SENSOR THERM
MEMBER OF THE NYNOMIC GROUP

Pyrometers
METIS M311 / M322
METIS H311 / H322

With letter identifier L: Pyrometer series optimized especially for laser applications.
With 17-pin connector and PID controller

Operating Manual

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1 General

1.1 Information to this Manual

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 and Standards

The product conforms to the following standards:

CE conformity:	DIN EN 61326-1 (electromagnetic compatibility)
Laser safety:	IEC 60825-1, laser class 2 (only devices equipped with laser targeting light)
RoHS:	2011/65/EU

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

The responsibilities of the delivery contract are valid as well as our general terms and conditions and terms of delivery and the valid statutory rule at date of the conclusion of contract.

1.3.1 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.

1.4 Terms of Warranty

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

1.5 Copyright

1.6 Spare Parts

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

1.7 Returning Goods

We ask you to request an **RMA number** for each returned goods. Due to system technical reasons it is not possible to edit the process without RMA number.
You will receive an RMA form, which has to be completed and sent to us by e-mail before delivery of the goods. It is important to pay attention to a short, accurate error description, as this can considerably reduce the repair time. You will immediately receive an RMA number. In order to be able to perform a warranty check in advance, we require the serial number(s) of the device(s).
Please return the items in suitable packaging to avoid damage during transport.
If you need to send this device back to us, the battery must be removed and may not be sent. Exceptions apply to trained resellers who have knowledge of the special transport and labeling regulations of the dangerous goods.

1.8 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.

2.2.1 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 this symbols for safety reasons.

⚠ CAUTION This combination of symbol and signal word 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.

2.2.2 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** due to a class 2 **laser targeting light**.


Indicates the **hazard for the eyes** from **optical radiation**.

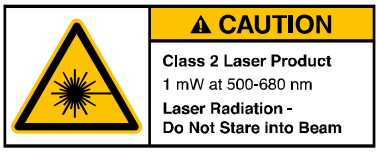

Indicates the **hazard** of **automatic startup** of machine parts.

2.3 Laser Targeting Light

For easy alignment, the pyrometers may be equipped with a laser targeting light, laser class 2 (according to IEC 60825-1. 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.

2.4 Device Labels

On the top of the device there is the type label (nameplate) as well as a warning sticker for devices with 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

2.5 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.

2.6 Responsibility of the Operators / Process Responsibility

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.
Sensortherm does not guarantee that the temperature control in all processes will meet the desired requirements. Sensortherm excludes the process responsibility.

3 Overview

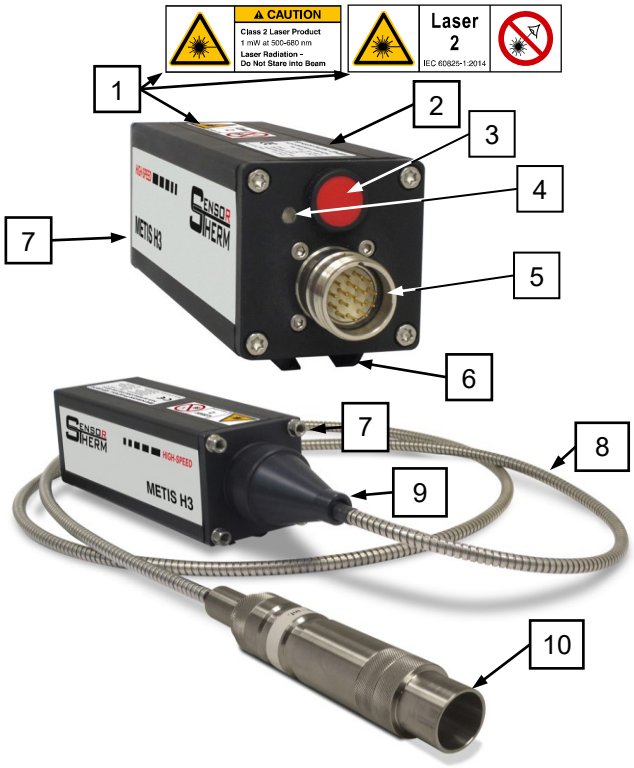
3.1 Intended Use

The 2-color pyrometers Metis M3 and H3 with letter identifier L (see **9.2**, **Type Number**) are devices for non-contact 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, user manual
(connecting cables are not included in scope of delivery and have to be ordered separately).

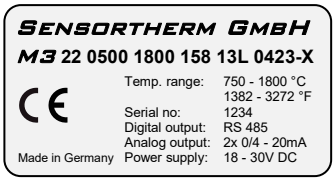
3.3 Model Design



1	Laser warning label
2	Device identification label
3	Laser targeting light push button
4	LED to indicate operating status
5	Connectors for power supply, 2 linear analog current outputs for manipulated variable and actual value, 4 digital inputs, 2 digital outputs, 1 analog input, a serial interface (M3: RS232 / RS485 switchable; H3: RS485)
6	Mounting rail
7	Mounting thread (M5) for front mounting the pyrometer or accessory
8	Mounting thread (M5) for front mounting the pyrometer or accessory
9	Optical fiber for transporting the heat radiation to the pyrometer
10	Tube to protect the optical fiber connection
11	Fiber optics with adjustable focus distance

3.4 Identification Label

The identification label on top of the device shows information to: manufacturer, reference number, temperature range, serial number, serial interface output (=digital output), analog output, power supply, country of manufacture and CE sign.
The composition of the type number is given in Chap. **9.2**.



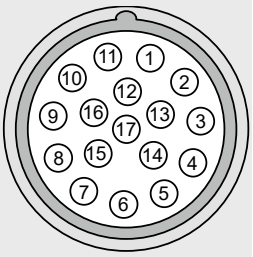
4 Electrical Connection

4.1 Cable Colors and Pin Assignment

The electrical connection of the pyrometer (supply voltage and measuring signal) will be done via the 17-pin connector on the device's rear side. For this purpose, pre-assembled connection cables are available as accessories (cables 20-wire + shield, with straight connector and optionally with integrated USB interface converter, see **9.3 Accessories**).

NOTICE The unit has 3 separate circuits: supply, interface and power outputs. The reference potentials GND should not be connected together. To prevent accidental short circuits, cable wires not in use should be secured to the supplied screw terminals.

Cable colors	No.	Function	Pins
White	1	+ 24 V DC Power supply (18–30 V DC)	3
Brown	2	0 V DC Power supply	1
Green	3	+ Analog output 1 (0 / 4–20 mA)	4
Yellow	4	- Analog output 1 (0 / 4–20 mA)	6
Blue	7	+ Analog output 2 (0 / 4–20 mA)	2
Red	8	- Analog output 2 (0 / 4–20 mA)	9
Black	9	Digital input 1 [1]	7
Violet	10	Digital input 2 [1]	10
Pink	6	Digital input 3 [1]	5
Grey	5	Digital input 4 [1]	8
Brown-green	14	Analog input [1]	14
Grey-pink	11	Digital output 1 [1]	11
Red-blue	12	Digital output 2 [1]	12
White-yellow	15	RS232: RxD	15
White-grey	17	RS485: B (+) [2]	
Brown-yellow	16	RS232: TxD	17
Brown-grey	18	RS485: A (-) [2]	
White-pink	19	DGND (ground for interface)	16
Brown-pink			
White-green	13	Reference voltage output (10 V ±1%, max. 10 mA) [1]	13
Housing	20	Shield (connect only for cable extension, do not connect in the control cabinet)	



View from outside to the 17-pin device plug

[1] Reference potential 0 V, brown

[2] H3 models only RS485

4.1.1 Factory Settings

Parameters	Factory settings
Temperature sub range	Corresponds to basic range
Response time t_{90}	Minimal (corresponds to: M3: <1 ms; H3: <80 µs)
Emissivity slope	1.000
Switch-off limit	10%
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 ..... 0–20 mA, output temperature: PID control output
Digital input 1 ..... Controller start/stop
Digital input 2 ..... No function
Digital input 3 ..... Clearing of peak picker
Digital input 4 ..... Laser targeting light on / off
Analog input ..... No function
Digital output 1 ..... Contact ready to use (device ready to operate)
Digital output 2 ..... Controller active

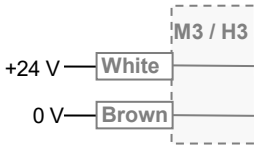
Inputs / outputs
Input debounce time ..... 100 ms
Output activation time ..... 0 ms
Output hold time ..... 10 ms
Limit switch: ..... center of temp. range °C / °F; hysteresis: 10°C / 20°F
Device over temperature: ..... 50°C / 120°F; hysteresis: 2°C / 5°F

PID controller

Setpoint	Center of temp. range	P-max	100%
Proportional band Xp	1%	P-min	0%
Derivative time Td	0 ms	P-Dyn	100%
Integral time Ti	10 ms	AutoTune	at each start (AutoTune target temp: 50%)
Sampling time	10 ms		
Ramp time	0 ms	Ramp time	0 ms
P-zsc	100%	Hold time	0 ms

INFO **to baud rate / buffer mode:** The factory setting of the baud rate is set to 115 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 **7.3.2.4**).

4.1.2 Power Supply



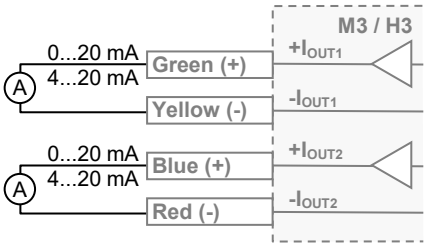
When connected to the supply voltage (standard 24 V DC, possible range 18–30 V) the unit is ready for operation with the following factory settings (changing the settings is possible via interface and **Software *SensorTools***, see **7**).
The supply voltage must be protected with a slow-blow fuse of 800 mA.

Interrupt the power supply to turn off the pyrometer, e.g. by disconnecting the connector.

Power status LED: Indicates the operating status of the pyrometer:

- **Orange** in the self-test phase, H3 during the initialization and thermostatic phase
- **Green** when the pyrometer is ready to operate
- **Red** when an error occurred (see **10.3 Trouble-shooting**).

4.1.3 Analog Output 1 and 2



Note: The outputs are galvanically isolated from the supply voltage.

2 analog outputs are available (e.g. for a temperature display device):

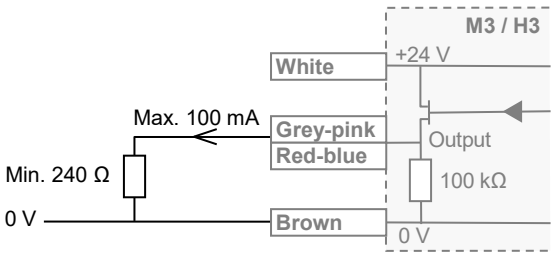
- adjustable to **0–20 mA** or **4–20 mA**
- **Analog output 1** always provides the measured temperature. The measuring temperature is assigned in the control window in *SensorTools*; see **7.3.1 Control window** in *SensorTools*).
- **Analog output 2** can be assigned to provide different signals:
  - 2-color temperature
  - 1 channel temperature (optional channel 1 or 2)
  - Device temperature
  - Control output (= manipulated variable) for PID controller

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**).

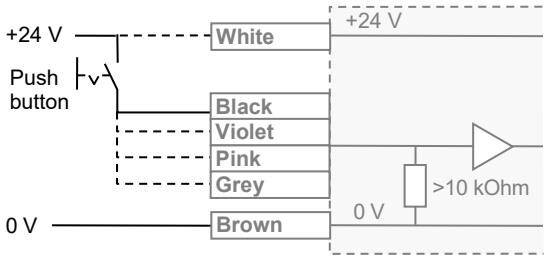
4.1.4 Digital Inputs / Outputs and Analog Input

7 ports are each available as (configuration under **7.3.2 Device settings and configuration → Digital Input / Output**):

- **2 Digital outputs:** output of a switching signal (invertible, see under **7.3.2** → Various settings → **Logic** NO / NC) to:
  - Device ready to operate (device ready and error-free after self-test)
  - Material detection (limit switch 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 device temperature
  - Signal strength too low (as dirty window alarm function: enables to detect the degree of contamination of the pyrometer‘s optics, viewing window or identify interferences (dust...) in the IR sensor’s sight path and trigger an alarm if necessary).
  - Controller activity of PID controller, control process within adjustable setpoint limits, control process successfully completed, hold time finished.



- **4 Digital inputs:** A voltage pulse of 24 V (exception: continuous voltage at "Activate controller"), pulse length adjustable via software (minimum 3 ms, factory settings 100 ms) under **7.3.2 → Digital Input / Output → debounce time** enables:
  - Clear of peak picker (see **6.8**)
  - Start / stop controller (PID controller, see **7.3.3**).
  - Activate controller: The control process is activated as long as voltage at the terminal is present.
  - Load (stored) pyrometer configuration (also PID controller parameters) (only digital inputs 1-3, see under **7.3.4 Setups**).
  - Switch on / off laser targeting light.
    (the targeting light will automatically switched off after 3 minutes if it is not switched off manually. Adjustable via software under **7.3.2 → 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.

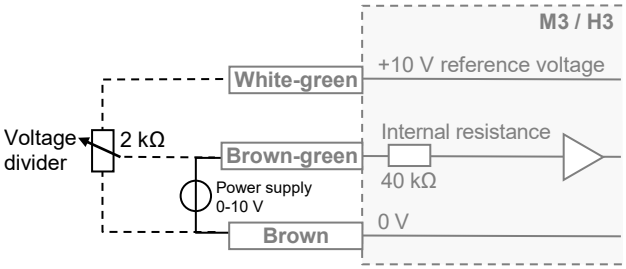
CAUTION **Laser radiation, laser class 2, do not look into the beam.**

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.

- **Analog input** (input 5)**:** An external voltage of 0-10 V can be used to externally adjust some parameters between their minimum and maximum setting values (settings about SensorTools software → **Digital Input / Output** → **Analog input**

  - The emissivity slope (0 V = 0.8; 10 V = 1.2)
  - The emissivity for every channel (0 V = 0.05; 10 V = 1.2)
  - The setpoint for PID controller (0 V = zero scale temperature, 10 V = full scale temperature)



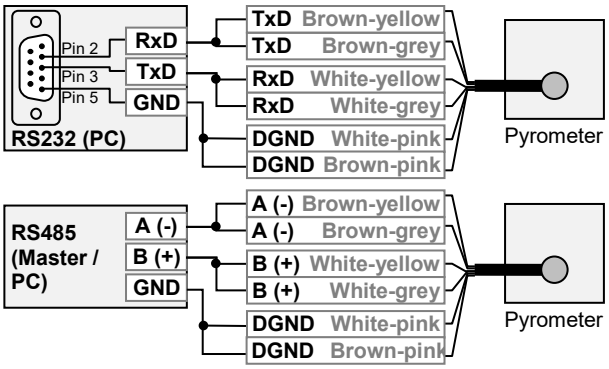
Setpoint input via external voltage 0...10 V: This voltage can also be made via the 10 V reference voltage output and a 2 kΩ potentiometer (connected as a voltage divider, the internal resistance of the input is 40 kΩ).
The external voltage does not have to be galvanically isolated, 0 V (brown) is ground reference, i.e. the ground of the external voltage must be connected to the device ground.

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 (in Baud) is limited by the cable length; it is halved with each doubling of the transmission path.

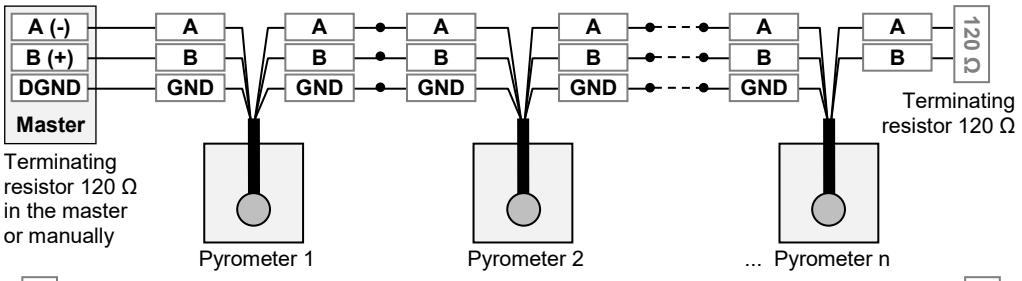
- **RS232:** about 7 m cable length with 19.2 Bd. Adjustable are values from 4.8 to 115.2 kBd.
- **RS485:** about 2 km with 19.2 kBd. Adjustable are values from 4.8 to 921.6 kBd.

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.
All interface cables must be connected in order to avoid reflections.

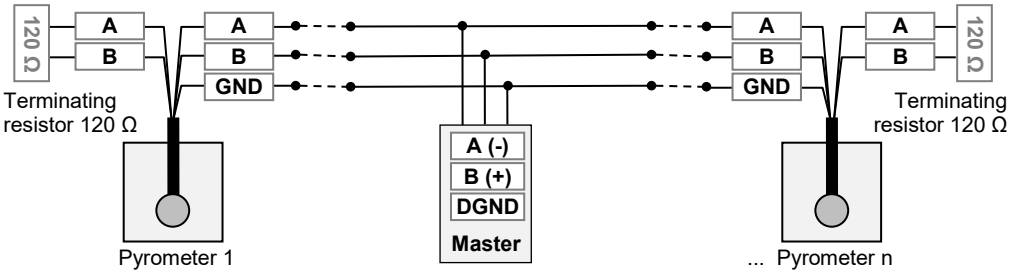


Connecting several pyrometers via RS485:
For a reflection-free operation with longer cables, pay attention to the correct cable termination. Termination at the physical bus is at the beginning and at the end.

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 USB Interface Converter (Accessory)

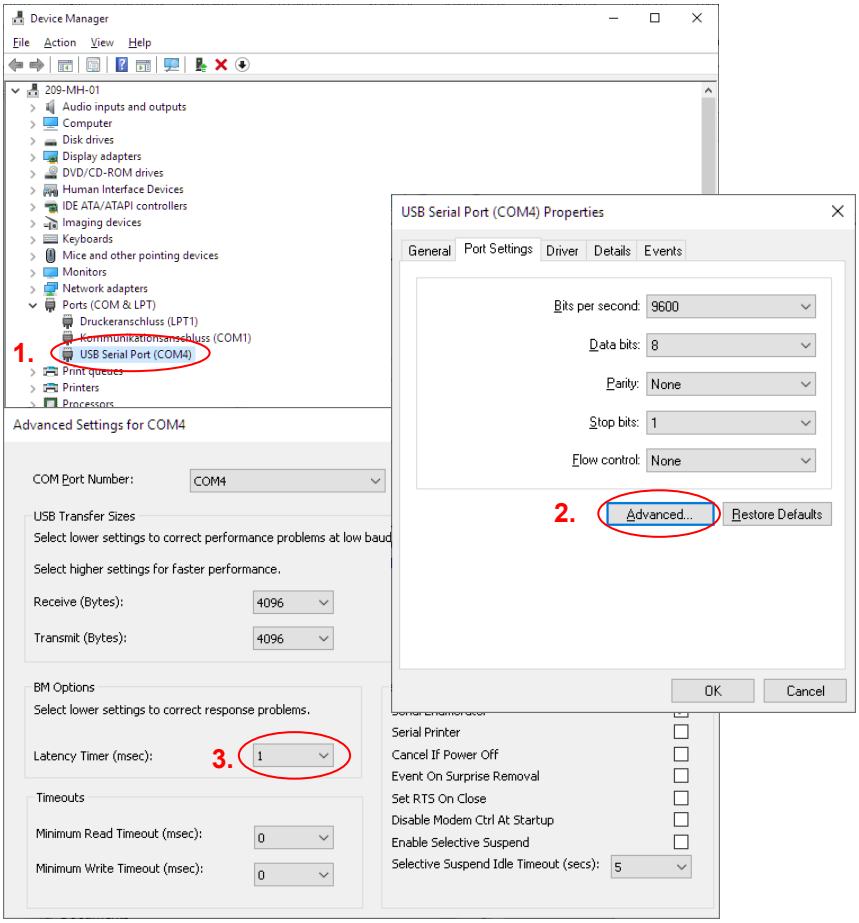
A quick and easy way to connect the pyrometer with a PC is to use an interface converter or a connecting cable with integrated interface converter (see **9.3 Accessories**). Depending on the operating system, suitable drivers are installed automatically or can be found on the CD supplied with the software *SensorTools* in the directory Drivers → FTDI_USB_COM or after installing *SensorTools* in the installation directory (updated driver for Windows from the FTDI website: http://www.ftdichip.com/Drivers/VCP.htm).

Cable colors Metis M3 / H3 (12-pin connector)		**Cable colors interface converter** RS232⇔USB (TxD / RxD) RS485⇔USB (A^- / B^+)
White-pink or brown-pink (DGND)	⇔	Black (GND)
White-yellow or white-grey (B^+ / RxD)	⇔	Orange (B^+ / TxD)
Brown-yellow or brown-grea (A^- / TxD)	⇔	Yellow (A^- / RxD)

To achieve the maximum transfer speed, it is absolutely necessary to change the latency time in the advanced port settings from 16 ms to 1 ms:

- Open Device Manager (Windows 10: Right-click on the Windows key and select "Device Manager" in the menu.
  Windows 7: Open Control Panel and select Device Manager).
- 1. Double click on "Ports (COM and LPT)" → USB Serial Port (COMx) of the interface converter.
- 2. Select the tab "Port settings" and then click on "Advanced".
- Set the waiting time to 1 ms (in "BM Options").

More information is available in the FTDI application note AN_107 - Advanced Driver Options.



4.1.6 Shielding

To meet the requirements for electromagnetic compatibility (EMC), only shielded cables should be used. The shield of our connection cables is connected on the pyrometer side in the plug housing. If faults occur during the pyrometer operation, the pyrometer should be connected to system ground. For this, the front-side end screws have to be used, the anodized housing is not a reliable electrical connection. The shielding wire is not connected to prevent ground loops and damage caused by transient currents. When extending the cable, the screen must be extended with.

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.
  During installation of the optical fiber, it is advisable that both plug ends are not yet connected to the pyrometer and the optics. Tensile and torsional stresses are to be avoided.

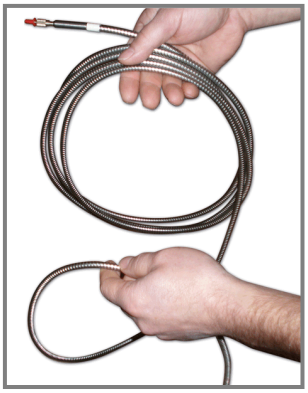
5.2 Mounting Optical Fiber / Optics (optical fiber devices)

5.2.1 Bending Radius Optical Fiber

The color code on the optical fiber identifies the optic diameter and minimum bending radius associated.
When laying the optical fiber it is to observe the minimum bending radius. A bending radius smaller than the specified minimum radius can cause a break of the optical fiber.

Color code of the optical fiber	Fiber diameter	Minimum bending radius
Blue	0.4 mm	150 mm
Red	0.2 mm	75 mm

5.2.2 Winding and Unwinding the Optical Fiber

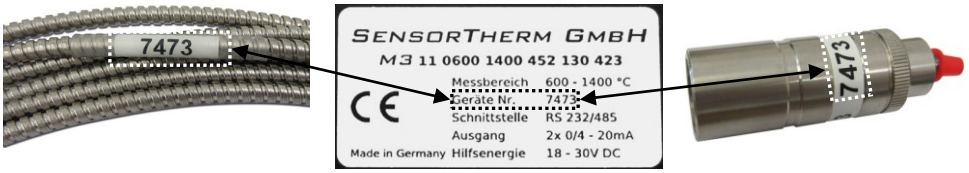


Always ensure that the minimum bending radius is not exceeded.
During winding and unwinding the optical fiber must be able to move easily and should not be twisted. Ideally, one hand winds up the light guide carefully, while the other hand guides the cable roll. For torsion-free winding only one side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

NOTICE Avoid strong tensile and torsional forces during rolling and mounting.

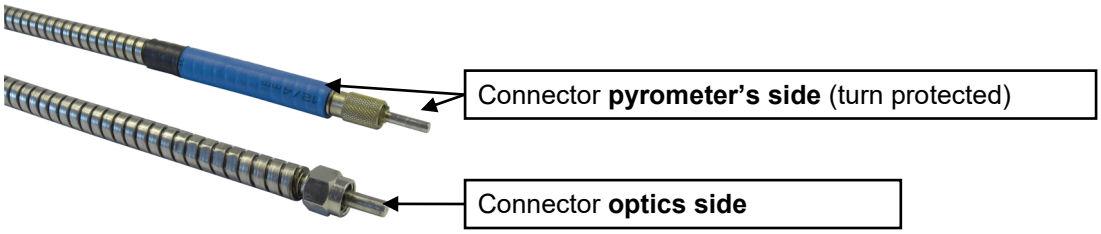
5.2.3 Mounting of Optical Fiber

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.



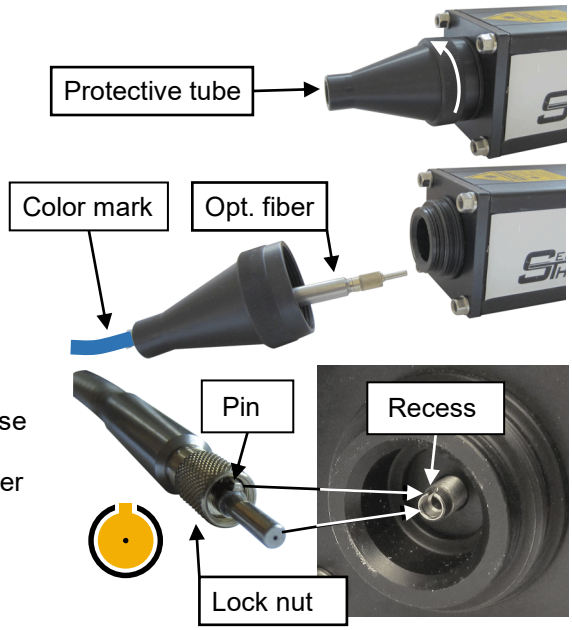
INFO When replacing the optics or the optical fiber, the instrument must be recalibrated to maintain the high measurement accuracy.

NOTICE **Remove the protective caps from the pyrometer and optics and fiber just before installation** to keep the connectors clean and to prevent the ingress of dirt.
Keep the protective caps to be able to protect against dirt in any subsequent dismantling or storage.



The optical fiber must be mounted on correct side:
The side with the shrink tube marking is to be mount on the pyrometer side, the side without marking on the optics side.

- Unscrew the light guide protective tube from the pyrometer's housing
- Pull the protective tube somewhat about the light guide 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.

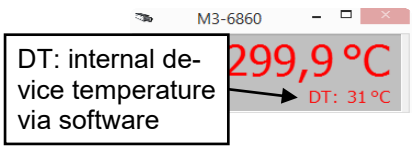


5.2.4 Connect the Optics

- 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

The internal housing temperature can be read out via the software *SensorTools* (see 7).

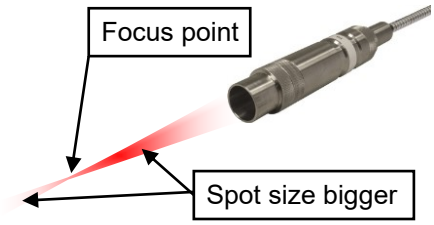


- It is also possible to configure one of the digital (switching) outputs in such a way that a corresponding signal is switched if exceeding the maximum temperature (see 4.1.4 **Configurable Inputs / Outputs** and under 7.3.2.1 **Digital Input / Output configuration**).

- The laser targeting light is deactivated at a device temperature above 55°C.

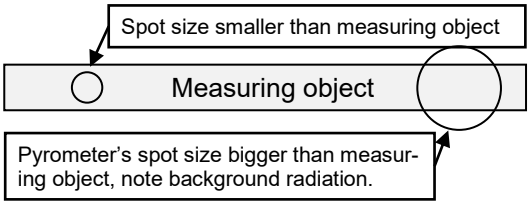
5.4 Ratio Technology / Alignment onto the Measuring Object

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 **6.1 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 taken into account.
- If the measuring diameter is larger than the object to be measured, care must be taken about the signal strength is not to be lower than the preset value, otherwise the system will switch off. The 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.

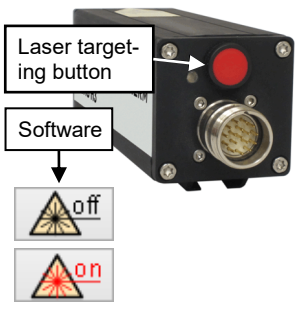
CAUTION **Laser radiation, laser class 2, do not look into the beam.**

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 rear panel or via software *SensorTools* (see **7.3.1**, **Control window**).

(The targeting light will automatically switched off after 3 minutes if it is not switched off manually. Adjustable via software under **7.3.2 Device Settings → Laser targeting light settings**).



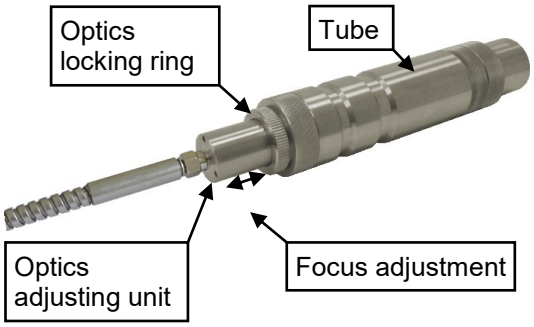
INFO **The laser targeting light is turned off at a device temperature above 55°C.**
If the targeting light cannot be turned on, the device's internal temperature may be too high. In this case, the installation location of the pyrometer must be checked.

5.5 Setting the Measuring / Focus Distance

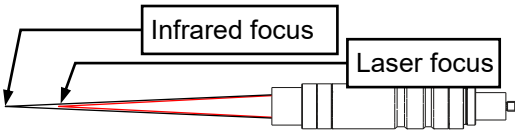
The focus distance is the distance in which the pyrometer's measuring diameter is the smallest. For optics with focus adjustment, the focus distance can be changed continuously within a predetermined range.

5.5.1 Focusable Fiber Optics

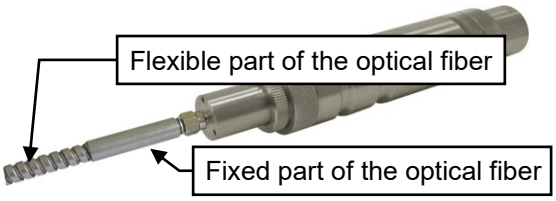
- Slightly loosen the optics lock ring so that the optics adjusting unit is just still movable.
- Slightly loosen the optics locking ring so that the optics adjusting unit can be pushed in and out.
- Switch on the laser targeting light of the pyrometer.
- To focus on the required measurement distance, the optics adjustment unit must be pulled out or inserted.



Note: 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.



NOTICE **Beware of tearing the optical fiber.**
Never pull on the flexible part of the optical fiber for focusing.



5.6 Spot Size Table

The following table show the optical data of the optics. The values in the tables are exemplary, intermediate measurement distances can be determined by interpolation. If the measuring distance (= focused distance) differs from the adjusted or specified, a measurement is also possible, but the spot size changes. The specified focus distances are valid from the front of the lens.

5.6.1 Focusable Fiber-Optics OQ30-90

Optics	**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 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

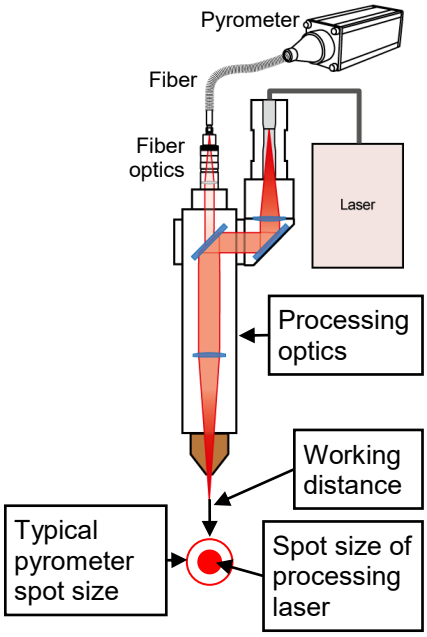
The appropriate signal height of the pyrometer is controlled by apertures.

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 **6.5**, **Switch-off Level / Signal Strength**). In this case, the measurement can be made possible again by installing the 9.5 mm aperture (see **5.8.1 Replacement of the adjustment unit**).

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.

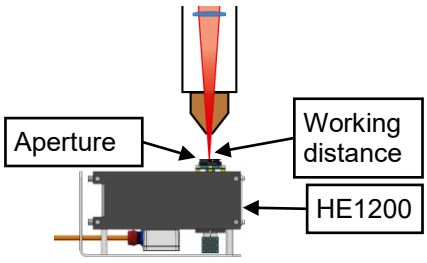
- First the focus distance of the pyrometer optics should be adjusted in relation to the HAZ (HAZ, heat affected zone) of the laser spot in order to meet the targeted diameter relation between HAZ and measuring spot of the pyrometer. Only for 2 color pyrometers it can be selected larger or smaller. For 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 (see **7.3.2.5**), allows the pyrometer to be adjusted for these signal losses at the main measurement temperature used.

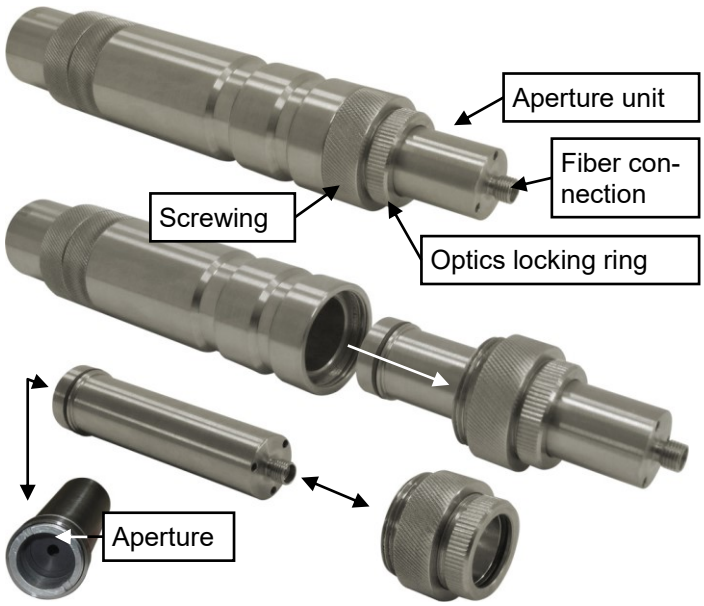


If the signal strength after single-point adjustment is still too low, it can be increased by factor of 10 by changing the aperture unit in the pyrometer optics to the next larger one, e.g. change from diameter 3 mm to 9.5 mm.

5.8.1 Replacement of the Aperture 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 apert in the screwing.
- Screw the unit of screwing and the optics adjustment unit back into the optics and firmly tighten the screwed connection.



6 Pyrometer Parameters / Settings

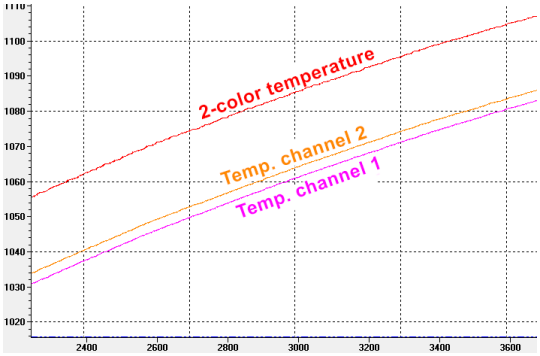
The pyrometer is ex works ready to measure with the factory settings. The connection to a PC is required for further adaptation to the measuring task and to configure the inputs and outputs, all settings can be made via the included software *SensorTools* (see **7**, ***SensorTools* Software**).
Further it is possible to communicate via interface commands directly to the pyrometer (see **11**, **Interface Commands**). The commands can be used for writing an own control or can be entered via a terminal software.

6.1 Emissivity Slope

Measuring objects having the same emissivity at the two different wavelength 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 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 (gain from 1.000 to 0.800, attenuation from 1.000 to 1.200).
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 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

Measuring object	Emissivity ε (Epsilon)	
	M311/H311 0.7-1.1 µm	M322/H322 1.45-1.8 µm
Blackbody	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

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.

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%. If the multiplication of the 3 parameters falls below 5%, the values are displayed in red in the *SensorTools* control window (see **7.3.1**).

6.3 Transmittance

Is a viewing window located between measuring object and pyrometer, the transmittance of the window must be considered during the measurement. Enter the transmittance of the window in order to obtain a correct measurement result.

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%. If the multiplication of the 3 parameters falls below 5%, the values are displayed in red in the *SensorTools* control window (see **7.3.1**).

6.4 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%. If the multiplication of the 3 parameters falls below 5%, the values are displayed in red in the *SensorTools* control window (see **7.3.1**).

6.5 Switch-off Level / Signal Strength

2-color pyrometers show correct temperature readout 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 goes below the adjustable minimum value, the measurement is switched off to avoid measurement errors. In this case the current output can be set to 0 or 4 mA or 20 mA, and also serial interface settings can be defined.
The switch-off limit can be set between 2 and 90%, for safe measurement a minimum value of 10% is recommended. The actual value of the signal strength should however be as high as possible (near 100).

6.5.1 Switch-off Verification

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

6.6 Dirty Window Alarm

A contamination monitoring function detects the degree of contamination in the optical path and can trigger an alarm.

6.7 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.

6.7.1 Dynamic Adaptation at Low Signal Levels

At the beginning of the temperature range, the response time is automatically increased in order to improve the signal quality.

6.8 Storage Mode Maximum Value Storage (Peak Picker) / Clear Time t_{CL}

The peak picker always sample and hold the highest value until it is delete manually or automatically:

Off: The peak picker is off and the instantaneous value is measured.

Clear externally: The peak value is cleared manually by an external button or machine contact (connection see **4.1.4 Digital Inputs / Outputs**). The external clearing also can be carried out with the command `lx` (see **11**, **Communication via Serial Interface / Interface Commands**).

Automatically: The peak 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.

6.9 Temperature Sub Range

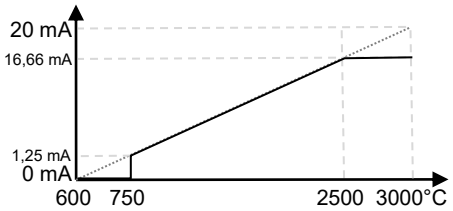
The temperature range can be scaled down in order to adapt it to specific measurement conditions (minimum range 51°C), e.g. to configure the automatic clear function of the peak picker (see **6.8**). A modified temperature range also can be set for the analog outputs to increase the resolution even further.

6.10 Customize Analog Output

The maximum value storage always records the highest value during a measurement and stores it until it is deleted manually or automatically:

- **Limit the analog output:** if the analog output is set smaller than the pyrometer's temperature range, the resolution of the analog output is increased even further.
- **Enlarge the analog output:** Entering a larger range as the pyrometer's range will scale the output. The output at the beginning of temperature range is 0 or4 ma, at the end of the pyrometer's temperature range the current output is that corresponding to the enlarged temperature range.

Example: 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 does not measure the temperature in the software shows UNDER. At the analog output (e.g. set to 0-20 mA) the output current is 0 mA as long as 750°C is reached, then 1.25 mA will be applied to the output. From 2500°C a consistently current is applied that would be present at a 600–3000°C device at 2500°C.



6.11 Analog Output

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 in the control window of *SensorTools*; see **7.3.1 Control window**).

  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: Channel 1 temperature output
  - Temperature channel 2: Channel 2 temperature output
  - Device temperature: Internal device temperature output
  - Control output: Manipulated variable of the PID controller
  - No output No signal is on the output

6.11.1 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).

6.11.2 Upscale-Burnout

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.

6.12 Interface Type (only M3 devices)

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

6.13 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

6.14 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.

6.15 Temperature Unit

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

6.16 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.

7 *SensorTools* Software

- **Installation**
  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. With the recommended requirements all software features should be fully available.

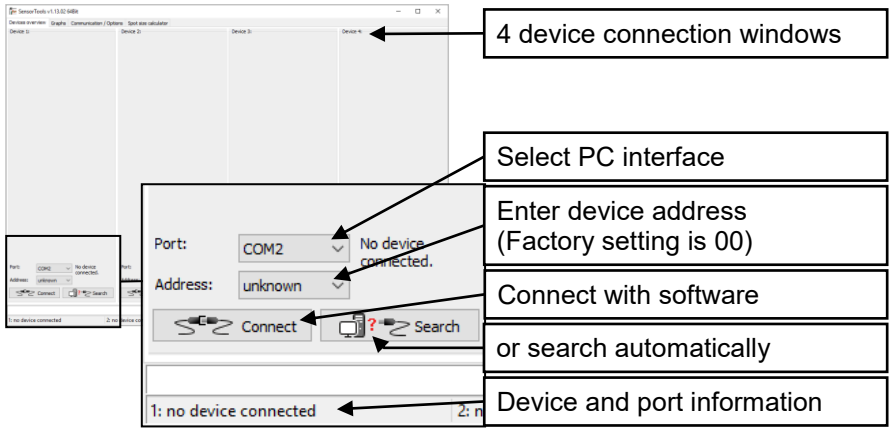
Min. system requirement:	Pentium IV processor with min. 1.6 GHz and 2 GB RAM 20 MB hard drive capacity for the program RS232 or RS485 interface or USB2 (use of an RS232 or RS485 to USB interface converter is required)
Recommended:	i7 multi-core processor with 3 GHz and 16 GB RAM 20 MB hard drive capacity for the program RS485 interface
Screen resolution	min. 1024x768
Operation system:	Windows Vista Ultimate, 7, 8, 8.1, 10

- To install, start the setup program. It can be found on the supplied CD or can be downloaded from sensortherm.de/en/download-section.
- Follow the on-screen instructions

INFO There are regularly provided software and firmware upgrades available that add functionality or fix bugs. It is recommended always to install the latest software and firmware (available on the home page in the download area under www.sensortherm.de/en/download-section).
In *SensorTools* can be checked to a new version, see **7.5 Communication / Options**).

7.1 Program Start / Connecting the Pyrometer

When the software is started, the device overview opens, in this case up to 4 pyrometers can be connected to the software.

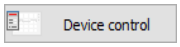


To connect in one of the 4 windows, proceed as follows:

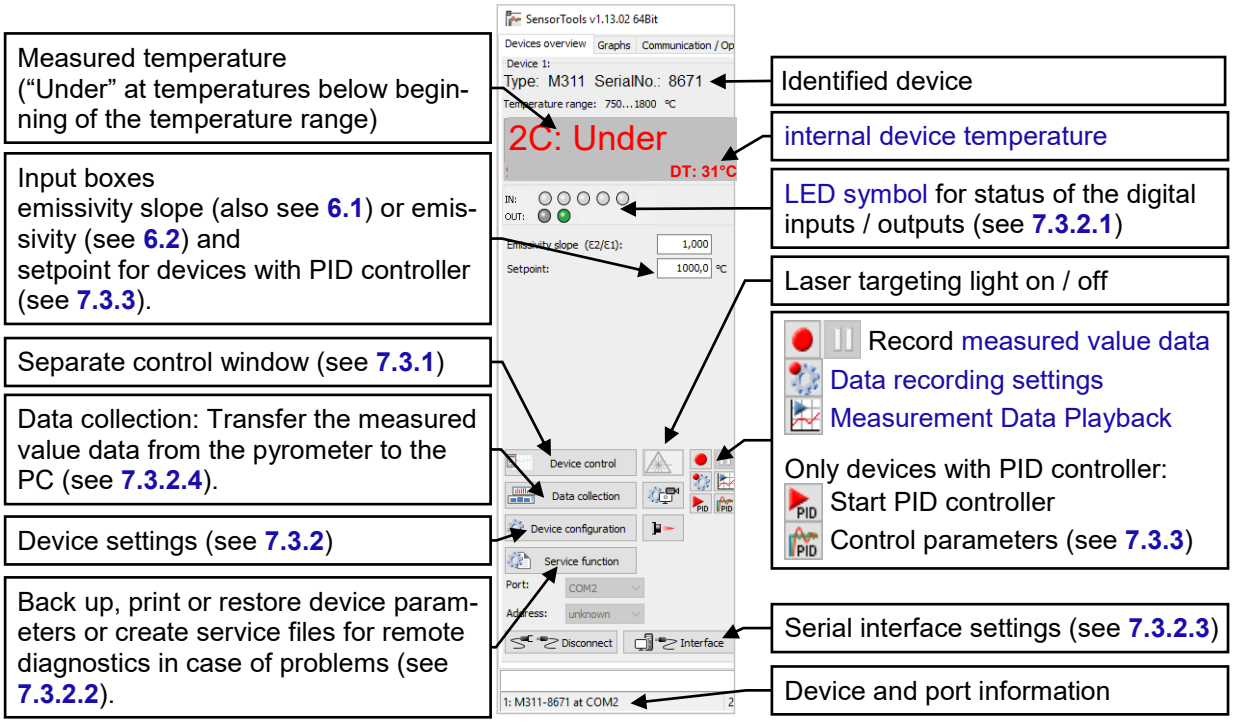
Port: COM2	If known, select the COM port or USB port the pyrometer is connected to.
Address: unknown	If known, enter device address (factory setting of all pyrometers is 00. A second device can not be connected with the same address).
Search	If the port and device address are unknown, "search" searches all PC ports in sequence and then automatically connect found devices.
Connect	Press the connect button to connect the pyrometer to the software. All pyrometer settings will be read out and displayed in the software.
Disconnect	When the pyrometer is connected, the button changes to "Disconnect". This disconnects the device from *SensorTools*.
1: M322-6877 at COM 2	The status line informs about device type, serial number and COM Port.

An identified pyrometer directly shows the current measuring temperature in the preselected measuring mode: 2C for 2-color temperature, in the control window changeable to C1 or C2 for 1-color temperature (channel 1 or channel 2). Additionally the internal device temperature (DT) can be read-out.

This device overview window provides a measured value indication with basic measurement parameter settings.



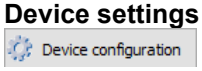
A separate control window (see **7.3.1**) additionally provides all available measurement-relevant functions and settings).
It is useful when switching to a different tab (e.g., in the graph representation).



Input fields (depending on the measuring mode)**:**

- The **emissivity slope** must be taken into account for **measurements in the 2-color mode** (2C) and adapted for the respective measuring material in order to obtain correct measured values (also see **6.1**)
- The **emissivity** must be taken into account for **measurements in 1 channel mode** (C1 or C2) during the measurement, and adapted at the pyrometer for the respective measuring material in order to obtain correct measured values (also see **6.2**)
- The **setpoint** of the PID controller, see **7.3.3**)
  - Via the **PID start button** the control process will start directly.
  - The control parameters can be defined in the **controller window** (see **7.3.3**)

Device settings are made here:



Via the **device configuration** basic device settings are made (see **7.3.2**).

- The recording function is used, as also in the graph window, to record the transferred measured value data for subsequent analysis to the hard disk (also see under **7.2.1** → **Information field**).
- opens the → **Data recording settings** (under chapter **7.2.1**)
- The **playback button** starts the *SensorTools* Viewer (see **7.4**) and represents the last temporarily stored measurement data, since the device was connected. These are not stored on hard disk as in recording, only buffered. The amount of data depends on the value "Maximum records in memory" (see **Data recording settings**). Each measurement storage consists of a data set: measurement temperature, date, time, emissivity, device temperature, setpoint if used, etc., and the higher the baud rate and transmission rate, the faster the value is reached.
  Data displayed in the *SensorTools* Viewer can be saved directly in the viewer.

- **Sighting settings:**
  -  the **laser targeting light** can be switched on and off.

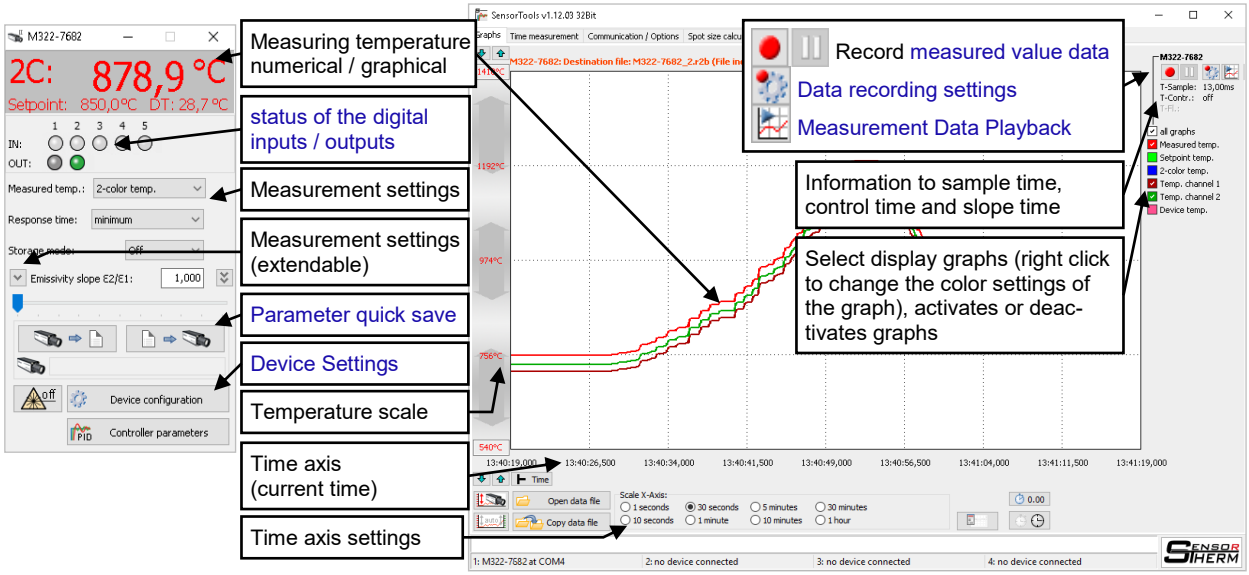
CAUTION **Laser radiation, laser class 2, do not look into the beam.**

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.

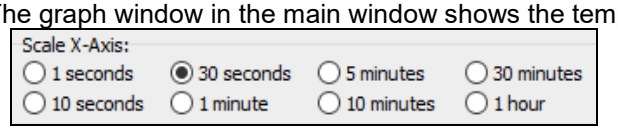
7.2 Software Window

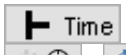
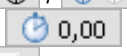
Control window **Main window**



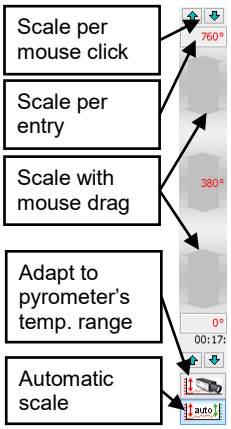
7.2.1 Main Window → Graphs

The graph window in the main window shows the temperature profile in time.

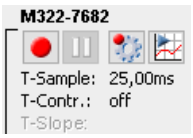
- 

  Scale X-Axis allows to set the time at which the graphs window is filled with measured values. If the time is changed, the graph is rebuild from the center of the window.
  -  rebuilds the graph from the left.
  -  Switches the X axis of the graph between time and a stopwatch where with pressing  the displayed time can be set to 0 at the current graph position.
  -  Opens a **control window** for each connected device, if they have not been activated in the connecting window (devices overview tab).

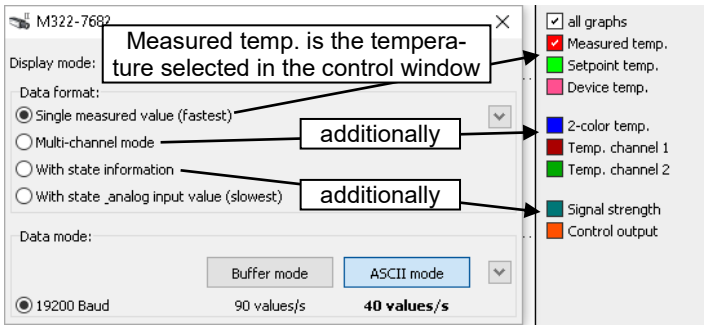
- **Scale the graph:** Beginning and end of temperature scale (left) and control output (right) scale can be adjusted to represent the relevant area reasonable
  - **Scale per mouse click:** With the green arrows of the upper and lower scale range is changed
  - **Scale per entry:** The upper and lower temperature can be entered via the keyboard.
  - **Scale with mouse drag:** With click, hold and drag on the gray arrows, the start and end or the entire area can be moved.
  - **Automatic scale:** automatically adjusts the scale (+10°C above the maximum value and -10°C below the minimum value):
    - reads out the pyrometers temperature range
    - selects the range from all selected display graphs and always the highest measured value.



- **Information field**
  - **M322-7682** in the example right shows pyrometer model and serial number.
  - The **sampling time T-Sample** Shows the time between the last two received measured values.
  - The **control time T-Contr.** shows the time a control process of the PID controller is running already.
  - When the **slope time measurement** is activated, the slope time **T-Slope** shows the time elapsed between the start and the end temperature. The settings can be found in the "Time measurement" window.



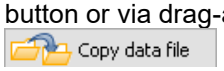
- **Select display graphs:**
  Depending on the data acquisition setting (see **7.3.2.4 Data Collection (Buffer Mode)**), different graphs can be shown or hidden.
  The color can be changed by right-clicking on a color field.
  - To **select and view multiple temperature channels** (e.g. 2-color + 1-color 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 of the **setpoint** of the **PID controller**, the multi-channel mode with status information should preferably be selected.



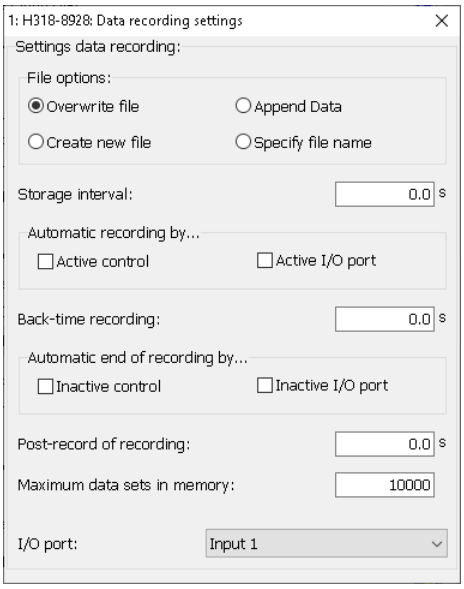
- The transferred measured value data can be **recorded** on hard disk for subsequent analysis. Click on the recording button to start and stop recording, the button ( ) flashes when the recording is active, Pause interrupts the recording. When recording is active, a red reference text (create file ...) is displayed above the graphics window.
  The amount of data that can be recorded depends on the baud rate (see also **7.3.2.3**) and the settings under **data collection (buffer mode)**, see **7.3.2.4**.

INFO for PID controller: The recording may be performed together with the controller start, when the corresponding setting is activated in the **Data recording settings** ( ) (automatic recording by: “active control“ as well as “automatic stop of recording by: inactive control“).

- The **playback button** starts the *SensorTools* Viewer (see **7.4**) and represents the last temporarily stored measurement data, since the device was connected. These are not stored on hard disk as in recording, only buffered. The amount of data depends on the value "Maximum records in memory" (see **Data recording settings** next page). Each measurement storage consists of a data set: measurement temperature, date, time, emissivity slope, emissivity, device temperature, setpoint if used, etc., and the higher the baud rate and transmission rate, the faster the value is reached.
  Data displayed in the *SensorTools* Viewer can be saved directly in the Viewer.

-  Selecting the "Viewer" button opens the *SensorTools* Viewer (see **7.4**) without displaying the cached data. in this up to 4 stored measurement value data files can be load (per "load" button or via drag-and-drop) and displayed graphically.
-  Press "**Copy data file**" to copy one or separate files into another folder. Select the files you want to copy, the original files are not removed. In the next window a folder can be selected where files should be copied. Then a file name is suggested containing date and time. All selected files will be numbered in sequence with the chosen name.

- **Data recording settings**



  - **File options:** The selected option is displayed in the main window (colored) above the graph with: pyrometer model and serial number, file name and a running 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 baud rate and buffer mode).
  - **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 temperatures (2-color and 1-color), a measured value dataset also contains emissivity slope, emissivities, device temperature and possibly more (depending on buffer mode settings, see **7.3.2.4**).
    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.

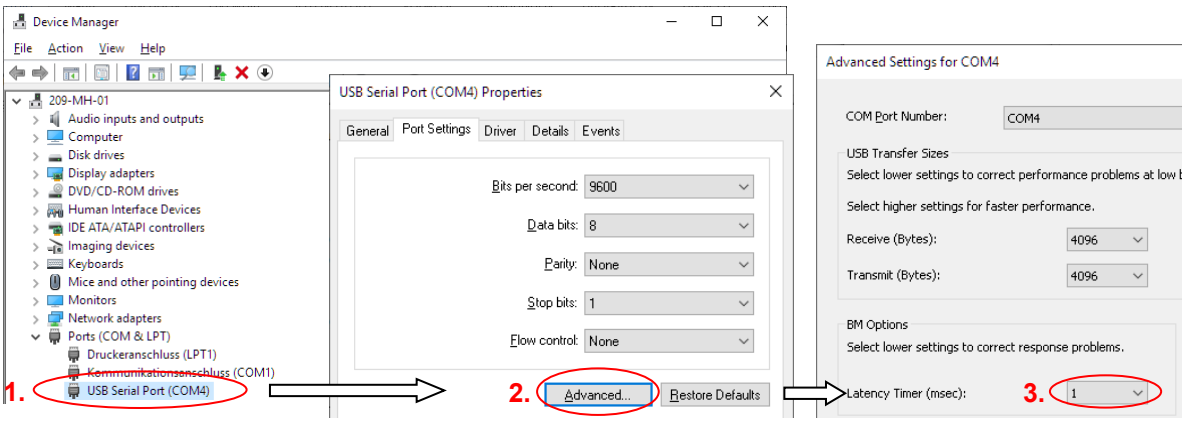
    INFO As soon as the data amount has reached the set value and new measured values are added continuously, the oldest ones are also continuously deleted. The higher the set value, the higher the power demanded by the PC. If the computer is not able to perform this task, buffer overflows occur, which are 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** an 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).

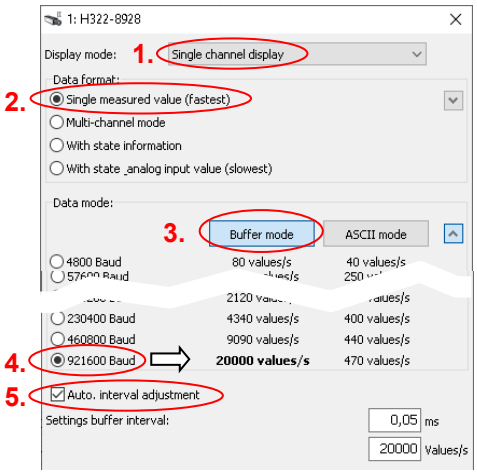
7.3 Settings for the Fastest Possible Measurement Data Recording

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:

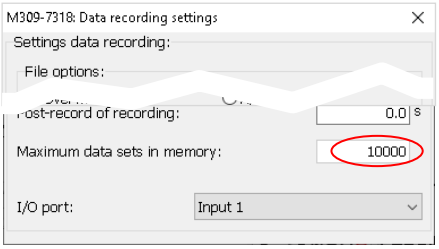


- Data collection Make settings for the fastest data transfer in the data collection window (in the device connecting tab or in the control window via "Device configuration"):
  - 1. Display mode: Single channel display.
  - 2. Data format: Single measured value (fastest).
  - 3. Data mode: Buffer mode.
  - 4. Baud rate: 921600 Baud.
  - 5. Activate „Automatic interval adjustment“.



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

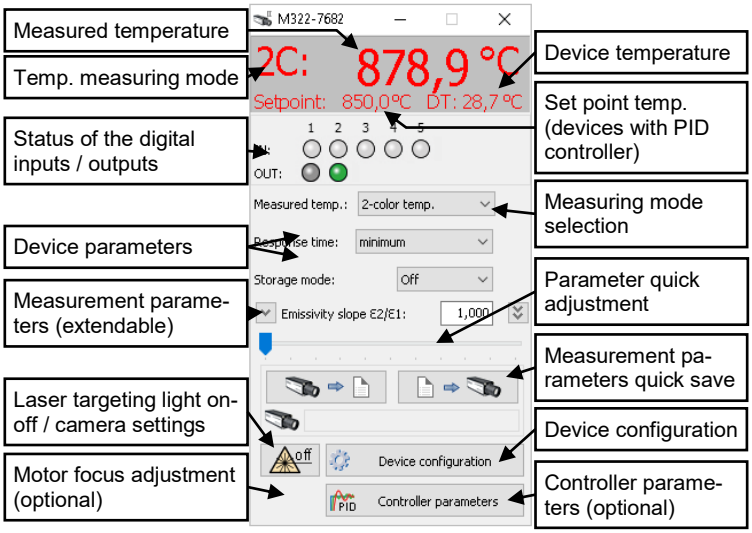
  Set the value under "Maximum data sets in memory" to 10000 and take over with the "Enter" key.
  Info: The value has been determined experimentally and can be set higher or lower depending on the PC configuration (setting range between 500 and approx. 10 million). With higher values, buffer overflows 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.



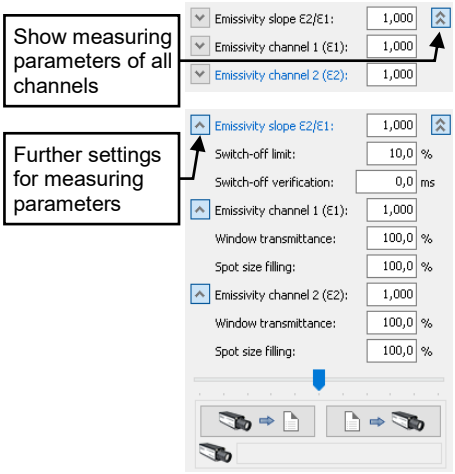
- click the red recording button to record the measured data. The storage path of the created data file is shown in the Communication / Options tab (at the bottom) and can be set individually if required.

INFO If the playback button is simply clicked without hard disk recording, the Viewer opens, but only as many values are transmitted as entered in the "Maximum data sets in memory" field. At a recording interval of 50 µs, there are about 0.5 seconds of recording with the settings listed, which is a very short time, which, moreover, would have to be saved manually in the Viewer if the data is to be used later.

7.3.1 Control Window



- Measuring mode **2C** means that the **2-color temperature** is displayed. In the measured temperature selection field it can be changed to **measuring temperature** of **channel 1 or channel 2**.
- The setpoint of the **PID controller** is always displayed.
  If a ramp time is defined, the setpoint can always display the updated value when the buffer mode with status information is selected in the data collection settings (see 7.3.2.4).
- The **internal device temperature (DT)** depends on the ambient temperature and the device self-heating.
  - M3 models are permissible up to maximum 80°C.
  - H3 models are permissible up to maximum 60°C.
  - The laser targeting light is deactivated at a device temperature from 55°C, below that temperature it can be used again.
- 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)
- **Adapt parameters:** Parameter changes are immediately transferred to the pyrometer.
  - **Device parameters**
    - The **response time t_{90}** (see 6.7) can be adapted to the measurement conditions. Selecting "Minimum" the pyrometer works with its shortest possible response time of <1 ms (M3) or <80 µs (H3). Under "User defined" times between 1 ms (M3) or 0.1 ms (H3) and 10 s can be entered.
    - **Storage mode** (see 6.8): switches on (and off) the **peak picker** and allows clear settings for the activated peak picker.
  - **Measurement parameters:** The displayed measuring parameter depends on the measuring mode. In case of ratio temperature measurements, the emissivity slope can be set (see 6.1); in the case of 1 channel measurements, the emissivity input field is available first.
    - The setting field can be expanded to display the measurement parameters for all channels.
    - To display further sub-parameters, each individual parameter can be extended
    - **Emissivity slope** (see 6.1): Adjustment of the surface properties in 2-color mode.
    - **Switch-off level** (see 6.5): Input when the measurement is turned off by low signal strength.
    - **Switch-off verification** (see 6.5.1): Input when the switch-off is actually made.
    - **Emissivity** (see 6.2): Adjustment of the surface properties in 1-color mode.
    - **Transmittance** (see 6.3): Transmittance of a window
    - **Spot size fill factor** (see 6.4): For 1-color measurements, for targets smaller than the spot size.



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%. If the multiplication of the 3 parameters falls below 5%, the values are **displayed in red** in the *SensorTools* control window.

Purple values indicate that a value in the hidden area is < 1 (indicating that something is out of adjustment).

- **Quick adjustment of parameters** : Changes the currently selected parameter (e.g. click with the mouse in a field or select it using the Tab key in sequence of the fields).
- **Parameter quick save:** Allows quick storage and retrieval of the set measurement parameters (PID parameters included at devices with integral PID controller).
  : Saves the current measurement parameters as *.ShortSetting file on the computer.
  : Loads a *.ShortSetting file from your computer into the pyrometer.
  H3-4865 A measurement parameters file currently loaded is displayed in the status bar with a file icon and the name of the file.
  A subsequent change of measured parameter is indicated by a pyrometer icon which shows that the parameters are read from the pyrometer.
- **Laser targeting light on / off** (off on): switching on and off.

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

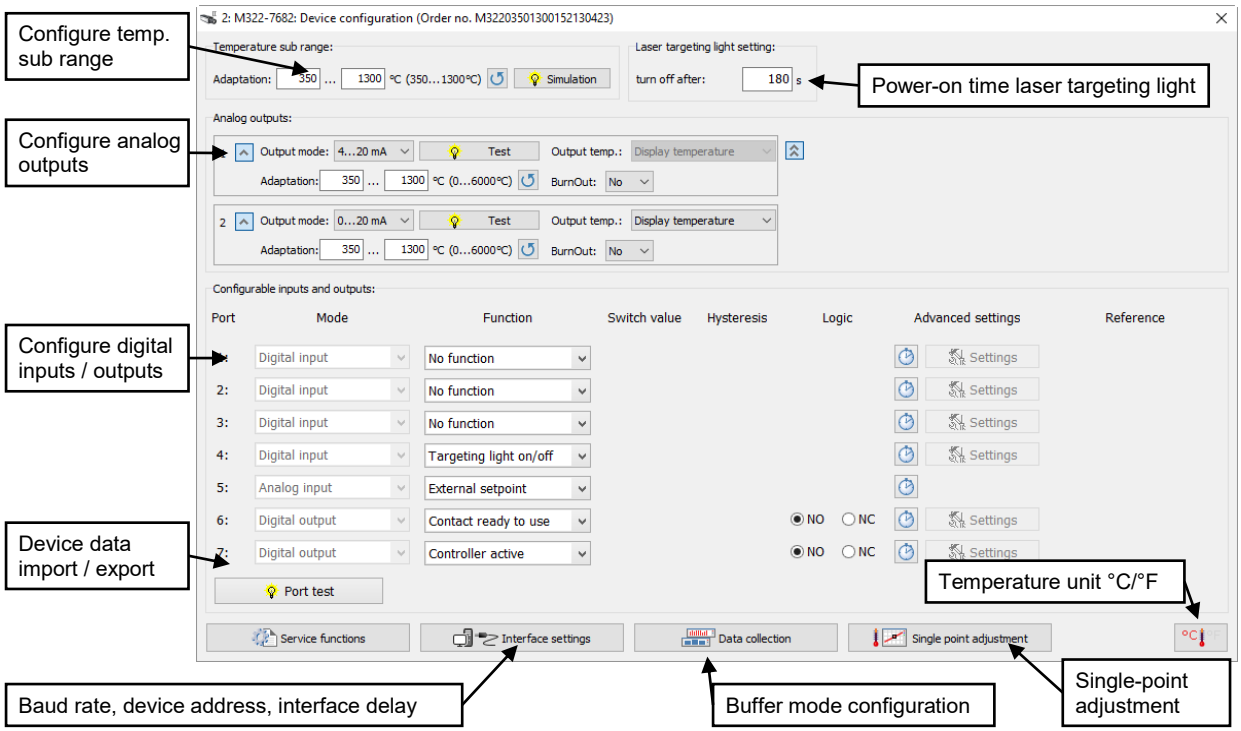
SAFETY INSTRUCTIONS

- 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.

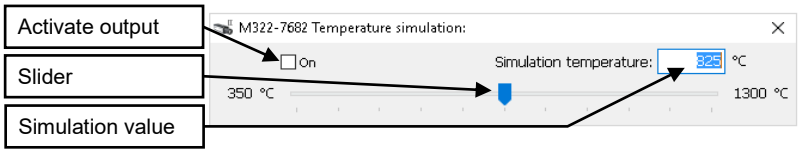
- Controller parameters **PID controller** (see **7.3.3 PID controller equipment**)
  Opens a window with the controller settings.

7.3.2 Device Settings and Configuration

Device configuration Here basic device settings are made.

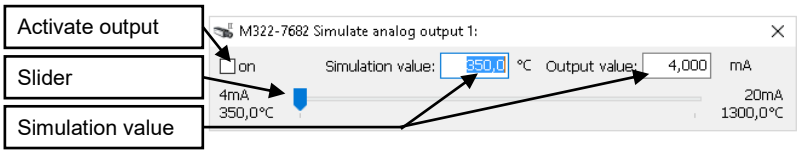


- **Temperature sub range** (also see **6.9**): Input of a temperature sub range.
  - Simulation: To test the functionality of the outputs:
    By moving the slider or by entering a value, the outputs are set accordingly.
    The output is only activated when the hook "on" is set.



- **Laser targeting light settings** (only devices with laser targeting light)**:** Time until a laser targeting light switches off automatically.

- 2 **Analog outputs** are available:
  - **0–20 mA** or **4–20 mA** sets the output current according to the requirements.
  - Test: To test the functionality of each 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.



  - **Analog output 1** always provides the measured temperature (that is always the temperature shown in the control window of *SensorTools* software (see also **7.3.1**).
  - **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** of the PID controller is set here as standard.
    - "**no output**" disables the analog output.

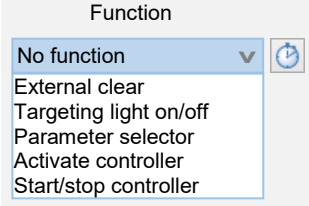
  - ⌄ Further adjustments can be made by extending the setting range
    - **Adaptation** (see **6.10**)**:** The temperature range assigned to the analog outputs can be scaled to the required application. Reduce the range for specific adaptation to the application, or enlarge the range to replace the pyrometer to systems with larger temperature range.
      ↺ With the reset button, the temperature range is set to the adjusted sub range.

- **Upscale-burnout** function**:**
  - **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 shadowing of the pyrometer's view field is set to the maximum current of 20 mA. This can be desirable, for example, in a furnace monitoring when the controller otherwise would recognize a cold oven and heat up fully and possibly burn out the oven.

7.3.2.1 Digital Input / Output Configuration

Each digital input and output can be assigned a function (also see **4.1.4 Digital Inputs / Outputs**).

- **Digital Inputs** (activated by voltage pulse or a voltage of +24 V):
  - **No function**: A switching signal at the input has no effect.
  - **External clearing**: Resets the peak value of the peak picker.
  - **Targeting light on/off**: (only available with equipment laser targeting light): Switches externally on or off the laser targeting light.
  - **Parameter selector** (also see **7.3.4 Setups**): For selection and activation of up to 7 pyrometer configurations, available with the inputs 1-3 (incl. control parameters of the PID controller).



- The inputs are binary coded, that is:
  - with one digital input only one Set-up can be activated
  - with 2 digital inputs there are 3 Setups available
  - Using all 3 inputs, 7 Setups can be accessed and activated

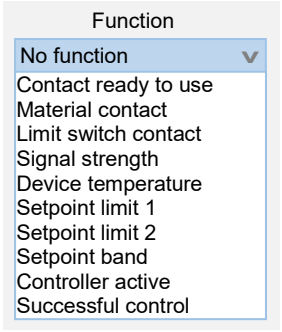
Setups that can be activated	**Digital Input** (**x** = function active)			**Active Setup**	**Digital Input** (**x** = input active)		
	1	**2**	**3**		1	**2**	**3**
1	**x**	–	–	1	**x**	–	–
2	–	**x**	–	2	–	**x**	–
4	–	–	**x**	3	**x**	**x**	–
1,2,3	**x**	**x**	–	4	–	–	**x**
1,4,5	**x**	–	**x**	5	**x**	–	**x**
2,4,6	–	**x**	**x**	6	–	**x**	**x**
1,2,3,4,5,6,7	**x**	**x**	**x**	7	**x**	**x**	**x**

- **Activate controller** (for PID controller): The control process is activated as long as voltage at the terminal is present.
- **Start / stop controller** (for PID controller): Each pulse starts or stops (alternating) the controller.

At all inputs:

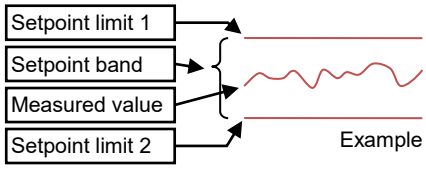
- **Time settings:** A **debounce time** can be selected, that is, a period the signal at least must be present at an input to be detected.

▪ **Digital output** mode: Output of a switching signal:
- **No function**: The output is deactivated (settings right beside have no function).
- **Ready to use contact**: Device is ready and error free after self-test.
- **Material contact** (only M3) for detecting whether a hot part is in the measuring field: The limit switch contact is switching, when 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:** if a certain temperature is exceeded or falling below a threshold.
- **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**: When exceeding the maximum internal device temperature.



For PID controller:

- **Setpoint limit 1 / setpoint limit 2**: 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 7.3.3).



- **Setpoint band**: 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**: Output is active when the controller is active.
- **Successful control**: Output is active when a control process is terminated (a possibly hold time has elapsed).

Various settings:

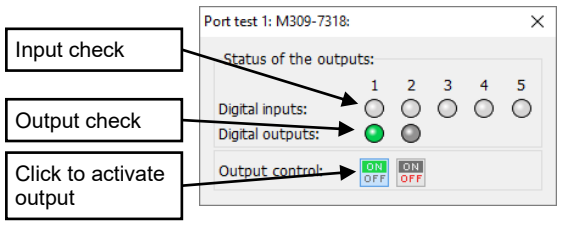
- **Switching value:** Activates the corresponding output at the set switching value (the LEDs 1-3 on the unit indicate the activated state).
- **Hysteresis:** The hysteresis is the value at how many degree below the limit value the output is switched back.
- **Logic:** The state of the digital outputs can be set:

- **NO** (normally open): outputs have in active state 24 volts to the pins and in inactive state 0 V (output max. 100 mA, load min. 300 Ω).
- **NC** (normally closed): outputs have in active state 0 volts to the pins and in inactive state 24 V (output max. 100 mA, load min. 300 Ω).

- **Extended settings:** Depending on the selection are either available:
  Time settings: A verification time and a hold time can be set:
  - **Verification time:** select “immediately” to activate the output function immediately when happening. A time between 1 and 65535 ms delays the activation accordingly.
  - With the **hold time**, the output can be kept active longer than the original signal.
    - **None:** signal is active as long as the function is active
    - **Process start:** signal is active up to the next start (of a program or manual start)
    - **Time value** (between 1 and 65534 ms): signal is active for the entered time.
- **Reference temperature:** The 2-color temperature or the temperature of one channel can be used to activate the output.
- Port test Here digital inputs and outputs can be checked for errors.

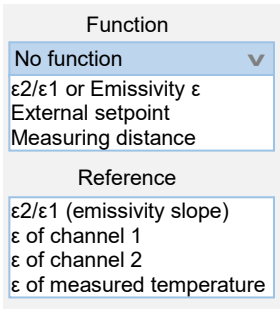
CAUTION **Using the test function with connected systems** activates the selected outputs and can thus **lead to an automatic startup** of these systems.
Always observe all safety instructions of these systems!

Click on an output check box to activate the corresponding output (only possible for selected digital outputs). A green LED symbol signalizes the activation.
Digital inputs are marked with a green LED symbol if connected and active.
The analog input 5 indicates an active LED when exceeding a voltage of 5 V.



Note: The activation of the outputs also activates the LEDs in the control window.

- **Analog input** mode: an external voltage (see under **4.1.4 → Analog input**) enables
  - To set external the **emissivity slope ε2/ε1** or the **emissivity ε** of each channel
    - **Reference:** Here you select whether the emissivity ratio or the emissivity has to be set externally.
  - External **setpoint** setting (at the PID controller)

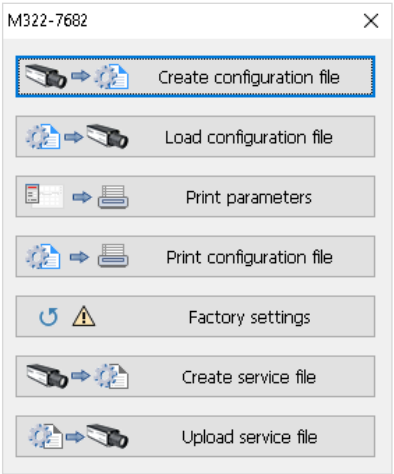


- **Temperature unit:**
  °C °F °C °F The temperature can be displayed and entered in °C or °F.
  Changing the mode will not change the entered values, no conversion will be done.

7.3.2.2 Service functions

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

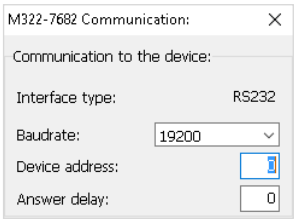
- **Create configuration file:** A configuration file (data format *.r2p) contains all pyrometer data and device settings that have been made. This can be used e.g. to setup a new pyrometer with the same values and settings or to save the current status in case of a device replacement.
- **Load configuration 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.



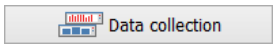
- **Create service file:** A service file includes all device data and all software settings made by user. Creating such a file can be useful if a problem can't be solved and help from our service could be useful.
- **Upload service file:** Transmitting a (possibly modified) file to the device it was created from.

7.3.2.3 Interface

For setting the **baud rate** (see **6.13**), **device address** (**6.14**) or **interface delay** (= answer delay, see **6.16**).

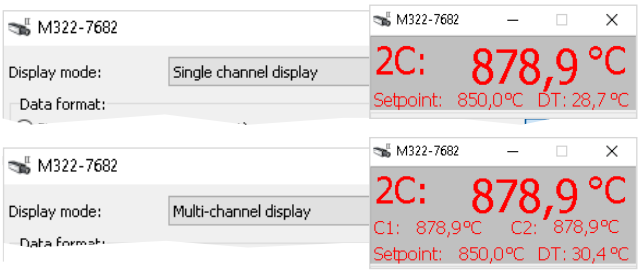


7.3.2.4 Data Collection (Buffer Mode)

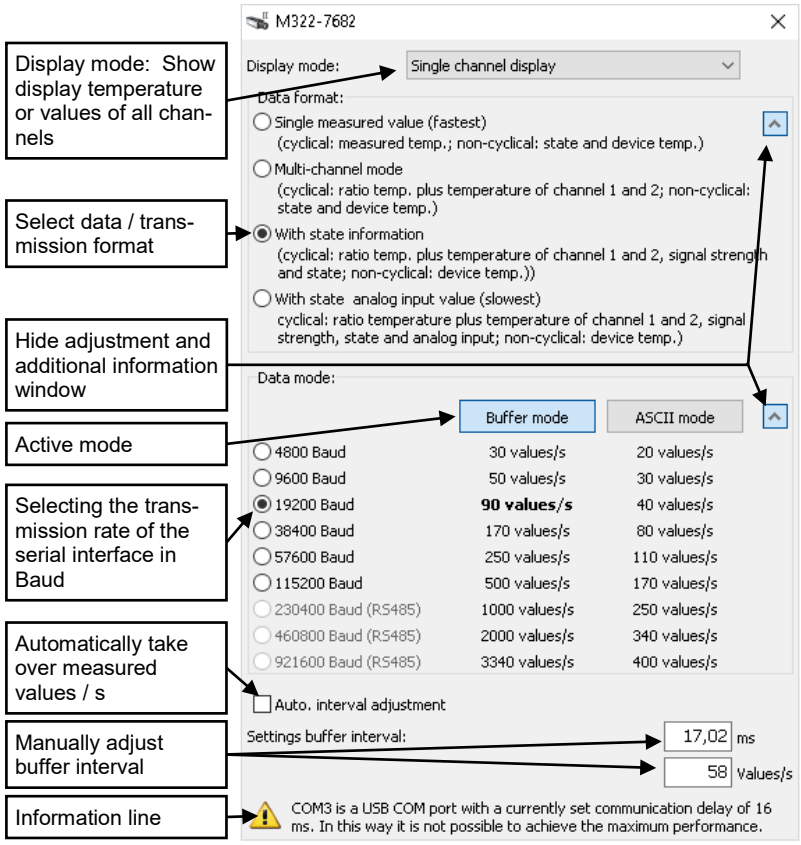


The measurement data transfer from pyrometer to the PC can vary depending on the requirements and computing power. Speed and transferable amount of data are dependent on the baud rate and the data mode. In the data collection window the amount of measured values are shown, determined by calculation for 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:**
  - **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**

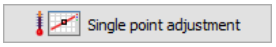


analog input value (slowest)**:** Multi-channel mode plus status information including analog input information.

INFO **to display multiple channels in the data acquisition window 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 (also see under **7.2.1 → Select display graphs**).

- **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 records in memory (see under **7.2.1 Main Window → Graphs → Data recording settings**).

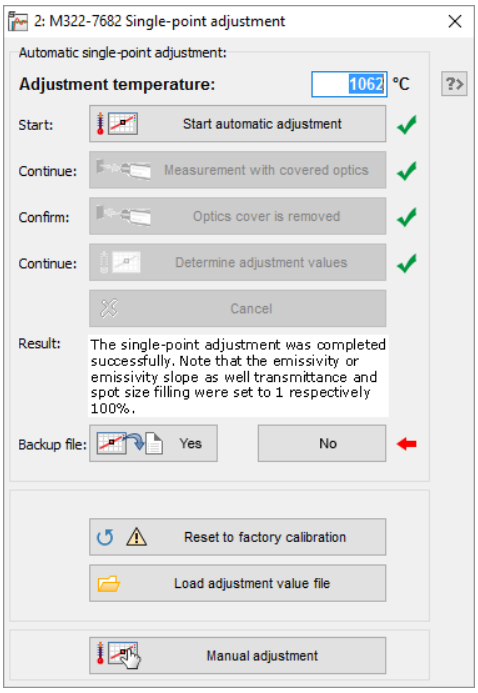
7.3.2.5 Single-Point Adjustment



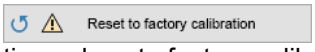
The **single-point adjustment function** is used to readjust the pyrometer to a mainly used measuring temperature.
The function can be used, e.g. to compensate optical losses in measurements through windows or lenses with unknown transmittance (for example, when coupling the pyrometer into a laser beam 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.

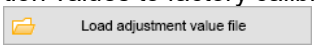
- **Preparation:**
  - Align the pyrometer to calibration source
  - Enter the calibration temperature (the calibration temperature should not be directly at the beginning of the temperature range, preferably about 20% of full scale above the start of temperature range).

- **Display of current status:**
  - : A red arrow indicates the current step that requires a user's action.
  - A spinning animation shows the currently being processed step.
  - A green checkmark signalizes the successful completion.
  - The procedure can be canceled at any time by clicking on "**Cancel**", then the device is reset to factory calibration.
  - Clicking on the help question mark will open a help text to the right.

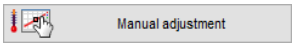


- A click on "**Start automatic adjustment**" starts the procedure.
  INFO This will set the emissivity slope and the emissivity of channel 1 and channel 2 to 1 (100%), will switch off the peak picker and set the response time to 5 ms. These values are not automatically set back to their previously set values and then have to be readjusted afterwards!
- **Measurement with covered optics (only M3 models):** At the determination of the so-called dark-offset, a measurement with completely darkened optics is carried out, this 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 blind during the operation. This takes up to 20 seconds, after completion, the button text changes to "Dark offset is determined".
- Remove the optics cover and **confirm** that the **optics cover is removed**.
- "**Determine adjustment values**" continues the automatic adjustment in front of the calibration source.
- **Result:** After finishing the adjustment of the success or failure will be displayed in text form.
- A **backup file** can be created with the determined adjustment values (adjustment value file). This can be used to write the values back into the device at any time, for example, when the device has been reset to factory calibration.

- 

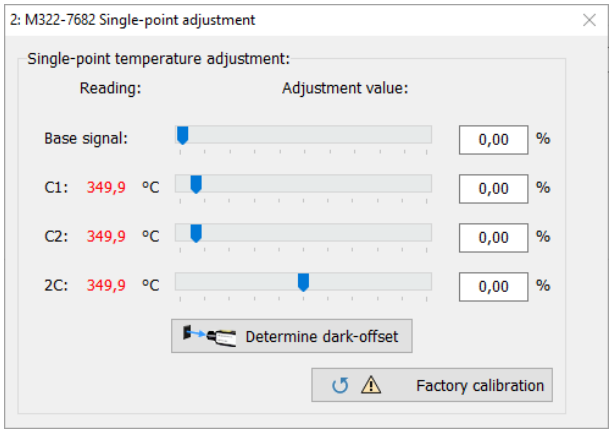
The instrument can be reset to factory calibration, this will reset all calibration values to factory calibration.
- 

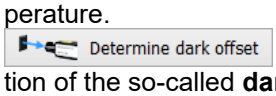
Load adjustment value file loads adjustment values from a saved file into the pyrometer.

- 

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.

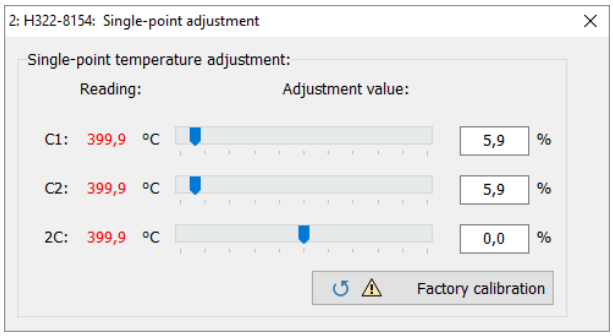
  Preparation: First, the parameters emissivity slope, emissivity of channel 1 and channel 2, transmittance and spot size filling should be set to 100%, as well as switch off the maximum value storage and set the response time to 5-10 ms.



  - **M3 models:**
    Move the sliders one by one:
    - **Base signal:** Move until the higher value of C1 or C2 has reached the target temperature.
    - 

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 blind during the operation (takes 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 are readjusted to the desired value. Deviates the temperature after dark 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.



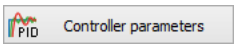
- **H3 models:**
  - Move the sliders one by one for channel 1 (C1), channel 2 (C2) and finally for the ratio temperature (2C) until the temperature value of the calibration source is measured correctly.

- 

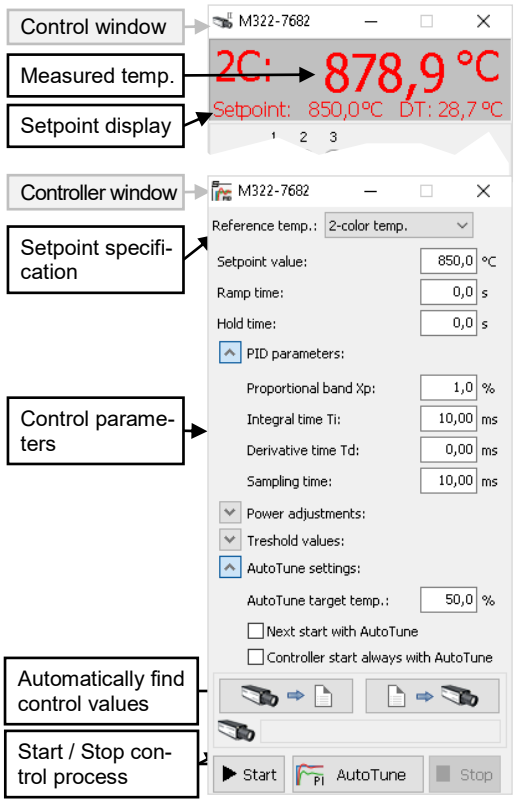
: The instrument can be reset to factory calibration, this will reset all calibration values to factory calibration (0.0%).

7.3.3 PID Controller

M3 and H3 pyrometers with a 17-pin connector are equipped with an integrated PID controller. With this, the temperature deviation 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 control signal is provided, via display and analog output 1 the current temperature reading is available (factory setting, assignment can be changed in the pyrometer port settings, see **6**, **Parameters / Settings** and **7.3.2 Device Settings and Configuration**).



An integrated PID controller is automatically detected by the software and activates the button for the controller configuration.
A setpoint and the necessary PID control parameters are entered directly in the software and transferred to the pyrometer by pressing the ENTER or tabulator key, control parameters also can be changed during running control mode.



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:** 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 **7.3.2.4**) 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 extension icon to open the grouped control parameters.

- **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
  - **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).
  - **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.

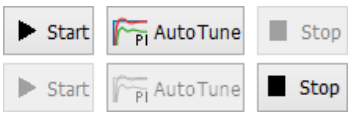
- **Power adaptation**
  - **P-min:** The minimum control output power defines the power set to the control output at least.
  - **P-max:** The maximum control output limits the power to the entered value.
  - **P-zsc:** Limits the control output power as long as the beginning of the sensor's or pyrometer's 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 which 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 Digital Inputs / Outputs** and under **7.3.2 → Digital Input / Output**) 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 **AutoTune settings:** The AutoTune function enables to find 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 Any residual heat of the measured object at a restart may potentially lead to unusable values.

- **Starting the Controller**



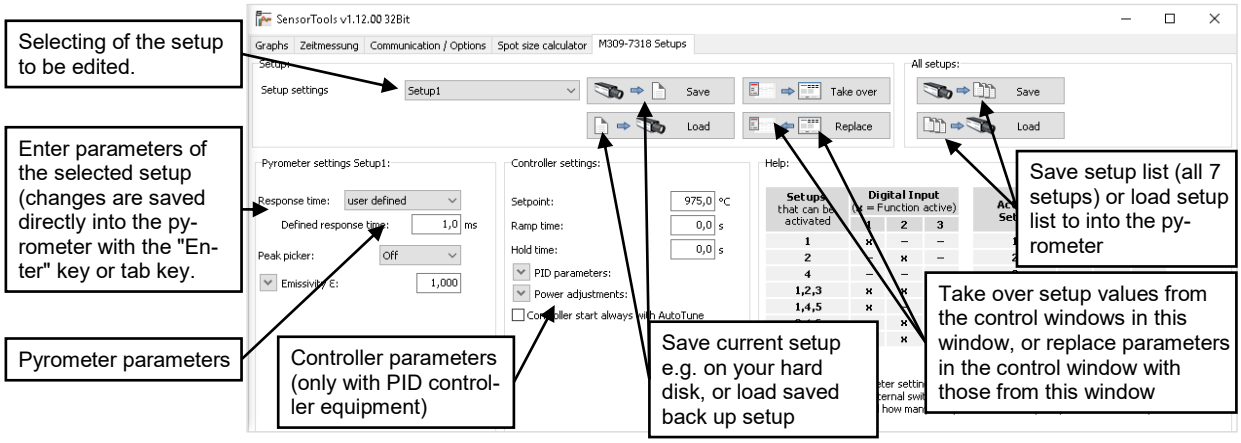
With the start button or via external push button (digital input 1 is configured for external controller start, see under **7.3.2.1 → Start / stop controller**), the control process is started.

The control process is running until it is stopped manually, or automatically after finishing a hold time (hold time starts if a setpoint value is reached).

INFO Recording can be started simultaneously with controller start if corresponding settings are made (see under **7.3.2 Device Settings and Configuration → Data recording settings** „automatic recording by: active control" as well as „automatic end of record by: inactive control") where required.

7.3.4 Setups

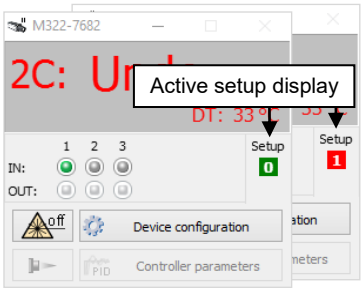
Up to 7 different parameter settings (setups) can be stored in the pyrometer and activated via digital inputs (i.e. via external switch), (see **4.1.4 Digital inputs / outputs**). Depending on which and how many setups are required, one, two or all three inputs have to be used (see under **7.3.1 Control window → Digital Input / Output**).



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.

NOTICE **With an active Setup, the pyrometer operates using the setup values.**
All adjustment possibilities in the control window are hidden.

Active setups are displayed:



- Setup 0 At least 1 digital input is set to "Parameter selector", but no input is activated (inputs to "low").
- Setup 1 At least 1 digital input is set to "Parameter selector" and at least 1 input is active ("high").

7.4 Graphical Measurement Data Playback in the *SensorTools* Viewer

The *SensorTools* Viewer is an independent program for the graphic display and evaluation of measured value data. Up to four r2b files can be displayed in each viewer instance.
To open:

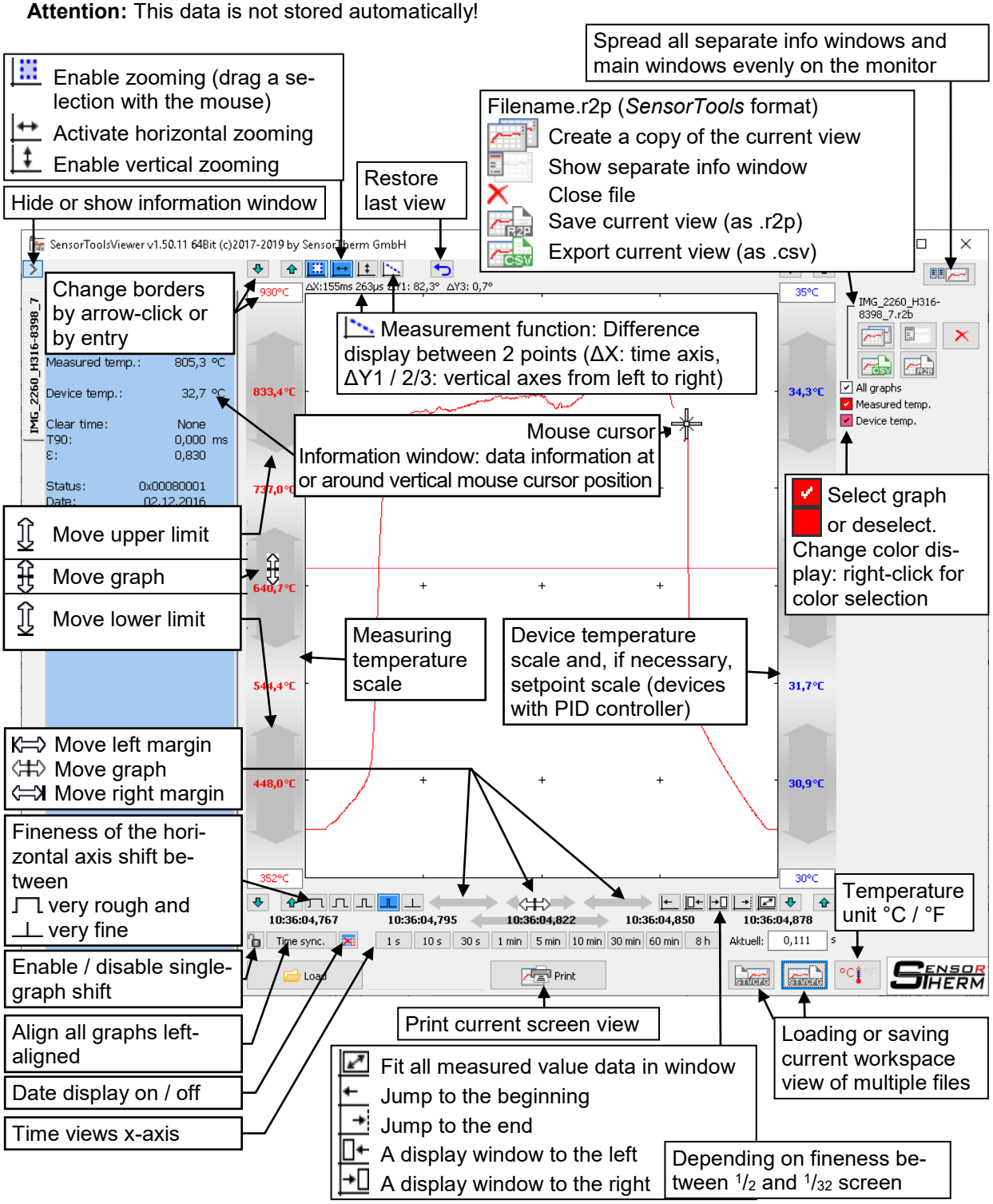
- From the Windows program directory "SensorTools".
- 

Clicking in the SensorTools graph window opens the (empty) *SensorTools* Viewer.
  - 

allows the opening of data files ( Standard data format *.r2b) or workspace files ( configuration format *.stvcfg). Data files are created via the *SensorTools* capture function, 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 automatically create a folder that will save the snippets of each data data file for easy transfer.

    INFO Loading an stvcfg file deletes already loaded and displayed r2b files from the Viewer.
    INFO Simply clicking on "Load" always opens the last used file path.
    Shift + click leads to the standard working directory (can be set in *SensorTools* in the "Communication / Options" tab, see **7.5**).
  - Loading via drag-and-drop: Data or workspace files can be dragged directly into the Viewer for example from Windows Explorer.
- Double-clicking on a data file or workspace file opens its own Viewer window.

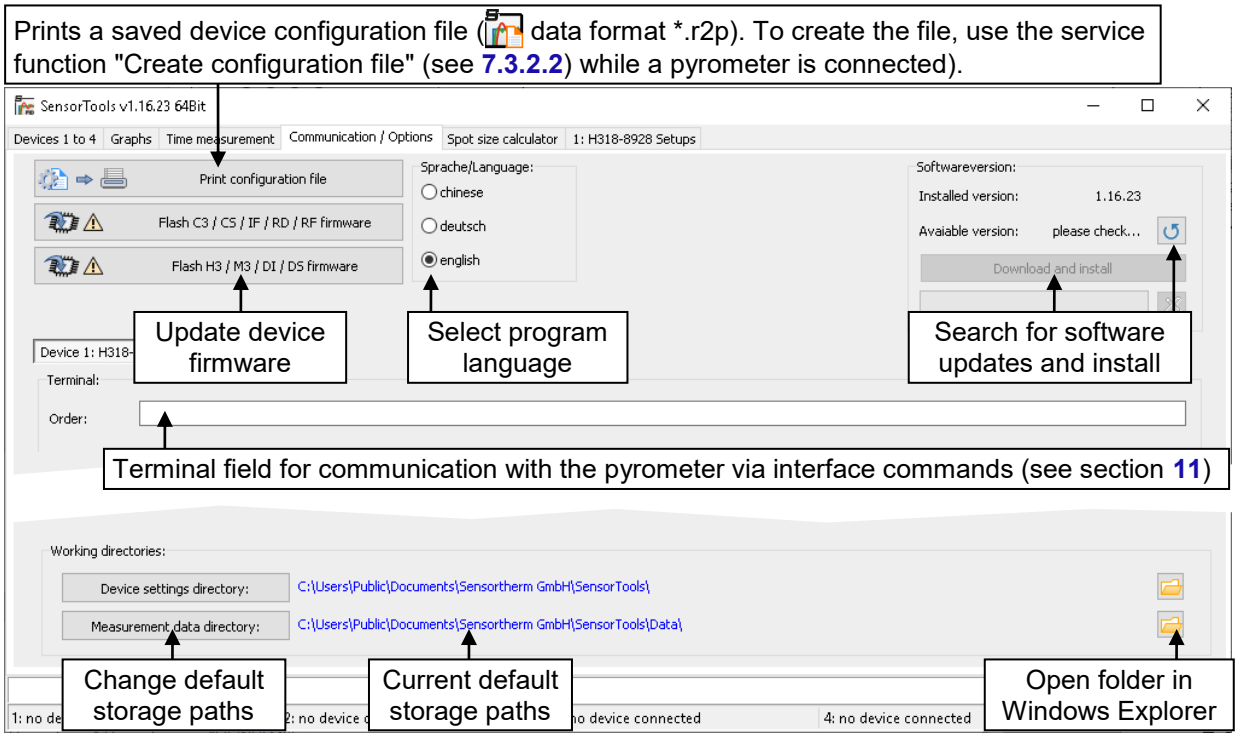
- (in the *SensorTools* device or graphs window) opens the *SensorTools* Viewer and passes the temporarily recorded measurement data, but only as many as set in the "Maximum data sets in memory" in the **Data recording settings**.
  Attention: This data is not stored automatically!



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

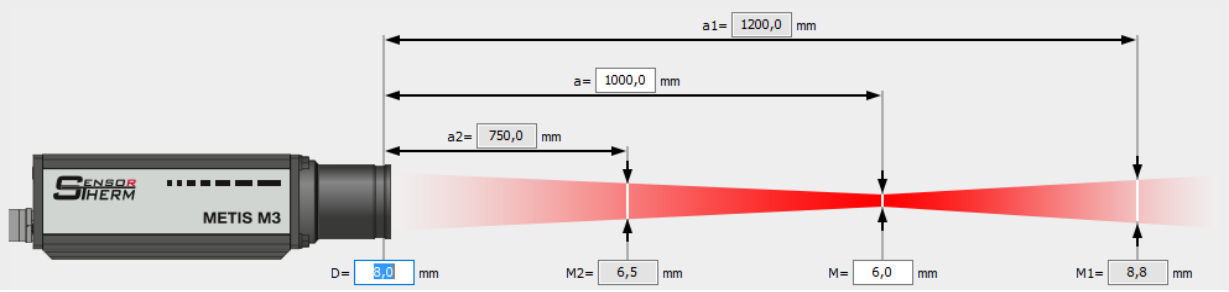
Temperature axis:			Time axis:		
	without key:	10° steps		without key:	as elected
	Alt key:	1° steps		Alt key:	1 Pixel
	Ctrl key:	25° steps		Ctrl key:	1/8 screen
	⇧ key:	50° steps		⇧ key:	1/4 screen
	⇧ + Ctrl key:	100° steps		⇧ + Ctrl key:	1/2 screen

7.5 Communication / Options



- **Firmware update H3 / M3 / DI / DS** starts the software *SensorFlash* (see **8**) to update the firmware of the pyrometer. Each *SensorTools* software has integrated the latest firmwares of its distribution date. Otherwise the latest firmware is available on the Sensortherm homepage in the download area under www.sensortherm.de/en/download-section.
  - The pyrometer must be connected via *SensorFlash*, therefore the *SensorTools* connection to the pyrometer will be disconnected when **Firmware update H3 / M3 / DI / DS** is selected.
  - Subsequently the software *SensorFlash* is opened (see **8**). Via this software the pyrometer must be connected, the flash file musst be selected and the flash operation can be performed.
- 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

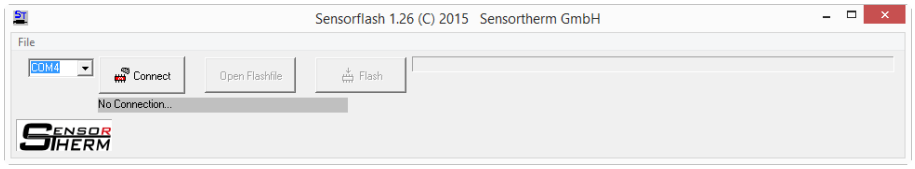


The spot size calculator is used to calculate the spot size diameter in front and behind the focused measuring distance. To do this, fill the white fields with the basic data (see **5.6.1 Spot size table**), then values in the gray fields can be calculated.

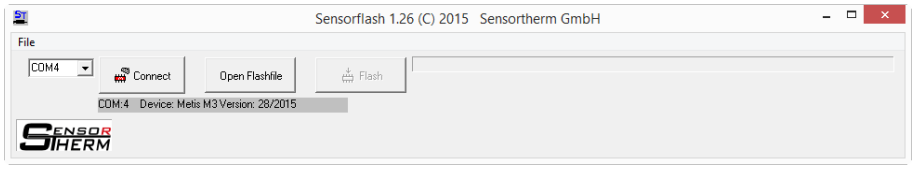
8 *SensorFlash* Software (Update Firmware)

The software *SensorFlash* is used to update the firmware of Sensortherm pyrometers. Press **Firmware Update H3 / M3** in the Communication/Options tab (see **7.5**) to start the software. Each *SensorTools* software has integrated the latest firmware files with the release date. In addition, the latest software and firmware releases is available on the home page in the download area under www.sensortherm.de/en/download-section.

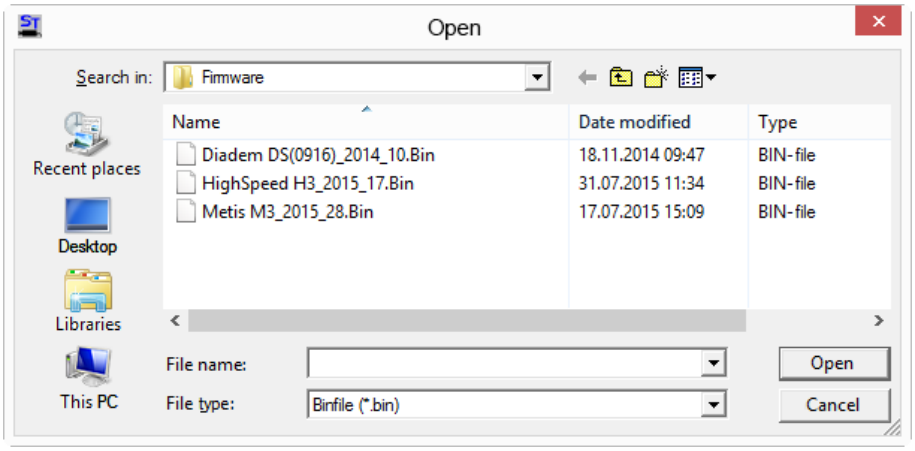
Select the COM port your pyrometer is connected with and press “Connect”.



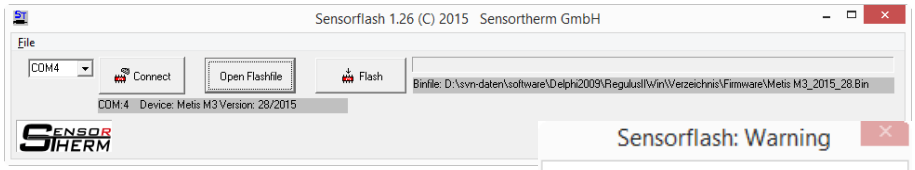
The grey status bar shows your device if connected.
Click “Open Flashfile” to select and open a new firmware file



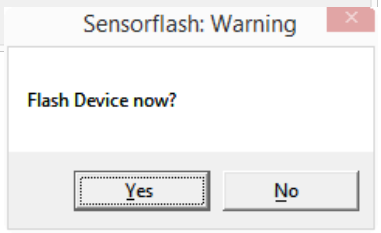
Select the new and suitable BIN file with a double click or with “Open”. (*SensorTools* firmware path: C:\Program Files (x86)\Sensortherm GmbH\SensorTools\Firmware).



Now the button ”Flash” is available, press it to start the upgrade process.

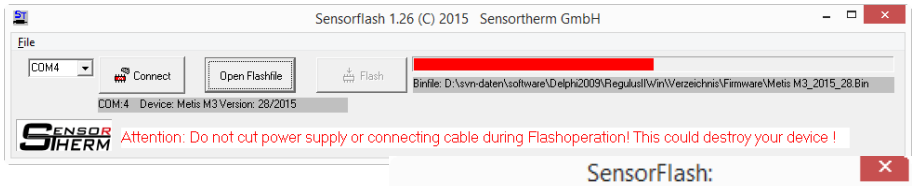


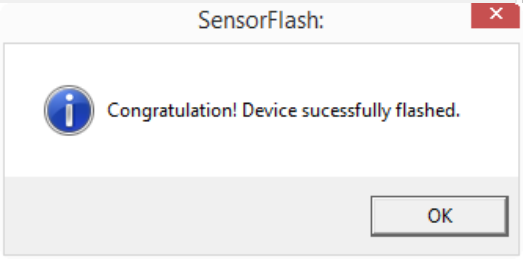
Confirm the safety note.



Important: Do not interrupt the power supply during this process!

The firmware will be flashed with the new version. Wait until the progress bar is finished and the confirmation message (Congratulation) appears.
The device is by pressing "OK" automatically logged out from *SensorFlash*, for further use with *SensorTools* the pyrometer must be re-connected (see **7.1 Program start / connecting the pyrometer**).





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: 0.75–0.93 µm / Channel 2: 0.93–1.1 µm *) Channel 1: 0.87 µm / Channel 2: 0.99 µm	Channel 1: 1.45–1.65 µm / Channel 2: 1.65–1.8 µm **) Channel 1: 1.4 µm / Channel 2: 1.64 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 (max. 115.2 kBd) or RS485 (max. 921.6 kBd), switchable. Resolution 0.1°C or 0.1°F	
Optics (optional)	Manual focusable or optional motorized focus or fixed focus optics	
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 (the laser targeting light is deactivated at a device temperature above 55°C / 131°F to prevent its overheating.)	

Device-specific H3

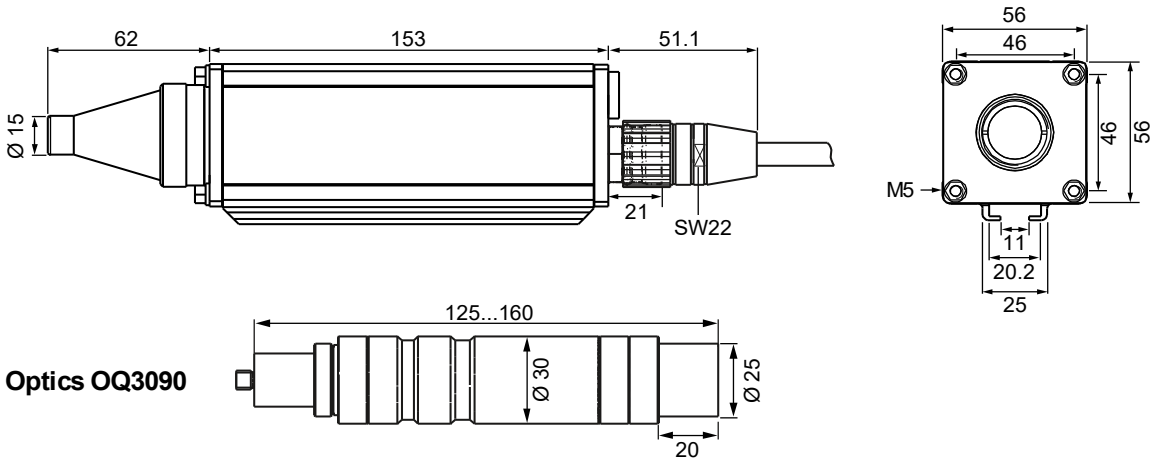
Model	H311	H322
Temperature ranges	600–1100°C 650–1300°C 750–1400°C 900–1800°C 1000–2000°C 1100–2200°C 1300–2500°C 1600–3300°C *)	350–800°C 400–1200°C 500–1300°C 550–1400°C 800–2000°C 1000–2500°C 1300–3000°C **)
Spectral range	Channel 1: 0.75–0.93 µm / Channel 2: 0.93–1.1 µm *) Channel 1: 0.87 µm / Channel 2: 0.99 µm	Channel 1: 1.45–1.65 µm / Channel 2: 1.65–1.8 µm **) Channel 1: 1.4 µm / Channel 2: 1.64 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 (max. 921.6 kBd). Resolution 0.1°C or 0.1°F	
Optics (optional)	Manual focusable optics (built-in or as fiber optics version)	
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 the laser targeting light is deactivated at a device temperature above 55°C / 131°F to prevent its overheating.	

Common Data

Temp. sub ranges	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)
Transmission	0.050–1.000 (corresponds 5–100% in 0.1% steps)
Spot size fill factor	0.050–1.000 (corresponds 5–100% in 0.1% steps)
Switch-off level	2–90%
Analog output signal	2 programmable analog outputs 0 or 4–20 mA, switchable, max. load: 500 Ω Output of a temperature proportional output current of 2-color temperature, 1-color channel 1 or 1-color channel 2 temperature, device temperature or control output. Both outputs can be set individually, inside or outside the temperature range.
Digital inputs	4 digital inputs: laser targeting light on/off, clearing of peak picker, trigger input for start / stop of measured value recording, load pyrometer configuration, start / stop controller.
Digital outputs	Digital outputs (max. 100 mA, no current limiting): limit switch, exceeding the beginning of temperature range (for material recognition), device ready after self-test, device over-temperature, signal strength too low. PID controller active, control process within limits, control process finished.
Analog input	0-10 V for analog set point definition for PID controlling, emissivity slope or emissivity.
Maximum value storage / Peak picker	Automatic hold mode or manual time settings to clear (reset) or external clear (via digital input)
Parameter settings	Via serial interface, PC software *SensorTools* or via self-compiled communication program: Slope/ratio, switch-off limit for measurement, switch-off limit for dirty window alarm, emissivity, transmission, fill factor, temperature sub range, settings for max. value storage, device address, baud rate, response time, selecting analog outputs 0/4–20 mA, interface RS232/RS485 (selection via interface command), °C/°F, language (English / German), measuring distance with motorized focus optics.
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	Laser targeting light (red, λ=650 nm, P< 1 mW, class II to IEC 60825-1)
Storage	Storage temperature: -20 to 85°C (-4 to 185°F) Relative humidity: max. 95%, no 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
Housing / protection class	Aluminum, IP65 to DIN 40 050 with plugged connector
Weight	700 g
CE label	According to EU directives for electromagnetic immunity

9.1 Dimensions

The case dimensions are the same for all models and differ in the mounting parts:



Optics OQ3090

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, 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	8	1	3	L	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) or 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	2	RS485
		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	L	Modification optimized for laser applications (17 pin connector, PID controller, digital inp. / outputs, 1 analog input)
19	Digital display	0	Without display
20	Analog outputs	2	2 analog outputs
21	Digital input / digital output	4	4 digital inputs + 1 analog input 0–10 V + 2 digital outputs
22	Optics	X	Special optics

9.3 Accessories

Ref. number	Meaning
AS53-XX *)	Connection cable with straight connector
AU43-XX *)	Connection cable with straight connector + RS232⇔USB interface converter
AV43-XX *)	Connection cable with straight connector + RS485⇔USB interface converter
AK50-XX *)	Connection cable for camera models
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
IF00-00	LED digital indicator for panel mounting
Regulus RD	PID program controller as bench top model
Regulus RF	PID program controller for panel mounting
KG14-00	Aluminum cooling jacket
KG20-00	Cooling plate for devices with focusable optics
KG31-00	Cooling cap for devices with focusable optics
BL10-00	Air purge accessory for devices with fixed focus optics
BL11-00	Air purge accessory for devices with focusable lens
BL13-00	Air purge accessory for fibre optic cable lens assembly OQ12
BL14-00	Air purge accessory for fibre optic cable lens assembly OQ25
HA10-00	Mounting bracket
HA15-00	Adjustable mounting bracket for fibre optic cable lens assembly OQ12
HA14-00	Adjustable mounting bracket for fibre-optic lens assembly OQ25
HA20-00	Swivel mounting base
HA21-00	Swivel mounting base for Metis with SC10
HA22-00	Swivel mounting base for cooling jacket
SC10-41	Scanning accessory
SC11-01	Line scanner, digital, programmable
SC12-01	Line scanner, programmable via internal keyboard and digital display

*) XX Specify length in meters (available in 5 m steps up to 15 m)

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 acetone. Use only high-purity acetone to avoid residues.

The objective lens is not
- to clean with solvents that contain acid
- immerse in water or other liquids to clean

10.2 Pyrometer Calibration

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

- Fiber-optic pyrometers must always be calibrated together with the associated optics and the optical fiber cable.
- A recalibration is also necessary if (for fiber optic pyrometers) the optics OQ12 is replaced by OQ25 or vice versa and / or a new fiber optic cable should be used.

10.3 Trouble-Shooting

A device malfunction is indicated by a red power status LED. 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 box, see Terminal field). For interpretation of the answer please contact us so that we can find a solution of the problem.

For improved support, a service file can be created via the software *SensorTools* (see in **7.3.2 Device Settings and Configuration → Service functions**) to be sent to Sensortherm for further support.

11 Communication via Serial Interface / 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 **7.5 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 **6.14**): 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	**Input in terminal program of *SensorTools*** without device address
00ar1<CR> sets the 2nd analog output to 4-20 mA **00ar** reads out how the analog output is set	**ar1<CR>** sets the 2nd analog output to 4-20 mA **ar** 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 analog output 2 X=2 (analog output 2); Y=0...8, output temperature or controller Y=0 = No output Y=3 = Temperature channel 2 Y=1 = 2-color temperature Y=6 = manipulated variable (devices with PID controller) Y=2 = temperature channel 1 Y=8 = Device temperature
an	X	Measured temperature (for temperature reading see mw command) X=0...3; 0=2-color channel; 1=channel 1; 2=channel 2
ar	X	Analog output 2 X=0...1; 0=0–20mA; 1=4–20mA
as	X	Analog output 1 X=0...1; 0=0–20mA; 1=4–20mA
ax	XXXX	Switch-off level in 1/10% XXXX=0x0014...0x0384 (corresponds to 2.0…90.0%)
az	XXXXXX	Response time of the switch-off (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		Poll of the buffer data (only one current packet!) Buffer mode 00: answer: AAAA AAAA = Display temperature (0xF001 => Overflow) Buffer mode 01: answer: AAAABBBBCCCC AAAA = 2-color temperature (0xF001 => Overflow) BBBB = Temperature channel 1 (0xF001 => Overflow) CCCC = Temperature channel 2 (0xF001 => Overflow) Buffer mode 02: answer: AAAABBBBCCCCDDDDEEEEFFFFGGHHIIJJ

AAAA = 2-color temperature (0xF001 => Overflow)
BBBB = Temperature channel 1 (0xF001 => Overflow)
CCCC = Temperature channel 2 (0xF001 => Overflow)
DDDD = Setpoint value at ramp function (current ramp setpoint value!)
EEEE = (Analog) control output (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 = Temperature channel 1 (0xF001 => Overflow)
CCCC = Temperature channel 2 (0xF001 => Overflow)
DDDD = Setpoint value of ramp function (current ramp setpoint value!)
EEEE = (Analog) control output (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 output 1	AutoTune active	Setup1	Display 1
Bit2	Status output 2	AutoTune at controller start	Setup2	Display 2
Bit3	Status output 3	Device ready	Unused	Unused
Bit4	Status input 1	Device hardware error	Unused	Unused
Bit5	Status input 2	Controller finished (successful)	Unused	Unused
Bit6	Status input 3	Targeting light active	Unused	Unused
Bit7 (msb)	Status input 4	Unused	Unused	Unused

br	X	Baud rate of serial interface X=2...6,8..9,a,b 2 = 4800 Baud 3 = 9600 Baud 4 = 19200 Baud 5 = 38400 Baud 6 = 57600 Baud 8 = 115200 Baud 9 = 230400 Baud a = 460800 Baud b = 921600 Baud
di dio	XXXX	Test current: Set temperature to XXXX (in °C) (4 digit hex) Cancel set temperature.
eg	XYYYY	Emissivity / emissivity slope X=0...2; YYYY=0x0050-1200 (corresponds 5-120%; in 0.1% steps) eg0 – emissivity slope 0800-1200 (0x0320...04b0) eg1 – emissivity slope channel 1 0050-1200 (0x0032...04b0) eg2 – emissivity slope channel 2 0050-1200 (0x0032...04b0)
et	XXXXXX	Response time (in steps of 100 µs) XXXXXX=0x000000-0186A0 (corresponds 0-10 s)
fh	X	Celsius/Fahrenheit selection X=0...1; 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 4 = error device temperature over Bit 1 = I2C error (video module) Bit 5 = error Eeprom Bit 2 = error device temperature Bit 6 = error motorized optics Bit 3 = error detector temperature Bit 7 = unused
ga	XX	Device address XX = 00...97 (2-digit dec.)
gh (ghX)	XYYYY	Hysteresis for limit switch X=1, 2 to value YYYY (in 1/10 degree)

gk (gkX)	XYYYY	Threshold for limit switch X X=1, 2 to value YYYY (in 1/10 degree)
ia (iaX)	XYYYY	Debounce time for digital input X X=1…5; Debounce time: YYYY=0x0000...03E8 (0-1000 ms)
if	X	Serial interface (only M3) X=0, 1; 0=RS232; 1=RS485 (that followed a baud rate of 19.2 KBd!)
in (inX)	XY	Configure input X X=1...4; YY=00...05 YY=00 – No function YY=01 – External clearing max. value storage YY=02 – Targeting light on/off YY=03 – Activate controller YY=04 – Controller start/stop YY=05 – Setup 0
la	X	State of targeting light X=0...2; 0= Targeting light off; 1= Targeting light on; 2= Targeting light off toggle
lg	X	Language 0 = English; 1 = German
lm	X	Set storage mode (peak picker) 0 = peak picker off (no storage) 1 = Time clearing peak picker (times: lt) 2 = External clearing of peak picker 3 = Automatic clearing of peak picker
lt	XXXXXX	Clear time maximum value storage (in 100 µs steps) XXXXXX=0x000000...03d090 (corresponds 0...25 s)
lx		External clearing of maximum value storage
mb		(Read) temperature range XXXX=Beginning of temp. range; YYYY=end of temp. range (all in 1/10 degree)
me	XXXXYYYY	Temperature sub range of pyrometer (Superordinate to the analog outputs) XXXX=Beginning of temp. range; YYYY=end of temp. range (all in 1/10 degree)
me (meX)	XYYYYZZZZ	Temp. range analog output X (X=1..2) (0…6553.5 °C/°F) YYYY= Beginning of temp. range; ZZZZ=end of temp. range (all in 1/10 degree)
mwX		Read measuring temperature (current value) (4-digit hex.) mw0 = current 2-color reading mw1 = current reading channel 1 mw2 = current reading channel 2
oa (oaX)	XYYYY	Activation time of the digital outputs X X=1, 2 YYYY=0x0000...ffff (corresponds 0-65535 ms)
oc (ocX)	XYY	Reference temperature for activating a digital output digital output X=1, 2; YY=0x00...02 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)
oh (ohX)	XYYYY	Hold time digital output X X=1, 2; hold time: YYYY (0x0000...fffe) 0-65534 ms (ffff => holt time infinite, until controller restart or program restart!)
op (opX)	XYY	Outputs (digital output X, X=1, 2) YY=(00...0A) YY=00 – no output YY=01 – device ready contact YY=02 – Material contact YY=03 – limit switch contact YY=04 – Signal(strength)contact 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 shutdown XXXX=0x0000...ffff (0...65535 s) X=0 => targeting light never turns of; 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, 2 (digital output) to value YYYY (hex in 1/10%)
sk	XYYYY	Signal strength contact level X=1, 2 (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 5%-100%) in 0.1% steps tg1 – Transmittance channel 1 0050-1000 (0x0032...03e8) tg2 – Transmittance channel 2 0050-1000 (0x0032...03e8)
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), Special function: xxxx => deactivate test!
tsc tsf	X X	Read temperature sensor (in °C/°F) (4-digit hex) tsc0 = Device temperature in 1/256°C tsf0 = Device temperature in 1/256°F tsc1 = Detector temperature in 1/256°C tsf1 = Detector temperature in 1/256°F
tw	XX	Interface delay XX
uh (uhX)	XYYYY	Hysteresis for over temperature contact (X=Digital output 1, 2) to value YYYY (1/256°C)
uk (ukX)	XYYYY	Device over-temperature threshold at digital output X X=1, 2 to value YYYY (in 1/256°C)
ve		Read device identifier and date of software

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 with 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 Grad)
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	Pmax XXXX=0001...03E8 (0.1...100.0%; 0.1% steps)

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

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