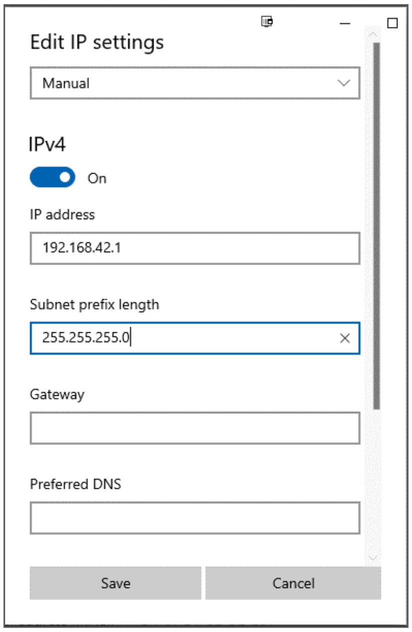


3. Under <Edit IP settings> select <Manual> and switch <IPv4> to On.



4. Make the following settings:

IP address:	192.168.42.x where x is an address between 0 and 255 except 132 which is already used by the Endurance sensor by factory default
Subnet prefix length:	255.255.255.0 (subnet mask)
Gateway:	{empty}
Preferred DNS:	{empty}



5. Close the dialog box by pressing on <Save>.

8.3 ASCII Programming

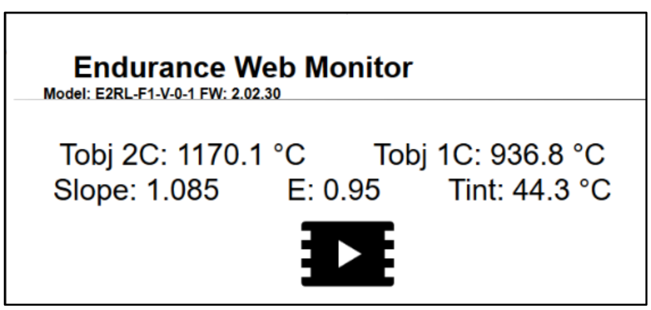
For the programming details, see section 14 ASCII Programming, page 111.

8.4 http Server

The sensor provides a built-in http server for one or more client computers based on the http protocol within an Intranet. Several information is available such as actual measured temperature, emissivity value, internal case temperature and – if present – a live stream from the built-in video camera.

For accessing the sensor's web interface, a standard web browser can be used. For that, you must provide the current IP address of the sensor.

Figure 8-2: Web Page



8.5 Video Streaming

Using the following instructions, the user can stream the video images from the sensor directly to the terminal device.

Initiates the video streaming from a sensor which is at the given network address:
http://193.221.142.172/camera?action=stream

Initiates the video streaming in vga format from a sensor which is at the given network address:
http://193.221.142.172/camera?action=stream&resolution=vga

Initiates the video streaming in 720p format from a sensor which is at the given network address:
http://193.221.142.172/camera?action=stream&resolution=720p

9 PROFINET IO

The PROFINET IO maps the object temperature, internal temperature and the status of the pyrometer via PROFINET IO. Furthermore, PROFINET IO allows you to change a subset of sensor parameters in data exchange mode. In the initialization phase, the PROFINET module determines the physical structure of the node and creates a local process image with the pyrometer.

The diagnostics concept is based on channel specific diagnostic messages which are mapped to the respective alarms. Coding standard is according to IEC 61158 PROFINET IO.

Specification:

Type:	PROFINET IO
Conformance class:	A
Real-Time class:	1 (RT) and the Real-Time class UDP
I/O update cycle time	1 ms

Configurable substitute value behavior in the event of error/failure

9.1 Configuration

The PROFINET IO takes over the task of the I/O device in PROFINET IO. Selecting the I/O module for the process data exchange and defining the time pattern happens during the I/O controller configuration.

Under PROFINET IO, the device manufacturer describes the device features in a GSD file, which is XML (Extensible Markup Language) coded and supplied to the end-user.

GSDML-V2.25-FlukeProcessInstruments-Endurance-20160616.xml

The I/O device is configured in accordance with the physical arrangement of the node (slot oriented).

Module slot 0 contains the PROFINET in its function as station substitute. It does not deliver process data itself, but provides the parameters required to perform communication settings of the I/O device (e.g. update cycle time).

Slot 1 (Input/output module) reflects the physical arrangement of the pyrometer, that deliver a part of the process and diagnostics data. All specific information on the relevant module is contained in the associated GSD file.

9.2 Parameters

The parameter setting of a connected pyrometer happens via “record data” sets. The I/O module allows diagnostics message to be locked or released. Once all parameter settings are performed, the I/O device signals that it is ready to send cyclic productive data.

Certain pyrometer characteristics are parameterizable during the configuration. The parameters of the pyrometer substitute are used to set the overall settings of the PROFINET I/O node. Some of the setting are used in the module as default settings and can be optionally overwritten within the module configuration.

Table 9-1: Pyrometer Parameters

Parameter	Description	Setting
Temperature unit	Set the temperature unit	Celsius
		Fahrenheit
Color mode		1 , 2 color
Slope	* 1000 (0.9 → 900)	850 … 1150
Emissivity	* 1000 (0.9 → 900)	100 … 1100
Transmissivity	* 1000 (1.0 → 1000)	100 … 1100
Sensor offset		-200 … +200
Sensor gain		800 … 1200
Averaging time	* 0.1s (1s → 10)	0 …3000
Valley hold time	* 0.1s (1s → 10)	0 …3000
Peak hold time	* 0.1s (1s → 10)	0 …3000
Setpoint relay	in °C /°F	dev. range min. max
Deadband		1 …99
Decay rate		0 …9999
Relay alarm output control		normally open, normally closed, permanently open, permanently closed
Laser control		off / on / flashing/ trigger
Panel lock		locked / unlocked
Analog output mode	Set output mode	0 … 20 mA / 4 … 20 mA
Bottom temperature of output	Set bottom temperature of analog output	0…9999°C/°F
Top temperature of output	Set top temperature of analog output	0…9999°C/°F

9.3 Messages

Table 9-2: Messages

Parameter	Description	Setting
Message diagnostics alarm	The diagnostics information of pyrometer is not transferred to the PROFINET IO controller	message inactive
	is transferred to the PROFINET IO controller	message active
Message process alarm	The process alarm of pyrometer is not transferred to the PROFINET IO controller	message inactive
	is transferred to the PROFINET IO controller	message active
Behavior on module fault		set process data to zero, set process data to last value

9.4 Input Data

Table 9-3: Input Data

Address without offset	Length	Format	Value
0	4 Byte	REAL (Big Endian, Motorola)	Target Temperature 2 color
4	4 Byte	REAL (Big Endian, Motorola)	Target Temperature 1 color wide
8	4 Byte	REAL (Big Endian, Motorola)	Target Temperature 1 color narrow
12	4 Byte	REAL (Big Endian, Motorola)	Internal temperature
16	4 Byte	DWORD	Error Code
20	1 Byte	BYTE Bit0 (Bool)	Trigger state (0 – reset, 1 – set)
21	2 Byte	INT (Big Endian, Motorola)	Measured attenuation

9.5 Output Data

The output data may be used to change the initialization of the device (which was set once at start-up) when the bus is in data exchange mode.

Table 9-4: Output Data

Address without offset	Length	Format	Value
0	1 Byte	BYTE	Type of parameter
1	4 Byte	REAL / WORD	

The <Type of parameter> gives the meaning of the following parameters with the same format as described in section 9.2 Parameters, page 68.

Table 9-5: Parameter Types

Type of parameter	Meaning	Format
0	Do not change anything	
1	Slope	REAL
2	Emissivity	REAL
3	Transmissivity	REAL
4	Averaging time	REAL
5	Peak hold time	REAL
6	Valley hold time	REAL
7	Set point for the relay	REAL
8	Laser control	WORD

If <Type of parameter> is set to 0 then the output data gets ignored. As default, it should be set to 0 (zero).

9.6 Diagnostics

The diagnostics information of the fieldbus communicator can be read out acyclically using standard diagnostics data sets defined in the PROFINET IO specification.

Errors occurring when configuring and setting the parameters of the fieldbus communicator and the connected pyrometer as well as external errors are reported by the communicator via channel specific diagnostic.

In productive data exchange between the I/O controller and the fieldbus PROFINET IO, one byte IOPS process data qualifiers are available for each module providing information of the validity of the pyrometer module data (good/ bad). In the event of an error occurs during operation, the problem-indicator in APDU-Status is set by the communicator and a diagnostic alarm is additionally transmitted.

Table 9-6: Error Codes

Bit	Description
0	Heater temperature over range
1	Heater temperature under range
2	Internal temperature over range
3	Internal temperature under range
4	Wide band detector failure
5	Narrow band detector failure
6	Energy too low
7	Attenuation for failsafe too high
8	Attenuation to activate relay too high
9	Two color temperature under range
10	Two color temperature over range
11	Wide band temperature under range
12	Wide band temperature over range
13	Narrow band temperature under range
14	Narrow band temperature over range
15	Alarm
16	Video overflow
17	PROFINET not ready
18	Heater not ready

10 EthernNet/IP

The EtherNet/IP module maps the object temperature, internal temperature, device status and other pyrometer data to its input assembly which is then sent onto the EtherNet/IP network using CIP. In the initialization phase, the device sends configuration data which is accessible for setup via the PLC programming software controller tags. Furthermore, EtherNet/IP allows you to change a subset of sensor parameters in data exchange mode using output data. For the device diagnostics, there is a special status register containing an error code, which is sent a part of the device's input data.

Specification:

- Device class: adapter device
- Device type: 06h (photoelectric sensor)

10.1 Configuration

The easiest way to incorporate an EtherNet/IP device into a PLC programming software project is by installing the EDS file and selecting the right module type. The device's input, output and config assemblies will be configured automatically. It is also possible to add the device manually using generic Ethernet module.

To allow for an easier implementation in automation projects, the device manufacturer describes the device features in an EDS file, which is supplied to the user and can be installed into the PLC programming environment using EDS hardware installation tool.

The EtherNet/IP device EDS file is named as:

EnduranceEIP_xxxxxxxx.eds

The EtherNet/IP device configuration using the EDS file (after it has been installed) only consists of choosing the right module, naming the device and typing in its IP address.

A manual configuration of the EtherNet/IP pyrometer is based on a generic Ethernet module. In this case, the assembly instance number and size must be typed in. The device settings are:

- Data type: SINT
- Input assembly instance 101, size 23 byte
- Output assembly instance 100, size 5 byte
- Configuration assembly instance 102, size 0 (the size of the configuration assembly is 58 bytes, however, sending it empty will cause an I/O failure. Configuration assembly is available when using EDS file.)

10.2 Parameters

All settable parameters of an Endurance pyrometer are available in the Configuration Data. Changing the parameters this way can only happen upon device initialization, i.e. when downloading the program to the PLC (default values are sent if no changes have been made). Once the parameter setting has been performed, the I/O device is ready to send cyclic productive data. While certain pyrometer characteristics are parameterizable only during the configuration, others can also be set in the data exchange mode using Output Data. The tables below contain all the parametrizable characteristics and are followed by a short implementation description.

The parameters included in the configuration data are accessible through controller tags in the PLC programming environment. Changing them in the controller tags will first have effect after downloading the program to the PLC. The programming software allows however for an easy saving of these tags so that the values can always be sent as default upon initialization.

Table 10-1: Pyrometer Parameters

Starting byte	Length	Name	Data type	Data value
0	1 Byte	Temperature unit	USINT	0x43 ('C') – Celsius 0x46 ('F') – Fahrenheit
1	1 Byte	Color mode	USINT	1 – one color 2 – two color
2	4 Byte	Slope	REAL	0.85 ... 1.15
6	4 Byte	Emissivity	REAL	0.1 ... 1.1
10	4 Byte	Transmissivity	REAL	0.1 ... 1.1
14	4 Byte	Device Offset	REAL	-200 … 200
18	4 Byte	Device Gain	REAL	0.8 ... 1.2
22	4 Byte	Average Time	REAL	0.0 ... 300.0
26	4 Byte	Peak hold Time	REAL	0.0 ... 300.0
30	4 Byte	Valley hold Time	REAL	0.0 ... 300.0
34	4 Byte	Set Point	REAL	Min. … Max. Temp.
38	4 Byte	Dead Band	REAL	1.0 ... 99.0
42	4 Byte	Decay Rate	REAL	0 ... 9999
46	1 Byte	Relay control	USINT	0 - normally open 1 - normally closed 2 - permanently open 3 - permanently closed
47	1 Byte	Laser/LED control	USINT	0 - off 1 - on 2 - flashing 3 - trigger
48	1 Byte	Panel lock state	USINT	0x4C ('L') – locked 0x55 ('U') – unlocked
49	1 Byte	mA output mode	USINT	0 – 0 to 20 mA 4 – 4 to 20 mA
50	4 Byte	Analog bottom of range	REAL	Min. to max. Temp.
54	4 Byte	Analog top of range	REAL	Min. to max. Temp.

10.3 Input Data

Table 10-2: Input Data

Attribute ID	Name	Data type*	Length	Access rule
0x01	Object temperature two color	REAL	4 Byte	Read
0x02	Object temperature one color wide	REAL	4 Byte	Read
0x03	Object temperature one color narrow	REAL	4 Byte	Read
0x04	Internal temperature	REAL	4 Byte	Read
0x05	Status	DWORD	4 Byte	Read
0x06	Trigger state	USINT	1 Byte	Read
0x07	Measured attenuation	UINT	2 Byte	Read

The data must be processed (copied) into especially created tags in a correct format in accordance to column “Format”. For example, to obtain the internal temperature of the device, one should create a REAL tag and an instruction copying 4 bytes of the device’s input data into this tag, beginning with byte 12.

10.4 Output Data

Once the pyrometer has been initialized and is running in the data exchange mode, only the below listed parameters can be changed, using the device's output data.

Table 10-3: Output Data

Address without offset	Length	Format	Value
0	1 Byte	BYTE	Type of parameter
1	4 Byte	REAL / UDINT	Parameter

The <Type of parameter> gives the meaning of the following parameters with the same format as described in section 10.2 Parameters, page 72.

Table 10-4: Parameter Types

Type of parameter	Meaning	Format
0	Does not change anything	-
1	Slope	REAL
2	Emissivity	REAL
3	Transmissivity	REAL
4	Averaging time	REAL
5	Peak hold time	REAL
6	Valley hold time	REAL
7	Set point for the relay	REAL
8	Laser/LED control	UDINT

To send the parameters and their values to the device, they must be stored in the controller tags first and then copied to their destination register in the device. Please note, that most of the values of the parameters are REALs whereas the parameter for laser control uses UDINT format – at least this value must be stored in a separate tag.

10.5 Diagnostics

The EtherNet/IP device has a designated status register. The bits of this register make up for an error code, which is sent as a part of input data.

0x05	Status	DWORD	4 Byte

It can be translated using the table below.

Table 10-5: Error Codes

Bit	Description
0	Heater temperature over range
1	Heater temperature under range
2	Internal temperature over range
3	Internal temperature under range
4	Wide band detector failure
5	Narrow band detector failure
6	Energy too low
7	Attenuation for failsafe too high
8	Attenuation to activate relay too high
9	Two color temperature under range
10	Two color temperature over range
11	Wide band temperature under range
12	Wide band temperature over range
13	Narrow band temperature under range
14	Narrow band temperature over range
15	Alarm
16	Video overflow
17	EtherNet/IP not ready
18	Heater not ready

11 Options

Options are items that are factory installed and must be specified at time of order.

The following are available:

- Fiber Optic Cable
- Laser Sighting
- Manufacturer's Calibration Certificate

11.1 Fiber Optic Cable

Fiber optic cables are available in the following options.

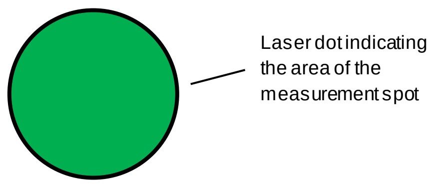
Table 11-1: Options for Fiber Optic Cables

Option	Length	Max. Ambient Temperature	Ingress Protection	Note
-01BL	1 m (3.3 ft)	200°C (392°F)	NEMA-4 (IP65)	
-03BL	3 m (9.8 ft)	200°C (392°F)	NEMA-4 (IP65)	
-06BL	6 m (19.7 ft)	200°C (392°F)	NEMA-4 (IP65)	
-10BL	10 m (32.8 ft)	200°C (392°F)	NEMA-4 (IP65)	not for EF2RL and EF2ML models
-22BL	22 m (72.2 ft)	200°C (392°F)	NEMA-4 (IP65)	not for EF2R and EF2M models (L and H models)
-01BL	1 m (3.3 ft)	315°C (599°F)	n/a	
-03BL	3 m (9.8 ft)	315°C (599°F)	n/a	
-06BL	6 m (19.7 ft)	315°C (599°F)	n/a	
-10BL	10 m (32.8 ft)	315°C (599°F)	n/a	not for EF2RL and EF2ML models
-22BL	22 m (72.2 ft)	315°C (599°F)	n/a	not for EF2R and EF2M models (L and H models)

11.2 Laser Sighting

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

Figure 11-1: Laser Sighting



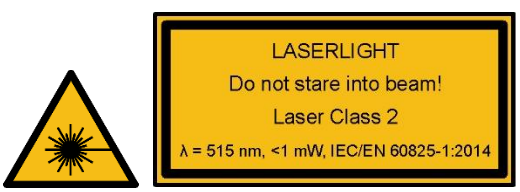
The laser is a Class II type laser with an output power less than 1 mW, and an output wavelength of 515 nm.

Note

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

Risk of Personal Injury

Avoid exposure to laser light! Eye damage can result.
Use extreme caution when operating!
Never look direct into the laser beam!
Never point directly at another person!
With an activated laser, avoid looking through the visual sighting port of the control panel.
Mirror and dispersion effects can injure eyes.



11.3 Manufacturer's Calibration Certificate

A sensor specific calibration certificate is assigned to the individual pyrometer and based on DAkkS (German accreditation body). The calibration certificate shows in a detailed list the sensor's accuracy as deviation values regarding the measurement normal under defined environmental conditions. In dependence of the sensor operation (e.g. smooth, harsh environment), a periodic re-calibration needs to be considered to guarantee the measurement stability and accuracy. The calibration is traceable to the International System of Units (SI) through National Metrological Institutes, such as NIST.

12 Accessories

12.1 Electrical Accessories

The following electrical accessories are available:

- High Temp 12-Wire Cable (E-2CCBxx)
- Low Temp 12-Wire Cable (E-2CLTCBxx)
- Ethernet PoE Cable (E-ETHxTCBxx)
- Terminal Block (E-TB)
- Terminal Block with Enclosure (E-TBN4)
- Power Supply DIN Rail (E-SYSPS)
- Power Supply with Terminal Box (E-PS)
- USB/RS485 Converter (E-USB485)
- PoE Injector (E-POE)
- 12-Pin Plug (E-2CCON)
- Aiming Light (E-FAFAL)

12.1.1 High Temp 12-Wire Cable (E-2CCBxx)

Use the High Temp 12-wire cable for the sensor to support power supply, all inputs, outputs, and the RS485 interface. The cable described below is a shielded 12-conductor cable, made of two twisted pairs plus 8 separate wires, all as tinned copper braid. The cable is equipped with a M16 DIN connector on one side and wire sleeves at the counter side. The outer diameter of the cable is 7 mm (0.28 in).

The cable withstands ambient temperatures up to 200°C (392°F) and is Teflon coated. Teflon coated temperature cables have good to excellent resistance to oxidation, heat, weather, sun, ozone, flame, water, acid, alkalis, and alcohol, but poor resistance to gasoline, kerosene, and degreaser solvents.

Figure 12-1: 12-Wire Cable, High Temp Version

Table 12-1: Cable Specification

P/N	Ambient Temperature	Length
E-2CCB4	-80 to 200°C (-112°F to 392°F)	4 m (13 ft)
E-2CCB8	-80 to 200°C (-112°F to 392°F)	8 m (26 ft)
E-2CCB15	-80 to 200°C (-112°F to 392°F)	15 m (49 ft)
E-2CCB30	-80 to 200°C (-112°F to 392°F)	30 m (98 ft)
E-2CCB60	-80 to 200°C (-112°F to 392°F)	60 m (197 ft)

Color	Number	Cross Section	Shield
black/red	2 wires	0.33 mm² (AWG 22)	none
black/white	1 twisted pair	0.22 mm² (AWG 24)	yes
purple/gray	1 twisted pair	0.22 mm² (AWG 24)	yes
green/brown/blue/orange/yellow/clear	6 wires	0.22 mm² (AWG 24)	none

Table 12-2: Color Assignment to DIN Connector

Color	Connector Pin	Description
Black	A	RS485-A
White	B	RS485-B
Gray	C	- mA In
Purple	D	+ mA In
White/drain	E	Shield
Yellow	F	Trigger
Orange	G	Relay (alarm)
Blue	H	Relay (alarm)
Green	J	+ mA Out
Brown	K	- mA Out
Black	L	Ground (power)
Red	M	+ 24 VDC

Risk of Personal Injury

Teflon develops poisonous gasses when it is exposed to flames!

Note

An ordered cable does ***not*** *include a terminal block!*

Note

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.

Note

If you purchase your own cable, use wire with the same specifications as herein mentioned. Maximum RS485 cable length is 1.200 m (4000 ft). Power supply feed in distance to the sensor should not extend the 60 m (200 ft) limit.

12.1.2 Low Temp 12-Wire Cable (E-2CLTCBxx)

Use the Low Temp 12-wire cable for the sensor to support power supply, all inputs, outputs, and the RS485 interface. The cable described below is a shielded 12-conductor cable, made of two twisted pairs plus 8 separate wires, all as tinned copper braid. The cable is equipped with a M16 DIN connector on one side and wire sleeves at the counter side. The outer diameter of the cable is 7.2 mm (0.28 in).

The cable withstands ambient temperatures up to 105°C (221°F) and is PUR (Polyurethane PUR- 11Y, Halogen free, Silicone free) coated. PUR coated cables are flexible and have good to excellent resistance to against oil, bases, and acids.

Figure 12-2: 12-Wire Cable, Low Temp Version

Table 12-3: Cable Specification

P/N	Ambient Temperature	Length
E-2CLTCB4	-40 to 105°C (-40 to 221°F)	4 m (13 ft)
E-2CLTCB08	-40 to 105°C (-40 to 221°F)	8 m (26 ft)
E-2CLTCB15	-40 to 105°C (-40 to 221°F)	15 m (49 ft)
E-2CLTCB30	-40 to 105°C (-40 to 221°F)	30 m (98 ft)
E-2CLTCB60	-40 to 105°C (-40 to 221°F)	60 m (197 ft)

Color	Number	Cross Section	Shield
black/red	2 wires	0.33 mm² (AWG 22)	none
black/white	1 twisted pair	0.22 mm² (AWG 24)	yes
purple/gray	1 twisted pair	0.22 mm² (AWG 24)	yes
green/brown/blue/orange/yellow/clear	6 wires	0.22 mm² (AWG 24)	none

Table 12-4: Color Assignment to DIN Connector

Color	Connector Pin	Description
Black	A	RS485-A
White	B	RS485-B
Gray	C	- mA In
Purple	D	+ mA In
White/drain	E	Shield
Yellow	F	Trigger
Orange	G	Relay (alarm)
Blue	H	Relay (alarm)
Green	J	+ mA Out
Brown	K	- mA Out
Black	L	Ground (power)
Red	M	+ 24 VDC

Risk of Personal Injury

Polyurethane may cause allergy and possibly cancer!

Note

*An ordered cable does **not** include a terminal block!*

Note

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.

Note

If you purchase your own cable, use wire with the same specifications as herein mentioned. Maximum RS485 cable length is 1.200 m (4000 ft). Power supply feed in distance to the sensor should not extend the 60 m (200 ft) limit.

12.1.3 Ethernet PoE Cable (E-ETHxTCBxx)

The Ethernet PoE cable comes with a four-pin male M12 D-coded connector, assigned to the sensors rear female M12 connector. The corresponding end of the Ethernet PoE cable is equipped with a general RJ45 snap-in connector.

The LT version of the cable is PUR coated and withstands ambient temperatures up to 80°C (176°F).

The HT version is Teflon coated and withstands ambient temperatures up to 180°C (356°F).

Figure 12-3: Ethernet PoE Cable

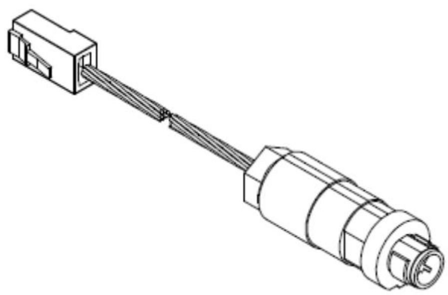


Figure 12-4: Pin Assignment (Front View)

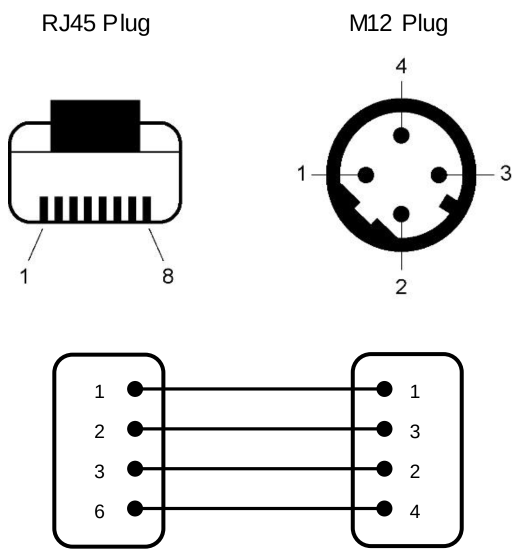


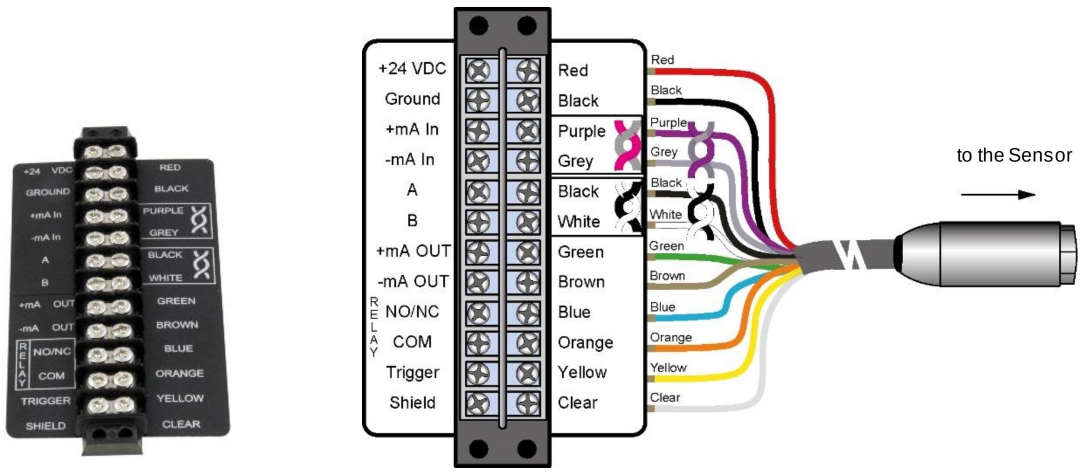
Table 12-5: Available Ethernet PoE Cables

P/N	Length	Ambient Temperature
E-ETHLTCB	7.5 m (25 ft)	80°C (176°F)
E-ETHLTCB25	25 m (82 ft)	80°C (176°F)
E-ETHLTCB50	50 m (164 ft)	80°C (176°F)
E-ETHCB	7.5 m (25 ft)	180°C (356°F)
E-ETHCB10	10 m (33 ft)	180°C (356°F)

12.1.4 Terminal Block (E-TB)

The terminal block accessory is for the connection of the sensor to the customer's industrial environment. It lists all different conductor colors on one side and the related signal names on the other side.

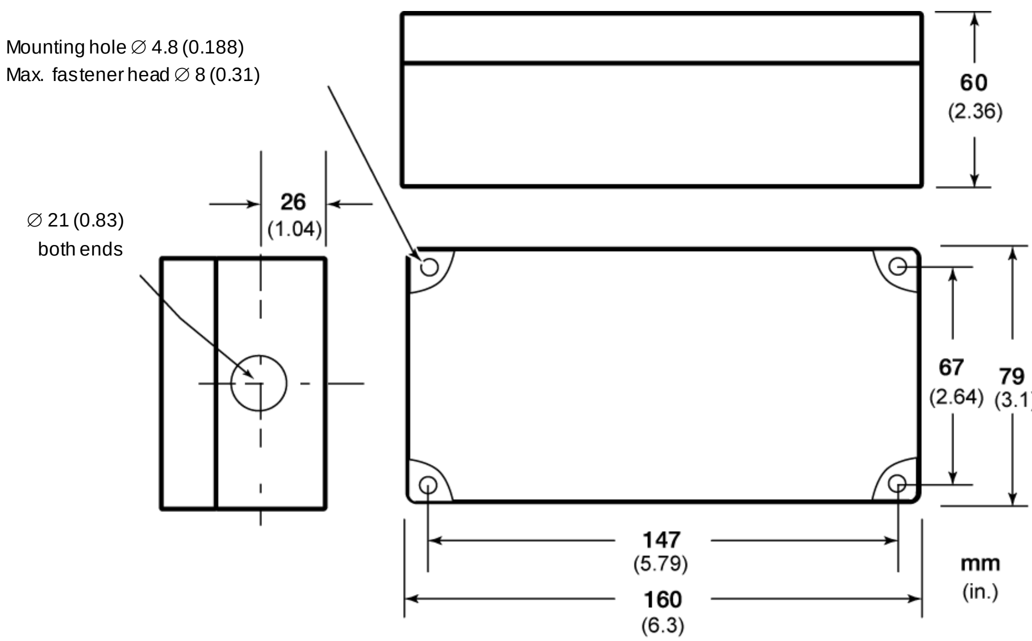
Figure 12-5: Terminal Block with Wire Color Assignment



12.1.5 Terminal Block with Enclosure (E-TBN4)

The terminal block accessory in an enclosure is for the connection of the sensor to the customer's industrial environment. The enclosure is IP67 (NEMA 4) protected, and the terminal block inside is identical to part E-TB.

Figure 12-6: Terminal Block with Enclosure



12.1.6 Power Supply DIN Rail (E-SYSPS)

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

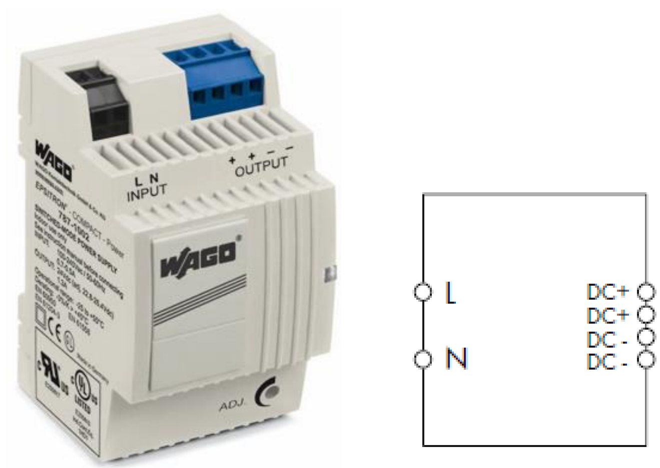
Risk of Personal Injury

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

Technical data:

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

Figure 12-7: Industrial Power Supply



[5]

[5] Copyright Wago®

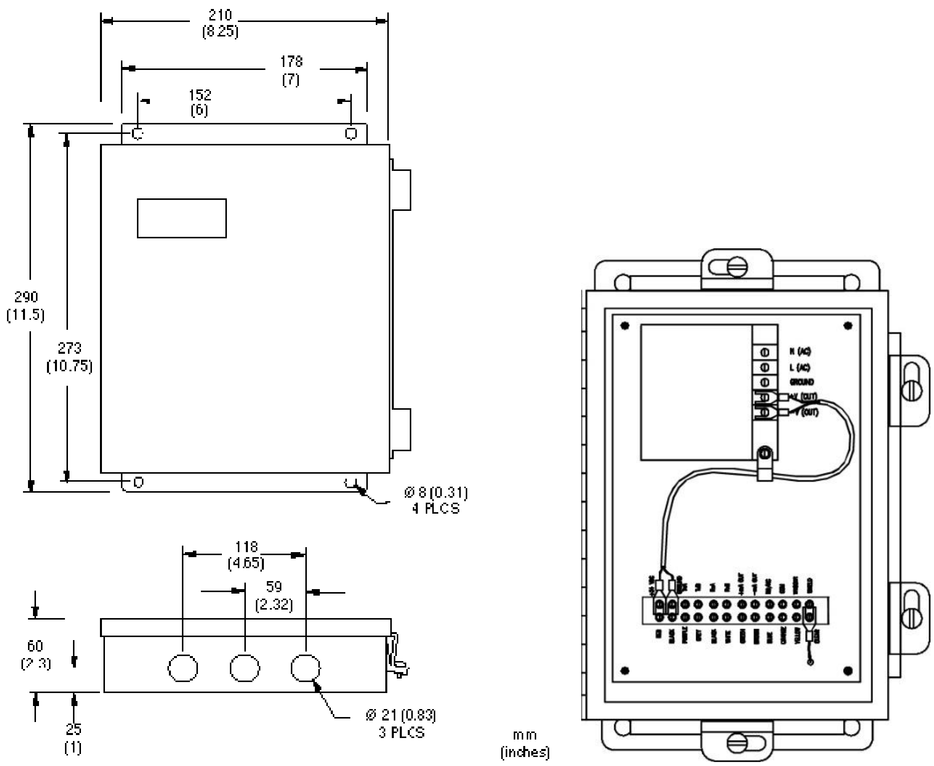
12.1.7 Power Supply with Terminal Box (E-PS)

The terminal box for the power supply is designed to provide IP65 (NEMA-4) protection to the terminal block, see section 12.1.4 Terminal Block, page 85, and a power supply for the sensor. The terminal box should be surface mounted using the flanges and holes provided. It should be mounted in such a manner to allow the free flow of air around the unit. Ambient temperatures for the terminal box should be kept within the range of 0 to 50°C (32 to 120°F), and humidity between 20 to 90%, non-condensing.

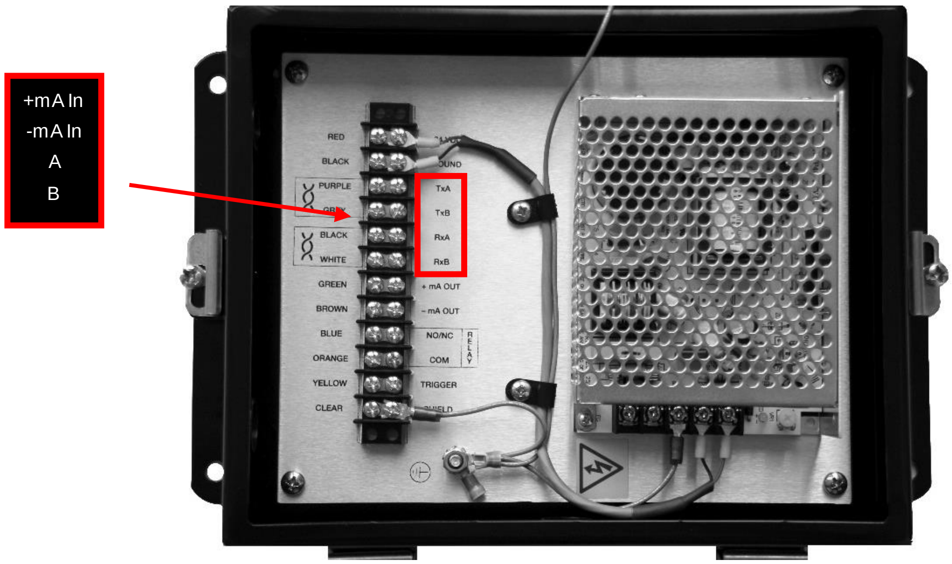
Technical data for the power supply:

AC input	100 – 240 VAC 50/60 Hz
DC output	24 VDC / 1.1 A

Figure 12-8: Power Supply with Terminal Box



To ensure correct wiring, stick the enclosed sticker onto the carrier plate as shown below.



12.1.8 USB/RS485 Converter (E-USB485)

The USB/RS485 converter allows you to connect your sensor to computers by using an USB interface.

Technical Data

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

Figure 12-9: USB/RS485 Converter

For more information, see section 7.4 Computer Interfacing, page 62.

12.1.9 PoE Injector (E-POE)

The PoE injector allows you to power the sensor over the Ethernet connection.

Technical Data

PoE standard	802.3af
PoE output power	15.4 W
PoE ports	1
Ethernet	100Base TX
Power supply	100 to 240 VAC / 50 to 60 Hz, 19 W
Operating temperature	0 to 50°C (32 to 122°F)
Humidity	10 to 90%, non-condensing
Dimensions L x W x H	146 x 64 x 42 mm (5.7 x 2.5 x 1.6 in)

Figure 12-10: PoE Injector

12.1.10 12-Pin Plug (E-2CCON)

The 12-pin plug is a female spare connector to replace a damaged one for the 12-wire cable, see section 12.1.1 High Temp 12-Wire Cable (E-2CCBxx), page 80 and section 12.1.2 Low Temp 12-Wire Cable (E-2CLTCBxx), page 82.

In case of shortening the existing 12-wire cable, you can assemble the spare connector by your own experienced technician.

Figure 12-11: 12-Pin Plug

12.1.11 Aiming Light (E-FAFAL)

The battery powered aiming light supports the aiming of the sensing head. Simply loosen the compression sleeve holding the fiber optic cable, loosen the screw at the heater block in the electronics housing, and pull the cable out of the heater block approximately 7 mm (0.25 in). Raise the fiber optic cable enough to slip the aiming light onto the end. Align the light beam on the target.

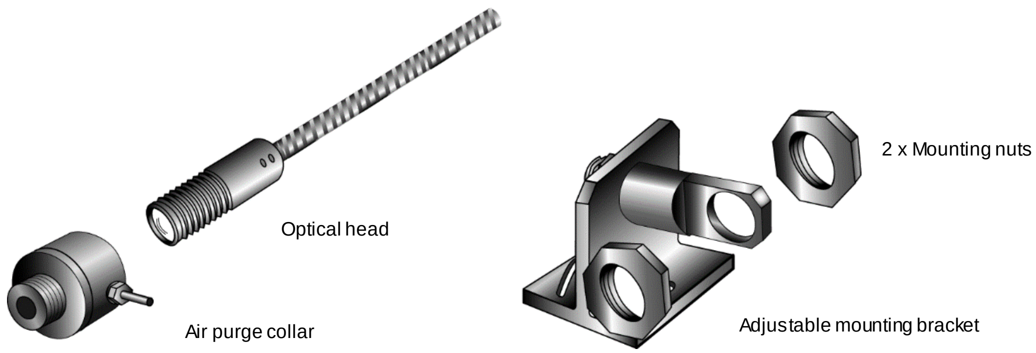
Figure 12-12: Aiming Light with Fiber Holder

12.2 Mechanical Accessories

The following mechanical accessories are available:

- Adjustable Mounting Bracket (E-FOMB)
- Air Purge Collar (E-FOHAPA)
- Fiber Optic Housing (E-FOXHx)
- Roof Mount Air Purge (E-FORFx)
- Cooling Platform (E-CP)

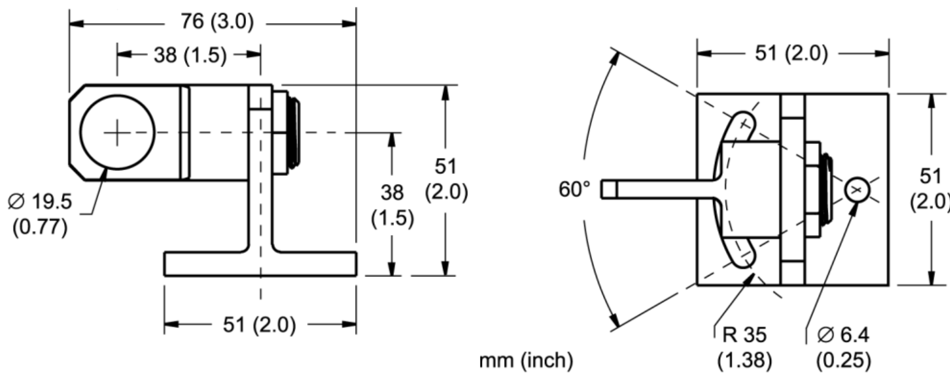
Figure 12-13: Mechanical Accessories (Selection)



12.2.1 Adjustable Mounting Bracket (E-FOMB)

The adjustable mounting bracket enables the optical head to be mounted in a movable location.

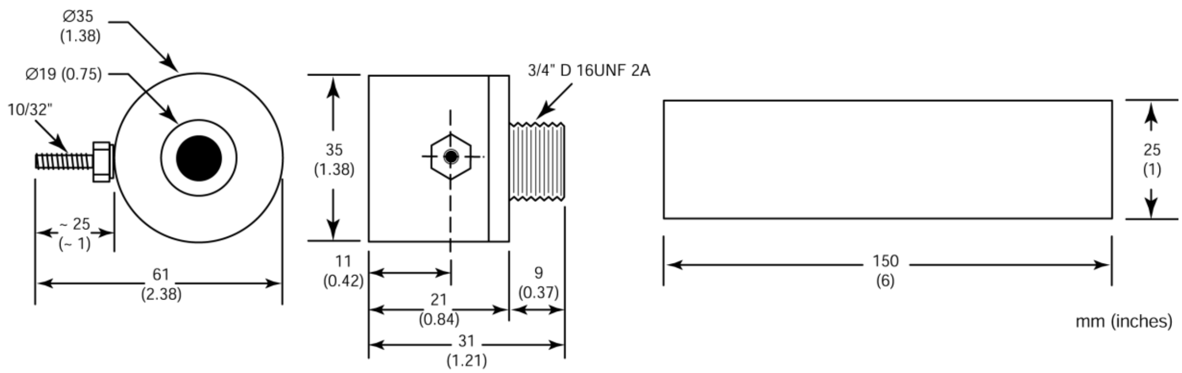
Figure 12-14: Adjustable Mounting Bracket



12.2.2 Air Purge Collar (E-FOHAPA)

The Air Purge Collar accessory is used to keep dust, moisture, airborne particles, and vapors away from the optical head's lens. It can be installed before or after the bracket. It must be screwed in fully. Air flows into the 1/8" NPT fitting and out the front aperture. Air flow should be a maximum of 0.5 - 1.5 l/s (0.13 – 0.4 gallons/s). 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). Also provided is a stainless-steel protection tube, 150 mm (6 in.) long by 25 mm (1 in.) diameter that threads onto the front of the air purge collar.

Figure 12-15: Air Purge Collar and Protection Tube



12.2.3 Fiber Optic Housing (E-FOXHx)

High temperature fiber-optic housing.

The Fiber Optic Housing accessory comes with air-knife purge, sapphire protective window, and air/protection hose. The accessory allows the sensing head and the fiber cable to operate continuously in an ambient operating temperature of as high as 450°C (842°F). A convenient mounting bracket is provided for the sensor head.

Two hose lengths are available:

- E-FOXH3: 3 m (9.8 ft)
- E-FOXH6: 6 m (20 ft)

Technical Data

Ambient temperature	450°C (842°F) at 3.5 bar (50 psi) compressed air at room temperature supplied at the inlet
Window material	Sapphire
Window transmission	0.865

Note

For correct temperature readings, the transmission factor of the Sapphire window needs to be considered via setting the transmissivity value in the sensor!

Figure 12-16: Fiber Optic Housing

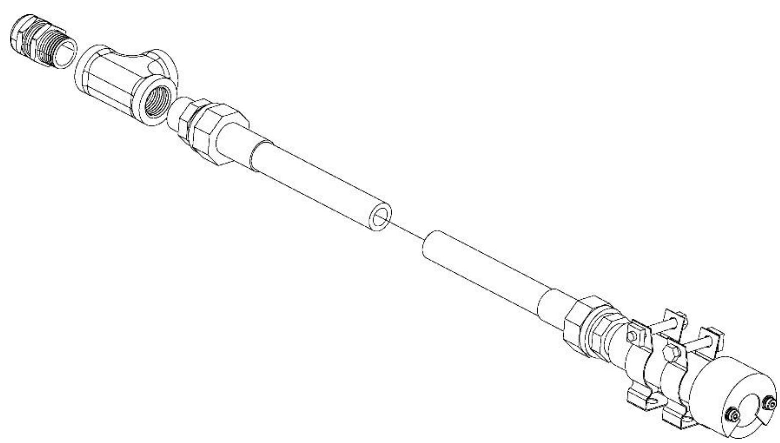


Figure 12-17: Schematic Diagram

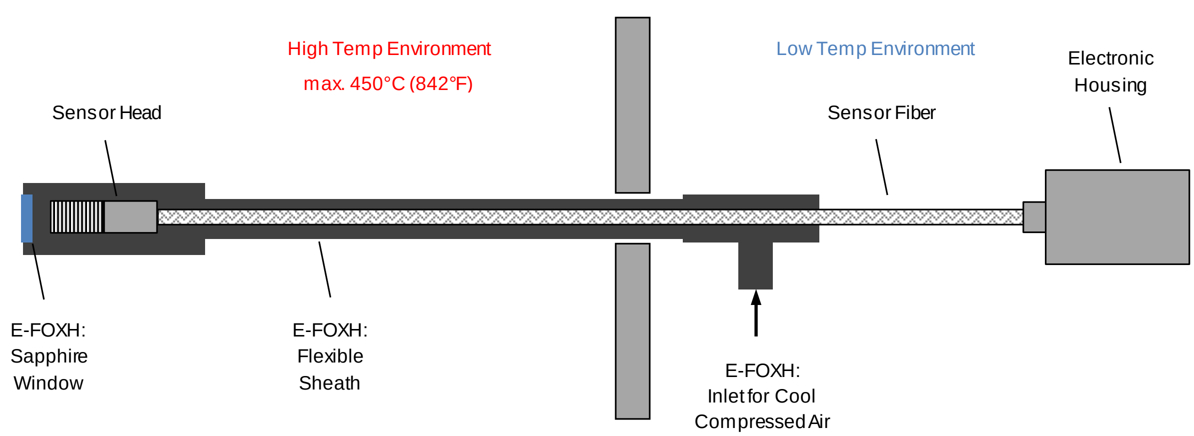
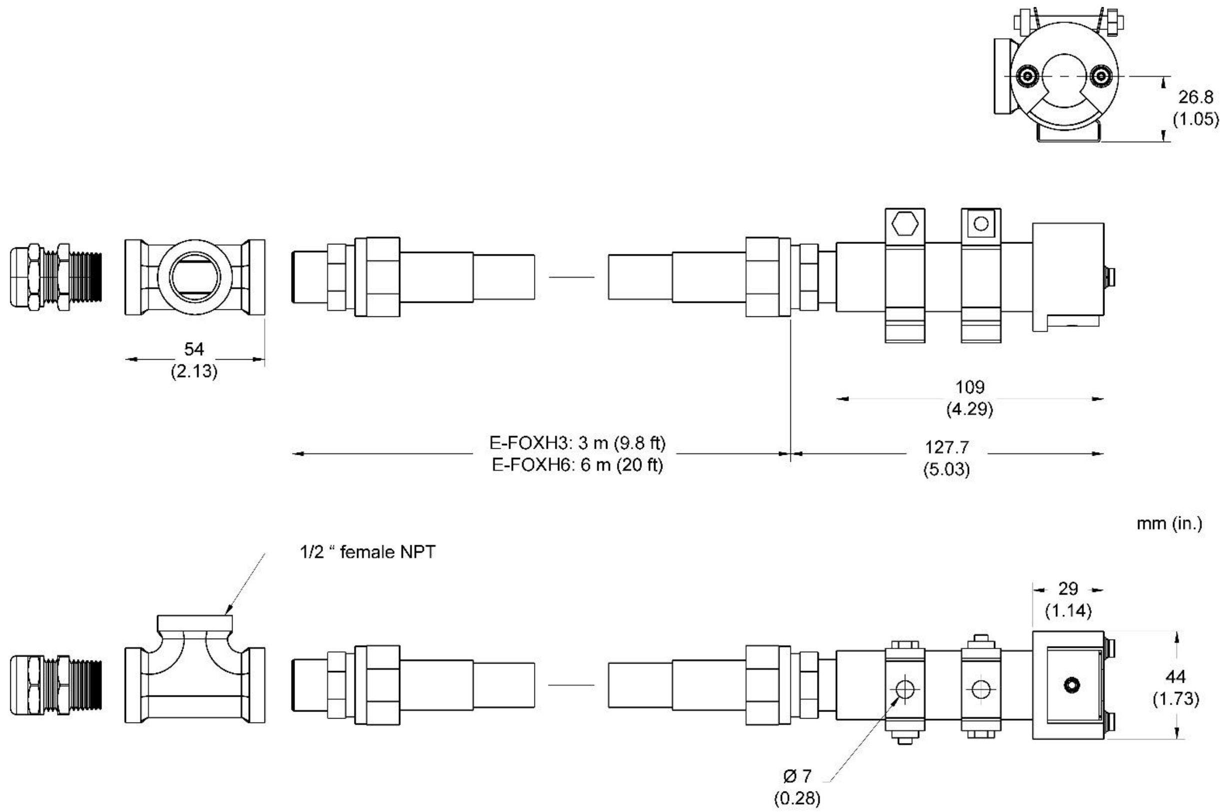


Figure 12-18: Dimensions



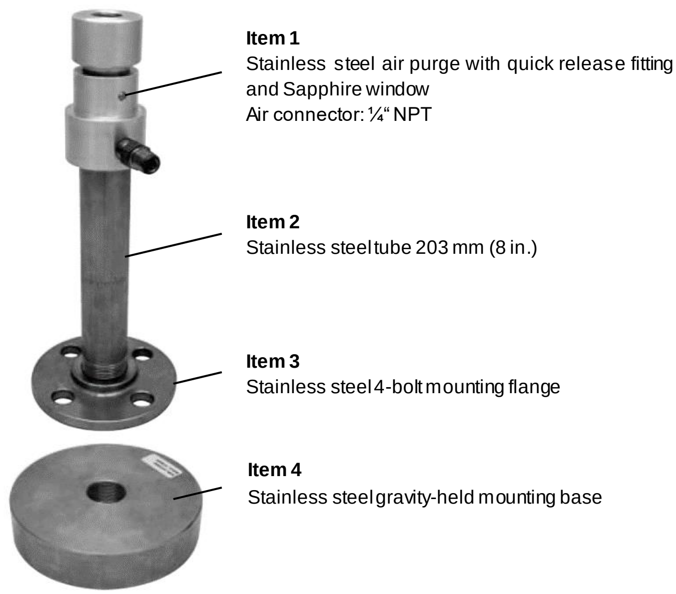
Risk of Personal Injury

In operation the fiber optic housing accessory is extremely loud. Ear protection is required.

12.2.4 Roof Mount Air Purge (E-FORFx)

The Roof Mount Air Purge accessory comes with quick release fitting and built-in Sapphire window.

Figure 12-19: Roof Mount Air Purge



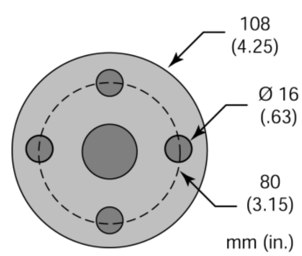


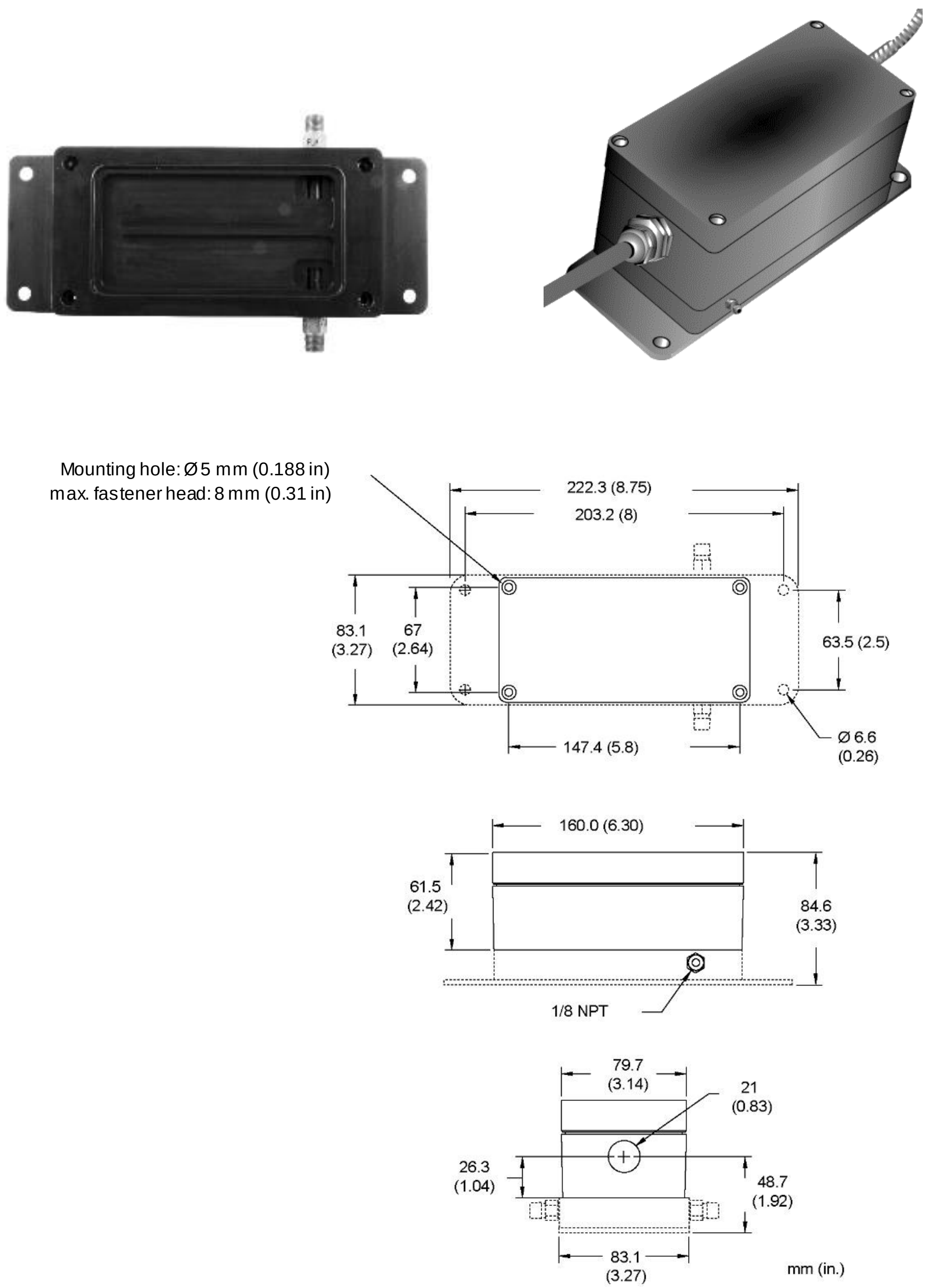
Table 12-6: Parts Numbers

Part Number	Description
E-FORFQP	Item 1
E-FORFMF	Item 1 + Item 2 + Item 3
E-FORFMC	Item 1 + Item 2 + Item 4

12.2.5 Cooling Platform (E-CP)

The cooling platform for the electronics housing can be used for ambient temperatures up to 150°C (302°F). For an efficient cooling a water flow of 2 l (0.53 gallons) per minute is recommended at a water temperature of 16°C (61°F).

Figure 12-20: Cooling Platform for Electronics Housing



13 Maintenance

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

13.1 Troubleshooting Minor Problems

Table 13-1: 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 lens	Clean the lens
Erroneous temperature	Wrong emissivity or slope	Correct the setting
Temperature fluctuates	Wrong signal processing	Correct Peak/Valley Hold or Average settings

13.2 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 shut down the process in the event of a set-up error, system error, or a failure in the sensor electronics.

Warning

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 temperature display indicates the possible failure area and the output circuits automatically adjust to the lowest or highest preset level. The following table shows the corresponding values and the error code transmitted over the digital interface.

Table 13-2: Fail-Safe Error Codes

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

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

Table 13-3: Error Codes for Analog Output

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

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.

If two or more errors occur simultaneously, the error with the highest priority overrules the lower priority errors. The highest priority error will be displayed on the temperature display and the assigned analog output value (see Table 13-3) will be set. For instance, in 2-color mode, if the internal ambient temperature is over the limit and the attenuation is too high, the unit outputs EIHH to the temperature display and sets an analog output current of 21 mA. However, since 2-color wide band and narrow band temperatures may all be presented simultaneously through digital interface, their over and under range conditions are independent.

The following order shows the priorities of possible failsafe conditions starting with the lowest priority.

1. narrow band temp. over range (lowest priority)
2. narrow band temp. under range
3. wide band temp. over range
4. wide band temp. under range
5. two-color temp. over range
6. two-color temp. under range

7. attenuation>95% (dirty window)
8. attenuation too high (> 95%)
9. energy too low
10. narrow band detector failure
11. wide band detector failure
12. internal temp. under range
13. internal temp. over range
14. heater control temp. under range
15. heater control temp. over range (highest priority)

Examples:

1. 1-color temperature is selected to show on the temperature display. 2-color temperature is transmitted in burst mode. Wide band temperature is under range. The 2-color temperature is 999°C.

   Outputs:

Temperature display:	EUUU
Digital interface:	C T999.0
Analog output:	2 to 3 mA
Relay:	abnormal state

2. 2-color temperature is selected to show on the temperature display. All three temperatures are transmitted in burst mode. Two-color temperature is 1021.0°C. Wide band temperature is 703.0°C. Narrow band temperature is 685.0°C. Attenuation is above 95%, the “dirty window” threshold.

   Outputs:

Temperature display:	1021.0
Digital interface:	C T1021.0 W703.0 N685.0
Analog output:	scaled to temperature, between 4 and 20 mA
Relay:	abnormal state

13.3 Window Cleaning

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

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

For fingerprints 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, as 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.

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

13.4 Replacing the Fiber Optic Cable

Note

Fiber cable assemblies for EF2R models (L and H variants) are not field replaceable without blackbody recalibration from the manufacturer! As such, it is strongly recommended not to disassemble the fiber optic cable for these models!

If the fiber optic cable ever needs to be removed or replaced, it can be removed from both the optical head and electronics enclosure without demounting them from their brackets.

Always clean the area around the fiber optic cable connectors before disconnecting. If any contaminants get into the open connectors, the sensor's accuracy will be compromised. After removing the cable, or before installing a new cable, the ends must always be protected until connected to the sensing head and electronics enclosure.

Spare cables are shipped with protective end caps. Always save these caps for use whenever the fiber optic cable must be disconnected. Any contamination to the fiber optic cable ends will degrade performance. To replace the fiber optic cable, you will need to disconnect it from both the optical head and the electronics enclosure. The following instructions will guide you through the process.

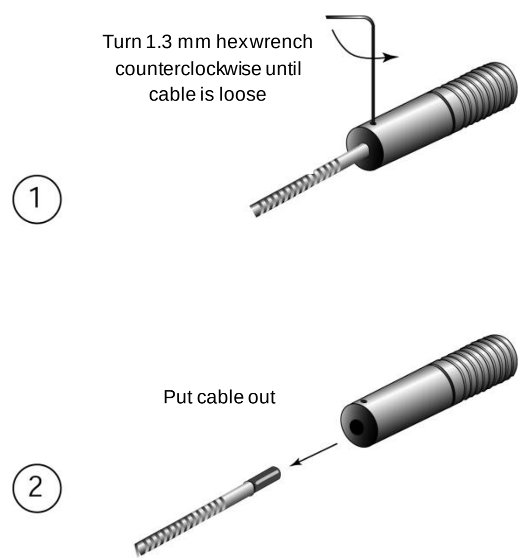
13.4.1 Removing the Fiber Optic Cable

13.4.1.1 Removing Cable from Optical Head

Complete the following steps to disconnect the fiber optic cable from the optical head:

1. Thoroughly clean the area around the optical head.
2. Insert a 1.3 mm hex wrench into the optical head hex screw and turn counterclockwise until the cable is loose.
3. Draw the fiber optic cable out of the optical head.
4. **Important** – If you plan to reconnect the same cable, immediately cover the end with a slip-on end cap to prevent contamination. Do not use any adhesive tape over the cable end.

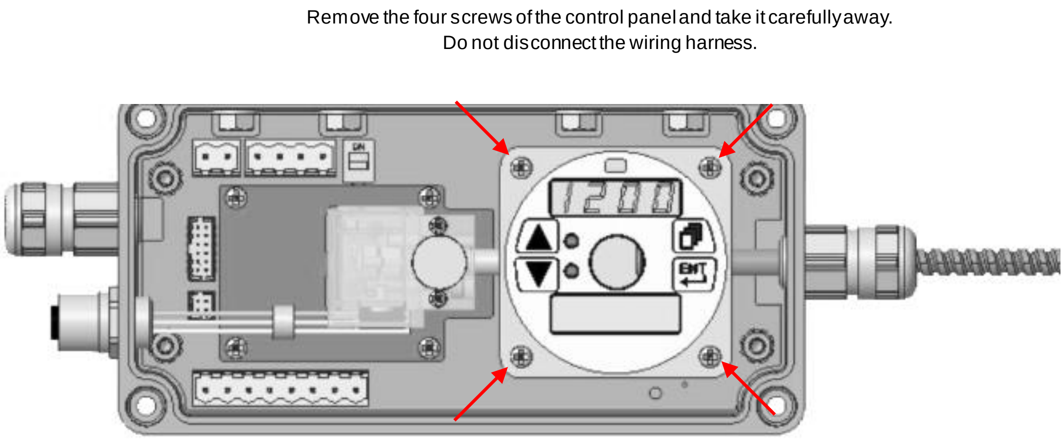
Figure 13-1: Removing the Fiber Optic Cable from the Optical Head



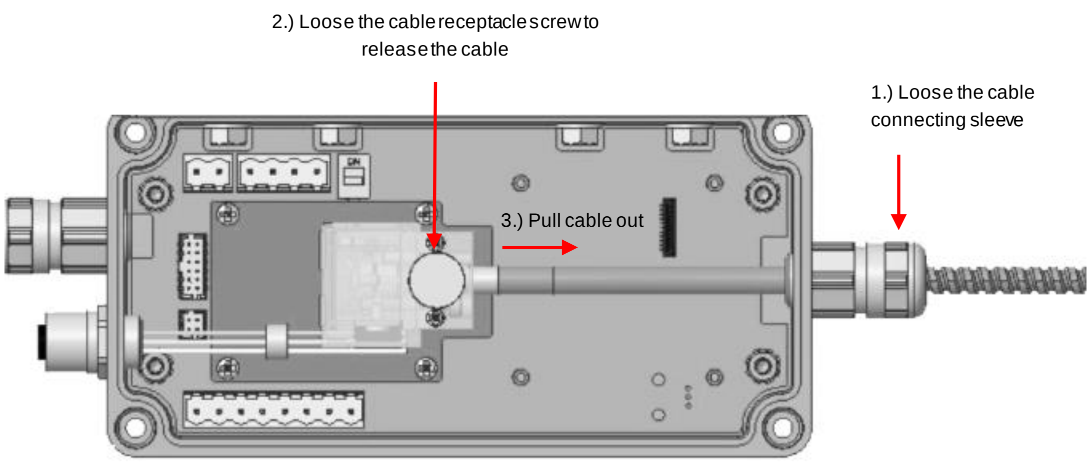
13.4.1.2 Removing Cable from Electronics Housing

Complete the following steps to disconnect the fiber optic cable from the electronics housing.

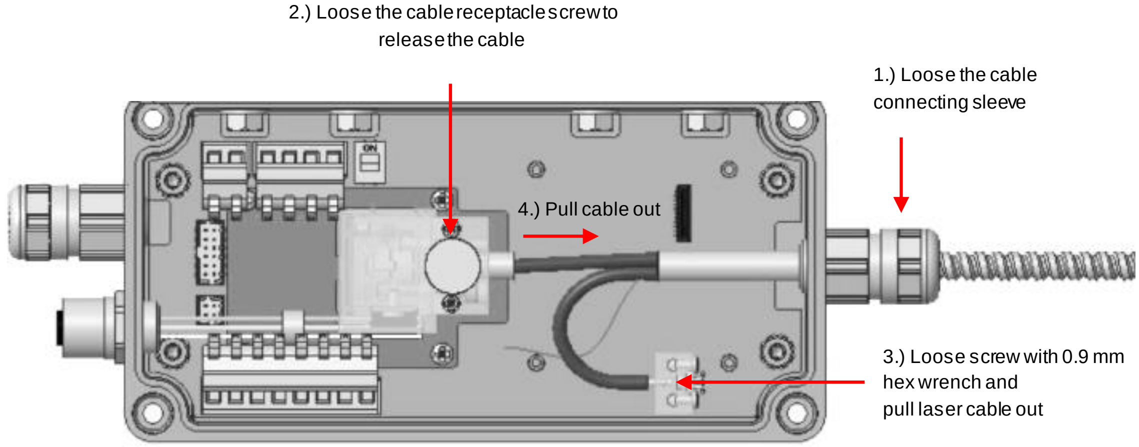
Figure 13-2: Removing the Fiber Optic Cable from the Electronics Housing



For Non-Laser Devices:



For Laser Devices:



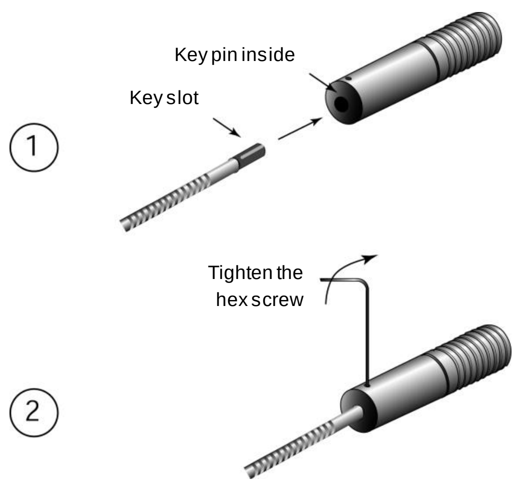
13.4.2 Mounting the Fiber Optic Cable

13.4.2.1 Attaching Cable to Optical Head

Complete the following steps to attach the fiber optic cable to the optical head:

1. The fiber optic cable ferrule has a key slot on its surface. Insert the ferrule into the rear of the optical head. Turn the head until the key on the ferrule's key slot engages the key pin inside the head.
2. Make sure cable is pushed in all the way before tightening hex screw! Tighten the hex screw with the 1.3 mm hex wrench until snug. **Do not over tighten!**

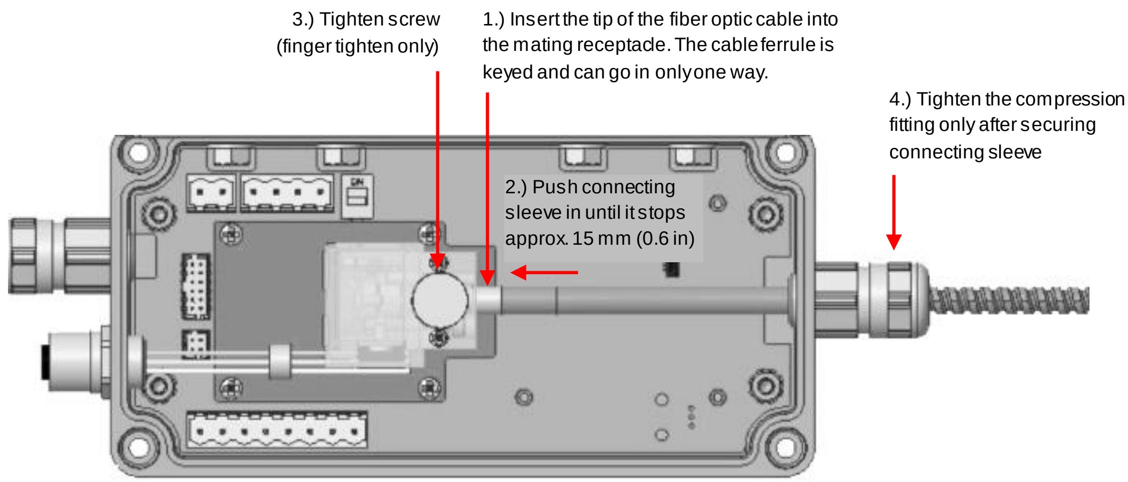
Figure 13-3: Attaching the Fiber Optic Cable to the Optical Head



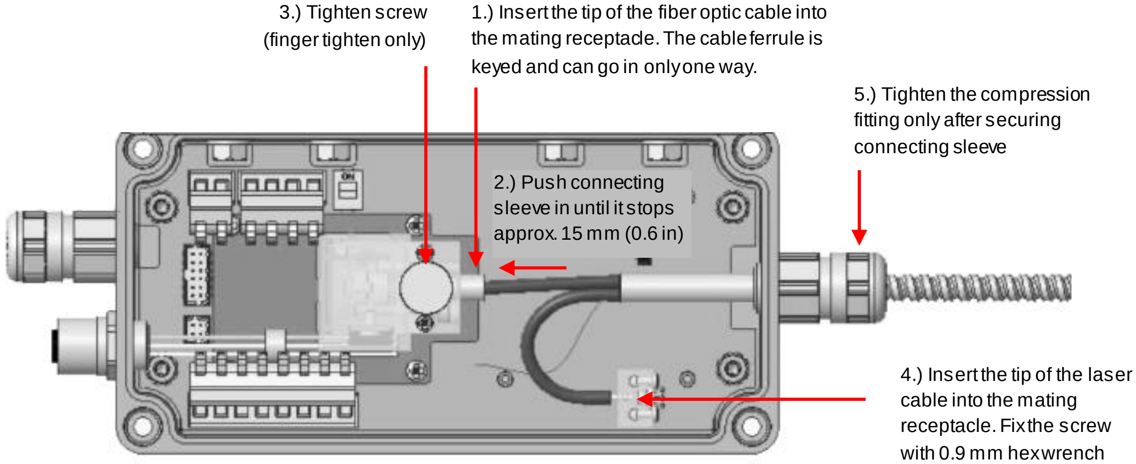
13.4.2.2 Attaching Cable to Electronics Housing

Complete the following steps to attach the fiber optic cable to the electronics housing.

For Non-Laser Devices:

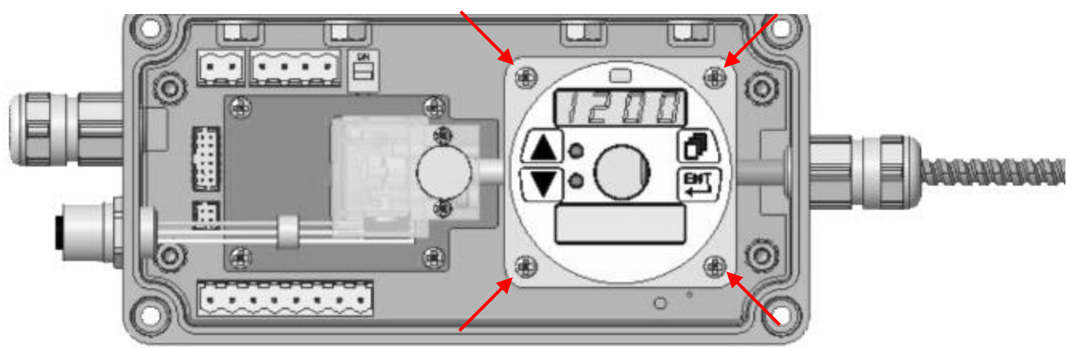


For Laser Devices:



For All Devices:

Move the control panel back and fix it with the screws.

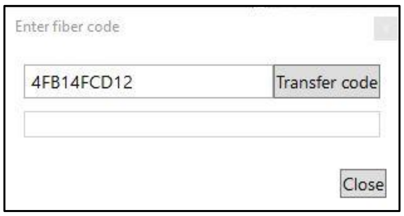


13.5 Fiber Calibration

Each replacement fiber optic cable is calibrated at the factory before shipping. The calibration constants are sent along with a label mounted on the cable. So you have to enter them into the appropriate <Change Fiber> submenu of the DataTemp Multidrop software program. This program sends the new calibration constants to the sensor's electronics.

The DataTemp Multidrop software comes with the data carrier you received. To run the program and enter new cable calibration constants, complete the following:

1. Install and run the DataTemp Multidrop software.
2. Establish the communication between the device and the software.
3. Navigate to the main menu <Devices>, select the submenu <Change Fiber>.
4. In the following dialog you are requested to input the calibration constants for the fiber cable.



5. Confirm your input by clicking on <Transfer code>. Wait until the transmission is complete. Exit the dialog box by pressing the button <Close>.

14 ASCII Programming

This section explains the sensor's communication protocol. A protocol is the set of commands that define all possible communications with the sensor. The commands are described along with their associated ASCII command characters and related message format information. Use them when writing custom programs for your applications or when communicating with your sensor with a terminal program over the RS485 or Ethernet interface.

14.1 Remote versus Manual Settings

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

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

All parameters set via the control panel, the RS485 or the Ethernet 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! It can be unlocked with the command XXXJ=U <CR>, where XXX is the multidrop address.

14.2 Command Structure

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

14.2.1 Timing

After transmitting one command, it is obligatory to wait for the response from the sensor before sending another. Make sure that a command sent was completely transmitted from the sender before the next command can be sent. The response time from the Endurance sensor back to the sender depends on the following factors:

- Operation mode Single or Multidrop, meaning without or with leading Multidrop address bytes in the response string
- Communication interface with different transmission speeds:
  - RS485: 1200 bps – 115.200 bps (~ 120 char/s – 11.520 char/s)
  - Ethernet: max. 100 Mbit/s (~ 10.000.000 char/s)

14.2.2 Requesting a Parameter (Poll Mode)

?E<CR>	"?" is the command for "request"
	"E" is the parameter requested
	<CR> carriage return ($0D_{hex}$) is closing the request

14.2.3 Setting a Parameter (Poll Mode)

E=0.975<CR>	"E" is the parameter to be set
	"=" is the command for "set a parameter"
	"0.975" is the value for the parameter
	<CR> carriage return ($0D_{hex}$) is closing the setting

14.2.4 Sensor Response

!E0.975<CR><LF>	"!" is the parameter for "answer"
	"E" is the parameter
	"0.975" is the value for the parameter
	<CR> <LF> (0Dhex 0Ahex) is closing the answer

For processing the received commands, the device typically needs about 200 ms. For certain commands, this time can be even longer.

14.2.5 Sensor Notification

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

#XI<CR><LF>	"#" is the parameter for "Notification"
	"XI" is the value for the notification (e.g. "XI" firmware reset)
	<CR> <LF> (0Dhex 0Ahex) is closing the notification
!XL<CR><LF>	"!" is the parameter for "Notification"
	"XL1" is the value for the notification (e.g. "XL1" laser switched on)
	<CR> <LF> (0Dhex 0Ahex) is closing the notification

14.2.6 Error Messages

An asterisk * will be transmitted back to the host in the event of an "illegal" instruction. An illegal instruction can be caused by a syntax error with the following response:

- "*Syntax Error" – a value entered in an incorrect format

14.3 Transfer Modes

There are two possible transfer modes for the serial interface.

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

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

V=P	"P" starts the poll mode
V=B	"B" starts the burst mode
$=UTIEEC	"$" sets the content of the burst string
	"U" for temperature unit
	"T" for target temperature
	"I" for internal case temperature of the sensor
	"E" for emissivity value
	"EC" for error code
?$	gives the burst string parameters while in poll mode, e.g. "UTIE"
?X$	gives the burst string content while in poll mode, e.g. "UC T0150.3 I0027.1 E0.950"

Return from burst mode to poll mode

V=P	„V=P" to be sent (it could be necessary to send the command more than one times)

14.4 Sensor Information

The sensor information is factory installed as read only values.

Table 14-1: Sensor Information

Command	Description	Answer (example)
?XU	Name of the sensor	"!XUEF1RL-F0-1-0-0-01BL"
?XV	Serial number of the sensor	"!XV43790010"
?XR	Firmware revision number	"!XR2.02.28"
?XH	Maximum temperature of the sensor	"!XH1000.0"
?XB	Minimum temperature of the sensor	"!XB50.0"

14.5 Sensor Setup

14.5.1 General Settings

U=C — sets the physical unit for the temperature value (C or F). In case of a changed physical unit all temperature related parameters (e.g., thresholds) are converted automatically.

E=0.950 — sets the emissivity according to the setting of "ES" command, see section 14.5.2 Emissivity Setting, page 113.

A=250 — sets the ambient background temperature compensation according to the setting of "AC" command, see section 14.5.3 Background Temperature Compensation, page 113.

XG=1.000 — sets the transmission

?T — asks for the target temperature

?I — asks for the internal temperature of the sensor

?Q — asks for the energy value of the target temperature

14.5.2 Emissivity Setting

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

ES=I — sets emissivity by a constant number

ES=E — sets the emissivity by the value taken from the analog input. For more information see section 5.7.2.1 Emissivity/Slope Setting, page 37.

?E — asks for the current emissivity value

14.5.3 Background Temperature Compensation

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

A=250.0 — current background temperature according to the setting of "AC" command

AC=0 — no compensation (internal sensor case temperature equal to background temperature)

AC=1 — compensation with a constant temperature value set with command "A"

AC=2 — background temperatue compensation with the value taken from the analog input. For more information see section 5.7.2.2 Background Temperature Compensation, page 38. Resulting temperature is read out by command "A".

14.5.4 Multiplex Mode for the Analog Input

In combination with the trigger input, the analog input can be multiplexed either to set the emissivity value or the temperature value for the background temperature compensation. For doing so, follow the steps below:

XTC=1 — activates the multiplex mode for the analog input

ES=E — sets the emissivity by the value taken from the analog input

AC=2 — background temperatue compensation with the value taken from the analog input

With these settings the function for the analog input can now be switched via the trigger:

- Active trigger → background temperatue compensation via the analog input
- Deactivated trigger → emissivity setting via the analog input

14.5.5 Temperature Hold Functions

The following table lists the various temperature hold functions along with their resets and timing values. Use this table as a guide for programming your sensor and adjusting the hold times. For further information see section 6.3 Post Processing, page 55.

14.6 Sensor Control

14.6.1 Analog Output

The current output corresponds to the target temperature value. Depending on the considered sensor model, the output can be set to current, voltage, or thermocouple.

XO=4	sets the current output range to 4-20 mA
H=500	sets the temperature for the top analog output value to 500 (in current scale) e.g., the top current output value of 20 mA shall represent 500°C
L=0	sets the temperature for the bottom analog output value to 0 (in current scale) e.g., the bottom current output value of 4 mA shall represent 0°C

Please note a minimum temperature span between “H” and “L” command values.

For testing purposes the output can be forced to provide a constant value using command “O”.

14.6.2 Relay Output

The relay output can be triggered by the following alarm sources:

- target temperature via command SAS=0
- internal sensor temperature via command SAS=1

The relay output can be set to:

K=0	relay contacts permanently open
K=1	relay contacts permanently closed
K=2	relay contacts triggered by alarm source, N.O. normally open (normally open: relay contacts are open while in the home position)
K=3	relay contacts triggered by alarm source, N.C. normally closed (relay contacts are closed while in the home position)

14.7 RS485 Communication

The serial RS485 communication is in 2-wire mode.

For setting the baud rate, the following command must be used.

D=384	sets the baud rate to 38400

14.8 Multidrop Mode

Up to 32 devices can be connected within an RS485 multidrop network, see section 7 RS485, page 60. To direct a command to one sensor among the 32 possible, it is necessary to “address” a command. Therefore, a 3-digit number is set prior the command. The 3-digit number is determined between 001 and 032. A unit with the address 000 is a single unit and not in multidrop mode.

XA=024	sets the device to address 24

Changing an address:

(e.g., the address is to be changed from 17 to 24)

Command	Answer	
“017?E”	“017E0.950”	*// asking one sensor on address 17*
“017XA=024”	“017XA024”	*// setting of a new address*
“024?E”	“024E0.950”	*// asking same sensor now on address 24*

If a command is transferred, starting with the 3-digit number 000, all units (with addresses from 001 to 032) connected will get this command – without to send an answer.

Command	Answer
“024?E”	“024E0.950”
“000E=0.5”	will be executed from all sensors, no answer
“024?E”	“024E0.500”
“012?E”	“012E0.500”

14.9 Command List

P ... Poll, B ... Burst, S ... Set, N ... Notification
n = number, X = uppercase letter

Notes:

- USB virtual serial interface settings: 9600 bps Baudrate, 8 data bits, 1 stop bit, no parity, no flow control
- RS485 serial interface settings refer to command 'D' on the command list below.
- A sent command should be closed with 0x0D or 0x0D,0x0A; response command is closed with 0x0D, 0x0A.

Description	Char	Value Format	Poll	Burst	Set	Legal Values	Factory Default
Burst string format	$		√		√		UTSI
Show list of commands	?		√				
Background temperature correction	A		√		√	min/max of temperature range	Low temperature range of sensor
Advanced hold with average	AA		√		√	0.0 - 300.0s	000.0
Ambient compensation control	AC		√		√	0 = no compensation 1 = compensation by command "A" 2 = external input	0
Top of mA range	AH		√		√	0.0 – 9999.0 (°C or °F)	High temperature range of sensor
Bottom of mA range	AL		√		√	0.0 – 9999.0 (°C or °F)	Low temperature range of sensor
Alarm Top mA output (fail safe)	AHO	nn.n	√		√	20.0 to 24.0	21.0
Alarm Bottom mA output (fail safe)	ALO	n.n	√		√	0.0 to 4.0	2.5
Measured attenuation	B	n - nn	√	√		00 to 99%	
Burst speed	BS	n - nnnnn	√		√	5 – 10000 ms	32 ms
Advanced hold threshold	C	nnnn.n	√		√	min/max of temperature range	Low temperature range of sensor
Camera color mode	CCM		√		√	C = displays all colors M = converts all colors into grayscale R = converts red colors into grayscale G = converts green colors into grayscale B = converts blue colors into grayscale	C
Current emissivity	CE	n.nnn – n.nnn	√			0.100 – 1.100	1.000
Camera auto gain mode	CGM		√		√	0 = off 1 = on	1
Baud rate	D	nnn - nnnn	√ √ √ √ √ √ √		√ √ √ √ √ √ √	012 = 1200 baud 024 = 2400 baud 096 = 9600 baud 192 = 19200 baud 384 = 38400 baud 576 = 57600 baud 1152 = 115200 baud Sensor restarts after a baud rate change; command not allowed in multidrop mode	38400 baud
Digital filter	DF	n	√		√	0 = OFF, 1 = ON	1
Sensor gain	DG	n.nnnnnn	√		√	0.8 to 1.2	1.000000
Top sensor gain	DGT	n.nnnnnn	√		√	0.8 to 1.2	1.0
DHCP / BOOTP	DHCP	n	√		√	0 = OFF, 1 = DHCP ON 2 = BOOTP ON	0
Sensor offset	DO	-nnn - +nnn	√		√	-200 to +200	0
Top sensor offset	DOT	-nnn - +nnn	√		√	-200 to +200	0.0
Emissivity	E	n.nnn	√	√	√	0.100 – 1.100	1.000
Extension board temperature	EBT	n.n - nnn.n	√	√		0.0 – 999.0 (°C or °F)	

Description	Char	Value Format	Poll	Burst	Set	Legal Values	Factory Default
Error Codes	EC	nnnnnnnnnnnnnnnn	√	√		2^{15} alarm detection 2^{14} narrow band temp. over range 2^{13} narrow band temp. under range 2^{12} wide band temp. over range 2^{11} wide band temp. under range 2^{10} two-color temp. over range 2^{9} two-color temp. under range 2^{8} attenuation>95% (dirty window) 2^{7} attenuation too high (> 95%) 2^{6} energy too low 2^{5} narrow band detector failure 2^{4} wide band detector failure 2^{3} internal temp. under range 2^{2} internal temp. over range 2^{1} heater control temp. under range 2^{0} heater control temp. over range	
Emissivity source	ES	X	√			I = set by a constant number according to the command "E" E = set by the analog input	I
Valley hold time (1)	F	n.n - nnn.n	√	√	√	0.0 – 300.0 s (300 s = ∞)	000.0
Average time (1)	G	n.n - nnn.n	√	√	√	0.0 – 300.0 s (300 s = ∞)	000.0
Gateway Address	GW	nnn.nnn.nnn.nnn	√		√	0.0.0.0 - 255.255.255.255	192.168.42.1
Top of mA temperature range	H	nnnn.n – nnnn.n	√	√	√	min/max of temperature range (°C or °F)	High temperature range of sensor
RS485 mode	HM	n	√		√	2 = 2 wire 4 = 4 wire	2
Sensor internal ambient	I	n.n - nnn.n	√	√		0°C/32°F – 65°C/149°F	
Analog input mA, current value	IN	nn.nn – nn.nn	√	√		0 - 20 or 4 - 20	
Analog input mode	INM	n	√		√	0 = 0 – 20 mA 4 = 4 – 20 mA	0
IP Address	IP	nnn.nnn.nnn.nnn	√		√	0.0.0.1 - 255.255.255.255	192.168.42.132
Switch panel lock	J	X	√		√	L = Locked U = Unlocked	Unlocked
Relay alarm output control	K	n	√		√	0 = Permanently Open 1 = Permanently Closed 2 = Normally Open 3 = Normally Closed	2
Bottom of mA temperature range	L	n.n – nnnn.n	√	√	√	0.0 – 9999.0 (°C or °F)	Low temperature range of sensor
Color mode	M	n	√	√	√	1 = 1 - color 2 = 2 - color	2
MAC Hardware Address	MAC	nnnnnnnnnnnn	√			e.g. 001d8d2aaa01	Set at factory calibration
Target temp:1C narrow	N	n.n - nnnn.n	√	√			
Net Mask	NM	nnn.nnn.nnn.nnn	√		√	0.0.0.1 - 255.255.255.255	255.255.255.0
Output current	O	nn	√	√	√	00 = controlled by unit 02 = under range 21 = over range 0 – 20 = current in mA	00
Output format	OIF					0 = temperature value format is float with one decimal place 1 = temperature value format is integer with four digits	0
Analog output gain	OUG	n.nn	√		√	0.01 to 100.0	1.0
Analog output offset	OUO	-nnn - +nnn	√		√	-200 to +200	0.0
Peak hold time (1)	P	n.n - nnn.n	√	√	√	0.0 – 300.0 s (300 s = ∞)	0.0
ProfiNet Name	PNN		√	√			
IP Port address	PORT	n - nnnnn	√		√	1 - 65535	6363
Wide Power	Q	n.nnnnnnn	√	√			
Narrow power	R	n.nnnnnnn	√	√			

Description	Char	Value Format	Poll	Burst	Set	Legal Values	Factory Default
Video relative reticle diameter	RC	n.n – nn.nn	√				
Ratio Spectral Correction Gain	RSG		√				1.0
Ratio Spectral Correction Intercept	RSO		√		√		0.0
Reset	RST				√		
Video relative reticle X-position	RX	n.n – nn.nn	√				
Video relative reticle Y-position	RY	n.n – nn.nn	√				
Slope	S	n.nnn	√	√	√	0.850 – 1.150	1.000
Alarm source	SAS		√		√	0 = object temperature 1 = internal temperature	0
Invalid current sample filter	SF	n	√		√	0 = off 1 = on Please contact technical support for guidance on use.	0
Slope source	SS	X	√		√	I = set by a constant number according to the command "S" E = set by the analog input	I
Set target temperature	STT	n.n – nnnn.n	√		√	min/max of temperature range (°C or °F)	Set at factory calibration
Target temp: 2C	T	n.n - nnnn.n	√	√			
Terminator resistor	TR	n	√		√	0 = OFF, 1 = ON	0
TCP/IP time out interval	TTI	n - nnn	√		√	0 = ∞, 1 – 240 s	120
Temperature units (scale)	U	X	√	√	√	C or F	non-US: C
Poll/burst mode	V	X	√		√	B = Burst , P = Polled	P
Target temp:1C wide	W	n.n - nnnn.n	√	√			
Web server	WS	n	√		√	0 = OFF, 1 = ON	0
Burst string content	X$		√				
Multidrop address	XA	nnn	√	√	√	000 to 032	000
Low temperature limit	XB	n.n - nnnn.n	√			0.0–9999.0	Set at factory calibration
Deadband	XD	nn	√		√	01 – 50 °C / 1.8 – 90 °F No effect if relay in alarm mode.	02
Decay rate	XE	nnnn	√		√	0-9999°C/°F	0
Restore factory defaults	XF				√		
Transmissivity	XG	n.nn	√	√	√	0.10 – 1.10	1.00
High temperature limit	XH	n.n – nnnn.n	√			0.0–9999.0	Set at factory calibration
Sensor initialization	XI	n	√	√	√	0 = flag reset, 1 = flag set	1
Heater temperature	XJ		√				
Laser / LED / Video switching	XL	n	√		√	0 = off 1 = on 2 = flashing 3 = switching via external trigger edge 4 = switching via external trigger level	0
Sensor model type	XM	X	√			L = Low Temperature H = High Temperature	Set at factory calibration
0 - 20 mA / 4-20 mA analog output	XO	n	√		√	0 = 0 - 20 mA 4 = 4 - 20 mA	4
Firmware revision	XR		√			e.g. 1.02.11	Set at factory calibration
Analog firmware revision	XRA		√			e.g. 1.02.01	Set at factory calibration
Setpoint / Relay function	XS	n.n – nnnn.n	√		√	0.0 to 3000°C / 5432°F Non-zero setpoint value puts unit in setpoint mode. Setpoint within unit's temperature range.	0
Trigger status	XT	n	√	√		0 = inactive, 1 = active	0
Trigger control	XTC	n	√		√	0 = normal 1 = emissivity/ambient control	0
Identify unit	XU		√			e.g. E1RL-F2-V-0-0	Set at factory calibration

Description	Char	Value Format	Poll	Burst	Set	Legal Values	Factory Default
Sensor serial number	XV	nnnnnnnn	√			e.g. 31712345	Set at factory calibration
Advanced hold hysterese	XY	n – nnnn	√		√	0-3000°C/°F	2
Attenuation to activate relay	Y	nn	√	√	√	0 to 95% energy	95%
Attenuation for failsafe	Z	nn	√	√	√	0 to 99% energy reduction	95%
Notes: (1) Setting either Average, Peak Hold or Valley Hold, sets non concerned signal post processing settings to factory default value							

15 Appendix

15.1 Optical Diagrams

15.1.1 EF1ML Models

Figure 15-1: Optical Diagrams EF1ML-F0 Models

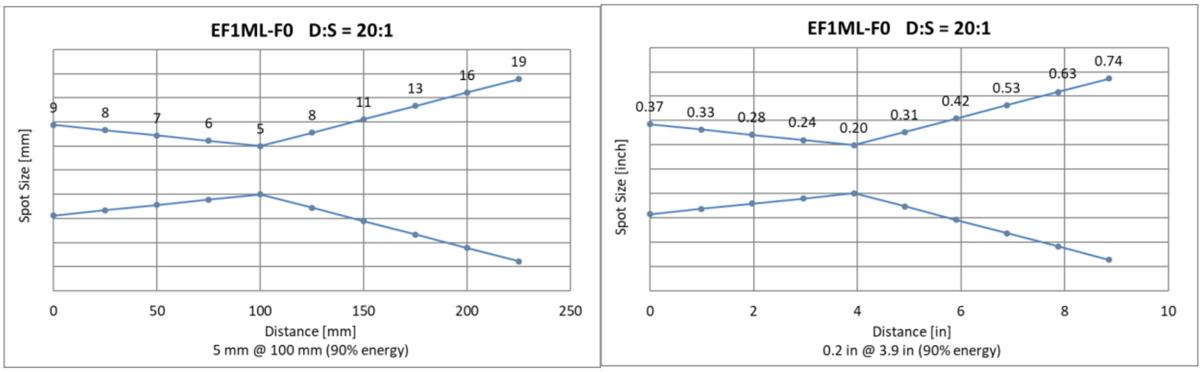


Figure 15-2: Optical Diagrams EF1ML-F1 Models

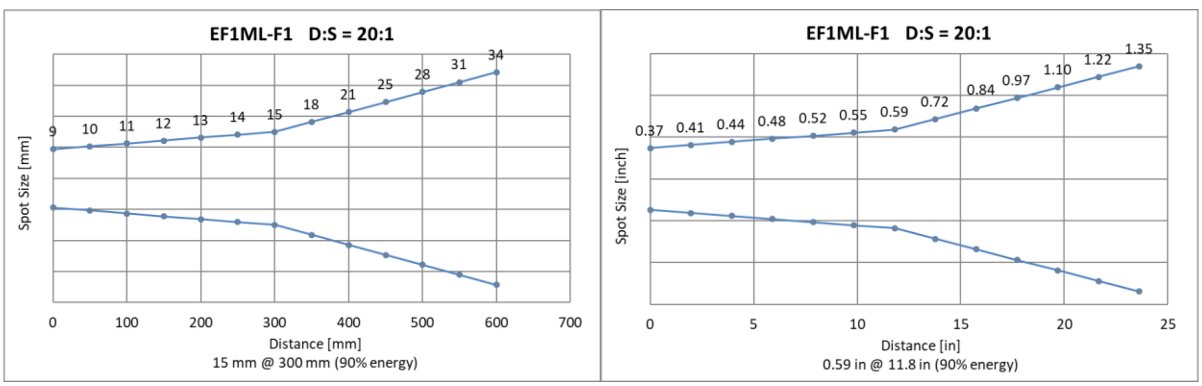
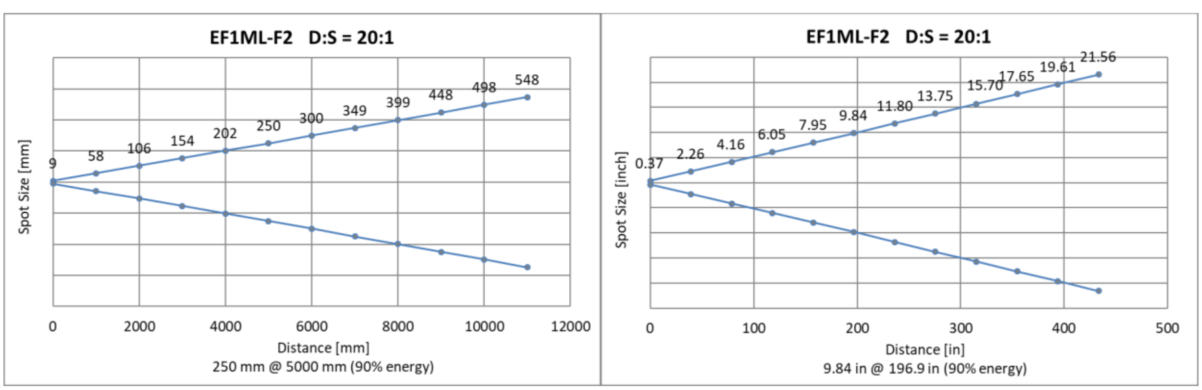


Figure 15-3: Optical Diagrams EF1ML-F2 Models



15.1.2 EF1MM Models

Figure 15-4: Optical Diagrams EF1MM-F0 Models

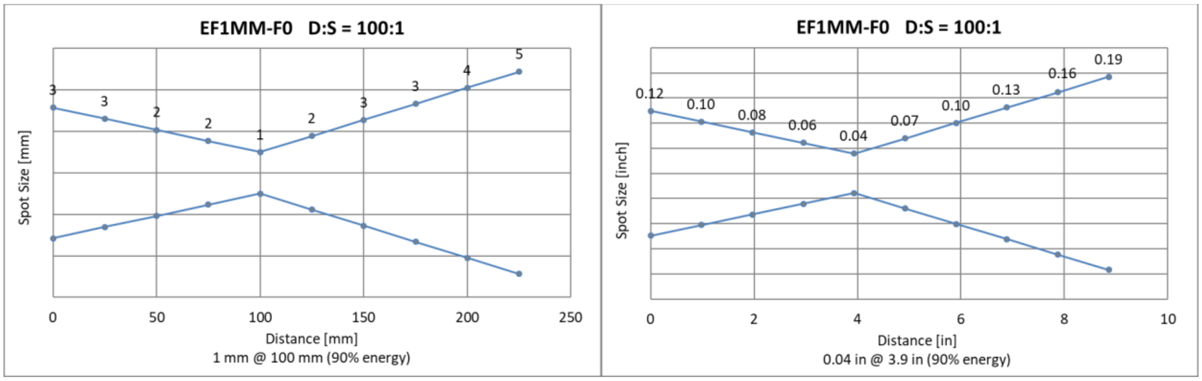


Figure 15-5: Optical Diagrams EF1MM-F1 Models

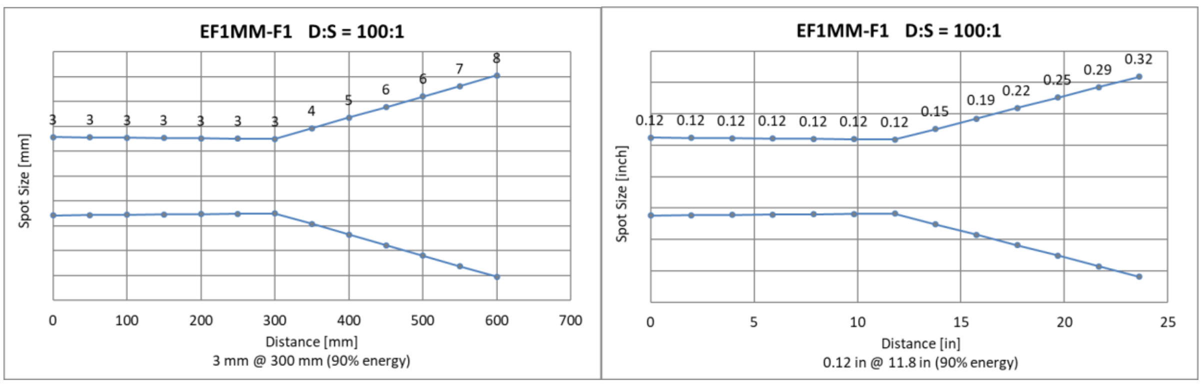
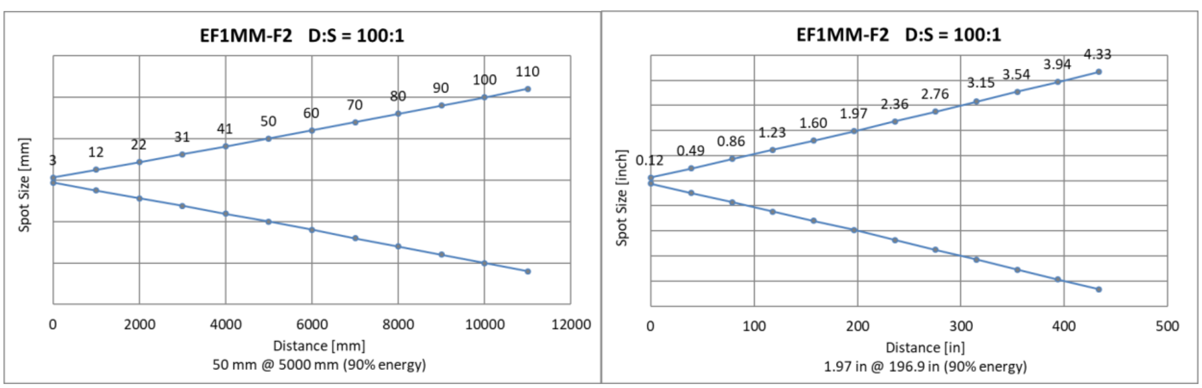


Figure 15-6: Optical Diagrams EF1MM-F2 Models



15.1.3 EF1MH Models

Figure 15-7: Optical Diagrams EF1MH-F0 Models

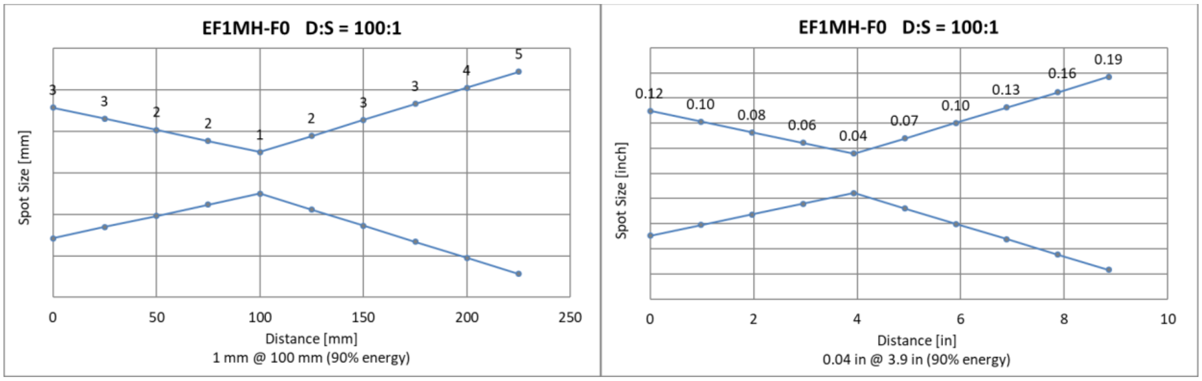


Figure 15-8: Optical Diagrams EF1MH-F1 Models

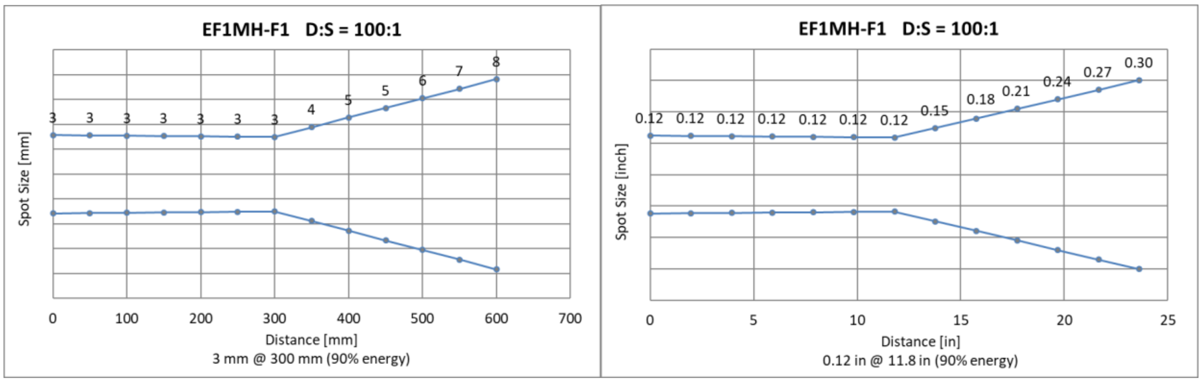
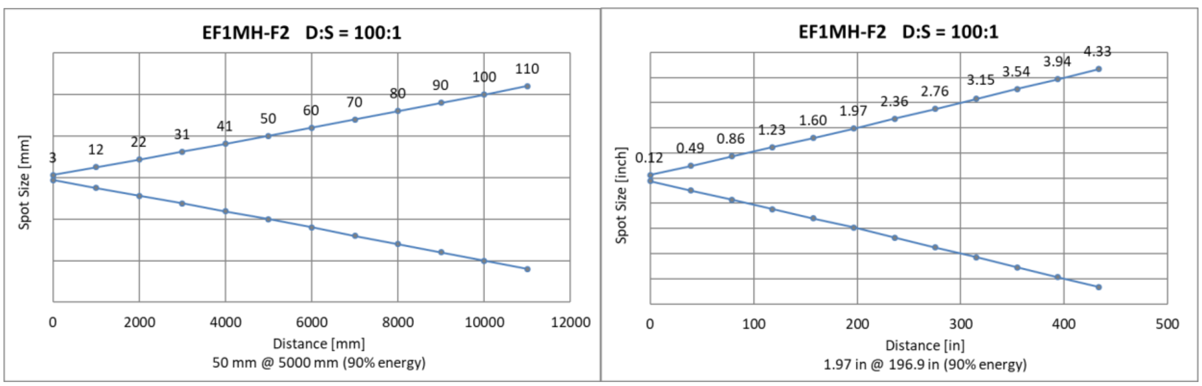


Figure 15-9: Optical Diagrams EF1MH-F2 Models



15.1.4 EF2ML Models

Figure 15-10: Optical Diagrams EF2ML-F0 Models

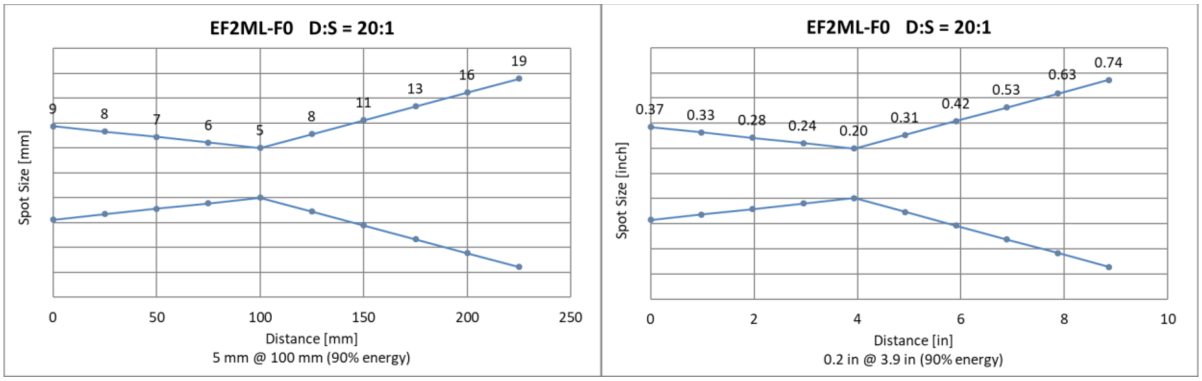


Figure 15-11: Optical Diagrams EF2ML-F1 Models

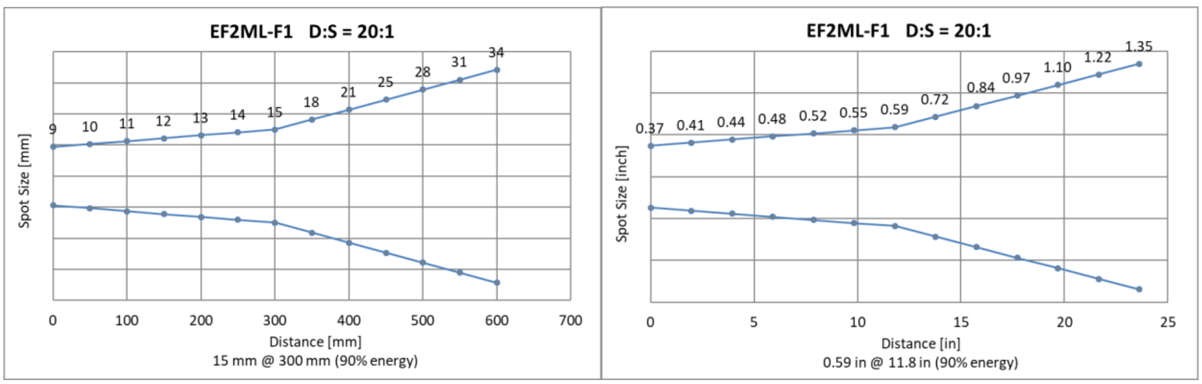
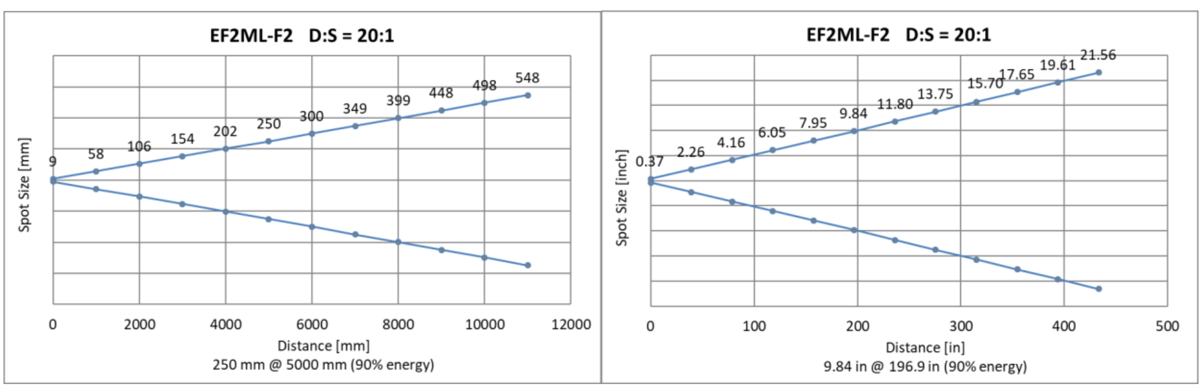


Figure 15-12: Optical Diagrams EF2ML-F2 Models



15.1.5 EF2MH Models

Figure 15-13: Optical Diagrams EF2MH-F0 Models

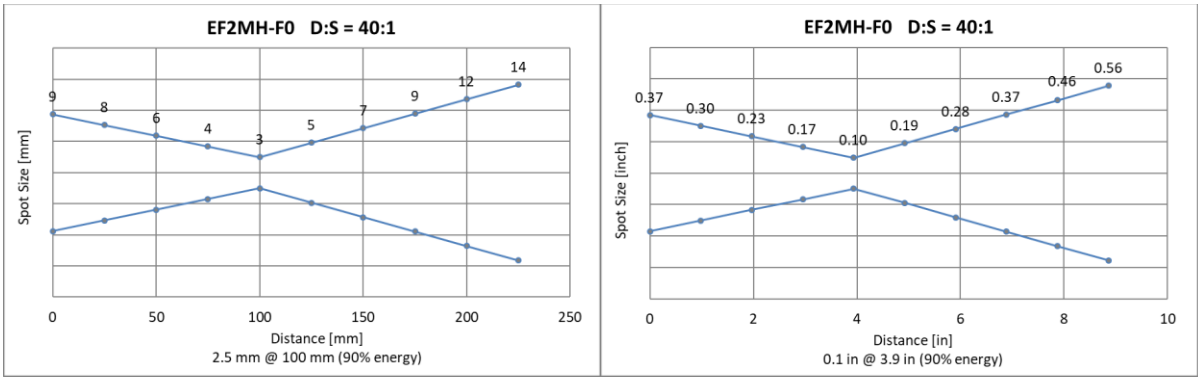


Figure 15-14: Optical Diagrams EF2MH-F1 Models

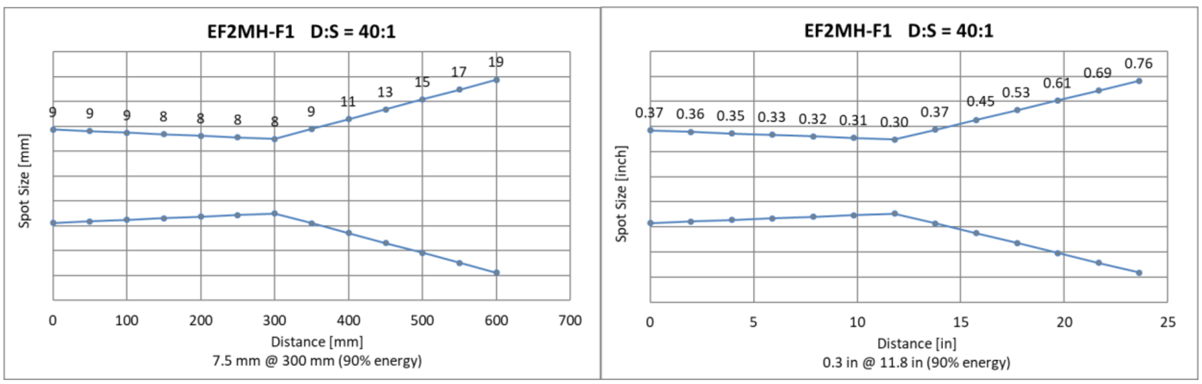
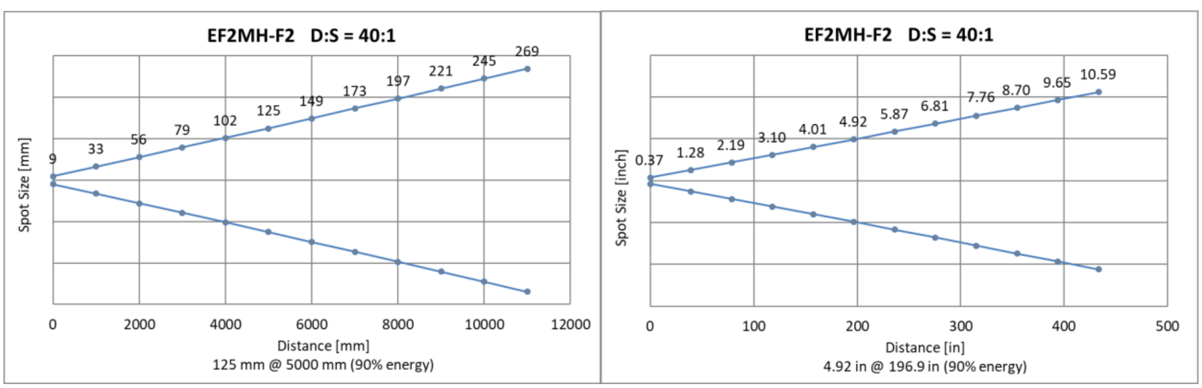


Figure 15-15: Optical Diagrams EF2MH-F2 Models



15.1.6 EF1RL Models

Figure 15-16: Optical Diagrams EF1RL-F0 Models

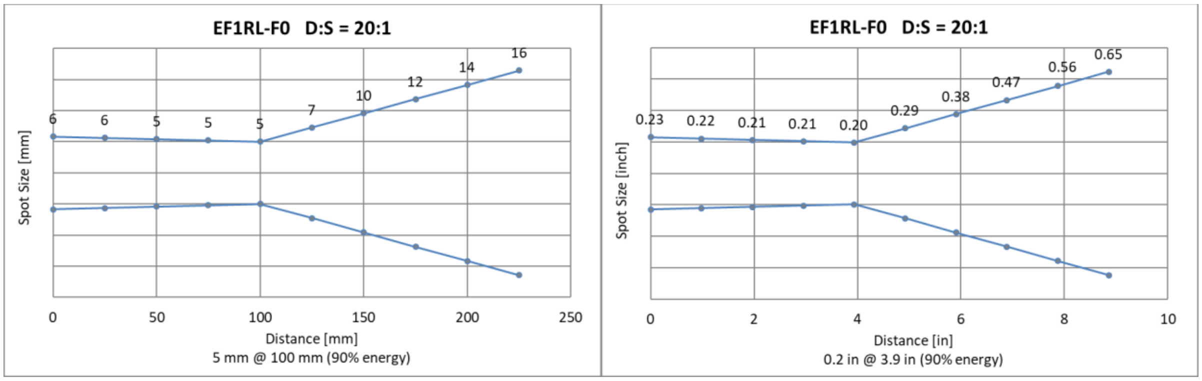


Figure 15-17: Optical Diagrams EF1RL-F1 Models

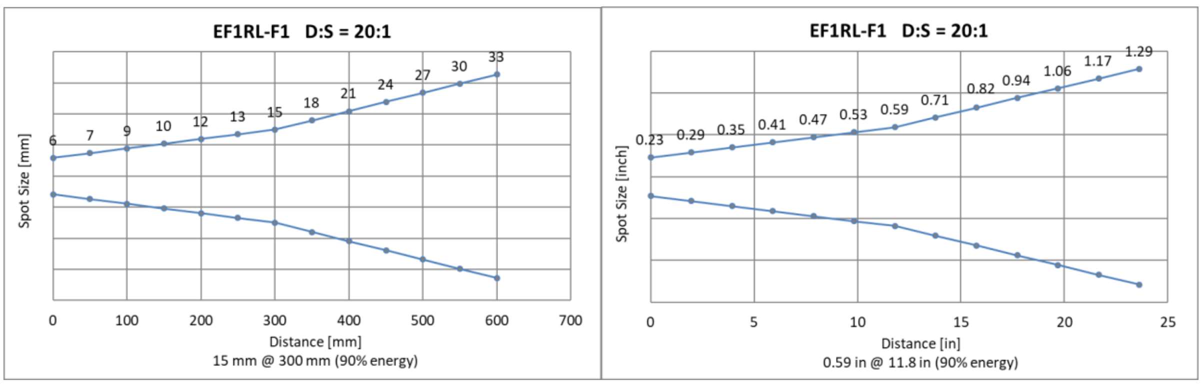
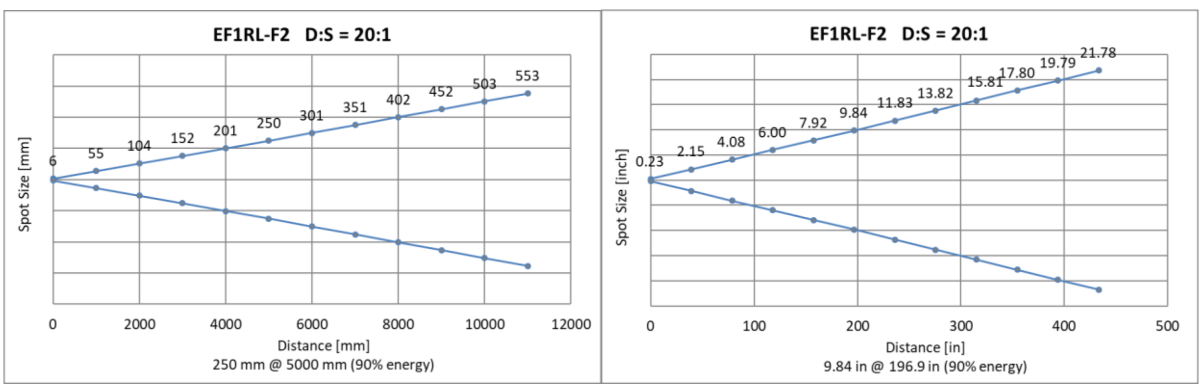


Figure 15-18: Optical Diagrams EF1RL-F2 Models



15.1.7 EF1RM Models

Figure 15-19: Optical Diagrams EF1RM-F0 Models

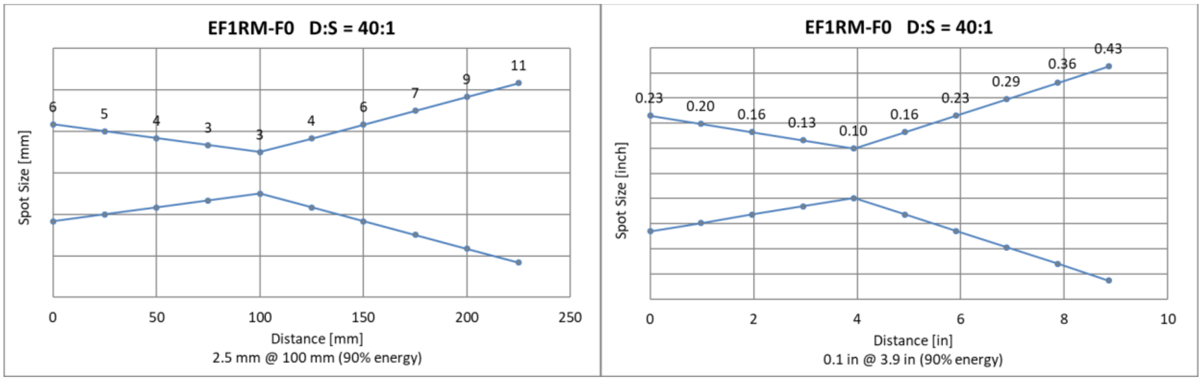


Figure 15-20: Optical Diagrams EF1RM-F1 Models

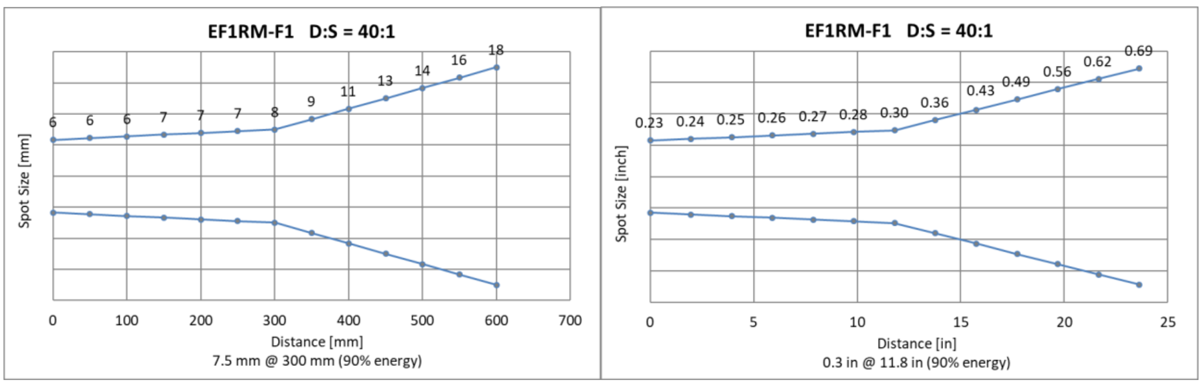
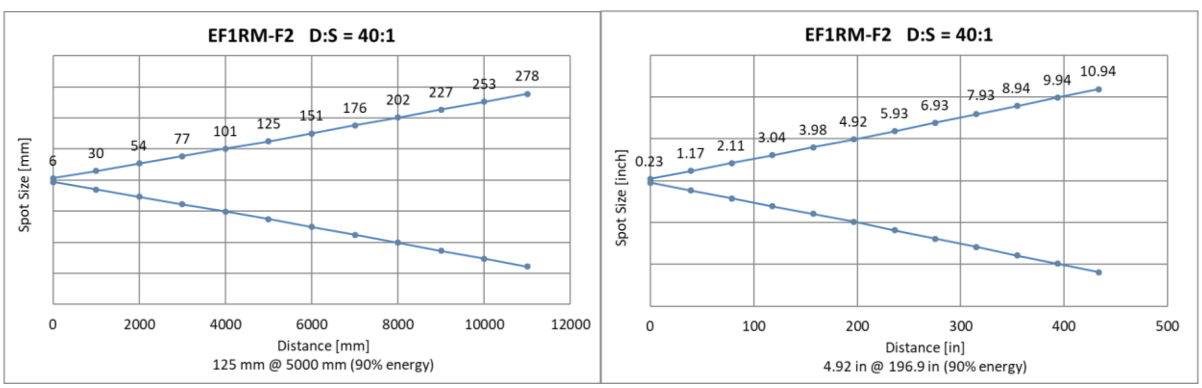


Figure 15-21: Optical Diagrams EF1RM-F2 Models



15.1.8 EF1RH Models

Figure 15-22: Optical Diagrams EF1RH-F0 Models

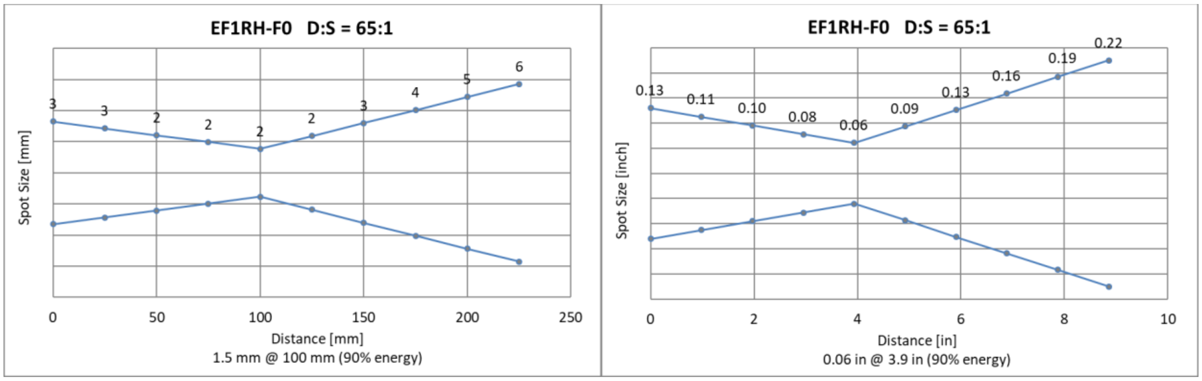


Figure 15-23: Optical Diagrams EF1RH-F1 Models

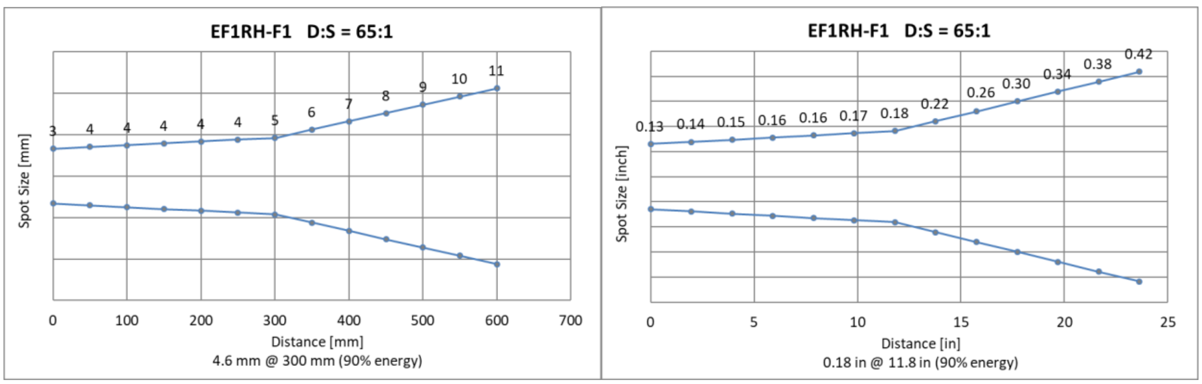
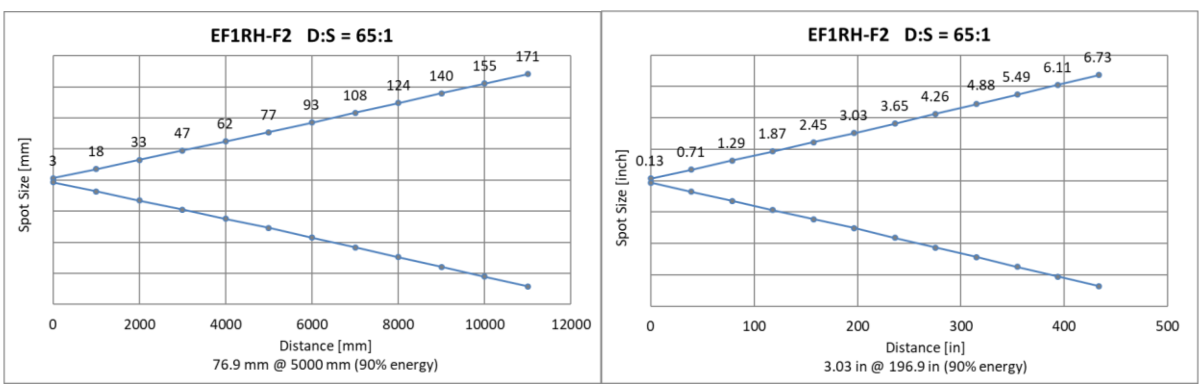


Figure 15-24: Optical Diagrams EF1RH-F2 Models



15.1.9 EF2RL Models

Figure 15-25: Optical Diagrams EF2RL-F0 Models

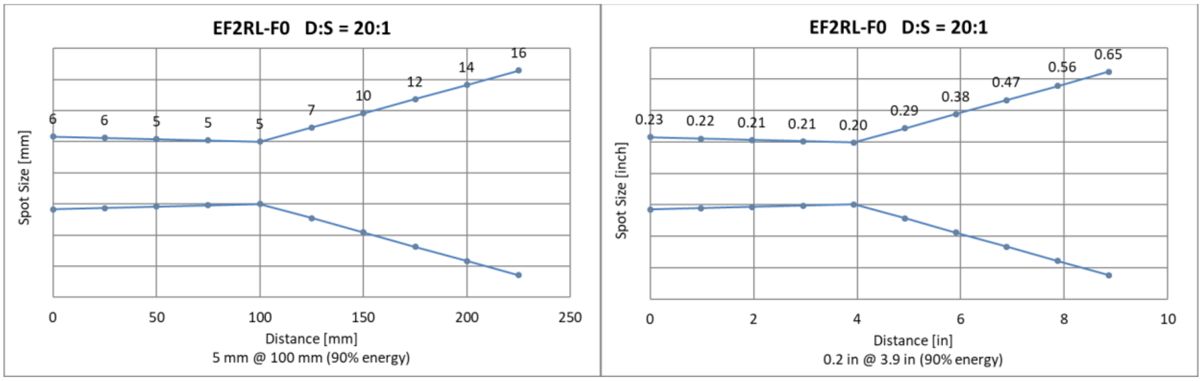


Figure 15-26: Optical Diagrams EF2RL-F1 Models

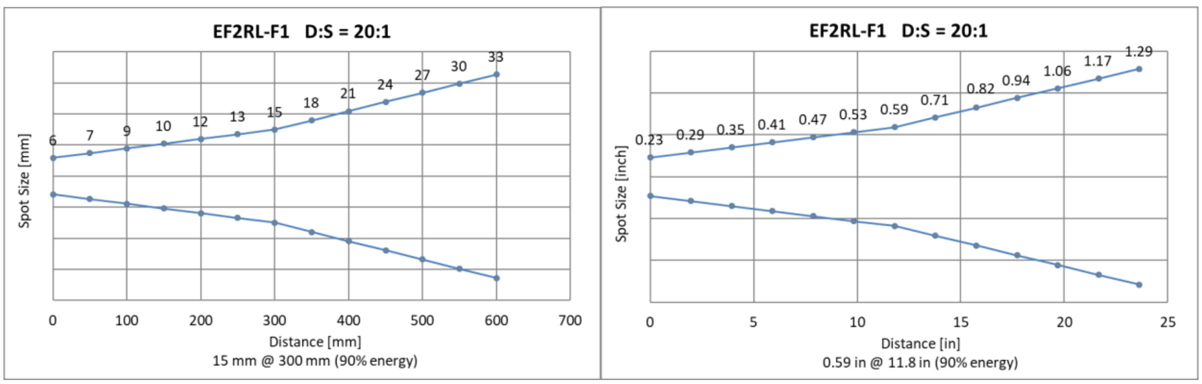
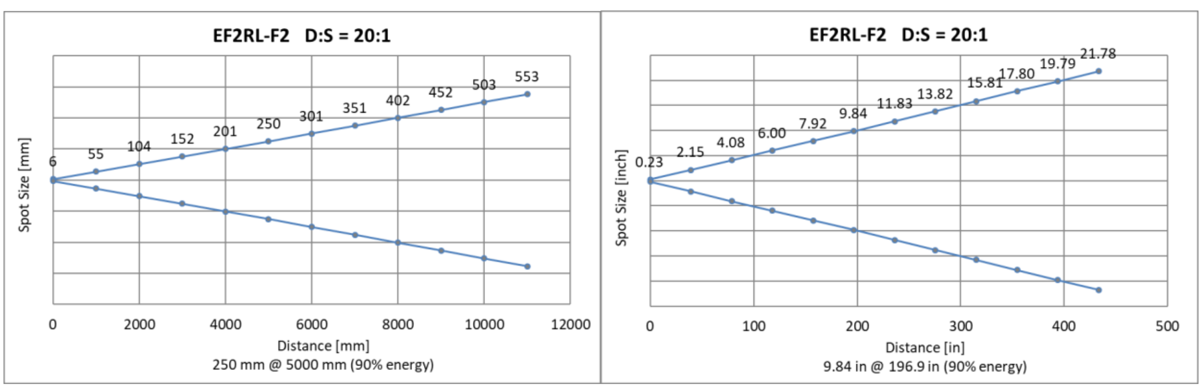


Figure 15-27: Optical Diagrams EF2RL-F2 Models



15.1.10 EF2RH Models

Figure 15-28: Optical Diagrams EF2RH-F0 Models

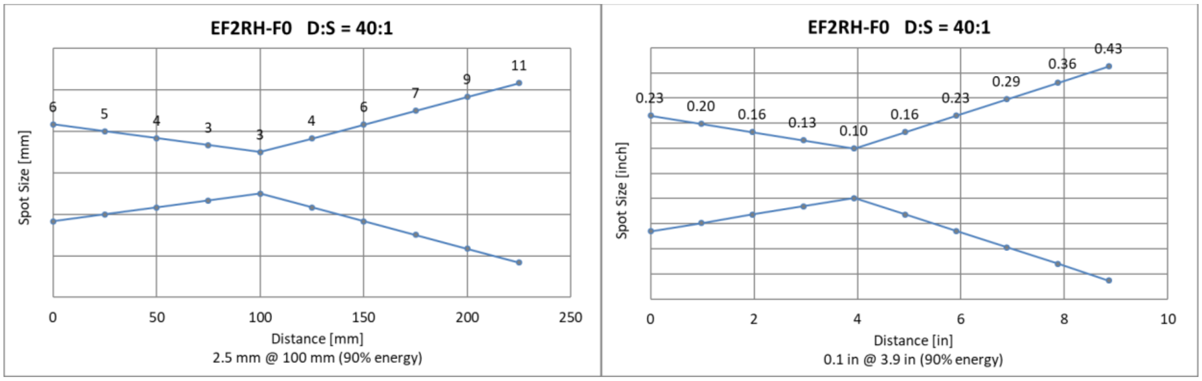


Figure 15-29: Optical Diagrams EF2RH-F1 Models

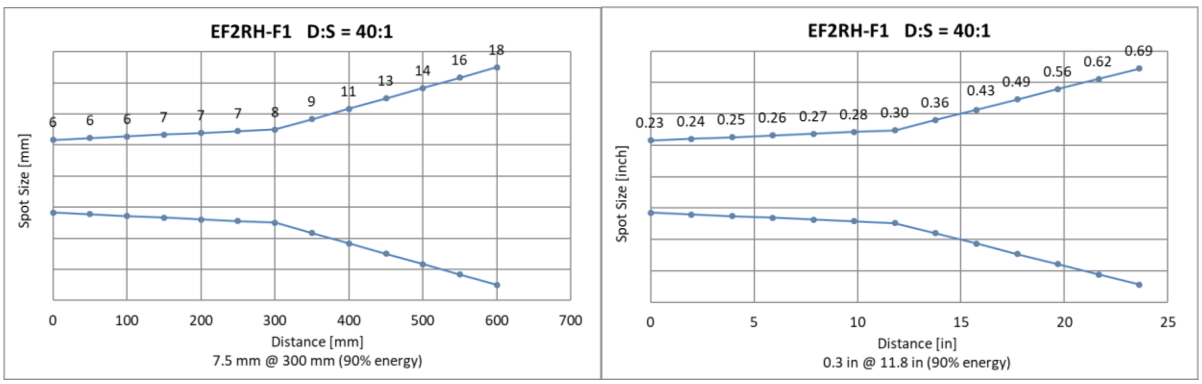
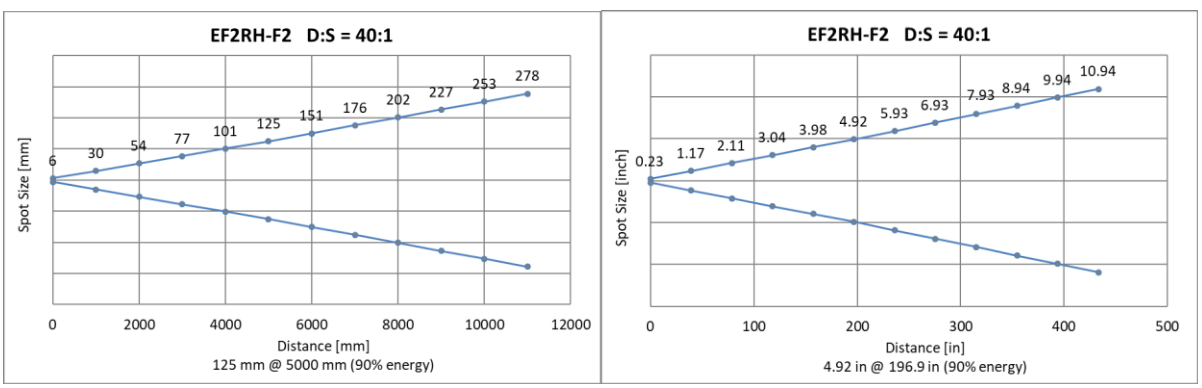


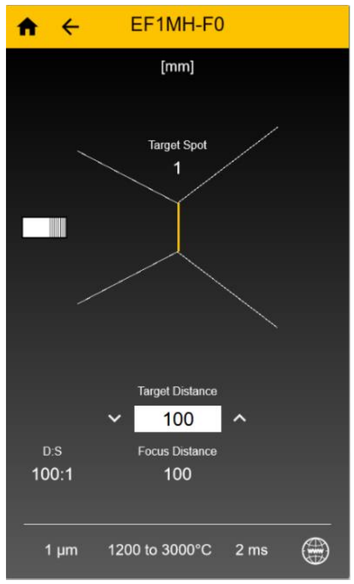
Figure 15-30: Optical Diagrams EF2RH-F2 Models



15.2 Spot Size Calculator

It is important that the sensor is mounted at a distance from the target, sufficient to be able to "see" the entire area of interest. For this reason, the manufacturer provides a field of view calculating software called "Spot Size Calculator", which allows the calculation of the resulting spot size for a given sensor model and based on a specific mounting distance.

Figure 15-31: Spot Size Calculator



The "Spot Size Calculator" tool is available via the following stores and locations:

As app for Windows 10 based desktop computers,
see Windows Store

Download from Windows Store

As app for Android mobiles,
see Google Play Store

GET IT ON Google Play

As App for the iOS mobiles (iPhone and iPad),
see App Store

Download on the App Store

As html5 web page, see
http://m.flukeprocessinstruments.com/SpotSizeCalculator/index.html

15.3 Determination of Emissivity

Emissivity (applicable for sensors in 1-color mode) is a measure of an object's ability to absorb and emit infrared energy. It can have a value between 0 and 1.0. For example, a mirror has an emissivity of < 0.1, while the so-called *blackbody* reaches an emissivity value of 1.0. If a higher than actual emissivity value is set, the output will read low, provided the target temperature is above its ambient temperature. For example, if you have set 0.95 and the actual emissivity is 0.9, the temperature reading will be lower than the true temperature.

An object's emissivity can be determined by one of the following methods:

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

15.4 Typical Emissivity Values

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

- Temperature
- Angle of measurement
- Geometry (plane, concave, convex)
- Thickness
- Surface quality (polished, rough, oxidized, sandblasted)
- Spectral range of measurement
- Transmission (e.g. thin films plastics)

To optimize surface temperature measurements, consider the following guidelines:

- Determine the object's emissivity using the instrument, which is also to be used for temperature measurements.
- Avoid reflections by shielding the object from surrounding temperature sources.
- For higher temperature objects, use instruments with the shortest wavelength possible.
- For translucent materials such as plastic foils or glass, ensure that the background is uniform and lower in temperature than the object.
- Mount the instrument perpendicular to the surface, if possible. In all cases, do not exceed angles more than 45° from incidence.

Table 15-1: Typical Emissivity Values for Metals

Material	Metals Emissivity 1 µm	1.6 µm
Aluminum		
Unoxidized	0.1-0.2	0.02-0.2
Oxidized	0.4	0.4
Alloy A3003, Oxidized		0.4
Roughened	0.2-0.8	0.2-0.6
Polished	0.1-0.2	0.02-0.1
Brass		
Polished	0.1-0.3	0.01-0.05
Burnished		
Oxidized	0.6	0.6
Chromium	0.4	0.4
Oxidized		
Copper		
Polished		0.03
Roughened		0.05-0.2
Oxidized	0.2-0.8	0.2-0.9
Gold	0.3	0.01-0.1
Haynes		
Alloy	0.5-0.9	0.6-0.9
Inconel		
Oxidized	0.4-0.9	0.6-0.9
Sandblasted	0.3-0.4	0.3-0.6
polished	0.2-0.5	0.25
Iron		
Oxidized	0.4-0.8	0.5-0.8
Unoxidized	0.35	0.1-0.3
Rusted		0.6-0.9
Molten	0.35	0.4-0.6
Iron, Cast		
Oxidized	0.7-0.9	0.7-0.9
Unoxidized	0.35	0.3
Molten	0.35	0.3-0.4
Iron, Wrought		
Dull	0.9	0.9
Lead		
Polished	0.35	0.05-0.2
Rough	0.65	0.6
Oxidized		0.3-0.7
Magnesium	0.3-0.8	0.05-0.3
Mercury		0.05-0.15
Molybdenum		
Oxidized	0.5-0.9	0.4-0.9
Unoxidized	0.25-0.35	0.1-0.35

	Metals Emissivity	
Material	**1 µm**	**1.6 µm**
Monel (Ni-Cu)	0.3	0.2-0.6
Oxidized		
Nickel		
Oxidized	0.8-0.9	0.4-0.7
Electrolytic	0.2-0.4	0.1-0.3
Platinum		
Black		0.95
Silver		0.02
Steel		
Cold-Rolled	0.8-0.9	0.8-0.9
Ground Sheet		
Polished Sheet	0.35	0.25
Molten	0.35	0.25-0.4
Oxidized	0.8-0.9	0.8-0.9
Stainless	0.35	0.2-0.9
Tin (Unoxidized)	0.25	0.1-0.3
Titanium		
Polished	0.5-0.75	0.3-0.5
Oxidized		0.6-0.8
Tungsten		
Polished	0.35-0.4	0.1-0.3
Zinc		
Oxidized	0.6	0.15
Polished	0.5	0.05

Table 15-2: Typical Emissivity Values for Non-Metals

	NON-METALS	
	Emissivity	
Material	**1 µm**	**1.6 µm**
Asbestos	0.9	
Asphalt		
Basalt		
Carbon		
Unoxidized	0.8-0.95	
Graphite	0.8-0.9	
Carborundum		
Ceramic	0.4	
Clay		
Coke	0.95-1.00	0.95-1.00
Concrete	0.65	
Cloth		
Glass		
Plate		
"Gob"		
Gravel		
Gypsum		
Ice		
Limestone		
Paint (non-al.)		
Paper (any color)		
Plastic, opaque at 500 µm thickness (20 mils)		
Rubber		
Sand		
Snow		
Soil		
Water		
Wood, Natural		

15.5 Determination of Slope

The following slope settings (applicable for sensors in 2-color mode) are approximate and will vary depending on the metal alloy and surface finish, as well as the application. These are supplied here as examples.

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

- Stainless Steel
- Cobalt
- Steel
- Iron
- Nickel

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

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

Molten iron also has an approximate slope setting of **1.060**.

How to determine slope?

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

Alternatively you can also use the sensor's matching function, see section 6.2.3 Unit Setup Menu, page 49.