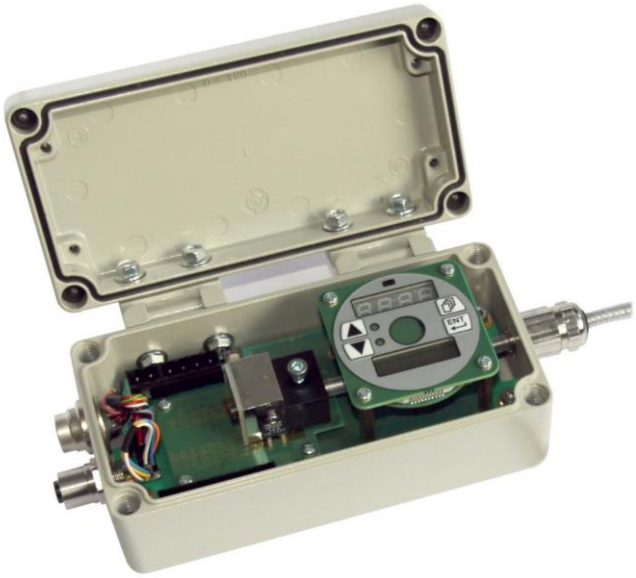
FLUKE
Process Instruments

Endurance® Series

Innovative High Temperature Fiber Optic Infrared Pyrometers



Users Manual

PN 4979744
Jan 2019, Rev. 1.2

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.

Specifications subject to change without notice.

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)
EN 60825-1:2015-07	Safety of laser products – Part 1: Equipment classification and requirements

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.

Contacts

Fluke Process Instruments

Fluke Process Instruments North America
Everett, WA USA
Tel: +1 800 227 8074 (USA and Canada, only)
+1 425 446 6300
solutions@flukeprocessinstruments.com

Fluke Process Instruments EMEA
Berlin, Germany
Tel: +49 30 4 78 00 80
info@flukeprocessinstruments.de

Fluke Process Instruments China
Beijing, China
Tel: +86 10 6438 4691
info@flukeprocessinstruments.cn

Fluke Process Instruments Japan
Tokyo, Japan
Tel: +81 03 6714 3114
info@flukeprocessinstruments.jp

Fluke Process Instruments Asia East and South
Mumbai, India
Tel: +91 22 62495028
Singapore
Tel: +65 6799 5578
sales.asia@flukeprocessinstruments.com

Worldwide Service

Fluke Process Instruments offers services, including repair and calibration. For more information, contact your local office or e-mail *support@flukeprocessinstruments.com*

www.flukeprocessinstruments.com

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1. Safety Instructions

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

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

Unacceptable Operation
The instrument should not be used for medical diagnosis.

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

Instrument Disposal

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

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

Helpful information regarding the optimal use of the instrument.

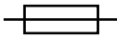
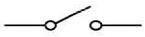
Warnings concerning operation to avoid instrument damage and personal injury.

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

Pay particular attention to the following safety instructions.

Use in 115/230 V~ electrical systems can result in electrical hazards and personal injury, if not properly protected. All instrument parts supplied by electricity must be covered to prevent physical contact and other hazards at all times.

Table 1: General Symbols

Symbol	Definition
	AC (Alternating Current)
	DC (Direct Current)
	Risk of danger. Important information. See manual.
	Hazardous voltage. Risk of electrical shock.
	Helpful information regarding the optimal use of the instrument.
	Earth ground
	Protective ground
	Fuse
	Normally-open (NO) relay
	Normally-closed (NC) relay
	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.

2. Description

These Endurance series pyrometers with an external, via fiber optic cable, attached sensor head are infrared noncontact temperature measurement systems. Such devices have a fixed focus, a laser beam pointing capability through the lens to the target, and different fiber optic cable types for specific wavelength infrared temperature measurements. 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 and an IP65 (NEMA-4) rated 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.

Endurance series pyrometers are available for different kind of temperature measurement applications and are separated into the following variants:

Table 2: Fiber optic head models and their assigned sensor spectral range

Model	Description
EF1ML, EF1MM, EF1MH -Monochrome (1-Color)-	1-C-sensor in spectral range of 1.0 µm for different temperature ranges
EF2ML, EF2MH -Monochrome (1-Color)-	1-C-sensor in spectral range of 1.6 µm for different temperature ranges
EF1RL, EF1RM, EF1RH -Ratio (2-Color)-	2-C-sensor in spectral range of 1.0 µm (nominal) for different temperature ranges
EF2RL, EF2RH -Ratio (2-Color)-	2-C-sensor in spectral range of 1.6 µm (nominal) for different temperature ranges

Monochrome (1-Color mode) types 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 (2-Color mode) types for specific temperature measurement applications
Such 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. Possible emissivity alterations should affect both detector wavelengths in an identical manner. Unfortunately is such identical influence on both detectors in general use not verifiable.

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 pyrometer types are able to measure and determine the object temperature in either one of both modes (1-Color / 2-Color), in which always 2 infrared detectors are active.

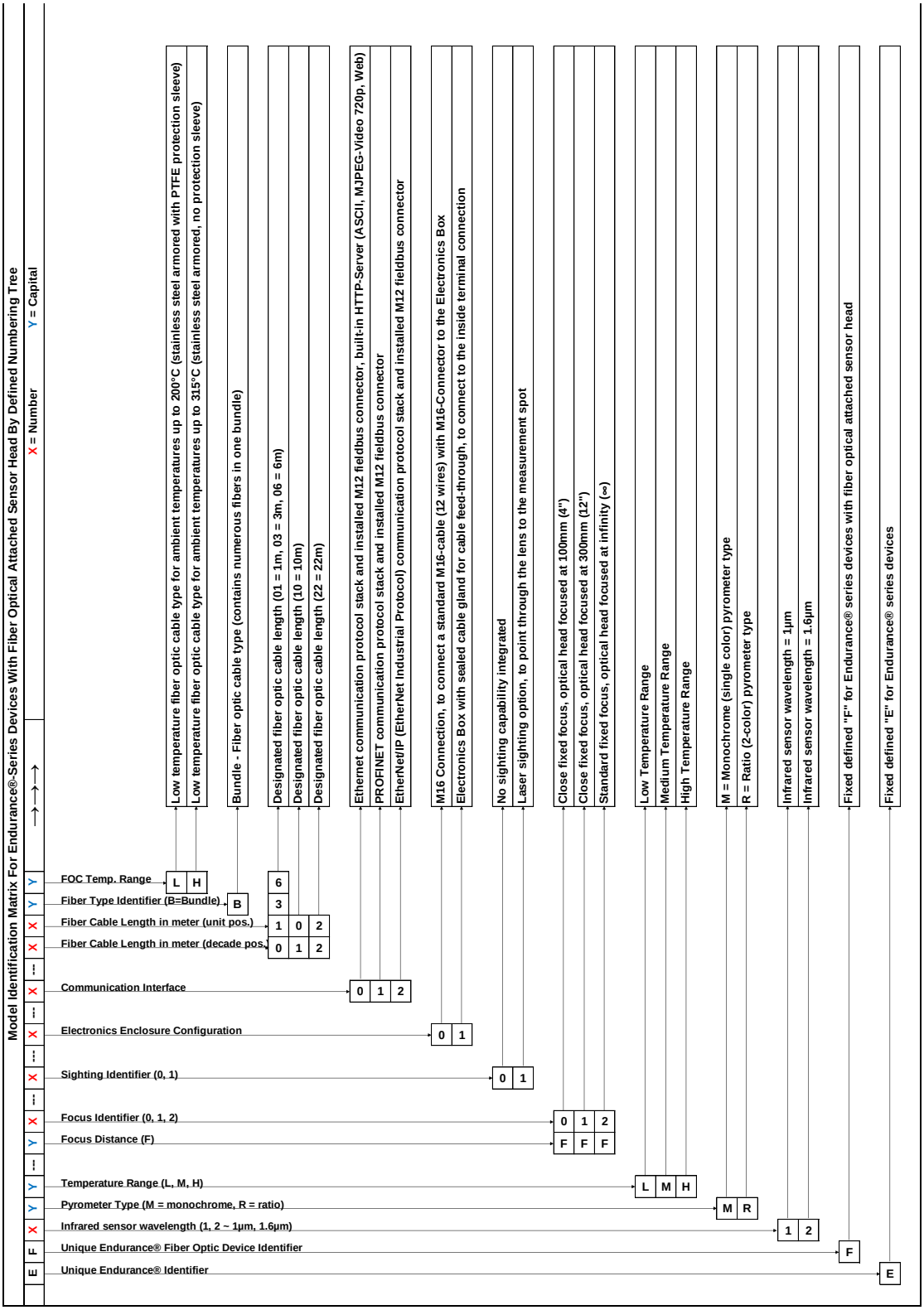


Figure 1: Identification matrix for Endurance fiber optic infrared pyrometers

2.1. Theory of Operation for Ratio (2-Color) Sensors

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.

2.1.1. Partially Obscured Targets

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

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

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

2.1.2. Targets Smaller Than Field of View

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

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

2.1.3. Emissivity and 1-Color (single wavelength) 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, refer to the appendix of this manual.

When target emissivity is uncertain or changing, a 2-Color sensor can be more accurate than a 1-Color instrument as long as the emissivity changes by the same factor in both wavelength bands. Accurate measurement results are dependent on the application and the type of material being measured. The emissivity of all real objects changes with wavelength and temperature, at varying degrees, depending on the material. To determine how to use 2-Color sensors with your application when uncertain or changing emissivities are a factor, please contact our sales representative or technical support department.

2.1.4. Slope (2-Color ratio) measurements

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 the appendix of this manual.

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

Experts figured out, that extreme dirt (dust, fingerprints) on the optical lens or vision window influences the Endurance 2-Color measurement chain. Unpredictable temperature readings may result in such a case!

3. Technical Data

3.1. General Specifications

General Specifications	
Device Model / **Parameter**	**EF1ML, EF1MM, EF1MH, EF2ML, EF2MH, EF1RL, EF1RM, EF1RH, EF2RL, EF2RH**
Environmental Rating for Housing	NEMA-4 (IEC 529, IP 65)
Ambient Temperature Head / Fiber Cable Electronics Housing w/o cooling plate Electronics Housing with cooling plate	 0 - 200°C (32 - 392°F) 0 - 60°C (32 - 140°F) 0 - 150°C (32 - 302°F)
Storage Temperature Electronics Housing	 -20 to 70°C (-4 to 158°F)
Fiber Cable Standard Type High Temperature Type	 Rated to 200°C (360°F), NEMA-4 (IP65), stainless steel armour, PTFE coated sleeve Rated to 315°C (600°F), stainless steel armour, no coated sleeve, see Device Options
Relative Humidity	10 to 95%
Electromagnetic Compatibility (EMC)	EN 61326-1:2013
Safety	EN 60825-1:2015-07 FDA laser safety compliant
Mechanical Shock Electronics Housing	 IEC 68-2-27 (5 G, 11 msec duration, 3 axes)
Vibrations Electronics Housing	 IEC 68-2-6 (2 G, 10 to 150 Hz, 3 axes)
Warm up Period	15 minutes
Weight Optical Head Electronics Housing	 ~100g (3.53 oz) ~710g (25.0 oz)
Housing Material Optical Head Electronics Housing	 Stainless Steel Aluminum diecast

3.2. Electrical Specifications

Electrical Specifications	
Parameter \ **Device Model**	**EF1ML, EF1MM, EF1MH, EF2ML, EF2MH, EF1RL, EF1RM, EF1RH, EF2RL, EF2RH**
Power Supply 20 to 48 VDC allowed, max. 12 W Power over Ethernet (IEEE 802.3af)	
Digital Input (External Trigger / Hold) Galvanically isolated TTL input signal (digital active low) To trigger: - Average-, Peak-, Valley Hold function - Restart of signal postprocessing - Switching the optional LASER sighting on/off	
Digital Output (Relay / Alarm Output) Galvanically isolated digital output of a potential-free solid state relay contact. The max. relay contact load is limited to 48 V, 300 mA. The relay contact behavior is settable via the user interface or a serial command to operate as following: - NO = Normally Open - NC = Normally Close - PO = Permanently Open - PC = Permanently Close	
Analog Input (0/4 – 20mA current loop input) Galvanically isolated analog input signal, to read in the current (0/4 – 20mA), given by an external device like PLC, Computer or any kind of process control device. The internal loop resistor per pyrometer is about 220Ω. Via a controlled current from an external device you are able to set/correct: - Verification of preset current values, given by external devices - Set emissivity (1-Color or 2-Color mode) - Set slope (2-Color devices only) - Set background temperature for background compensation	
Analog Output (current loop, 0/4 – 20mA) Galvanically isolated analog output signal, to stimulate output currents in the range (0/4 - 20 mA). The output signal is an active output with 16 Bit resolution, to drive a maximum resistive load of 500Ω. Just the acquired object temperature, measured by either 1C or 2C devices, displayed on on the Endurance control panel, is converted to a 16 bit current equivalent. The user has to define the temperature measurement range and must assign the lower and upper range limits to the current equivalent (0 – 20mA / 4 – 20mA).	
RS485 Serial Communication Interface (4-/2-wire full/half duplex transmission) Galvanically isolated 4- or 2-wire RS485 communication interface. The ordered 'Electronics Enclosure Configuration' option (M16-connector/Cable gland) determines the 4-/2-wire capability. - Data format: 8 bit, no parity, 1 stop bit - Data rate (Bit/s): 1200, 2400, 9600, 19200, 38400, 57600, 115200 - Default data rate (factory setup): 38400 Bit/s	
Digital Network Communication Interface Galvanically isolated 4-wire network communication interface: - Full duplex, 100 Mbit (100Base-TX / IEEE 802.3u) - Power over Ethernet (PoE) capability, referred to PoE standard IEEE 802.3af, mode A, 10/100 Mbit, mixed DC & data - TCP/IP, UDP, HTTP, Webserver - Additional communication options like Profinet and Ethernet IP	

3.3. Measurement Specifications

Measurement Specifications				
Parameter \ **Device Model**		**EF1ML, EF1MM, EF1MH, EF2ML, EF2MH, EF1RL, EF1RM, EF1RH, EF2RL, EF2RH**		
Temperature range for fiber optical device models				
Model	**Detector wavelength**	**Temp. in °C**	**Temp. in °F**	**D:S**
EF1ML	1.0 µm Si detector	475 - 900°C	887 - 1652°F	20:1
EF1MM	1.0 µm Si detector	800 - 1900°C	1472 - 3452°F	100:1
EF1MH	1.0 µm Si detector	1200 - 3000°C	2192 - 5432°F	100:1
EF2ML	1.6 µm InGaAs detector	250 - 800°C	482 - 1472°F	20:1
EF2MH	1.6 µm InGaAs detector	400 - 1700°C	752 - 3092°F	40:1
EF1RL	1.0 µm Si/Si detector	500 - 1100°C	932 - 2012°F	20:1
EF1RM	1.0 µm Si/Si detector	700 - 1500°C	1292 - 2732°F	40:1
EF1RH	1.0 µm Si/Si detector	1000 - 3200°C	1832 - 5792°F	65:1
EF2RL	1.6 µm InGaAs detector	275 - 1000°C	527 - 1832°F	20:1
EF2RH	1.6 µm InGaAs detector	350 - 1300°C	662 - 2372°F	40:1
Accuracy (no signal attenuation)				
EF1ML (> 475°C / 887°F)		± (0.3% T_{meas} + 2°C), T_{meas} in °C		
EF1MM (> 800°C / 1472°F)		± (0.3% T_{meas} + 2°C), T_{meas} in °C		
EF1MH (>1200°C / 2192°F)		± (0.3% T_{meas} + 2°C), T_{meas} in °C		
EF2ML (> 250°C / 482°F)		± (0.3% T_{meas} + 2°C), T_{meas} in °C		
EF2MH (> 400°C / 752°F)		± (0.3% T_{meas} + 2°C), T_{meas} in °C		
EF1RL (> 500°C / 932°F)		± (0.3% T_{meas} + 2°C), T_{meas} in °C		
EF1RM (> 700°C / 1292°F)		± (0.3% T_{meas} + 2°C), T_{meas} in °C		
EF1RH (>1000°C / 1832°F)		± (0.3% T_{meas} + 2°C), T_{meas} in °C		
EF2RL (> 275°C / 527°F)		± (0.3% T_{meas} + 2°C), T_{meas} in °C		
EF2RH (> 350°C / 662°F)		± (0.3% T_{meas} + 2°C), T_{meas} in °C		
Repeatability (no signal attenuation)				
EF1ML (> 475°C / 887°F)		± 1°C (± 2°F)		
EF1MM (> 800°C / 1472°F)		± 1°C (± 2°F)		
EF1MH (>1200°C / 2192°F)		± 1°C (± 2°F)		
EF2ML (> 250°C / 482°F)		± 1°C (± 2°F)		
EF2MH (> 400°C / 752°F)		± 1°C (± 2°F)		
EF1RL (> 500°C / 932°F)		± 1°C (± 2°F)		
EF1RM (> 700°C / 1292°F)		± 1°C (± 2°F)		
EF1RH (>1000°C / 1832°F)		± 1°C (± 2°F)		
EF2RL (> 275°C / 527°F)		± 1°C (± 2°F)		
EF2RH (> 350°C / 662°F)		± 1°C (± 2°F)		
Temperature Resolution				
Integrated Temperature Display		±1°C (±2°F)		
Current Loop (Analog I/O)		±0.1°C (±0.2°F)		
Network / RS485 interface		±0.1°C (±0.2°F)		
Temperature Coefficient		0.03% full scale change per 1°C change in ambient temperature		
Response Time at 95% Reading				
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		
Selectable Analog Current output		0-20 mA or 4-20 mA (galvanic isolated) 16 bit resolution, max. impedance: 500 Ω		

Emissivity Coefficient (1-Color mode) all device models	Digitally adjustable in increments of 0.001 0.100 to 1.100
Slope Coefficient (2-Color mode) EF1ML, EF1MM, EF1MH, EF2ML, EF2MH EF1RL, EF1RM, EF1RH, EF2RL, EF2RH	Digitally adjustable in increments of 0.001 N/A N/A 0.850 to 1.150 0.850 to 1.150
Signal Processing	Averaging, Peak hold or Valley hold
Averaging Range	0.1 to 299.9 s (300 s = ∞)
Peak Hold Range	0.1 to 299.9 s (300 s = ∞)
Valley Hold Range	0.1 to 299.9 s (300 s = ∞)
Noise Equivalent Temperature (NET)	1°C peak to peak, target emissivity of 1.00, no attenuation, 3°C peak to peak for all attenuation conditions

3.4. Optical Specifications

Optical Specifications	
Optical Resolution D:S EF1ML EF1MM EF1MH EF2ML EF2MH EF1RL EF1RM EF1RH EF2RL EF2RH	(assumes 95% energy at the focus point) D:S = 20:1 D:S = 100:1 D:S = 100:1 D:S = 20:1 D:S = 40:1 D:S = 20:1 D:S = 40:1 D:S = 65:1 D:S = 20:1 D:S = 40:1
Lens Options	F0: 100 mm (3.9 in) F1: 300 mm (12 in) F2: infinity (∞)
Sighting Options	LASER spot pointing

The properties of Endurance fiber optic infrared pyrometers are:

- Fixed focus
- LASER sighting/pointing option
- Small fiber optic attached sensor head with up to 22 m (866 in) specific fiber cable

Three fixed focus distances are optional orderable:

- F0 focus at 100 mm (4")
- F1 focus at 300 mm (12")
- F2 focus at infinity (∞)

For measurements performed in the 1-Color mode, make sure that the target completely fills the measurement spot.

The focus and model options determine the spot size propagation, regarding the distance between the sensor head and the measurement spot. All option dependent spot size propagation diagrams are shown below.

For further information, see section 12.5 Optical Diagrams, page 95.

3.5. Dimensions

The pictures below illustrate the dimensions of the Endurance Electronics Housing, the model specific external heads and the related adjustable mounting bracket.

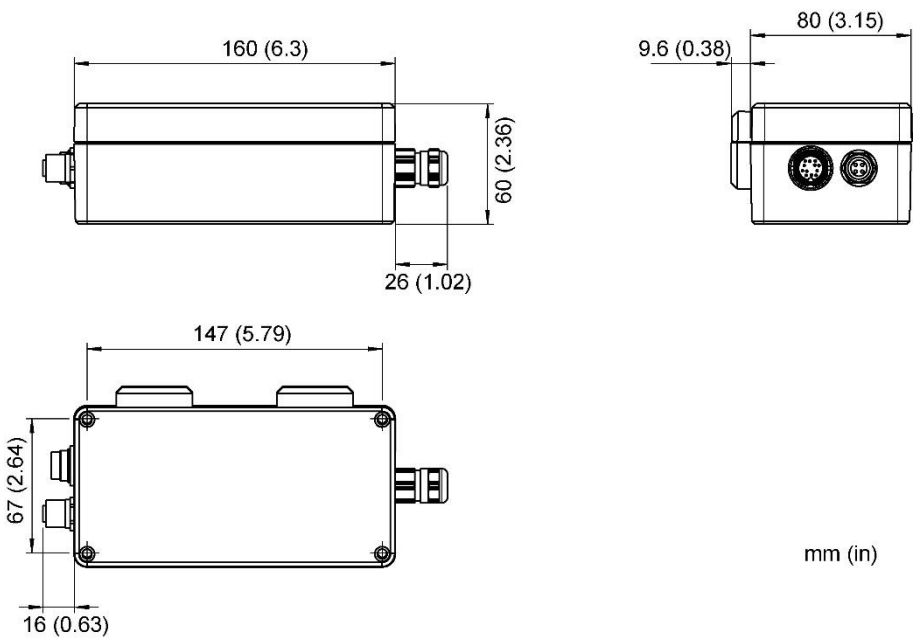


Figure 2: Dimensions of the Endurance Electronics Housing

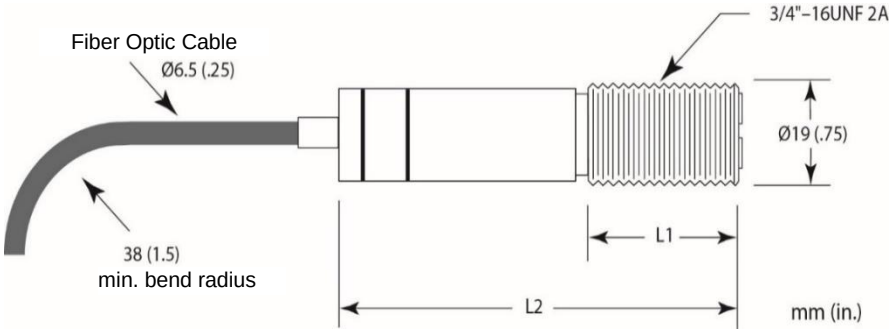


Table 3: Dimensions of available sensor heads

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.)

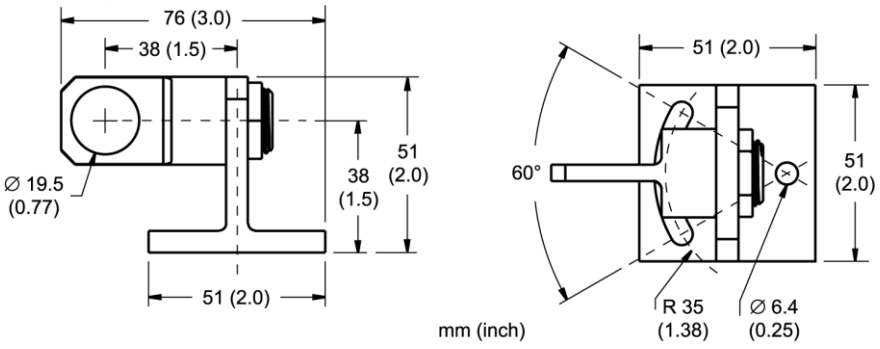


Figure 3: Dimensions of the adjustable mounting bracket

3.6. Scope of Delivery

The Endurance standard device delivery includes the following:

- Endurance-Series Infrared Pyrometer with fiber optical attached sensor head
- Two mounting nuts to fix the external sensor head
- Adjustable mounting bracket to mount the external sensor head (E-FOMB
- Data carrier, which contains Multidrop Software, Operating Instructions and Quickstart guide
- Printed version of the Quickstart guide

4. Sensor Location

Sensor location and configuration depends on the application. Before deciding on a location, you need to be aware of the ambient temperature at the location, the atmospheric quality at the location (especially for 1-Color temperature measurements), and the possible electromagnetic interference at the 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. Also, wiring and conduit runs must be considered, including computer wiring and connections, if used. The following subsections cover topics to consider before you install the sensor.

4.1. Ambient Temperature

The optical head is designed to operate in ambient temperatures up to 200°C (390°F). The electronics enclosure is designed to operate in ambient temperatures between 0°C (32°F) and 60°C (140°F). Internal temperatures outside this range will cause a failsafe error.

4.2. Atmospheric Quality

Partial smoke, fumes, dust, or other contaminants in the air, as well slight dirt on the lens are typically not a problem when using the 2-Color mode (if the attenuation is equal in both spectral bands). However, if the lens gets too dirty, it cannot detect enough infrared energy to measure accurately, and the instrument will indicate a failure. It is good practice to always keep the lens clean. The Air Purge Collar helps keep contaminants from building up on the lens.

If you use air purging, make sure an air supply with the correct air pressure is installed before proceeding with the sensor installation.

4.3. Electrical Interference

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

Mount the electronics enclosure as far away as possible from potential sources of electrical interference, such as motorized equipment producing large step load changes.

- Use shielded wire for all input and output connections.
- Make sure the shield wire from the electronics to terminal block cable is earth grounded.
- For additional protection, use conduit for the external connections. Solid conduit is better than flexible conduit in high noise environments.
- Do not run AC power for other equipment in the same conduit.

When installing the Endurance 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.

4.4. Distance to Object

The optimal distance to the measuring object depends on the optical lens focus (F0, F1, F2) of the sensor head and the needed measurement spot size. Please see section 3.4, Optical Specifications for detailed information regarding the focus options. The Endurance 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.

4.5. Sensor Placement (1-Color Mode)

Sensor placement for 1-Color temperature measurements is more critical than for 2-Color measurements. The sensor must have an unobstructed view to the target. Any obstruction on the lens, the front window, or in the atmosphere influences the temperature reading accuracy. The sensor distance to the target can be anywhere beyond the minimum requirements, as long as the target completely fills the field of view.

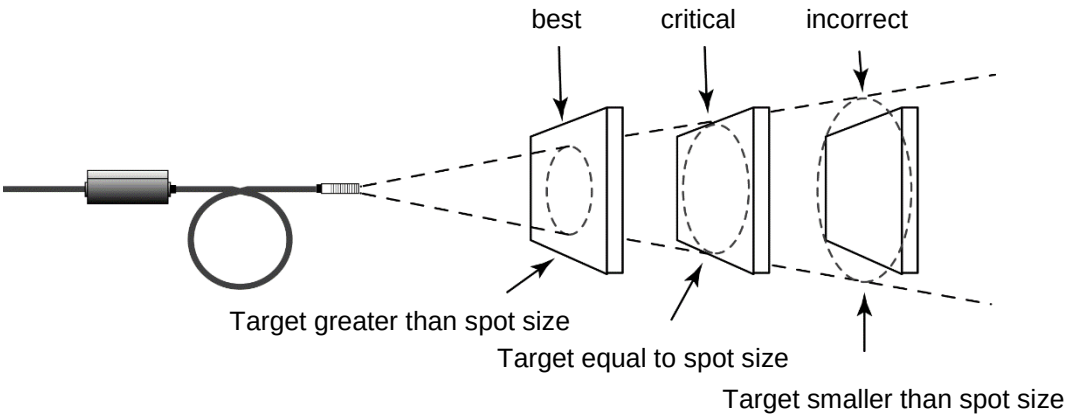


Figure 4: Proper Sensor Placement in 1-Color Mode

4.6. Sensor Placement (2-Color Mode)

The following figure demonstrates the sensor placement under various conditions, where valid 2-Color temperature measurements are possible. Note, however, that if the sensor signal is reduced more than 95% (including emissivity and obscuration of the target), the sensor accuracy also degrades.

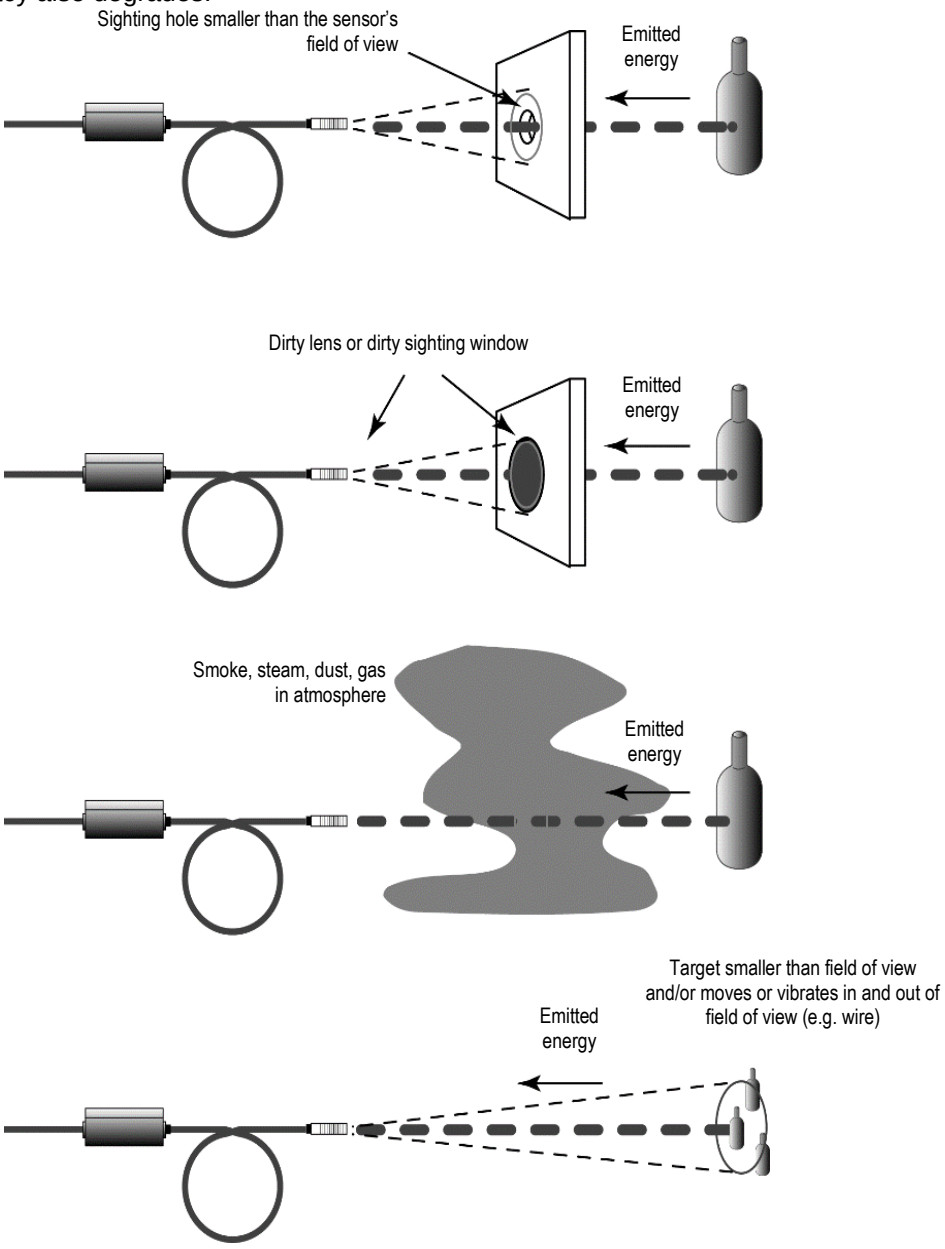


Figure 5: Sensor Placement in 2-Color Mode

4.7. Viewing Angles

The optical head can be placed at any angle to the target up to 30° for 1-Color measurement mode, or up to 45° for 2-Color measurement mode.

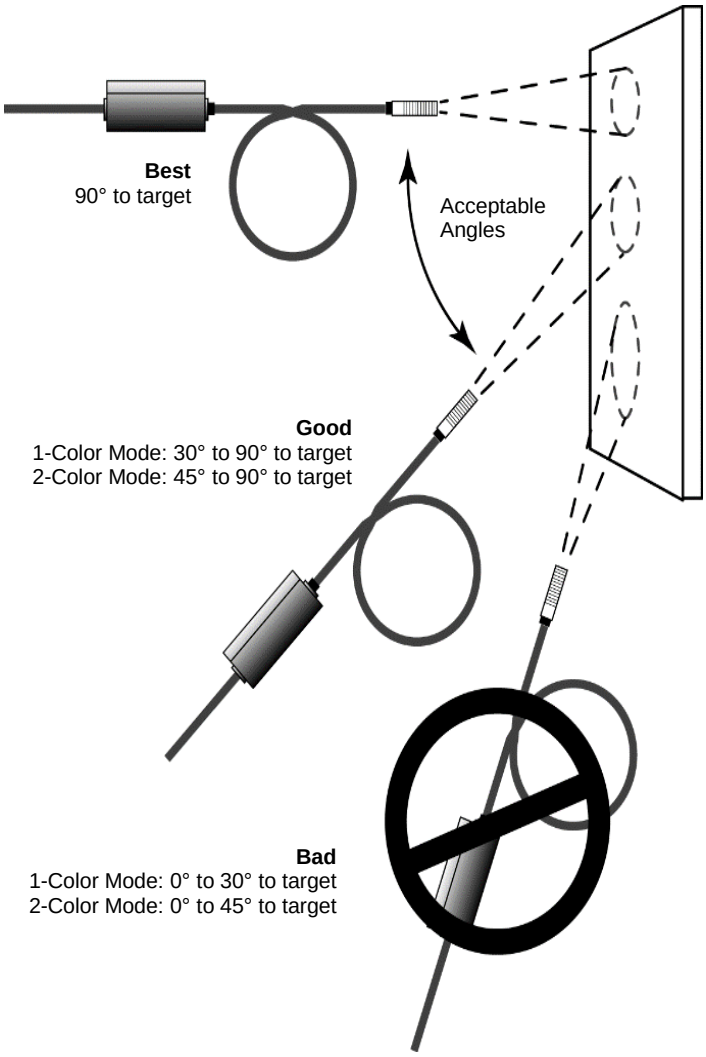


Figure 6: Acceptable Sensor Viewing Angles

5. Installation

5.1. Mounting the Sensor

After all preparations are complete according to section 4 Sensor Location, page 13 ff., you can install the sensor.
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.
You may need to "snake" the fiber optic cable through and around any obstacles, such as beams, walls, support columns, etc., or, if your installation requires, through conduit, before attaching the end to the electronics enclosure. (Do not attach until you aim the optical head.) The cable can be disconnected from the electronics box for aiming or threading through conduit during installation. The cable is keyed and can only be inserted one way into the electronics enclosure.

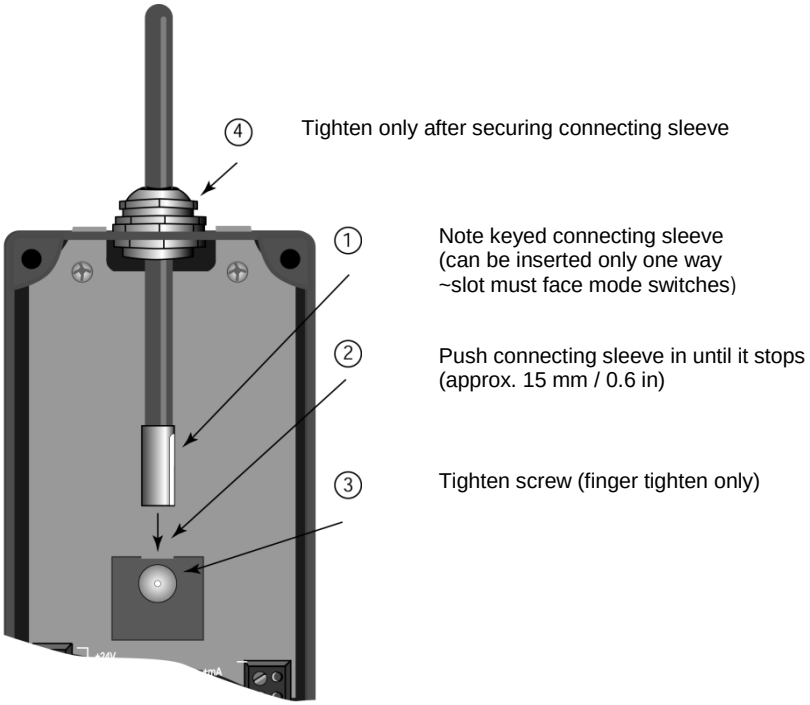


Figure 7: Connecting the Fiber Optic Cable

5.2. Mounting the Sensor Head of Laser sighting devices

Sensors equipped with a sighting laser use a branched fiber optic cable. Insert the cable through the bushing and behind the laser module. Note: one branch is large (sensor) and one branch is small (sighting laser).

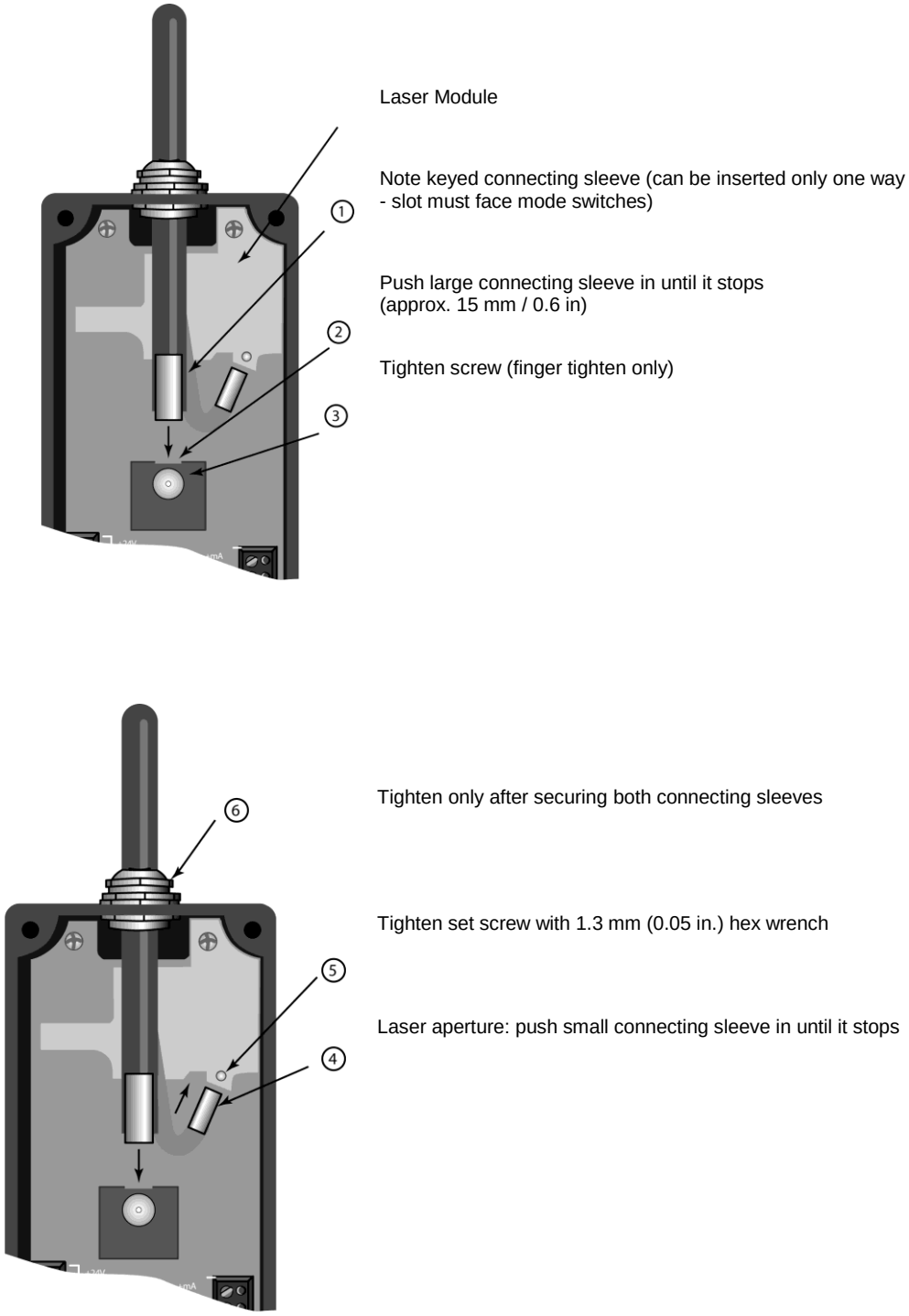


Figure 8: Mounting the Fiber Optic Cable for Laser sighting devices

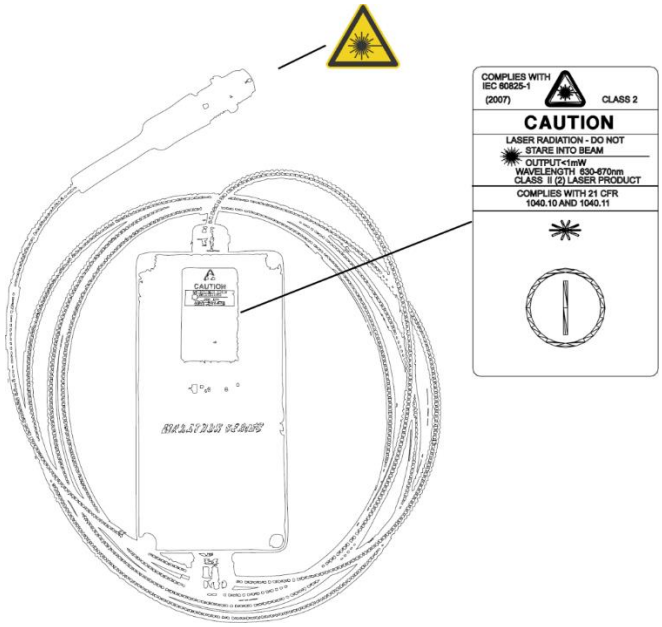


Figure 9: Caution / Attention hint for devices with ordered LASER sighting option

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

5.3. Aiming and Focusing

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.

Make sure that the sensor is in 1-color mode when using this aiming technique!

Another aiming can be done by means of a battery powered aiming light. Simply loosen the compression sleeve holding the fiber optic cable, loosen the screw at the heater block, 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.

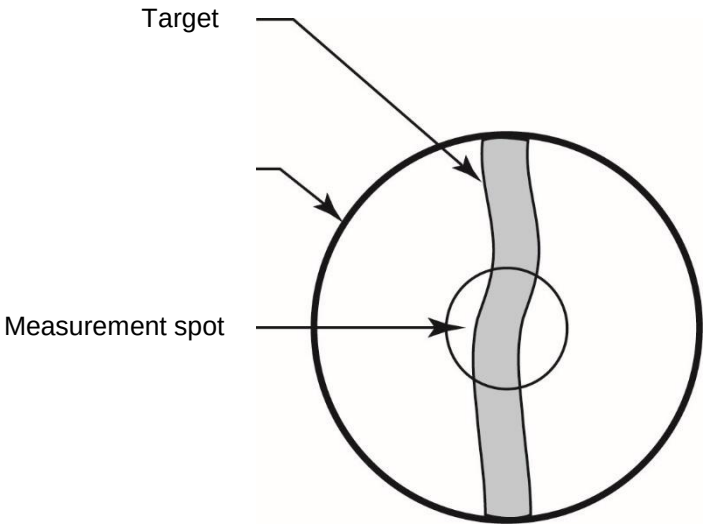


Figure 10: Schematic diagram of the target and measurement spot

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

For aiming and focusing the external optical head to the measurement target spot, please refer to Measurement spot diagrams for the various focus options shown under see section 3.4 Optical Specifications, page 11.

5.4. Fiber Optic Cable

Fiber optic cables and optical heads can withstand hot ambient temperatures up to 200°C (390°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. 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. If the cable needs to be changed, it could be field replaceable. A calibration program for replaced fiber cables is included with your sensor. Longer fiber optic cables allow the electronics enclosure to be well away from hostile environments.
The fiber optic cable is field replaceable, see section 11.4 Replacing the Fiber Optic Cable, page 88. The fiber optic cable and head are one component. The cable can be disconnected from the electronics box for aiming or threading through conduit during installation. The cable is keyed and can only be inserted one way into the electronics enclosure.

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!

5.5. Electrical Installation of the Electronics Housing

The Endurance-Series pyrometers with fiber optic attached sensor head are available in two different variants:

- The standard electronics housing variant is equipped with two IP67 protected connector sockets. A big M16-metric thread 12-pin DIN connector houses a half duplex RS485 interface, trigger input, relay contact, current loop input, current loop output and 24V power supply lines. The second one, a small M12-metric thread 4-socket connector houses a 100Mbit/s LAN/Ethernet link with integrated Power over Ethernet (PoE) capability.
- The optional electronics housing variant is equipped with a cable gland/grommet instead of the big standard M16 connector, to feed in the customer specific process wiring. To preserve the IP67 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). Only the cable gland variant with the customer specific wiring allows to run the device in a full duplex RS485 mode. To use the full duplex RS485 capability and all Endurance interface lines via the customer specific cable gland wiring, you need at least a shielded cable with 14 single wires. Be aware, that the two RS485 wire pairs should be arranged as twisted pairs, to minimize electrical impacts.

Endurance-Series pyrometer can communicate via both integrated interfaces (LAN/Ethernet & RS485) simultaneously. Please keep in mind, if doing this, that data corruption or inconsisty may occur.

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

To power the electronics housing by 24VDC, you can either use an external 24VDC power supply, attached to the 12-wire M16 cable or the PoE (Power over Ethernet) capability, where the power is injected over the 4-wire Ethernet cable (M 12) by a PoE-injector. The standard 12-wire cable is used to wire all analog/digital inputs and outputs of the electronics housing.

For reliable performance it is recommended that the power supply be no more than 60 m (200 feet) away!

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

5.5.1. Electronics housing with M16 and M12 connector

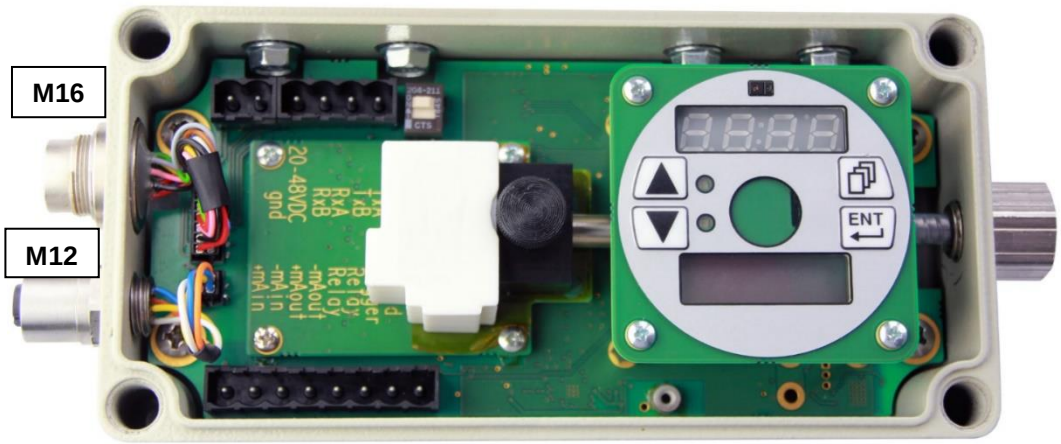
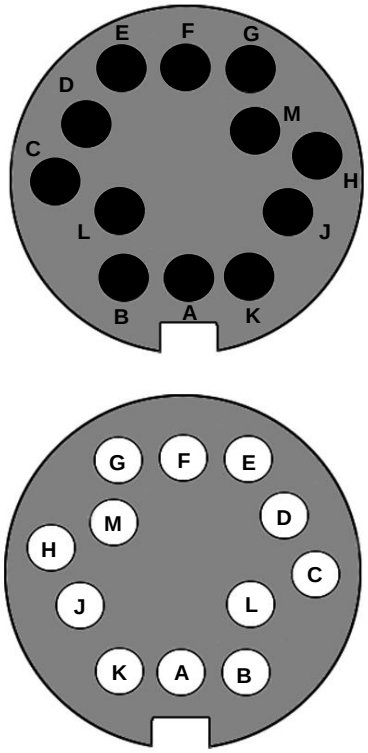


Figure 11: Standard electronics housing with M16 and M12 connector on left side

5.5.1.1.M16 12-Pin DIN Connector Signal Assignment

In case wiring/re-wiring a M16 12-socket DIN connector or a supplied accessory cable connector, refer to the following illustration and table for the wiring layout.

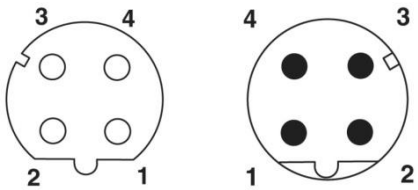


Pin	Color	Description
A	Black*	A
B	White*	B
C	Grey*	- mA In
D	Purple*	+ mA In
E	White/Drain	Shield
F	Yellow	Trigger
G	Orange	Relay
H	Blue	Relay
J	Green	+ mA Out
K	Brown	– mA Out
L	Black	Power Ground
M	Red	+ 24 VDC
Note: Twisted Pairs*		A/B and C/D

Figure 12: M16 connector, the corresponding socket and the wire coding table

5.5.1.2.M12 4-Socket LAN/Ethernet Connector

The LAN/Ethernet connector on Endurance-Series side is a M12 4-socket connector type, D-coded, suited for industrial Ethernet with IP67 protection rate and a screw retention feature. Via the LAN/Ethernet connector the Endurance-Series device can also be powered as a PD (Powered Device) by a PSE (Power Sourcing Equipment) in a PoE (Power over Ethernet) mode. In such operation mode a PoE injector or a PoE switch is needed. Refer to PoE standard IEEE 802.3af, mode A, 10/100 Mbit mixed DC & data.



Signal	Pin RJ45	Pin M12-4
TD+	1	1
TD-	2	3
RD+	3	2
RD-	6	4

Figure 13: M12 Socket (left) and the corresponding cable plug (right)

5.5.2. Electronics housing variant with cable gland / grommet

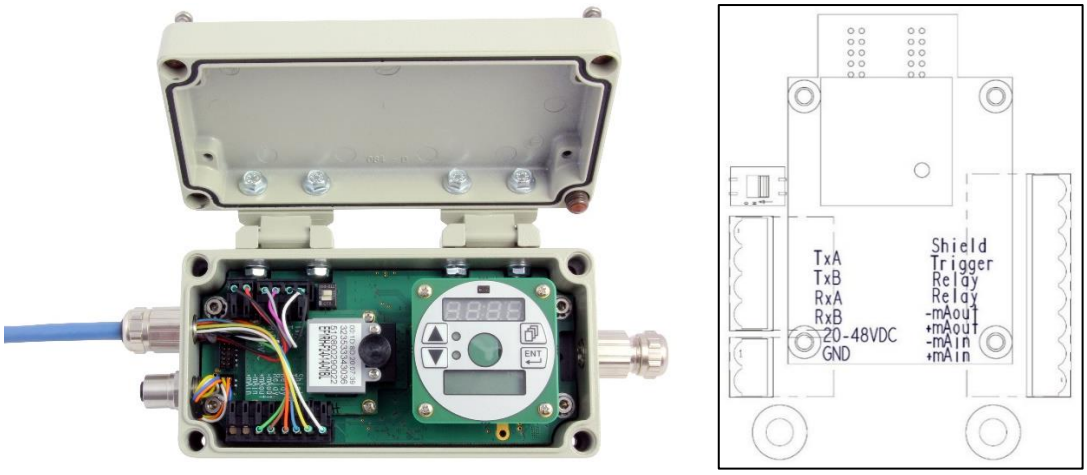


Figure 14: Internal signal assignment of the cable gland/grommet variant

In case the of choosing the cable gland/grommet variant, please refer to the upper signal assignment, printed on the inside wiring board.

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

5.5.3. Accessory Cables and Terminal Block

As accessories for the Endurance-Series devices there are two different communication cables types and a specific terminal block available. Both sensor cables can be ordered in several cable lengths and two different ambient temperature ratings.

The sensors housing is NEMA-4 (IEC 529, IP65) rated.

To prevent possible electrical shock, fire, or personal injury make sure that the sensors housing is grounded before use.

5.5.3.1. M16 12-Conductor shielded cable

The 12-conductor shielded connecting cable is used to wire all the fundamental inputs and outputs like RS485 interface, trigger input, relay contact, current loop input, current loop output and 24V power supply wires to the Endurance-Series sensor. The cable is equipped with an IP67 rated M16 12-socket DIN connector at one end and colored wires with cable end sleeves at the counter side.

See below the colored wire to signal assignments, which are identical to the specific terminal block labeling. For more cable details see section 9.1 Electrical Accessories, page 66.

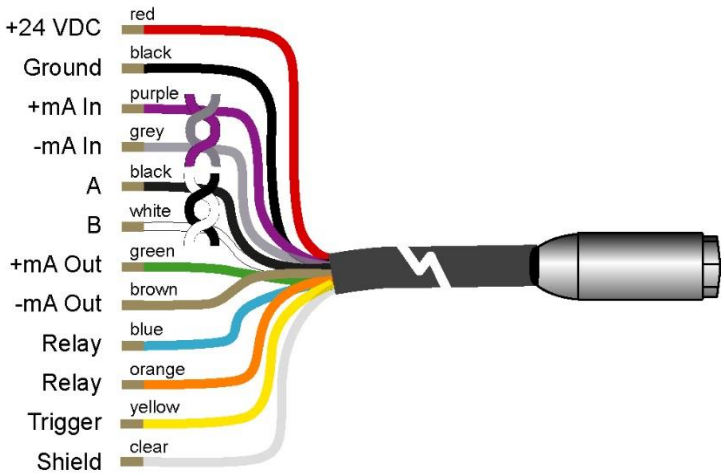


Figure 15: M16 12-Conductor shielded cable with colored wire/signal assignments

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 or SHIELD.

- **Longer cables are available from the factory.**
- **Limit power cables to 60 m (200 ft) or less. RS485 cables can be extended up to 1200 m (4000 ft).**
- **Avoid installing the sensor cable in noisy electrical environments such as around electrical motors, switch gear, or induction heaters.**

5.5.3.2.M12 4-Conductor shielded cable

The 4-conductor shielded connecting cable is used to link the Endurance-Series device to a LAN/Ethernet device. A standardized cable, equipped with a M12 4-pin connector type, D-coded, suited for industrial Ethernet with IP67 protection rate and a screw retention feature on one side and a RJ45 connector type on the counter side is used. Via the 4-conductor cable the Endurance-Series device can also be powered as a PD (Powered Device) by a PSE (Power Sourcing Equipment) in a PoE (Power over Ethernet) mode. Refer to PoE standard IEEE 802.3af, mode A, 10/100 Mbit mixed DC & data.

Figure 16: M12 4-Conductor shielded cable with RJ45 on counter side

5.5.3.3.Endurance specific terminal block

An Endurance specific terminal block is available to attach the 12-wire color-coded sensor cable via the terminal block to the process world.

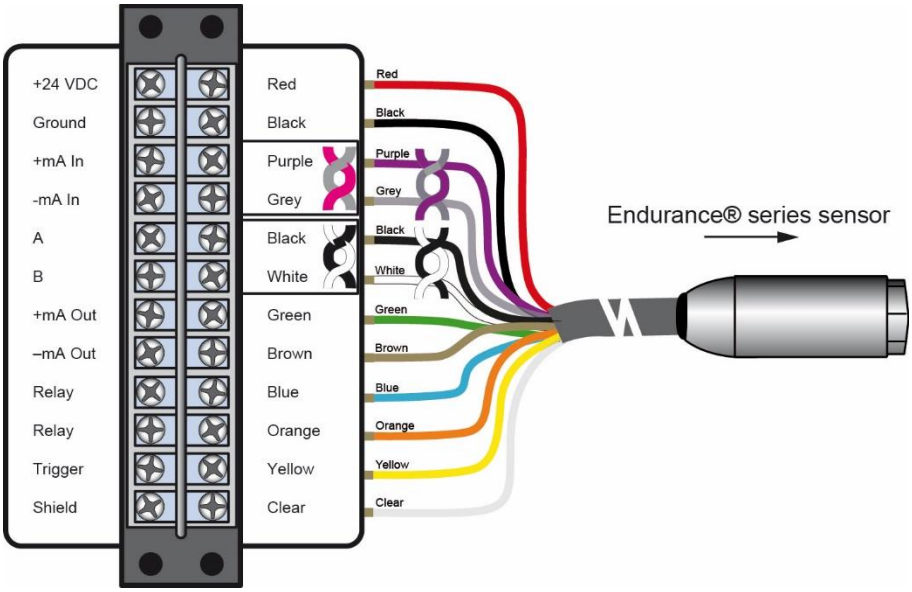


Figure 17: Endurance series labeled terminal block

5.5.4. Power Supply

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

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

5.5.5. Computer Interfacing via RS485 link

The distance between the sensor and a computer can be up to 1200 m (4000 ft.) via RS485 interface. This allows ample distance from the harsh environment, where the sensing system is mounted, to a control room or pulpit where the computer is located. The USB/RS485 Interface Converter allows you to connect your Endurance sensor to computers by using an 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.

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

Only the 2-wire (half duplex) RS485 communication is supported on Endurance devices with the M16 – 12 pin standard connector. The disadvantage is that the data transfer is just alternating possible in one direction at a time. The maximum communication baud rate between the Endurance device and the USB/RS485 converter is 115.200 kBaud. A Baud rate of 38.4 kBaud is the default (preset) value in the Endurance series device during factory setup.

Just the 2-wire (half duplex) mode is supported in serial RS485 communication by Endurance devices with M16 – 12 pin connector!
The 4-wire full duplex serial RS485 communication is only possible, if the cable gland/grommet variant is choosen and a customer specific cable is correctly wired to the inside pin header in the electronics housing.

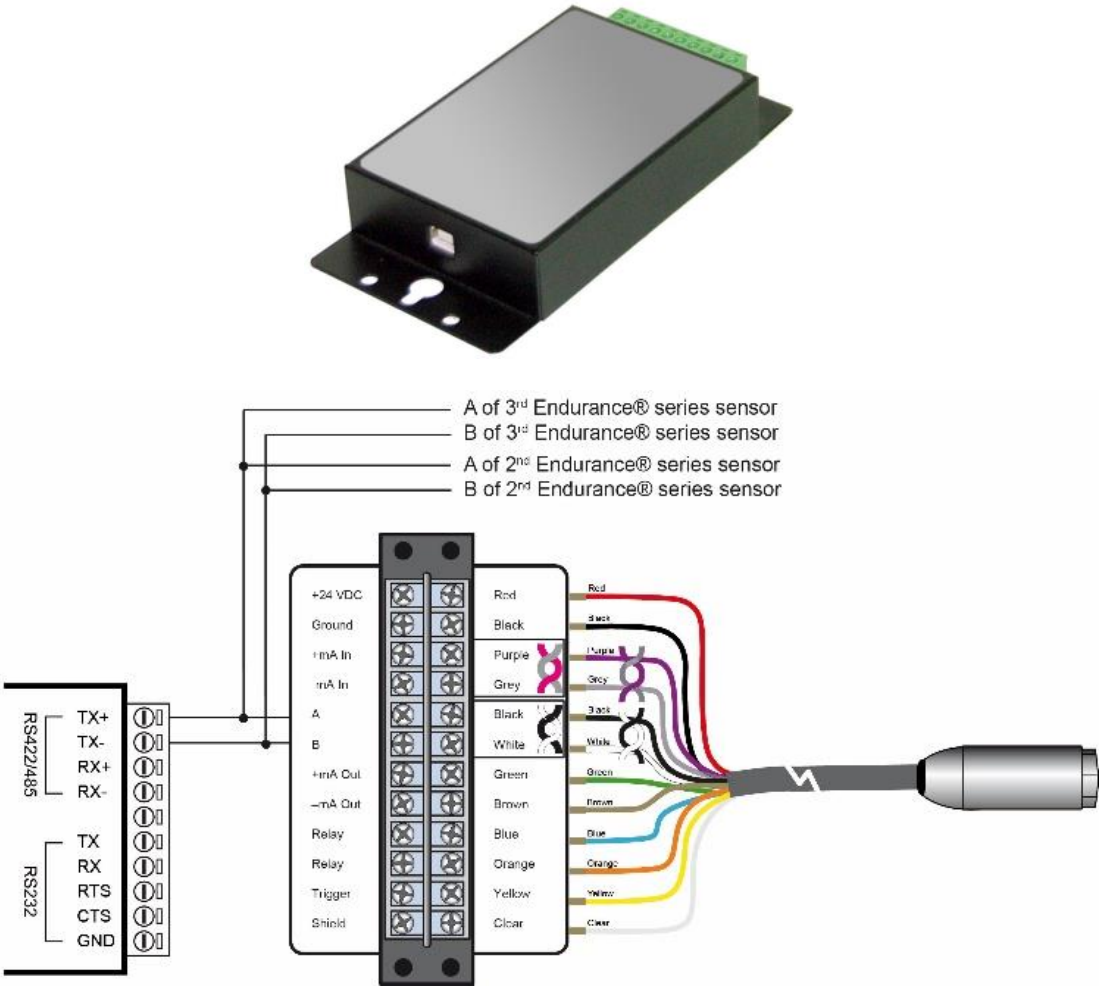


Figure 18: USB/RS485 Converter (E-USB485) in half-duplex configuration

Multiple Endurance sensors in a RS485 Multidrop Network Wiring
For an installation of two or more Endurance sensors in a RS485 network (2-wire, half duplex), each Endurance sensor needs it's specific RS485 network address (1 - 32), preset via the Endurance control panel (user interface) or alternatively via a standard terminal program (operating system dependent). Once all the units are addressed, wire up the units in the 2-wire multidrop manner, whereas all A-signals, as well all B-signals have to be connected to common lines. The common A-signals have to be routed to the TX+ and the common B-signals to TX- terminal at the selected USB/RS485 converter.

5.5.6. Addressing the Endurance sensor in a RS485 Multidrop Network

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

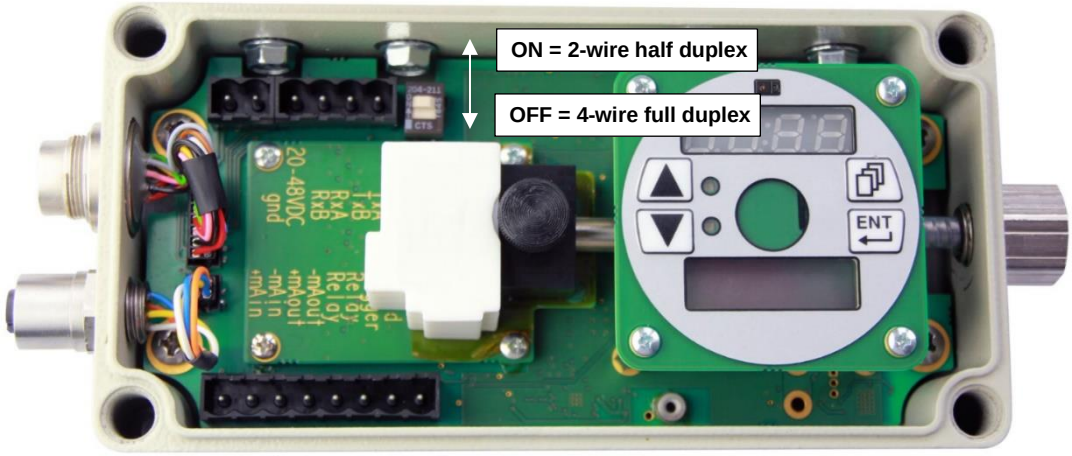
- Each sensor must have a unique address greater zero (1 - 32).
- Each sensor must be set to the same baud rate (default is 38.4 kBaud).
- Once all the units are addressed, wire up the units in the 2-wire multidrop manner, keeping all A & B to be common.
- Now you can run the supplied Endurance software,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

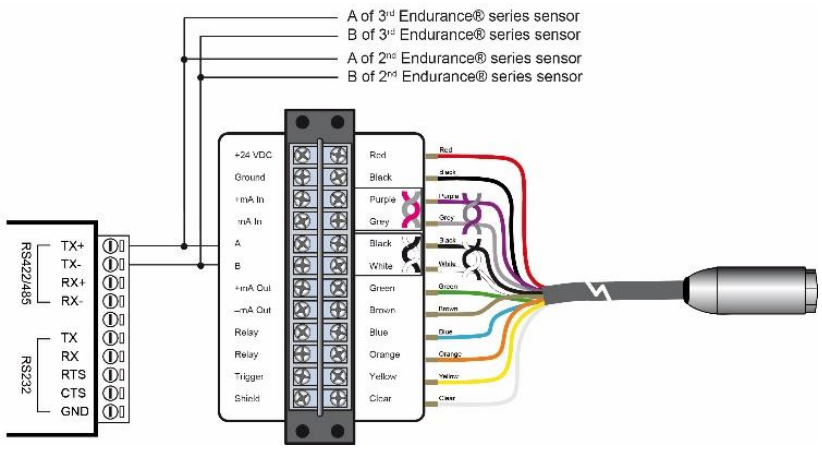
5.5.7. Using the RS485 Serial Communication Interface

The Endurance RS485 serial communication interface is galvanically isolated and allows half-duplex (2-wire) or full-duplex (4-wire) data transmission. The ordered 'Electronics Enclosure Configuration' option determines the half- or full-duplex capability.

Electronics Enclosure Configuration with M16 connector:

- Data format: 8 bit, no parity, 1 stop bit
- Data rate (Bit/s): 1200, 2400, 9600, 19200, 38400, 57600, 115200
- Default data rate (factory setup): 38400 Bit/s
- Half duplex transmission with multidrop line capability, network compatible up to 32 connected Endurance sensors. The fully allocated M16 connector with standard signal assignment (12 wires) just allows 2-wire half duplex transmission. In such case, the Electronics box internal sliding switch **has to** be set in 'ON' position.





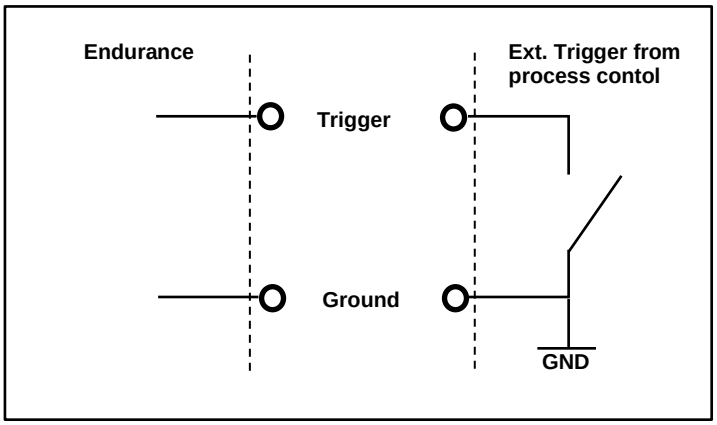
Electronics Enclosure Configuration with cable gland/grommet:

- Data format: 8 bit, no parity, 1 stop bit
- Data rate (Bit/s): 1200, 2400, 9600, 19200, 38400, 57600, 115200
- Default data rate (factory setup): 38400 Bit/s
- Half/full duplex transmission with multidrop line capability. Network compatible up to 32 connected Endurance sensors. In use of the 2-wire half duplex transmission mode, the Electronics box internal sliding switch **has to** be in 'ON' position. For the full duplex (4-wire) transmission mode, set the internal sliding switch to 'OFF' position. To have all possible signal lines plus the 4-wire full duplex transmission mode available, a customized cable with 14-wires is needed.

5.5.8. Using the Digital Input (External Trigger / Postprocessing Hold)

The Endurance Digital Input is a galvanically isolated, digital active low input signal to trigger the following preset actions:

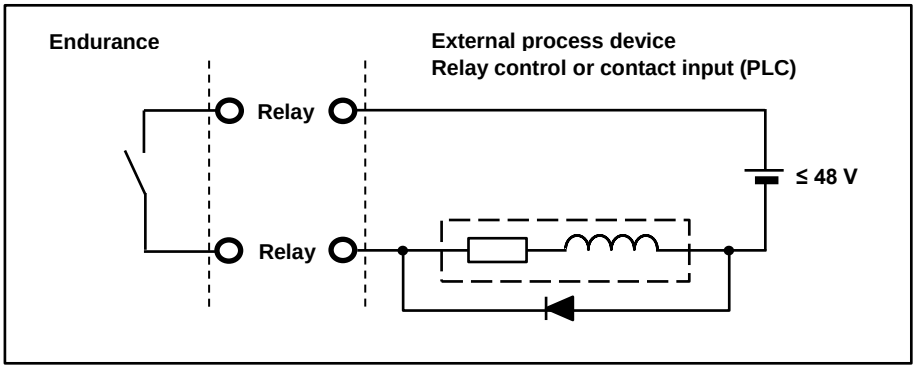
- To restart a running postprocessing function, if the Endurance device is setup for Average Hold, Peak Hold or Valley Hold postprocessing
- To switch a Laser of an optional integrated Laser sighting function ON/OFF



5.5.9. Using the Digital Output (Relay / Alarm Output)

The Endurance Digital Output is a galvanically isolated potential-free solid state relay contact. The max. relay contact load is limited to 48 V, 300 mA. The relay contact behavior is settable via the user interface or a serial command to operate as following:

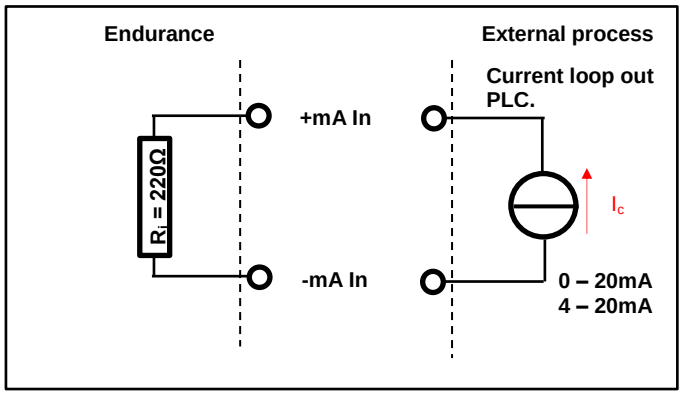
- NO = Normally Open
- NC = Normally Close
- PO = Permanently Open
- PC = Permanently Close



5.5.10. Using the Analog Input (0/4 – 20mA current loop input)

The Endurance Analog Input is a galvanically isolated current loop input signal, to interprete the current (0/4 – 20mA), given by an external device like PLC, Computer or any kind of process control device. The internal loop resistor of the Endurance device is about 220Ω. Via a controlled current from an external device you are able to set/correct:

- Set current from ext. device and read the current via defined serial command “IN”
- Set emissivity (1-Color or 2-Color mode)
- Set slope (2-Color devices only)
- Set background temperature for background compensation



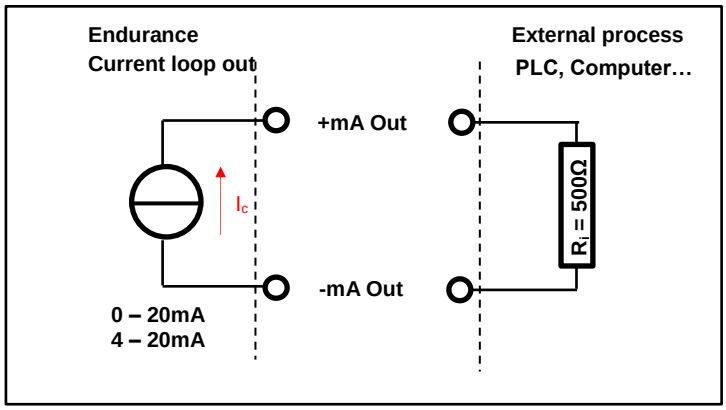
5.5.11. Using the Analog Output (0/4 – 20mA current loop output)

The Endurance Analog Output is a galvanically isolated current loop output signal, to stimulate output currents (0/4 - 20 mA). The output signal is an active output with 16 Bit resolution, to drive a maximum resistive load of 500Ω. Just the object temperature, measured by either 1C or 2C devices, is converted to a 16 bit current equivalent. The user has to define the temperature measurement range and must assign the lower and upper range limits to the current equivalent (0 – 20mA / 4 – 20mA).
The following formula demonstrates the output current (I_c) calculation regarding the given measurement span [upper temperature(T_U) – lower temperature(T_L)].

Given example values:

- Upper meas. Temp. (T_u): 2000°C, Lower meas. Temp.(T_L): 1000°C
- Choosen output current range: 4 – 20mA, I_{CL} = 4mA at T_L → I_{CU} = 20mA at T_U
- Actual meas. Temp.: Tmeas = 1578°C

$$\mathrm{Ic} = \mathrm{Icl} + \frac{\mathrm{Icu} - \mathrm{Icl}}{\mathrm{Tu} - \mathrm{Tl}} * (\mathrm{Tmeas} - \mathrm{Tl}) = 4\mathrm{mA} + \frac{20\mathrm{mA} - 4\mathrm{mA}}{2000°\mathrm{C} - 1000°\mathrm{C}} * (1578°\mathrm{C} - 1000°\mathrm{C}) = 13.25\mathrm{mA}$$



6. Device Control

Once you have your sensor(s) 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, PROFINET or Ethernet/IP communication interface. The Endurance software, a MS-Windows based setup and configuration program is supplied with your sensor. You can also create custom programs using the communication protocols listed in section 10, Programming Guide.

6.1. Control Panel

The Endurance fiber optic infrared pyrometers are equipped with a control panel, which is located inside the sealed electronics housing. It is the user interface for manual operation and consists of an upper target temperature display, a lower information/configuration display, one red alarm LED, one green status LED and several setting/controlling buttons, as shown in Figure 19. The control panel is primarily for setting up the pyrometer prior to nonstop operation. After the setup and configuration for nonstop operation, the screwable sealed housing cover has to be closed to protect the user panel for nonstop operation. You are able to configure sensor settings via the control panel or remotely via a computer or a programmable logic controller.

- **Upper Display (green):** 7-segment, 4 digits LED type to display the measured object temperature or error codes.
- **Lower Display (green/red):** Background illuminated graphics display type. Resolution is 32 * 136 pixels to display 2 text lines of about 16 characters per line. It is the main screen/menu display, which shows all information and configuration topics.
- **LED1 (red):** Indicates the Laser on/off status
- **LED2 (green):** Sensor alarm status, steady green after warm-up phase
- **4 Control buttons:** Up, Down, Browse, Enter to step through the menu and for entering setup values

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 the RS485, the LAN/Ethernet, the PROFINET IO, the Ethernet/IP communication interface or a specific key command over the control panel, the Endurance device can be unlocked.

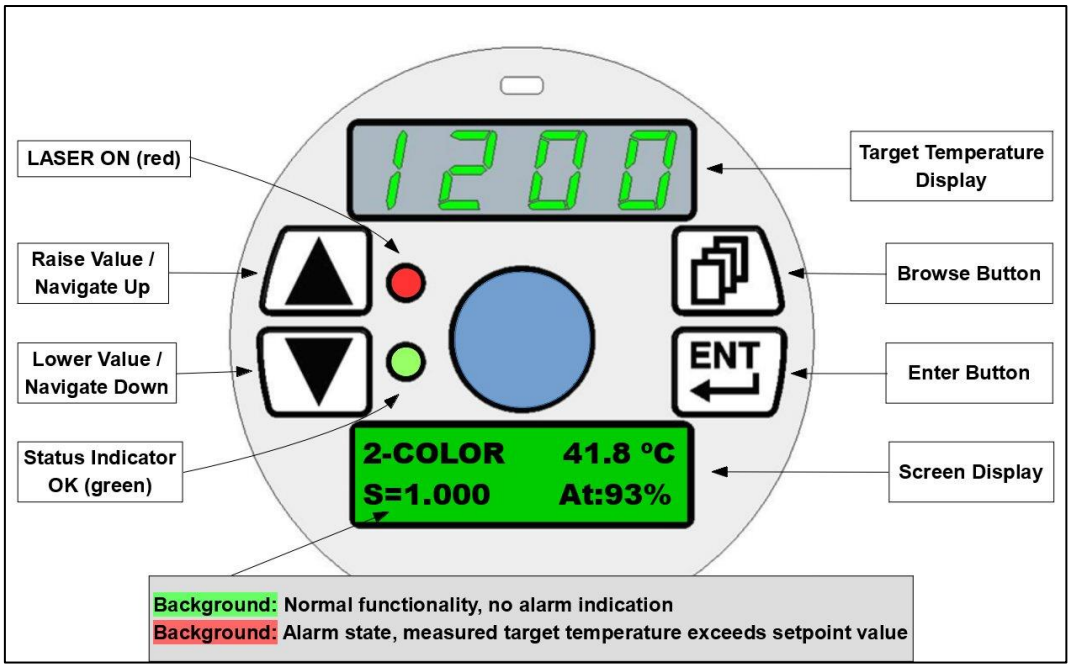


Figure 19: Control Panel

6.1.1. The Object / Target Temperature Display (green 7-segment LED type)

Figure 20: Upper Object/Target Temperature Display

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

- In normal operation after warm up phase, it displays the current measured object 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), done in the “CONFIGURATION MENU” and described hereafter.

- In abnormal operation, during warm up phase or in failure case, discovered through the failsafe-circuit, it displays an error code (e.g. ECHH, ECUU, EUUU, EAAA…). Please see section 11.2, Fail-Safe Operation.

6.1.2. The Screen / Menu Display

Figure 21: Lower Screen / Menu Display

The Screen/Menu Display is the central user interface display, which shows all selected menus, their submenus and parameters. In dependence of the selected main menu item, it displays the first submenu item as default. The menu, sub-menu and entry selection will be done by specific buttons, described herein afterwards.

6.1.3. The LASER Sighting Indicator LED (red)

Figure 22: Upper LASER Sighting Activation LED (red)

Indicates the activation (switched-on) of the integrated **green** color LASER sighting option.

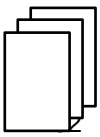
6.1.4. The Status Indicator LED (green)

Figure 23: Lower Status Indicator LED (green)

Is blinking during warm up phase or in case of an error. Shows a steady green after warm up period to indicate an error free function of the Endurance device.

6.1.5. The 4 Control Panel Pushbuttons

6.1.5.1. The Browser Button



The Browser Button serves as a selector for one of the five submenus. A specific submenu selection can be done in the following ways:

- Pressing the Browser Button several times in series to toggle between the 5 submenus

- Holding the Browser Button pressed, toggles between the 5 submenus about every 2 sec

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

6.1.5.2.The ENTER Button

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, displayed in the 2nd row of the Screen/Menu display. To store updated entries a final press of the Enter Button is needed. With the Enter Button you also walk through multiple section entries, like network IP-addresses (4 subfields with a value range of 0-255).

6.1.5.3.The Navigate Up Button

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.

6.1.5.4.The Navigate Down Button

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. The control panel menu structure and their associated entries

There are five (5) submenus available via the control panel:

- INFORMATION MENU (delivers condensed Endurance device information)
- CONFIGURATION MENU (display and alteration of configuration settings)
- UNIT SETUP MENU (display and alteration of device setups)
- INTERFACE MENU (display and alteration of integrated interface setups)
- ANALOG MENU (display and alteration of integrated current loop Analog-I/O)

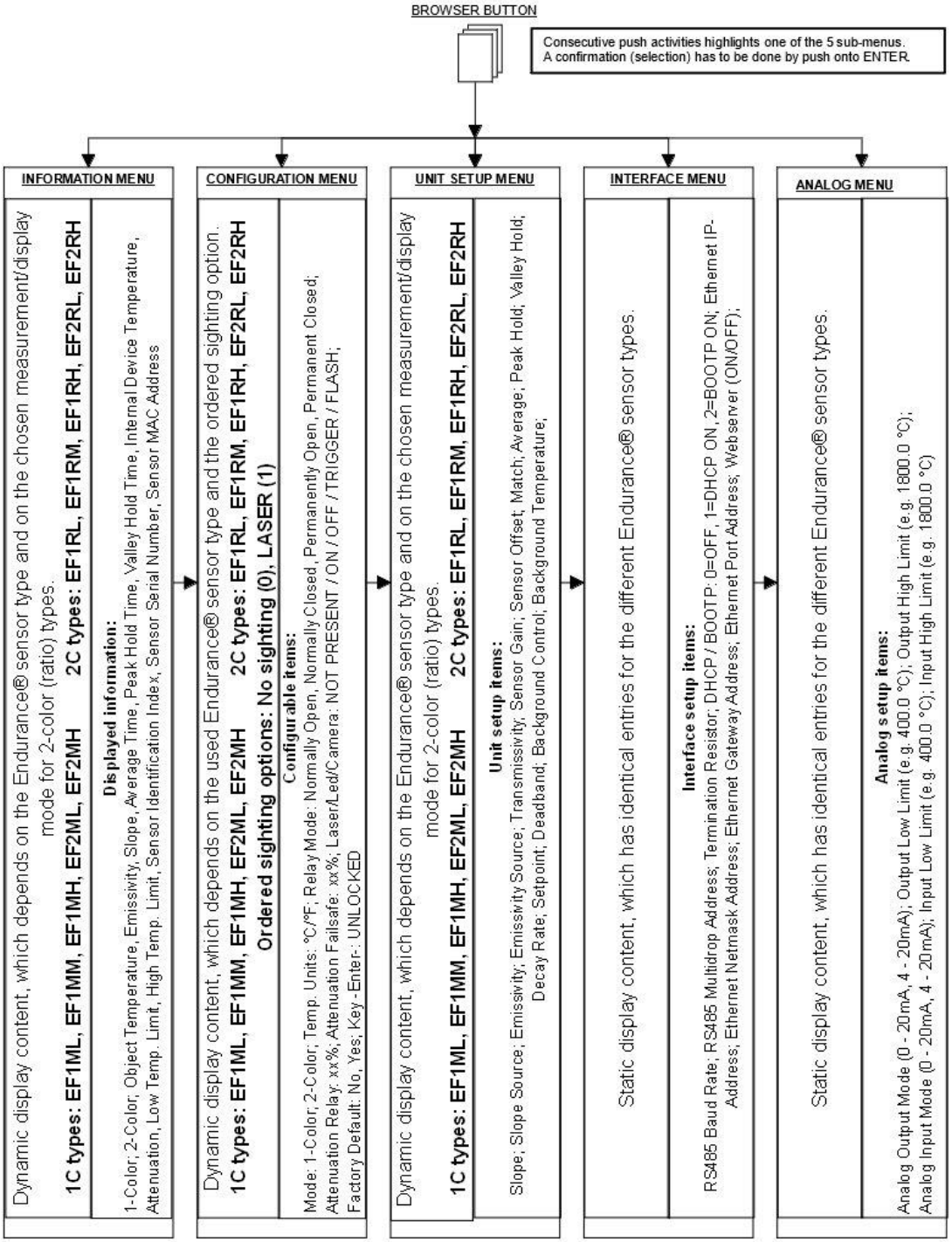


Figure 24: Overview about the menu structure with five (5) sub-menus

6.2.1. The INFORMATION MENU

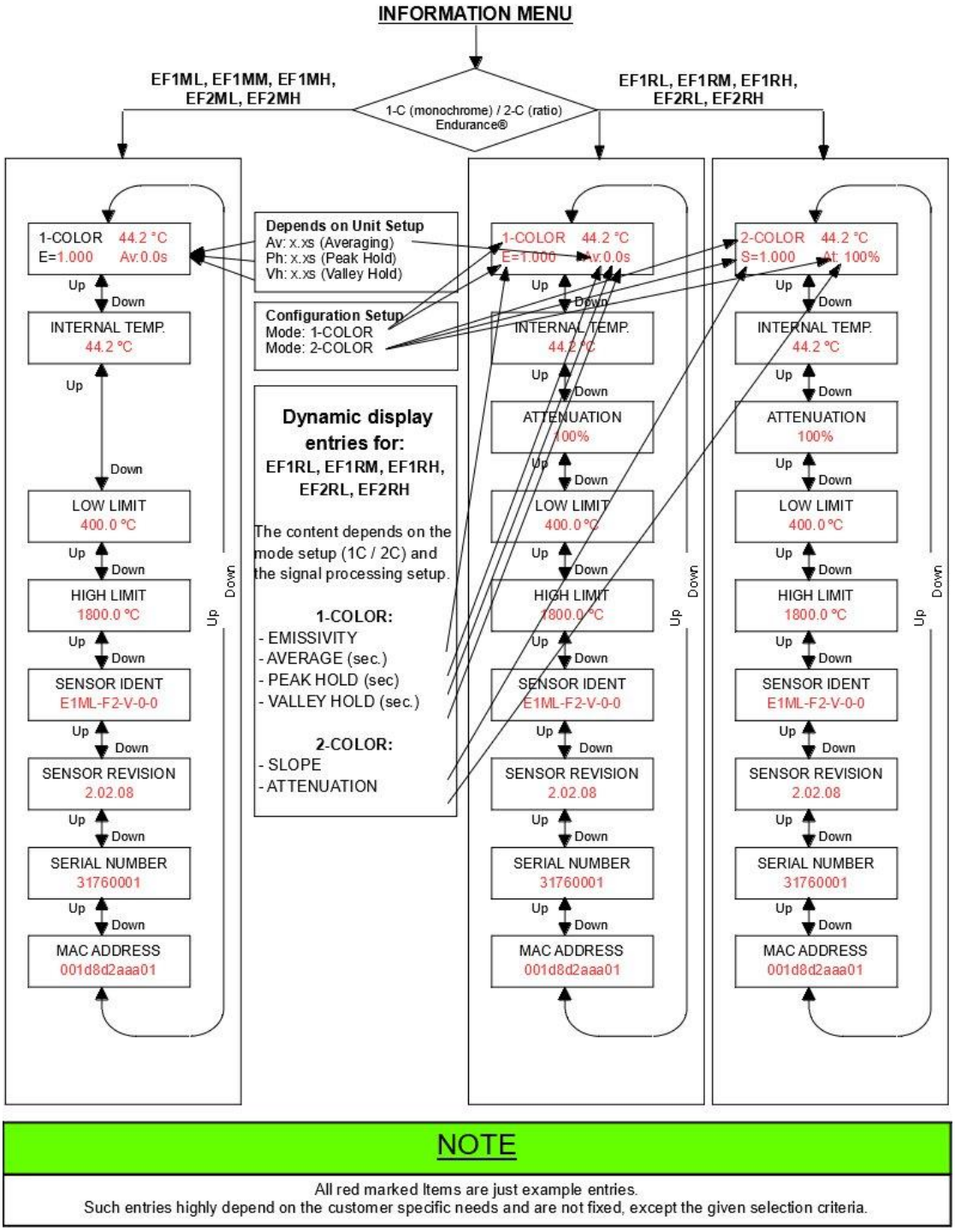


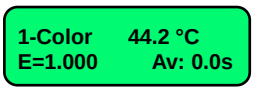
Figure 25: The INFORMATION MENU with sensor type related variations

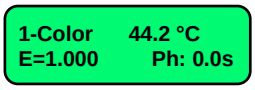
The INFORMATION MENU consists of nine (9) selectable subentries, which are **not** user modifiable and are just for information purpose. Only the top subentry content varies in dependence of the Endurance sensor type or the configured measurement/display mode for EF1RL, EF1RM, EF1RH, EF2RL, EF2RH ratio devices.

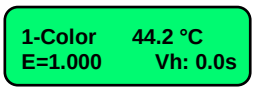
Order of subentry appearance:

1. Subentry: CONDENSED INFO FIELD
   The content for 1-Color Endurance sensor types (EF1ML, EF1MM, EF1MH, EF2ML, EF2MH) or 1C-mode of ratio sensor types (EF1RL, EF1RM, EF1RH, EF2RL, EF2RH) varies regading the signal processing setup.

   The content for EF1ML, EF1MM, EF1MH, EF2ML, EF2MH and EF1RL, EF1RM, EF1RH, EF2RL, EF2RH sensor types in 1C-mode is as follows:

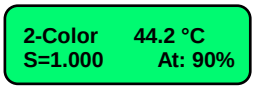
   

   a.) Mode: 1-Color Fix for EF1ML, EF1MM, EF1MH, EF2ML, EF2MH or setup in configuration for EF1RL, EF1RM, EF1RH, EF2RL, EF2RH
   b.) Internal Temperature: Displayed in °C or °F as set in configuration setup menu
   c.) Emissivity: As preset in unit setup menu
   d.) Average, Peak Hold or Valley Hold time: As preset in unit setup menu

   The content for 2-Color Endurance sensor types (EF1RL, EF1RM, EF1RH, EF2RL, EF2RH) in 2C-mode is as follows:

   a.) Mode: 2-Color As set in configuration setup menu for EF1RL, EF1RM, EF1RH, EF2RL, EF2RH
   b.) Internal Temperature: Displayed in °C or °F as set in configuration setup menu
   c.) Slope: As preset in unit setup menu
   d.) Attenuation: Measured attenuation value by the Endurance ratio device

2. Subentry: INTERNAL TEMP.
   Displays the internal device temperature in °C or °F (e.g. 39.8 °C)

3. Subentry: ATTENUATION
   The subentry is just available and visible on 2-Color Endurance sensor types. A percentage value of the measured attenuation will be displayed (e.g. 100%)

4. Subentry: LOW LIMIT
   Displays the low limit temperature of the measurement range in °C/°F (e.g. 400.0 °C)

5. Subentry: HIGH LIMIT
   Displays the high limit temperature of the measurement range in °C/°F (e.g. 1800.0 °C)

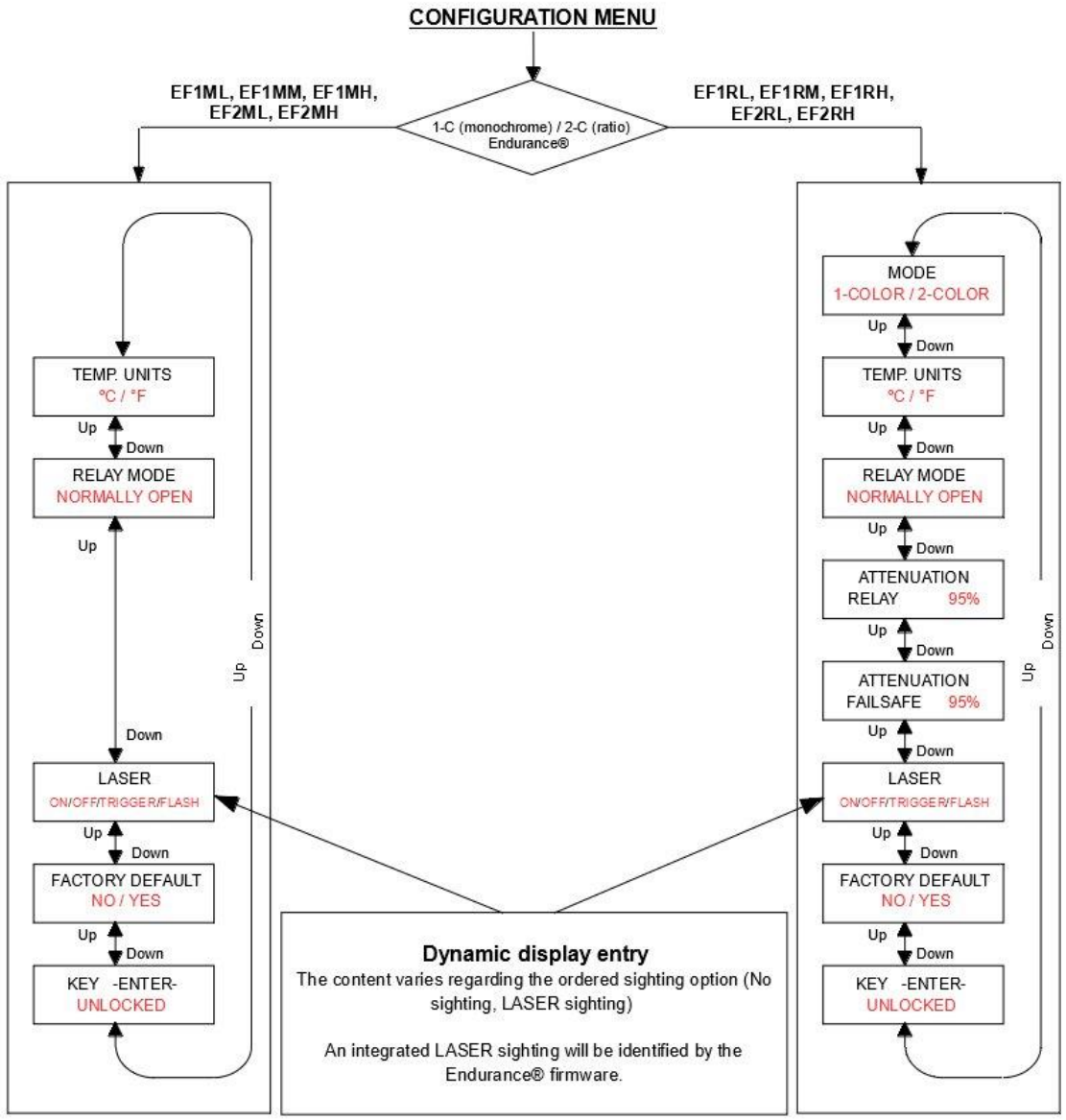
6. Subentry: SENSOR IDENT
   Displays the Endurance sensor identification number, where the sensor model, the focus, the sighting, the cooling and communication options are integrated (e.g. EF1ML-F2-1-0-0-10BL).

7. Subentry: SENSOR REVISION
   Displays the Endurance sensor firmware revision number (e.g. 2.02.08)

8. Subentry: SERIAL NUMBER
   Displays the Endurance sensor serial number (e.g. 31760001)

9. Subentry: MAC ADDRESS
   Displays the unique assigned Endurance sensor MAC address for network communication via Ethernet / Profinet (e.g. 001d8d200001)

6.2.2. The CONFIGURATION MENU



NOTE

All red marked Items are just example entries.
Such entries highly depend on the customer specific needs and are not fixed, except the given selection criteria.

Figure 26: The CONFIGURATION MENU with sensor type related variations

The CONFIGURATION MENU consists of maximum eight selectable subentries, which are user modifiable to configure the Endurance device. Monochrome devices (EF1ML, EF1MM, EF1MH, EF2ML, EF2MH) have a reduced configuration menu with just five (5) selectable subentries. There is no need to configure for monochrome devices a 2-Color mode or to preset attenuation margins. Regarding the ordered sighting option (LASER), the assigned subentry is dynamically updated.

Order of subentry appearance:

1. Subentry: MODE
   The subentry MODE is just available for 2-Color (ratio) Endurance sensor devices, where you can force the device to display the measured temperature values in either one of both modes. With the ▲ ▼ keys, you can toggle between 1–Color and 2–Color.

2. Subentry: TEMP. UNITS
   Shows the configured display temperature unit (°C / °F).
   With the ▲ ▼ keys, you can toggle between the display temperature units °C or °F.

3. Subentry: RELAY MODE
   Shows the configured RELAY MODE of the potential free relay contact.
   With the ▲ ▼ keys, you can toggle between the different relay contact behaviors like:
   NORMALLY OPEN
   PERMANENT CLOSED
   PERMANENTLY OPEN
   NORMALLY CLOSED

4. Subentry: ATTENUATION RELAY
   Shows the configured ATTENUATION RELAY in % of attenuation.
   With the ▲ ▼ keys, you can toggle between 0% to 95% of attenuation.

5. Subentry: ATTENUATION FAILSAFE
   Shows the configured ATTENUATION FAILSAFE in % of attenuation.
   With the ▲ ▼ keys, you can toggle between 0% to 95% of attenuation.

6. Subentry: LASER
   Shows the identified sighting device, regarding the ordered sighting option.
   If the Endurance firmware cannot identify a pointing device, then NO DEVICE FOUND will be displayed. If an identified pointing device (LASER) is present, you can toggle with the ▲ ▼ keys, between ON and OFF to activate or deactivate the pointing device. After an ON confirmation by ENTER-key, the red pointing device LED shows the activation status and the high intensity LASER is working.
   Do not look direct into the LASER, if activated

7. Subentry: FACTORY DEFAULT
   Shows, if the Endurance device shall be configured (preset) by factory default values.
   With the ▲ ▼ keys, you can toggle between NO and YES.

8. Subentry: KEY -ENTER-
   Shows the LOCKED / UNLOCKED status to avoid unintended user control interactions, if the Endurance device is in permanent network or data transmission process. Via a serial or network command, the control user interface can be locked or unlocked.
   With the ▲ ▼ keys, you can toggle between LOCKED and UNLOCKED, to retrieve user access by the control interface.

6.2.3. The UNIT SETUP MENU

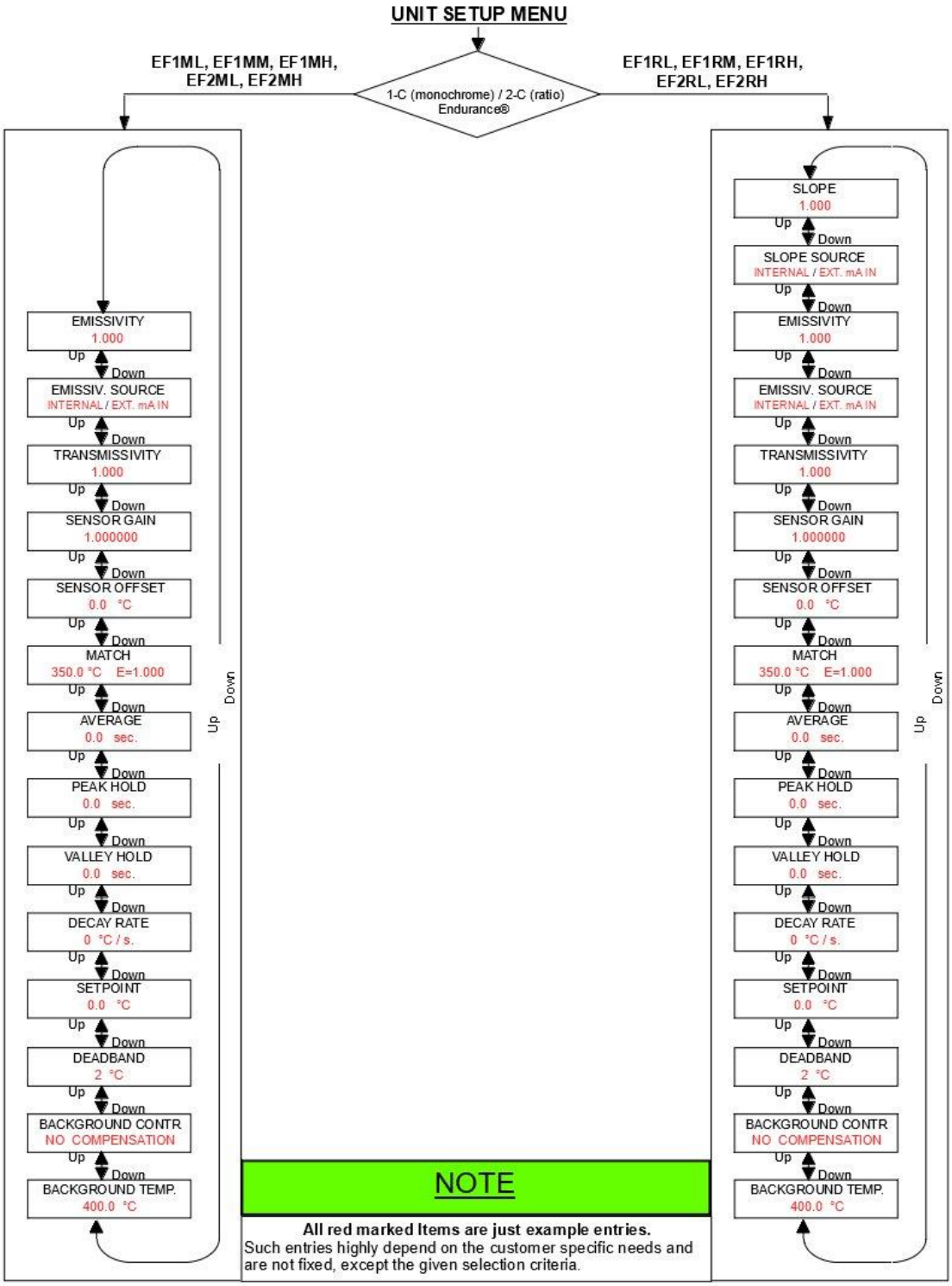


Figure 27: The UNIT SETUP MENU with sensor type related variations

The UNIT SETUP MENU consists of maximum sixteen (16) selectable subentries, which are user modifiable to setup the Endurance device for special measurement treatment. Under the UNIT SETUP MENU, you are able to influence the temperature measurement accuracy, post processing, background compensation or object surface characteristics. Such specific adaptations lead to better measurement results, optimized by the experienced user.

Order of subentry appearance:

1. Subentry: SLOPE
   The subentry SLOPE is just available for 2-Color (ratio) Endurance sensor devices, to correct the temperature reading by adaptation of the slope value.
   With the ▲ ▼ keys, you can toggle between slope values from 0.850 to 1.150

2. Subentry: SLOPE SOURCE
   The SLOPE SOURCE subentry is just available for 2-Color (ratio) Endurance sensor devices, to assign the source for the slope input value. The slope input value may come from the preset value under SLOPE (1. Subentry, INTERNAL) or via an external current loop analog input (EXTERNAL mA IN).
   With the ▲ ▼ keys, you can toggle between INTERNAL and EXTERNAL mA IN

3. Subentry: EMISSIVITY
   The subentry EMISSIVITY is to correct the object temperature reading by adaptation of the emissivity value. Emissivity values can be object temperature dependent.
   With the ▲ ▼ keys, you can toggle between emissivity values from 0.100 to 1.100

4. Subentry: EMISSIVITY SOURCE
   EMISSIVITY SOURCE is to assign the source for the emissivity input value. The emissivity input value may come from the preset value under EMISSIVITY (3. Subentry, INTERNAL) or via an external current loop analog input (EXTERNAL mA IN).

5. Subentry: TRANSMISSIVITY
   The subentry TRANSMISSIVITY is to correct the object temperature reading by adaptation of the transmissivity value.
   With the ▲ ▼ keys, you can toggle between transmissivity values from 0.10 to 1.10

6. Subentry: SENSOR GAIN
   The subentry SENSOR GAIN is to correct the object temperature reading by a gain multiplicator. The standard gain multiplicator value is 1.000000.
   With the ▲ ▼ keys, you can toggle between gain values from 0.800000 to 1.200100

7. Subentry: SENSOR OFFSET
   The subentry SENSOR OFFSET is to correct the object temperature reading by addition of an offset value. The standard offset value is 0.0 °C / °F.
   With the ▲ ▼ keys, you can toggle between offset values from -200.0 °C to +200.0 °C.

8. Subentry: MATCH
   The subentry MATCH adapts the displayed object temperature to the real object temperatures. You can affect the current temperature reading by override it with the real, alternatively measured, object temperature. In 1C-mode, the match confirmation corrects the object emissivity value to match the current temperature reading. The match confirmation in 2C-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”.

9. Subentry: AVERAGE
   The subentry AVERAGE is for the activation of the average function for signal post processing. A signal averaging over a set time span will be performed. With the ▲ ▼ keys, the range for the average time can be set from 0.1 to 300.0 seconds, whereas just 0.1 - 299.9 seconds will be interpreted as averaging duration. A value of 300.0 seconds 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.

10. Subentry: PEAK HOLD
    The subentry PEAK HOLD is for the activation of the peak hold function for signal post processing. A signal peak-hold over a set time span will be performed. 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. With the ▲ ▼ keys, the range for the peak hold time can be set from 0.1 to 300.0 seconds, whereas just 0.1 - 299.9 seconds will be interpreted as peak hold duration. A value of 300.0 seconds 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.

11. Subentry: VALLEY HOLD
    The subentry VALLEY HOLD is for the activation of the valley hold function for signal post processing. A signal valley-hold over a set time span will be performed. 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. With the ▲ ▼ keys, the range for the valley hold time can be set from 0.1 to 300.0 seconds, whereas just 0.1 - 299.9 seconds will be interpreted as valley hold duration. A value of 300.0 seconds indicates that valley 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 valley hold function and restarts the valley holding with the current temperature reading.

12. Subentry: DECAY RATE
    The decay rate is the linear signal decay for a given time span. The unit for decay is in K/sec, °C/sec or °F/sec. Via the control panel, just the linear signal slope (decay) is settable.
    With the ▲ ▼ keys, you can toggle between decay values from 0 °C/s to 9999 °C/s.

13. Subentry: SETPOINT
    The SETPOINT function is a temperature supervising alarm mechanism, which can be activated. A setpoint entry defines a maximum supervising value for the target temperature. If the setpoint value is exceeded, an alarm state will be signaled by a relays contact. A zero (0.0 °C) entry as a 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. Once the Setpoint is activated 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).

14. Subentry: 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/F.
    With the ▲ ▼ keys, you can toggle between deadband values from 1 °C/F to 99 °C/F.

15. Subentry: BACKGROUND CONTR
    The BACHGROUND CONTR subentry is a selector, which refers to a temperature compensation source for the object background, to correct influenced objects temperature readings.
    With the ▲ ▼ keys, you can toggle the selector between “NO COMPENSATION”, “EXTERNAL mA IN” and “TEMP. VALUE”, whereas “TEMP. VALUE” refers to the preset background temperature under subentry: BACKGROUND TEMP.

16. Subentry: BACKGROUND TEMP.
    BACKGROUND TEMP. is to correct the object temperature reading by background temperature compensation. With the ▲ ▼ keys, you can toggle between background temperature values from “LOW LIMIT” to “HIGH LIMIT” (e.g. 400.0 °C to 1800.0 °C).

6.2.4. The INTERFACE MENU

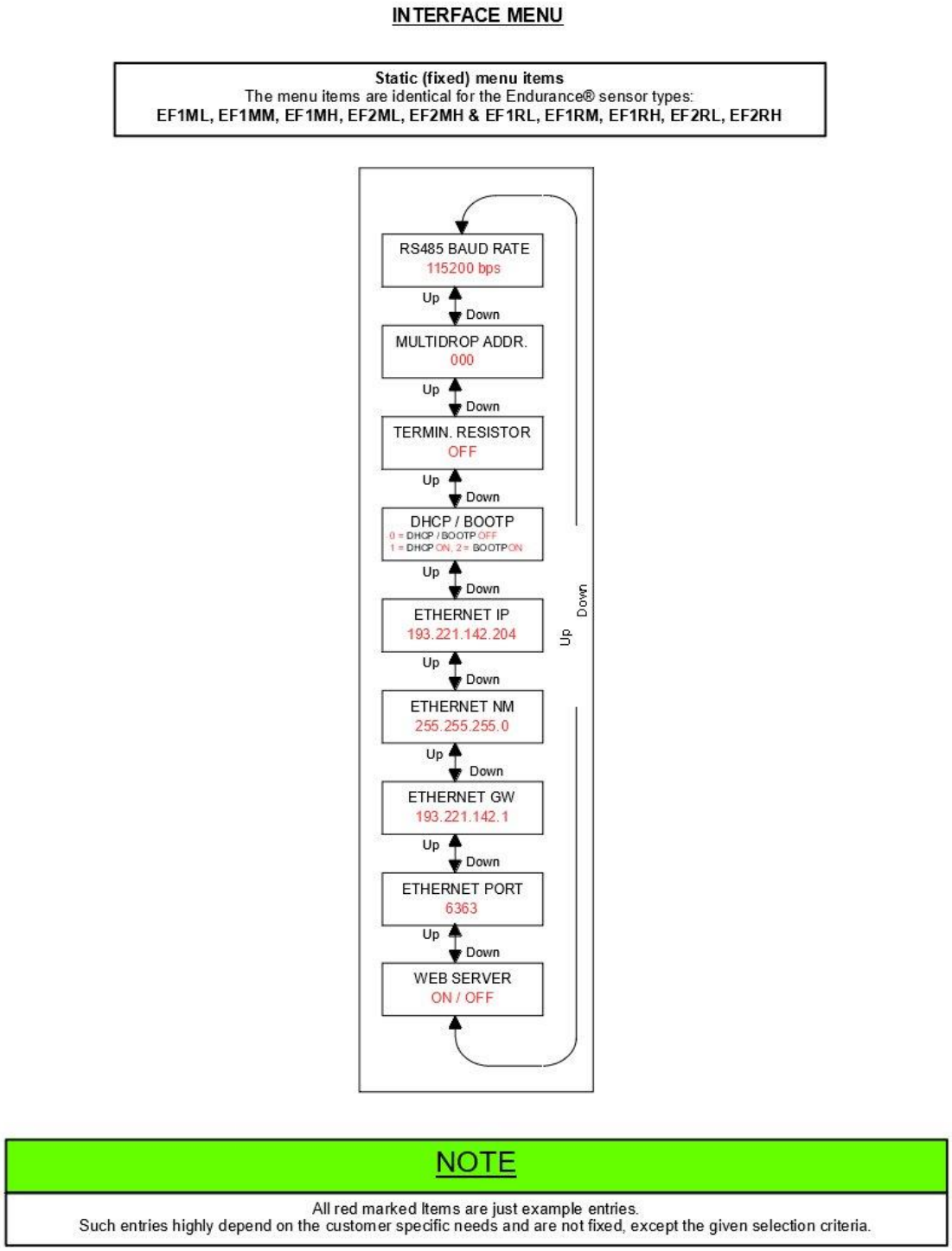


Figure 28: The static (fixed) INTERFACE MENU

The INTERFACE MENU is identical for all Endurance series types. It consists of nine (9) selectable subentries, which are user modifiable to setup all the integrated Endurance communication interfaces.

Order of subentry appearance:

1. Subentry: RS485 BAUD RATE
   The subentry RS485 BAUD RATE is to set the RS485 communication baud rate, whereat the default baud rate is set to 38400 bps
   With the ▲ ▼ keys, you can toggle between the following communications baud rates:
   1200 bps, 2400 bps, 9600 bps, 19200 bps, 38400 bps, 57600 bps, 115200 bps

2. Subentry: MULTIDROP ADDR.
   The subentry MULTIDROP ADDR. is to assign a specific serial multidrop address to an Endurance device, which is working in a 2-wire (half duplex) multidrop environment, where several devices interact with each other.
   With the ▲ ▼ keys, you can toggle between sub-addresses from 000 to 032

3. Subentry: TERMIN. RESISTOR
   The subentry TERMIN. RESISTOR is to reduce signal reflections over long distance connections by inserting a termination resistor of 120Ω.
   With the ▲ ▼ keys, you can toggle between ON and OFF (120Ω insertion)

4. Subentry: DHCP / BOOTP
   The subentry DHCP / BOOTP is to indicate to a network DHCP or BOOTP server, to obtain a dynamic Ethernet address. The DHCP or BOOTP server assigns the Endurance device a dynamic address out of an address pool.
   With the ▲ ▼ keys, you can toggle for dynamic address assign service between
   0 = DHCP/BOOTP OFF
   1 = DHCP ON
   2 = BOOTP ON

5. Subentry: ETHERNET IP
   The subentry ETHERNET IP is to set a fix unique network device address for the Endurance device, if DHCP in inactive. The assigned address has to fit in the network address pool of your subnet.
   The ENTER button selects in a consecutive way the IP address byte aaa.bbb.ccc.ddd
   With the ▲ ▼ keys, you can toggle the individual address byte between 0 and 255

6. Subentry: ETHERNET NM
   The subentry ETHERNET NM is to set a fix unique network mask address to integrate the Endurance device in an existing subnet domain. The assigned address has to fit in the network address pool of your subnet.
   The ENTER button selects in a consecutive way the NM address byte aaa.bbb.ccc.ddd
   With the ▲ ▼ keys, you can toggle the individual address byte between 0 and 255

7. Subentry: ETHERNET GW
   The subentry ETHERNET GW is to set a fix unique network gateway address to integrate the Endurance device in an existing subnet domain. The assigned address has to fit in the network address pool of your subnet.
   The ENTER button selects in a consecutive way the GW address byte aaa.bbb.ccc.ddd
   With the ▲ ▼ keys, you can toggle the individual address byte between 0 and 255

8. Subentry: ETHERNET PORT
   The subentry ETHERNET PORT is to set a fix port address for the relevant network services of the Endurance device in an existing subnet domain. The assigned port address is used for any special network request by the Endurance device.
   With the ▲ ▼ keys, you can toggle the TCP/UDP port address from 0 to 65535

9. Subentry: WEB SERVER
   The subentry WEB SERVER is to activate the Endurance device internal web server functionality for web based applications.
   With the ▲ ▼ keys, you can toggle the WEB SERVER selector between OFF and ON

6.2.5. The ANALOG MENU

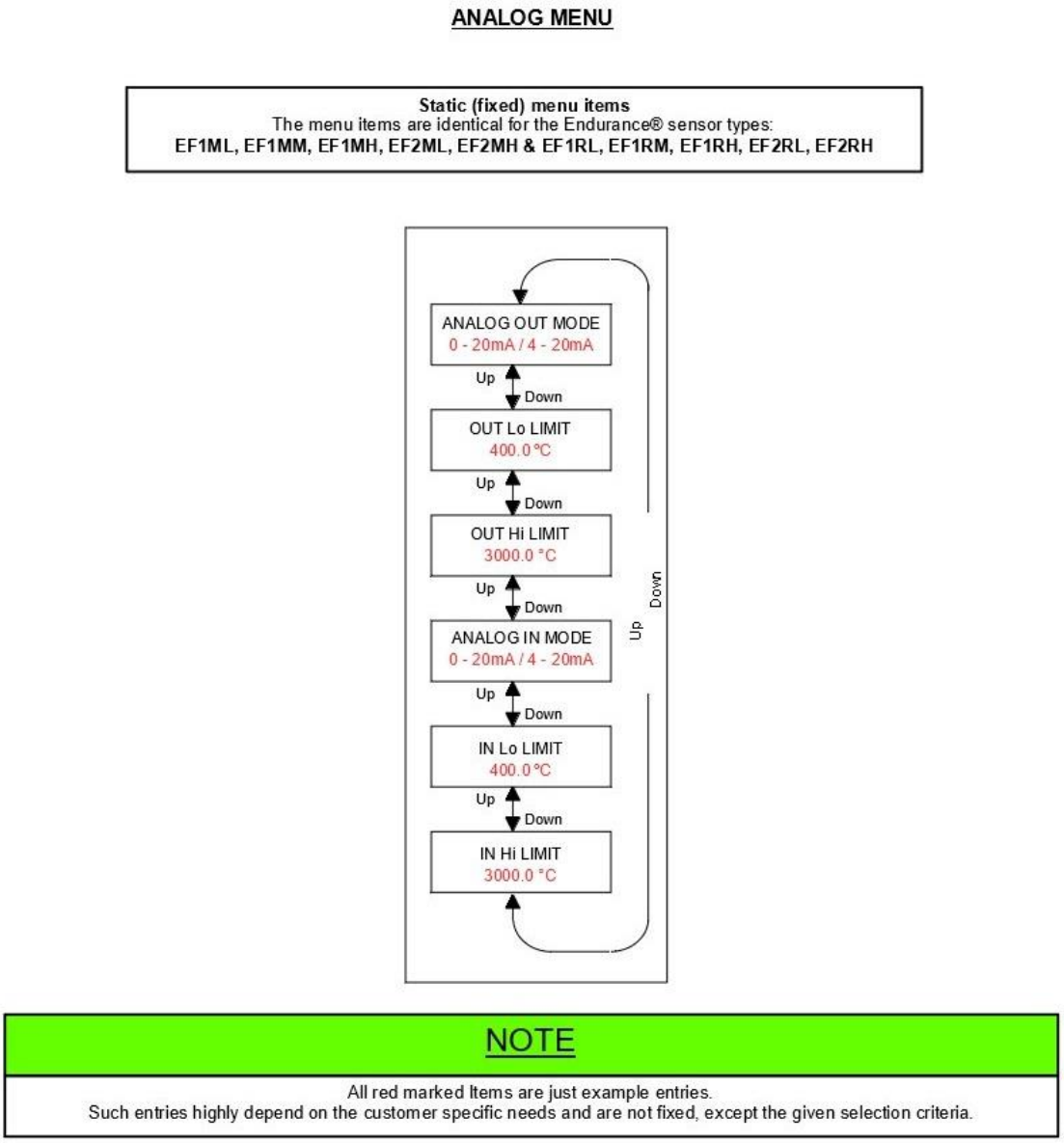


Figure 29: The static (fixed) ANALOG MENU

The ANALOG MENU displays and accepts settings of the integrated analog interfaces.
Two current loop analog interfaces are integrated in the Endurance devices:

Analog Output: 0 – 20mA, 4 – 20mA
Analog Input: 0 – 20mA, 4 – 20mA

Order of subentry appearance:

1. ANALOG OUT MODE (▲ ▼ toggles between 0 – 20mA, 4 – 20mA)
2. OUT Lo LIMIT (▲ ▼ toggles between 0.0 °C to 9999.0 °C)
3. OUT Hi LIMIT (▲ ▼ toggles between 0.0 °C to 9999.0 °C)
4. ANALOG IN MODE (▲ ▼ toggles between 0 – 20mA, 4 – 20mA)
5. IN Lo LIMIT (▲ ▼ toggles between 0.0 °C to 9999.0 °C)
6. IN Hi LIMIT (▲ ▼ toggles between 0.0 °C to 9999.0 °C)

7. Signal Processing

The activation and modification of signal processing functions and their associated parameters is possible via the PC based Endurance software, Ethernet or RS485 programming commands, or over the Endurance control panel (inside electronics enclosure).

7.1. Averaging

Averaging is to smooth the output signal. The output signal smooth algorithm depends on the defined time basis. The output signal tracks the detector signal with significant time delay in which noise and short peaks will be smoothend. A longer average time smoothens the 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 seconds, whereas just 0.1 - 299.9 seconds will be interpreted as averaging duration. A value of 300.0 seconds 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.

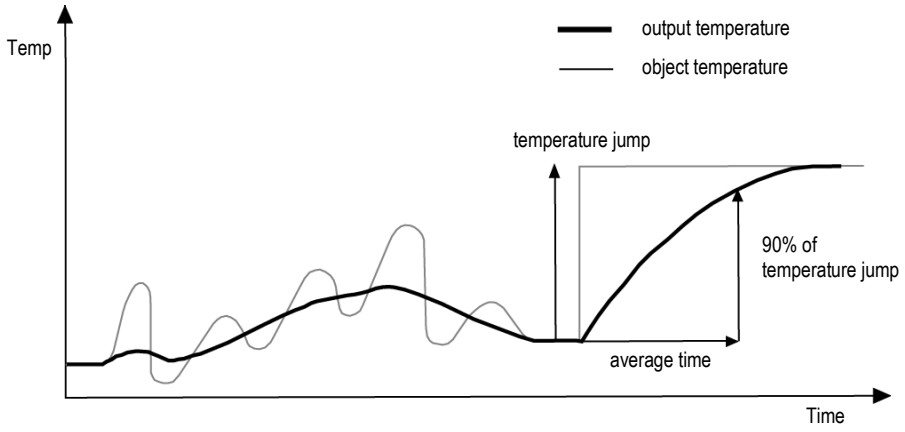


Figure 30: Averaging

Attention: 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.

Once Averaging is set above 0, it automatically activates. Note that other hold functions (like Peak Hold or Valley Hold) do not work concurrently.

7.2. 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 seconds, whereas just 0.1 - 299.9 seconds will be interpreted as peak hold duration. A value of 300.0 seconds 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.

7.2.1. Reset Peak Hold by Peak Hold Time expiration

Once the Peak Hold Time is set between 0.1 until 299.9 seconds, 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.

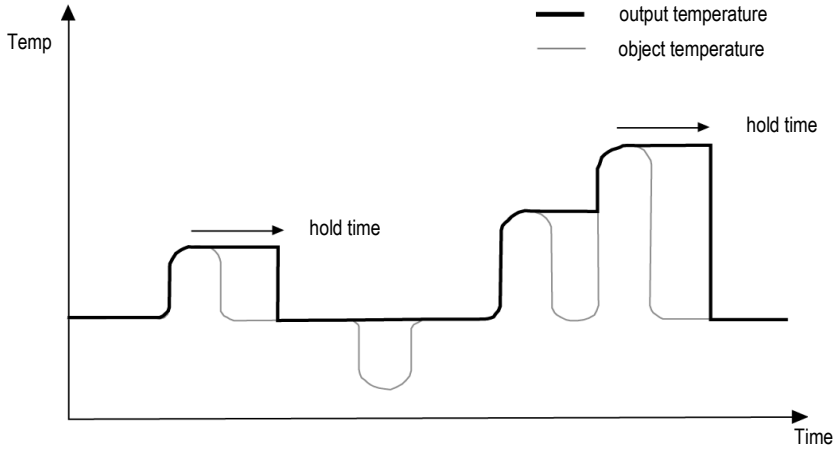


Figure 31: Peak Hold reset by Peak Hold Time expiration

7.2.2. Reset Peak Hold by external Trigger signal

Once the Peak Hold Time is set to 300 seconds, 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 as long as 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.

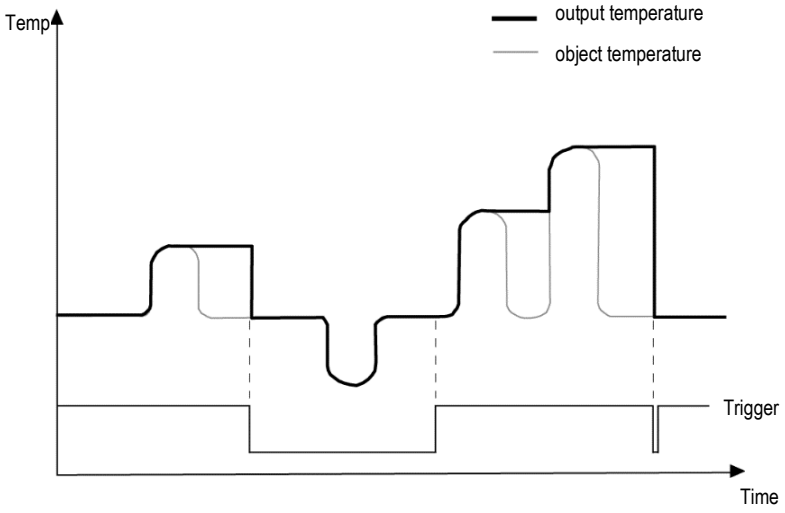


Figure 32: Peak Hold reset by external Trigger signal

Note that other signal processing functions (like Averaging or Valley Hold) do not work concurrently with Peak Hold.

7.2.3. Signal Slope (decay) in case of Peak Hold Reset

Three different signal drop (decay) functionalities are implemented and may be activated by the PC based Endurance software, Ethernet or RS485 programming commands, or over the Endurance control panel (inside electronics enclosure). Via the control panel is just an entry field given to set the linear signal slope (decay).

7.2.3.1.Perpendicular signal drop (default mode)

The default mode (perpendicular signal drop) is activated, if both relevant signal decay values (linear decay & averaging decay) are set to zero (0.0 Kelvin/second). This can be achieved via the PC based Endurance software, Ethernet or RS485 programming commands, or over the Endurance control panel (inside electronics enclosure).

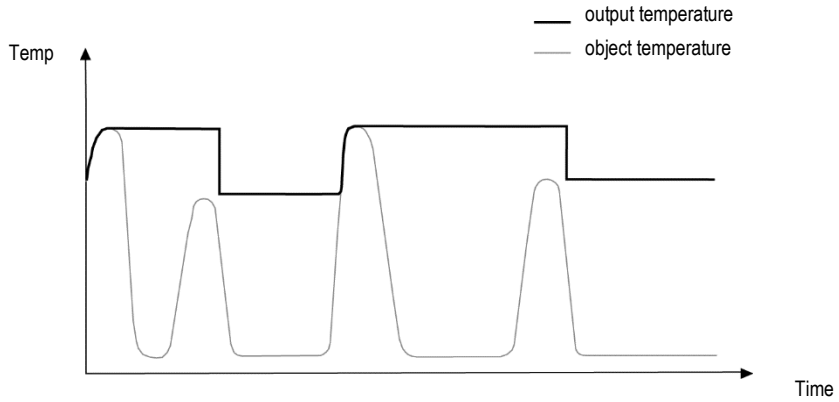


Figure 33: Perpendicular Signal Drop (default mode)

7.2.3.2.Linear signal drop (decay mode)

The signal drop follows a linear decay function, where the decay value is given in Kelvin/second. The linear decay value is settable via the PC based Endurance software, an Ethernet/LAN or RS485 programming command <XE>, or over the Endurance control panel (inside electronics enclosure).

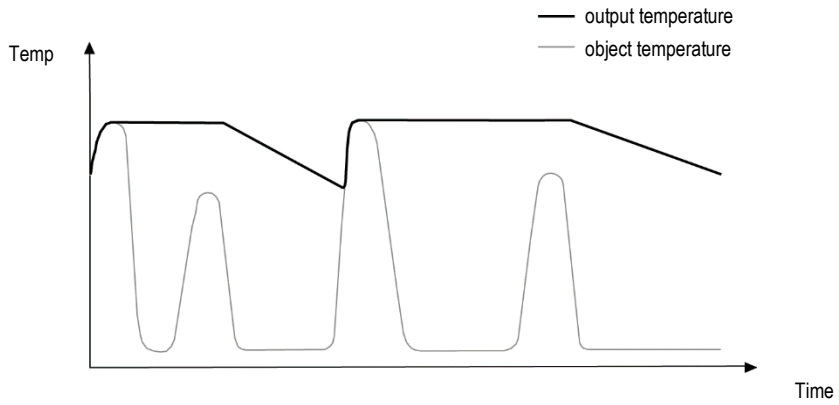


Figure 34: Linear Signal Drop (decay mode)

7.2.3.3.Average time dependent signal drop (averaging mode)

The signal drop follows an averaging time function. The average time is the amount of time the output signal needs to reach 90% magnitude compared to a perpendicular drop. This parameter is set by means of the programming command <AA>.

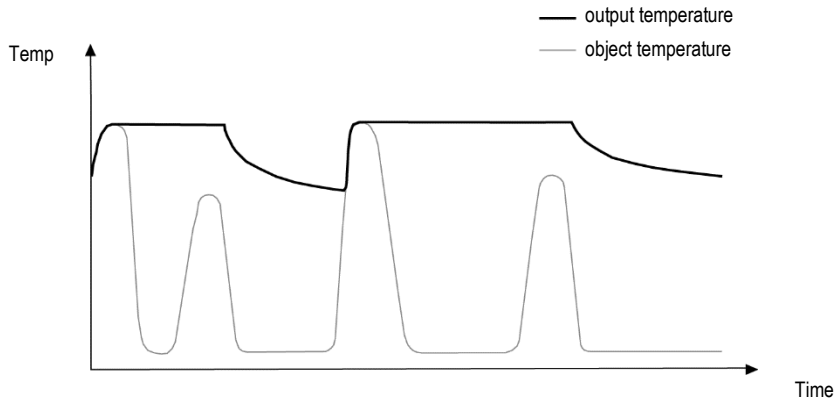


Figure 35: Average Time Dependent Signal Drop (averaging mode)

7.3. Advanced Peak Hold

This function searches the sensor signal for a local peak and writes this value to the output until a new local peak is found. Before the algorithm restarts searching for a local peak, the object temperature has to drop below a predefined threshold. If the object temperature raises above the held value which has been written to the output so far, the output signal follows the object temperature again. If the algorithm detects a local peak while the object temperature is currently below the predefined threshold the output signal jumps to the new maximum temperature of this local peak. Once the actual temperature has passed a peak above a certain magnitude, a new local peak is found. This magnitude is called hysteresis.
The threshold is set by means of the programming command <C>, for hysteresis use the command <XY>.

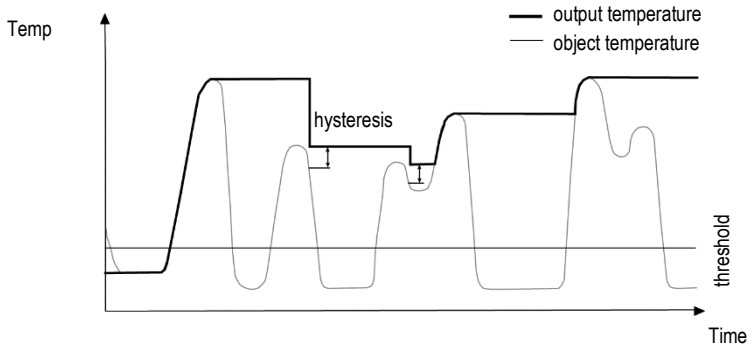


Figure 36: Advanced Peak Hold

7.4. Valley Hold

This function works similar to 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 seconds, whereas just 0.1 - 299.9 seconds will be interpreted as valley hold duration. A value of 300.0 seconds 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.

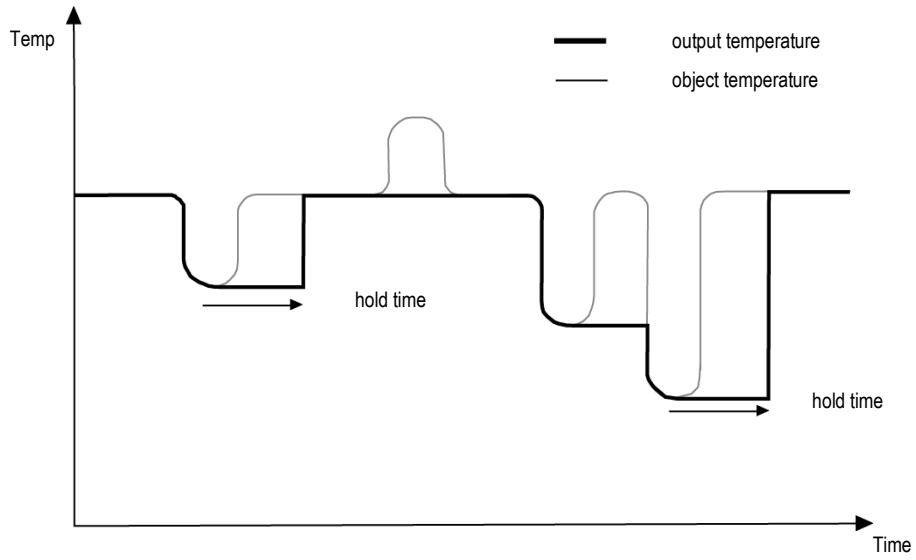


Figure 37: Valley Hold

Once Valley Hold is set above 0, it automatically activates. 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.

Note that other signal processing functions (like Averaging or Peak Hold) do not work concurrently with Valley Hold.

7.5. Advanced Valley Hold

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

7.6. Setpoint

The Setpoint function is a temperature supervising alarm mechanism, which can be activated. A Setpoint entry defines a maximum supervising value for the target temperature. If the Setpoint value is exceeded, an alarm state will be signaled by a relays contact. A zero (0.0) entry as a 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. Once the Setpoint is activated the relay changes state as the current temperature passes the setpoint temperature.

7.7. Deadband

Deadband is a zone of flexibility around the Setpoint. The alarm does not go abnormal until the temperature exceeds the Setpoint value by the number of set deadband degrees. Thereafter, it does not go normal until the temperature is below the Setpoint by the number of set deadband degrees. The Deadband is factory preset to ± 2° (C or F). Adjusting the Deadband entry is accomplished through software or manual input via the control panel. For information regarding the Endurance sensor communication protocols, see section 10, Programming Guide.
The following figure is an example of the Deadband around a Setpoint temperature of 960°C (1760°F).

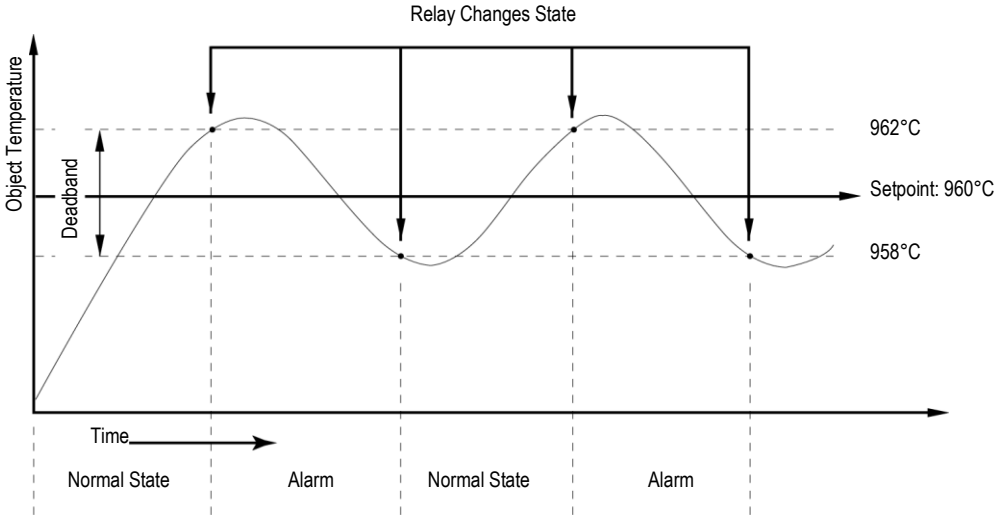


Figure 38: Deadband Example

7.8. Outputs

7.8.1. Analog Output (current loop)

Is a current loop output circuit to drive analog output lines. It can be set to 0-20mA or 4-20mA output 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 500Ω. A 16-Bit DAC (Digital Analog Converter) guarantees a current loop resolution better than 0.1 per temperature unit (°C / °F) over the total measurement range. A specific feature for the testing or calibrating of connected equipment allows the current loop output to bet set to specific values, under range or over range in RS485 or LAN/Ethernet operation mode. Via such functionality you can force the circuit, operating in the 4-20mA mode, to transmit an output current less than 4mA (e.g. 2.0 or 3.0mA) or above 20mA (e.g. 21.0 or 22.0mA).

7.8.2. Relay Outputs

The relay output is used as an alarm for failsafe conditions or as a setpoint relay. Please refer to section 11.2, Fail-Safe Operation. Relay output relate to the current target temperature, displayed on the green 7-segment LED display. The relay output can be used to indicate an alarm state or to control external actions. The relay functionality can either be set by the control panel (user interface), an RS485 or LAN/Ethernet command in dependence of the connected equipment to the following states:

- NO (NORMALLY OPEN)
- NC (NORMALLY CLOSE)
- PO (PERMANENTLY OPEN)
- PC (PERMANENTLY CLOSE)

The relay states PO / PC can be used to detect wiring problems between the Endurance sensor and the process environment, where the relay contact signal acts as a trigger.

7.8.3. Trigger

AVERAGE, PEAK HOLD or VALLEY HOLD can be reset by shorting the Trigger input signal to Ground for a minimum of 10 msec. This can be done either with a momentary switch or a relay. The Reset signal causes a new reading of the current measured temperature and restarts the selected signal post processing function.

7.9. Factory Defaults

To globally reset the unit to its factory default settings, go to the “factory default” menu item under the configuration screen menu display. The baud rate and communications mode (single device or multiple devices / multidrop) will not be affected.

Table 4: Factory Defaults

Parameter	EF1ML, EF1MM, EF1MH, EF2ML, EF2MH	EF1RL, EF1RM, EF1RH, EF2RL, EF2RH
Mode (1C / 2C)	1C	2C
Temperature Unit (°C / °F)	°C	°C
Slope	n/a	1.000
Emissivity	1.000	1.000
Transmissivity	1.00	1.00
Average	0.0	0.0
Peak Hold	0.0	0.0
Valley Hold	0.0	0.0
SETPOINT in (°C / °F)	0.0	0.0
DEADBAND in (°C / °F)	2	2
RS485 Communication Mode	2-wire , 38.400 Baud *	2-wire, 38.400 Baud *
MULTIDROP ADDRESS	000 (single sensor)	000 (single sensor)
TERMINAL RESISTOR	OFF	OFF
DHCP / BOOTP	OFF	OFF
ETHERNET IP-ADDRESS	192.168.42.132	192.168.42.132
ETHERNET NETMASK	255.255.255.0	255.255.255.0
ETHERNET GATEWAY ADDR.	192.168.42.1	192.168.42.1
ETHERNET PORTNUMBER	6363	6363
WEB SERVER	OFF	OFF
ANALOG OUTPUT MODE	4 – 20mA	4 – 20mA
OUT Lo LIMIT for 4 mA	Low limit sensor temp. (e.g. 400.0°C)	Low limit sensor temp. (e.g. 400.0°C)
OUT Hi LIMIT for 20 mA	High limit sensor temp. (e.g.1800.0°C)	High limit sensor temp. (e.g.1800.0°C)
ANALOG INPUT MODE	4 – 20mA	4 – 20mA
IN Lo LIMIT for 4 mA	Low limit sensor temp. (e.g. 400.0°C)	Low limit sensor temp. (e.g. 400.0°C)
IN Hi LIMIT for 20 mA	High limit sensor temp. (e.g.1800.0°C)	High limit sensor temp. (e.g.1800.0°C)
Serial Output Transmission Mode	Burst mode, Default string = UTSI	Burst mode, Default string = UTSI
Relay Output Control	Controlled by unit, NO function, indicates failsafe alarms	Controlled by unit, NO function, indicates failsafe alarms
Set Output Current	Controlled by unit, 4-20 mA	Controlled by unit, 4-20 mA
Lockout Control Panel Access	Unlocked	Unlocked

* RS485 Modes, like Baud Rate or 2-wire half duplex are unchanged, when the factory defaults are restored

8. Device Options

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

- Fiber optic cable lengths:
  1, 3, 6, 10 m (3, 10, 20, 33 ft), 22 m (72 ft) for selected models
- ISO Calibration Certificate, based on NIST/DAkkS certified probes (E-CERT)
- High Temperature Fiber Cable (HT), rated to 315°C (600°F)
- Laser Sighting (L) for selected models
- Communication option (0 = Standard, 1 = PROFINET, 2 = Ethernet/IP)

The High Temperature Fiber Cable excludes PTFE coating and IP65 (NEMA-4) rating!

8.1. Focus (3 focus options available)

In dependence of the scheduled operation and environment, the customer has to select the right focus distance prior to place the order.

- F0 focused at 100mm (4")
- F1 focused at 300mm (12")
- F2 focused at infinity ∞

8.2. Laser Sighting (Sighting Option 1)

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 green spot indicating the center of the area being measured.

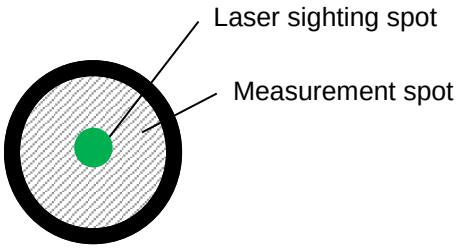
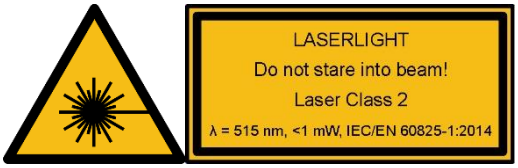


Figure 39: LASER Sighting Indication

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

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!
Mirror and dispersion effects can injure Eyes.



The laser is a Class II, AlGaInP type laser with an output power less than 1 mW, and an output wavelength of 515 nm. The laser complies with FDA Radiation Performance Standards, 21CFR, subchapter J, and meets IEC 825, Class 2 specifications

8.3. PROFINET IO (Communication Option 1)

The PROFINET IO interface (Communication Option 1) is an addendum to the already incorporated LAN/Ethernet communication (Standard Communication Option 0). Endurance PROFINET IO takes place over the existing LAN/Ethernet communication hardware, see chapter 3.2, Electrical Specifications on page 8. An extra implemented software stack guarantees the PROFINET IO communication functionality. That extra SW stack operates fully independant of the standard LAN/Ethernet protocol stack and allows a common use of both protocols over the same hardware.

8.3.1. Description

The Endurance PROFINET IO module 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 Endurance PROFINET determines the physical structure of the node and creates a local process image with pyrometer.
The diagnostics concept based on channel specific diagnostic messages, which are mapped to the respective alarms. Coding standard is according to IEC 61158 PROFINET IO.

The Endurance PROFINET IO module characteristics are:

- Conformance class: A
- Real-Time class: 1 (RT) and the Real-Time class UDP
- Connection: 1 x M12
- Transfer speed of up to 100Mbit/s full-duplex, also with autonegotiation
- I/O update cycle time from 1 ms.
- Configurable substitute value behavior in the event of error/failure

8.3.2. I/O Device Configuration

The Endurance PROFINET 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. The configuration and parameter setting of the Endurance PROFINET based upon the device's GSD (Generic Station Description) file.

8.3.2.1. GSD File

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.

The Endurance PROFINET device GSD file is:
GSDML-V2.25-FlukeProcessInstruments-Endurance-20160616.xml

8.3.2.2. Configuration

The Endurance PROFINET IO device configuration is in accordance with the physical arrangement of the node (slot oriented).

Module slot 0 contains the Endurance 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.

8.3.3. Parameter Setting

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.

8.3.3.1. Pyrometer parameters

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.

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

8.3.3.2.Profinet alarm behavior

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

8.3.4. Structure of the input/output data

8.3.4.1.Pyrometer module input data

The input data length is 23 Byte.

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

8.3.4.2.Pyrometer module output data

The output data length of Input/Output module is 5 Byte. 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.

To do so the following structure is defined:

Address without offset	Length	Format	Value
0	1 Byte	BYTE	Type of parameter
1	4 Byte	REAL/ WORD (Big Endian, Motorola)	Parameter

The <Type of parameter> gives the meaning of the following parameters (with the same format as described in the section 8.3.3.1 for Pyrometer parameters)

Parameter type	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).

8.3.5. 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 modules 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 Endurance 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.

8.3.5.1.The error bits of the pyrometer status register (Error code)

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

8.4. Ethernet/IP (Communication Option 2)

The Ethernet/IP interface (Communication Option 2) is an addendum to the already incorporated LAN/Ethernet communication (Standard Communication Option 0). Endurance Ethernet/IP takes place over the existing LAN/Ethernet communication hardware, see chapter 3.2, Electrical Specifications on page 8. An extra implemented software stack guarantees the Ethernet/IP communication functionality. That extra SW stack operates fully independent of the standard LAN/Ethernet protocol stack and allows for a common use of both protocols over the same hardware.

8.4.1. Description

Endurance Ethernet/IP module basic characteristics:

- Device class: adapter device
- Device type: 06h (Photoelectric sensor)
- Connection: 1 x M12
- Transfer speed up to 100Mbit/s full-duplex, auto-negotiation capable

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 Endurance Ethernet/IP sends the device's configuration data which is accessible for setup via the PLC programming software Controller Tags. Furthermore, Endurance 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.

8.4.2. 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 (Endurance). 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.

8.4.2.1.EDS File

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 end-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.eds

8.4.2.2.Configuration

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, see the following figures. Other settings are optional.

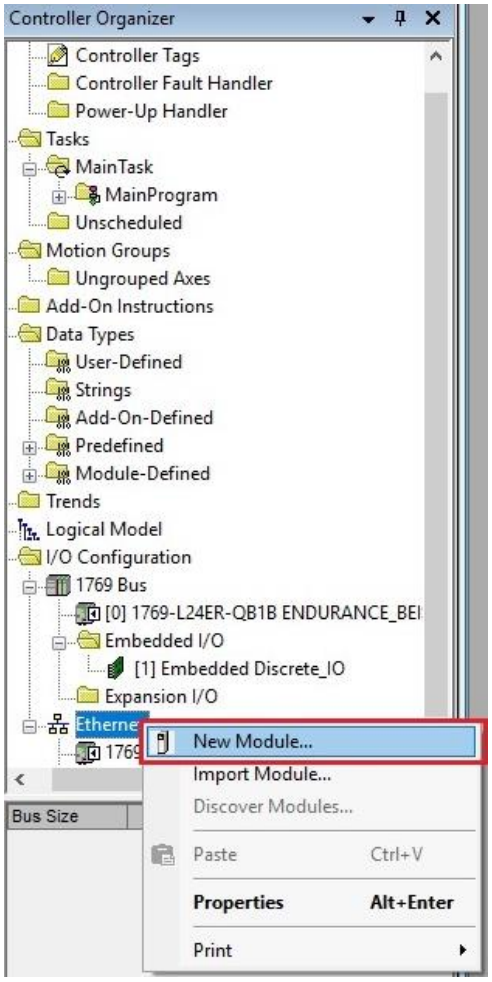


Figure 40: Adding modules using Controller Organizer

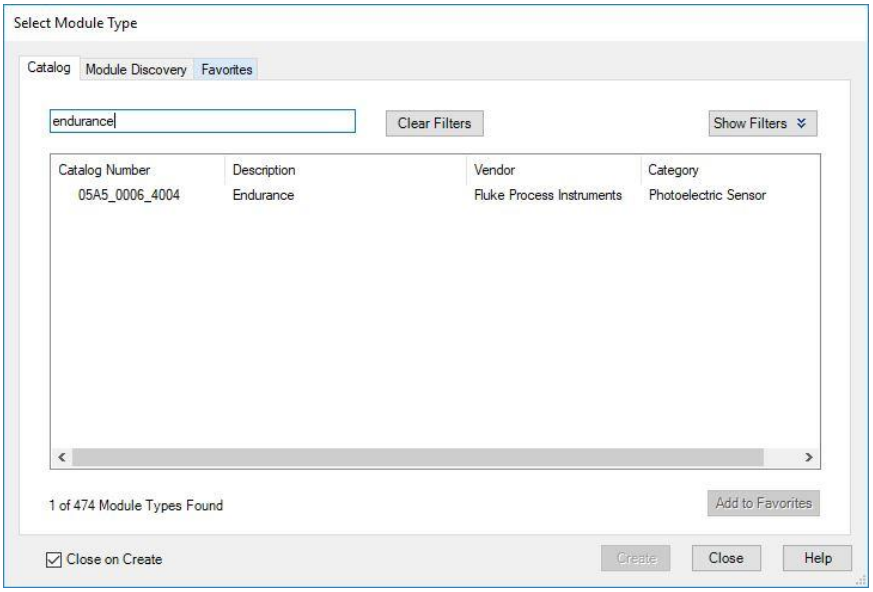


Figure 41: Selecting Endurance EDS from the Library

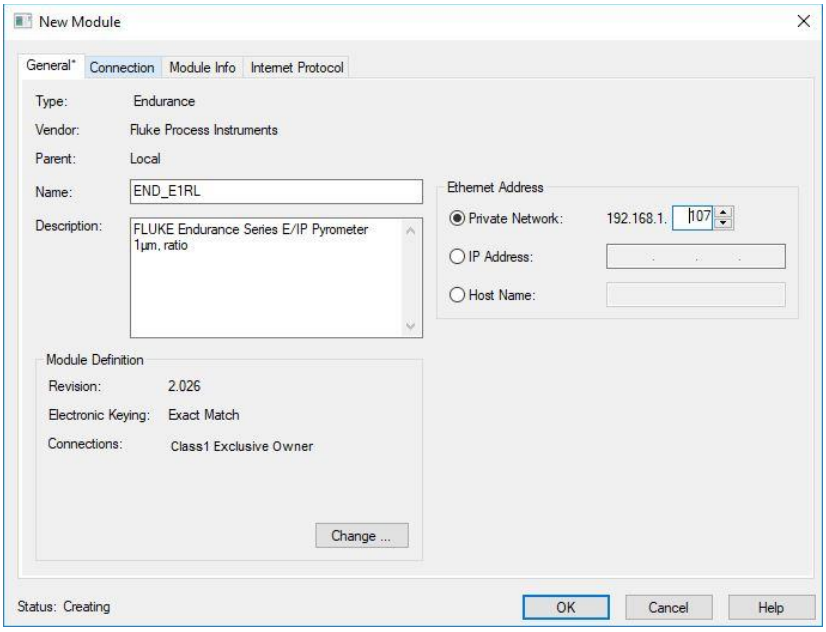


Figure 42: Device Settings (EDS)

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.)

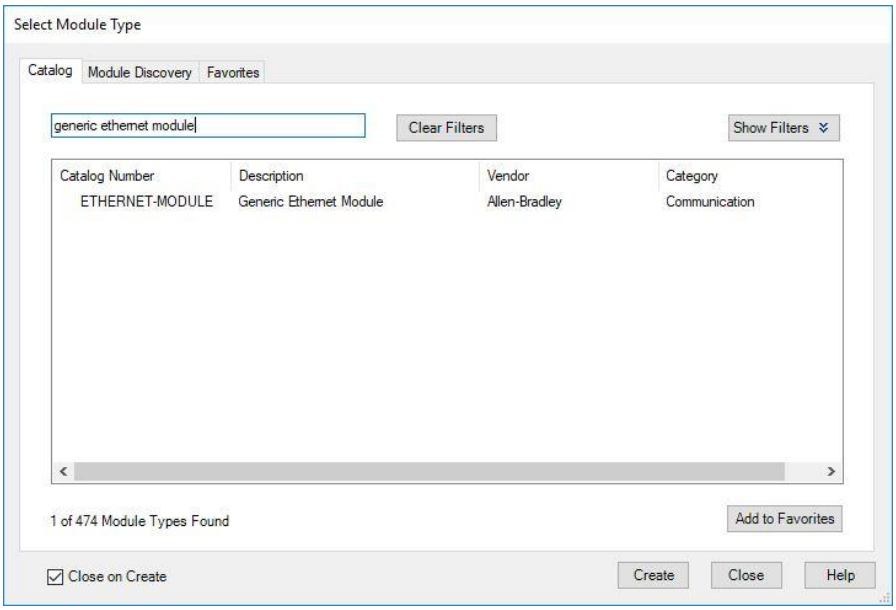


Figure 43: Selecting Generic Ethernet Module from the Library

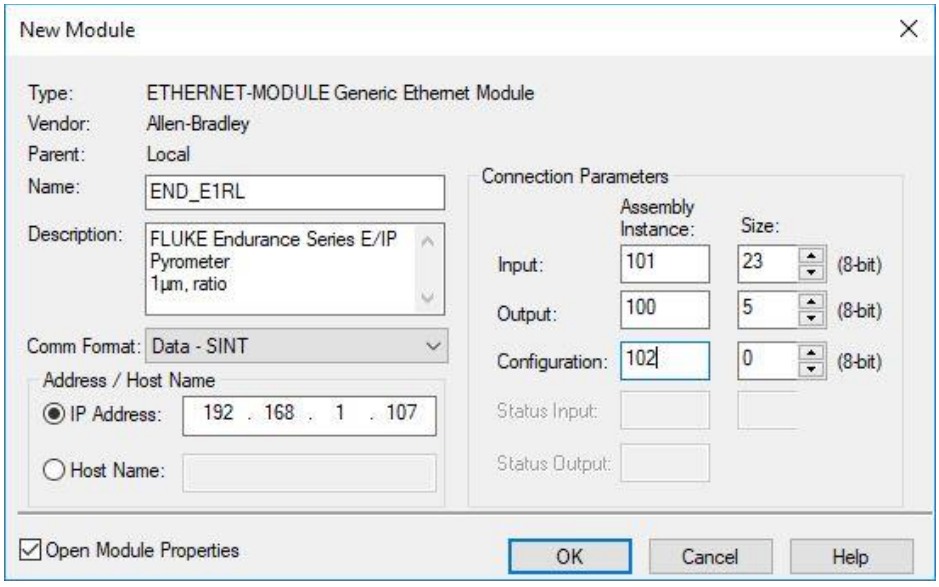


Figure 44: Device Settings via Manual Configuration

8.4.3. Parameter Setting

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.

8.4.3.1.Pyrometer Parameters, per Configuration Data

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

The configuration data length is 58 Byte.

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..20mA 4 – 4..20mA
50	4 Byte	Analog bottom of range	REAL	Min. … Max. Temp.
54	4 Byte	Analog top of range	REAL	Min. … Max. Temp.

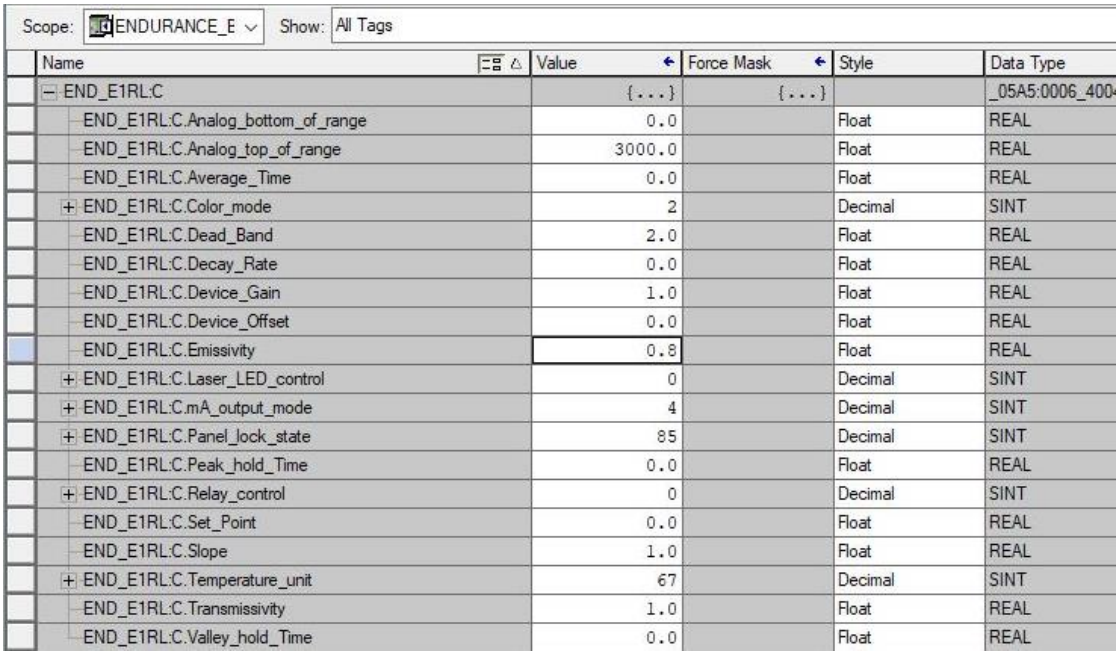


Figure 45: Endurance Configuration Data as seen in Controller Tags (Rockwell Studio5000 Software)

8.4.3.2.Pyrometer Parameters, per Output Data

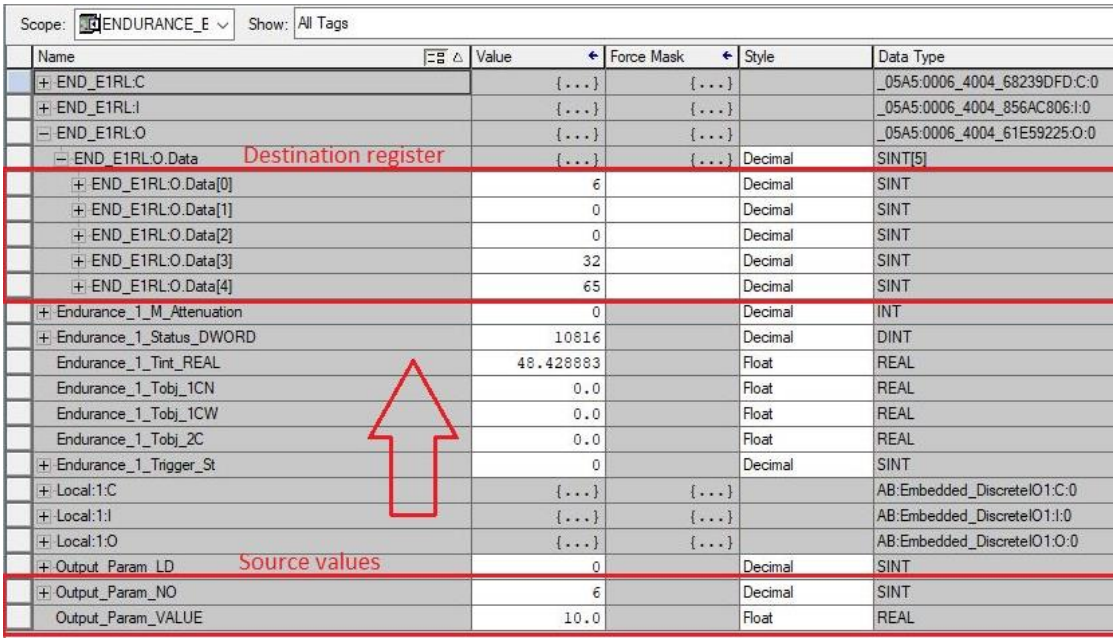
Once the pyrometer has been initialized and is running in the data exchange mode, only the below listed parameters can be changed, using the device's output data. The command consists of 5 bytes, the first being parameter number and the following 4 – parameter value.

Starting byte	Length	Format	Value
0	1 Byte	BYTE	Parameter number
1	4 Byte	REAL / UDINT	Parameter value

The parameter number corresponds to the following parameters:

Parameter number	Parameter name	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, as in the example below. Please note, that the values of the parameters 1 to 7 are REALs whereas the parameter 8 (laser control) value uses UDINT format – at least this value must be stored in a separate tag.



Name	Value	Force Mask	Style	Data Type
END_E1RL:C	{...}	{...}		_05A5:0006_4004_68239DFD:C:0
END_E1RL:I	{...}	{...}		_05A5:0006_4004_856AC806:I:0
END_E1RL:O	{...}	{...}		_05A5:0006_4004_61E59225:O:0
END_E1RL:O.Data	{...}	{...}	Decimal	SINT[5]
END_E1RL:O.Data[0]	6		Decimal	SINT
END_E1RL:O.Data[1]	0		Decimal	SINT
END_E1RL:O.Data[2]	0		Decimal	SINT
END_E1RL:O.Data[3]	32		Decimal	SINT
END_E1RL:O.Data[4]	65		Decimal	SINT
Endurance_1_M_Attenuation	0		Decimal	INT
Endurance_1_Status_DWORD	10816		Decimal	DINT
Endurance_1_Tint_REAL	48.428883		Float	REAL
Endurance_1_Tobj_1CN	0.0		Float	REAL
Endurance_1_Tobj_1CW	0.0		Float	REAL
Endurance_1_Tobj_2C	0.0		Float	REAL
Endurance_1_Trigger_St	0		Decimal	SINT
Local:1:C	{...}	{...}		AB:Embedded_DiscreteIO1:C:0
Local:1:I	{...}	{...}		AB:Embedded_DiscreteIO1:I:0
Local:1:O	{...}	{...}		AB:Embedded_DiscreteIO1:O:0
Output_Param_LD	0		Decimal	SINT
Output_Param_NO	6		Decimal	SINT
Output_Param_VALUE	10.0		Float	REAL

Figure 46: Controller tags: Parameter number and value and their destination registers in the device

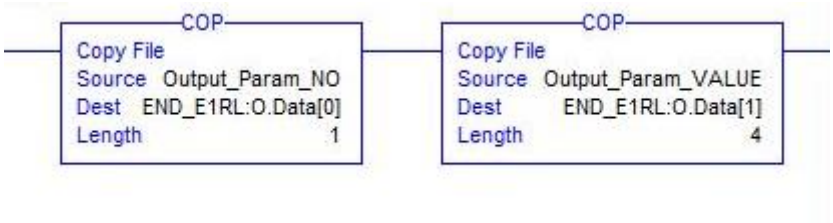


Figure 47: Sample instruction for sending output data

8.4.3.3.Pyrometer Input Data

The Ethernet/IP device Input data length is 23 bytes, transferred as SINT.

Input data structure:

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

*target data type after conversion

The data must be processed (copied) into especially created tags in a correct format in accordance to column “Data type”. 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.

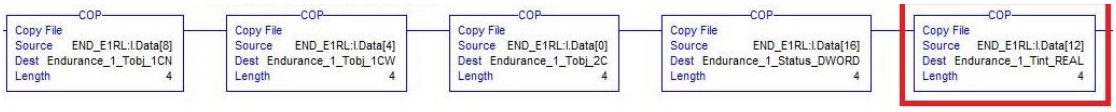


Figure 48: Input data conversion

8.4.3.4.Pyrometer 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

and which can be translated using the table below.

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	EthernetIP not ready
18	Heater not ready

8.5. ISO Calibration Certificate, based on DAkkS (German accreditation body)

A device specific Endurance calibration certificate is orderable and is assigned to the individual Endurance pyrometer. The calibration certificate shows in a detailed list the device accuracy as deviation values regarding the measurement normal under defined environmental conditions. In dependence of the Endurance device operation (e.g. smooth, harsh environment), a periodic re-calibration needs to be taken into account, 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.
Each calibration task (first and subsequent) have to be ordered as separate line items.

9. Accessories

A full range of accessories for various applications and industrial environments are available. Accessories include items, that may be ordered at any time and added on-site. These include but are not limited to the following:

9.1. Electrical Accessories

Table 5: Electrical Accessories

Code	Description
Electrical Accessories	
E-2CCB4	High-temp (200°C) multi-conductor cable with connector, 4m (13 ft.) not including terminal strip
E-2CCB8	High-temp (200°C) multi-conductor cable with connector, 8m (26 ft.) not including terminal strip
E-2CCB15	High-temp (200°C) multi-conductor cable with connector, 15m (50 ft.) not including terminal strip
E-2CCB30	High-temp (200°C) multi-conductor cable with connector, 30m (100 ft.) not including terminal strip
E-2CCB60	High-temp (200°C) multi-conductor cable with connector, 60m (200 ft.) not including terminal strip
E-2CLTCB4	Low-Temp (85°C) multi-conductor cable with connector, 4m (13ft.) not including terminal strip
E-2CLTCB8	Low-Temp (85°C) multi-conductor cable with connector, 8m (26ft.) not including terminal strip
E-2CLTCB15	Low-Temp (85°C) multi-conductor cable with connector, 15m (50 ft.) not including terminal strip
E-2CLTCB30	Low-Temp (85°C) multi-conductor cable with connector, 30m (100 ft.) not including terminal strip
E-2CLTCB60	Low-Temp (85°C) multi-conductor cable with connector, 60m (200ft.) not including terminal strip
E-ETHLTCB	Ethernet cable, 80°C max., 7.5 meters (25ft.) long
E-ETHLTCB25	Ethernet cable, 80°C max., 25 meters (80ft.) long
E-ETHLTCB50	Ethernet cable, 80°C max., 50 meters (160ft.) long
E-ETHCB	Ethernet cable, 180°C max., 7.5 m (25ft.) long
E-ETHCB10	Ethernet cable, 180°C max. 10 m (33ft.) long
E-TB	Endurance terminal block accessory
E-TBN4	Endurance terminal block in a NEMA 4 enclosure
E-SYSPS	24 VDC 1.2 A industrial power supply, DIN rail mount
E-PS	Power Supply (24VDC, 110/220VAC input) & Endurance Terminal Block mounted in a NEMA 4 (IP65) enclosure
E-POE	PoE Injector provides power and also acts as a single Ethernet hub (115/230VAC input)
E-2CCON	12-pin DIN Cable connector for multi-conductor cable
E-USB485	USB to RS232/422/485 converter

9.1.1. High Temp. Multi-conductor cable with M16 connector (E-2CCBxx)

Use the High Temp. 12-wire multi conductor cable (E-2CCBxx) for wiring the Endurance sensor with the 24 VDC power supply, all inputs, outputs, and the RS485 interface. It is a shielded 12-conductor cable, made of 2 twisted pairs plus 8 separate wires, equipped with a M16 DIN connector on one side and wire sleeves at the counter side. The cable is Teflon coated and withstands ambient temperatures from -80 to 200°C (-112°F to 392°F). Teflon coated temperature cables have well to excellent resistance to oxidation, heat, weather, sun, ozone, flame, water, acid, alkalis, and alcohol, but poor resistance to gasoline, kerosene, and degreaser solvents.

Purchasable High Temp. 12-wire multi-conductor cables lengths are 4m (13ft.), 8m (26ft.), 15m (50ft.), 30m (100ft.), 60m (200ft.), see Table 5.

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

Teflon develops poisonous gasses, when it is exposed to flames!

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

If you purchase your own High Temp. Multi-conductor cable, use wire with the same specifications as herein mentioned. Maximum RS485 cable length is 1.200 m (4000 ft). Power supply (24VDC) feed in distance to the Endurance sensor should not extend the 60m (200 ft.) limit.

An ordered Multi-Conductor Cable does not include a terminal block!

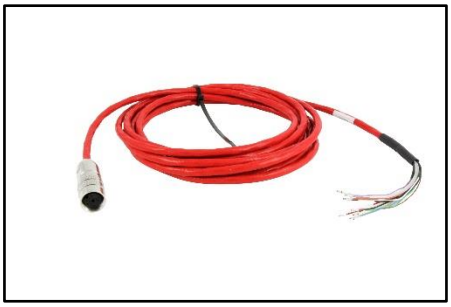


Figure 49: High Temp. Multi-Conductor Cable with M16 Connector (E-2CCBxx)

9.1.2. Low Temp. Multi-conductor cable with M16 connector (E-2CLTCBxx)

Use the Low Temp. 12-wire multi conductor cable (E-2CLTCBxx) for wiring the Endurance sensor with the 24 VDC power supply, all inputs, outputs, and the RS485 interface. It is a shielded 12-conductor cable, made of 2 twisted pairs plus 8 separate wires, equipped with a M16 DIN connector on one side and wire sleeves at the counter side. The cable is PUR (Polyurethane) coated and withstands ambient temperatures from -40 to 105°C (-40°F to 221°F). PUR coated cables are flexible and have well to excellent resistance to against oil, bases, and acids.

Purchasable Low Temp. 12-wire multi-conductor cables lengths are 4m (13ft.), 8m (26ft.), 15m (50ft.), 30m (100ft.), 60m (200ft.), see Table 5.

- Temperature: -40 to 105°C (-40°F to 221°F)
- Cable material PUR- 11Y (Polyurethane), Halogen free, Silicone free
- Cable diameter: 7.2 mm (0.283 in) nominal
- Conductors:
  - Power supply: 2 wires (black/red)
    - Conductor: 0.2 mm² (AWG 24), stranded tinned copper
    - Isolation: PE- 2YI1
    - Shield: none
  - RS485 interface: 2 twisted pairs (black/white and purple/gray)
    - Conductor: 0,2 mm² (AWG 24), stranded tinned copper
    - Isolation: PE- 2YI1
    - Shield: CDV-15, 85% covered
  - Outputs and Ground: 6 wires (green/brown/blue/orange/yellow/clear)
    - Conductor: 0,2 mm² (AWG 24), stranded tinned copper
    - Isolation: PE- 2YI1
    - Shield: none

Polyurethane (Isocyanate) may cause allergy and is under a cloud to cause cancer!

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

If you purchase your own High Temp. Multi-conductor cable, use wire with the same specifications as herein mentioned. Maximum RS485 cable length is 1.200 m (4000 ft). Power supply (24VDC) feed in distance to the Endurance sensor should not extend the 60m (200 ft.) limit.

An ordered Multi-Conductor Cable does not include a terminal block!

Figure 50: Low Temp. Multi-Conductor Cable with M16 Connector (E-2CLTCBxx)

9.1.3. High Temp. Ethernet cable with M12 connector (E-ETHCBxx)

Use the High Temp. 4-conductor cable (E-ETHCBxx) to connect the Endurance sensor to a LAN/Ethernet device. It is a standardized cable, equipped with a D-coded, M12 4-pin connector type and a RJ45 connector on the counter side, and is suited for industrial Ethernet applications. The M12 connector is IP67/NEMA 4 rated and has a screw retention feature. Via the 4-conductor cable, the Endurance sensor may be powered as a PD (Powered Device) by a PSE (Power Sourcing Equipment) in a PoE (Power over Ethernet) mode. Refer to PoE standard IEEE 802.3af, mode A, 10/100 Mbit mixed DC & data. The cable is Teflon coated and withstands ambient temperatures form -80 to 200°C (-112°F to 392°F). Teflon coated temperature cables have well to excellent resistance to oxidation, heat, weather, sun, ozone, flame, water, acid, alkalis, and alcohol, but poor resistance to gasoline, kerosene, and degreaser solvents.

Purchasable High Temp. Ethernet 4-conductor cables lengths are 7.5m (25ft.), 10m (33ft.), see Table 5.

Figure 51: High Temp. Ethernet Cable with M12, RJ45 Connector (E-ETHCBxx)

9.1.4. Low Temp. Ethernet cable with M12 connector (E-ETHLTCBxx)

Use the Low Temp. 4-conductor cable (E-ETHLTCBxx) to connect the Endurance sensor to a LAN/Ethernet device. It is a standardized cable, equipped with a D-coded, M12 4-pin connector type and a RJ45 connector on the counter side, and is suited for industrial Ethernet applications. The M12 connector is IP67/NEMA 4 rated and has a screw retention feature. Via the 4-conductor cable, the Endurance sensor may be powered as a PD (Powered Device) by a PSE (Power Sourcing Equipment) in a PoE (Power over Ethernet) mode. Refer to PoE standard IEEE 802.3af, mode A, 10/100 Mbit mixed DC & data. The cable is PUR (Polyurethane) coated and withstands ambient temperatures from -40 to 105°C (-40°F to 221°F). PUR coated cables are flexible and have well to excellent resistance to against oil, bases, and acids.

Purchasable Low Temp. Ethernet 4-conductor cables lengths are 7.5m (25ft.), 25m (80ft.), 50m (160ft.), see Table 5.

Figure 52: Low Temp. Ethernet Cable with M12, RJ45 Connector (E-ETHLTCBxx)

9.1.5. Endurance Terminal Block Accessory (E-TB)

The Endurance Terminal Block Accessory (E-TB) is for the connection of the Endurance sensor to the customer's industrial environment. It lists all different conductor colors on the right-hand-side and oppositely the related signal names.

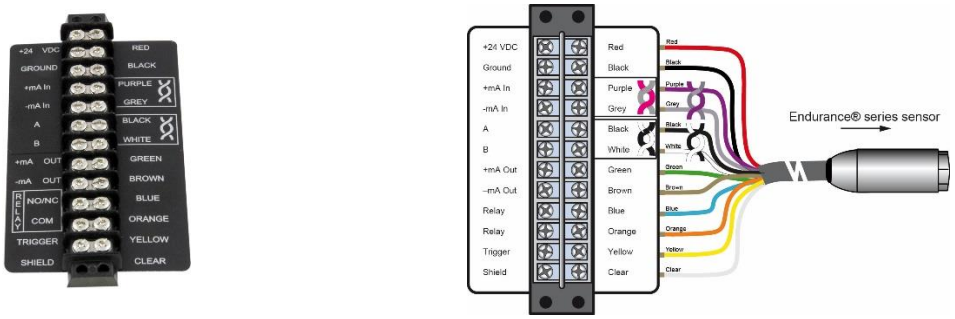


Figure 53: Endurance Terminal Block (E-TB) with wire color assignment

9.1.6. Endurance Terminal Block in a NEMA 4 enclosure (E-TBN4)

The Endurance Terminal Block in a NEMA 4 enclosure (E-TBN4) is for the connection of the Endurance sensor to the customer's industrial environment. It is an IP67/NEMA protected Terminal Block with sealed cable inlets. The inside the sealed case installed Terminal Block is equal to the above-described E-TB type.

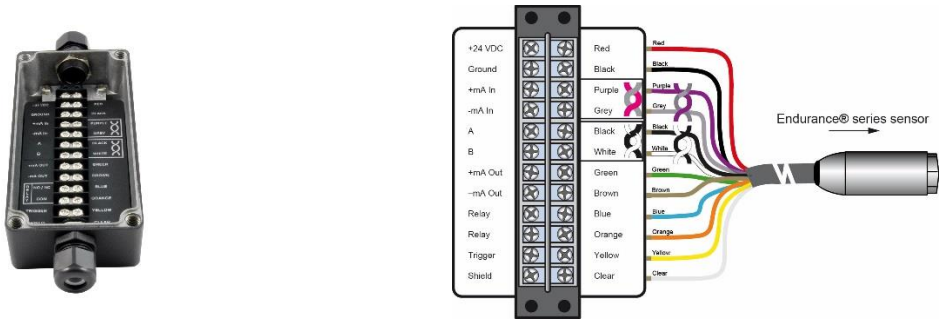


Figure 54: Endurance Terminal Block in a NEMA 4 Enclosure (E-TBN4)

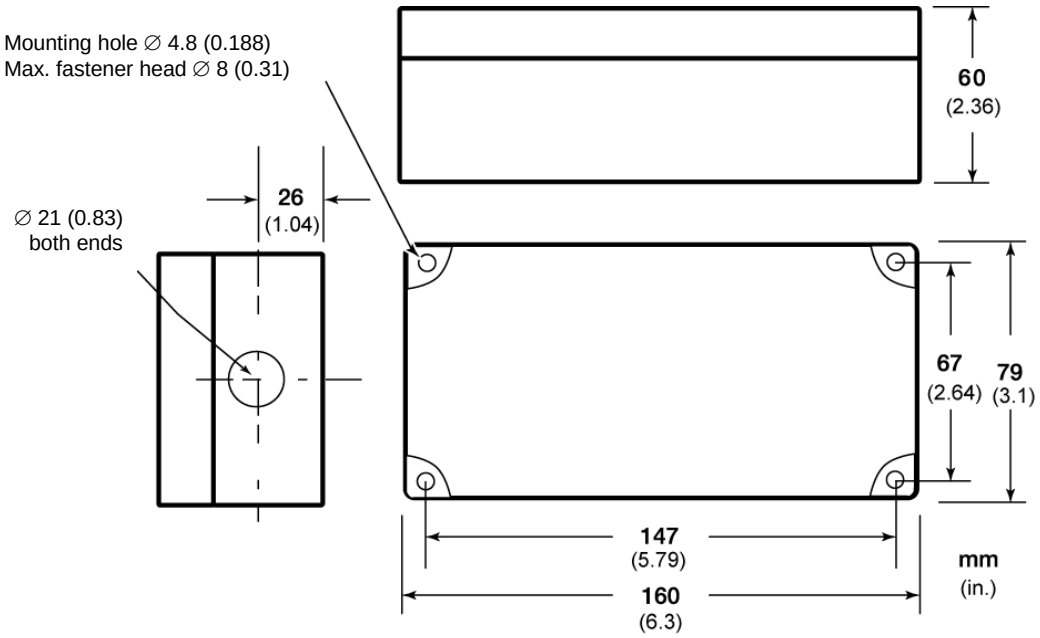


Figure 55: Dimensions of Enclosure

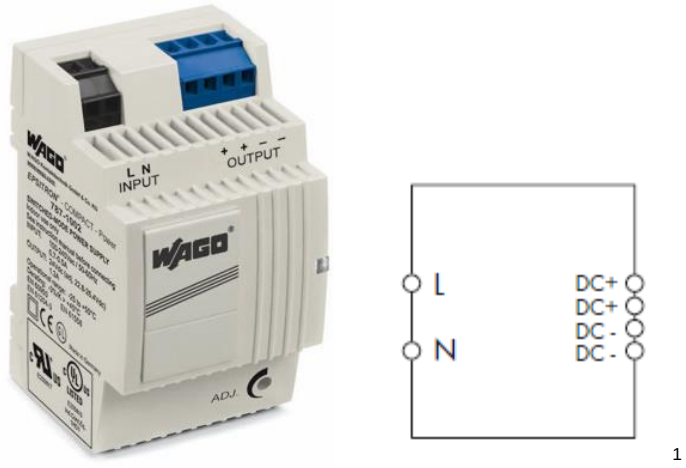
9.1.7. Industrial power supply, DIN rail mount (E-SYSPS)

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

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

Technical data:

Protection class	prepared for class II equipment (IEC/EN 61140)
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
Wire cross sections (input/output)	0.08 to 2.5 mm² (AWG 28 to 12)



[1]

Figure 56: Industrial Power Supply (E-SYSPS)

[1] Copyright Wago®

9.1.8. Power supply in NEMA 4/IP65 case (E-PS)

The terminal box is designed to provide IP65 (NEMA-4) protection to the terminal block, see section 5.5, Electrical Installation of the Electronics Housing, and a power supply for the sensor. The box should be surface mounted using the flanges and holes provided. It should be mounted in such a manner to allow the free flow of air around the unit.

Technical data for the power supply:

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

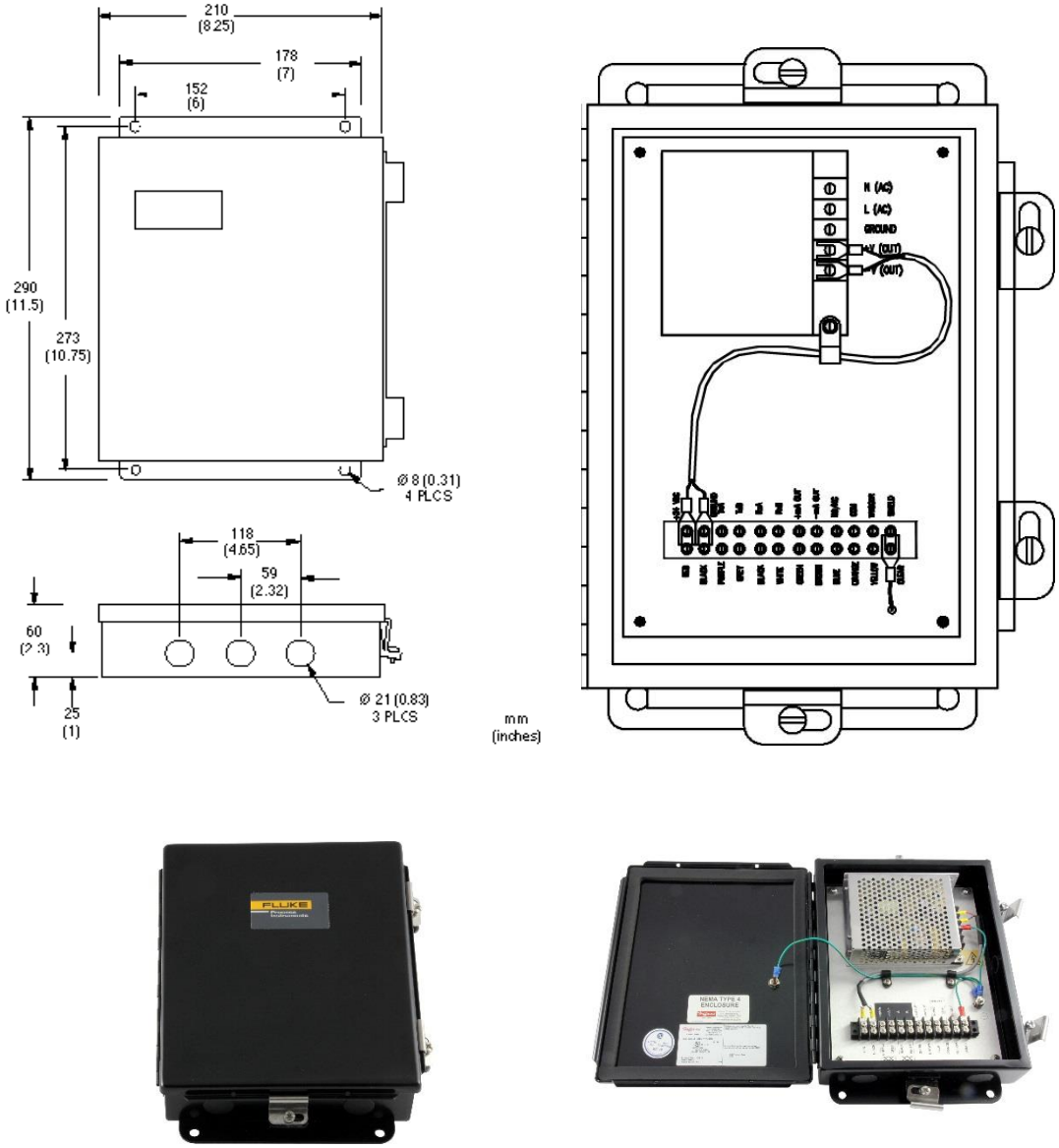


Figure 57: 24VDC, 1.1A, 100-240VAC power supply in NEMA 4/IP65 case (E-PS)

9.1.9. PoE Injector to provide power over a single Ethernet hub (E-POE)

With the PoE injector option, you can power the Endurance device over the Ethernet/LAN connection. This is also possible, if you operate the device over a PLC (Programmable Logic Controller) link via the PROFINET IO or Ethernet/IP protocol. Such connections use the same communication hardware, see section 3.2 on page 8.

Ethernet	
Fast Ethernet (RJ45)	1
Standards	
IEEE 802.3 10-BASE-T (Ethernet)	Supported
IEEE 802.3u 100-BASE-TX (Fast Ethernet)	Supported
IEEE 802.3af Power over Ethernet	Supported
Transmission Media	
10Base T	Cat. 3, 4, 5 UTP/STP
100Base TX	Cat. 5, 5e UTP/STP
PoE Function	
Number of PoE Out Ports	1
PoE Output Power	15.4W
802.3af Standard Compatible	Yes
Over Current Protection	Supported
Circuit Shorting Protection	Supported
Power Pin Assignment	1/2(+), 3/6(-)
PoE PD Auto Detection	Supported
General	
LED Indicators	Power, PoE
Power Input	100~240VAC / 50~60Hz
Power Consumption	19W
Dimensions	146 (L) x 64 (W) x 42 (H) mm
Weight	0.2 kg
Operating Temperature	0°C ~ 50°C (32°F ~ 122°F)
Storage Temperature	-20°C ~ 70°C (-4°F ~ 158°F)
Humidity Operating:	10~90% (Non-condensing)
Storage:	10~90% (Non-condensing)
Safety Certifications	CE, C-Tick, FCC, VCCI, LVD
Accessory	
Included Accessories	Power cord, QIG

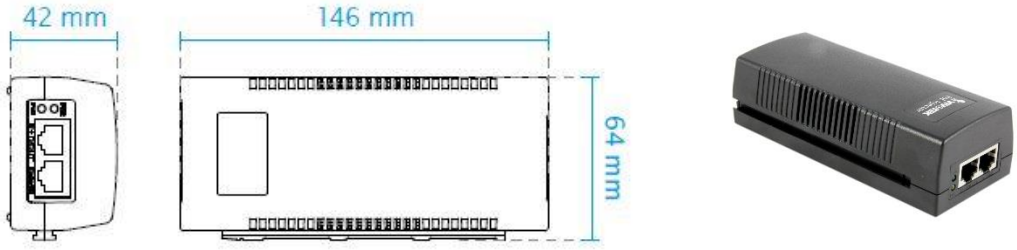


Figure 58: PoE Injector to provides power over a single Ethernet hub (E-POE)

9.1.10. 12-socket DIN Cable connector (E-2CCON) for multi-conductor cable

The 12-socket DIN Cable connector is a spare connector to replace a damaged one. In case of shortening the existing multi-conductor cable, you can assemble the spare connector by your own experienced technician. Please see in chapter 5.5.1.1, M16 12-Pin DIN Connector Signal Assignment for detailed information.

Figure 59: 12-socket DIN Cable connector (E-2CCON) for multi-conductor cable

9.1.11. USB to RS232/422/485 converter (E-USB485)

The USB to RS232/422/485 converter (E-USB485) is for the direct adaptation of an Endurance series device to a standard PC via the USB-interface. The converter supports auto configuration in data format, baud rate and RS485 data flow direction control. It is able to automatical configure RS-232, RS-422 or RS-485 signals to baud rate without external switch setting. Furthermore, the converter is equipped with 3000V DC of isolation and internal surge-protection on each data lines to protect the host computer and converter against high voltage spikes, as well as ground potential difference. Please see under section 5.5.5, Computer Interfacing via RS485 link for detailed system interfacing.

Specifications:

- USB interface: Fully compliant with V1.0, 2.0 specification.
- USB to serial bridge controller; Prolific PL2303HX.
- RS-232 signal: 5 full-duplex (TXD, RXD, CTS, RTS, GND).
- RS-422 signal: Differential 4 full-duplex wires (TX+, RX+, TX-, RX-).
- RS-485 signal: Differential 2 half-duplex wires (D+, D-).
- Data Format: Asynchronous data with all common combination of bits, parity, stop.
- Parity type: None, odd, even mark, space.
- Data bit: 5, 6, 7, 8.
- Stop bits: 1, 1.5, 2.
- Cable: USB type A to type B.
- Communication speed: form 300bps to 256Kbps.
- RS-422/485 line protection: Against surge, short circuit, and voltage peak.
- Transmission distance: RS422/485 Up to 4000ft (1200M).
- Connection type: Screw terminal accepts AWG #12~30 wires.
- Signal LED: Power on, TX, RX.
- Direct power from USB port.
- Power consumption: 1.2W.
- Isolation voltage: 3000V DC.
- Operating environment: 0 to 60℃.
- Storage temperature: -20 to 70℃.
- Humidity: 10-90% non-condensing.
- Dimension: 151mm X 75mm X 26mm.
- Weight: 375g.

Figure 60: USB to RS232/422/485 converter (E-USB485)

9.2. Accessories for Fiber Optic Sensors only

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

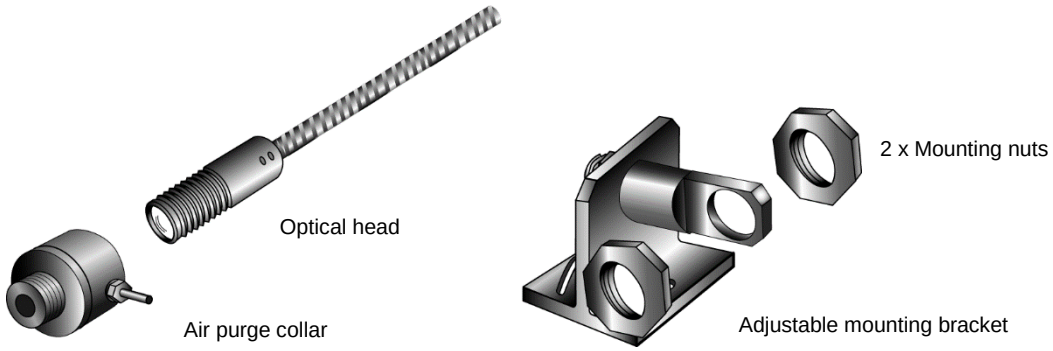


Figure 61: Accessories (Selection)

9.2.1. Air Purge Collar

The Air Purge Collar accessory is used to keep dust, moisture, airborne particles, and vapors away from the optical head's lens. It can be installed before or after the bracket. It must be screwed in fully. Air flows into the 1/8” NPT fitting and out the front aperture. Air flow should be a maximum of 0.5 - 1.5 liters/sec (1 - 3 cfm). Clean (filtered) or “instrument” air is recommended to avoid contaminants from settling on the lens. Do not use chilled air below 10°C (50°F). Also provided is a stainless steel protection tube, 150 mm (6 inches) long by 25 mm (1 inch) diameter that threads onto the front of the air purge collar.

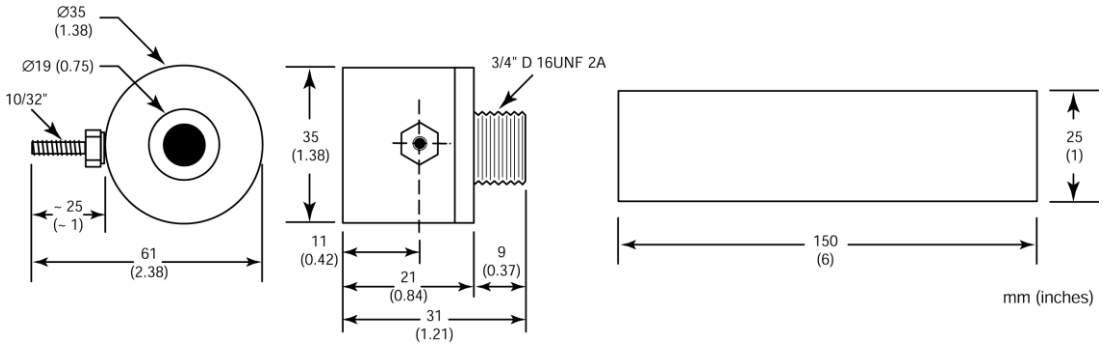
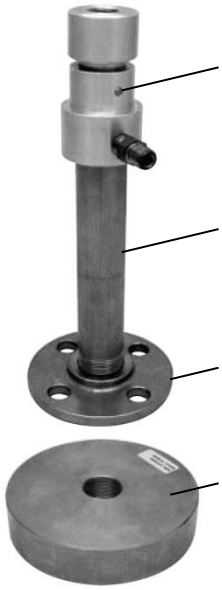


Figure 62: Air Purge Collar and Protection Tube (E-FOHAPA)

9.2.2. Fitting System

Flexible accessory selections allow you to pick and choose the accessories you need.



Item 1
Stainless steel air purge with quick release fitting and Sapphire window
Air connector: ¼“ NPT

Item 2
Stainless steel tube 203 mm (8 in)

Item 3
Stainless steel 4-bolt mounting flange

Item 4
Stainless steel gravity-held mounting base

Figure 63: Flexible Fitting System

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

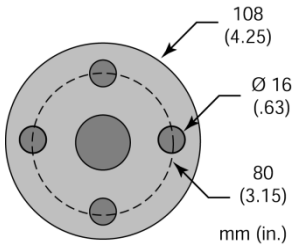
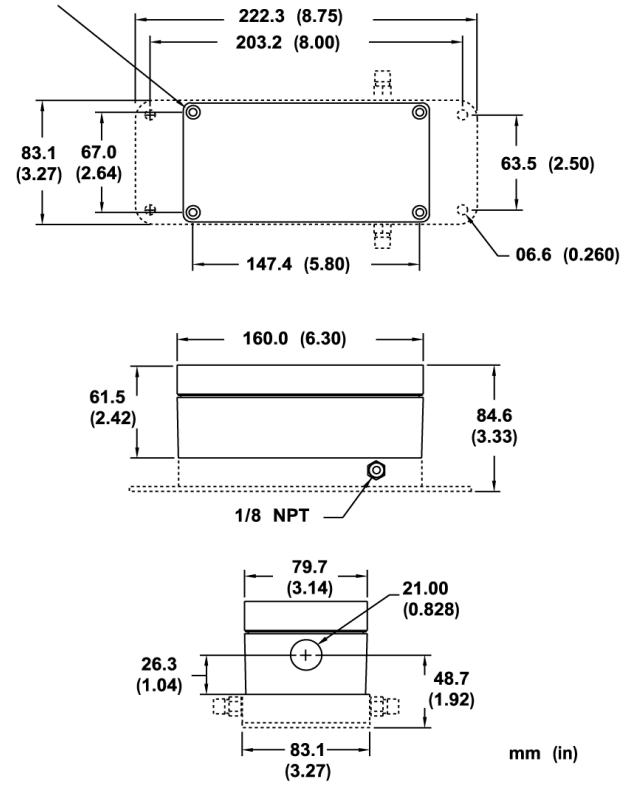


Figure 64: Dimension for 4-Bolt Mounting Flange

9.2.3. Cooling Platform for Electronics Housing



(E-CP)

10. Programming Guide

This section explains the sensor's communication protocol to be used when writing custom programs for your applications or when communicating with your sensor with a terminal program over RS485 or LAN/Ethernet interface.

10.1. Remote versus Manual Considerations

Since the sensor includes a local user interface, the possibility exists for a person to make manual changes to parameter settings. To resolve conflicts between inputs to the sensor, 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 (user interface), the RS485 (2-wire, half duplex) or the LAN/Ethernet interface are retained in the sensor's nonvolatile memory.

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

10.2. Command Structure

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

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

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

For a new parameter setting by the user, a range check of allowed values will be performed by the Endurance firmware. If an out of range for a parameter is detected by the firmware, a Range Error is indicated and transmitted back by the Endurance sensor.

All commands via RS485 or LAN/Ethernet interface have to be entered in upper case (capital) letters.

After transmitting one command via RS485 or LAN/Ethernet link, the sender has to wait for the response from the Endurance device before sending a subsequent one. The response time from the Endurance device back to the sender depends on the following factors:

- Operation mode of the Endurance sensor (single or multidrop), without or with leading device address bytes in the response string
- Chosen transmission link (RS485 or LAN/Ethernet) with different transmission speed
    - RS485: 1200 bps – 115.200 bps (~ 120 char/sec – 11.520 char/sec)
    - LAN/Ethernet: max. 100 Mbit/sec (~ 10.000.000 char/sec)

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

- An “out-of-range” parameter value
- Any not defined command character or value entered in the incorrect format (syntax error)
- Lower case character(s) entered (all characters must be upper case)

10.3. Transfer Modes

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

10.3.1. Poll Mode

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

10.3.2. Burst Mode

The Endurance sensor transmits the user-defined output string continuously via RS485 (at selected baud rate) or LAN/Ethernet (max. 100Mbps) in a user defined burst interval time. A user defined burst string may contain several parameters in the user defined order.

The string may contain the following parameters:

1. Temperature unit ($=U) in °C or °F
2. Target temperature ($=T[2C-mode], $=W[wide band], $=N[narrow band]) in °C or °F
3. Power ($=Q[wide band], $=R[narrow band]) in mW
4. Emissivity ($=E) in the range from 0.0 – 1.10
5. Transmissivity ($=XG) in the range from 0.0 – 1.10
6. Attenuation ($=B) in the range from 0 – 100%
7. Average time ($=G) in the range from 0.0 – 300.0 sec
8. Peak hold time ($=P) in the range from 0.0 – 300.0 sec
9. Valley hold time ($=F) in the range from 0.0 – 300.0 sec
10. Internal ambient temperature ($=I) in the range from 0.0 – 100.0 in °C or °F
11. Top of temperature range ($=H) in the range from 0.0 – 9999.0 in °C or °F

An example string for the burst request command $=UTQEGH<CR>

The cyclically transmitted Endurance sensor string is: C T1250.5 Q400.5 E1.00 G7.5 H3000.0 <CR><LF>

10.4. Command List

The table below describes the available commands via RS485 or LAN/Ethernet interface.

Table 6: Command List

Description	Char	Format (2)	P (1)	B (1)	S (1)	Legal Values	Factory Default
Burst string format	$	(3)	√		√	(3)	UTSI
Show list of commands	?		√				
Ambient correction	A		√			min/max range	Low end of sensor range
Advanced hold w. average	AA		√			0.0-300.0s	000.0
Ambient compens. control	AC		√			0, 1 or 2	0
Top of mA range	AH		√			min/max range	High end of sensor range
Bottom of mA range	AL		√			min/max range	Low end of sensor range
Measured attenuation	B	nn - nn	√	√		00 to 99%	n/a
Burst speed	BS	n - nnnnn	√		√	5 - 10000msec	32msec
Advanced hold threshold	C		√			min/max range	Low end of sensor range
Current emissivity	CE	n.nnn – n.nnn				0.100 – 1.100	1.000
Baud rate (6)	D	nnn - nnnn	√ √ √ √ √ √ √		√ √ √ √ √ √ √	12 = 1200 baud 24 = 2400 baud 96 = 9600 baud 192 = 19200 baud 384 = 38400 baud 576 = 57600 baud 1152 = 115200 baud	38400 baud
Digital filter	DF	n	√		√	0 = OFF, 1 = ON	1
DHCP / BOOTP	DHCP	n	√		√	0 = OFF, 1 = DHCP ON 2 = BOOTP ON	0
Sensor gain	DG	n.nnnnnn - n.nnnnnn	√			0.800000 up to 1.200000	1.000000
Sensor offset	DO	-nnn - +nnn	√			-200 up to +200	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)	
Error Codes (9)	EC	nnnnnnnn	√	√		0000 – FFFF (Hex)	
Emissivity source	ES	X	√			I or E	I
Valley hold time (4)	F	n.n - nnn.n	√	√	√	0.0 – 300.0 sec (300 s = ∞)	000.0
Average time (4)	G	n.n - nnn.n	√	√	√	0.0 – 300.0 sec (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 range (°C or °F)	Upper end of sensor range
Sensor internal ambient	I	n.n - nnn.n	√	√		0°C/32°F – 65°C/149°F	
Analog input mA	IN	nn.nn – nn.nn				0-20 or 4-20	
Analog input mode	INM	n				0 = 0-20mA, 4 = 4-20mA	4
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)	Lower end of sensor range
Mode–ER series	M	n	√	√	√	1 = 1 - color 2 = 2 - color	2
MAC Hardware Address	MAC	nnnnnnnnnnnn	√			e.g. 001d8d2aaa01	Set at factory calibration
Target temp – 1-Color 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 00 – 20 = current in mA	00
Peak hold time (4)	P	n.n - nnn.n	√	√	√	0.0 – 300.0 sec (300 s = ∞)	0.0
IP Portaddress	PORT	n - nnnnn	√		√	1 - 65535	6363
Wide Power	Q	n.nnnnnnn	√	√			
Narrow power	R	n.nnnnnnn	√	√			
Video relative reticle diameter	RC	n.n – nn.nn	√				
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
Slope source	SS	X	√			I or E	I
Set target temperature	STT	n.n – nnnn.n	√		√	0.0 – 9999.0 (5)	Set at factory calibration
Target Temperature 2-Color	T	n.n - nnnn.n	√	√			
Terminator resistor	TR	n	√		√	0 = OFF, 1 = ON	0 = OFF
TCP/IP time out interval	TTI	n - nnn	√		√	0 = ∞, 1 – 240 sec	0
Temperature units (scale)	U	X	√	√	√	C or F	non-US: C
Poll/burst mode	V	X	√		√	B = Burst , P = Polled	P = Polled
Target temp: 1-Color wide	W	n.n - nnnn.n	√	√		(5)	
Web server ON/OFF	WS	n	√		√	0 = OFF, 1 = ON	0 = OFF
Burst string contents (3)	X$		√				
Multidrop address	XA	nnn	√	√	√	000 to 032	000
Low temperature limit	XB	n.n - nnnn.n	√			0.0–9999.0 (5)	Set at factory calibration
Deadband (7)	XD	nn	√		√	01 – 55 in °C / 01 – 99 in °F	02
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 (5)	Set at factory calibration
Sensor initialization	XI	n	√	√	√	0 = flag reset, 1 = flag set	1
LASER / LED / Video ON / OFF	XL	n	√		√	0 = OFF, 1 = ON	0 = OFF
Sensor model type	XM	X	√			L = Low Temp., H = Hi Temp	Set at factory calibration
0 - 20 mA / 4-20 mA analog output	XO	n	√		√	0 = 0 - 20 mA, 4 = 4 - 20 mA	4
Sensor firmware revision no.	XR	Xn	√			e.g. 1.02.11	Set at factory calibration
Sensor analog part revision no.	XRA	Xn	√			e.g. 1.02.01	Set at factory calibration

Setpoint / Relay function	XS	n.n – nnnn.n	√		√	0.0 to 3200.0°C / 5792.0°F (8)	0.0
Trigger	XT	N	√	√		0 = inactive, 1 = active	0
Identify unit	XU	Varies	√			e.g. E1RL-F2-V-0-0	Set at factory calibration
Sensor serial number	XV	nnnnnnnn	V			e.g. 31712345 (8 digits)	Set at factory calibration
Attenuation to activate relay	Y	nn	√	√	√	0 to 95% energy	95%
Attenuation for failsafe	Z	nn	√	√	√	0 to 99% energy reduction	95%

Notes:
(1) Commands may appear as Polled for (queried), Burst string item or Set command
(2) n = number, X = uppercase letter.
(3) see section 10.3.2 Burst Mode, page 80
(4) Setting either Average, Peak Hold or Valley Hold, sets non concerned signal post processing settings to factory default value
(5) In current scale °C or °F
(6) The sensor restarts after a baud rate change. (Command is not allowed in multidrop mode.)
(7) No effect if relay in alarm mode.
(8) Non-zero setpoint value puts unit in setpoint mode. Setpoint is in current scale °C or °F and must be within unit's temperature range.
(9) Error Codes returned out of ?EC-Command (16 Bit-Word, 0000000000000000 – 1111111111111111)

Table 7: Assignment of Error-Codes

2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}
Alarm detection	**Narrow band temperature over range**	**Narrow band temperature under range**	**Wide band temperature over range**	**Wide band temperature under range**	**Two-color temperature over range**	**Two-color temperature under range**	**Attenuation > 95% ("dirty window")** (1)**	**Attenuation too high (> 95%) (1)**	**Energy too low**	**Narrow band detector failure**	**Wide band detector failure**	**Internal temperature under range**	**Internal temperature over range**	**Heater control temperature under range**	**Heater control temperature over range**

10.5. Command Examples

Table 8: Command Examples

Description	HOST Query →	SENSOR Answer	HOST Set →	WHERE USED (1) P	B	S
Burst string format	001?$	001!$UTSI	001$=UTSI	√		√
Show list of commands	001?			√		
Measured attenuation	001?B	001!B12		√	√	
Baud rate	001?D	001!D384	001D=384			√
Emissivity	001?E	001!E0.95	001E=0.95	√	√	√
Average time	001?G	001!G1.2	001G=1.2	√	√	√
Top of mA range	001?H	001!H2000.0	001H=2000.0	√	√	√
Sensor internal ambient	001?I	001!I37.9		√	√	
Switch panel lock	001?J	001!IJL	001J=L	√		√
Relay alarm output control	001?K	001!K0	001K=0	√		√
Bottom of mA range	001?L	001!L1200.0	001L=1200.0	√	√	√
Mode – ER series	001?M	001!M1	001M=1	√	√	√
Target temperature, 1-Color narrow	001?N	001!N1158.0			√	
Output current	001?O	001!O10	001O=10	√	√	√
Peak hold time	001?P	001!P5.6	001P=5.6	√	√	√
Power	001?Q	001!Q36.102000		√	√	
Narrow Power	001?R	001!R2.890000		√	√	
Slope	001?S	001!S0.850	001S=0.850	√	√	√
Target temperature, ER series 2-Color	001?T	001!T1225.0		√	√	
Temperature units	001?U	001!UC	001U=C	√	√	√
Poll/Burst mode		001!VP	001V=P			√
Target temperature, 1-Color wide	001?W	001!W1210.0		√	√	
Burst string contents	001?X$	001!UC T1200.5 S0.850 I37.9		√		
Multidrop address	001?XA	001!XA013	001XA=013	√	√	√
Low temperature limit	001?XB	001!XB400.0		√		
Deadband	001?XD	001!XD12	001XD=12	√		√
LASER / LED / Video ON / OFF	001?XL	001!XL1	001XL=1	√		√

P = Poll Mode (Request for a parameters)

B = Burst Mode (continuous sending of parameters in the burst string)

S = Set (Command for setting a parameters)

N = Notification (Acknowledgment for setting a parameter)

The given examples are related to a unit in a multidrop network, addressed with address 001. Stand-alone units (address 000) don't have an address information in the command.

11. Maintenance

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

11.1. Troubleshooting Minor Problems

Table 9: 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 slope or emissivity	Correct the setting
Temperature fluctuates	Wrong signal processing	Correct Peak Hold or Average settings

11.2. Fail-Safe Operation

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

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

11.2.1. Fail-Safe Error Codes (displayed or transmitted via electrical interfaces)

When an error or failure does occur, the temperature display indicates the possible failure area, and the output circuits automatically adjust to their lowest or highest preset level. The following table shows the values displayed on the 7-segment temperature display and transmitted over the RS485 or LAN / Ethernet interface.

Table 10: Error Codes in 1-Color Mode

Symptom	Error Code	Priority
Heater control temperature over range	ECHH	1 (high)
Heater control temperature under range	ECUU	2
Internal temperature over range	EIHH	3
Internal temperature under range	EIUU	4
Temperature under range	EUUU	5
Temperature over range	EHHH	6 (low)

Table 11: Fail-safe Error Codes

Condition	2-Color	1-Color (wide band)**	1-Color* (narrow band)**	Priority
Heater control temperature over range	ECHH	ECHH	ECHH	1 (high)
Heater control temperature under range	ECUU	ECUU	ECUU	2
Internal temperature over range	EIHH	EIHH	EIHH	3
Internal temperature under range	EIUU	EIUU	EIUU	4
Wide band detector failure	EHHH	EHHH	<temperature>	5
Narrow band detector failure	EHHH	<temperature>	EHHH	6
Energy too low	EUUU	<temperature>	<temperature>	7
Attenuation too high (>98%)	EAAA	<temperature>	<temperature>	8
Attenuation too high >95% ("dirty lens", relay will go to “alarm” state)	<temperature>	<temperature>	<temperature>	9
2-color temperature under range	EUUU	<temperature>	<temperature>	10
2-color temperature over range	EHHH	<temperature>	<temperature>	11
1-color temperature (wide) under range	<temperature>	EUUU	<temperature>	12
1-color temperature (wide) over range	<temperature>	EHHH	<temperature>	13
1-color temperature (narrow) under range	<temperature>	<temperature>	EUUU	14
1-color temperature (narrow) over range	<temperature>	<temperature>	EHHH	15 (low)

* only available via RS485 or LAN / Ethernet 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%)

11.2.2. Analog Output current values in dependence of Fail-Safe Error Codes

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

Table 12: Current Output Values in accordance to an Error

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

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 7-segment temperature display and the assigned analog output (current) value (see Table 12) will be set. For instance, in 2-Color mode, if the internal ambient temperature is over the limit and the attenuation is to high too, the unit outputs EIHH to the temperature display and sets an analog output current of 21 mA on the analog current loop output lines. However, since 2-Color wide band and narrow band temperatures may all be presented simultaneously through RS485 or LAN / Ethernet interface, their over and under range conditions are independent.

Following order shows the priorities of the possible failsafe conditions:

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

highest priority

lowest priority

Examples of failsafe conditions:

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
RS485 or LAN/Ethernet:	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
RS485 or LAN/Ethernet:	C T1021.0 W703.0 N685.0
Analog Output:	scaled to temperature, between 4 and 20 mA
Relay:	abnormal state

11.3. Cleaning the Lens

Keep the lens clean at all times. Any foreign matter (dust, fingerprints…) on the lens or window surface will affect 1-Color measurement accuracy and may affect 2-Color accuracy too. However, care should be taken when cleaning the lens.

To clean the window, do the following:

1. Lightly blow off loose particles with “canned” air (used for cleaning computer equipment) or a small squeeze bellows (used for cleaning camera lenses).
2. Gently brush off any remaining particles with a soft camel hairbrush 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

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

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

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

11.4. Replacing the Fiber Optic Cable

Fiber cable assemblies for LASER sighting option are not field "replaceable" without blackbody recalibration! As such, spare LASER sighting fiber cable assemblies are not available!

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.

Please be aware of the following when removing or installing cables:

- Make sure cable connectors at the sensing head and electronics enclosure are clean before removing and/or replacing the fiber optic cable.
- Replacement fiber optic cables of the same length can be recalibrated in the field by using the supplied Fiber Replacement Calibration software. Replacement fiber optic cables of different lengths require recalibration at the factory, or at a factory-authorized service center. Contact your sales representative for details.

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 be protected at all times until connected to the sensing head and electronics enclosure. 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.

11.4.1. Removing the Fiber Optic Cable

11.4.1.1. Removing the Fiber Optic Cable from the 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 (0.050") hex wrench into the optical head hex screw and turn counter clockwise 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.

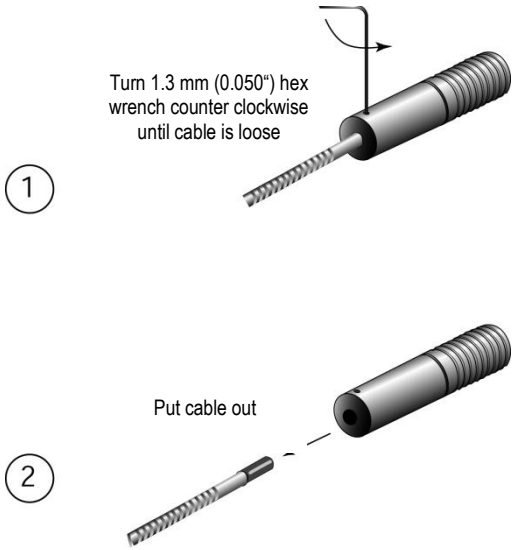


Figure 66: Removing the Fiber optic Cable from the Optical Head

11.4.1.2. Removing the Fiber Optic Cable from the Electronics Housing

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

1. First loosen the cable connecting sleeve.
2. Loosen the cable receptacle screw to release the cable.
3. Pull cable from electronics enclosure, and immediately place a protective cap over the end of the fiber optic cable. Do not use adhesive tape on the cable end.

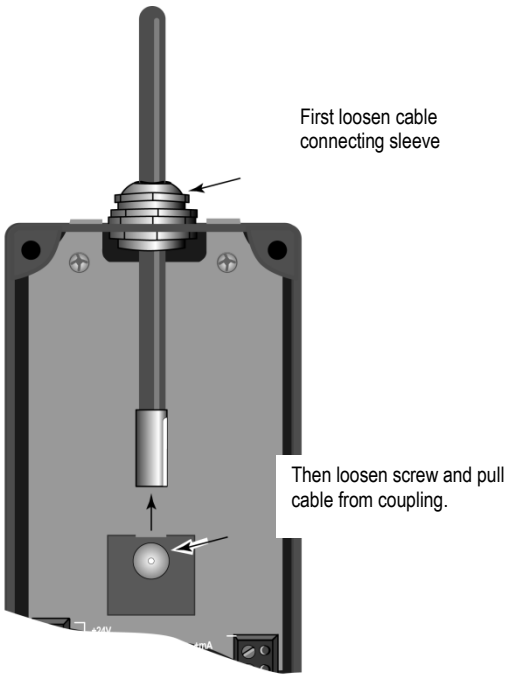


Figure 67: Removing the Fiber optic Cable from the Electronics Housing

11.4.2. Mounting the Fiber Optic Cable

11.4.2.1. Attaching the Fiber Optic Cable to the 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 (0.050") hex wrench until snug. **Do not over tighten!**

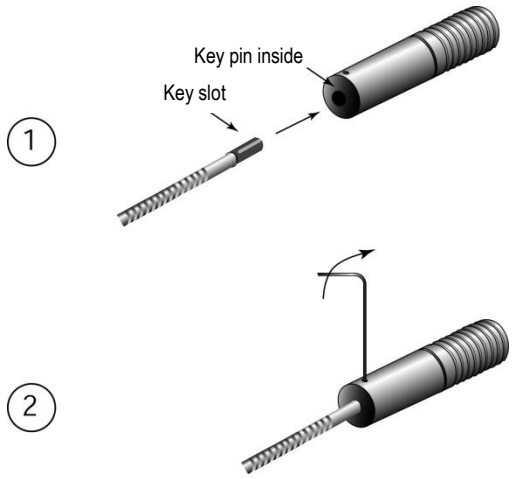


Figure 68: Attaching the Fiber optic Cable to the Optical Head

11.4.2.2. Attaching the Fiber Optic Cable to the Electronics Housing

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

1. Insert the tip of the fiber optic cable into the mating receptacle on the electronics enclosure. The cable ferrule is keyed and can go in only one way.
2. Push connecting sleeve in until it stops (approx. 15 mm / 0.6 in), see Figure 7: Connecting the Fiber Optic Cable, page 17
3. Tighten the screw (finger tighten only) on the mating receptacle.
4. Tighten the cable's compression fitting.

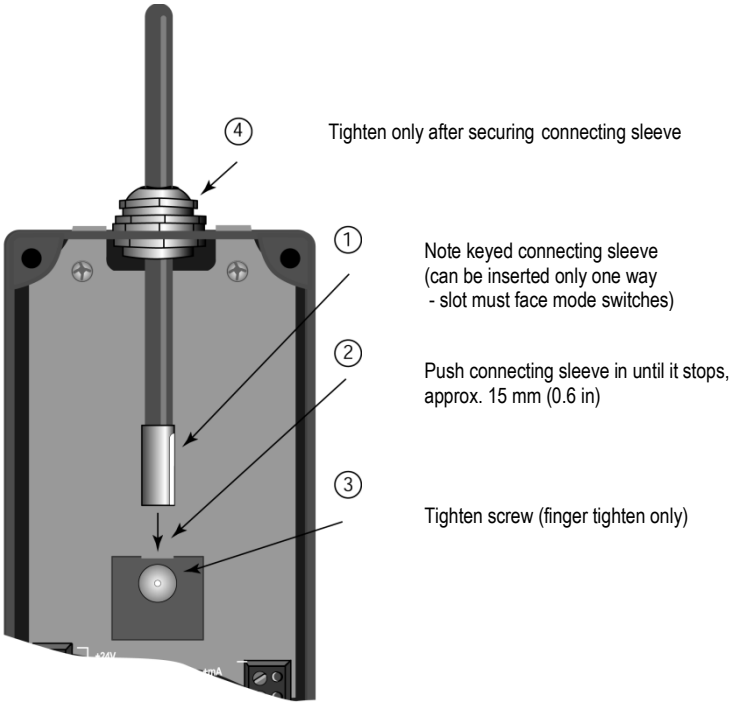


Figure 69: Attaching the Fiber Optic Cable to the Electronics Housing

11.4.3. 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 Fiber Calibration software program. This program sends the new calibration constants, through the RS485 connection, to the sensor's electronics.
The Fiber Calibration program comes with the other software programs you received. To run the program and enter new cable calibration constants, complete the following:

1. The program can not be launched from the CD. Thus you have to copy the Fiber calibration exe-file from the software CD to the hard disk of your computer, e.g. by means of the Windows Explorer.
2. For launching the program, you have to select the file and to push the <Enter> button.
3. In the following dialog you are requested to select the right COM port with the plugged unit. For establishing the communication click on the <Done> button.
4. The main screen appears. Click on the <Fiber ID> button.
5. In the following dialog you are requested to input the calibration constants for the fiber cable. The dialog must be closed with clicking on the <Finish> button.
6. The transmission of the new calibration constants to the unit is initialized by clicking on the <Download Calibration Constants> button. Attention: Do not interrupt the data transmission!
7. The click on the <Exit> button completes the recalibration of the fiber cable.

12. Addendum

12.1. Determination of Slope (for 2 – color operation)

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

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

- Stainless Steel
- 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
- Rhodium
- Tungsten
- Cobalt
- Steel
- Molybdenum
- Platinum

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.

12.2. Attenuation

Three causes may contribute to the loss of IR signal from the target:

1. Low target emissivity
2. Target is too small to fill the measured spot size
3. 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 and/or obstruction in the field of view.

The following figures show the percentage of allowed signal reduction over the temperature range of a ratio glass fiber sensor. Refer to these graphs to estimate what percentage of target area must be visible to the sensor at temperatures below the minimum temperature (95% attenuation) as shown in this manual.

12.3. Determination of Emissivity (for 1-Color operation)

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

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

1. Determine the actual temperature of the material using an RTD (PT100), a thermocouple, or any other suitable method. Next, measure the object's temperature and adjust emissivity setting until the correct temperature value is reached. This is the correct emissivity for the measured material.
2. If possible, apply flat black paint to a portion of the surface of the object. The emissivity of the paint must be above 0.98. Next, measure the temperature of the painted area using an emissivity setting of 0.98. Finally, measure the temperature of an adjacent area on the object and adjust the emissivity until the same temperature is reached. This is the correct emissivity for the measured material.

12.4. 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:

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

Table 13: Typical Emissivity Values (Metals)

Emissivity at 1 µm for Metals	
Material	**Emissivity**
Aluminum	
unoxidized	0.1-0.2
oxidized	0.4
roughened	0.2-0.8
polished	0.1-0.2
Brass	
polished	0.1-0.3
Burnished	0.6
Chromium	0.4
Copper	
polished	0.05
roughened	0.05-0.2
oxidized	0.2-0.8
Gold	0.3
Haynes	
Alloy	0.5-0.9
Inconel	
oxidized	0.4-0.9
sandblasted	0.3-0.4
electropolished	0.2-0.5
Iron	
oxidized	0.4-0.8
unoxidized	0.35
molten	0.35

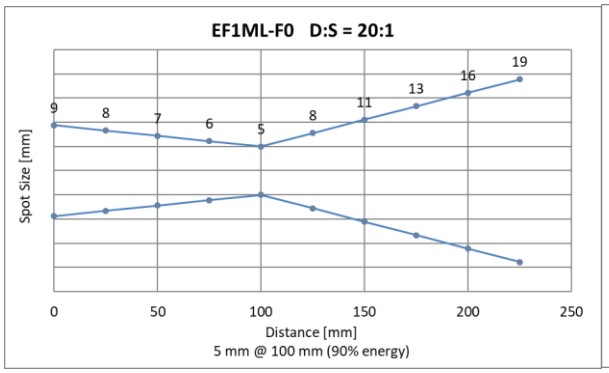
Emissivity at 1 µm for Metals	
Material	**Emissivity**
Iron, cast	
oxidized	0.7-0.9
unoxidized	0.35
molten	0.35
Magnesium	0.3-0.8
Molybdenum	
oxidized	0.5-0.9
Monel (Ni-Cu)	0.25-0.35
Nickel	
unoxidized	0.3
Oxidized	0.8-0.9
electrolytic	0.2-0.4
Silver	0.04
Steel	
cold rolled	0.8-0.9
polished sheet	0.35
molten	0.35
oxidized	0.8-0.9
stainless	0.35
Tin (unoxidized)	0.25
Titanium	
polished	0.5-0.75
Zinc	
oxidized	0.6
polished	0.5

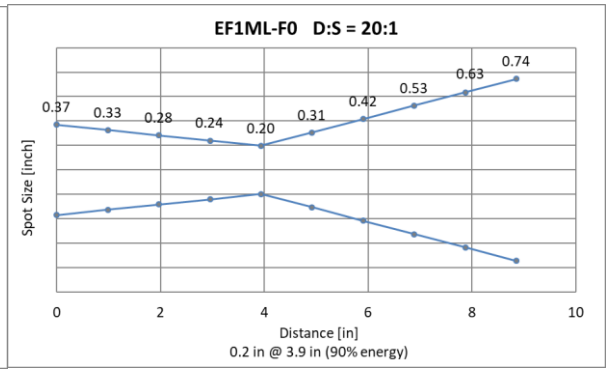
Table 14: Typical Emissivity Values (Non-Metals)

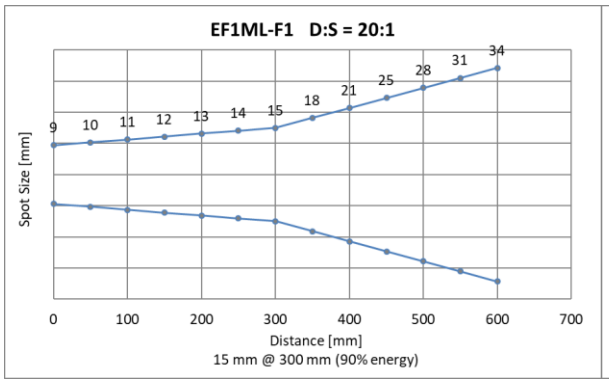
Emissivity at 1 µm for Non-Metals	
Material	**Emissivity**
Asbestos	0.9
Ceramic	0.4
Concrete	0.65
Carbon	
unoxidized	0.8-0.95
graphite	0.8-0.9

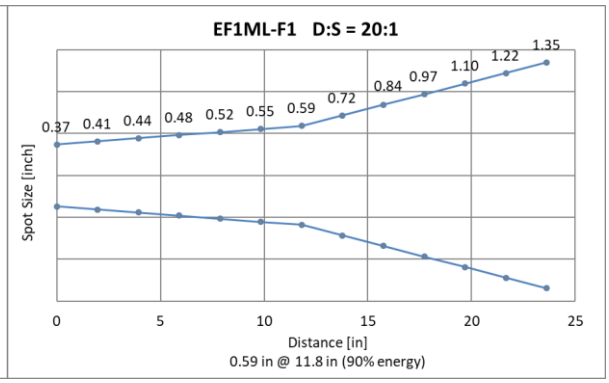
12.5. Optical Diagrams

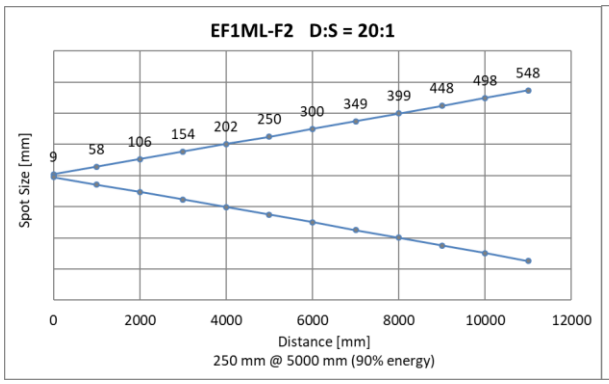
12.5.1. EF1M Models

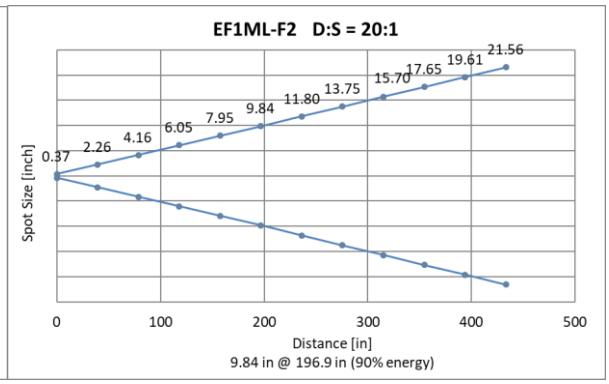


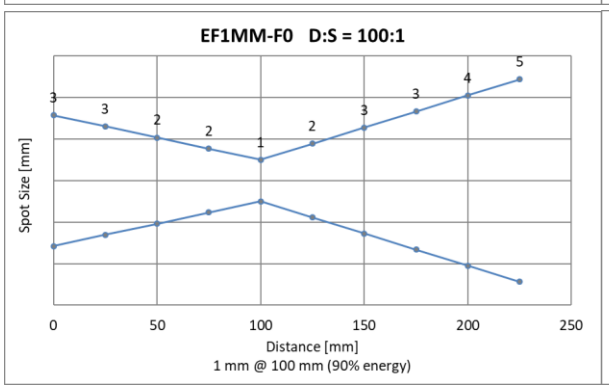


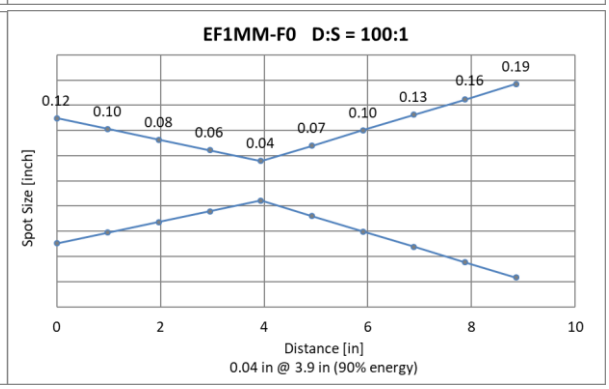


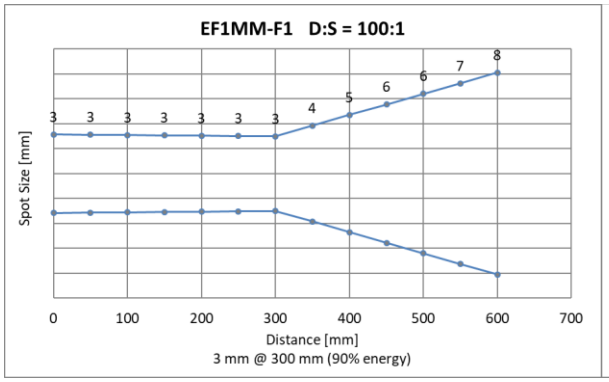


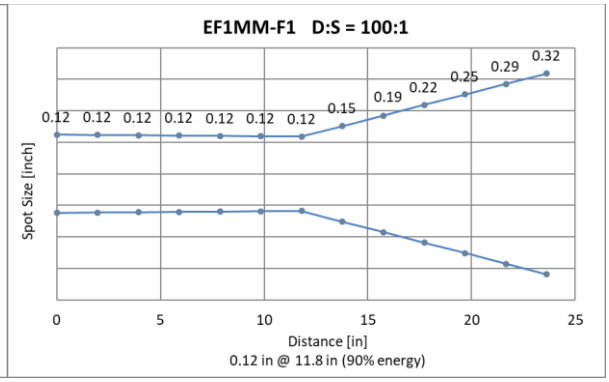


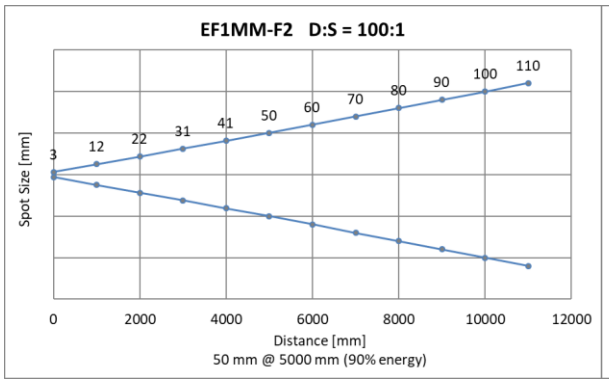


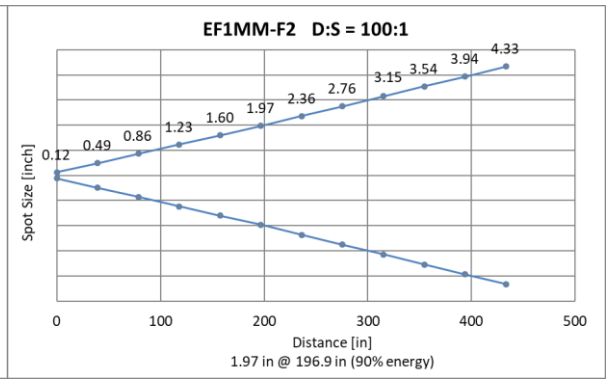


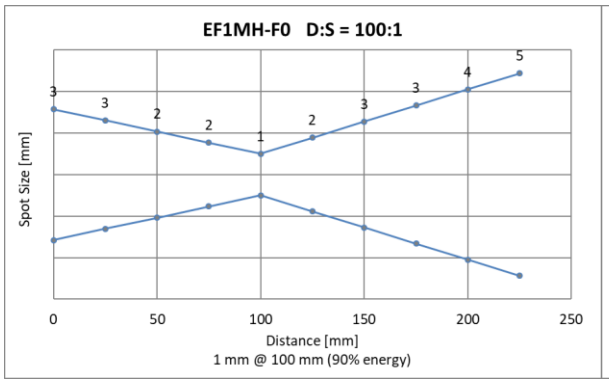


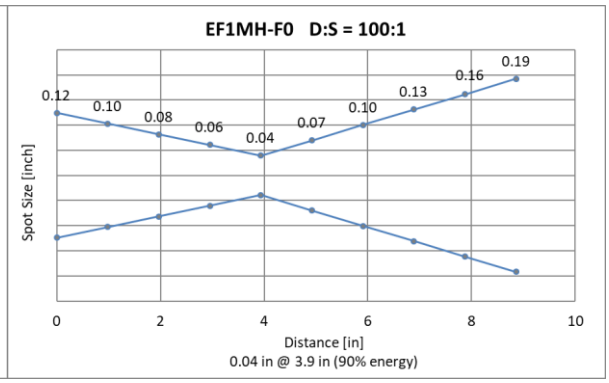

EF1MM-F1 D:S = 100:1
Spot Size [mm]
3 3 3 3 3 3 3 4 5 6 6 7 8
0 100 200 300 400 500 600 700
Distance [mm]
3 mm @ 300 mm (90% energy)

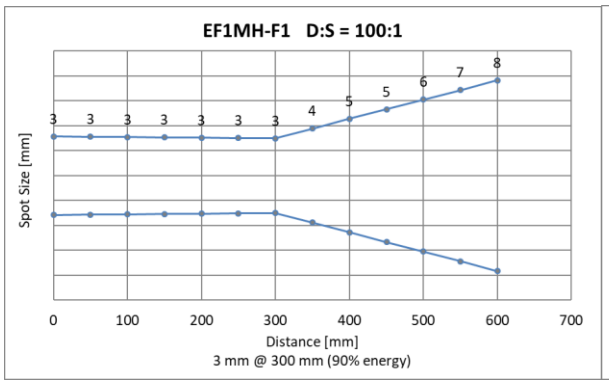

EF1MM-F1 D:S = 100:1
Spot Size [inch]
0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.15 0.19 0.22 0.25 0.29 0.32
0 5 10 15 20 25
Distance [in]
0.12 in @ 11.8 in (90% energy)

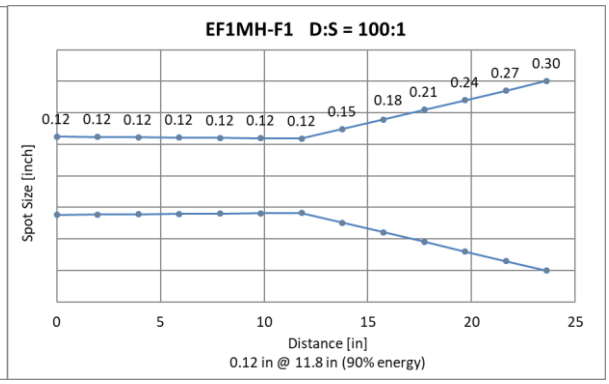

EF1MM-F2 D:S = 100:1
Spot Size [mm]
3 12 22 31 41 50 60 70 80 90 100 110
0 2000 4000 6000 8000 10000 12000
Distance [mm]
50 mm @ 5000 mm (90% energy)

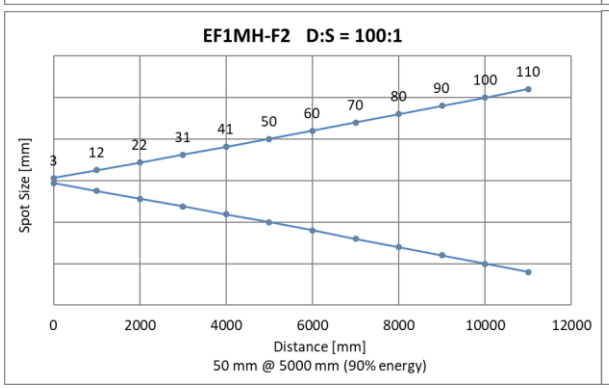

EF1MM-F2 D:S = 100:1
Spot Size [inch]
0.12 0.49 0.86 1.23 1.60 1.97 2.36 2.76 3.15 3.54 3.94 4.33
0 100 200 300 400 500
Distance [in]
1.97 in @ 196.9 in (90% energy)


EF1MH-F0 D:S = 100:1
Spot Size [mm]
3 3 2 2 1 2 3 3 4 5
0 50 100 150 200 250
Distance [mm]
1 mm @ 100 mm (90% energy)


EF1MH-F0 D:S = 100:1
Spot Size [inch]
0.12 0.10 0.08 0.06 0.04 0.07 0.10 0.13 0.16 0.19
0 2 4 6 8 10
Distance [in]
0.04 in @ 3.9 in (90% energy)


EF1MH-F1 D:S = 100:1
Spot Size [mm]
3 3 3 3 3 3 3 4 5 6 7 8
0 100 200 300 400 500 600 700
Distance [mm]
3 mm @ 300 mm (90% energy)


EF1MH-F1 D:S = 100:1
Spot Size [inch]
0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.15 0.18 0.21 0.24 0.27 0.30
0 5 10 15 20 25
Distance [in]
0.12 in @ 11.8 in (90% energy)


EF1MH-F2 D:S = 100:1
Spot Size [mm]
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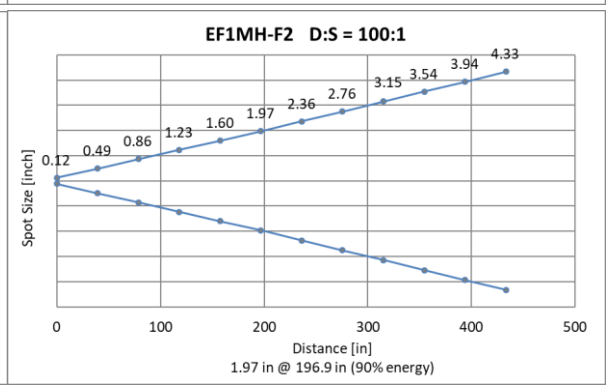
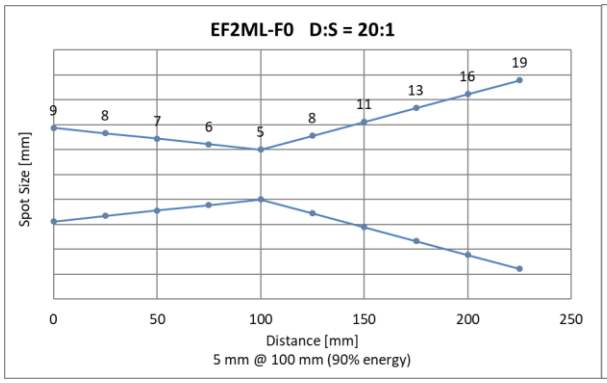
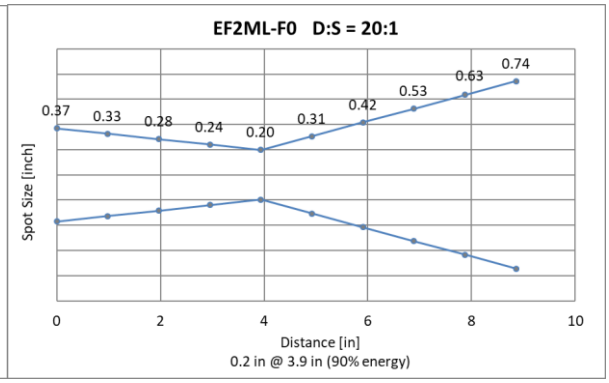
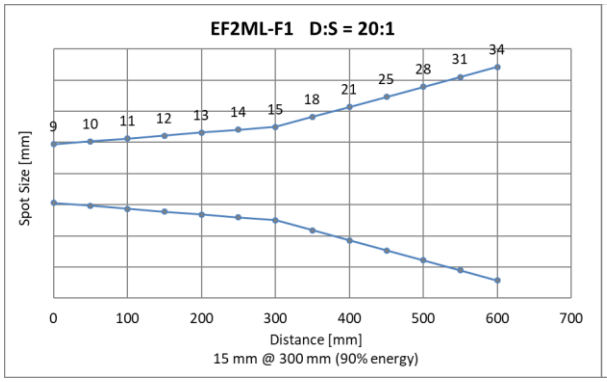
0 2000 4000 6000 8000 10000 12000
Distance [mm]
50 mm @ 5000 mm (90% energy)

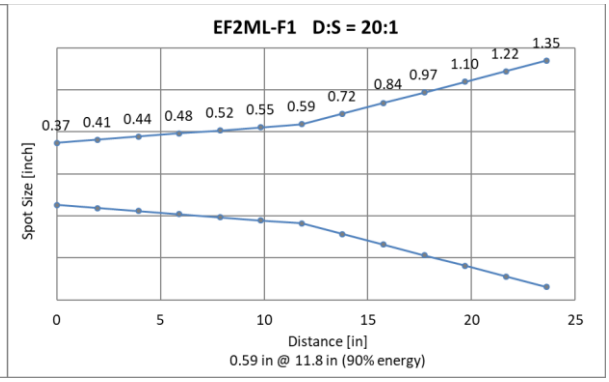

EF1MH-F2 D:S = 100:1
Spot Size [inch]
0.12 0.49 0.86 1.23 1.60 1.97 2.36 2.76 3.15 3.54 3.94 4.33
0 100 200 300 400 500
Distance [in]
1.97 in @ 196.9 in (90% energy)

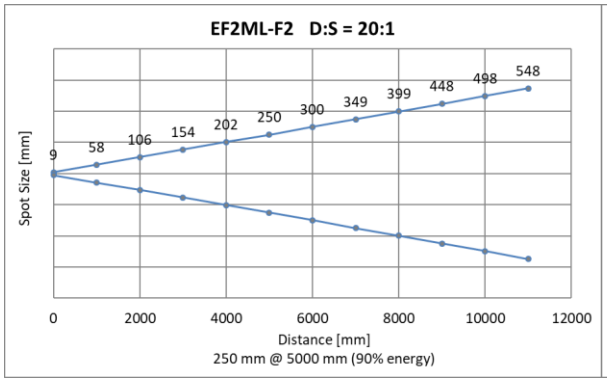
12.5.2. EF2M Models

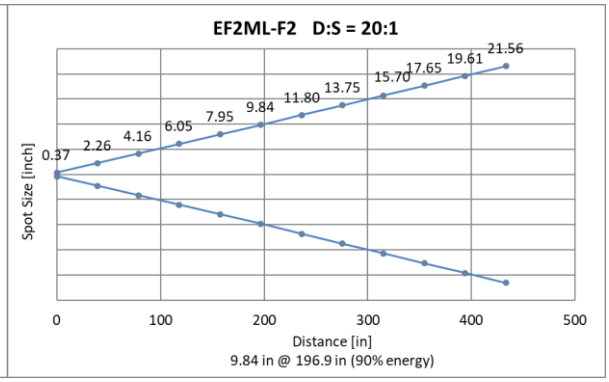


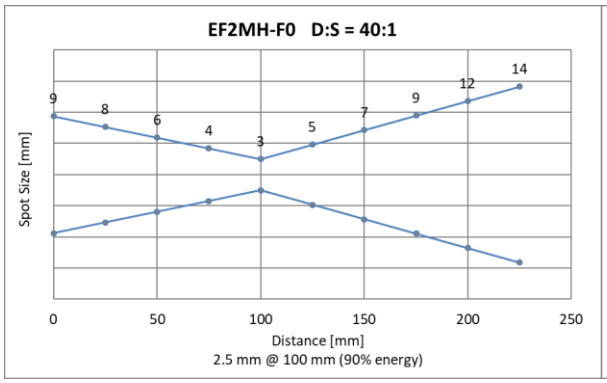


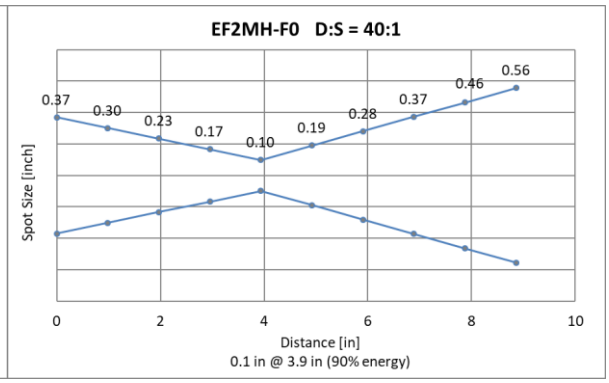


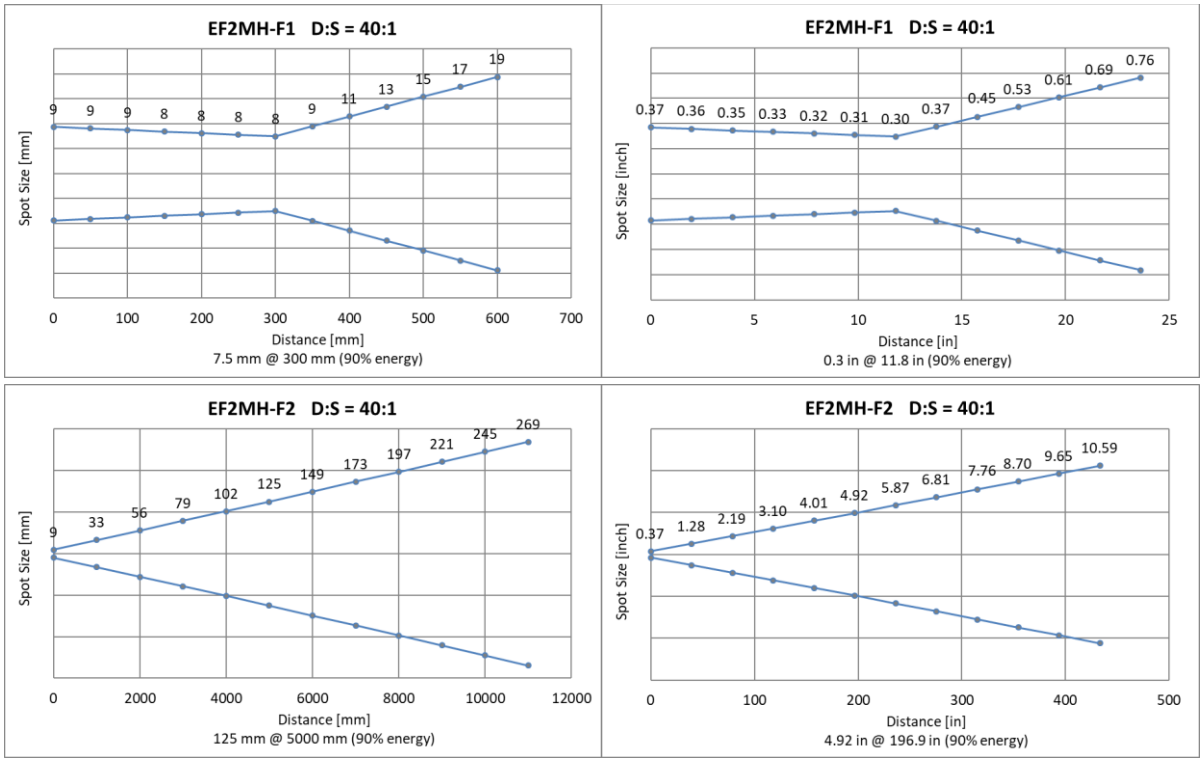




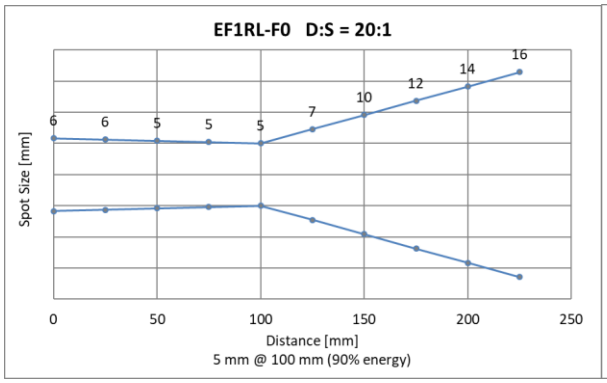


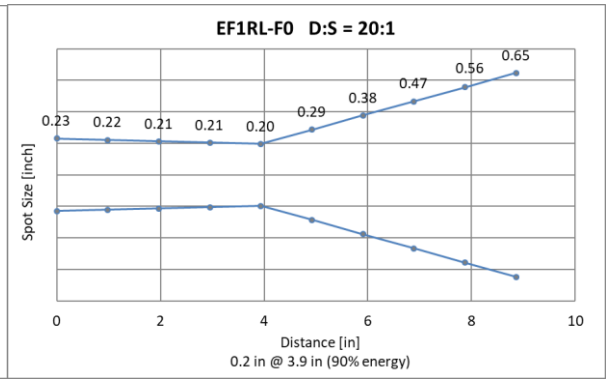


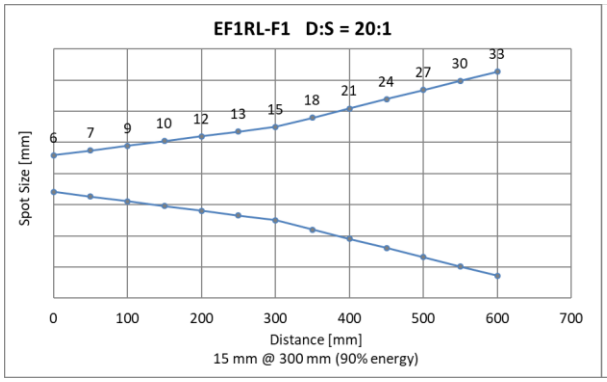


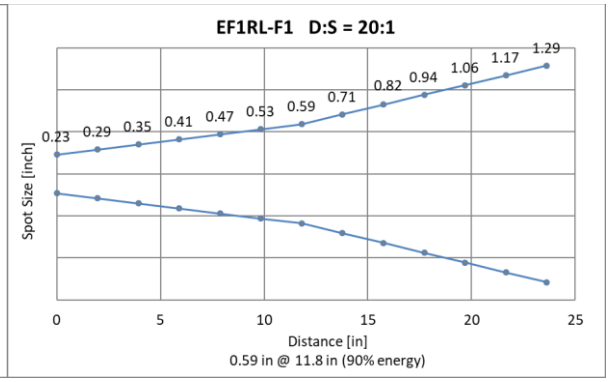

EF2MH-F1 D:S = 40:1
Spot Size [mm]
9 9 9 8 8 8 8 9 11 13 15 17 19
0 100 200 300 400 500 600 700
Distance [mm]
7.5 mm @ 300 mm (90% energy)
EF2MH-F1 D:S = 40:1
Spot Size [inch]
0.37 0.36 0.35 0.33 0.32 0.31 0.30 0.37 0.45 0.53 0.61 0.69 0.76
0 5 10 15 20 25
Distance [in]
0.3 in @ 11.8 in (90% energy)
EF2MH-F2 D:S = 40:1
Spot Size [mm]
9 33 56 79 102 125 149 173 197 221 245 269
0 2000 4000 6000 8000 10000 12000
Distance [mm]
125 mm @ 5000 mm (90% energy)
EF2MH-F2 D:S = 40:1
Spot Size [inch]
0.37 1.28 2.19 3.10 4.01 4.92 5.87 6.81 7.76 8.70 9.65 10.59
0 100 200 300 400 500
Distance [in]
4.92 in @ 196.9 in (90% energy)

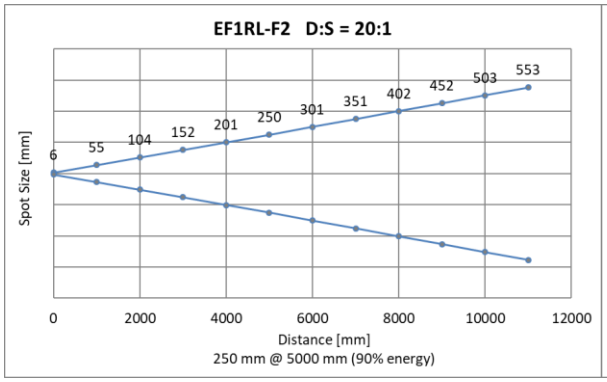
12.5.1. EF1R Models

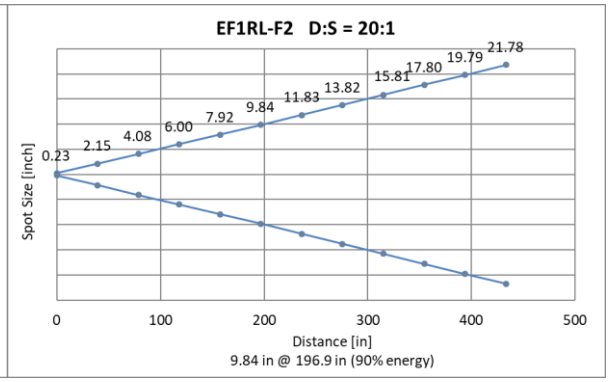


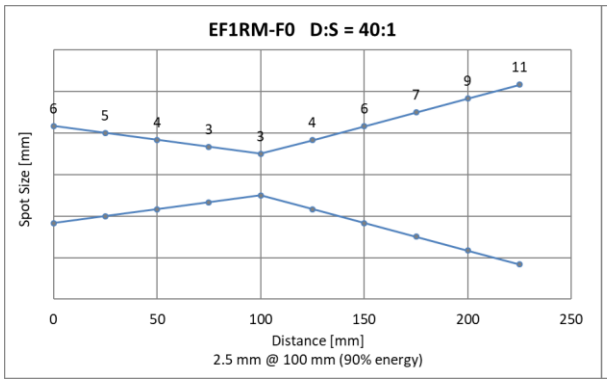


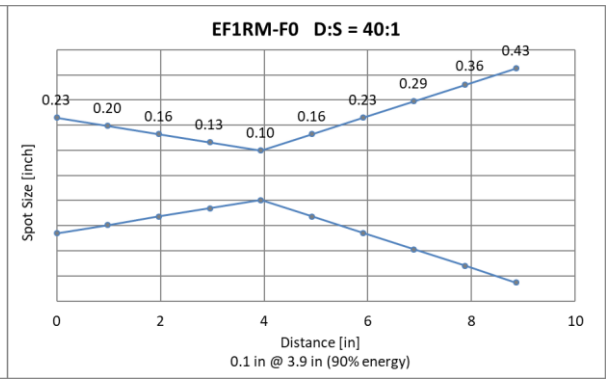


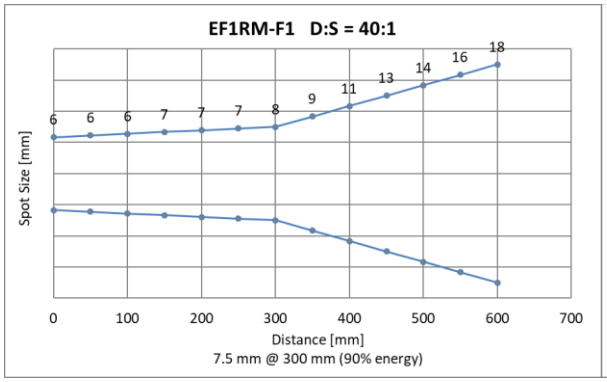


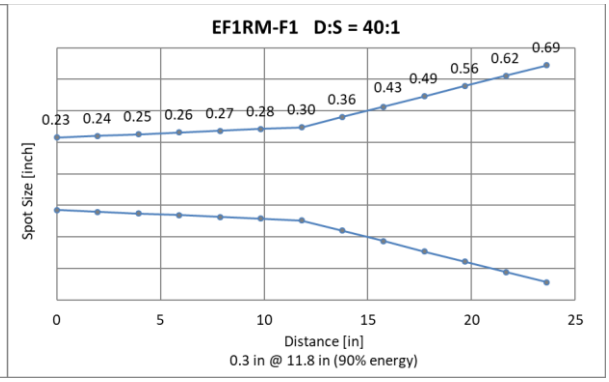


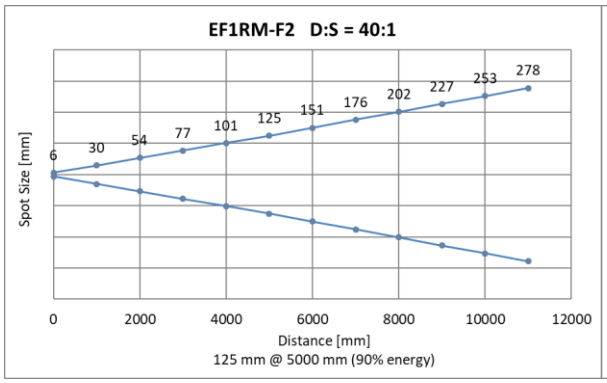


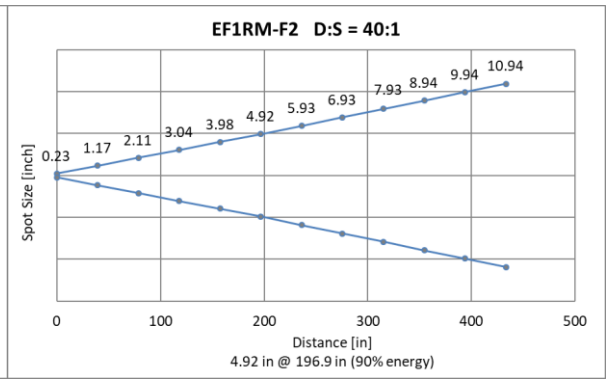


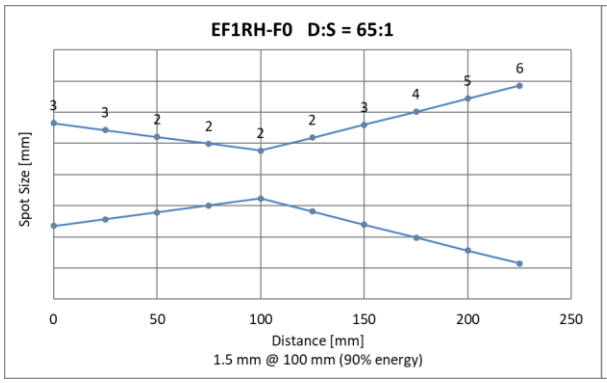


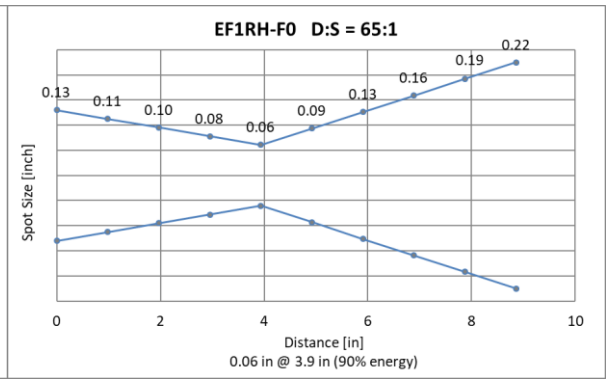

EF1RM-F1 D:S = 40:1
Spot Size [mm]
6 6 6 7 7 7 8 9 11 13 14 16 18
0 100 200 300 400 500 600 700
Distance [mm]
7.5 mm @ 300 mm (90% energy)

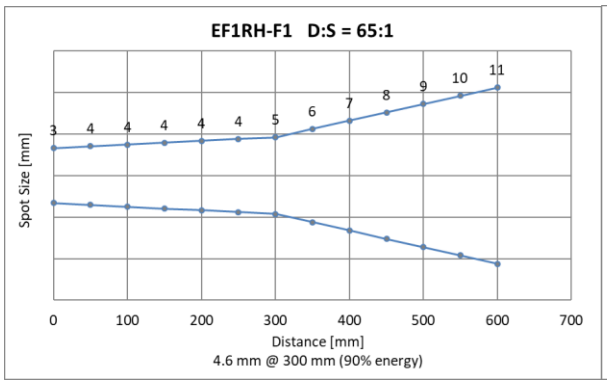

EF1RM-F1 D:S = 40:1
Spot Size [inch]
0.23 0.24 0.25 0.26 0.27 0.28 0.30 0.36 0.43 0.49 0.56 0.62 0.69
0 5 10 15 20 25
Distance [in]
0.3 in @ 11.8 in (90% energy)

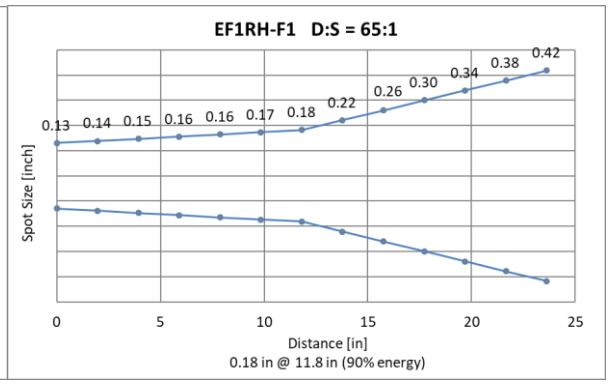

EF1RM-F2 D:S = 40:1
Spot Size [mm]
6 30 54 77 101 125 151 176 202 227 253 278
0 2000 4000 6000 8000 10000 12000
Distance [mm]
125 mm @ 5000 mm (90% energy)

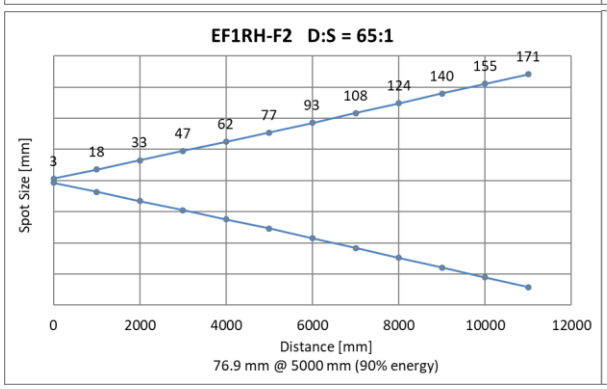

EF1RM-F2 D:S = 40:1
Spot Size [inch]
0.23 1.17 2.11 3.04 3.98 4.92 5.93 6.93 7.93 8.94 9.94 10.94
0 100 200 300 400 500
Distance [in]
4.92 in @ 196.9 in (90% energy)

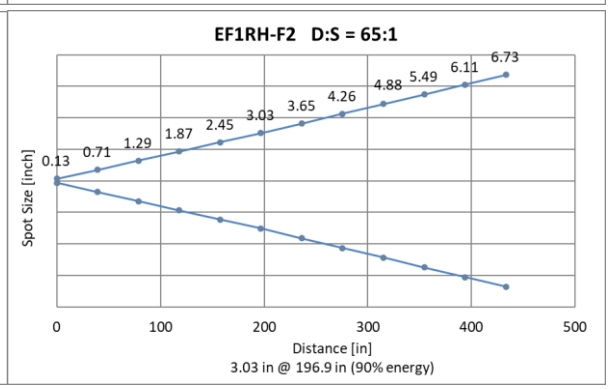

EF1RH-F0 D:S = 65:1
Spot Size [mm]
3 3 2 2 2 2 3 4 5 6
0 50 100 150 200 250
Distance [mm]
1.5 mm @ 100 mm (90% energy)


EF1RH-F0 D:S = 65:1
Spot Size [inch]
0.13 0.11 0.10 0.08 0.06 0.09 0.13 0.16 0.19 0.22
0 2 4 6 8 10
Distance [in]
0.06 in @ 3.9 in (90% energy)

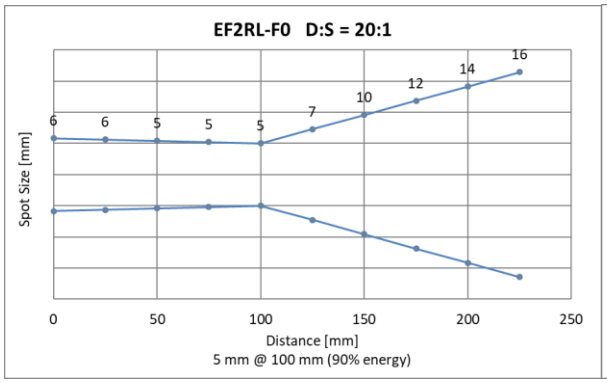

EF1RH-F1 D:S = 65:1
Spot Size [mm]
3 4 4 4 4 4 5 6 7 8 9 10 11
0 100 200 300 400 500 600 700
Distance [mm]
4.6 mm @ 300 mm (90% energy)

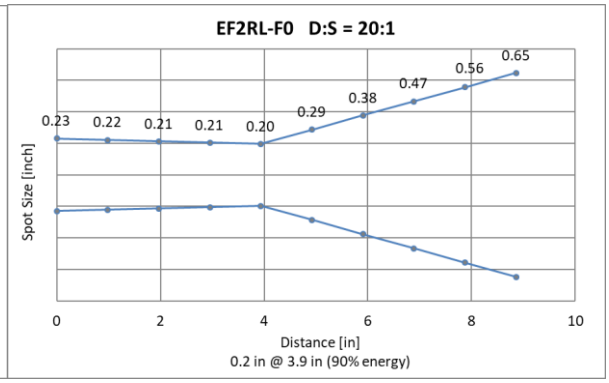

EF1RH-F1 D:S = 65:1
Spot Size [inch]
0.13 0.14 0.15 0.16 0.16 0.17 0.18 0.22 0.26 0.30 0.34 0.38 0.42
0 5 10 15 20 25
Distance [in]
0.18 in @ 11.8 in (90% energy)

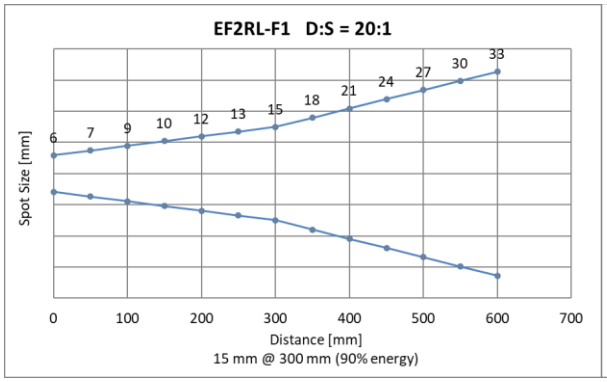

EF1RH-F2 D:S = 65:1
Spot Size [mm]
3 18 33 47 62 77 93 108 124 140 155 171
0 2000 4000 6000 8000 10000 12000
Distance [mm]
76.9 mm @ 5000 mm (90% energy)

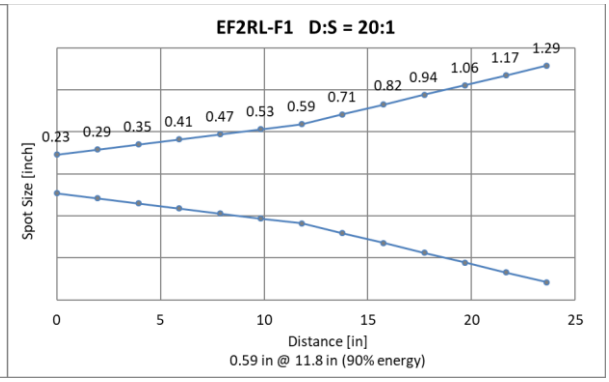

EF1RH-F2 D:S = 65:1
Spot Size [inch]
0.13 0.71 1.29 1.87 2.45 3.03 3.65 4.26 4.88 5.49 6.11 6.73
0 100 200 300 400 500
Distance [in]
3.03 in @ 196.9 in (90% energy)

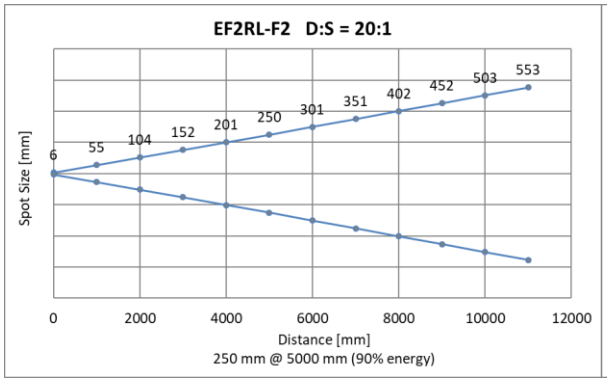
12.5.1. EF2R Models

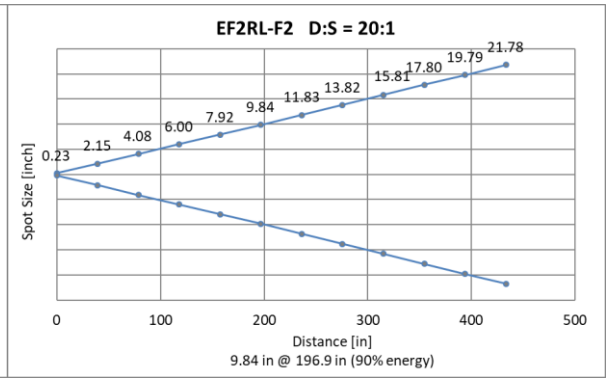


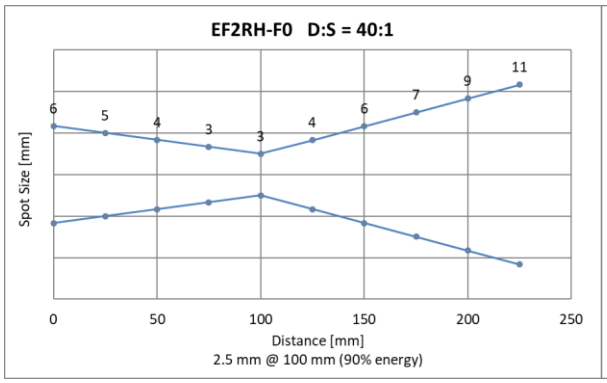


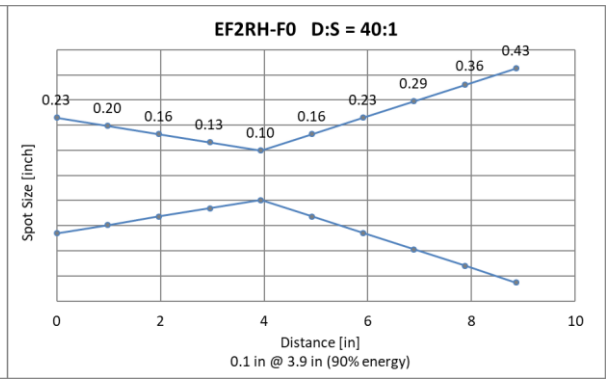


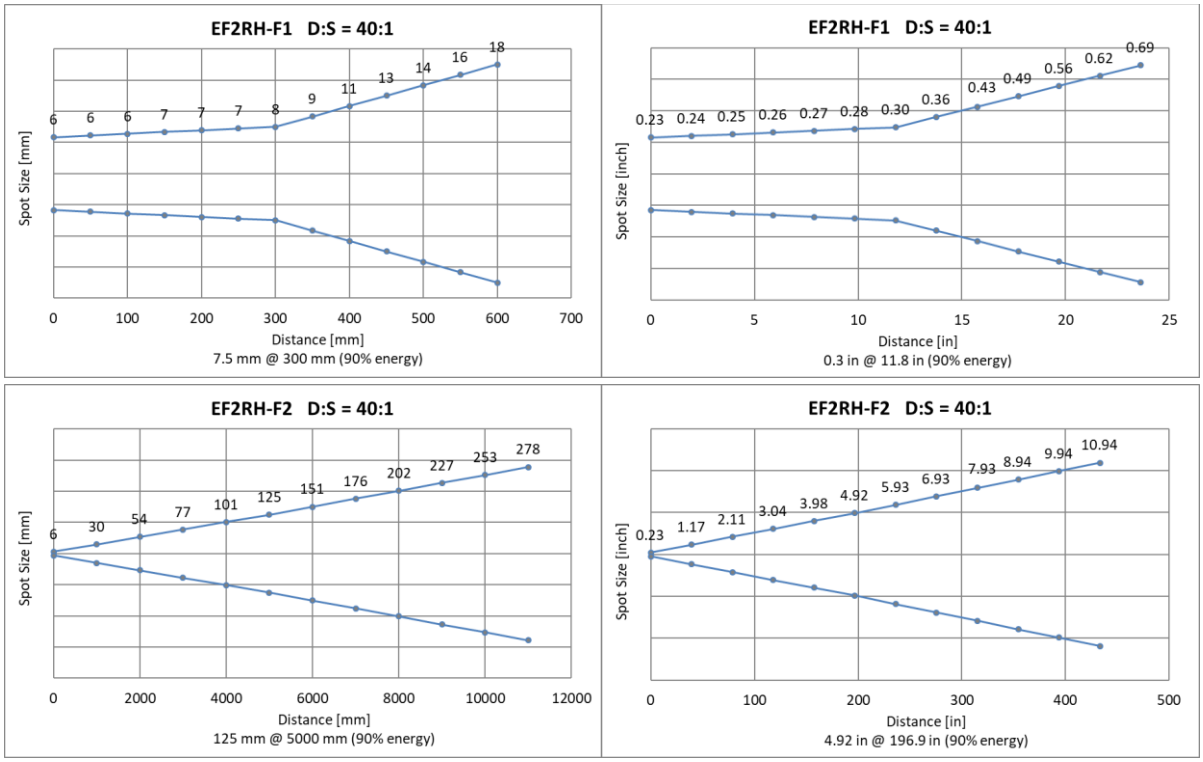











EF2RH-F1 D:S = 40:1
Spot Size [mm]
6 6 6 7 7 7 8 9 11 13 14 16 18
0 100 200 300 400 500 600 700
Distance [mm]
7.5 mm @ 300 mm (90% energy)
EF2RH-F1 D:S = 40:1
Spot Size [inch]
0.23 0.24 0.25 0.26 0.27 0.28 0.30 0.36 0.43 0.49 0.56 0.62 0.69
0 5 10 15 20 25
Distance [in]
0.3 in @ 11.8 in (90% energy)
EF2RH-F2 D:S = 40:1
Spot Size [mm]
6 30 54 77 101 125 151 176 202 227 253 278
0 2000 4000 6000 8000 10000 12000
Distance [mm]
125 mm @ 5000 mm (90% energy)
EF2RH-F2 D:S = 40:1
Spot Size [inch]
0.23 1.17 2.11 3.04 3.98 4.92 5.93 6.93 7.93 8.94 9.94 10.94
0 100 200 300 400 500
Distance [in]
4.92 in @ 196.9 in (90% energy)