MEMBER OF THE NYNOMIC GROUP

Pyrometers
METIS M311 / M322
METIS H311 / H322

Pyrometer series optimized especially for laser applications. With letter identifier M or N.
With 12-pin connector, display and push button device configuration.

Operating Manual

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1 General

1.1 Information to this Manual

This manual is valid for the products listed on the front page, using original parts from Sensortherm.
This manual enables the safe and efficient use with the device. The manual is part of the instrument and has to be kept in a location where users always have access to.
Read this manual carefully before operating. For secure working all security notes and operation procedures in this manual has to be followed.
Additionally, the local accident prevention regulations and common safety regulations of the instruments' operational area are valid.
The descriptions may differ from the current delivery status since the pyrometer is continuously developed. Illustrations in this manual are for basic understanding and can differ from the actual construction.

1.2 CE Conformity

The product conforms to the following EU directives:
2011/65/EU RoHS
2014/30/EU Electromagnetic Compatibility
DIN EN 60825-1:2015, laser class 2

CE

1.3 Limitation of Liability

All information and notes in this manual are made under consideration of valid standards and rules, state of technology and our expert knowledge for many years.
The producer assumes no liability for damages due to:

- Non-observance of this manual
- Usage out of intended use
- Assignment of unskilled personnel
- Unauthorized modifications
- Technical modifications
- Usage of spare parts not approved.

1.4 Terms of Warranty

The general terms and conditions for sales and services of Sensortherm GmbH apply.

1.5 Devices with PID controller

The PID controller has been designed to control temperatures in a variety of applications, especially for controlling fast processes. The temperature control accuracy depends on the appropriate choice of control parameters and on the process itself. Sensortherm excludes process responsibility.

1.6 Copyright

1.7 Spare Parts

It is recommended to purchase spare parts and accessories direct from Sensortherm (manufacturer).

1.8 Returning Goods

An **RMA number** must be requested for each device to be sent in. You will find an RMA application form on our website https://www.sensortherm.de/en/repair-service/, which can be provided with your address, the device data and a reason for sending it in. However, you can also contact us directly and will then receive an RMA form that must be filled out and sent to us by e-mail. Once we have received the data and entered it into our system, you will receive a confirmation e-mail from us with your data and the RMA number. Print out this e-mail and enclose it with the shipment.
Shipments that arrive with us freight collect and shipments without an RMA number cannot be processed.
Please return items in suitable packaging to avoid damage in transit.

1.9 Disposal

Do not dispose of the product in the household waste (WEEE Directive).
Dispose of the product properly when it is no longer usable: pyrometers include electrical and electronic waste and have to be recycled or disposed environmentally friendly or to send to the manufacturer for disposal.

2 Safety

2.1 Use of the Manual

- Any person who is going to work with the device must have read and understood the operating manual before beginning.
- Operation and maintenance of the system is only to be performed by trained personnel.
- This manual is to be kept and handed over when passed on.

2.2 Supplementary Information about the Operation

The following symbol is used to simplify the search for useful information:

INFO indicates useful tips, recommendations and information for efficient and trouble-free operation.

2.3 Warning Notes

The following symbols are used in this manual and, if applicable, on the device as a mark for information, restrictions, preventive measures and security notes. This information indicates risks and how they can be avoided.
Please pay attention to these symbols for safety reasons.

⚠ CAUTION The hazard symbol with the signal word CAUTION on a yellow background indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.

NOTICE indicates a potentially hazardous situation that can lead to property and environmental damage if not avoided.

SAFETY INSTRUCTIONS indicate specific safety-related instructions or procedures.

2.4 Safety Labels / Symbols

Additionally to the warning notes used in this manual, the following warning symbols are used. Warning symbols are also to find on the device. Follow all measures marked with the label to avoid injury.

 Indicates **general hazards**.	 Indicates the **hazard for the eyes** from **optical radiation**.
 Indicates the **hazard for the eyes** due to a class 2 **laser targeting light**.	 Indicates the **hazard** of **automatic startup** of machine parts.

2.5 Device Labels

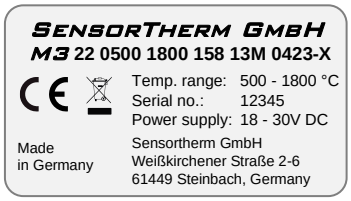
On the top of the device there is the type label (nameplate) as well as a warning sticker for the laser targeting light.

- Mount the device in a manner that the labels are still clearly visible after installation.
- Keep the warning signs in always legible condition.
- Replace damaged labels.

2.6 Identification Label

The identification label on top of the device shows information to:

- Manufacturing company
- Series / order number (for breakdown see chap. **9.2**)
- Temperature range, device number and power supply
- CE sign and crossed-out waste container product mark (see **1.9 Disposal**)
- Country of manufacture, manufacturing company and address

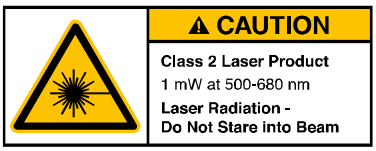


2.7 Laser Targeting Light

For easy alignment, the pyrometers are equipped with a laser targeting light, laser class 2. The laser emits a visible red light with a maximum power of < 1 mW and a wavelength around 650 nm.

Laser warning label on the device (depending on the country of delivery)**:**

US sticker



EU sticker

SAFETY INSTRUCTIONS

- Never look into the direct or reflected laser beam.
- Do not point the laser to anyone.
- If laser radiation hits the eye, avert one's eyes immediately.

2.8 Electrical Connection

When connecting or when working on the mains voltage, the general safety guidelines are to be observed, e.g., when connecting power transformers. Supply voltage can be lethal when touching. Improper installation can cause serious injury or physical damage. Only qualified personnel are allowed to work with mains voltage.

2.9 Responsibility of the Operator

If the device is used in the commercial sector the operator is subject to the legal responsibilities for workplace safety.
In addition to the safety instructions in this manual follow the regulations of safety, accident prevention and environmental protection. If the device is integrated into a system, the safety of the system in which the device is integrated is in the responsibility of the installer of the system.

3 Overview

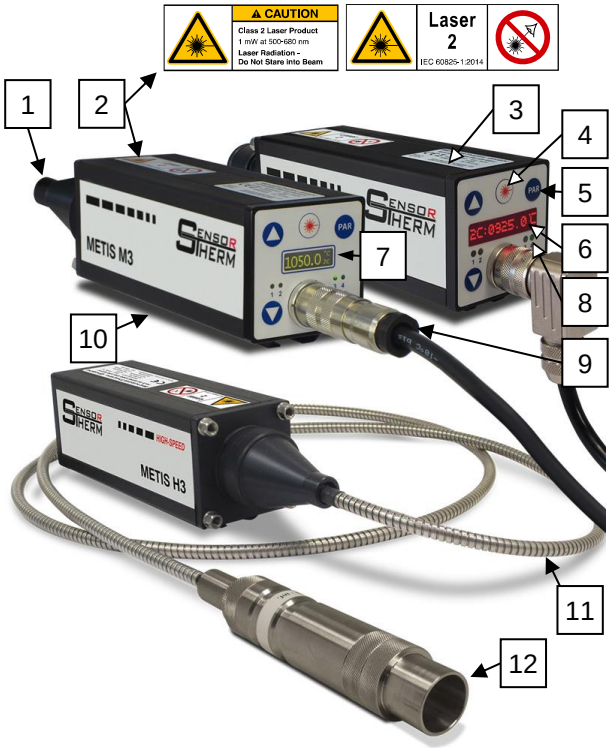
3.1 Intended Use

The 2-color pyrometers of the series Metis M3 and H3 with letter identifier M or N (see **9.2**, type number) are devices for non-contact infrared temperature measurement, optimized especially for laser applications. They are suitable for measurements on metals, ceramics, graphite and similar with temperature ranges between 300 and 3300°C (M3) or 350 and 3300°C (H3), depending on the model.

3.2 Scope of Delivery

Pyrometer, software *SensorTools,* works certificate, operating manual
(connecting cables are not included in scope of delivery and have to be ordered separately).

3.3 Model Design



1	Tube to protect the optical fiber connection
2	Laser warning label (depending on the country of delivery)
3	Device identification label
4	Laser targeting light push button
5	Keypad
6	Red LED display (devices up to ca. 10/2020)
7	Green-yellow OLED display (devices from ca. 10/2020)
8	LEDs to indicate operating status and active switching outputs
9	Connectors for power supply, 2 linear analog current outputs, a serial interface (M3: RS232 / RS485 switchable; H3: RS485) and 3 configurable inputs / outputs
10	Mounting rail
11	Optical fiber for transporting the infrared radiation to the pyrometer
12	Fiber optics with adjustable focus distance

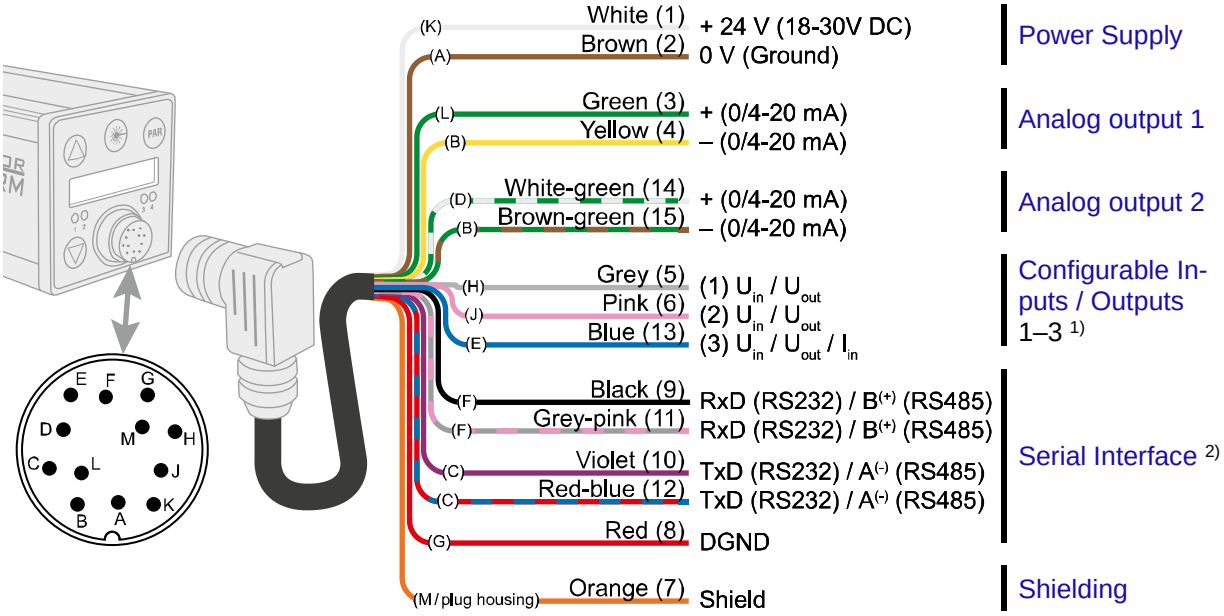
3.4 Device / Software Features

All functions described require the latest firmware on the pyrometer. If something is missing or is described differently than on your device, we recommend updating to the latest firmware (see **8 *SensorFlash* Software (firmware update)**.

4 Electrical Connection

4.1 Cable Colors and Pin Assignment (14-wire connection cables)

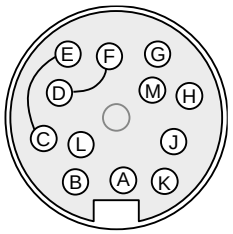
The electrical connection of the pyrometer (supply voltage and measuring signal) will be done via the connector on the rear panel. For this purpose, pre-assembled connection cables are available as accessories (see **9.3 Accessories**). To prevent accidental short circuits, cable wires not in use should be secured by using the supplied screw terminals.



1) Reference potential 0 V, brown
2) H3 models only RS485

NOTICE **We generally recommend the use of the current 14-wire connection cables. Precaution when using 12-wire connection cables that were delivered before 2015:**
Connection cable for the previous models METIS and SIRIUS cannot be connected without restrictions on a M3 / H3 pyrometer!

Connection cables delivered before 2015 are bridged in the cable connector on pins E-C and D-F. Connecting such a cable to a M3 pyrometer, serial interface and analog output 2 and digital input / output 3 are connected and the galvanic isolation between the outputs is bypassing. Thereby the pyrometer is not destroyed, but the functions are no longer available. Using such a cable only analog output 1 is available as output.

Cable colors old Sensortherm cable	Function	Pins	
White	Power supply +24 V DC	K	
Brown	Power supply 0 V DC (ground)	A	
Green	+ Analog output (0/4–20 mA)	L	
Yellow	- Analog output (0/4–20 mA)	B	
Grey	Targeting light, external switch (bridge to K)	H	
Pink	Maximum value storage, external clearing (bridge to K)	J	
Orange	Screen	M	
Red	DGND (Ground for interface)	G	
Black	RxD (RS232) or B1 (RS485)	F	
Violet	TxD (RS232) or A1 (RS485)	C	
Grey / pink	RxD (RS232) or B2 (RS485) (bridge to F)	D	
Red / blue	TxD (RS232) or A2 (RS485) (bridge to C)	E	

Connector pins cable socket (solder side)

4.1.1 Factory Settings

Parameters	Factory Settings
Display	2-color temperature
Temperature sub range	Corresponds to basic range
Response time t_{90}	Min (corresponds to: M3: <1 ms; H3: <80 µs)
Emissivity slope	1.000
Switch-off limit	10%, hysteresis: 2%
Switch-off verification	0 ms
Emissivity ε (channel 1 and 2)	1.00 (corresponds to 100%)
Transmittance	100%
Spot size fill factor	100%
Serial interface RS232 / 485	RS485
Data transmission speed (baud rate)	115.2 kBd
Buffer mode	off (at “on”: buffer interval: 100 ms, single reading)
Upscale Burnout function	off
Device address	00
Interface delay	00 (for RS232 and RS485)
Maximum value storage	off
Laser targeting switch-off time	180 s
Analog output 1	4–20 mA, output temperature: measured temperature
Analog output 2	4–20 mA, output temperature: no temperature output
Digital input / output 1	set to input: external switching on / off targeting light
Digital input / output 2	set to input: maximum value storage external clearing
Digital input / output 3 / Analog in	set to input: no function
Input debounce time	100 ms
Output activation time	0 ms
Output hold time	10 ms
Limit switch:	center of temp. range °C / °F; hysteresis: 10°C / 20°F
Device over temperature:	50°C / 120°F; hysteresis: 2°C / 5°F

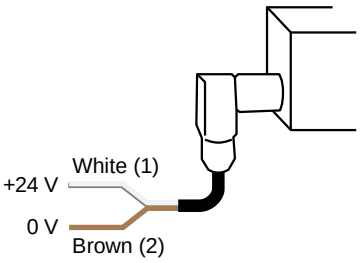
With integrated PID controller:

Analog output 2	0-20 mA, output set to control output	P-zsc	100%
Digital input / output 2	Digital input: controller start	P-max	100%
Setpoint	Center of temp. range	P-min	0%
Proportional band Xp	1%	P-Dyn	100%
Derivative time Td	0 ms	AutoTune	at each start (AutoTune power: 50%)
Integral time Ti	10 ms	Ramp time	0 ms
Sampling time	10 ms	Hold time	0 ms
Ramp time	0 ms		

INFO **to baud rate:** The factory setting of the baud rate is set to 115.2 kBd to ensure also at longer interface cables a working data transfer. For data transmissions with the highest speed, baud rate and buffer mode must be adjusted (see **7.1.4.12**).

4.1.2 Power Supply

With connection to the supply voltage (standard is 24 V DC, possible range 18–30 V) the unit is ready for operation with the factory settings. H3 devices are thermostated and need a while to be ready for operation, until that the display shows "warm-up", the software shows "Wait". By connecting the power supply, the current firmware version is displayed for a few seconds on the display.
Interrupt the power supply to turn off the pyrometer, e.g., by disconnecting the connector.

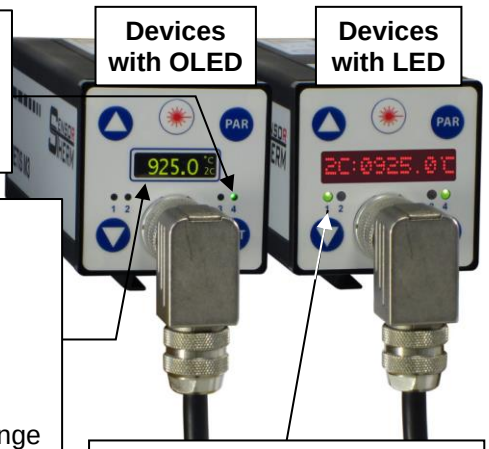


4.1.2.1 Displays on the Device

LED 4: operating status:
- **Orange:** self-test phase (M3 ca. 2 s; H3 during the initialization and thermostatic phase for ≤ 3 min.)
- **Green**: Pyrometer is ready for operation.
- **Red:** a device error occurred (see **10.3 Troubleshooting**)

Main display:
- **Measured temperature** with **temperature unit °C** or **°F**.
  Additional displays:
  2C: 2-color temperature
  C1: 1-color temperature channel 1
  C2: 1-color temperature channel 2
  Special displays:
  – – – – Measuring temp. below beginning of temperature range
  OVER Measuring temperature above end of temp. range

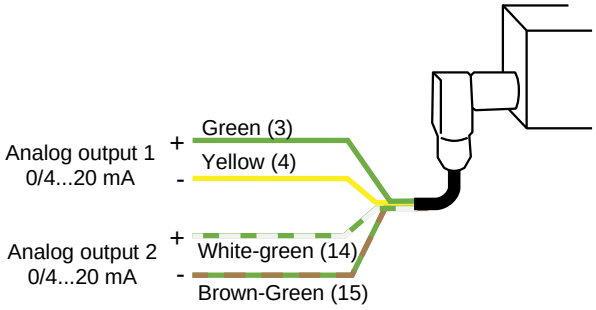
  Device display set to „Suppressed“ in section **7.1.4**):
  – – – – – – – – – – devices with LED display
  No display devices with OLED display
- **Device menu / parameters** (see **6.2**)



LEDs 1, 2, 3:
Green: shows activated digital outputs (see **4.1.4 configurable inputs / outputs**).

4.1.3 Analog Outputs

2 analog outputs are available (e.g. for an external temperature display device):
- adjustable to **0–20 mA** or **4–20 mA**
- **Analog output 1** always provides the measured temperature (always the temperature displayed on the device display or the control window or Devices Tab in *SensorTools*).
- **Analog output 2** can be assigned to provide different signals:
  - **2-color temperature**
  - **1-color temperature**, optional channel 1 or 2
  - **Control output** (= manipulated variable) when equipped with a PID controller
  - **Device temperature**

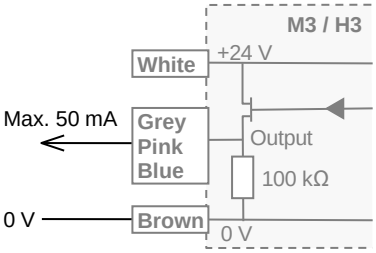


The outputs are galvanically isolated from the supply voltage

INFO **on older models:** If the same settings are possible on analog output 1 as on analog output 2, the device has an older firmware version. A firmware update to the latest version eliminates this possibility and thus prevents the analog output 1 from accidentally provide a different temperature signal than is displayed (Firmware update see section **8**).

4.1.4 Configurable Inputs / Outputs

3 ports are each available as:



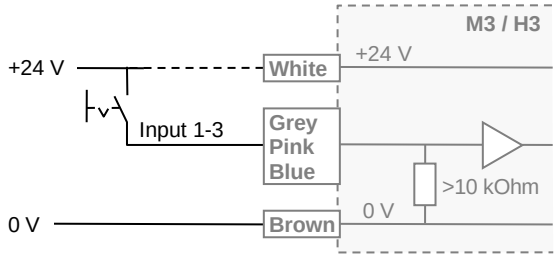
- **Digital output** provides a switching signal:
  - **Device ready to operate**: device ready and error-free after self-test.
  - **Material detection** (only M3): turns on when exceeding the beginning of temperature range.
  - **Limit switch** when a certain temperature threshold is exceeded or falling below.
  - Exceeding the maximum allowed **internal device temperature**.
  - **Signal strength too low** (for use as pollution monitoring: allows to detect the degree of contamination of the optics or of a viewing window or to identify interferences (dust ...) in the IR sensor's sight path and trigger an alarm if necessary).

- When equipped with PID controller: **controller activity, control within definable setpoint limits, control completed successfully, hold time finished.**

INFO The maximum output current is limited to 50 mA.

INFO The logic of the signal can be inverted (see **7.1.4 Device configuration → Logic** NO / NC)

- **Digital inputs** for activating functions via voltage pulse (external button) or continuous voltage (switch).
  - **Clearing the peak picker** by voltage pulse.
  - **Start controller** by voltage pulse (only devices with PID controller).
  - **Activate controller** as long as voltage is present at the connection (only devices with PID controller).
  - **Load pyrometer configuration** (**Setups**) by voltage pulse (digital input "parameter selector").
  - **Switch on / off laser targeting light** (when equipped with a laser targeting light)
    (the targeting light will automatically switch off after 3 minutes if it is not switched off manually. The switch-off time is adjustable via software under **7.1.4 Device configuration → Laser targeting light settings**).



Note: The input is safely detected as "high" at a voltage > 15.5 V and safely detected as "low" at a voltage < 3.0 V.

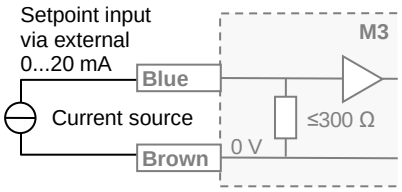
CAUTION Laser radiation, laser class 2, do not look into the beam.

SAFETY INSTRUCTIONS

- Never look into the direct or reflected laser beam.
- Do not point the laser to anyone.
- If laser radiation hits the eye, avert one's eyes immediately.

INFO A **debounce time** can be selected, that is, a period the signal at least must be present at an input so that it can be recognized and processed by the system (3 ms are specified by the pyrometer hardware). Values between immediately (0) to 1 s can be set.

- **Analog input** (only M3 and on port 3) for external adjustment of some parameters between their smallest and largest setting value.
  - **Emissivity slope** (0 mA = 0.8; 20 mA = 1.2)
  - **Emissivity** for every channel (0 mA = 0.05; 20 mA = 1.2)
  - **Setpoint** at devices with PID controller (0 mA = zero scale temperature, 20 mA = full scale temp.)



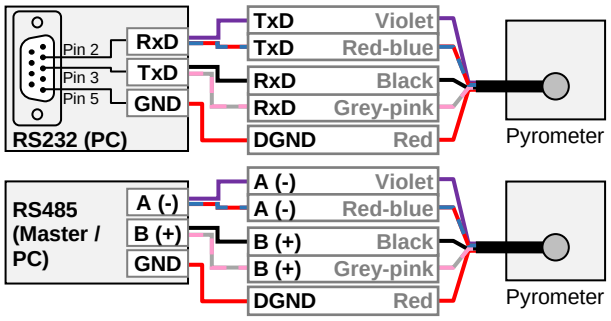
INFO The analog input requires a current source of 0-20 mA and can be generated, for example, via a setpoint generator.
For activation, input 3 must be activated via the *SensorTools* software in the device configuration (see **7.1.4**)

4.1.5 Serial Interface RS232 / RS485 (M3: switchable RS232 / RS485; H3: only RS485)

The serial interface is used for digital communication of the pyrometer with another computer, for example a PC for data transmission to the software *SensorTools*. The interface transmits all measured data according to the setting as well as device information and parameters.
The maximum transmission speed (Baud rate) is limited by the cable length; it is halved with each doubling of the transmission path.

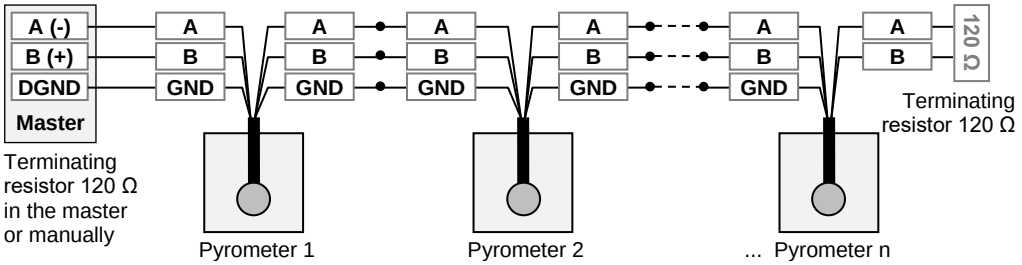
- **RS232:** about 7 m cable length with 19.2 kBd. Adjustable are values from 4.8 to 115.2 kBd.
- **RS485:** about 2 km with 19.2 kBd. Adjustable are values from 4.8 to 921.6 kBd.

Connecting one pyrometer via RS232 or RS485:
In a short RS232 or RS485 connection to the master (computer receiving the data), the pyrometer is connected directly as a point-to-point connection with the master.
It is advantageous to connect all interface cables in order to avoid reflections.

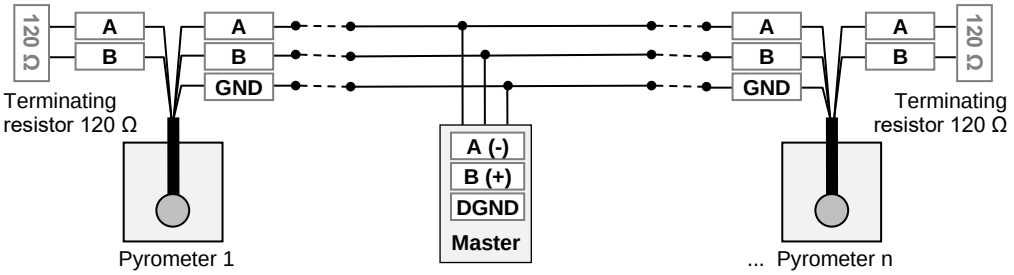


Connecting several pyrometers via RS485:
For a reflection-free operation with longer cables, pay attention to the correct cable termination. Termination at the physical bus is on front and rear.

Master at the beginning:



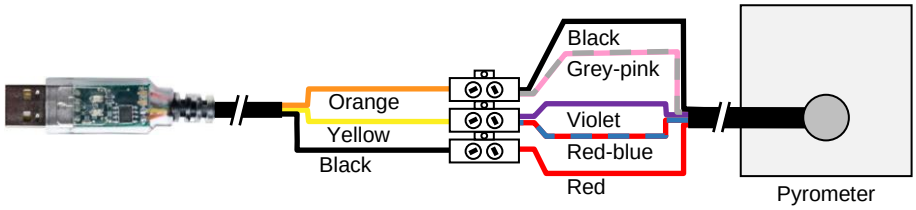
Master in the middle:



When operating multiple devices (up to 32 are possible), each device needs to assign its own address (directly on the device or via software *SensorTools*), under which it can be addressed later. For this purpose, initially, each device must be connected individually and provided with an address (00-97). After that, all devices can be connected.
If specific parameters for all devices should be changed simultaneously, the global address 98 is used (there is no response from the device). If the address of a device is unknown, you have the opportunity to address each device independently of the set address with the global address 99 (connect only one device).

4.1.5.1 Interface Converter (Accessory)

A quick and easy way to connect the pyrometer to a PC is to use an interface converter or a connecting cable with integrated interface converter (see **9.3 Accessories**).

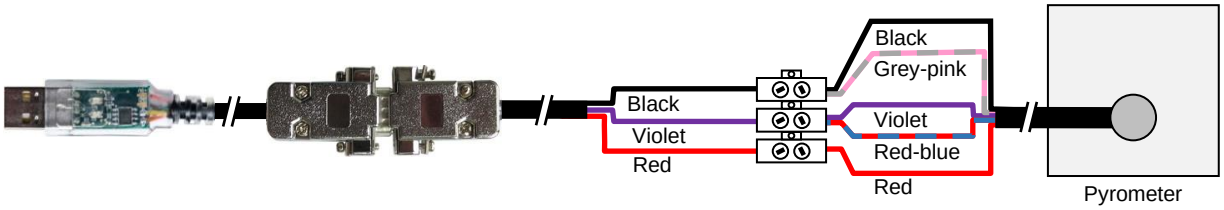


Orange:	B^+ (RS485) / TxD (RS232)	Black / grey-pink:	B^+ (RS485) / RxD (RS232)
Yellow:	A^- (RS485) / RxD (RS232)	Violet / red-blue:	A^- (RS485) / TxD (RS232)
Black	GND	Red:	GND

- Interface converter **DK5485:** RS485 to USB for baud rates up to 921.6 kBd (recommended)
- Interface converter **DK5232:** RS232 to USB for baud rates up to 115.2 kBd (slower data transfer)

A suitable driver must be installed so that the interface converter is recognized by *SensorTools*. After installing *SensorTools*, the driver can be found in the installation directory in the "Driver" subfolder or can be downloaded from the FTDI homepage: www.ftdichip.com/Drivers/VCP.htm.

Alternatively, the interface converters are available with a 9-pin Sub-D connector instead of open connection wires. This can be used if a type of AM pyrometer connection cable has been ordered. This includes a 1 m cable with Sub-D socket, which can be used to flexibly connect the interface converter.

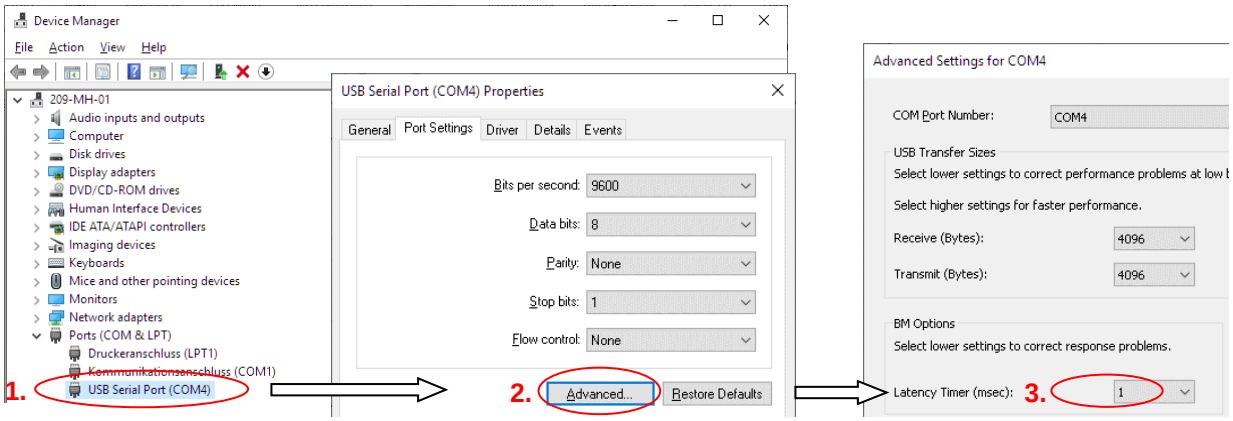


Black:	B^+ (RS485) / TxD (RS232)	Black / grey-pink:	B^+ (RS485) / RxD (RS232)
Violet:	A^- (RS485) / RxD (RS232)	Violet / red-blue:	A^- (RS485) / TxD (RS232)
Red:	GND	Red:	GND

- Interface converter **DK4000:** RS485 to USB for baud rates up to 921.6 kBd (recommended)
- Interface converter **DK3000:** RS232 to USB for baud rates up to 115.2 kBd (slower data transfer)

4.1.5.2 Maximum Transfer Speed

To achieve the maximum transfer speed, it is necessary to change the latency time in the advanced port settings from the default 16 ms to 1 ms (administrator rights required):



1. Open Device Manager (right-click on the Windows Start button ( ) and select "Device Manager" in the menu).
2. Double click on "Ports (COM and LPT)" → USB Serial Port (COMx) of the interface converter.
3. Select the tab "Port settings" and then click on "Advanced".
4. Set the latency timer to 1 ms (in "BM Options").

4.1.6 Shielding / Avoidance of Cable-Related Interferences

For trouble-free signal transmission between the pyrometer and evaluation devices such as external displays or PC / PLC, the connection via cable with electromagnetic shielding is necessary. Our connection cables have a shield that is connected in the connector housing and connected to the pyrometer housing via the pyrometer connector. On the connection side, the screen is led out via the orange wire.

To prevent interference from electromagnetic fields, potential differences or compensating currents, the shielding should only be connected on one side:

- Connect the pyrometer housing to the system ground (via one of the M5 screws on the front of the optics) and do not connect the shielding (orange wire at the end of the cable) (but connect it for example to one of the screw terminals supplied, to avoid accidental short circuits). The pyrometer housing is anodized and is therefore not suitable for connecting an earth connection.
- Mount the pyrometer ungrounded (insulated attachment, ensure, the pyrometer does not have an electrical connection to the system at any point) on the system and connect the shielding (orange wire at the end of the cable) to the ground of the PC or PLC.

5 Mechanical Installation

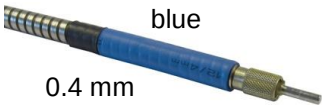
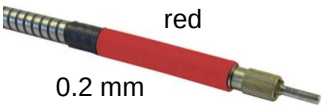
5.1 Mounting

- The **mounting rail** on the bottom case is for the stable take-up of for example of a ball and socket mounting (for fiber optics devices a mounting angle is recommended, see **9.3 Accessories**)
- Front M5 **threaded screws** can also be used for mounting (all 4 threads has to be used for fixing).
- Unusual oscillations or vibrations should be damped by appropriate measures, if necessary, helps the use of rubber absorbers when mounting.
- To protect the **optical fiber**, it should be exposed as little as possible to permanent movement and mechanical stress. Lay the optical fiber as possible with a large bending radius, especially if it is carried along moving parts.

5.2 Mounting Optical Fiber / Optics

5.2.1 Bending Radius of Optical Fiber

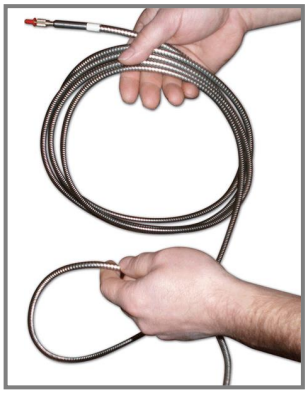
The color code on the optical fiber identifies the optic diameter and minimum bending radius associated.

Color marking optical fiber	 blue	 red
Fiber diameter	0.4 mm	0.2 mm
Minimum bending radius	**150 mm**	**75 mm**

When laying the optical fiber, it is to observe the minimum bending radius. A bending radius smaller than specified can cause a stretched or broken optical fiber.

5.2.2 Winding and Unwinding the Optical Fiber

Always ensure that the minimum bending radius is not exceeded.
During winding and unwinding the optical fiber must be able to move easily and should not be twisted. Ideally, one hand winds up the light guide carefully, while the other hand guides the cable roll. For torsion-free winding only one side of the optical fiber should be connected, then the other can be moved freely.



NOTICE **Avoid strong tensile and torsional forces** during installation, optical fiber could break.

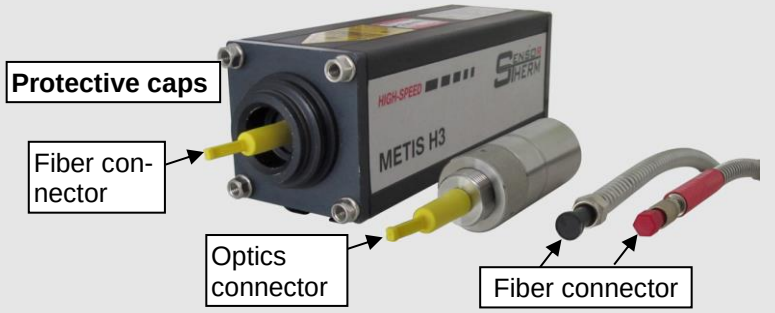
5.2.3 Serial Number of Optical Fiber

Assignment fiber to pyrometer and optics: Each fiber is uniquely associated to a pyrometer and optics. For identification, all three components are tagged with the same device number. The measurement accuracy can only be guaranteed with proper assignment.

INFO To meet the high accuracy, the instrument should be recalibrated when replacing an optics or the fiber optic cable. A single-point adjustment using the Single-Point Adjustment function may be sufficient.

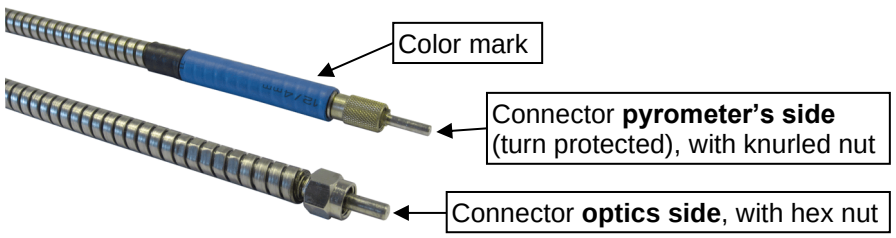
NOTICE **Only remove the protective caps from the pyrometer and optics and fiber directly before assembly** to prevent dirt from getting in and scratching the fiber connections during assembly.

Keep the protective caps to ensure protection again in the event of later disassembly or storage.

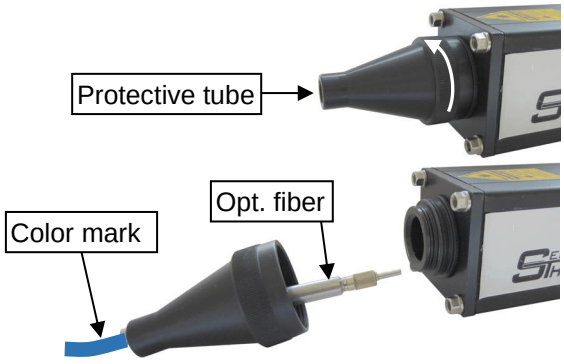


The optical fiber has to be mounted true-sided:

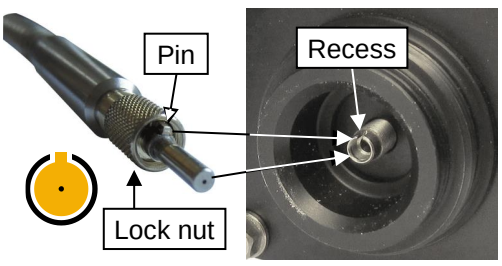
- The colored heat shrink tube marker matches to the pyrometer side.
- The optics fit on the side without marking.



- Unscrew the optical fiber protective tube from the pyrometer's housing.
- Pull the protective tube a little about the optical fiber on the colored side to avoid pulling it over the complete fiber after fiber assembly.



- Remove the protective caps from the pyrometer and optical fiber, insert the side with the turn protected fiber connector to the pyrometer, and make sure that pin and recess snap together.
- Tighten lock nut hand-tight (do not use a tool, otherwise the screw or optical fiber can be damaged).
- Finally screw the protective tube back on the pyrometer housing.



5.2.4 Connect the Optics

- Remove the protective caps from optical fiber and optics.
- The fiber-optic connectors on the side of the optics does not require special adjustment and is just plugged and screwed.
- Tighten lock nut hand-tight (do not use a tool, otherwise the screw or optical fiber can be damaged).

5.3 Ambient Temperature

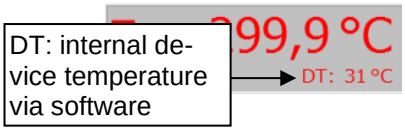
- **M311 and M322 fiber optic devices** are designed for ambient temperatures between 0 and 80°C (32 and 176°F) on the housing.
- **H311 and H322 fiber optic devices** are designed for ambient temperatures between 0 and 60°C (32 and 140°F) on the housing.
- **Optical fiber** and **fiber optics** can be exposed to ambient temperatures between -20 and 250°C (-4 and 482°F) on the optics side and up to 120°C (248°F) on the housing side.

INFO **to avoid overheating of the laser targeting light:** The laser targeting light is deactivated at an internal device temperature above 65°C / 149°F (M3 devices) or above 60°C / 140°F (H3 devices).

INFO **to avoid premature aging of the OLED display:**
- If no key is pressed for 10 minutes, the OLED display is darkened.
- The OLED display is darkened from an internal device temperature of 60°C / 140°F.
- The OLED display is switched off from an internal device temperature of 75°C / 167°F.

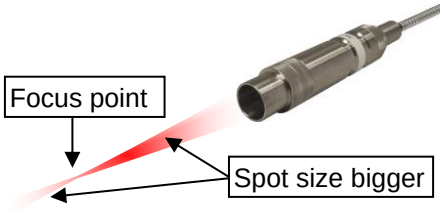
Below these temperatures, the laser targeting light can be used again, or the OLED works with its full brightness.

- The internal device temperature can be read out in the connection area or in the control window of the *SensorTools* software.
- It is possible to configure one of the switching outputs so that a corresponding signal is switched when the maximum temperature is exceeded (see **4.1.4 Configurable Inputs / Outputs** and under **7.1.4 → Configurable Inputs / Outputs**).



5.4 Ratio Technology / Alignment onto the Measuring Object

In opposition to radiation pyrometers, 2-color pyrometer measure in two spectral ranges simultaneously and determine the temperature by forming the radiation ratio (quotient).
In this method, it is not necessary to know the emissivity of the measurement material when it is a gray body.
Via the *SensorTools* software the 2-color temperature and the temperatures of the individual channels can be shown simultaneously to identify possible wavelength dependency (see **0 Emissivity slope**).
To detect the temperature correctly, the pyrometer must be properly aligned to the object to be measured. At the focus point of the optics (infrared focus distance) the spot size diameter is the smallest. Also, measurements in the defocused area can be done to determine the average temperature of a bigger spot.



To get a correct measurement result, the following requirements must be observed:
- When measuring through windows, the optical properties of the window material must be considered.
- At measuring diameters larger than the object to be measured, care must be taken that the signal strength is not lower than the set value, otherwise the system will switch off. Factory setting is 10%.
- Entering a fill factor that indicates how much percent of the measuring field is filled, has no influence if using the 2-color measuring mode. In 1-color mode measurements can be performed with objects smaller than the spot size.

5.4.1 Alignment with the Laser Targeting Light

The laser targeting light is a conical red laser beam with the largest diameter directly at the lens and the smallest in the focus distance.

INFO The position of laser targeting light focus and pyrometer focus do not match.

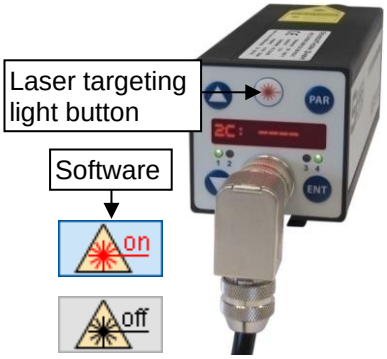
CAUTION Laser radiation, laser class 2, do not look into the beam.

SAFETY INSTRUCTIONS

- Never look into the direct or reflected laser beam.
- Do not point the laser to anyone.
- If laser radiation hits the eye, avert one's eyes immediately.

Turn on / off: Via the targeting light button on the devices rear panel or via software *SensorTools* (in the **Connection Window** or **control window**).

The targeting light will automatically switch off after 3 minutes. The switch-off time is adjustable via software (see under **7.1.4 Device Configuration → Laser targeting light settings**).



INFO The laser targeting light is turned off at a device temperature above 65°C (M3 devices) or 60°C (H3 devices).
If the targeting light does not turn on, probably the device's internal temperature is too high. If the temperature falls below the switch-off value, the laser will work again.

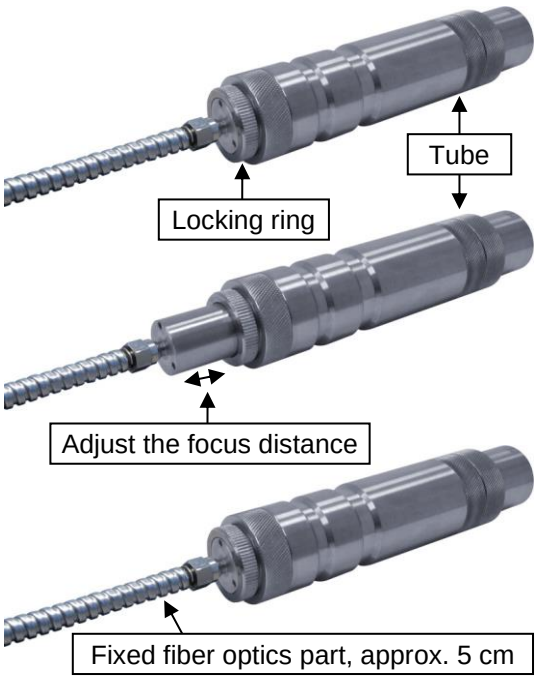
INFO to the spot size: The size of the laser point does not match to the spot size; spot sizes are given in the **Spot Size Table**.

INFO to M311: The laser targeting light is pulsed in these devices, i.e. the laser is alternately on or a measurement is taking place. This is necessary because the spectral range of the pyrometer and the red laser targeting light influence each other. For certain measuring tasks, such as when using the peak picker, this must be taken into account by using the laser targeting light only for alignment; the measurement itself should then only be carried out with the laser targeting light switched off.

5.5 Adjusting the Focus Distance

The focus distance is the distance in which the pyrometer's measuring diameter is the smallest.
For optics with focus adjustment, the focus distance can be changed continuously within a predetermined range.

- Loosen the locking ring a little by hand.
- To set the focus distance, pull or push the rear part of the optics out of the tube by hand. You can pull on the front, fixed part of the optical fiber, which is about 5 cm from the plug.
- Tighten the locking ring again hand-tight.

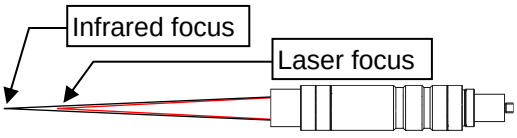


INFO to the laser point size: In the focus distance, the laser point shows the smallest diameter.

INFO to optics position:
- Lens fully extended: shortest focus distance.
- Lens fully inserted: divergent focus distance.
- Lens in between: focus distance according to **Spot Size Table**.

NOTICE Only pull the fixed part of the fiber optic directly on the connector to focus, otherwise the fiber optic may break.

INFO to infrared focus and laser focus: Infrared focus and laser focus are not at the same place, the infrared focus distance is about 5% farther away from the lens than the laser focus.



5.6 Spot Size Table

The table below specifies the spot sizes for different focused measuring distances. The values in the tables are exemplary, intermediate measurement distances must be determined by interpolation. If the measuring distance differs from the adjusted or specified focus distance, a measurement is also possible, but the spot size changes (usually it is larger). Focus distances are specified from lens front.

	Model Temperature ranges [°C]	**M322:** 300-1000°C **H311:** FSC <1500°C **H322:** FSC <1200°C	**M311/ M322:** all other temp. ranges **H311:** FSC ≥1500°C **H322:** FSC ≥1200°C
	Meas. distance a [mm]	**Spot size diameter M [mm]**	
OQ30-90	340	1.3	0,8
	400	1.7	1
	450	2	1.15
	500	2.3	1.31
	600	2.8	1.62
	700	3.3	2
	800	4	2.26
	900	4.3	2.5
	1000	4.5	2.9
	1500	7	3.5
	2000	10	4.7

	2500	10.4	5.2
	3000	14	7.5
	3500	15.5	8
	4000	19	11
Aperture diameter D: 10-13 mm		Fiber Ø 0.4 mm	Fiber Ø 0.2 mm

(D is dependent on the optics pull-out: optics pulled out: higher value, optics inserted: smaller value)
FSC = Full scale temperature

Delivery versions of optics OQ30-90:

Optics	Characteristics	For models with end of temperature range
OQ30-90 L1	3 mm aperture (delivery status, incl. 9.5 mm replacement aperture)	H311: ≥ 2000°C M311: ≥ 2100°C
OQ30-90 L2		M322 / H322: ≥ 2300°C
OQ30-90 11	9.5 mm aperture (delivery status)	H311: < 2000°C M311: < 2100°C
OQ30-90 22		M322 / H322: < 2300°C

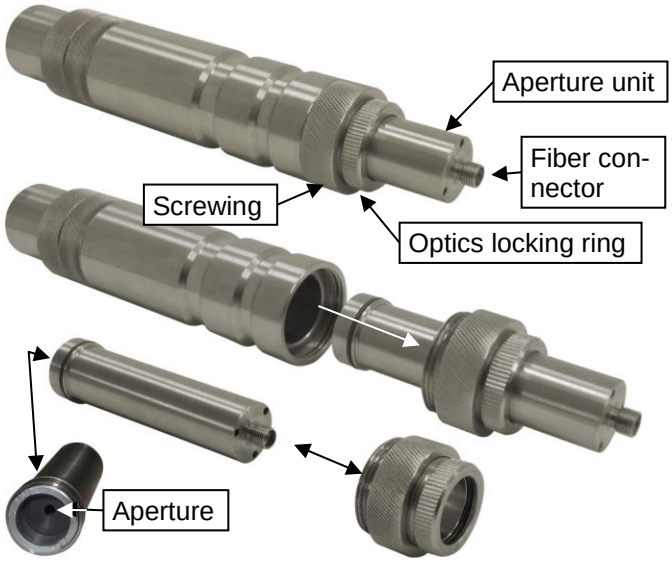
The appropriate signal height of the pyrometer is controlled by apertures.

Using the 9.5 mm replacement aperture: For measuring objects smaller than the spot size diameter or measurements through the processing optics of a laser system, the radiation intensity received by the pyrometer may under certain circumstances be reduced so much that a measurement is no longer possible (see also **6.2.4**, **Switch-off Level / Signal Strength**). In this case, the measurement can be made possible again by installing the 9.5 mm aperture (see **5.6.1 Replacement of the adjustment unit**).

5.6.1 Replacement of the Aperture / Adjustment Unit

Aperture units are available with apertures with different aperture diameters, 3 and 9.5 mm.

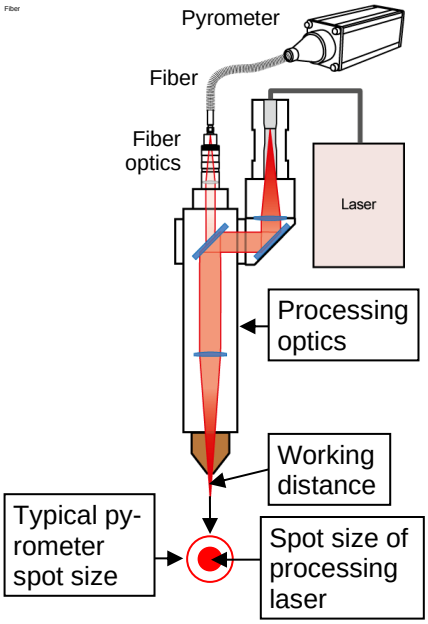
- Remove the optical fiber from the optical fiber connector.
- Unscrew the screwing and pull it out together with the optics adjustment unit.
- Loosen the optics locking ring slightly.
- Move the optics adjustment unit with the next larger aperture in the screwing.
- Screw the unit of screwing and the optics adjustment unit back into the optics and firmly tighten the screwed connection.



5.7 Coupling and Alignment of Optics in a Processing Optics

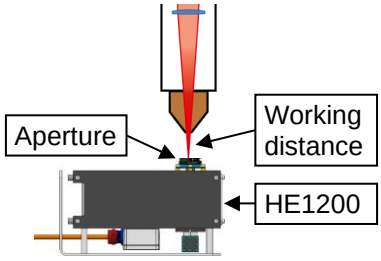
If the pyrometer's fiber optics is coupled into the processing optics, it must be aligned. For this purpose, switch on the laser targeting light of the pyrometer.

- First the focus distance of the pyrometer optics should be adjusted in relation to the HAZ (HAZ, heat affected zone) of the laser spot in order to meet the targeted diameter relation between HAZ and measuring spot of the pyrometer. Only for 2 color pyrometers it can be selected larger or smaller. For 1-color devices, the pyrometer spot size must be smaller than the HAZ. The pyrometer IR focus position can be determined with the HE1200 using suitable measuring methods.
- Second step is to adjust the pyrometer axis (represented by the pyrometer's laser targeting light) and IR laser axis (represented by the pilot laser of the IR laser) at least to be coincident in the working distance, in best case to be collinear.



5.8 Adapt the Optics to the Laser Processing Optics

Pyrometers have a factory calibration and adjustment for a direct view to the measurement object. When the pyrometer or optics is coupled into a laser processing optics, signal losses and spectral changes result from transmission properties of the lenses, coating influences or when the object size is smaller than the pyrometer spot size.
The *SensorTools* software's **single-point adjustment** function, allows the pyrometer to be adjusted for these signal losses at the main measurement temperature used (see **7.1.4.13**).



If the signal strength after single-point adjustment is still too low, it can be increased by factor of 10 by changing the aperture unit in the pyrometer optics to the next larger one, e.g. change from diameter 3 mm to 9.5 mm.

6 Configuring the Pyrometer

Basic pyrometer settings can be made using the setting buttons on the back of the device in order to adapt it to the measuring task:

- Measurement parameters
- Analog outputs
- Interface

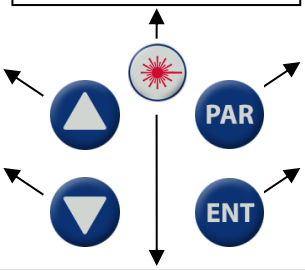
When connected to a PC, these and other settings can be made using the SensorTools software supplied (see Chapter **7**) or via interface commands (see Chapter **11**).

- Scaling the analog outputs (see **7.1.4.6**)
- Set the configurable inputs / outputs (see **7.1.4.8**)
- Send test signals to the analog and digital inputs/outputs (see **7.1.4.9**)
- Define measurement parameter sets for activation via digital inputs (see **7.1.4.8.1.1 Setups**)
- Perform single-point adjustment to match the measurement through windows (see **7.1.4.13**)

6.1 Key Functions

Arrow keys: Settings can be done with the arrow keys. Keep the button pressed to change the values faster, reasonable for example when changing a temperature value. A changed value is shown by a blinking display and will only be saved when pressing “Enter”, pressing PAR calls the next parameter point.
If 60 seconds of inactivity have been made, the display jumps back to the measurement display without taking over any modified values.

Laser targeting light (depending on configuration): Turns on and off the laser targeting light.



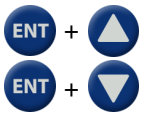
Parameter: Press the button repeated to get access to all settings sequentially (see **6.2**, **Parameters / Settings**). If a subcategory is found, this is indicated with a > (e.g. MEASPARA.>). Pressing ENTer the subcategories are called.

Enter: opens a parameter category or takes over a modified parameter value.

CAUTION **Laser radiation, laser class 2, do not look into the beam.**

SAFETY INSTRUCTIONS

- Never look into the direct or reflected laser beam.
- Do not point the laser to anyone.
- If laser radiation hits the eye, avert one's eyes immediately.



Channel switching: When pressing an arrow key while holding down the ENTer key, the unit will cycle through the channels 2C (2-color measurement) / C1 (1-color measurement in channel 1) / C2 (1-color measurement in channel 2).

Key lock: Press the arrow keys and the ENTer key simultaneously for approx. 3 s to activate or deactivate the key lock. With locked keys, no parameters can be called and changed.

6.2 Parameters / Settings

The table shows the adjustable parameters in order they appear on the pyrometer, detailed description in the next chapters.

Parameters	Meaning	Settings
DISPLAY>	Measuring temperature on the device display: 2-color temperature (2C), temperature channel 1 (C1, longer range), channel 2 (C2, shorter range)	2C, C1, C2
MEASPARA.>	Measurement parameters	–
T90	Response time t_{90}	MIN / 01 ms–10.0 s
STMOD	Storage mode peak picker: peak picker off, with time clear (TIME, time settings under CLR), extern cleared (EXT), automatic cleared (AUTO), with trigger function (TRIG)	OFF / TIME / EXT. / AUTO / TRIG
CLR	Clear time settings with STMODE set to time clear (only if STMODE set to TIME)	OFF / 01 ms–25.0 s
SLO	Emissivity slope Ɛ2/Ɛ1	0.800–1.200
SW.OFF	Switch-off limit	2.0–90.0%
Ɛ1	Emissivity channel 1	0.050–1.200
TR1	Transmittance channel 1	5.0–100.0%
Ɛ2	Emissivity channel 2	0.050–1.200
TR2	Transmittance channel 2	5.0–100.0%
FF	Spot size filling (fill factor)	5.0–100.0%
ZSC	Zero scale temperature (beginning of temp. sub range)	e.g. 0400°C

FSC	Full scale temperature (end of temperature sub range)	e.g. 1300°C
TU	Temperature unit °C / °F	CELSIUS /FAHREN.
OUTPUTS>	Analog outputs	–
ANALOG>	Settings of analog output	–
A1	Analog output 1, current output	0–20 mA / 4–20 mA
A1TST	Test current (10 mA at 0-20 mA, 12 mA at 4-20 mA)	OFF / 10 mA or 12 mA
A2	Analog output 2, current output	0–20 mA / 4–20 mA
A2OUT	Analog output 2 signal: off, 2-color temperature (2C), temperature channel 1 (C1), temp. channel 2 (C2), control output (only devices with PID controller), device temperature (DTMP)	OFF / 2C / C1 / C2 / CTR. / DTMP
A2TST	Test current (10 mA at 0-20 mA, 12 mA at 4-20 mA) (not available if A2OUT is set to OFF)	OFF / 10 mA or 12 mA
INTERFACE>	Serial interface	–
RSTYP	Interface type (only M3)	232 / 485
BD	Baud rate	4.8–115.2 kBd (RS232) 4.8–921.6 kBd (RS485)
ADD	Address	00–97
DELY	Delay	00–20
FB.ADR	Fieldbus address (at Profibus devices)	00–127
FB.MODE	Fieldbus mode (at Profibus- / Profinet devices)	0–2
MISC>	Miscellaneous settings	
LG	Language	ENGLISH / DEUTSCH
N.PIN	Set (new) pin for push button lock	OFF / 0000–9999
FACT.SET	Reset to factory default settings	N / Y

INFO These settings are available with the latest firmware. Missing settings in your device can be added by updating the device firmware. By connecting the power supply, the current firmware version is displayed for a few seconds, a firmware update is possible with the Software ***SensorFlash*** (see **8**).

6.2.1 Response Time t_{90}

The response time t_{90} indicates the time that the pyrometer needs to reach 90% signal height of a 100% temperature step event.
The response time can be adjusted between minimum and 10 seconds.

6.2.1.1 Dynamic Adaptation at Low Signal Levels

At the beginning of the temperature range, increasing signal noise is to be expected. Therefore the response time at the beginning of the temperature range is automatically increased in several steps.

6.2.2 Peak Picker Storage Mode / Clear Time

The peak picker always records the highest value during a measurement and holds it until it is deleted manually or automatically:

Off: The peak picker storage is off and the instantaneous value is measured.
Clear externally: The maximum value is cleared manually by an external button or machine contact (connection see **4.1.4 Configurable Inputs / Outputs**). The external clearing also can be carried out with the command `lx` (see **11**, **Communication via Serial Interface / Interface Commands**).
Automatically: The maximum value is cleared, if after a "cold break" a new hot measuring object appears in the measuring beam. "Cold break" means that the measuring temperature

must be below of the beginning of the temperature range. The "cold break" must correspond to at least the length of the set response time.

Time 0.01…25 s: Clears the maximum value after the specified time

INFO At too long clear times important temperature information can be lost at sinking temperatures).

Trigger: The sampling time is defined by an external button to be active. The maximum value display appears after releasing the button.

6.2.3 Emissivity Slope

Measuring objects having the same emissivity at the two different wavelengths are called grey bodies (e.g. well oxidized iron or steel surfaces). They can be measured accurately with the setting 1.00 for the emissivity slope without correction.

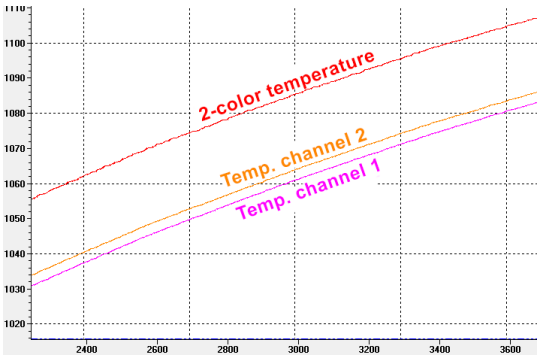
Measuring objects that emit the same on the two wavelengths of a 2-color pyrometer are often referred to as "Gray bodies" (e.g. well oxidized iron or steel surfaces). They can be measured accurately with the setting 1.00 for the emissivity slope without correction.

Measuring objects whose emissivity is different on the two wavelengths of the pyrometer (e.g. shiny unoxidized metal surfaces) need for accurate temperature measurement a correction setting, the so-called emissivity slope $\varepsilon_2/\varepsilon_1$. The value can be larger or less than 1, depending on whether the emissivity of channel 1 or 2 is higher.

- 0.800–1.000: gain, temperature display will be higher
- 1.000–1.200: Attenuation, temperature display will be lower

For correct 2 color measurement the emissivity ratio for an object should be constant over the measuring temperature range. If that does not apply, the accuracy will be affected.

In the *SensorTools* software the 2-color temperature and those of the two channels can be displayed at the same time. A 2-color measurement is usually correct if the curves of the two channels in the required measuring range run uniformly parallel, so the ratio is constant. If the temperature values of the curves are identical (at the same emissivity setting), then the emissivity slope is 1. Do they run parallel, so the correct value for the emissivity ratio must be found, such by comparative measurement with a thermocouple and subsequent ratio setting until the temperatures match.



6.2.4 Switch-off Level / Signal Strength / Dirty Window Monitoring

2-color pyrometers measure even with reduced signal strength, such as those occur in a partially filled measuring field, or dust, smoke, steam, or a window in the beam path between pyrometer and the measuring object. If the signal strength is too low for a reliable measurement, the measurement is switched off to avoid measurement errors. In this case, the beginning of the temperature range is set to the outputs, i.e. 0 or 4 mA depending on the setting.
The switch-off limit can be set between 2 and 90%, recommended for a reliable measurement is a minimum value of 10%.
Furthermore, a digital output can be set using the *SensorTools* software, which is activated when the signal strength falls below a certain value. This e.g. can be used as contamination or dirty window monitoring.

6.2.4.1 **Switch-off Verification** (only via *SensorTools* software)

If signal strength is below minimum, a time can be entered that defines when this switching-off takes effect.

6.2.5 Emissivity ε (when used in 1-color mode)

If the pyrometer is used in 1-color mode, the measurement corresponds to that of a conventional radiation pyrometer. For correct 1-color measurement the emissivity needs to be set correctly.

The emissivity indicates the radiated power of an object in relation to a so-called blackbody source with emissivity 1. To obtain correct readings, the emissivity must be taken into account in the measurement and adapted for the respective measuring material on the pyrometer. Each material has a max. emissivity of 1 which can be set, an adjustment of up to 1.2 can be used. The emissivity adjustment above 1 allows for temperature corrections due to higher background reflection.

For temperature measurement of metal surfaces, it is helpful to use short wavelength spectral range pyrometers, if possible, because here the emissivity is higher than in the long-wave range.

The listed emissivity values are typical values, which were determined in the laboratory and confirmed in application-oriented measurements. They can vary due to material-dependent conditions, as in metals additionally to the surface texture alloy components play an important role for the emissivity.

- Shown emissivity ranges are mostly caused by surface conditions like roughness, rough surfaces have higher emissivities. For determining the correct emissivity also a comparison measurement can be performed with a thermocouple.
- “n.s.“ (not specified) means that no values exist for this wavelength range, e.g. because a reasonable measurement in this wavelength or temperature range is not performed.

Measuring object	**Emissivity ε** (Epsilon)	
	M311/H311 0.7-1.1 µm	**M322/H322 1.45-1.8 µm**
Black Body Source	1	1
Aluminum, shiny	n.s.	0.05-0.2
Aluminum, oxidized	n.s.	0.3-0.4
Aluminum, sandblasted, rough	n.s.	0.4-0.5
Aluminum, black anodized	n.s.	0.9
Lead oxidized	n.s.	n.s.
Bronze	0.2-0.4	0.2-0.4
Iron, liquid	0.15-0.3	0.1-0.25
Iron, shiny	0.3-0.4	n.s.
Iron, oxidized	0.7-0.9	0.65-0.85
Graphite	0.8-0.92	0.8-0.9
Gold, shiny	0.02-0.05	0.02-0.05
Inconel, shiny	0.35-0.45	0.4
Inconel, oxidized	0.65-0.75	0.6-0.7
Copper, shiny	0.10	0.05-0.1
Copper, oxidized	0.3-0.7	0.2-0.8
Magnesium, shiny	n.s.	0.15-0.2
Magnesium, oxidized	n.s.	0.3-0.5
Brass, shiny	0.5-0.7	0.5-0.7
Brass, oxidized	0.6-0.8	0.6-0.7
Molybdenum, oxidized	0.7-0.9	0.7-0.85
Nickel	0.22	0.15-0.2
Porcelain, glazed	0.6	0.6
Porcelain, rough	0.8-0.9	0.8-0.9
Platinum	0.4	0.35
Soot	0.95	0.95
Chamotte	0.45-0.6	0.45-0.6
Slag	0.85	0.8-0.85
Silver, shiny	0.01	0.01
Silver, oxidized	0.05-0.2	0.05-0.2
Steel, shiny	0.4-0.55	0.3-0.45
Steel, oxidized	0.8-0.9	0.7-0.9
Steel, rolled	0.8-0.9	0.8-0.9
Stoneware, glazed	0.86-0.9	0.8-0.9
Stainless steel	0.4-0.9	0.4-0.9
Titanium, shiny	0.35-0.45	0.3-0.4
Titanium, oxidized	0.55-0.85	0.55-0.85
Tungsten, shiny	0.3-0.4	0.3-0.4
Tungsten, oxidized	0.7-0.9	0.7-0.85
Brick	0.85-0.9	0.8-0.9
Zinc	0.45-0.58	0.45-0.55

Measurement deviations at a 10% false set emissivity at a temperature of 700°C:			
	+10%	-6.5°C	-10.5°C
	-10%	+7°C	+11.5°C

INFO Emissivity, transmittance and spot size fill factor are directly related to each other, the result of the multiplication of the 3 parameters has to be minimum 5%.

6.2.6 Window Transmittance

If there is a sight glass between the measuring object and the pyrometer, there is a reduction in the signal, that is compensated by using the ratio measurement technique. In the case of measurements in 1-color mode, this signal weakening leads to a reduced temperature display, which can be compensated by entering the transmittance of the sight glass.

Settings:
- **5%–100%**

INFO Emissivity, transmittance and spot size fill factor are directly related to each other, the result of the multiplication of the 3 parameters has to be minimum 5%.

6.2.7 Spot Size Fill Factor

Entering a fill factor that indicates how much percent of the measuring field is filled, has no influence if using the 2-color measuring mode (see also **5.4 Alignment to the Measuring Object**).
In 1-color mode: Measurements of objects that are smaller than the pyrometer's spot size can be performed when measuring hot objects in front of a cold background. In this case the fill factor specifies how much percent of the measuring field is filled.

INFO Emissivity, transmittance and spot size fill factor are directly related to each other, the result of the multiplication of the 3 parameters has to be minimum 5%.

6.2.8 Temperature Sub Range

The temperature range can be scaled down to a temperature sub range in order to adapt it to specific measurement conditions (minimum range 51°C), e.g. to increase the accuracy of the analog output.

6.2.9 Temperature Unit

Temperature values can be displayed in °C or °F.

6.2.10 Analog Outputs

The 2 analog outputs can be set separately:
- Depending on the connected devices to **0–20 mA** or **4–20 mA**
- **Analog output 1** always provides the measured temperature (the temperature displayed on the device and in *SensorTools*).

  INFO With older firmware versions, the same settings are possible as at analog output 2. A firmware update to the latest version eliminates this possibility and prevents, that the output of analog output 1 is accidentally different to the displayed temperature signal. Firmware update see section **8**).

- **Analog output 2** can be assigned to provide different signals:
  - 2-color temperature: 2-color temperature output
  - Temperature channel 1: 1-color temperature channel 1 output
  - Temperature channel 2: 1-color temperature channel 2 output
  - Device temperature: Internal device temperature output
  - Control output: Manipulated variable on models with PID controller
  - No output No signal is on the output

6.2.10.1 Test Current

On the device itself and via software a test current can be set to the output. Via software this current is adjustable, on the pyrometer the current is fixed to 10 mA (at 0–20 mA) or 12 mA (at 4–20 mA).

6.2.10.2 Upscale-Burnout (only via *SensorTools* software)

In case of jump down of temperature read out, the output current is set to 20 mA instead of usually the lowest.

- **Disabled upscale-burnout** (standard)**:** The analog output at sudden shadowing of the pyrometer's view field is the lowest current (0 or 4 mA).
- With **enabled upscale-burnout** function, the analog output at sudden jump down of the pyrometer's view field is set to the maximum current of 20 mA. This is useful to avoid increase of laser power to maximum in closed loop operation.

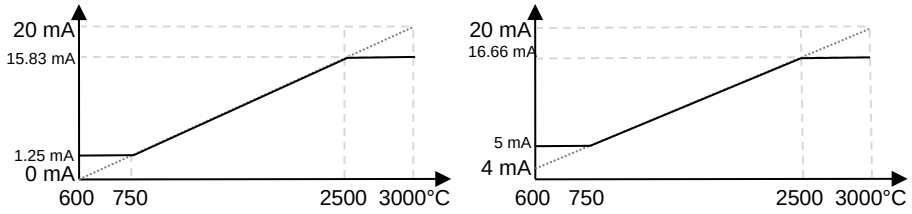
6.2.10.3 Scaling Analog Outputs (only via *SensorTools* software)

The analog outputs can be scaled to suit special circumstances, e.g. for replacement with a device with a larger measuring range.

- **Increasing the temperature range** beyond that of the pyrometer scales the analog output accordingly. It should be noted that the pyrometer cannot measure outside of its measuring range and behaves differently there, depending on the firmware version:
  - **M3 devices from firmware 01-2023 are switchable in the initial behavior:**
    It can be set what happens below the beginning of the temperature range, either 0 or 4 mA is provided to the output, or the current that corresponds to that of the enlarged temperature range is provided to the output constantly (as with all older firmware versions).
    H3 units always operate according to the "Scaled current under ZSC" function.
  - At the end of the pyrometer temperature range, the current that corresponds to the increased temperature range is always provide to the output.
- **Decreasing the scope of the temperature range** can be made to increase the resolution of the output.

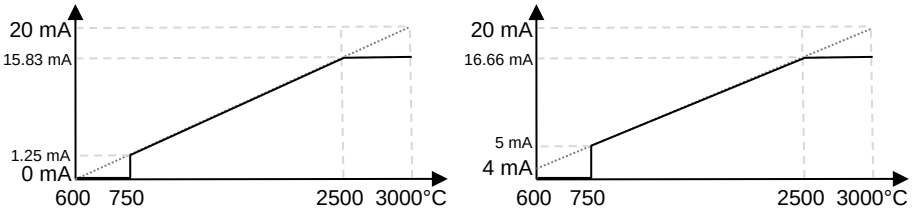
Example of increasing the scope of the temperature range: A pyrometer with temperature range 750–2500°C should be adapted to the range 600–3000°C. In the range of 600–750°C, the pyrometer cannot measure yet; it shows – – – – or in the software "Under".

- Analog option **Scaled current below ZSC** selected:
  At the analog output set to 0-20 mA, a constant 1.25 mA is providing to the output until 750°C is reached, with 4-20 mA a constant 5 mA is providing to the output until 750°C is reached.



  From 2500°C the same current is providing to the output as a 600-3000°C device would providing to the output at 2500°C, in the example this would be 15.83 mA at 0-20 mA and 16.66 mA at 4- 20mA.

- Analog option **0/4mA below ZSC** selected**:**
  At the analog output set to 0-20 mA, 0 mA is providing to the output until 750°C is reached, with 4-20 mA corresponding 4 mA. From 750°C the current then jumps to that of the scaled output of 1.25 mA at 0-20 mA or 5 mA at 4-20 mA.



From 2500°C the same current is providing to the output as a 600-3000°C device would providing to the output at 2500°C, in the example this would be 15.83 mA at 0-20 mA and 16.66 mA at 4- 20mA.

6.2.11 Interface Type (only M3 devices)

RS232 or RS485 is selectable per software or at device (see **4.1.5 Serial Interface RS232 / RS485**).

6.2.11.1 Baud Rate

Selectable baud rates (see **4.1.5 Serial Interface RS232 / RS485**):
- RS232: 4.8 to 115.2 kBd
- RS485: 4.8 to 921.6 kBd

6.2.11.2 Address

For several devices with RS485 operation a device address between 00 and 97 can be assigned (see **4.1.5 Serial Interface RS232 / RS485**).
Device addresses from 00 to 97 are valid. Addresses 98 and 99 are with special functions. The global address 99 can be used to communicate with every controller, independent of the set device address. This allows communication with devices with unknown addresses. The address 98 is a group address used for RS485 devices in bus operation. With this address devices do not answer, useful to change parameters of all connected devices at the same time.

6.2.11.3 Interface Delay / Answer Delay

When operating pyrometers via RS485, it may happen that the connection is not fast enough to detect the response of pyrometer time to a command from the master, e.g. because the line is still busy with sending before receiving. This sometimes occurs in older PCs or interface adapters or by slow switching times of interface adapters and manifests itself in transmission errors of interface commands, so errors when parameters are changed or of measured values transmission.
In this case, a delay for delaying the data transfer can be entered, the value specifies the main circulating time and can be set from 00-20. The transmission of commands to the pyrometer is thus somewhat delayed, but it can work with existing peripherals.

6.2.12 Key Lock

Changing the parameters (PAR key) on the device can be deactivated or protected by entering a 4-digit pin (settings on the device (from firmware 2017_01), see **6.1 Key Function** or via software, see **7.1.4**, **Device Configuration**; only available at devices from firmware version 2016_18; update firmware see section **8**). If activated, this pin must be entered before parameters with the PAR button can be changed on the device.

7 *SensorTools* Software

- **Possibilities:**
  - carry out all device settings
  - Configure signal inputs / outputs (not possible directly on the device)
  - Display measured values, numerically or as a graph
  - Display the internal device temperature
  - Record measurement curves (incl. measurement parameters)
  - Display measurement curves using the *SensorTools* Viewer software included in the program package

- **Installation**
  - The current setup program can be downloaded from our website in the download area: https://www.sensortherm.de/en/downloads/#anleitungen_software. In addition to the software, the latest version of these instructions and, if necessary, other device-specific files are also available there.
  - For the download, the model and serial number must be entered, which can be found on the device nameplate.
  - **Min. system requirement**: Pentium IV processor with min. 1.6 GHz and 2 GB RAM
    20 MB hard drive capacity for the program
    RS232 or RS485 interface or USB2 (use of an RS232 or RS485 to USB interface converter is required)

    With the minimum requirements devices can be connect and configured. When capturing or recording data, the performance is potentially impaired, that is errors or interruptions in data transfer can occur.
  - **Recommended:** i7 multi-core processor with 3 GHz and 16 GB RAM
    Screen resolution: min. 1024x768
    Operation systems: Windows 7, 8, 8.1, 10

    With the recommended requirements all software features should be fully available.
  - To install, start the setup program and follow the on-screen instructions. If the program is installed under a different admin account, it is recommended not to start the program directly with the installer, otherwise the program file paths will also point to this and not to the current user.

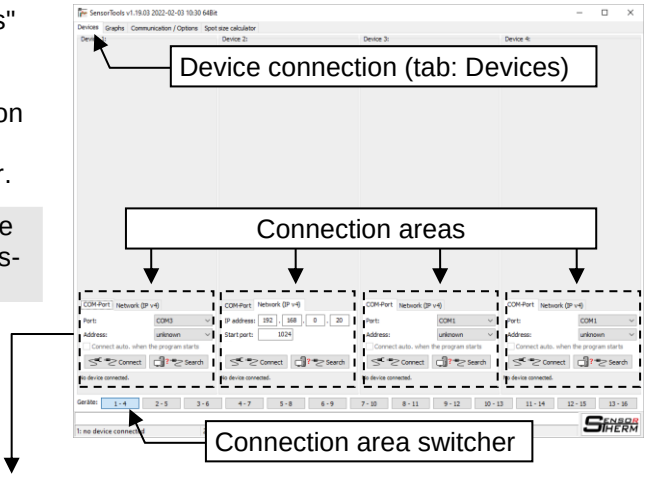
INFO Software and firmware updates that expand the range of functions or eliminate errors are made available regularly. It is recommended to always install the latest software and firmware. In SensorTools you can check whether a more recent firmware or program version is available, see **7.1.4.10 Service functions** and **7.4 Communication / Options**.

7.1 Program Start / Connecting the Pyrometer

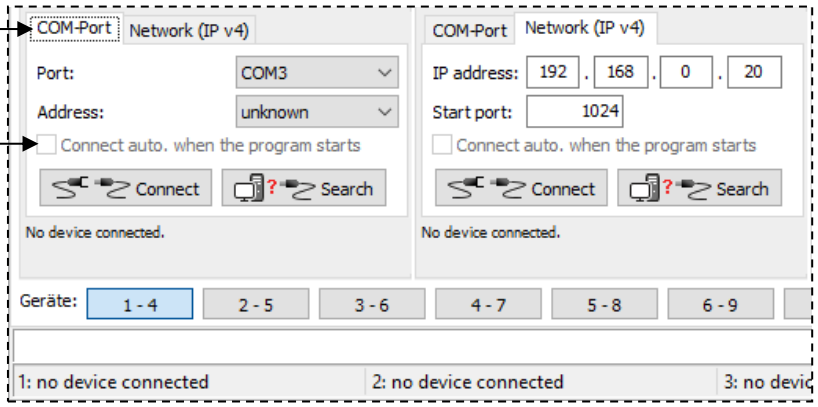
The device connection takes place in the "Devices" tab, up to 16 devices connected to the PC can be connected in the software here.
The number of visible connection areas depends on the window width. The connection areas can be switched using the lower connection area switcher.

INFO The more devices are connected, the more powerful the PC has to be in order to be able to display all the graphs.

Proceed as follows to connect a device in one of the windows:



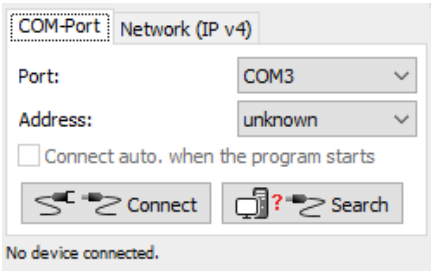
Select tab:
- **COM port**, if the pyrometer is connected via the RS232 or RS485 interface.
- **Network (IP v4)** is only available for devices with Ethernet.
  The pyrometer is preset to a DHCP network and can be found using the "Search" function. If only a fixed IP can be used, the pyrometer must first be connected via a serial interface so that the network settings can be adjusted accordingly.



Connect automatically, when the program starts connects the last connected device automatically the next time the program starts (only for COM port, not available for network).
- The function is only active once a device has been successfully connected.
- The automatic connection only works with an entered device address (00-97, not "unknown").

7.1.1 Connect via COM Port

- Select the **COM port** or **USB port** to which the pyrometer is connected (if known, otherwise try all available ports one after the other).
- Enter the **device address** (if known, in "Unknown", the software automatically searches).
- "**Connect**" connects the pyrometer to the set port.
- If the port and device address are unknown, "**Search**" searches through all PC ports one after the other and then connects a device that is found automatically.

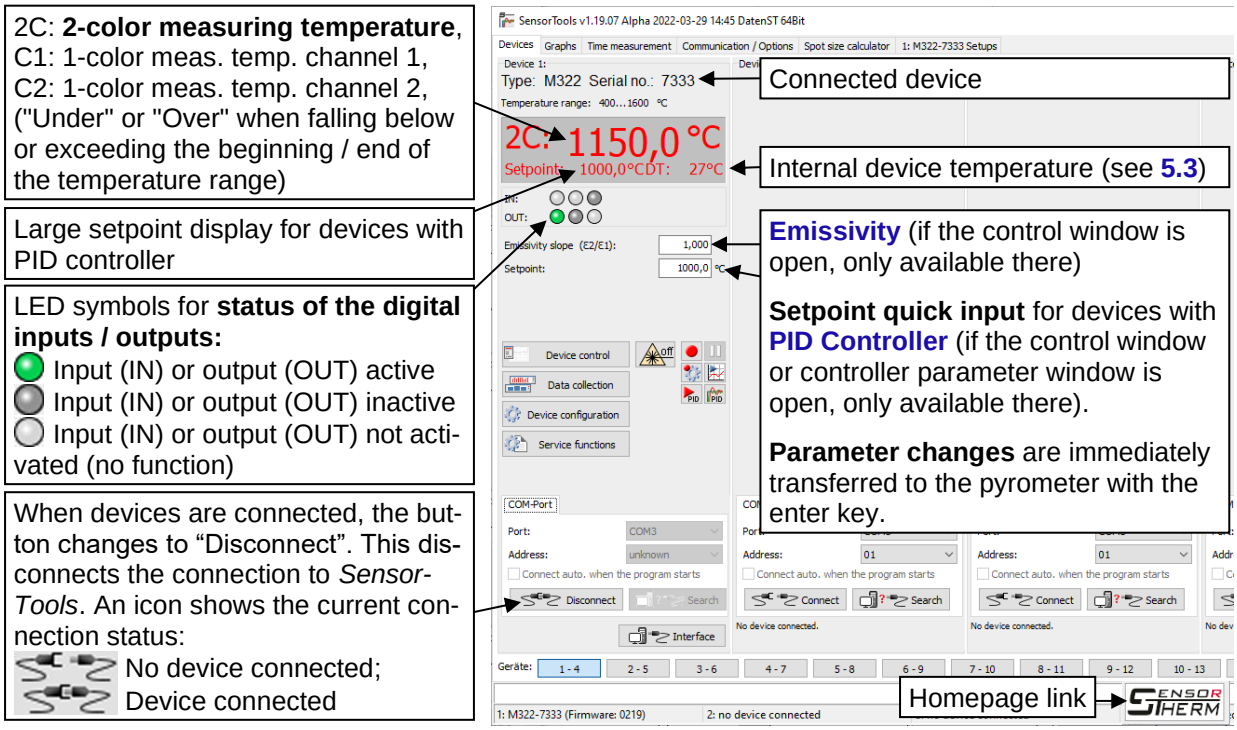


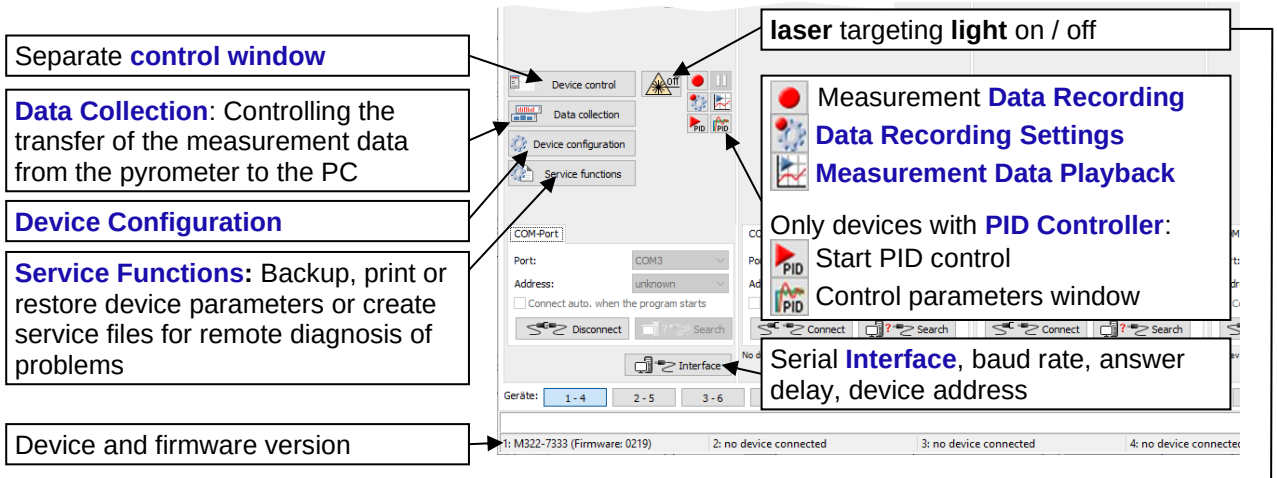
INFO It is not possible to connect 2 devices with the same device address.

7.1.2 Connection Window / Devices Tab

When the device is connected, all **pyrometer settings** as well as the current **measurement temperature** (2-color or 1-color) and **internal device temperature** are read out and displayed.

INFO **for settings on the device:** a pyrometer connected to the software has blocked push buttons. "**KEY LOCK**" appears when pressing a key.





- The **laser** targeting **light** this can be switched on and off (/)

CAUTION **Laser radiation, laser class 2, do not look into the beam.**

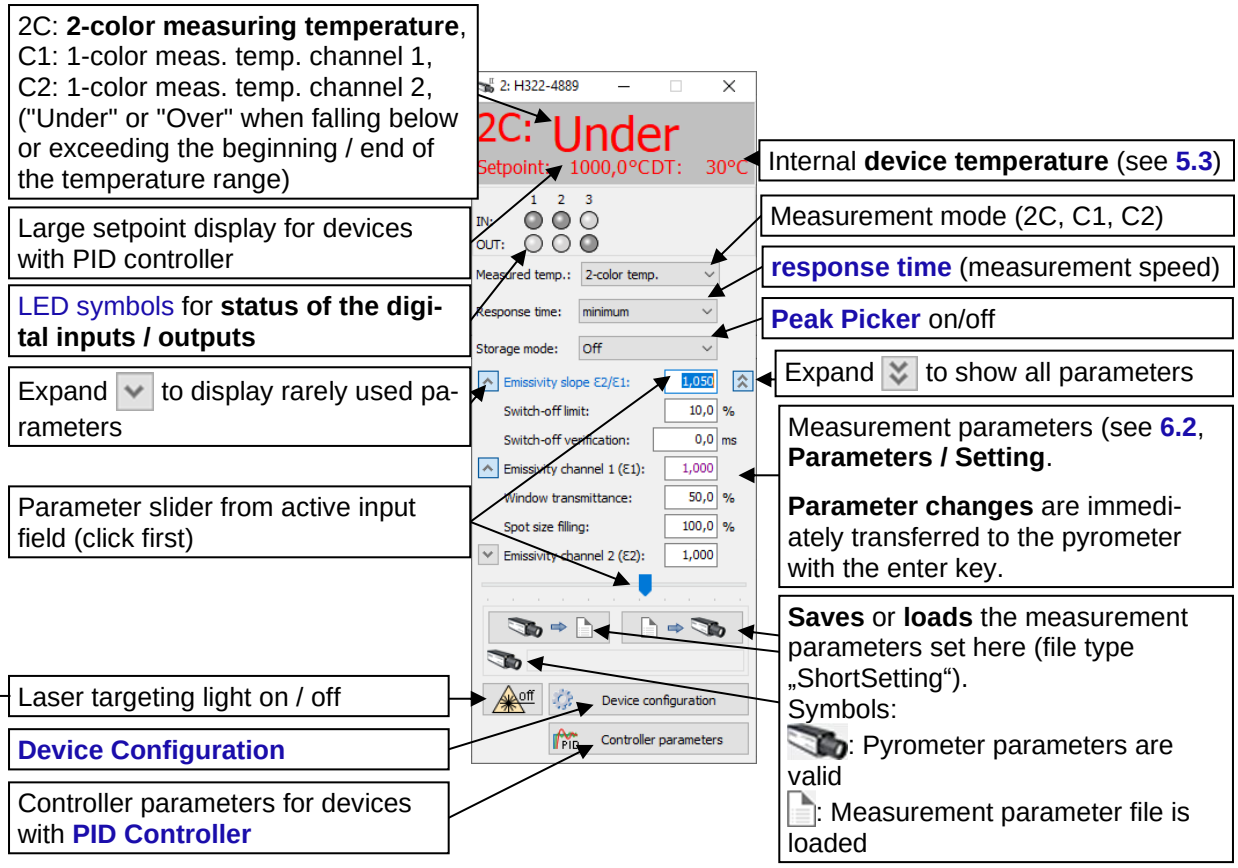
SAFETY INSTRUCTIONS

- Never look into the direct or reflected laser beam.
- Do not point the laser to anyone.
- If laser radiation hits the eye, avert one's eyes immediately.

7.1.3 Control Window

Kontrollfenster

A separate control window also provides all available measurement-related functions and settings.
It is helpful when switching to another tab (e.g. to the graph display).



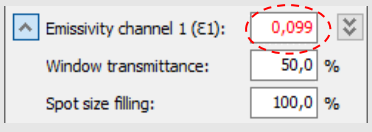
- The **laser targeting light** this can be switched on and off (on / off)

CAUTION **Laser radiation, laser class 2, do not look into the beam.**

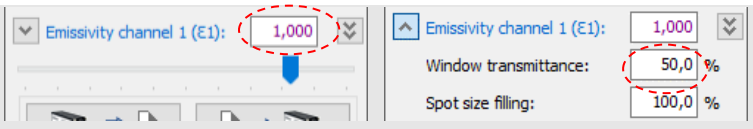
SAFETY INSTRUCTIONS

- Never look into the direct or reflected laser beam.
- Do not point the laser to anyone.
- If laser radiation hits the eye, avert one's eyes immediately.

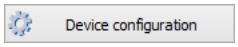
INFO **on an emissivity shown in red:** Emissivity, transmittance and spot size fill factor are directly related to each other, the result of the multiplication of the 3 parameters has to be minimum 5%. If the multiplication of the 3 parameters falls below 5%, the values are displayed in red.



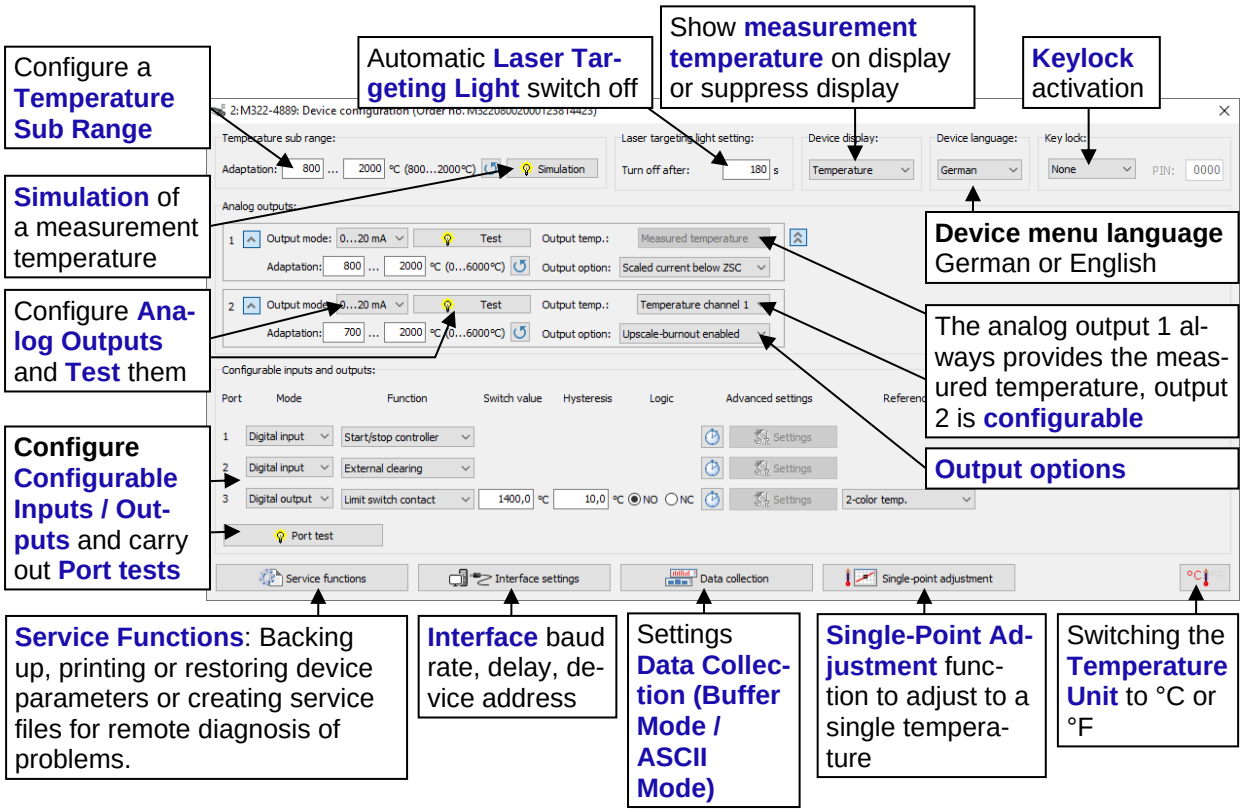
INFO on an **emissivity displayed in violet:** indicates that something is misaligned in the lower (possibly collapsed) area.



7.1.4 Device Configuration



Here basic device settings are made.



7.1.4.1 Temperature Sub Range

- **Adaptation:** The temperature range can be reduced to adapt it to special measuring conditions (minimum temperature span 51°C).
  resets the temperature range to the adjacent total temperature range.
- **Simulation** simulates a measured temperature at the outputs (see **7.1.4.9 Test functions**).

7.1.4.2 Laser Targeting Light Settings

The time can be entered here when a switched-on laser targeting light switches off automatically.
Times: between 5 and 900 s (15 min).

7.1.4.3 Device Display

Enables or disables the measurement temperature display.

Temperature:
shows the measured temperature on the display

Suppressed:
- **Devices with OLED display:** display is switched off
- **Devices with LED display:** shows lines over the entire display instead of the temperature display

7.1.4.4 Device language

Changes the language of the parameter menu on the device to English or German.

7.1.4.5 Keylock

To lock or unlock the key functions on the device (enabling on the device, see **6.1**).

- **None:** All functions can be changed using the buttons on the unit.
- **Active:** The buttons on the unit are disabled.
- **Menu lock:** activates an input field for a 4-digit PIN code, which enables to protect changing of parameters (PAR key) on the device. If activated, this code must be entered on the device before parameters with the PAR button can be changed.

7.1.4.6 Analog Outputs

- **Output mode** sets the output current to **0...20 mA** or **4...20 mA**.
- **Output temperature**
  - **Analog output 1** always provides the measured temperature, which is shown on the device display or in the *SensorTools* control window or Devices Tab.
  - **Analog output 2** (will be displayed after expansion with) is configurable, here at **output temperature** you can select which output signal should be provide:
    - The **ratio temperature** or that of **each channel** can be set assigned to the output.
    - **Device temperature** is the internal pyrometer temperature (scaled from 0 to 100°C).
    - **Controller output:** The **manipulated variable** at devices with a PID controller is set here as standard.
    - "**No output**" disables the analog output.
- **Test** can be used to set a test current at the respective output (see **7.1.4.9 Test functions**).

 Further adjustments can be made by extending the setting range

- **Adaptation:** The analog outputs can be scaled between 0 and 6000°C to adapt them to special circumstances, e.g. to replace for a device with a larger temperature range or to obtain a higher output resolution (see **6.2.10.3**).

  With the reset button, the temperature range is set to the adjusted temperature sub range.

- **Output options**
  - If the beginning of the temperature range is reduced under "Adaptation" in order to scale the analog output, a decision must be made what should happen below the beginning of the pyrometer temperature range, since the pyrometer cannot measure from the lowered beginning value to the beginning of the pyrometer temperature range.
    - **Scaled current below ZSC** outputs a constant current equal to that of the extended temperature range until the pyrometer's lower range value is reached.
    - **0/4mA below ZSC** (only available with M3, not with H3) outputs 0 mA or 4 mA until the beginning of the pyrometer temperature range is reached, depending on whether the output is set to 0-20 mA or 4-20 mA is.
  - **Upscale burnout:** when the pyrometer field of view is suddenly obscured, the output is set to the maximum current of 20 mA instead of the standard 0 or 4 mA output. This function can, for example, be desirable for furnace monitoring if the control would otherwise detect a cold furnace and heat it up fully, possibly burning it out.
    If the upscale burnout function is used together with a reduced beginning of temperature range (under "Adaptation"), this means that 20 mA are set to the output, before the pyrometer's beginning of temperature range is reached, not 0 or 4 mA.

7.1.4.7 Temperature Unit

 The temperature can be displayed and entered in °C or °F. Changing the mode will not change the entered values, no conversion will be done.

7.1.4.8 Configurable Inputs / Outputs:

The 3 inputs / outputs can be set as a digital output or input or port 3 as an analog input and assigned a function (for connection see also **4.1.4 Configurable Inputs / Outputs**).

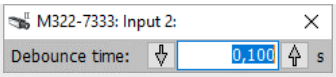
7.1.4.8.1 Digital Input Mode

for calling up pyrometer functions externally

Functions	Description / switching trigger
No function	A switching signal at the input has no effect.
External clearing	Resets the maximum value of the maximum value memory by contact.
Targeting light on/off	(devices with laser targeting light only) Turns the targeting light on or off.
Activate controller	(only devices with PID controller) Activates the control as long as voltage is present at the connection.
Start/stop controller	(only devices with PID controller) Starts or stops the controller with each pulse (alternately).
Parameter selector	To call up and activate up to 7 pyrometer configurations (incl. control parameters for devices with PID controller). The inputs are binary coded, i.e. ▪ with one digital input only one Setup can be activated ▪ with 2 digital inputs there are 3 Setups available ▪ using all 3 inputs, 7 Setups can be accessed and activated

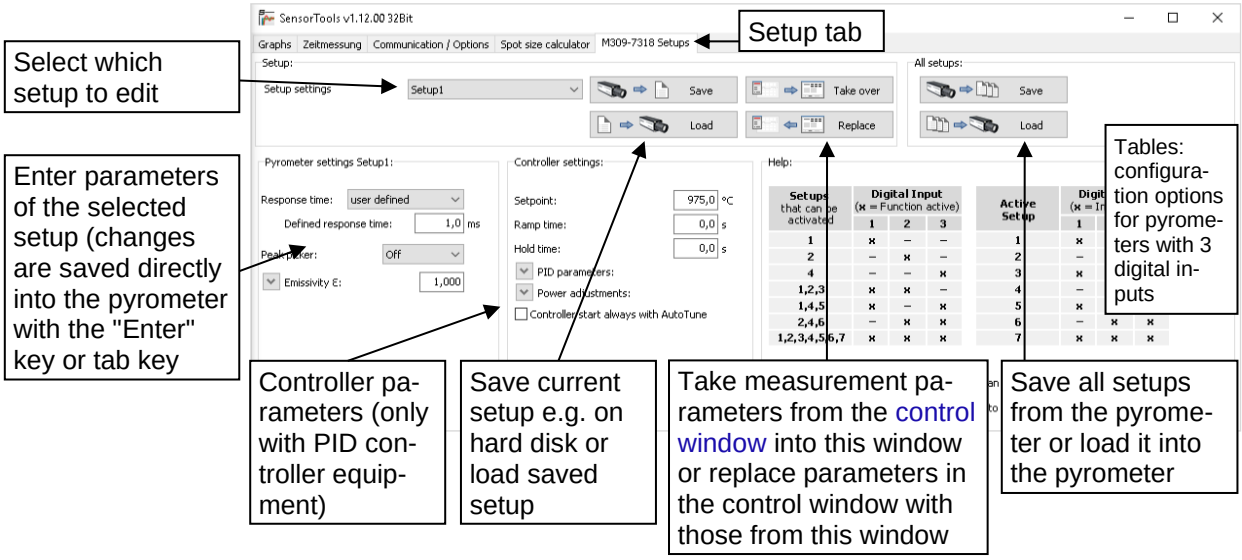
	Inputs to be activated		
	Input 1	**Input 2**	**Input 3**
Setup 1	**x**	**–**	**–**
Setup 2	**–**	**x**	**–**
Setup 3	**x**	**x**	**–**
Setup 4	**–**	**–**	**x**
Setup 5	**x**	**–**	**x**
Setup 6	**–**	**x**	**x**
Setup 7	**x**	**x**	**x**

Time settings	A debounce time can be selected, that is, a period the signal at least must be present at an input so that it can be recognized and processed by the system (3 ms are specified by the pyrometer hardware). Values: "immediately" (0) to 1 s.



7.1.4.8.1.1 Setups

Setups are a set of stored measurement parameters that can be activated via the digital inputs. "Parameter selector" must be selected as the digital input in the device configuration (for connection see **4.1.4 Configurable inputs / outputs**).



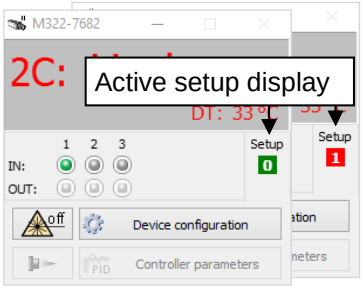
The parameters for the selected setup can be entered directly in this window using the keyboard, with Enter or the Tab key they are transferred to the pyrometer.
Setups can be saved individually or as a complete list to the PC and loaded from there.

INFO **when values are hidden in the control window:** With an active Setup, the pyrometer operates using the setup values, all adjustment possibilities in the control window are hidden.

Active setups are displayed:

At least 1 digital input is set to "Parameter selector", but no input is activated (inputs to "low").

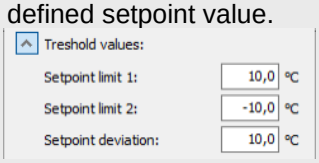
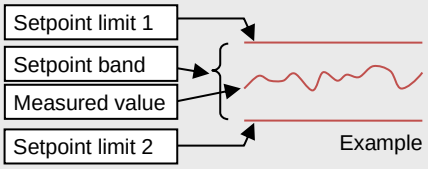
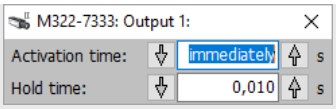
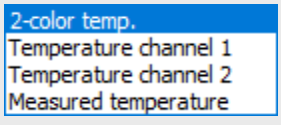
At least 1 digital input is set to "Parameter selector" and at least 1 input is active ("high").



7.1.4.8.2 Digital Output Mode

for the output of a switching signal

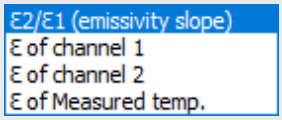
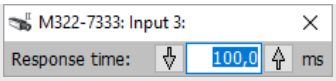
Functions	Description
No function	The output is deactivated.
Contact ready to use	Device readiness: device ready and error-free after self-test.
Material contact	(only M3) To detect whether a hot part is in the measuring field: Switches if the beginning of the temperature range is exceeded by 1% of the temperature range span (the clear time of the peak picker has to be set to ≥1 s or to Auto).
Limit switch contact	Switches when the entered switching value is exceeded.
Signal strength contact	Signal strength too low (for use as dirty window alarm: identifies the degree of contamination of the optics or a window or detects interferences (dust ...) in the beam path and trigger an alarm if activated).
Device temperature	Switches when a defined (internal) device temperature is exceeded.

Setpoint limit 1 / Setpoint limit 2:	(only devices with PID controller) The setpoint limit is a limit temperature above or below the setpoint temperature that should not exceeded or to be below. Two setpoints can be defined. The output is activated if the measured value exceeds the defined setpoint value. The output is also activated if the measured value falls below the defined value. Entry of the setpoint value has to be done relative to the setpoint, positive or negative, e.g. 20°C if the setpoint value is 800°C and the output should be active at 820°C. Values will be entered in the PID controller form (see **7.4**). 
Setpoint band	(only devices with PID controller) The setpoint band is composed of the 2 setpoint limits and defines a range within the temperature has to be. The output is activated if the measured value is outside the defined value. 
Controller active	(only devices with PID controller) Output is active when the controller is active.
Successful control	(only devices with PID controller) Output is active when a control process is terminated (a possibly hold time has elapsed).
Switch value Hysteresis 500,0 °C 10,0 °C	▪ Switching value: Activates the output at the entered value. ▪ Hysteresis: The hysteresis indicates by how many degrees below the entered switching value it is switched back again.
Logic ◉ NO ○ NC	Switching logic of the outputs: NO (Normally Open): Outputs have in ▪ active state 24 V ▪ inactive state 0 V NC (Normally Closed): Outputs have in ▪ active state 0 V ▪ inactive state 24 V
Time settings	Activation time: ▪ "immediately" (0) activates the output immediately when the event occurs. ▪ Time specification (0.001 – 65.534 s): Activation is delayed accordingly.  Hold time: ▪ None: Signal is only active during the function. ▪ Time entry (1–65534 ms)**:** For the entered time the output is kept longer active than the original signal.
Reference (with material contact, limit switch contact, setpoint limit 1, setpoint limit 2 and setpoint band)	The 2-color temperature or that of a channel can be used to activate the output. If the measurement temperature is selected, the selected temperature is always used as the reference. 

7.1.4.8.3 Analog Input Mode

for external adjustment of some parameters between their smallest and largest setting value

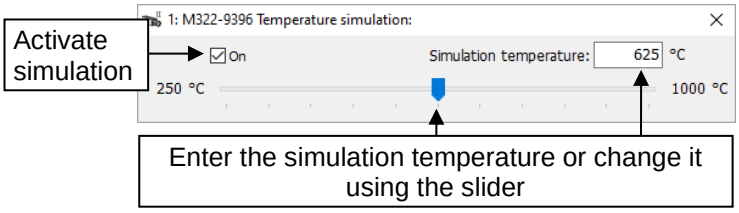
Functions	Description
No Function	A current signal at the input has no effect.
Ɛ2/ Ɛ1, Emissivity Ɛ	The emissivity slope or the emissivity for 1-color measurements can be adjusted externally.

	Under Reference it is specified more precisely whether the emissivity ratio or the emissivity should be set. If Ɛ from measuring temperature is selected, the currently selected temperature is always used as the reference. 
Setpoint value	(only devices with PID controller) The setpoint can be adjusted
Time settings	With a response time, the input signal can be averaged to reduce interferences on the electric line. The longer the time, the slower the adjustments, but also more effective (Values: 0-1000 ms). 

7.1.4.9 Test Functions

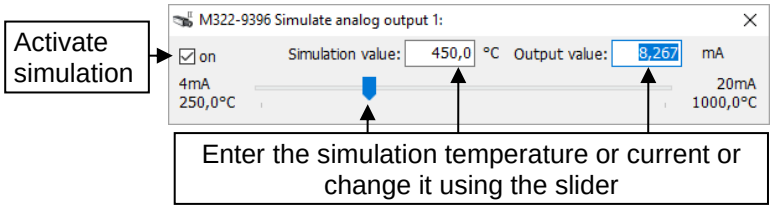
CAUTION **Using the test function with connected systems** activates the selected outputs and can thus **lead to an automatic startup** of these systems.
Always observe all safety instructions of these systems!

- Simulation **simulates a measured temperature** that is shown on the device display and in the software, as well as controls the interface and analog output and thus also has an effect on set limit contacts, for example.



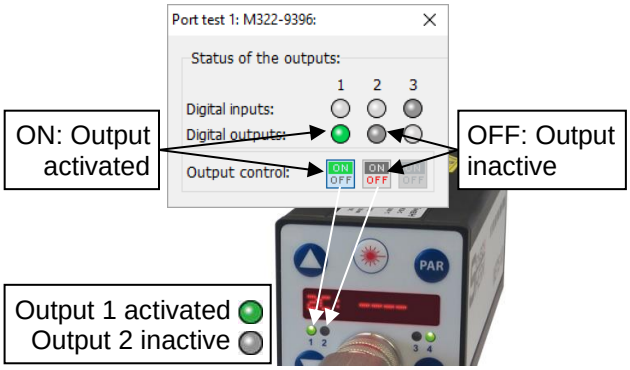
The temperature to be simulated can be changed using the slider or entered in the temperature input field and accepted with "Enter" on the keyboard. Click the hook "On" to activate the simulation and switch from normal measurement to simulation.

- Test emits a **test current** at the **analog output**.



By moving the slider or by entering a value the corresponding current is set to the output.
The output is only activated when the hook "on" is set.

- Port test is used to **test activated digital outputs**.
Outputs can only be tested if they have previously been set in the device configuration. They can then be activated and deactivated under "Output Control" with the ON-OFF switches.

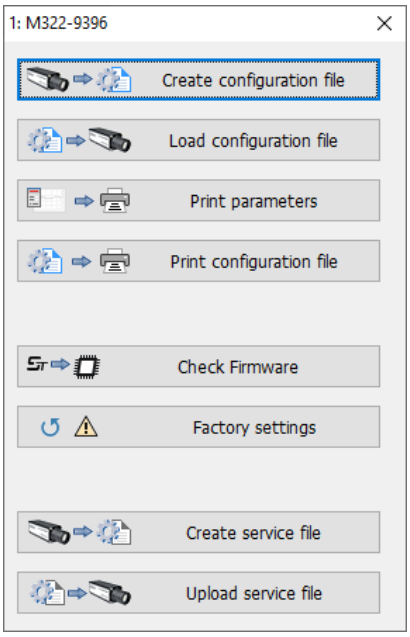


Digital inputs are recognized as active and displayed if they are set in the device configuration and the necessary voltage is present at the input.

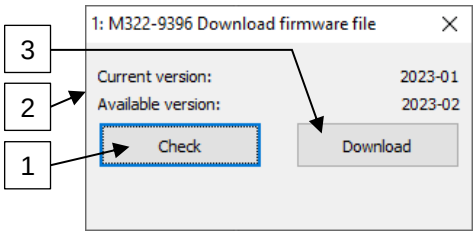
The status of the **digital inputs / outputs** is indicated by an LED symbol:
- Input (IN) or output (OUT) active
- Input (IN) or output (OUT) inactive
- Input (IN) or output (OUT) not activated (no function)

7.1.4.10 Service Functions

Service functions To back-up, for printing or restore device parameters or create service files for remote diagnosis of problems.



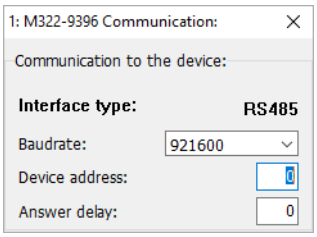
- **Create configuration file:** A configuration file (data format *.r2p) contains all pyrometer data and device settings that have been made. This can be used e.g. to setup a new pyrometer with the same values and settings or to save the current status in case of a device replacement.
- **Load configuration file:** load a previously saved configuration data in the pyrometer.
- **Print parameters:** Prints the parameters of the currently connected device.
- **Print configuration file:** Prints a saved file.
- **Factory settings:** Resets the device to its factory defaults.
- **Create service file:** A service file includes all device data and all software settings made by user. Creating such a file can be useful if a problem can't be solved and help from our service could be useful.
- **Upload service file:** Transmitting a (possibly modified) file to the device it was created from.
- **Check firmware:** Opens a window to check and download a current firmware file, the current version is displayed.



1. Clicking on "Check" checks whether a newer firmware than that in the pyrometer is available.
2. If there is a newer version than the current version, this is displayed as the available version.
3. If a newer version is available than the one installed in the device, the "Download" button will be activated. Click on it to automatically load the file with the .bin extension into the Windows Downloads directory, it is about 700 KB in size.
   The installation is carried out via the ***SensorFlash*** update software. In the "**Communication / Options**" tab, click on **Flash firmware H3 / M3 / DI / DS** to start the software.

7.1.4.11 Interface

Interface settings For setting the **Baud rate** (can also be changed via the settings in **Data mode**), **device address** and **Interface Delay / Answer Delay**.

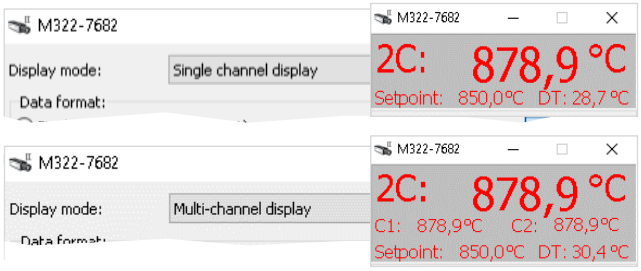


The **interface type** RS232 or RS485 is only displayed, but cannot be changed via software, since a currently connected interface converter would no longer work after the change. However, the interface can be changed directly on the device (select menu item RSTYP → 232 or 485) or via the interface command „**if**“ in the **Terminal field** of *SensorTools*. The device is then disconnected from the software and a corresponding interface converter is required for further communication.

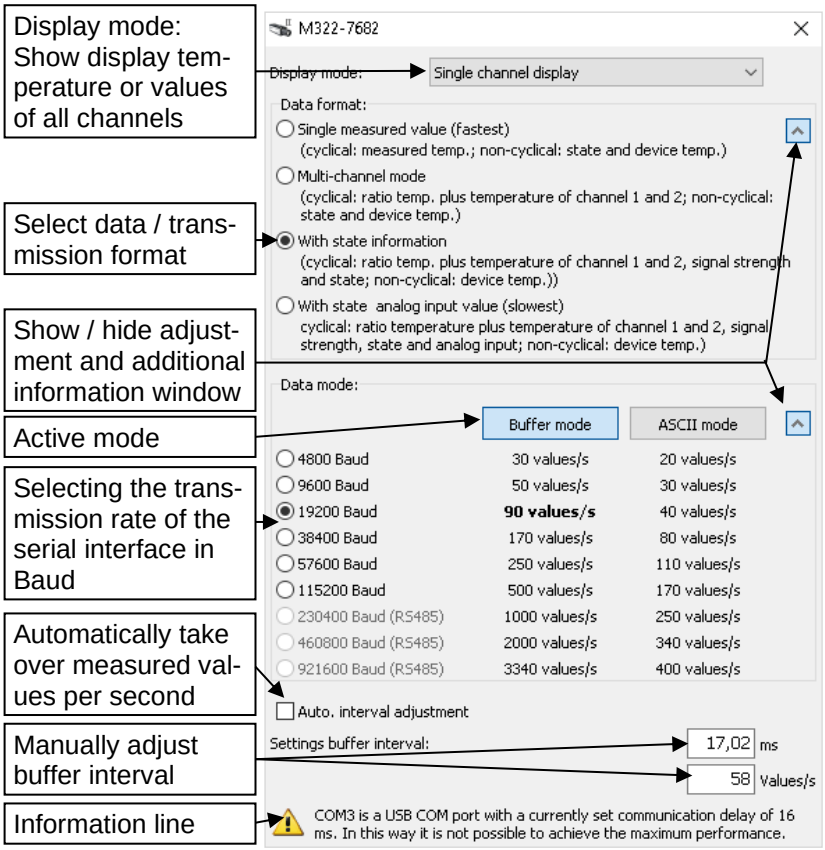
7.1.4.12 Data Collection (Buffer Mode / ASCII Mode)

Data collection The measurement data transfer from pyrometer to the PC can vary depending on the requirements and computing power. Speed and transferable amount of data are dependent on the baud rate and the data mode. In the data collection window, the amount of measured values are shown, determined by calculation for each baud rate and each mode. When set to "Auto. interval adjustment", the corresponding values of baud rate selection will be entered automatically in the field on bottom right. When required, they still can be adjusted manually, for example, if the calculated values still give problems.

- **Display mode** switches between**:**
  - **Single channel display:** The control window displays the current temperature measurement, the device temperature and the setpoint value at devices equipped with a PID controller.
  - **Multi-channel display:** The *SensorTools* control window displays all temperatures (2-color, channel 1, channel 2, device temperature) and the setpoint value at devices equipped with a PID controller. This mode forces at least the multi-channel mode in the buffer mode setting.



- **Data format:** When measurement data are transmitted, the amount of transmitted information can be selected. The selection affects the speed.
  - **Single measured value** (fastest)**:**
    Saves and transmits the temperature value shown on the display. Is used with M3 and H3 models together with the buffer mode at 921.6 kBd to ensure error-free high-speed communication.
  - **Multi-channel mode:**
    Transmits the temperatures of all channels simultaneously and displays them in the software.
  - **With state information:**
    Multi-channel mode plus control information (I/O states, laser targeting active,...). Devices with PID controller have this mode set by force.



  - **With state information and analog input value** (slowest)**:** multi-channel mode plus status information including analog input information.

INFO **to display multiple channels in the Graphs tab of the software:**
To select and view multiple temperature channels, at least the multi-channel mode must be set in the data collection settings. For additional indication of the setpoint at devices with PID controller, preferably the multi-channel mode with status information should be selected.

- **Data mode:**
  - **ASCII mode:** The pyrometer always transfers separate readings to the software and shows each in the graph as a pixel. In addition to the transmission of measured values, also regularly status values are transmitted (limit contacts or active laser targeting light...), so that measured values do not always arrive at the same time interval.
    For most applications this speed is sufficient, a modern PC can transmit every 5 ms a value at 921 Kbits.
  - **Buffer mode:** Measurement data are temporarily stored in the internal pyrometer-buffer and periodically transferred to the software in blocks. The buffer interval defines how fast the internal FIFO buffer of the pyrometer is filled. The shorter the time, the more data per communication block will be transferred.

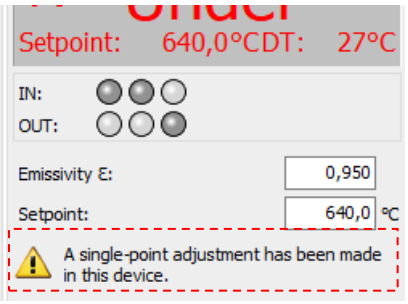
An interval time set too fast in relation to the baud rate and computing power leads to buffer overflows, which are represented by vertical bars in the graph. A modern PC reaches intervals of about 0.3 ms at 921.6 Kbits without buffer overflow, at 57 Kbits intervals of approximately 3.6 ms. If buffer overflows occur, the interval time can be increased, the baud rate can be increased, or unnecessary programs and background services be stopped. A minor impact also has the reduction of the **Maximum data sets in memory** in the **Data Recording Settings**).

7.1.4.13 Single-Point Adjustment Function

The single-point adjustment function is used to readjust the pyrometer to a mainly used measuring temperature.
The function can be used, e.g. to compensate optical losses in measurements through windows or lenses with unknown transmittance (for example, when coupling the pyrometer into a laser beam delivery system).
For this purpose, the pyrometer has to be aligned to a calibration source with this required temperature or a portable calibration source is positioned at the measuring point and the adjustment function is carried out.

NOTICE This function adjusts the pyrometer to one specific temperature and ensures accurate measurements in the range around this temperature.

INFO **to identify a pyrometer that has performed a single-point adjustment:** The pyrometer itself does not show whether the factory adjustment is running or whether a single-point adjustment has been carried out. However, a hazard symbol with the text "A single-point adjustment has been made in this device" can be seen in the **Devices Tab** when a single-point adjustment has been carried out. This can also be seen in the manual adjustment window, where the adjustment values of M3 devices differ from 0.0% (see **7.1.4.13.2**). H3 devices have a fixed value of mostly 5.9% for K1 and K2.



Preparation: Align the pyrometer with the required temperature to a calibration source or position a portable calibration source at the measuring point and perform the calibration function.

7.1.4.13.1 Automatic Single-Point Adjustment

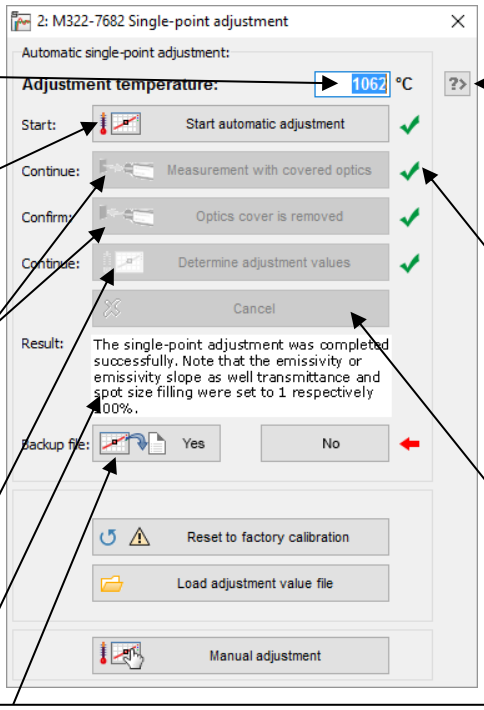
1. Enter the calibration temperature (must be at least 20% of the total temperature range above the beginning of the measuring range).

2. Start adjustment

3. Measurement with covered optics (only M3 models): Cover the lens so it is opaque and start the measurement. Leave the lens covered until the green tick appears on the right and the next step is active (can take up to 20 seconds).

4. Determine adjustment values continues the automatic adjustment in front of the calibration source.

5. Result: After finishing the adjustment of the success or failure will be displayed in text form.



Open help text

Current step that requires a user's action.

Current processing step.

Successfully completed step.

With "**Cancel**" the device is reset to factory calibration.

Backup file: Saved adjustment values can be written back to the same device at any time via "Load adjustment file", e.g. to load different adjustment files or if the instrument has been reset to factory calibration.

INFO The single-point adjustment sets the emissivity slope to 1 and the emissivity of channel 1 and 2 to 1 (100%), switches off the peak picker and sets the response time to 5 ms.
These values are not automatically set to the previous used values and have to be readjusted as required.

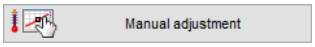
INFO Each single -point adjustment deletes an existing one and replaces it with the new one.

- 

Reset to factory calibration resets all single-point adjustment values so that it measures again with the original complete adjustment.
- 

Load adjustment value file loads adjustment values from a saved file into the pyrometer.

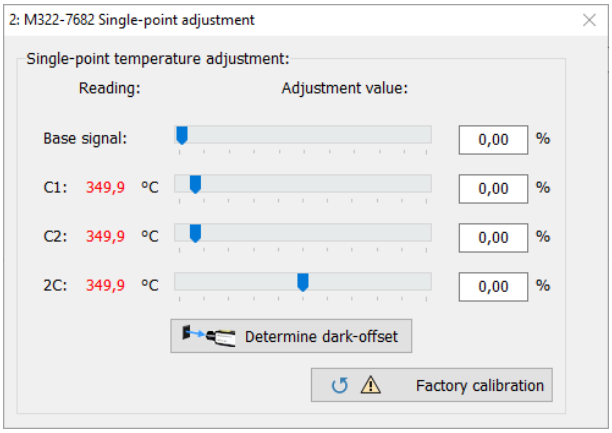
7.1.4.13.2 Manual Adjustment



The single-point adjustment function also can be performed manually with sliding controllers. In this case the numerical value of the adjustment can be observed.

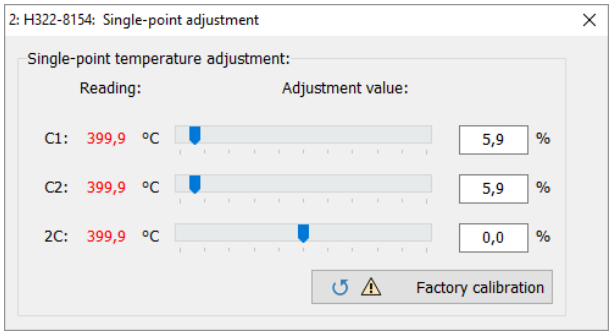
- **Preparation:** First, the parameters emissivity slope, emissivity of channel 1 and channel 2, transmittance and spot size filling should be set to 100%, as well as switch off the maximum value storage and set the response time to 5-10 ms.

- **M3 models:**
  Move the sliders one by one:



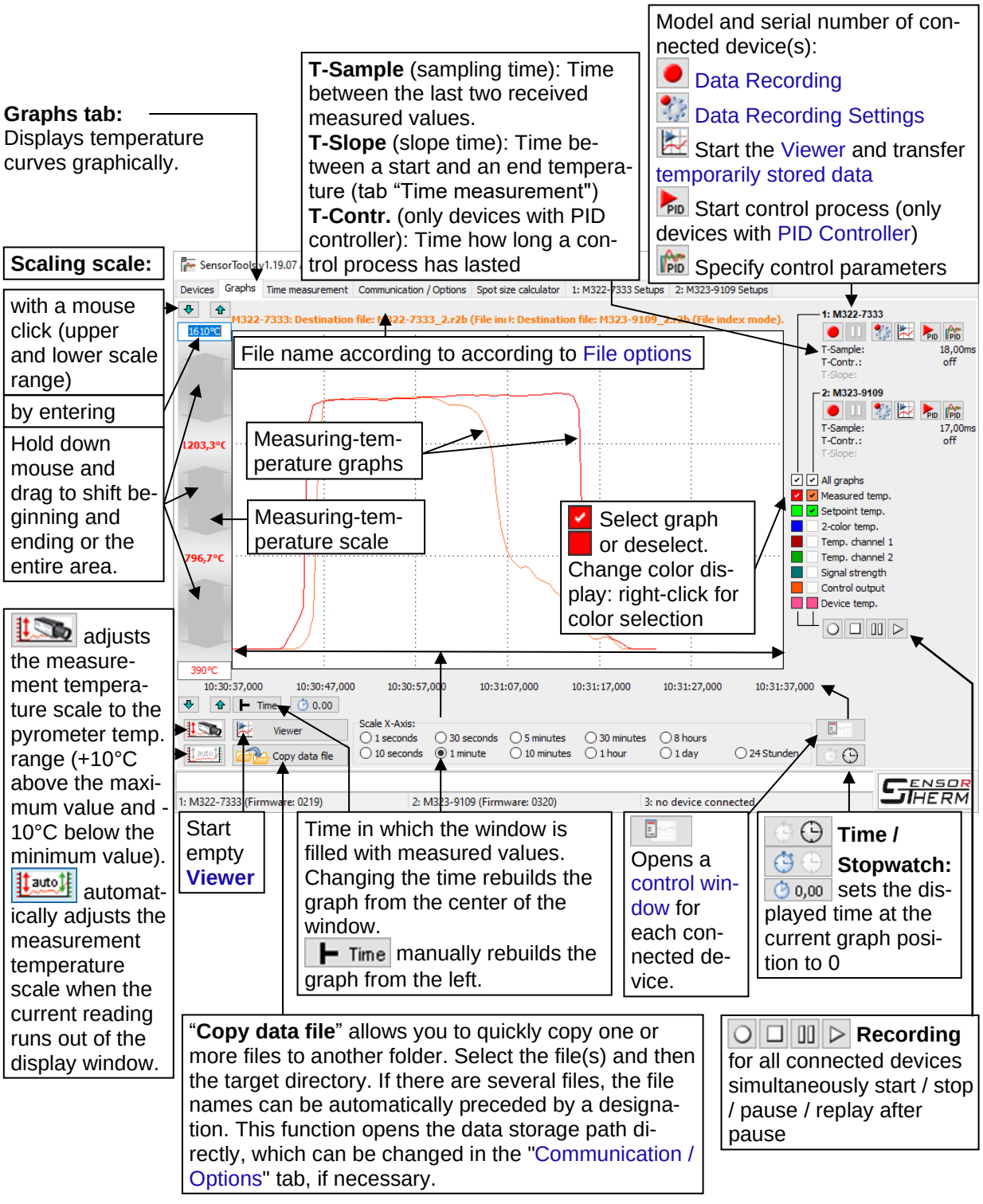
  - **Base signal:** Move until the higher value of C1 or C2 has reached the target temperature.
  - Determine dark offset In the determination of the so-called **dark-offset**, a measurement with completely darkened optics is carried out, which can increase the accuracy outside the adjusted temperature: Cover the lens opaque (for example, press the hand in front of the optics) and keep it covered during the operation (can take up to 20 seconds).
  - **C1 or C2:** Then readjust the other channel (C1 or C2) to the target temperature.
    When determining the dark-offset, under circumstances the values of C1 or C2 can be slightly misaligned. In this case C1 and C2 must be readjusted to the desired value. Deviates the temperature after dar- offset by several degrees, this indicates the lens was not darkened 100% and ambient light has penetrated. Then repeat the step.
  - **2C:** Finally, adjust the 2-color temperature until the temperature value of the calibration source is shown correctly.

- **H3 models:**
  - Move the sliders one by one for channel 1 (C1), channel 2 (C2) and finally for the ratio temperature (2C) until the temperature value of the calibration source is measured correctly.



- Factory calibration The instrument can be reset to factory calibration, this will reset all calibration values to factory calibration (0.0%).

7.2 Graphical Measurement Representation



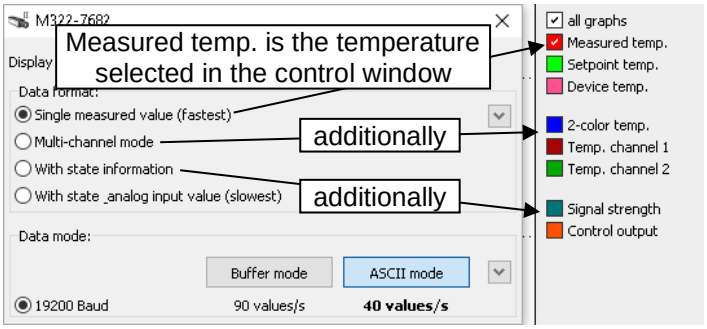
INFO **to temporarily stored data:** As soon as a device is connected in *SensorTools*, measurement data is continuously saved (buffered). The amount of data is defined under "**Maximum data sets in memory**" in the **Data Recording Settings** and can be adjusted there:

- for an error-free **display of the graph**. If the amount of data is set too high for the computer's performance, buffer overflows occur, which are shown as continuous vertical lines.
- for **passing to the *SensorTools* Viewer**. The measurement data can be displayed in the viewer by clicking the playback button ( ). There they can be evaluated more precisely and, if necessary, saved permanently as a file.

Note: Only the set amount of data is transferred, not the complete measurement data since a device is connected. With very fast baud rate and 10000 data sets in memory it could be that just around 0.5 seconds is in memory temporarily stored and transferred to the Viewer. Not very much, so if more values are required, the Data Recording function must be used ( ).

- for the "**Back-time recording**" function, also in the **Data Recording Settings** ( ). If a recording is started, the measurement data file can also be preceded by the measurement data from the buffer.

- **Select display graphs:** Depending on the data collection settings (see **7.1.4.12 Data Collection (Buffer / ASCII Mode)**), different graphs can be shown or hidden.
  - To select and view **multiple temperature channels** (e.g. 2-color temperature + 1-color temperature), at least the multi-channel mode must be set.
  - To display the **signal strength**, the multi-channel mode with status information must be selected.
  - For **displaying the setpoint** at devices with **PID controller**, the multi-channel mode with status information should preferably be selected.



7.2.1 Data Recording

The direct storage of all measured value data is possible via the **recording function**. The amount of data that can be stored is only limited by the hard disk capacity. Here, also the amount of data and thus the file size is directly related to the baud rate and the **Data Collection** settings. Saved files can be displayed in the *SensorTools* Viewer (see **Viewer**).

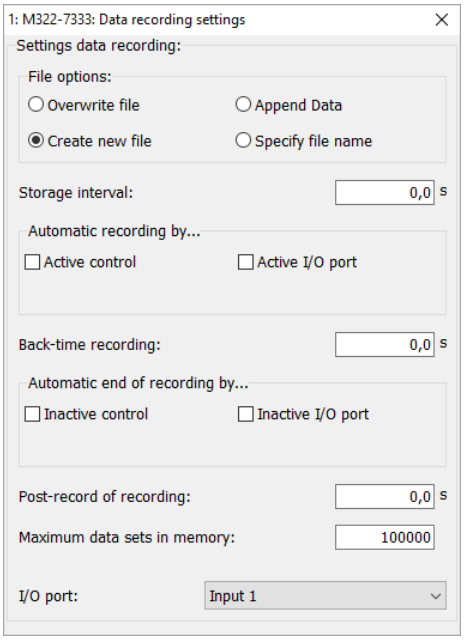
The **recording button** is available in the devices tab or the graphs tab. Every mouse click starts and stops the data recording. When recording is active, the button ( ) flashes, pause ( ) interrupts it. If the **Post-record of recording** function is activated, the button flashes correspondingly longer after stopping.

- The **File name** is displayed above the graph, according to the **File options** in the **Data Recording Settings**.
- The **storage path** of the data file created is shown in the **Communication / Options** tab at the bottom and can also be set individually there, if required.
- The data recording can be extended with the "**Back-time recording**" function or the **Post-record of recording** function at the beginning or the end.
- In the **Data mode**, the type of measured value transmission is specified together with the baud rate. The setting also affects the transmission speed.
  - The higher the **baud rate**, the more measured values per second can be transmitted.
  - The **ASCI mode** always transmits individual measured values and displays them. Depending on the baud rate, between 10 and 400 measured values per second can be displayed.
  - The **buffer mode** is faster, here the measurement data is transferred in blocks. Depending on the baud rate, between 20 and 3330 measured values per second can be displayed, but the PC must be more powerful for this.

- In addition to the measurement temperature, the emissivity slope or the emissivity, device temperature and status information, such as active inputs or outputs, are also saved. The **Data format** is used to set whether additional information is to be displayed, such as the setpoint for devices with a PID controller or the status of a set analog input. However, more information may slow down the transmission.

INFO **for devices with PID controller:** The recording can take place at the same time as the controller starts if this is activated accordingly in the **Data Recording Settings** ( ) ("Automatic recording by: Active control" and, if applicable, "Automatic end of recording by: Inactive control").

7.2.1.1 Data Recording Settings



button to find in the Devices Tab or the Graphs tab.

- **File options:** the chosen option is displayed in the graphs tab above the graph with model and serial number as well as a colored target File name and sequential number.
  - **Overwrite File** (**red**)**:** Overrides the same file with each new recording.
  - **Create new file** (**orange**) creates a separate file for each recording.
  - **Append data** (**green**)**:** With each new recording, the new values are appended to the previous one.
  - **Specify file name** (**violet**)**:** Each time a recording is started, first a window opens in which memory name and location must be entered.
- **Storage interval:** Writes a reading in the file with the set storage interval. At 0.0 s the storage is done as fast as possible (depending on Data mode and baud rate).
- **Automatic recording by:**
  - **Active control** (shows only effect when equipped with a PID controller): Starts recording automatically when a controller-start takes place (also at an external start).
  - **Active I/O port:** Starts recording when a digital input or output is active. The port selection will be done at I/O port at the bottom of the window.
- **Back-time recording:** If the record button is pushed (or recording is activated by active I/O port and setting "automatic recording by active I/O port" is checked), values are stored retroactively for the entered time but only as many, as entered under "Maximum data sets in memory".
- **Automatic end of recording by:**
  - **Inactive control** (shows only effect when equipped with a PID controller): Stops recording when a control process is stopped (even with automatic or external stop, error, etc.).
  - **Inactive I/O port:** Stops recording when a digital input or output is disabled.
- **Post-record of recording:** recording can be continued for a while if control process is stopped, e.g. to record a cool down process.
- **Maximum data sets in memory:** Number of measured value data sets that are buffered for display in the graph window or for back-time recording or when the *SensorTool* Viewer is opened. In addition to the measuring temperature, a measured value dataset also contains emissivity, device temperature and possibly more (depending on buffer mode settings, see **7.1.4.12**).
  Between 500 and 10 million records can be set. Higher values mean that e.g. in the graph window, when switching the time scale setting of the x-axis, more values can be displayed again. Even if post-record of recording is activated, more data can be stored retroactively. Also, the number of values that are transferred to the Viewer by pressing the play button ( ) is affected.

  INFO As soon as the data amount has reached the set value and new measured values are added continuously, the oldest ones are also continuously deleted. The higher the set value, the higher the power demanded by the PC. If the computer is not able to perform this task, buffer overflows occur, which are represented in the graph window by continuously redrawn vertical bars. Then the value must be set lower until the display works correctly.
- As **I/O port** a digital input as well as output can be selected.

  INFO If an output is used, the assigned function can be used for controlling the automatic recording, for example for automatic recording when a certain temperature is exceeded (limit switch activated).

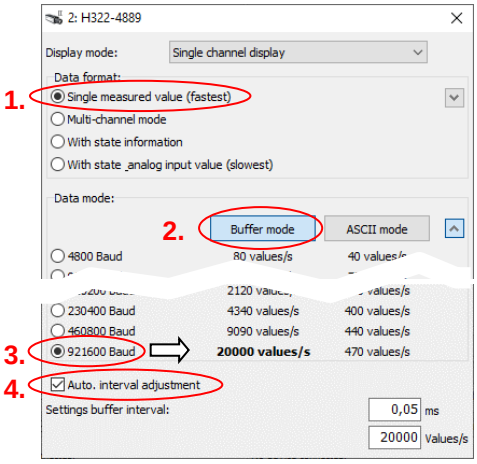
7.2.1.2 Settings for the Fastest Possible Measurement Data Recording

SensorTools can record very fast processes with recording intervals from approx. 50 µs (H3) or 300 ms (M3), if the corresponding settings have been made:

- Use pyrometer with RS485 interface and interface converter RS485 to USB if necessary.
- Set the latency time to 1 ms in the Windows Device Manager for the USB interface used (see **4.1.5.2**).

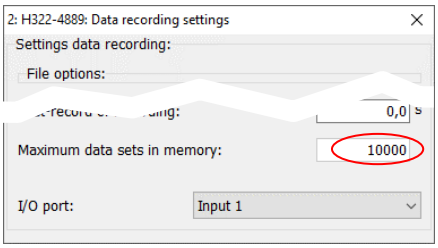
Data collection Make settings for the fastest data transfer in the data collection window (in the device connecting tab or in the control window via "Device configuration"):

1. Data format: Single measured value (fastest).
2. Data mode: Buffer mode.
3. Baud rate: 921600 Baud.
4. Activate “Automatic interval adjustment”.



- Adjust data recording settings (in the device connection area or in the graph window):

  Set the value under "Maximum data sets in memory" to 10000 and take over with the "Enter" key.



INFO The value has been determined experimentally and can be set higher or lower depending on the PC configuration (setting range between 500 and approx. 10 million). With higher values, buffer overflows may occur, which are shown in the graph window after a short time by vertical bars. Then the value should be set lower (also see the description "Maximum data sets in memory" in the Data Recording Settings.

7.3 *SensorTools* Viewer: Graphical Measurement Data Playback

The *SensorTools* Viewer is an independent program for graphic display and evaluation of measured value data. It opens in the language set in *SensorTools*.

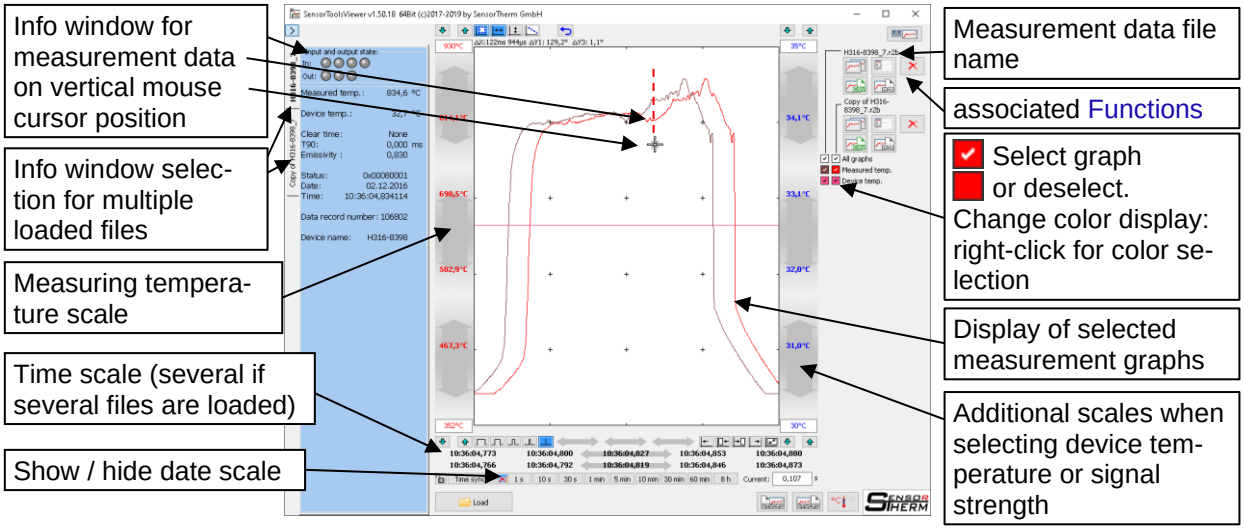
7.3.1 Load / Open Measurement Data File(s)

- Up to **four measurement data files** can be loaded and displayed in a viewer window, in addition to it several viewer instances can be opened:
  - Viewer The viewer opens without file content via the **playback symbol** in the graphs tab.
  - via the small **playback symbols** in the *SensorTools* connection area or the graphs tab the temporarily stored data will be passed to the *SensorTools* Viewer, that are those that have been recorded since the device was connected to the software. However, these are only as many as set in the "Maximum data sets in memory" in the Data Recording Settings.
    To be noted: This data is not stored automatically!
  - Load (directly in the viewer): **opens from the last opened file path**.
    ⇧ key + Load: opens from **standard working directory** (standard working directories can be set in *SensorTools* in the "Communication / Options" tab, also see **7.4**).
  - Via **drag-and-drop**, e.g. from the Windows Explorer files can be dragged directly into the viewer.
  - **Double-clicking** on a measurement data file opens its own viewer window and displays all measurement data in the window.

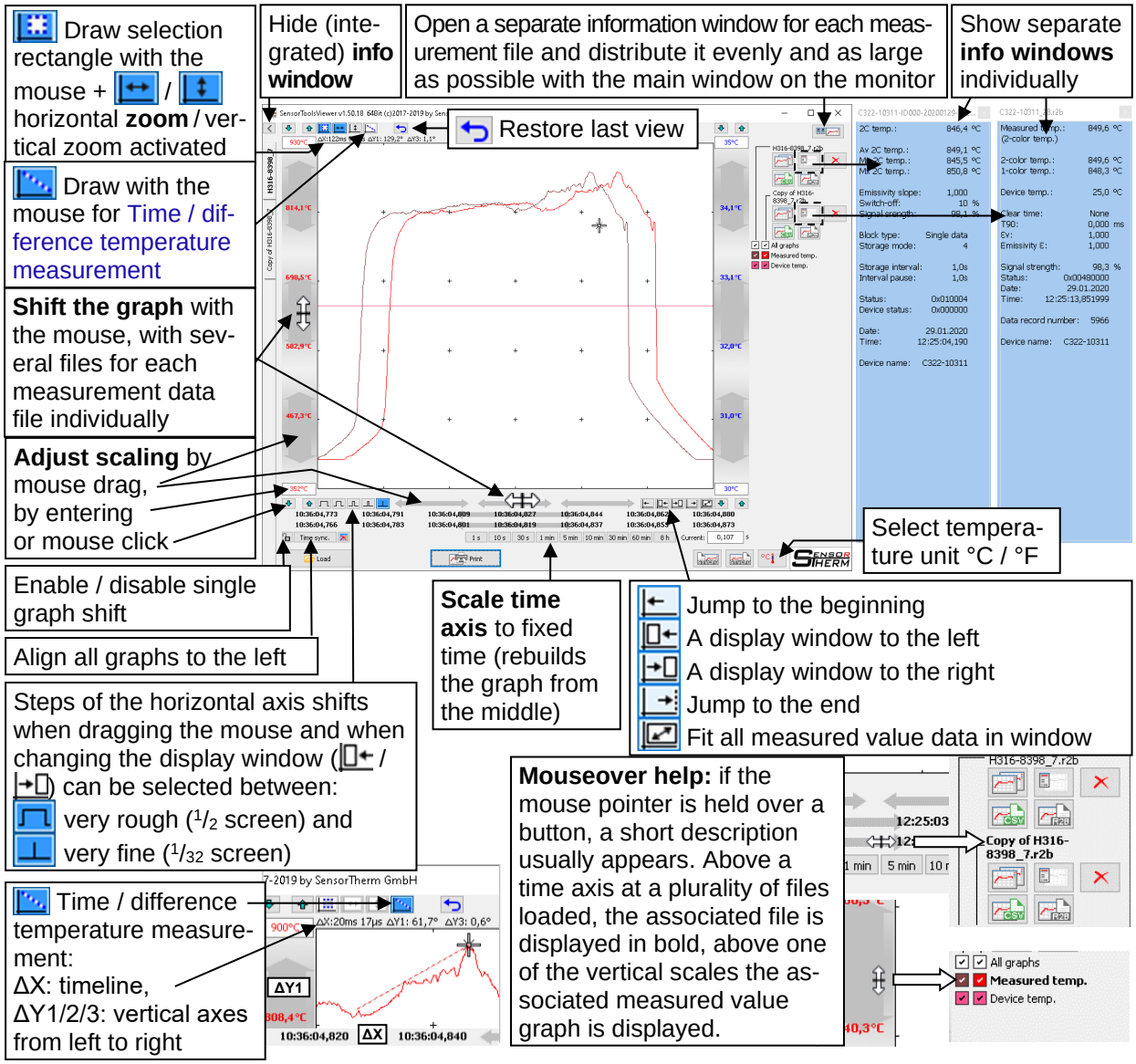
- The following **file types** can be selected:
  - ***SensorTools* data file** (***.r2b**, file icon:): The standard data format for recording measurement data in *SensorTools*.
  - ***SensorTools* Viewer view file** (***.stvcfg**, file icon:): workspace files store a view of multiple data files, e.g. to be sent as a comparative detail view. When saving a workspace file, you can choose in a selection window whether a folder should be created automatically in which the selected data files are saved as r2b so that they can be sent easily or if the original file path should be used.

  INFO Loading an stvcfg file deletes already loaded and displayed r2b files from the Viewer.

7.3.2 Overview



7.3.3 Customize Views / Measurement Data Evaluating



Shortcuts: Moving the X or Y axes while pressing keys.

Temperature axis:			Time axis:		
without key:		10° steps	without key:		as elected
Alt	key:	1° steps	Alt	key:	1 pixel
Ctrl	key:	25° steps	Ctrl	key:	1/8 screen
⇧	key:	50° steps	⇧	key:	1/4 screen
⇧ + Ctrl	key:	100° steps	⇧ + Ctrl	key:	1/2 screen

7.3.4 Copy, Save, Print, Export...

Functions **for each measurement data file** (top right):

- Creates a copy of the current view
- Opens a separate information window
- Closes the respective file
- Saves the current view as .r2b
- Exports the current view as .csv

General (below):
View of multiple files

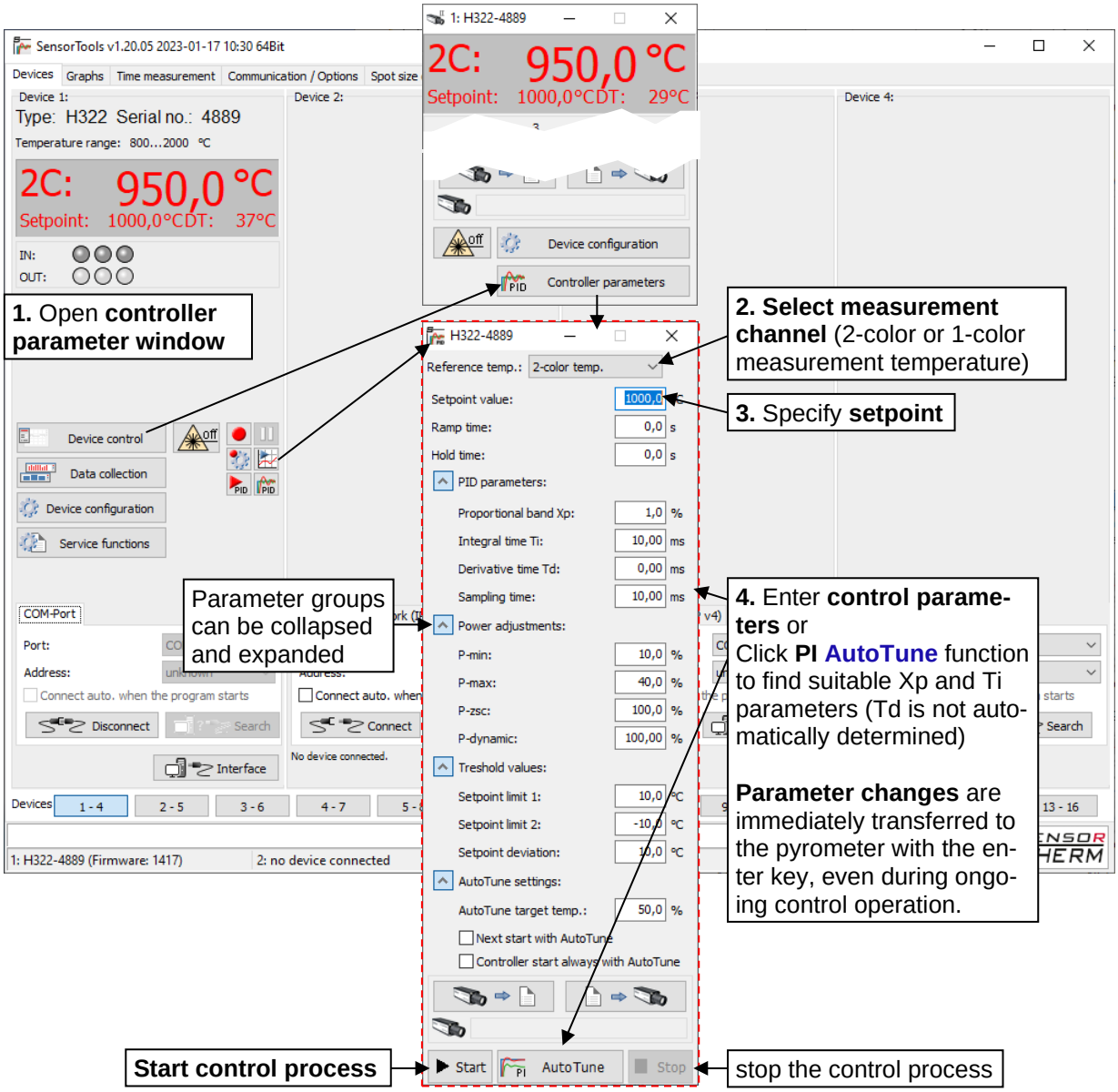
- Loading multiple files simultaneously
- Saves the current view of multiple files as .stvcfg.
- Prints the current screen view.

7.4 PID Controller Equipment

M3 and H3 pyrometers can optionally be equipped with an integrated PID controller. With this, the temperature signal is converted into a manipulated variable signal via a PID software controller. A setpoint value and the necessary PID parameters are set to trigger a corresponding control value output. At the analog output 2, the manipulated variable is provided, via display and analog output 1 the current temperature reading is available.

An integrated PID controller is automatically recognized by the software and activates

- the buttons for the controller setting window (Controller parameters in the control window and in the devices tab).
- the control start / stop buttons (Start / Stop in the controller setting window and in the devices tab).
- additional functions of the Configurable Inputs / Outputs.



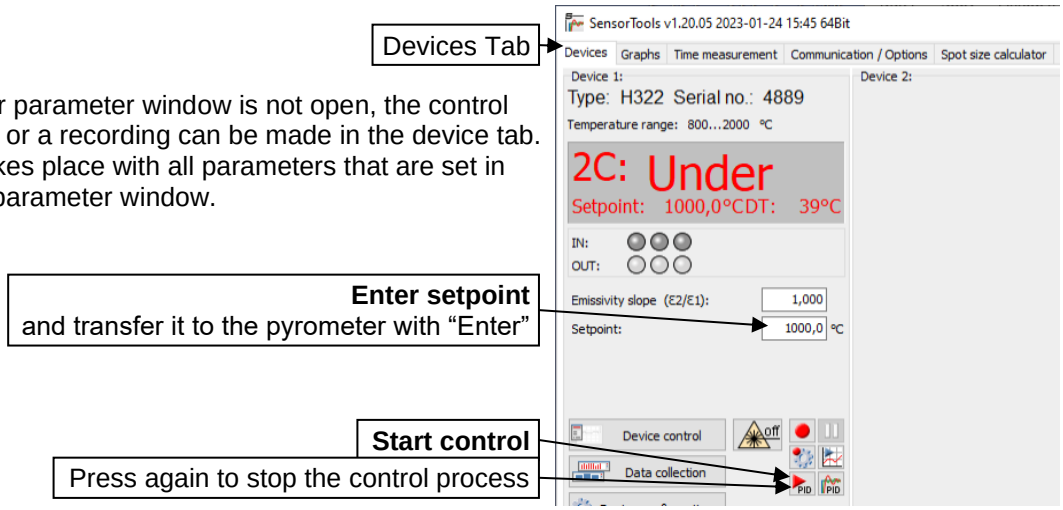
The control process is carried out until it is stopped manually or stops automatically if a hold time has been entered that runs from the time the setpoint is reached.

INFO **if the controller start does not work:** If a digital input "Activate controller" is activated, the controller process can only be started if 24 V are present at the input.

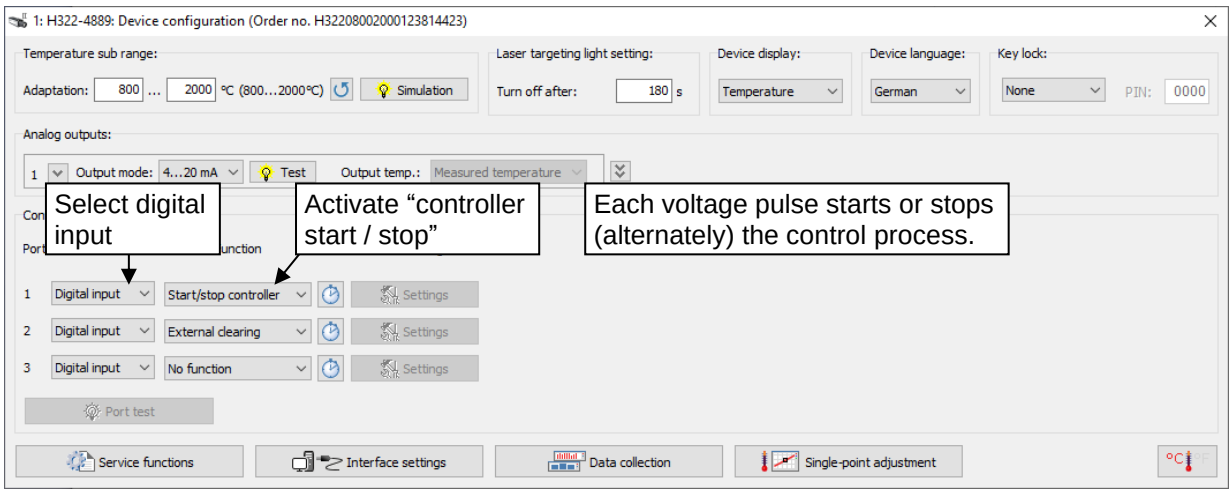
INFO in processes where the temperature is to be controlled from a value higher than the setpoint to a lower value, the controller cannot actively control anything, since reaching the temperature depends on the cooling speed of the material.

7.4.1 Start / Stop from the Devices Tab

If the controller parameter window is not open, the control can be started or a recording can be made in the device tab. The control takes place with all parameters that are set in the controller parameter window.



7.4.2 Start / stop via the Digital Input "Controller Start / Stop"



7.4.3 Control Parameters

- **Always visible parameters:**
  - **Reference temperature:** selects the temperature that is displayed in the control window (same function as in the control window)
  - **Setpoint value:** Setpoint specification
  - **Ramp time** (in 100 ms)**:** The setpoint temperature will be approached by increasing the temperature with a uniform gradient of the temperature within the entered time (the setpoint temperature in the grey field above can show updated ramp temperatures if the buffer mode settings in the data collection settings (see **7.1.4.12**) are set to “with state information”).
  - **Hold time:** when reaching the desired value, the setpoint value in can be maintained at the current value. The control process stops automatically after the hold time is elapsed.

Click the **expand icons** to open the control parameters sorted into groups.

- **PID parameters:**
  - **Proportional band Xp:** The proportional band represents the reciprocal of the gain of the controller (Entering 0.1-1000%, 0.1 = highest gain, 1000 = lowest gain).
  - **Integral time Ti:** The integral time constant represents a kind of smoothing or delay**.**
    INFO Ti is a multiple of the sampling time. Therefore, changes in the sample have an impact on this value.
  - **Derivative time Td:** The derivative time constant slowdowns the rapid rise to prevent overshooting (if, for example, the actual value has almost reached the target value but still strong increases, Td slows a further increasing to prevent an overshoot).
    INFO Td is a multiple of the sampling time. Therefore, changes in the sample have an impact on this value.
  - **Sampling time:** Select how quick temperature values will be read out of the sensor. Select the parameter depending on the inertia of the heating process
    INFO Ti and Td are a multiple of the sampling time. Therefore, changes in the sampling effect changes in Ti and Td.

- **Power adaptation:**
  - **P-min:** The minimum control output power defines the power set to the control output at least.
  - **P-max:** The maximum control output limits the power to the entered value.
  - **P-zsc:** Limits the control output power as long as the beginning of the pyrometer's temperature range is reached. This is useful to avoid a too fast start of a heating process because the object temperature is out of the pyrometer's temperature range.
  - **P-dynamic:** Limits the power, the control output can control suddenly (standard 100%).

- **Other functions:**
  - **Setpoint limit 1 and 2:** Activates every selected "setpoint limit" output (see **4.1.4 Configurable Inputs / Outputs** and under **7.1.4 → Configurable Inputs / Outputs**) if set temperature is exceeded or falls below. The required temperature has to be set relative to the setpoint temperature (in the control parameter field), not as absolute value.
  - **Setpoint deviation:** defines the maximum permissible deviation between setpoint and actual value. Used to detect if a ramp is within tolerance and then initiate the subsequent hold time.

- AutoTune The **AutoTune** function enables to detect automatically useful values for the proportional Xp and integral time constant Ti. The function tries to find the values Xp and Ti without overshooting the setpoint temperature.
  - The **AutoTune target temperature** defines the temperature that is used for Xp and Ti determination. The entry occurs in % and defines the difference between setpoint and actual value (example: setpoint is 1000°C, the measurement object is cold which means the actual value is the pyrometer's beginning of temperature range and thus, for example, 500°C, then the target temperature is 750°C at 50% factory setting). Only a value below 100% prevents a temperature exceeding during P-I-determination and thus a possibly material destruction due to overheating.
  - **Next start with AutoTune:** Check this box to activate the AutoTune function with the next controller start. Starting the controller with "Start" will start first the AutoTune process followed by the programmed control process. This also works fort an external control start. The function is only active for one controller start and will be unchecked with the next start.
  - **Controller start always with AutoTune:** Starts every time the AutoTune function when the controller is started.

    INFO The AutoTune process always starts from the current actual value (measured value). At a restart any residual heat of the object can thus potentially lead to unusable values.

7.4.3.1 Short help for finding the control parameters P, I and D

Basically, in a thermal process, different control parameters will be determined for different temperatures.

- **Proportional band Xp:**
  Xp is a dimensionless number representing the reciprocal of the gain of the controller.

  At Xp = 100% the controller gain is 1.
  at Xp = 0.1% the gain is 1000, at Xp = 1000% the gain is only one tenth.

  This amplification simply increases the control output (manipulated variable) without delay, the further apart the setpoint and actual value are. If you select Xp too small (=gain too high), it may be that the controller tends to oscillate. If Xp is too large (= gain too small), the control output may not be modulated high enough at all.

  With proportional control alone, the actual value of the temperature always remains below the setpoint (if no oscillation occurs), because if the control deviation is 0, the control output would also be set to 0 and no further heating energy would be supplied. A permanent control deviation is thus obtained.

- **Integral time Ki:**
  Ki is specified in units of time (e.g. in seconds). It represents a kind of smoothing or delay time and integrates control deviations to correct the control output so that no remaining control deviation remains.

  Basic rule:
  Ki must be at least as large as the (thermal) time constant of the heating circuit.

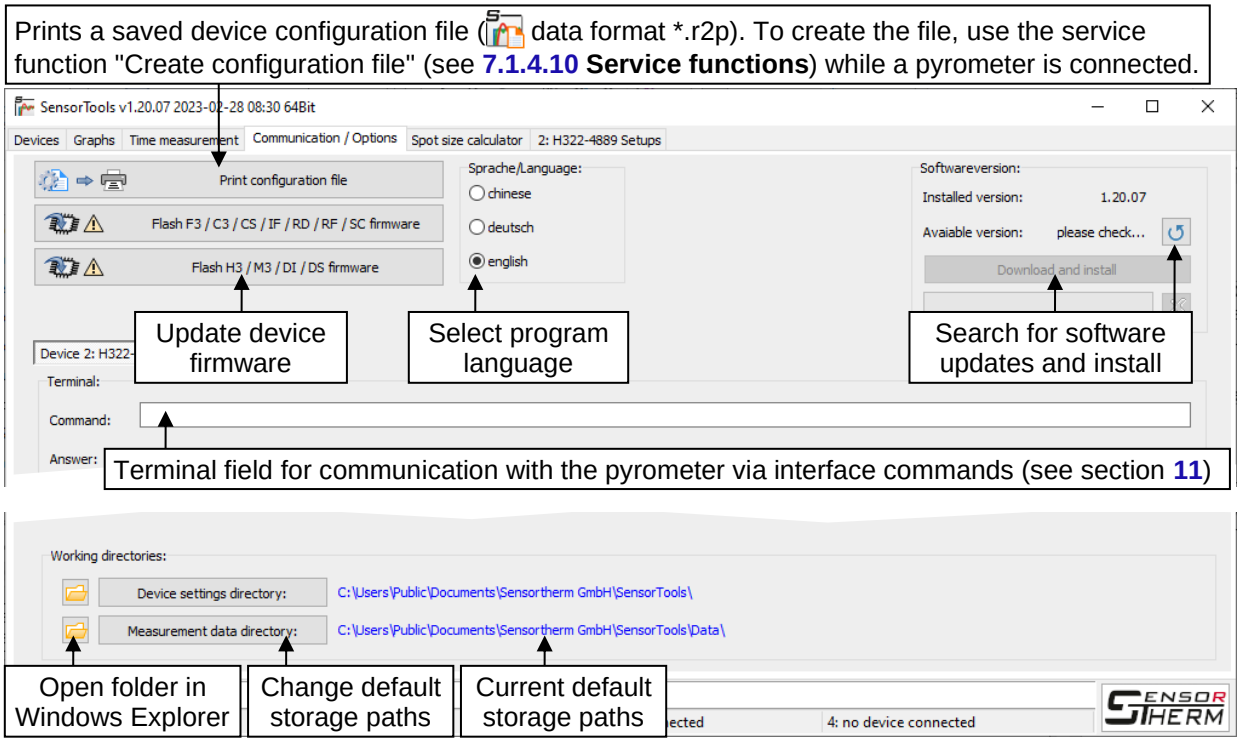
  For example, for a ceramic black body, Ki must typically be in the range of minutes, while fractions of a second may be sufficient for a filament.

  Increasing the time Ki makes the control process slower but also more stable.
  Decreasing Ki can result in overshoot or even continuous oscillation.

- **Derivative time Kd:**
  Kd is also given in units of time. It represents the look-ahead component of the controller. For example, if the setpoint has almost reached the actual value but is still rising sharply, Kd "brakes" the rapid increase and prevents overshoot.

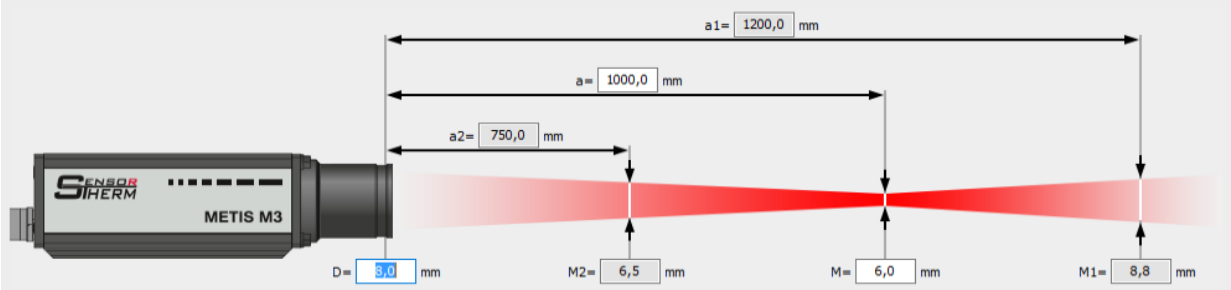
  Method:
  Start with Kd = 0, then set Kd = Ki/4 and see if the transient effect goes better.

7.5 Communication / Options



- **Flash H3 / M3 / DI / DS firmware** starts the ***SensorFlash*** software to update the firmware of the pyrometer. A corresponding firmware file is required for this. It can be downloaded using the "Check firmware" service function (see **7.1.4.10 Service functions**) if the check shows that a more recent version than the one installed in the device is available.
  To be able to connect the pyrometer to *SensorFlash*, it must first be disconnected from *SensorTools* in the Devices tab, the appropriate COM port must then be selected in *SensorFlash*, and the device connected again.
- The **working directories** specify the device settings locations (all software-internal and device-specific data such as Service Functions or ShortSetting files stored via the Control Window) and for measurement recording.
  The storage paths can only be changed if no device is connected.

7.6 Spot Size Calculator



The spot size calculator is used to calculate the spot size diameter in front of and behind the focus distance. To do this, first enter the white fields with the focus distance, the associated spot size diameter and the aperture according to the **Spot Size Table**. A measuring distance or spot size diameter can then be entered in a gray field and confirmed with the Enter key, the corresponding equivalent value in the associated gray field is calculated directly.

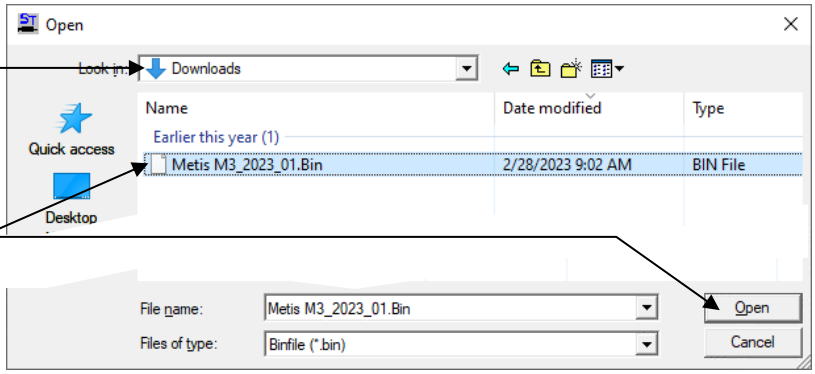
8 *SensorFlash* Software (Firmware Update)

The *SensorFlash* software is used to update the firmware of Sensortherm pyrometers. Press **Flash H3 / M3 / DI / DS firmware** in the Communication / Options tab (see **7.5**) to start the software, an updated firmware file can be downloaded via the **Service Functions**.

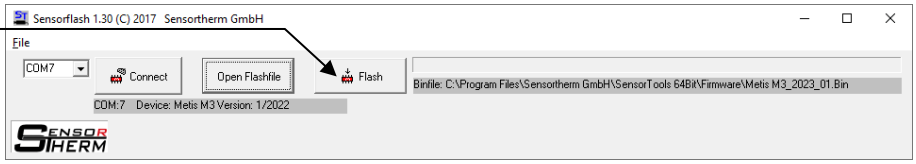
1. Select the interface that the pyrometer is connected to.
2. Press “Connect”.

3. Detected device
4. Click on “Open Flash File”.

5. Call up the "Downloads" directory of the previously downloaded firmware file.
6. Select and open the appropriate bin file. It consists of the series name, the year of publication and a consecutive year number.

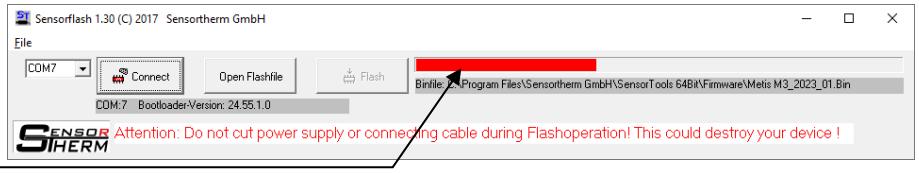


7. Click on the “Flash” button that is now available.



8. Confirm security query.

9. The firmware is now transferred to the device. Wait for the progress bar to run out and the confirmation message (Congratulation) to appear.



NOTICE **Do not interrupt the power supply during the process, the device could be destroyed!**

10. After pressing “OK”, the device is automatically disconnected from *SensorFlash*.
For further use with *SensorTools*, the pyrometer must be reconnected (see **7.1 Program Start / Pyrometer Connection**).

9 Technical Data

Device-specific M3

Model	M311	M322
Temperature ranges	600–1400°C 650–1500°C 750–1800°C 900–2500°C 1000–3000°C *) 1100–3300°C *)	300–1000°C 350–1300°C 400–1600°C 500–1800°C 600–2300°C 800–3000°C **) 1000–3300°C **)
Spectral range	channel 1: 0.93–1.1 µm / channel 2: 0.75–0.93 µm *) channel 1: 0.99 µm / channel 2: 0.87 µm	channel 1: 1.65–1.8 µm / channel 2: 1.45–1.65 µm **) channel 1: 1.64 µm / channel 2: 1.4 µm
Detector	2 x Silicon	2 x InGaAs
Response time t_{90}	< 1 ms (with dynamical adaptation at low signal levels), adjustable up to 10 s	
Exposure time	< 0.5 ms	
Uncertainty (ε = 1, t_{90} = 1s, T_A = 23°C)	0.5% of reading in °C + 1K (The measurement uncertainty is reached after a warm-up phase of min. 20 minutes; device must be connected to the power supply)	
Repeatability (ε = 1, t_{90} = 1s, T_A = 23°C)	0.1% of reading in °C + 1 K	
Temperature coefficient (deviations to 23°C)	From 10 to 60°C: 0.04%/K From 0 to 10°C and 60 to 80°C: 0.06%/K	
Serial interface	RS232 (4.8 to 115.2 kBd) or RS485 (4.8 to 921.6 kBd), switchable. Resolution 0.1°C or 0.1°F	
Power consumption	max. 6 VA (all outputs unconnected)	
Ambient temperature	0 to 80°C / 32 to 176°F, fiber optic and optics on optics side: -20 to 250°C / -4 to 482°F (to prevent its overheating, the laser targeting light is deactivated at a device temperature above 55°C / 131°F).	

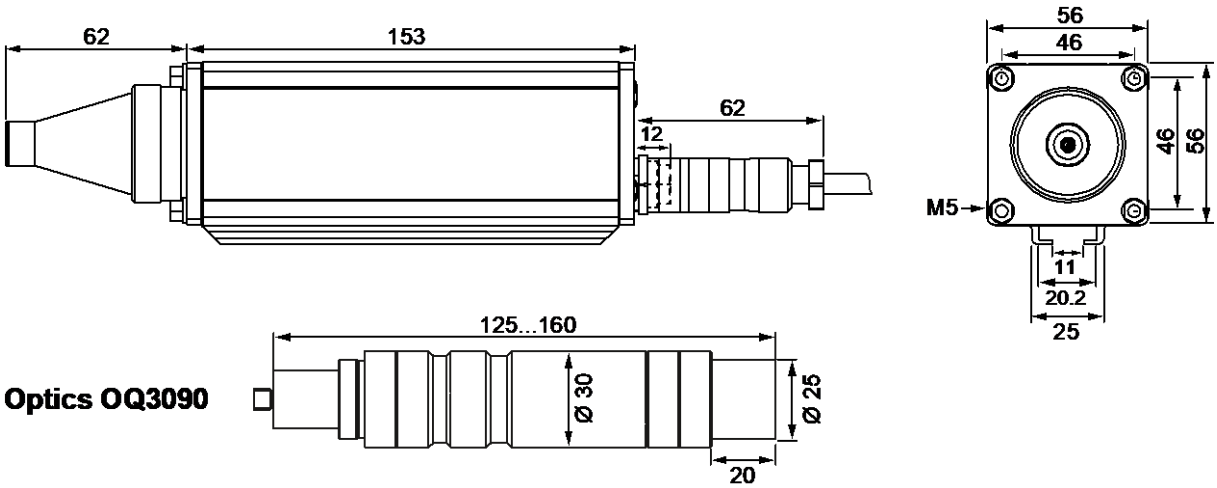
Device-specific H3

Model	H311	H322
Temperature ranges	600–1100°C 650–1300°C 750–1400°C 900–1800°C 1000–2000°C 1100–2200°C 1300–2500°C 1600–3300°C *)	350–800°C 400–1200°C 500–1300°C 550–1400°C 800–2000°C 1000–2500°C 1300–3000°C **)
Spectral range	channel 1: 0.93–1.1 µm / channel 2: 0.75–0.93 µm *) channel 1: 0.99 µm / channel 2: 0.87 µm	channel 1: 1.65–1.8 µm / channel 2: 1.45–1.65 µm **) channel 1: 1.64 µm / channel 2: 1.4 µm
Detector	2 x Silicon	2 x InGaAs
Response time t_{90}	< 80 µs, adjustable up to 10 s	
Exposure time	< 40 µs	
Uncertainty (ε = 1, t_{90} = 1s, T_A = 23°C)	0.5% of reading in °C + 1K	
Repeatability (ε = 1, t_{90} = 1s, T_A = 23°C)	0.2% of reading in °C + 1 K	
Serial interface	RS485 (4.8 to 921.6 kBd). Resolution 0.1°C or 0.1°F	
Power consumption	max. 12 VA (all outputs unconnected)	
Ambient temperature	0 to 60°C / 32 to 149°F, fiber optic and optics on optics side: -20 to 250°C / -4 to 482°F (to prevent its overheating, the laser targeting light is deactivated at a device temperature above 55°C / 131°F).	

Common Data

Temp. sub range	Any range adjustable within the temperature range (minimum span 50°C)
Emissivity slope	0.800–1.200
Emissivity ε	0.050–1.200 (corresponds 5–120% in 0.1% steps)
Transmittance	5–100% in 0.1% steps
Spot size fill factor	5–100% in 0.1% steps
Switch-off level	2–90%
Analog outputs	2 scalable analog outputs 0 or 4–20 mA, switchable, max. load: 500 Ω Resolution 0.0015% of the adjusted sub range temperature (16 Bit). User selectable: 2-color temperature, 1-color temperature channel 1 or channel 2, device temperature or control output (if equipped with a controller). Outputs can be scaled, inside or outside the temperature range.
3 configurable Inputs / outputs	▪ Digital inputs (max. 3 inputs, protected against reverse polarity): laser targeting light on/off, clearing of peak picker, controller start (when equipped with PID controller), load pyrometer configuration, trigger input for start / stop of measured value recording. ▪ Digital outputs (max. 3 outputs, max. 50 mA, protected against short circuit): limit switch, exceeding the beginning of temperature range (for material recognition), device ready after self-test, device over-temperature, signal strength too low. When equipped with PID controller: controller active, control process within limits, control process finished. ▪ Analog input (0–20 mA, protected against reverse polarity and incorrect connection): analog adjustment of the emissivity, or setpoint for PID controller (when equipped with PID controller).
Maximum value storage / Peak picker	Automatic hold mode or manual time settings to clear (reset) or external clear (via digital input)
Display	Devices with LED: 10-digit LED display (5 mm high) for temperature display or device settings Devices with OLED: Dot matrix, green-yellow, 128 x 32 Dots (5.6 mm high) for temperature display or device settings (to avoid premature aging of the OLED display, it is darkened if no button is pressed for 10 minutes and from an internal temperature of 60°C (140°F). The display is switched off from an internal device temperature of 75°C (167°F)) Resolution 0.1°C / °F
Parameter settings	Push buttons on the device, serial interface, PC software *SensorTools* or via self-compiled communication program: Emissivity slope, switch-off limit for measurement, switch-off limit for dirty window alarm, emissivity, transmittance, fill factor, temperature sub range, settings for peak picker, device address, baud rate, response time, analog outputs selection 0 or 4–20 mA, interface RS232 or RS485 (selection on the device only), °C/°F, language (English / German)
Power supply	24 V DC (18–30 V DC), protected against reverse polarity
Isolation	Voltage supply, analog and digital output are galvanically isolated from each other
Sighting method	Laser targeting light (red, λ=650 nm, P< 1 mW, laser class 2 to IEC 60825-1:2015)
Optics	Manually focusable fiber optics
Housing / protection class	Aluminum / IP65 (when the connector is plugged in)
Storage	Storage temperature: -20 to 85°C (-4 to 185°F) Relative humidity: max. 95%, non-condensing conditions, do not store outdoors, protect from direct sunlight, store dry and dust-free, do not exposed to corrosive media, avoid mechanical vibrations
Relative humidity	Non-condensing conditions
Weight	650 g (1.32 lbs)
CE label	According to EU directives

9.1 Dimensions



9.2 Composition of the Type Number

The equipment version of the pyrometer is encoded in the 22-digit model number as follows (Example type number H322 with fiber optics, optimized for laser applications, temperature range 600–1300°C; laser targeting light, special optics OQ30-90):

Digit	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22
Expl.:	H	3	2	2	0	6	0	0	1	3	0	0	1	5	3	8	1	M	4	2	3	X

Digit	Indication of the various points	Code	Meaning / Example
01-02	Series M3	M3	Metis M3
	Series H3	H3	Metis H3
03-04	Spectral range	11	0.75–1.1 µm (2 x Si) 0.78 + 0.99 µm (2 x Si)
		22	1.45–1.8 µm (2 x InGaS) 1.4+1.64 µm (2 x InGaS)
05-08	Beginning of temperature range [°C]	0600	600°C
09-12	End of temperature range [°C]	1300	1300°C
13	Sighting	1	Laser targeting light
14	Serial interface	5	RS232 / RS485 (switchable)
15	Lens type	3	Fiber optic cable 0.2 mm Ø with focusable optics
		4	Fiber optic cable 0.4 mm Ø with focusable optics
16-17	Minimum response time	13	<1 ms
		81	80 µs
18	Configuration	M	Modification optimized for laser applications (12 pin connector, display, push buttons, 3 configurable inputs / outputs)
		N	Modification optimized for laser applications (12 pin connector, PID controller, display, push buttons, 3 digital inputs / outputs)
19	Digital display	4	With display (12 pin connector)
20	Analog outputs	2	2 analog outputs
21	Digital input / digital output	3	3 digital inputs / outputs / 1 analog input 0–20 mA (with 12 pin connector)
22	Optics	X	Special optics

9.3 Accessories

Order no.	Meaning
AL11-XX *)	Connection cable with right angled connector
AL43-XX *)	Connection cable with straight connector
AM11-XX *)	Connection cable with right angled connector + 1 m interface cable with SUB-D plug
AM43-XX *)	Connection cable with straight connector + 1 m interface cable with SUB-D plug
AU11-XX *)	Connection cable with right angled connector + RS232⇔USB interface converter
AU43-XX *)	Connection cable with straight connector + RS232⇔USB interface converter
AV11-XX *)	Connection cable with right angled connector + RS485⇔USB interface converter
AV43-XX *)	Connection cable with straight connector + RS485⇔USB interface converter
DK5485	Interface converter RS485⇔USB, 1.7 m cable, open wire ends
DK4000	Interface converter RS485⇔USB, 1.7 m cable, 9-pin Sub-D-connector
DK5232	Interface converter RS232⇔USB, 1.7 m cable, open wire ends
DK3000	Interface converter RS232⇔USB, 1.7 m cable, 9-pin Sub-D-connector
NG12-00	Din-rail power supply 24 V DC, 1.6 A
NG15-00	Desktop power supply 24 V DC, 2.5 A
IF0000	LED digital indicator for panel mounting
Regulus RD	PID program controller as bench top model
Regulus RF	PID program controller for panel mounting
BL14-00	Air purge accessory for fiber optic cable lens assembly OQ25 / OQ30
HA10-00	Mounting bracket
HA14-00	Adjustable mounting bracket for fiber optics OQ25 / OQ30

*) XX Specify length in meters (available in 5 m steps)

10 Maintenance

⚠ CAUTION switch off supply voltage.
Before beginning any maintenance, switch off power supply or pull connector on the pyrometer to prevent injury by accidentally activated laser targeting light!

10.1 Cleaning

Clean the lens with a soft cloth and a little ethanol.

Do not
- clean the optics with solvents that contain acid
- immerse the optics in water or other liquids to clean

10.2 Pyrometer Calibration / Adjustment

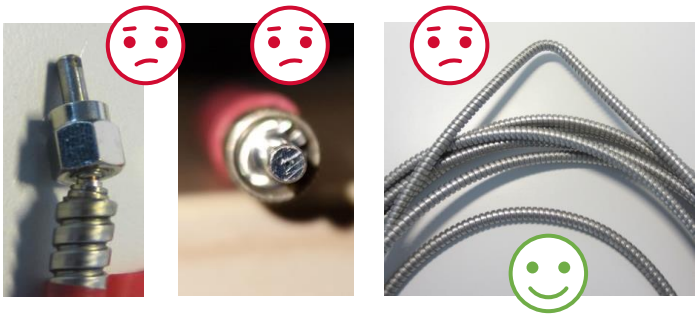
To obtain the measurement accuracy, we recommend to re-calibrate the pyrometer periodically (annually) with the help of calibration sources and optionally adjustment at Sensortherm.

- Fiber-optic pyrometers must always be adjusted together with the associated optics and the optical fiber cable.
- Readjustment is also required if the lens is to be replaced and/or a new fiber optic cable is to be used.

10.3 Troubleshooting

Before sending the pyrometer in for repair, check whether the fault can be identified and eliminated using the list.

- **Optical fiber connection broken** directly on the optics (caused e.g. by pulling the optical fiber while the optics is fixed, a measurement is no longer possible here) or **connector scratched** (caused by laying the fiber without protective connector cap, temperature display too low) or **minimum bending radius undershot** (causes a strong weakening of the signal with corresponding measurement errors).
  → Install a new optical fiber.



- **Emissivity slope** (or emissivity with 1-color measurements) **is set too high** (temperature reading too low) or **emissivity slope** (or emissivity with 1-color measurements) **is set too low** (temperature reading too high).
  → Correct the emissivity slope or emissivity according to the material.
- **Measurement error due to HF interference**, e.g. pyrometer too close to an inductor.
  → Shield incorrectly connected. Connect according to chapter **4.1.6**.
- **Device malfunction**, indicated by a red operating status LED (right LED 4). This may be a data transmission error or a firmware problem.
  → If the interface is not affected, the error can be read out via the **fs** command (in the Terminal field, see **7.5**). For interpretation of the answer please contact us so that we can find a solution of the problem.
  To further limit the possibilities, a **service file** can be created via the software *SensorTools* (see under **7.1.4.10 Service Functions**) that can be sent to Sensortherm for further support.

11 Communication via Interface Commands

Interface commands are used to communicate directly with a Sensortherm pyrometer. Commands can be used to write an own access control or can be entered in the terminal field of the software *Sensor-Tools* (see **7.4 Communication / Options**) or entered via a terminal software.

- Data is exchanged in ASCII format with the following transmission parameters:
  8 bit, 1 stop bit, even parity (8,1,e)
- Command sequence to write parameters:
  2-digit **device address → command → parameter → <CR>** (Carriage Return)
- Command sequence to read out the current set parameters:
  2-digit **device address → command → <CR>** (Carriage Return)

INFO

- **Device address** (also see in **6.2.11.2**): In factory setting the device address is 00 but can be changed directly at the pyrometer (under INTERFACE> → ADD).
  In the Terminal field of the *SensorTools* software no address is required.
- **Parameters** are encoded in hexadecimal unless specified otherwise.
- When writing with **valid parameters**, the response will be **ok + <CR>**
- When writing with **invalid parameters**, the response will be **no + <CR>**
- Deviating reading commands are in parentheses at the respective commands.

Example:

Input in terminal programs with device address 00:
0ar1<CR> sets the 2nd analog output to 4-20 mA
00ar<CR> reads out how the analog output is set

Input in the Terminal field of *SensorTools* without device address
ar1<CR> sets the 2nd analog output to 4-20 mA
ar<CR> reads out how the analog output is set

INFO The following commands are valid with the newest firmware version.

Command	Parameter	Description / Settings
aa (aaX)	XY	Output of the adjustable analog output 2 (X=2 = analog output 2) Y = 0...8, output temperature or controller Y = 0 = No output Y = 1 = 2-color temperature Y = 2 = Temperature channel 1 Y = 3 = Temperature channel 2 Y = 6 = manipulated variable (devices with PID controller) Y = 8 = Device temperature
an	X	Measured temperature (for temperature reading also see mw command) X = 0 = 2C channel; 1 = channel 1; 2 = channel 2
ar	X	Output mode: analog output 2 X = 0 = 0–20mA; 1 = 4–20mA
as	X	Output mode: analog output 1 X = 0 = 0–20mA; 1 = 4–20mA
ax	XXXX	Switch-off level in 1/10% XXXX = 0x0014...0x0384 (corresponds to 2.0 to 90.0%)
az	XXXXXX	Response time of the shutdown (in steps of 100 µs to 10 s) XXXXXX = 0x000000...0x0186A0
bn		Reference number pyrometer (18-digit ASCII)
bn1		Reference number pyrometer (21-digit ASCII)
bum	XX	Buffer mode selection (XX = 00...03)

bup — Transmission of measured data:

Reading the buffer data (only one current packet!)
Buffer mode 00: answer: AAAA
AAAA = Measured temperature (0xF001 => Overflow)

Buffer mode 01: answer: AAAABBBBCCCC
AAAA = 2-color temperature (0xF001 => Overflow)
BBBB = 1-color temperature channel 1 (0xF001 => Overflow)
CCCC = 1-color temperature channel 2 (0xF001 => Overflow)

Buffer mode 02: answer: AAAABBBBCCCCDDDDEEEEFFFFGGHHIIJJ
AAAA = 2-color temperature (0xF001 => Overflow)
BBBB = 1-color temperature channel 1 (0xF001 => Overflow)
CCCC = 1-color temperature channel 2 (0xF001 => Overflow)
DDDD = Setpoint value at ramp function (current ramp setpoint value!)
EEEE = (Analog) controller manipulated variable (0-1000) in % (0.0-100.0%)
FFFF = Signal strength (0-1000) in % (0.0-100.0%)
GG = Data status byte 0
HH = Data status byte 1
II = Data status byte 2
JJ = Data status byte 3

Buffer mode 03: answer: AAAABBBBCCCCDDDDEEEEFFFFGGHHIIJJ
AAAA = 2-color temperature (0xF001 => Overflow)
BBBB = 1-color temperature channel 1 (0xF001 => Overflow)
CCCC = 1-color temperature channel 2 (0xF001 => Overflow)
DDDD = Setpoint value at ramp function (current ramp setpoint value!)
EEEE = (Analog) controller manipulated variable (0-1000) in % (0.0-100.0%)
FFFF = Signal strength (0-1000) in % (0.0-100.0%)
GG = Data status byte 0
HH = Data status byte 1
II = Data status byte 2
JJ = Data status byte 3
KKKK = Analog input in Bit (0x0000–0x0FFF)
LLLL = unused (0xFFFF)
NNNN = Measured temperature (0xF001 => Overflow)
MMMM = unused (0xFFFF)

Data status bytes:

Bit	GG	HH	II	JJ
Bit0 (lsb)	Fahrenheit active	Controlling active	Setup0	Display 0
Bit1	Status digital output 1	AutoTune active	Setup1	Display 1
Bit2	Status digital output 2	AutoTune at controller start	Setup2	Display 2
Bit3	Status digital output 3	Device ready	unused	unused
Bit4	Status digital input 1	Device hardware error	unused	unused
Bit5	Status digital input 2	Controller finished successful	unused	unused
Bit6	Status digital input 3	Targeting light active	unused	unused
Bit7 (msb)	unused	unused	unused	unused

br X — Baud rate of serial interface
X=2...6,8..9,a,b

2 = 4800 Baud	5 = 38400 Baud	9 = 230400 Baud
3 = 9600 Baud	6 = 57600 Baud	a = 460800 Baud
4 = 19200 Baud	8 = 115200 Baud	b = 921600 Baud

eg XYYYY — Emissivity / emissivity slope
X = 0...2; YYYY = 0x0050-1200 (corresponds 5 to 120%; in 0.1% steps)
eg0 = emissivity slope = 0x0320...04b0 (0800-1200)
eg1 = emissivity slope channel 1 = 0x0032...04b0 (0050-1200)
eg2 = emissivity slope channel 2 = 0x0032...04b0 (0050-1200)

et XXXXXX — Response time (in steps of 100 µs)

		XXXXXX = 0x000000-0186A0 (corresponds to 0-10 s)
fh	X	Celsius/Fahrenheit selection X = 0 = Celsius; 1 = Fahrenheit
ff	XYYYY	Fill factor (spot size filling) X = 1, 2; YYYY=0050-1000 (corresponds 5%-100%) in 0.1% steps ff1 – Fill factor channel 1 0050-1000 (0x0032...03e8) ff2 – Fill factor channel 2 0050-1000 (0x0032...03e8)
fs		Read error status: Bit0 = Error A/D converter Bit 1 = I2C error (video module) Bit 2 = error device temperature Bit 3 = error detector temperature Bit 4 = error device temperature over Bit 5 = error Eeprom Bit 6 = error motorized optics Bit 7 = unused
ga	XX	Device address XX = 00...97 (2-digit dec.)
gh (ghX)	XYYYY	Hysteresis for limit switch X (X = 1...3) to value YYYY (in 1/10 degree)
gk (gkX)	XYYYY	Threshold for limit switch X (X = 1...3) to value YYYY (in 1/10 degree)
ia (iaX)	XYYYY	Debounce time for digital input X (X = 1...3) Debounce time: YYYY=0x0000...03E8 (0-1000 ms)
if	X	Serial interface (only M3) X = 0 = RS232; 1 = RS485 (that followed a baud rate of 19.2 KBd!)
io	XX	Configure digital inputs/outputs Bit 0 =1 => inputs 1 active / output 1 inactive, otherwise reversed; Bit 1 =1 => inputs 2 active / output 2 inactive, otherwise reversed; Bit 2 =1 => inputs 3 active / output 3 inactive, otherwise reversed.
in (inX)	XYY	Configure input X =1...3; YY = 00...05 YY = 00 – No function YY = 01 – External clearing peak picker YY = 02 – Targeting light on (devices with targeting light) YY = 03 – Activate controller (devices with controller) YY = 04 – Controller start / stop (devices with controller) YY = 05 – Setup 0
la	X	State of targeting light; X=0...2; X = 0 =Targeting light off; 1 = Targeting light on; 2 = Targeting light toggle
lg	X	Language X = 0 = English; 1 = German
lm	X	Set storage mode (peak picker) 0 = peak picker off (no storage) 1 = Time delete (then lt applies) 2 = External clearing of peak picker 3 = Automatic clearing of peak picker
lt	XXXXXX	Clear time of peak picker (in 100 µs steps) XXXXXX=0x000000...03d090 (corresponds to 0...25 s)
lx		External clearing of peak picker
mb		(Read) temperature range XXXX = Beginning of temp. range; YYYY = end of temp. range in °C/°F
me	XXXXYYYY	Temperature sub range of pyrometer (superordinate to the analog outputs) XXXX = Beginning of temp. range; YYYY = end of temp. range in °C/°F
me (meX)	XYYYYZZZZ	Scale analog output temperature range X (X = 1, 2) (0…6553.5 °C/°F) YYYY = Beginning of temp. range; YYYY = end of temp. range in °C/°F
mwX		Read measured temperature (current value) (4-digit hex.) mw0 = current 2-color reading mw1 = current channel 1 reading mw2 = current channel 2 reading
oa (oaX)	XYYYY	Activation time of the digital outputs X (X=1...3) YYYY=0x0000...ffff (corresponds to 0-65535 ms)
oc (ocX)	XYY	Reference temperature for activating a digital output (X=1…3) YY = 00 = 2-color, 01 = channel 1, 02 = channel 2
od	XX	Output inversion (logic NO to NC)

		Bit0 = 0 (digital output 1 = NO), Bit0 = 1 (digital output 1 = NC), Bit1 = 0 (digital output 2 = NO), Bit1 = 1 (digital output 2 = NC), Bit2 = 0 (digital output 3 = NO), Bit2 = 1 (digital output 3 = NC)
oh (ohX)	XYYYY	Hold time digital output X (X = 1...3) Hold time: YYYY (0x0000...fffe) 0-65534 ms
op (opX)	XYY	Outputs (digital output X, X=1...3) YY=0x00...0A YY=00 – no output YY=01 – device ready contact YY=02 – Material contact YY=03 – limit switch contact YY=04 – unused YY=05 – Over temperature YY=06 – Setpoint limit 1 YY=07 – Setpoint limit 2 YY=08 – Setpoint band YY=09 – Controller active YY=0A – Control successful
pia	XXXX	Automatic targeting light switch off XXXX = 0x0000...ffff (0 to 65535 s) X = 0 => targeting light never turns off; X = 1…65535 => switches off after X seconds
re (re0)		Device reset
sl		Read signal strength (answer: 4-digit hex in 1/10%)
sh	XYYYY	Hysteresis for signal strength contact X = 1...3 (digital output) to value YYYY (hex in 1/10%)
sk	XYYYY	Switching value for signal strength contact for X = 1...3 (digital output / signal strength contact) to value YYYY (hex in 1/10%)
sn		Read serial number (5-digit dec.)
tg	XYYYY	Transmittance X = 1, 2; YYYY = 0050-1000 (corresponds to 5%-100%) in 0.1% steps tg1 – Transmittance channel 1 = 0x0032...03e8 (0050-1000) tg2 – Transmittance channel 2 = 0x0032...03e8 (0050-1000)
to	XXXX	Output test: Bit0 = 0 (digital output 1 = inactive), Bit0 = 1 (digital output 1 = active) Bit1 = 0 (digital output 2 = inactive), Bit1 = 1 (digital output 2 = active) Bit2 = 0 (digital output 3 = inactive), Bit2 = 1 (digital output 3 = active) Special function: xxxx => deactivate test!
tsc / tsf	X	Read temperature sensor (in °C/°F) (4-digit hex) tsc0 = Device temperature in 1/256°C tsc1 = Detector temperature in 1/256°C tsf0 = Device temperature in 1/256°F tsf1 = Detector temperature in 1/256°F
tw	XX	Interface delay XX
uh (uhX)	XYYYY	Hysteresis for over-temperature contact (X = digital output 1...3) to value YYYY (1/256°C)
uk (ukX)	XYYYY	Device over-temperature threshold at digital output X X = 1...3 to value YYYY (in 1/256°C)
ve	XXYYZZ	Read device identifier and date of firmware XX = 55 ≙ M3 2-color types, XX = 29 ≙ H3 2-color types, YY = consecutive firmware number, ZZ = last 2 numbers of year

Old commands: to standardize the command structure, some old commands with numeric parameters are replaced with new ones with hexadecimal coded. The old commands still work, but should no longer used in reprogramming:

ms	(Read temperature value, 5-digit. dec.)	→ mw	em	(Emissivity, 2-digit. dec.)	→ eg1
kt1	(Read temperature channel 1)	→ mw1	en1	(Emissivity channel 1, 2-digit. dec.)	→ eg1
kt2	(Read temperature channel 2)	→ mw2	en2	(Emissivity channel 2, 2-digit. dec.)	→ eg2
qt	(Read 2-color temperature, 5-digit. dec.)	→ mw0	ev	(Emissivity slope, 4-digit. dec.)	→ eg0
ez	(Response time, 1-digit. dec.)	→ et	aw	(Switch-off level, 2-digit. dec.)	→ ax
lz	(Max. value, 1-digit. dec.)	→ lm in combination with lt	gt	(Device temperature, 2-digit. dec.)	→ ts

In addition, for devices with built-in PID controller

hz	XXXX	Hold time: XXXX=0x0000...ffff (in ms)
ob	XXXX	Next controller start with AutoTune XXXX=0x00C8...03E8 (20.0...100.0% in 0.1% steps)
rg	X	Controller handle (X=0, 1, 3) 0 = Stop controller 1 = Start controller 3 = Controller with AutoTune
ro	XX	Controller options: Bit 0 = Clear of Ti (sets the integration sum of the PID control to 0 to prevent an undershoot if a control process is done from a higher to a lower value), Bit 4 = AutoTune optimization at every control start
r0 (ro0)	X	Controller options (not memory-resistant) bit0 = next controller start with AutoTune
rz	XXXX	Ramp time in ms XXXX=0x0000...ffff)
sg1	XXXX	Temperature deviation from setpoint value ± 3000° for limit value 1 XXXX=0x8AD0...7530 (in two's complement, 1/10 degree)
sg2	XXXX	Temperature deviation from setpoint value ± 3000° for limit value 2 XXXX=0x8AD0...7530 (in two's complement, 1/10 degree)
sw	XXXX	Setpoint value (XXXX in 1/10 degree)
td	XXXXXX	Derivative time constant Td (in sampling times) XXXXXX=0x000000...00ffff
ti	XXXXXX	Integral time constant Ti (in sampling times) XXXXXX=0x000000...00ffff
xa	XXXX	Sampling time in 10 µs steps M3: XXXX=0x0064...09C4 (1 ms...25 ms), H3: XXXX=0x000A...09C4 (0.1 ms...25 ms)
xb	XXXX	Setpoint deviation (in 1/10 degree)
xl	XXXX	P dynamic XXXX=0x0000...2710 (0.01...100.00%; 0.01% steps)
xp	XXXX	Proportional band Xp XXXX=0x0000...2710 (0.1...1000.0%; 0.1% steps)
ym	XXXX	Minimum control output power Pmin XXXX=0x0000...03E7 (0.0...99.9%; 0.1% steps)
ys	XXXX	P-zs XXXX=0x0000...03E8 (0.0...100.0%; 0.1% steps)
yx	XXXX	P-max XXXX=0001...03E8 (0.1...100.0%; 0.1% steps)

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