DM Laser Series

Laser/ Laser-Fast/ Laser-Metal/ Laser-Glas/ Laser-Folia

Infrared Sensor

User Manual

CE-Conformity

The product complies with the following standards:

EMC:	EN 61326-1:2006 (Basic requirements)
	EN 61326-2-3:2006
Safety Regulations:	EN 61010-1:2001
Laser safety:	EN 60825-1:2007

The product accomplishes the requirements of the EMC Directive 2004/108/EG and of the Low Voltage Directive 2006/95/EG.

Read the manual carefully before the initial start-up. The producer reserves the right to change the herein described specifications in case of technical advance of the product. References to other chapters are marked as **[▶ ...]**.

Warranty

Each single product passes through a quality process. Nevertheless, if failures occur please contact the customer service at once. The warranty period covers 24 months starting on the delivery date. After the warranty is expired the manufacturer guarantees additional 6 months warranty for all repaired or substituted product components. Warranty does not apply to damages, which result from misuse or neglect. The warranty also expires if you open the product. The manufacturer is not liable for consequential damage. If a failure occurs during the warranty period the product will be replaced, calibrated or repaired without further charges. The freight costs will be paid by the sender. The manufacturer reserves the right to exchange components of the product instead of repairing it. If the failure results from misuse or neglect the user has to pay for the repair. In that case you may ask for a cost estimate beforehand.

Content

Description

The sensors of the DM-Laser series are noncontact infrared temperature sensors.
They calculate the surface temperature based on the emitted infrared energy of objects **[▶ Basics of Infrared Thermometry]**. An integrated double laser aiming marks the real measurement spot location and spot size at any distance on the object surface.
The sensor housing of the DM-Laser head is made of stainless steel (IP65/ NEMA-4 rating) – the sensor electronics is placed in a separate box made of die casting zinc.

The DM-Laser sensing head is a sensitive optical system. Please use only the thread for mechanical installation.
Avoid mechanical violence on the head – this may destroy the system (expiry of warranty).

Scope of Supply

- DM-Laser sensing head with connection cable and electronic box
- Mounting nut and mounting bracket (fixed)
- Operators manual

Maintenance

Lens cleaning: Blow off loose particles using clean compressed air. The lens surface can be cleaned with a soft, humid tissue moistened with water or a water based glass cleaner.

PLEASE NOTE: Never use cleaning compounds which contain solvents (neither for the lens nor for the housing).

Cautions

Avoid abrupt changes of the ambient temperature. In case of problems or questions which may arise when you use the DM-Laser, please contact our service department.

Model Overview

The sensors of the DM-Laser series are available in the following basic versions:

Model	Model code	Measurement range	spectral	typical applications response
DM-Laser	751	-50…975°C	8-14 µm	non-metallic surfaces
DM-Laser F	751F	-50…975°C	8-14 µm	fast processes
DM-Laser 1M	1ML/ 1MH/ 1MH1	485… 2200°C	1 µm	metals and ceramic surfaces
DM-Laser 2M	2ML/ 2MH/ 2MH1	250… 2000°C	1,6 µm	metals and ceramic surfaces
DM-Laser 3M	3ML/ 3MH-H3	50… 1800°C	2,3 µm	metals at low object temperatures (from 50°C)
DM-Laser MT	MT	200…1450°C	3,9 µm	measurement through flames
DM-Laser F2	F2	200…1450°C	4,24 µm	measurement of CO_2-flame gases
DM-Laser F6	F6	200…1450°C	4,64 µm	measurement of CO-flame gases
DM-Laser 5G	5GL/ 5GH	100…1650°C	5,2 µm	measurement of glass

In the following chapters of this manual you will find only the short model codes.
On the 1M, 2M, 3M and 5G models the whole measurement range is split into several sub ranges (L, H, H1 etc.).

Factory Default Settings

The unit has the following presetting at time of delivery:

Signal output object temperature	0 – 5 V
Emissivity	0,970 [LT/ LTF/ MT/ F2/ F6/ 5G] 1,000 [1M/ 2M/ 3M]
Transmissivity	1,000
Average time (AVG)	0,2 s/ 0,1 s [LTF, MT, F2, F6]/ inactive [1M/ 2M/ 3M]
Smart Averaging	inactive [LT, 5G]
Peak hold	inactive
Valley hold	inactive

	751/751F	1ML	1MH	1MH1	2ML	2MH	2MH1	3ML	3MH
Lower limit temperature range [°C]	0	485	650	800	250	385	490	50	100
Upper limit temperature range [°C]	500	1050	1800	2200	800	1600	2000	400	600
Lower alarm limit [°C] (normally closed)	30	600	800	1200	350	500	800	100	250
Upper alarm limit [°C] (normally open)	100	900	1400	1600	600	1200	1400	300	500

Lower limit signal output	0V
Upper limit signal output	5V
Temperature unit	°C
Ambient temperature compensation (on LT and LTF output at OUT-AMB as 0-5 V signal)	internal head temperature probe
Baud rate [kBaud]	115
Laser	inactive

Smart Averaging means a dynamic average adaptation at high signal edges.
[Activation via software only].
[▶ Appendix C]

	3MH1	3MH2	3MH3	MT	F2	F6	5GL	5GH
Lower limit temperature range [°C]	150	200	350	200	200	200	100	250
Upper limit temperature range [°C]	900	1200	1800	1450	1450	1450	1200	1650
Lower alarm limit [°C] (normally closed)	350	550	750	400	400	400	200	350
Upper alarm limit [°C] (normally open)	600	1000	1200	1200	1200	1200	500	900
Lower limit signal output	0 V							
Upper limit signal output	5 V							
Temperature unit	°C							
Ambient temperature compensation internal head temperature probe (on MT, F2, F6 and 5G output at OUT-AMB as 0-5 V signal)								
Baud rate [kBaud]	115							
Laser	inactive							

Technical Data

General Specifications

	Sensing head	Electronic box
Environmental rating	IP65 (NEMA-4)	IP65 (NEMA-4)
Ambient temperature [1)]	-20...85°C	-20...85°C
Storage temperature	-40...85°C	-40...85°C
Relative humidity	10...95 %, non condensing	10...95 %, non condensing
Material	stainless steel	die casting zinc
Dimensions	100 x 50 mm, M48 x 1,5	89 x 70 x 30 mm
Weight	600 g	420 g
Cable length	3 m (Standard), 8 m, 15 m	
Cable diameter	5 mm	
Ambient temperature cable	105°C max. [High temperature cable (optional): 180°C]	
Vibration	IEC 68-2-6: 3G, 11… 200Hz, any axis	
Shock	IEC 68-2-27: 50G, 11ms, any axis	
EMI	89/336/EWG	
Software	optional	

[1)] Laser will turn off automatically at ambient temperatures >50°C.

Electrical Specifications

Power Supply	8…36V DC
Current draw	max. 160 mA
Aiming laser	635 nm, 1 mW, On/ Off via programming keys or software
Outputs/ analog	
Channel 1	selectable: 0/ 4…20 mA, 0…5/ 10 V, thermocouple (J or K) or alarm output (Signal source: object temperature)
Channel 2 (LT/ LTF/ MT/ F2/ F6/ G5 only)	Head temperature [-20...180°C] as 0…5 V or 0…10 V output or alarm output (Signal source switchable to object temperature or electronic box temperature if used as alarm output)
Alarm output	Open collector output at Pin AL2 [24 V/ 50 mA]
Output impedances	
mA	max. loop resistance 500 Ω (at 8-36V DC),
mV	min. 100 KΩ load impedance
Thermocouple	20 Ω
Digital interfaces	USB, RS232, RS485, CAN, Profibus DP, Ethernet (optional plug-in modules)
Relay outputs	2 x 60V DC/ 42 VAC_{RMS}, 0,4 A; optically isolated (optional plug-in module)
Functional inputs	F1 - F3; software programmable for the following functions: - external emissivity adjustment, - ambient temperature compensation, - trigger (reset of hold functions)

Measurement Specifications [751 models]

	751	751F
Temperature range (scalable)	-50...975°C	-50...975°C
Spectral range	8...14 µm	8...14 µm
Optical resolution	75:1	50:1
System accuracy [1) 2)]	±1°C or ±1 % [3)]	±1,5°C or ±1,5 % [4)]
Repeatability [1) 2)]	±0,5°C or ±0,5 % [3)]	±1°C or ±1 % [4)]
Temperature resolution	0,1°C [3)]	0,5°C [4)]
Response time (90% signal)	120 ms	9 ms
Warm-up time	10 min	10 min
Emissivity/Gain	0,100…1,100 (adjustable via programming keys or software)	
Transmissivity	0,100…1,000 (adjustable via programming keys or software)	
Signal processing	Average, peak hold, valley hold (adjustable via programming keys or software)	

[1)] at ambient temperature 23±5°C; whichever is greater
[2)] Accuracy for thermocouple output: ±2,5°C or ±1 %
[3)] at object temperatures >0°C
[4)] at object temperatures ≥ 20°C

Measurement Specifications [Laser-Metal 1M models]

	1ML	1MH	1MH1
Temperature range (scalable)	485...1050°C	650...1800°C	800...2200°C
Spectral range	1 µm	1 µm	1 µm
Optical resolution	150:1	300:1	300:1
System accuracy [1) 2)]	---------------- ±(0,3% of reading +2°C) [3)] -------------		
Repeatability [1) 2)]	---------------- ±(0,1% of reading +1°C) [3)] -------------		
Temperature resolution	---------------------------- 0,1°C [3)] -------------------------		
Exposure time (90% signal)	---------------------------- 1 ms [4)] ---------------------------		
Emissivity/ Gain	0,100…1,100 (adjustable via programming keys or software)		
Transmissivity	0,100…1,000 (adjustable via programming keys or software)		
Signal processing	Average, peak hold, valley hold (adjustable via programming keys or software)		

[1)] at ambient temperature 23±5°C
[2)] Accuracy for thermocouple output: ±2,5°C or ±1%
[3)] ε = 1/ Response time 1s
[4)] with dynamic adaptation at low signal levels

Measurement Specifications [Laser-Metal 2M models]

	2ML	2MH	2MH1
Temperature range (scalable)	250...800°C	385...1600°C	490...2000°C
Spectral range	1,6 µm	1,6 µm	1,6 µm
Optical resolution	150:1	300:1	300:1
System accuracy [1) 2)]	---------------- ±(0,3 % of reading +2°C) [3)] -------------		
Repeatability [1) 2)]	---------------- ±(0,1 % of reading +1°C) [3)] -------------		
Temperature resolution	----------------------------- 0,1°C [3)] --------------------------		
Exposure time (90% signal)	----------------------------- 1 ms [4)] ----------------------------		
Emissivity/ Gain	0,100…1,100 (adjustable via programming keys or software)		
Transmissivity	0,100…1,000 (adjustable via programming keys or software)		
Signal processing	Average, peak hold, valley hold (adjustable via programming keys software)		

[1)] at ambient temperature 23±5°C
[2)] Accuracy for thermocouple output: ±2,5°C or ±1%
[3)] ε = 1/ Response time 1s
[4)] with dynamic adaptation at low signal levels

Measurement Specifications [Laser-Metal 3M models]

	3ML	3MH	3MH1	3MH2
Temperature range (scalable)	50...400°C [1]	100...600°C [1]	150...900°C	200...1200°C
Spectral range	2,3 µm	2,3 µm	2,3 µm	2,3 µm
Optical resolution	60:1	100:1	300:1	300:1
System accuracy [2] [3]	±(0,3% of reading +2°C) [4]			
Repeatability [2]	±(0,1% of reading +1°C) [4]			
Temperature resolution	0,1°C [4]			
Exposure time (90% signal)	1 ms [5]			
Emissivity/Gain	0,100...1,100 (adjustable via programming keys or software)			
Transmissivity	0,100...1,000 (adjustable via programming keys or software)			
Signal processing	Average, peak hold, valley hold (adjustable via programming keys or software)			

1) TObject > THead+25°C
2) at ambient temperature 23±5°C
3) Accuracy for thermocouple output: ±2,5°C or ±1%
4) ε = 1/ Response time 1s
5) with dynamic adaptation at low signal levels

Measurement Specifications [Laser-Metal 3M/ MT/ F2/ F6 models]

	3MH3	MT	F2	F6
Temperature range (scalable)	350...1800°C	200...1450°C	200...1450°C	200...1450°C
Spectral range	2,3 µm	3,9 µm	4,24 µm	4,64 µm
Optical resolution	300:1	45:1	45:1	45:1
System accuracy [1,2]	±(0,3 % of read. +2°C) [3]	-------------------- ±1% [3,4] ------------------------------		
Repeatability [1]	±(0,1 % of read. +1°C) [3]	-------------------- ±0,5% [3,4] --------------------------		
Temperature resolution	0,1°C [3]	0,1°C	0,1°C	0,1°C
Exposure time (90 % signal)	1 ms[5]			
Response time (90 % signal)	10 ms[5]	10 ms[5]	10 ms[5]	
Emissivity/Gain	0,100...1,100 (adjustable via programming keys or software)			
Transmissivity	0,100...1,000 (adjustable via programming keys or software)			
Signal processing	Average, peak hold, valley hold (adjustable via programming keys or software)			

[1] at ambient temperature 23±5°C
[2] Accuracy for thermocouple output: ±2,5°C or ±1%
[3] ε = 1/ Response time 1s
[4] at object temperatures >300°C
[5] with dynamic adaptation at low signal levels

Measurement Specifications [Laser-Glas models]

	G5L	G5H
Temperature range (scalable)	100...1200°C	250...1650°C
Spectral range	5,2 µm	5,2 µm
Optical resolution	45:1	70:1
System accuracy [1) 2)]	---------- ±1°C or ±1%[3) 4)] ---------	
Repeatability [1)]	-------- ±0,5°C or ±0,5% [3) 4)] ------	
Temperature resolution	0,1°C [3)]	0,2°C [3)]
Response time (90% signal)	120 ms	80 ms
Emissivity/ Gain	0,100...1,100 (adjustable via programming keys or software)	
Transmissivity	0,100...1,000 (adjustable via programming keys or software)	
Signal processing	Average, peak hold, valley hold (adjustable via programming keys or)	

[1)] at ambient temperature 23±5°C
[2)] Accuracy for thermocouple output: ±2,5°C or ±1%
[3)] ε = 1/ Response time 1s
[4)] whichever is greater

Optical Charts

The following optical charts show the diameter of the measuring spot in dependence on the distance between measuring object and sensing head. The spot size refers to 90% of the radiation energy.
The distance is always measured from the front edge of the sensing head.

The size of the measuring object and the optical resolution of the infrared thermometer determine the maximum distance between sensing head and measuring object.
In order to prevent measuring errors the object should fill out the field of view of the optics completely.
Consequently, the spot should at all times have at least **the same size** like the object or should be **smaller than** that.

D = Distance from front of the sensing head to the object
S = Spot size

751

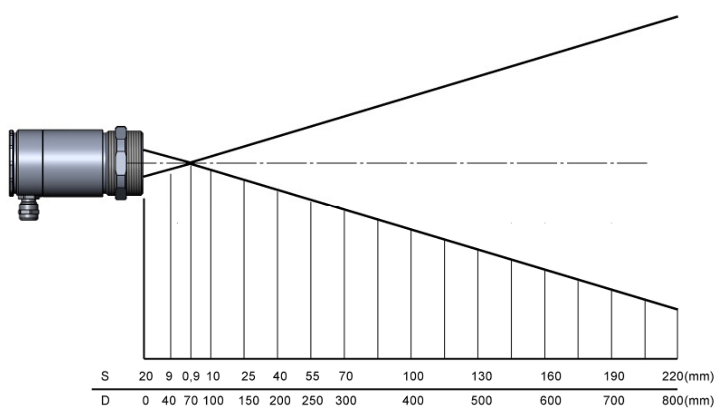
Optics: SF

D:S (focus distance) = 75:1/ 16mm@1200mm
D:S (far field) = 34:1

751

Optics: CF1

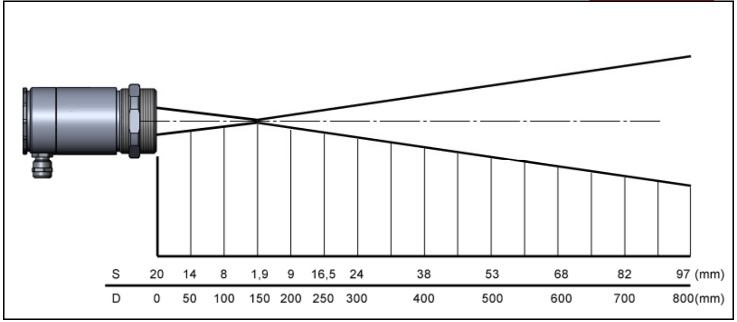
D:S (focus distance) = 75:1/ 0,9mm@70mm
D:S (far field) = 3,5:1



751

Optics: CF2

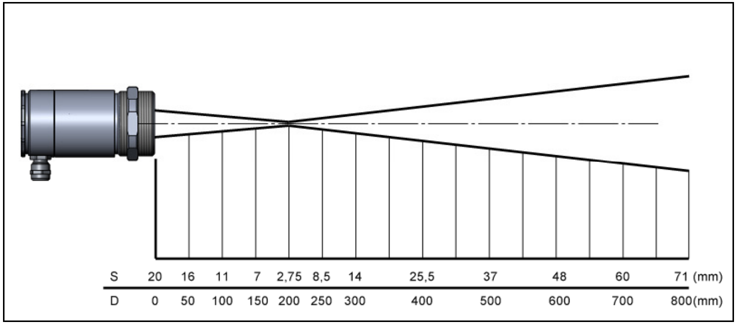
D:S (focus distance) = 75:1/ 1,9mm@150mm
D:S (far field) = 7:1



751

Optics: CF3

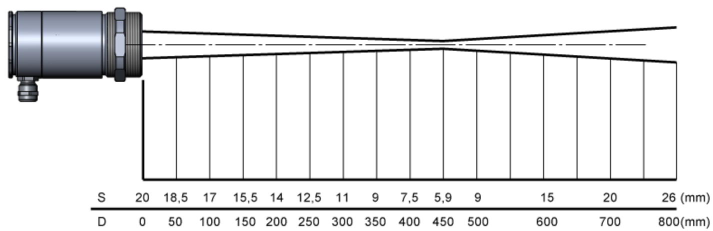
D:S (focus distance) = 75:1/ 2,75mm@200mm
D:S (far field) = 9:1



751

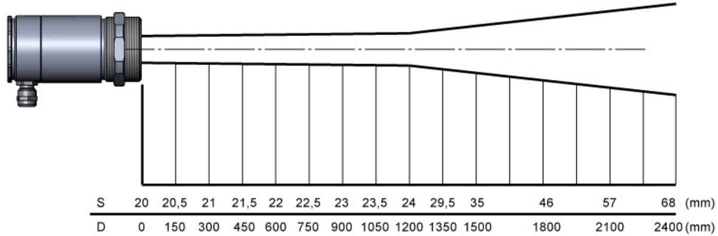
Optics: CF4

D:S (focus distance) = 75:1/ 5,9mm@450mm
D:S (far field) = 18:1



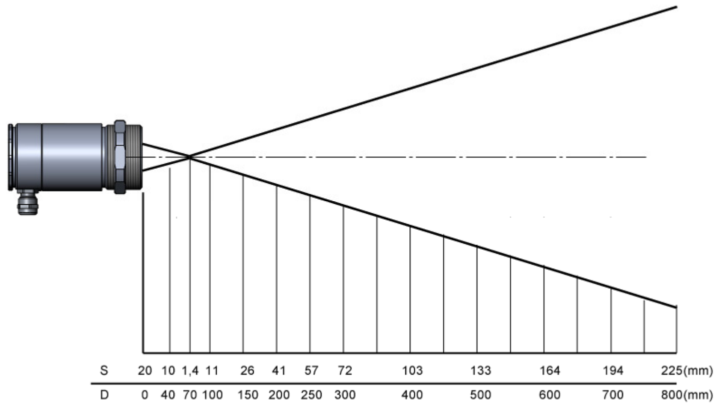
751F
Optics: SF

D:S (focus distance) = 50:1/ 24mm@1200mm
D:S (far field) = 20:1



751F
Optics: CF1

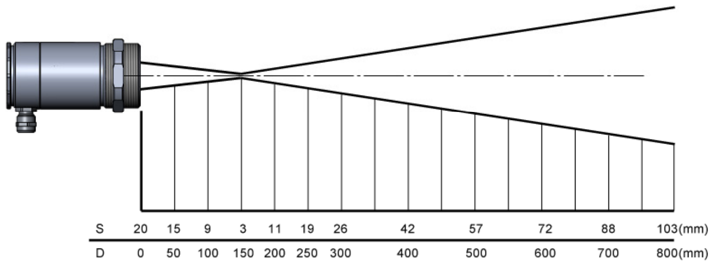
D:S (focus distance) = 50:1/ 1,4mm@70mm
D:S (far field) = 1,5:1



751F

Optics: CF2

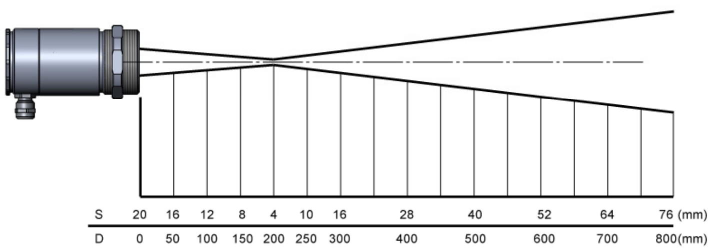
D:S (focus distance) = 50:1/ 3mm@150mm
D:S (far field) = 6:1



751F

Optics: CF3

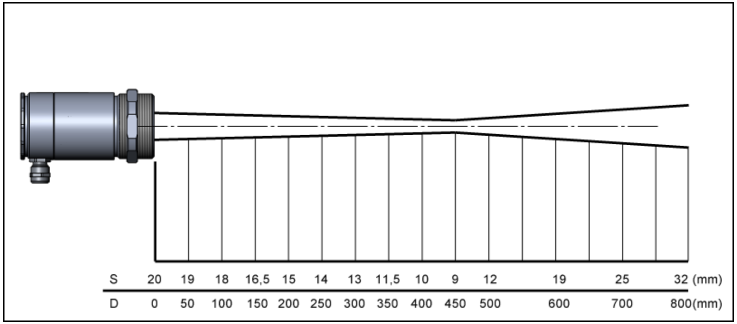
D:S (focus distance) = 50:1/ 4mm@200mm
D:S (far field) = 8:1



751F

Optics: CF4

D:S (focus distance) = 50:1/ 9mm@450mm
D:S (far field) = 16:1

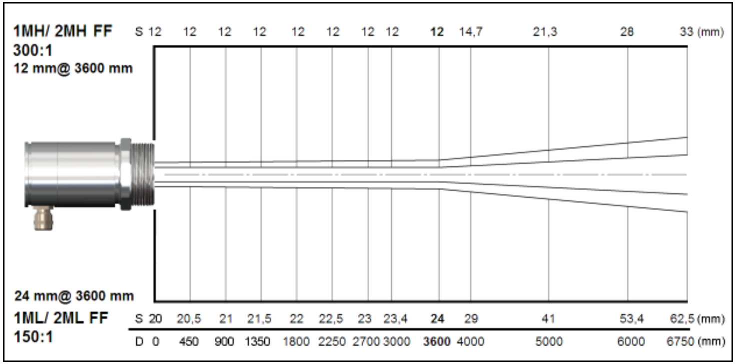


1MH/ 1MH1/ 2MH/ 2MH1 Optics: FF

D:S (focus distance) = 300:1/ 12mm@3600mm
D:S (far field) = 115:1

1ML/ 2ML Optics: FF

D:S (focus distance) = 150:1/ 24mm@3600mm
D:S (far field) = 84:1

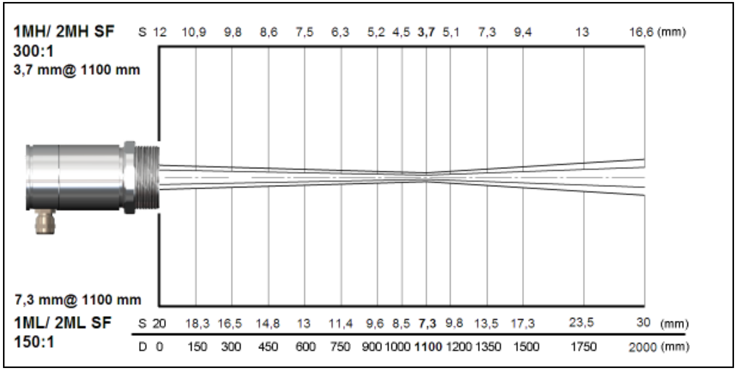


1MH/ 1MH1/ 2MH/ 2MH1 Optics: SF

D:S (focus distance) = 300:1/ 3,7mm@1100mm
D:S (far field) = 48:1

1ML/ 2ML Optics: SF

D:S (focus distance) = 150:1/ 7,3mm@1100mm
D:S (far field) = 42:1

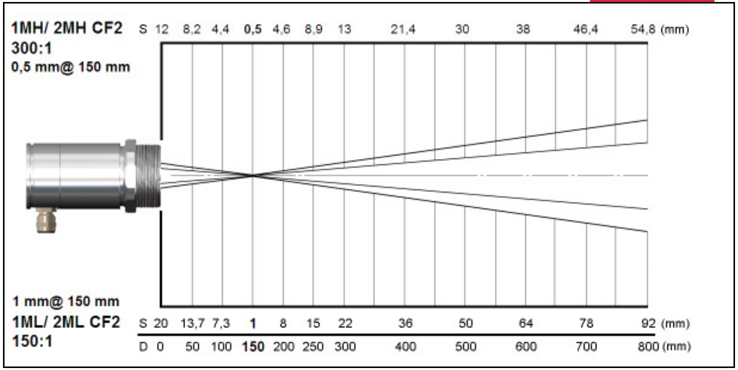


1MH/ 1MH1/ 2MH/ 2MH1 Optics: CF2

D:S (focus distance) = 300:1/ 0,5mm@150mm
D:S (far field) = 7,5:1

1ML/ 2ML Optics: CF2

D:S (focus distance) = 150:1/ 1mm@150mm
D:S (far field) = 7:1

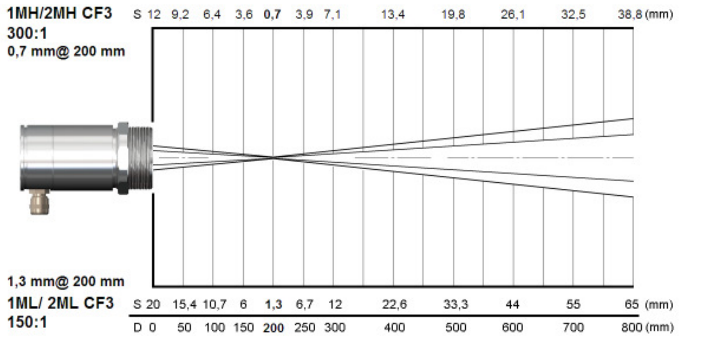


1MH/ 1MH1/ 2MH/ 2MH1 Optics: CF3

D:S (focus distance) = 300:1/ 0,7mm@200mm
D:S (far field) = 10:1

1ML/ 2ML Optics: CF3

D:S (focus distance) = 150:1/ 1,3mm@200mm
D:S (far field) = 10:1

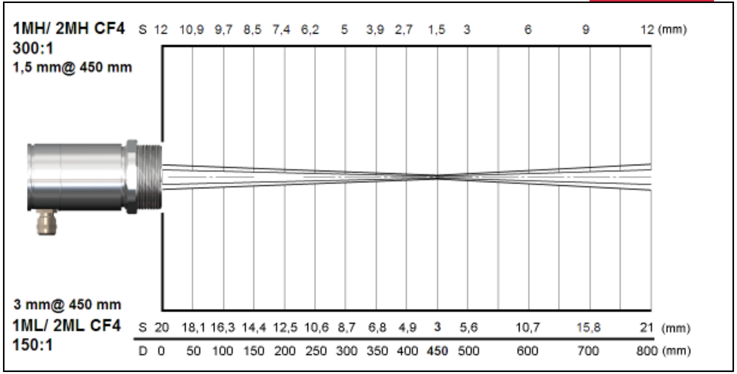


1MH/ 1MH1/ 2MH/ 2MH1 Optics: CF4

D:S (focus distance) = 300:1/ 1,5mm@450mm
D:S (far field) = 22:1

1ML/ 2ML Optics: CF4

D:S (focus distance) = 150:1/ 3mm@450mm
D:S (far field) = 20:1

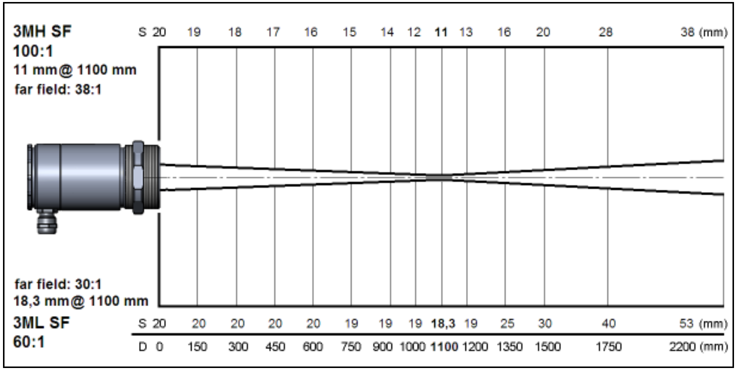


3MH Optics: SF

D:S (focus distance) = 100:1
11mm@1100mm
D:S (far field) = 38:1

3ML Optics: SF

D:S (focus distance) = 60:1
18,3mm@1100mm
D:S (far field) = 30:1

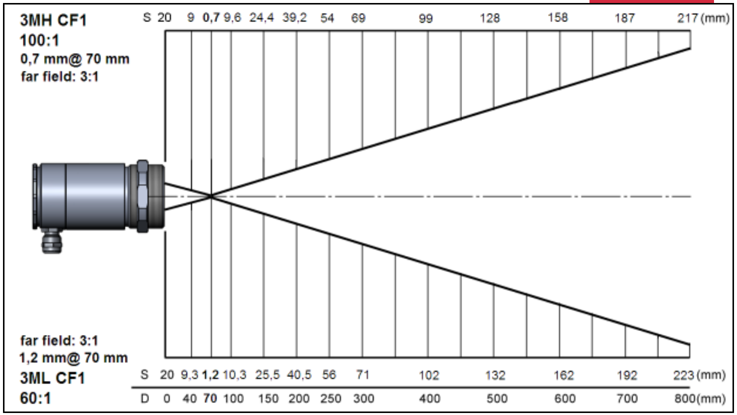


3MH Optics: CF1

D:S (focus distance) = 100:1
0,7mm@70mm
D:S (far field) = 3:1

3ML Optics: CF1

D:S (focus distance) = 60:1
1,2mm@70mm
D:S (far field) = 3:1

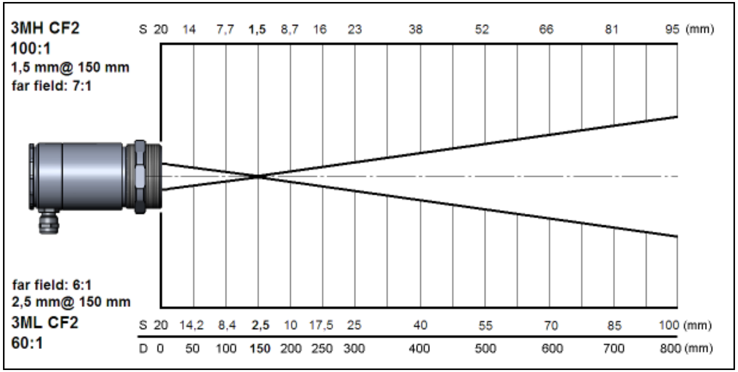


3MH Optics: CF2

D:S (focus distance) = 100:1
1,5mm@150mm
D:S (far field) = 7:1

3ML Optics: CF2

D:S (focus distance) = 60:1
2,5mm@150mm
D:S (far field) = 6:1

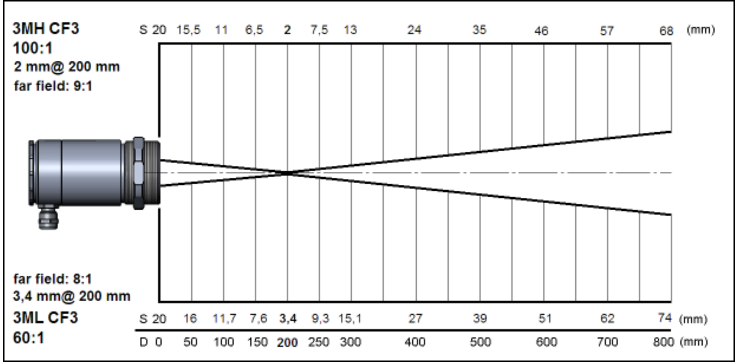


3MH Optics: CF3

D:S (focus distance) = 100:1
2mm@200mm
D:S (far field) = 9:1

3ML Optics: CF3

D:S (focus distance) = 60:1
3,4mm@200mm
D:S (far field) = 8:1

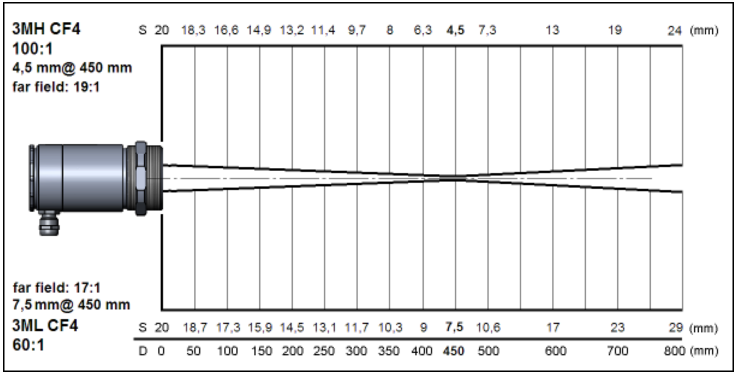


3MH Optics: CF4

D:S (focus distance) = 100:1
4,5mm@450mm
D:S (far field) = 19:1

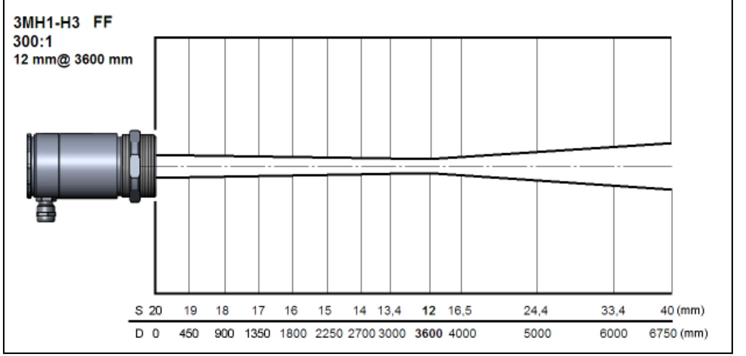
3ML Optics: CF4

D:S (focus distance) = 60:1
7,5mm@450mm
D:S (far field) = 17:1



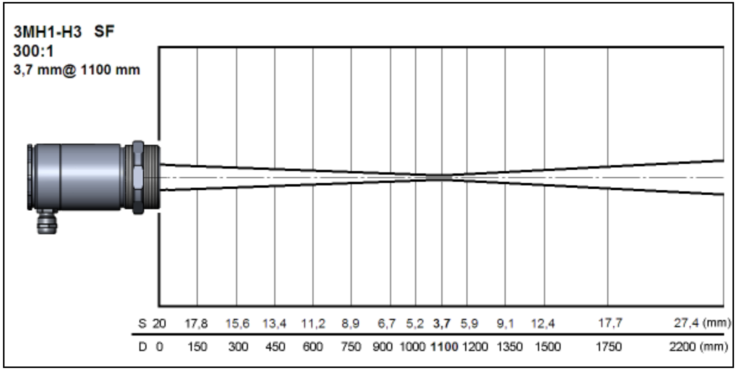
3MH1-H3 Optics: FF

D:S (focus distance) = 300:1
12mm@3600mm
D:S (far field) = 115:1



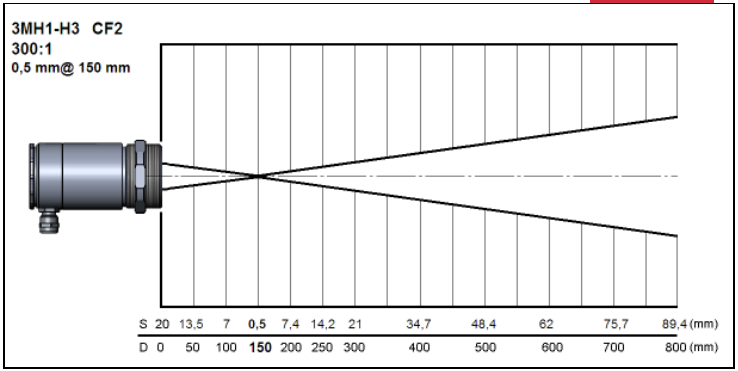
3MH1-H3 Optics: SF

D:S (focus distance) = 300:1
3,7mm@1100mm
D:S (far field) = 48:1



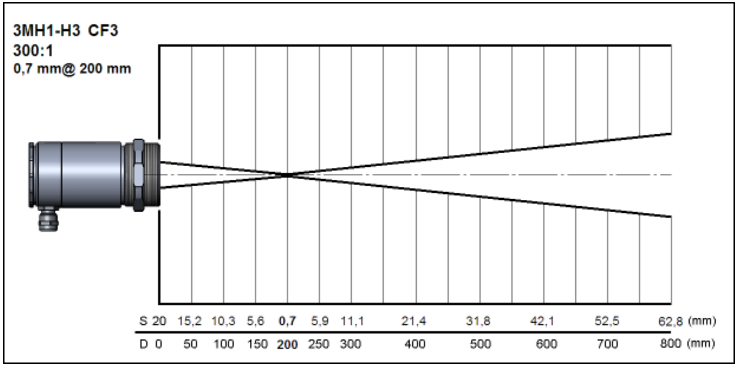
3MH1-H3 Optics: CF2

D:S (focus distance) = 300:1
0,5mm@150mm
D:S (far field) = 7,5:1



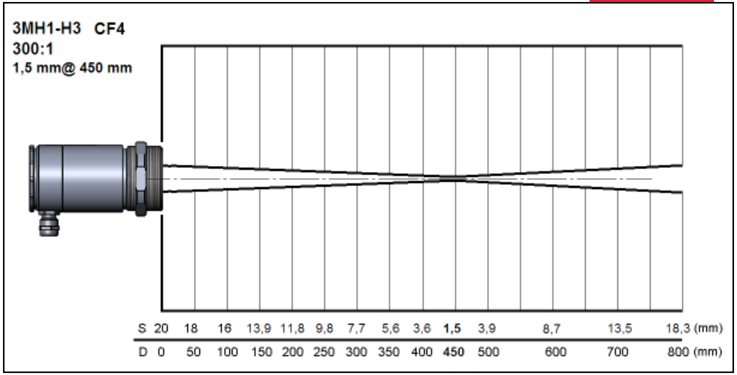
3MH1-H3 Optics: CF3

D:S (focus distance) = 300:1
0,7mm@200mm
D:S (far field) = 10:1



3MH1-H3 Optics: CF4

D:S (focus distance) = 300:1
1,5mm@450mm
D:S (far field) = 22:1

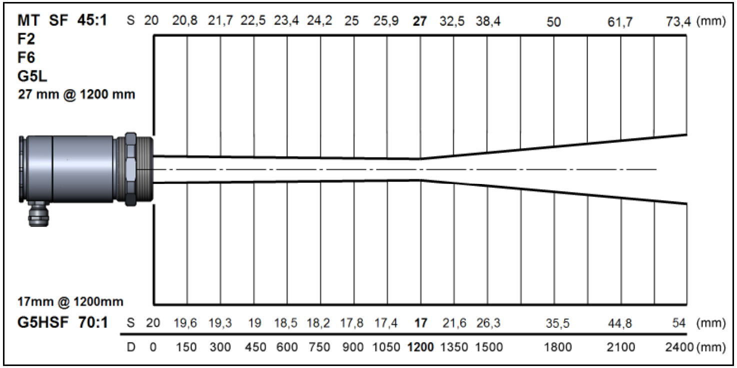


MT/ F2/ F6/ 5GL Optics: SF

D:S (focus distance) = 45:1/ 27mm@1200mm
D:S (far field) = 25:1

5GH Optics: SF

D:S (focus distance) = 70:1/ 17mm@1200mm
D:S (far field) = 33:1

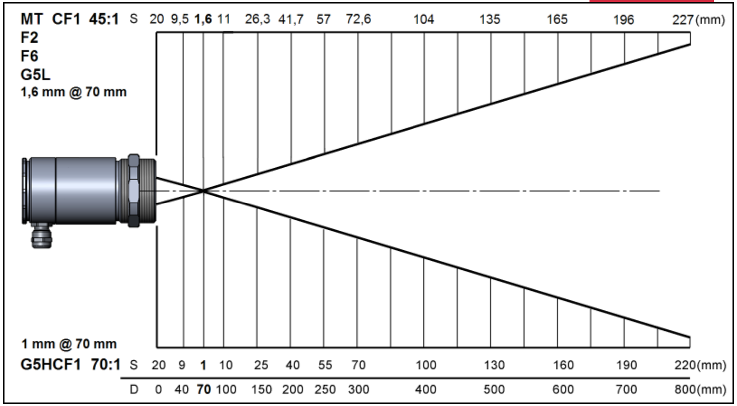


MT/ F2/ F6/ 5GL Optics: CF1

D:S (focus distance) = 45:1/ 1,6mm@70mm
D:S (far field) = 3:1

5GH Optics: CF1

D:S (focus distance) = 70:1/ 1mm@70mm
D:S (far field) = 3,4:1

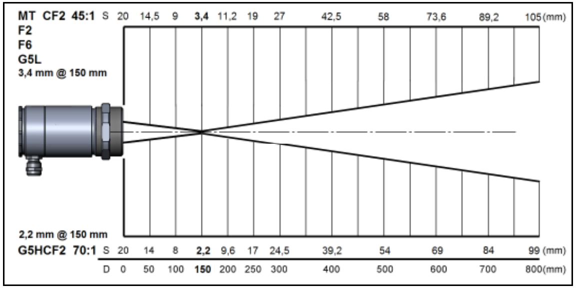


MT/ F2/ F6/ 5GL Optics: CF2

D:S (focus distance) = 45:1/ 3,4mm@150mm
D:S (far field) = 6:1

5GH Optics: CF2

D:S (focus distance) = 70:1/ 2,2mm@150mm
D:S (far field) = 6,8:1

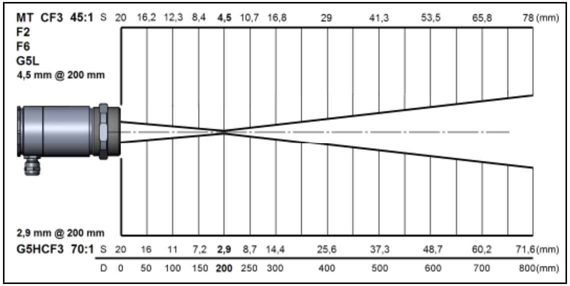


MT/ F2/ F6/ 5GL Optics: CF3

D:S (focus distance) = 45:1/ 4,5mm@200mm
D:S (far field) = 8:1

5GH Optics: CF3

D:S (focus distance) = 70:1/ 2,9mm@200mm
D:S (far field) = 9,2:1

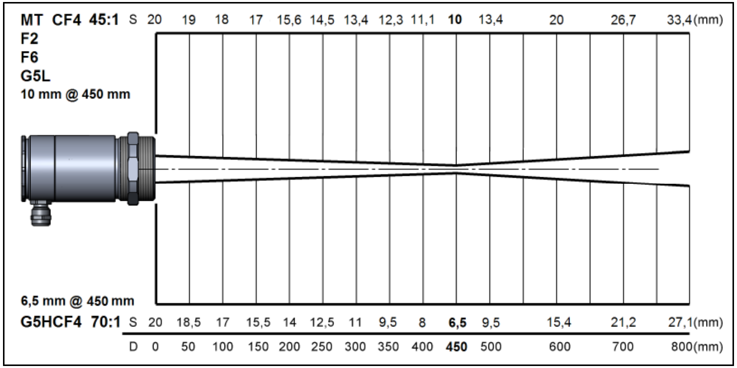


MT/ F2/ F6/ 5GL Optics: CF4

D:S (focus distance) = 45:1/ 10mm@450mm
D:S (far field) = 15:1

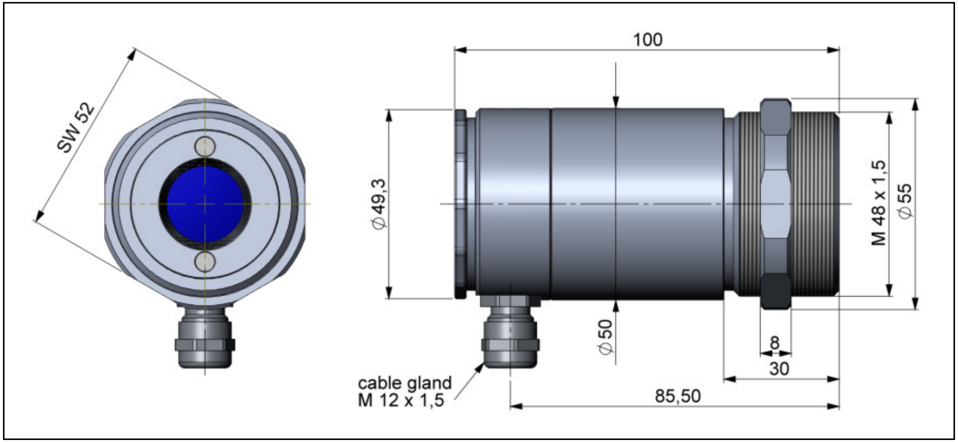
5GH Optics: CF4

D:S (focus distance) = 70:1/ 6,5mm@450mm
D:S (far field) = 17,7:1



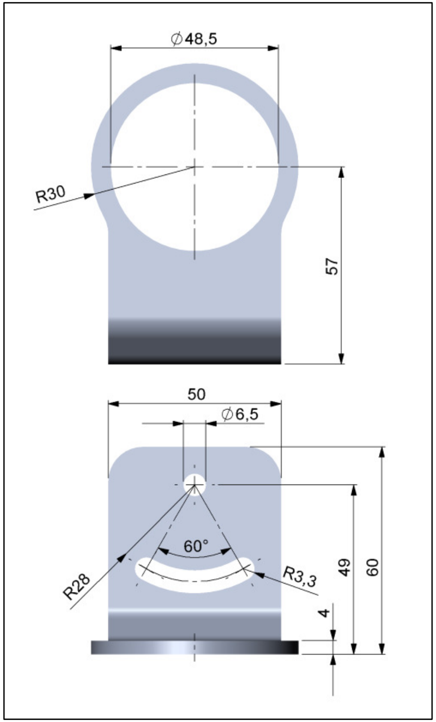
Mechanical Installation

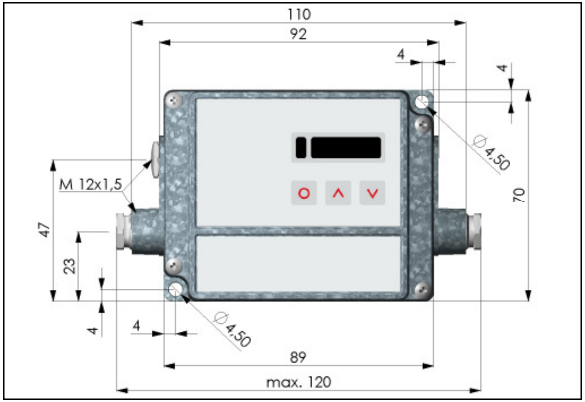
The DM-Laser is equipped with a metric M48 x 1,5 thread and can be installed either directly via the sensor thread or with help of the supplied mounting nut (standard) and fixed mounting bracket (standard) to a mounting device available.

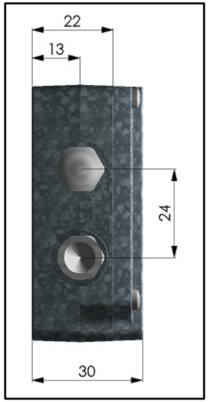


DM-Laser sensing head

Make sure to keep the optical path clear of any obstacles.







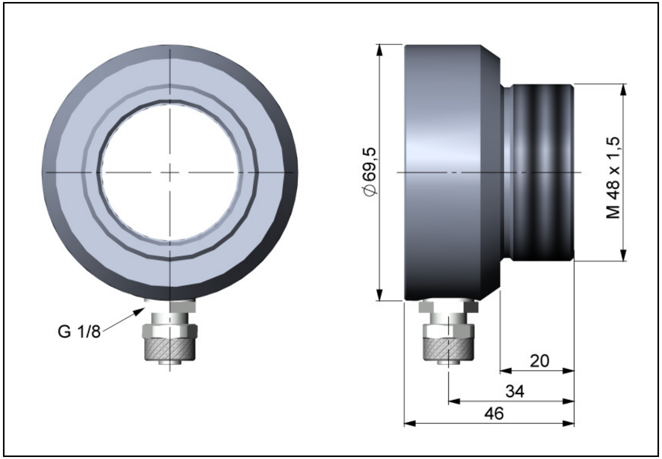
Electronic box

For an exact alignment of the head to the object please activate the integrated double laser.
[▶ Operating/ Laser sighting]

Accessories

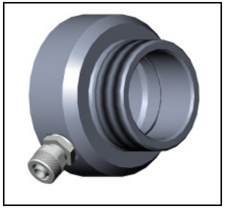
Air Purge Collar

The lens must be kept clean at all times from dust, smoke, fumes and other contaminants in order to avoid reading errors. These effects can be reduced by using an air purge collar. Make sure to use oil-free, technically clean air, only.

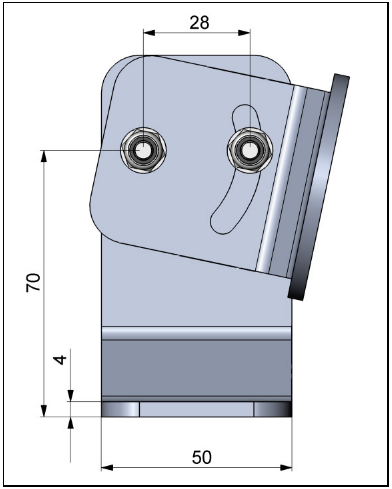


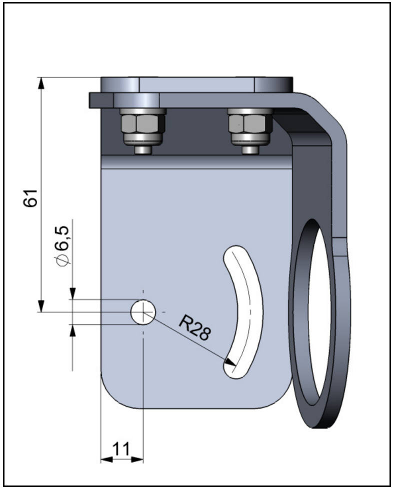
Air purge collar
Hose connection: 6x8 mm

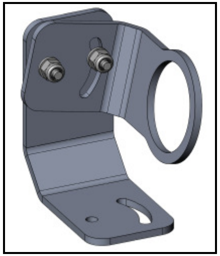
The needed amount of air (approx. 2...10 l/ min.) depends on the application and the installation conditions on-site.



Mounting Bracket



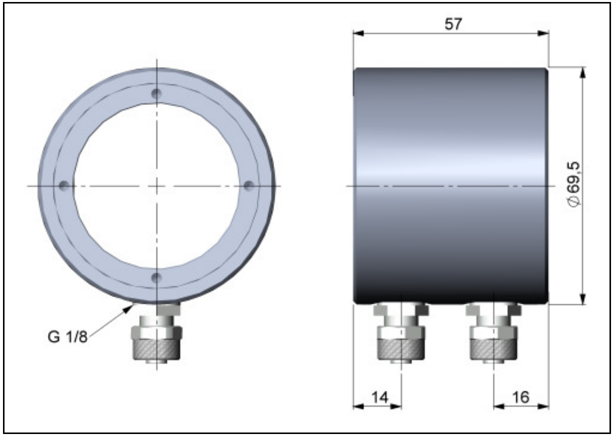




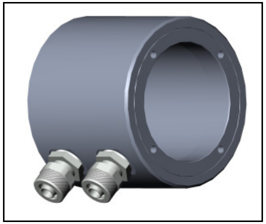
Mounting bracket, adjustable in two axes

This adjustable mounting bracket allows an adjustment of the sensor in two axis.

Water Cooled Housing



To avoid condensation on the optics an air purge collar is recommended.

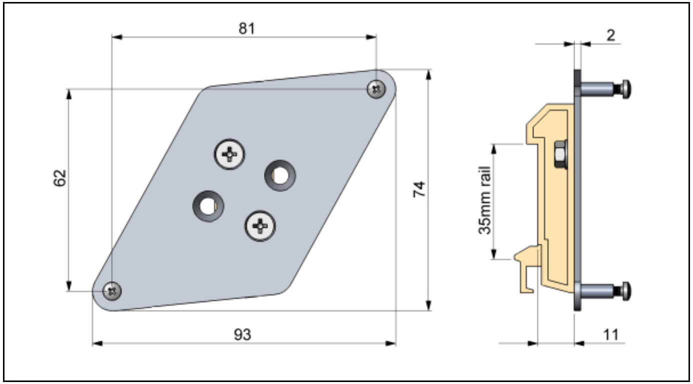


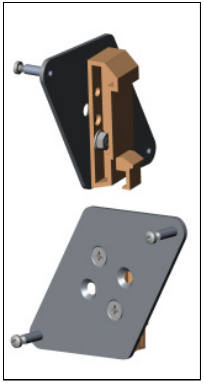
Water cooled housing
Hose connection: 6x8 mm
Thread (fitting): G 1/8 inch

The sensing head can be used at ambient temperatures up to 85°C without cooling. For applications, where the ambient temperature can reach higher values, the usage of the optional water cooled housing is recommended (operating temperature up to 175°C). The sensor should be equipped with the optional high temperature cable (operating temperature up to 180°C).

Rail Mount Adapter for Electronic box

With the rail mount adapter the DM-Laser electronics can be mounted easily on a DIN rail (TS35) according EN50022.





Rail mount adapter

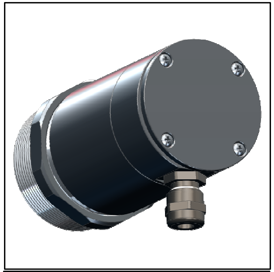
► All accessories can be ordered using the according part numbers in brackets

Electrical Installation

Cable Connections

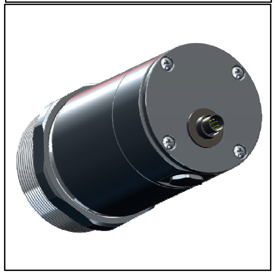
Basic version

The basic version is supplied with a connection cable (connection sensing head-electronics). For the electrical installation of the DM-Laser please open at first the cover of the electronic box (4 screws). Below the display are the screw terminals for the cable connection.



Connector version

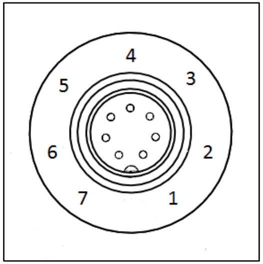
This version has a connector plug integrated in the sensor backplane. Please use the original ready-made, fitting connection cables which are optionally available. Please note the pin assignment of the connector (see next page).



For the Cooling jacket the connector version is needed.

Pin assignment of connector plug (connector version only)

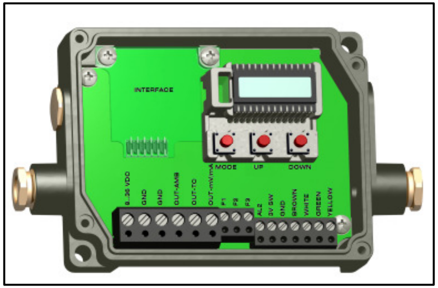
PIN	designation	wire color (original sensor cable)
1	Detector signal (+)	yellow
2	Temperature probe head	brown
3	Temperature probe head	white
4	Detector signal (–)	green
5	Ground Laser (–)	grey
6	Power supply Laser (+)	pink
7	–	not used



Connector plug (Outer view)

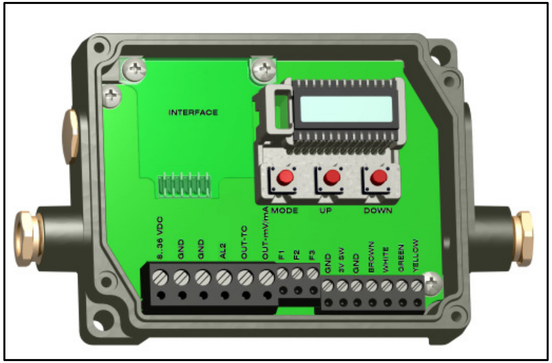
Designation [models 751/ 751F/ MT/ F2/ F6/ 5G]

+8..36V DC Power supply	
GND	Ground (0V) of power supply
GND	Ground (0V) of internal in- and outputs
OUT-AMB	Analog output head temperature (mV)
OUT-TC	Analog output thermocouple (J or K)
OUT-mV/mA	Analog output object temperature (mV or mA)
F1-F3	Functional inputs
AL2	Alarm 2 (Open collector output)
3V SW	PINK/ Power supply Laser (+)
GND	GREY/ Ground Laser (–)
BROWN	Temperature probe head
WHITE	Temperature probe head
GREEN	Detector signal (–)
YELLOW	Detector signal (+)



Designation [Laser-Metal models 1M/ 2M/ 3M]

+8..36V DC Power supply	
GND	Ground (0V) of power supply
GND	Ground (0V) of internal in- and outputs
AL2	Alarm 2 (Open collector output)
OUT-TC	Analog output thermocouple (J or K)
OUT-mV/mA	Analog output object temperature (mV or mA)
F1-F3	Functional inputs
GND	Ground (0V)
3V SW	PINK/ Power supply Laser (+)
GND	GREY/ Ground Laser (–)
BROWN	Temperature probe head (NTC)
WHITE	Head ground
GREEN	Head power
YELLOW	Detector signal



Opened electronic box (1M/ 2M/ 3M) with terminal connections

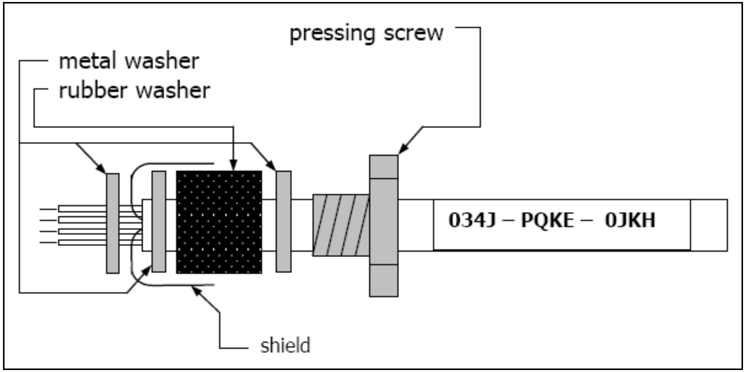
Power supply

Please use a power supply unit with an output voltage of **8…36V DC** which can supply **160 mA.**

CAUTION: Please do never connect a supply voltage to the analog outputs as this will destroy the output !
The DM-Laser is not a 2-wire sensor !

Cable Assembling

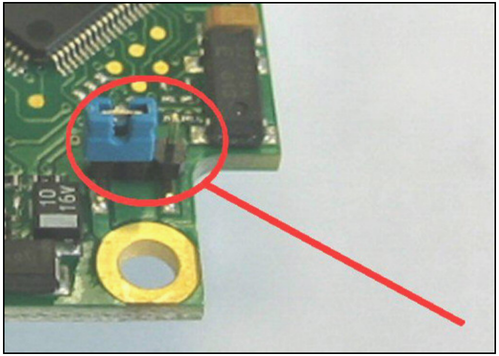
The cable gland M12x1,5 allows the use of cables with a diameter of 3 to 5 mm.
Remove the isolation from the cable (40 mm power supply, 50 mm signal outputs, 60 mm functional inputs). Cut the shield down to approximately 5 mm and spread the strands out. Extract about 4 mm of the wire isolation and tin the wire ends.
Place the pressing screw, the rubber washer and the metal washers of the cable gland one after the other onto the prepared cable end. Spread the strands and fix the shield between two of the metal washers. Insert the cable into the cable-gland until the limit stop. Screw the cap tight.
Every single wire may be connected to the according screw clamps according to their colors.



Use shielded cables only. The sensor shield has to be grounded.

Ground Connection

At the bottom side of the mainboard PCB you will find a connector (jumper) which has been placed from factory side as shown in the picture [left and middle pin connected]. In this position the ground connections (GND power supply/ outputs) are connected with the ground of the electronics housing.
To avoid ground loops and related signal interferences in industrial environments it might be necessary to interrupt this connection.
To do this please put the jumper in the other position [**middle** and **right** pin connected].
If the thermocouple output is used the connection GND – housing should be interrupted generally.



Exchange of the Sensing Head

From factory side the sensing head has already been connected to the electronics. Inside a certain model group an exchange of sensing heads and electronics is possible.

After exchanging a head the calibration code of the new head must be entered into the electronics.

Entering of the Calibration Code

Every head has a specific calibration code, which is printed on the head. For a correct temperature measurement and functionality of the sensor this calibration code must be stored into the electronic box.
The calibration code consists of five blocks with 4 characters each.

Example: **EKJ0 – 0OUD – 0A1B – A17U – 93OZ**
block1 block2 block3 block4 block5

For entering the code please press the **Up** and **Down** key (keep pressed) and then the **Mode** key.
The display shows **HCODE** and then the 4 signs of the first block. With **Up** and **Down** each sign can be changed, **Mode** switches to the next sign or next block.

After you have modified the head code a reset is necessary to activate the change.
[▶ Operating]

You will find the calibration code on a label fixed on the head. Please do not remove this label or make sure the code is noted anywhere. The code is needed if the electronic has to be exchanged.

Exchange of the Head Cable

The sensing head cable can also be exchanged if necessary. For a dismantling on the head side please open at first the cover plate on the back side of the head. Then please remove the terminal block and loose the connections. After the new cable has been installed please do the same steps in reverse order. Please take care the cable shield is properly connected to the head housing.

As exchange cable a cable type with same wire profiles and specification should be used to avoid influences on the accuracy.

Outputs and Inputs

Analog Outputs

The DM-Laser has two analog output channels.

Output channel 1

This output is used for the object temperature. The selection of the output signal can be done via the programming keys **[▶ Operating]**. The software allows the programming of output channel 1 as an alarm output.

Output signal	Range	Connection pin on CTlaser board
Voltage	0 ... 5 V	OUT-mV/mA
Voltage	0 ... 10 V	OUT-mV/mA
Current	0 ... 20 mA	OUT-mV/mA
Current	4 ... 20 mA	OUT-mV/mA
Thermocouple	TC J	OUT-TC
Thermocouple	TC K	OUT-TC

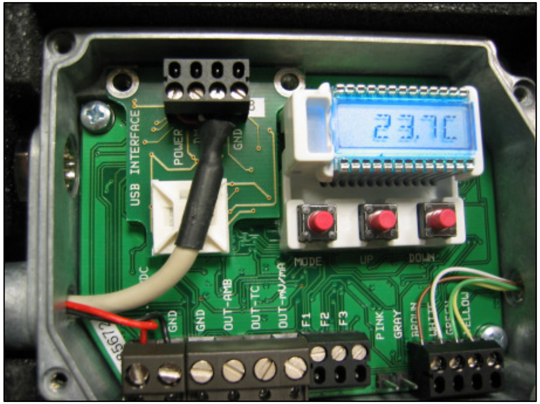
According to the chosen output signal there are different connection pins on the mainboard (**OUT-mV/mA** or **OUT-TC**).

Output channel 2 [on LT/ 5G only]

The connection pin OUT AMB is used for output of the head temperature **[-20…180°C as 0…5 V or 0…10 V signal]**. The software allows the programming of output channel 2 as an alarm output.
Instead of the head temperature **THead** also the object temperature **TObj** or electronic box temperature **TBox** can be selected as alarm source.

Digital Interfaces

DM-Laser sensors can be optionally equipped with an USB-,
RS232-, RS485-, CAN Bus-, Profibus DP- or Ethernet-interface.
If you want to install an interface, plug the interface board into the place provided, which is located beside the display. In the correct position the holes of the interface match with the thread holes of the electronic box. Now press the board down to connect it and use both M3 x 5 screws for fixing it. Plug the preassembled interface cable with the terminal block into the male connector of the interface board.



The Ethernet interface requires at minimum 12V supply voltage. Please pay attention to the notes on the according interface manuals.

Relay Outputs

The DM-Laser can be optionally equipped with a relay output. The relay board will be installed the same way as the digital interfaces. **A simultaneous installation of a digital interface and the relay outputs is not possible.** The relay board provides two fully isolated switches, which have the capability to switch max. 60V DC/ 42V AC_{RMS}, 0,4 A DC/AC. A red LED shows the closed switch.

The switching thresholds are in accordance with the values for alarm 1 and 2 **[► Alarms/ Visual Alarms]**.
The alarm values are set according to the ► **Factory Default Settings**.
To make advanced settings (change of low- and high alarm) a digital interface (USB, RS232) and the software is needed.

Functional Inputs

The three functional inputs F1 – F3 can be programmed with the software, only.

F1 (digital): trigger (a 0 V level on F1 resets the hold functions)
F2 (analog): external emissivity adjustment **[0–10 V: 0 V ► ε=0,1; 9 V ► ε=1; 10 V ► ε=1,1]**
F3 (analog): external compensation of ambient temperature/ the range is scalable via software **[0–10 V ► -40…900°C / preset range: -20…200°C]**
F1-F3 (digital): emissivity (digital choice via table)

A non connected input represents:
F1=High | F2, F3=Low.
[High level: ≥ +3 V…+36 V | Low level: ≤ +0,4 V…36 V]

Alarms

The DM-Laser has the following Alarm features:

All alarms (alarm 1, alarm 2, output channel 1 and 2 if used as alarm output) have a fixed **hysterese of 2K**.

Output channel 1 and 2 [channel 2 on LT/ G5 only]
To activate the according output channel has to be switched into digital mode. For this purpose the software is required.

Visual Alarms
These alarms will cause a change of the color of the LCD display and will also change the status of the optional relays interface. In addition the Alarm 2 can be used as open collector output at pin **AL2** on the mainboard **[24V/ 50mA]**.

From factory side the alarms are defined as follows:

Alarm 1	**Norm. closed/ Low-Alarm**
Alarm 2	**Norm. open/ High-Alarm**

Both of these alarms will have effect on the LCD color:

BLUE:	**alarm 1 active**
RED:	**alarm 2 active**
GREEN:	**no alarm active**

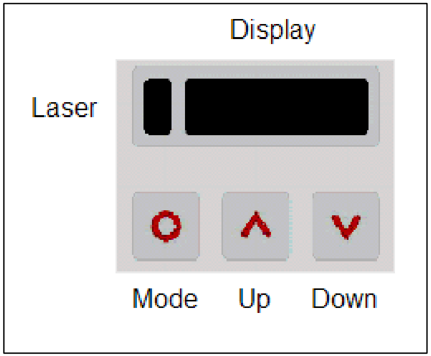
For extended setup like definition as low or high alarm **[via change of normally open/ closed]**, selection of the signal source **[TObj, THead, TBox]** a digital interface (e.g. USB, RS232) including the software is needed.

Operating

After power up the unit the sensor starts an initializing routine for some seconds. During this time the display will show **INIT**. After this procedure the object temperature is shown in the display. The display backlight color changes according to the alarm settings
[▶ Alarms/ Visual Alarms].

Sensor Setup

The programming keys **Mode**, **Up** and **Down** enable the user to set the sensor on-site. The current measuring value or the chosen feature is displayed. With **Mode** the operator obtains the chosen feature, with **Up** and **Down** the functional parameters can be selected – **a change of parameters will have immediate effect**. If no key is pressed for more than 10 seconds the display automatically shows the calculated object temperature (according to the signal processing).



Pressing the Mode button again recalls the last called function on the display. The signal processing features **Peak hold** and **Valley hold** cannot be selected simultaneously.

Factory Default Setting
To set the CTlaser back to the factory default settings, please press at first the **Down**-key and then the **Mode**-key and keep both pressed for approx. 3 seconds.
The display will show **RESET** for confirmation.

Display	Mode [Sample]	Adjustment Range
S ON	Laser Sighting [On]	**ON**/ **OFF**
142.3C	Object temperature (after signal processing) [142,3 °C]	fixed
127CH	Head temperature [127 °C]	fixed
25CB	Box temperature [25 °C]	fixed
142CA	Current object temperature [142 °C]	fixed
□ MV5	Signal output channel 1 [0-5 V]	□ **0-20** = 0–20 mA/ □ **4-20** = 4–20 mA/ □ **MV5** = 0–5 V/ □ **MV10** = 0-10 V/ □ **TCJ** = thermocouple type J/ □ **TCK** = thermocouple type K
E0.970	Emissivity [0,970]	**0,100 ... 1,100**
T1.000	Transmissivity [1,000]	**0,100 ... 1,100**
A 0.2	Signal output Average [0,2 s]	**A----** = inactive/ **0,1 … 999,9 s**
P----	Signal output Peak hold [inactive]	**P----** = inactive/ **0,1 … 999,9 s**/ **P oo oo oo oo** = infinite
V----	Signal output Valley hold [inactive]	**V----** = inactive/ **0,1 … 999,9 s**/ **V oo oo oo oo** = infinite
u 0.0	Lower limit temperature range [0 °C]	**depending on model**/ inactive at TCJ- and TCK-output
n 500.0	Upper limit temperature range [500 °C]	**depending on model**/ inactive at TCJ- and TCK-output
[0.00	Lower limit signal output [0 V]	according to the range of the selected output signal
] 5.00	Upper limit signal output [5 V]	according to the range of the selected output signal
U °C	Temperature unit [°C]	**°C**/ **°F**
| 30.0	Lower alarm limit [30 °C]	**depending on model**
|| 100.0	Upper alarm limit [100 °C]	**depending on model**
XHEAD	Ambient temperature compensation [head temperature]	**XHEAD** = head temperature/ **-40,0 … 900,0 °C** (for LT) as fixed value for compensation/ returning to XHEAD (head temperature) by pressing **Up** and **Down** together
M 01	Multidrop adress [1] (only with RS485 interface)	**01 … 32**
B 9.6	Baud rate in kBaud [9,6]	**9,6**/ **19,2**/ **38,4**/ **57,6**/ **115,2** kBaud

S ON Activating (**ON**) and Deactivating (**OFF**) of the **Sighting Laser**. By pressing Up or Down the laser can be switched on and off.

□ MV5 Selection of the **Output signal**. By pressing Up or Down the different output signals can be selected (see table).

E0.970 Setup of **Emissivity**. Pressing Up increases the value, Down decreases the value (valid for all further functions). The emissivity is a material constant factor to describe the ability of the body to emit infrared energy
[▶ Emissivity]

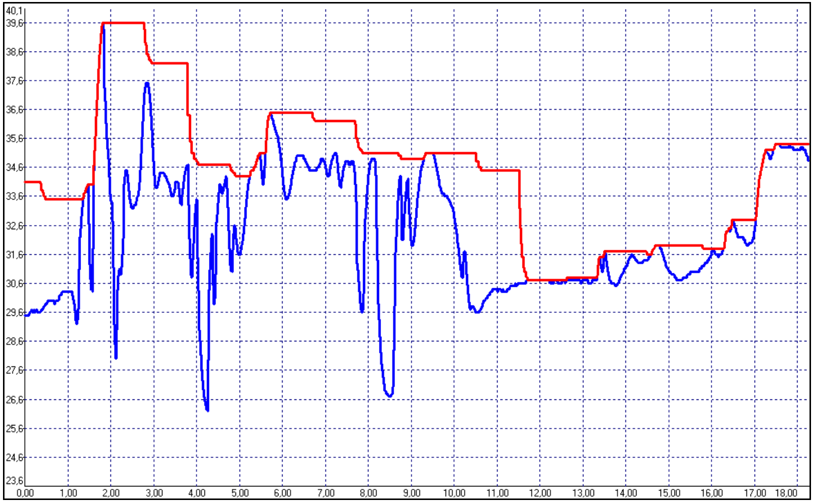
T1.000 Setup of **Transmissivity**. This function is used if an optical component (protective window, additional optics e.g.) is mounted between sensor and object. The standard setting is 1.000 = 100% (if no protective window etc. is used).

A 0.2 Setup of **Average time**. If the value is set to **0.0** the display will show. (function deactivated). In this mode an arithmetic algorithm will be performed to smoothen the signal. The set time is the time constant. This function can be combined with all other post processing functions.

P---- Setup of **Peak hold**. If the value is set to **0.0** the display will show **---** (function deactivated).
In this mode the sensor is waiting for descending signals. If the signal descends the algorithm maintains the previous signal peak for the specified time. After the hold time the signal will drop down to the second highest value or will descend by 1/8 of the difference between the previous peak and the minimum value during the hold time. This value will be held again for the specified time. After this the signal will drop down with slow time constant and will follow the current object temperature.

V---- Setup of **Valley hold**. If the value is set to **0.0** the display will show **---** (function deactivated).
In this mode the sensor waits for ascending signals. The definition of the algorithm is according to the peak hold algorithm (inverted).

Signal graph with P----



— TProcess with Peak Hold (Hold time = 1s)
— TActual without post processing

u 0.0 Setup of the **Lower limit of temperature range**. The minimum difference between lower and upper limit is **20 K**. If you set the lower limit to a value ≥ upper limit the upper limit will be adjusted to **[lower limit + 20 K]** automatically.

n 500.0 Setup of the **Upper limit of the temperature range**. The minimum difference between upper and lower limit is **20 K**: The upper limit can only be set to a value = lower limit + 20 K.

[0.00 Setup of the **Lower limit of the signal output.** This setting allows an assignment of a certain signal output level to the lower limit of the temperature range. The adjustment range corresponds to the selected output mode (e.g. 0-5 V).

] 5.00 Setup of the **Upper limit of the signal output**. This setting allows an assignment of a certain signal output level to the upper limit of the temperature range. The adjustment range corresponds to the selected output mode (e.g. 0-5 V).

U °C Setup of the **Temperature unit** [°C or °F].

| 30.0 Setup of the **Lower alarm limit.** This value corresponds to Alarm 1 **[▶ Alarms/ Visual Alarms]** and is also used as threshold value for relay 1 (if the optional relay board is used).

|| 100.0 Setup of the **Upper alarm limit.** This value corresponds to Alarm 2 **[▶ Alarms/ Visual Alarms]** and is also used as threshold value for relay 2 (if the optional relay board is used).

XHEAD Setup of the **Ambient temperature compensation**. In dependence on the emissivity value of the object a certain amount of ambient radiation will be reflected from the object surface. To compensate this impact, this function allows the setup of a fixed value which represents the ambient radiation.

If **XHEAD** is shown the ambient temperature value will be taken from the head-internal probe.
To return to **XHEAD** please press **Up** and **Down** together.

Especially if there is a big difference between the ambient temperature at the object and the head temperature the use of **Ambient temperature compensation** is recommended.

M 01 Setup of the **Multidrop address**. In a RS485 network each sensor will need a specific address. This menu item will only be shown if a RS485 interface board is plugged in.

B 9.6 Setup of the **Baud rate** for digital data transfer.

Laser Sighting

The DM-Laser has an integrated double laser aiming. Both of the laser beams are marking the exactly location and size of the measurement spot, independent from the distance. At the focus point of the according optics **[▶ Optical Charts]** both lasers are crossing and showing as one dot the minimum spot. This enables a perfect alignment of the sensor to the object.

WARNING: Do not point the laser directly at the eyes of persons or animals! Do not stare into the laser beam. Avoid indirect exposure via reflective surfaces!

The laser can be activated/ deactivated via the programming keys on the unit or via the software. If the laser is activated a yellow LED will shine (beside temperature display).
At ambient temperatures >50°C the laser will be switched off automatically.

Error messages

The display of the sensor can show the following error messages:

- **OVER** temperature overflow
- **UNDER** temperature underflow
- **^^^CH** head temperature to high
- **vvvCH** head temperature to low

Software

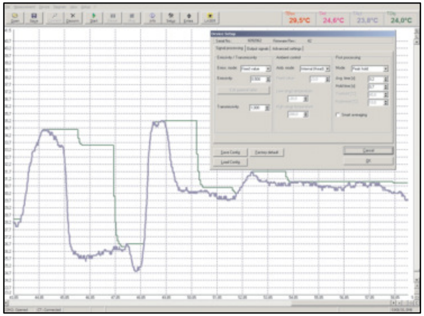
Installation

Insert the installation CD into the according drive on your computer. If the autorun option is activated the installation wizard will start automatically.
Otherwise please start **setup.exe** from the CD-ROM. Follow the instructions of the wizard until the installation is finished.

Min. system requirements:
- Windows XP
- USB interface
- Hard disc with at least 30 MByte free space
- At least 128 MByte RAM
- CD-ROM drive

The installation wizard will place a launch icon on the desktop and in the start menu.
If you want to uninstall the software from your system please use the **uninstall icon** in the start menu.

You will find a detailed software manual on the CD.



Main Features:

- Graphic display for temperature trends and automatic data logging for analysis and documentation
- Complete sensor setup and remote controlling
- Adjustment of signal processing functions
- Programming of outputs and functional inputs

Communication Settings

Serial Interface

Baud rate:	9,6...115,2 kBaud (adjustable on the unit or via software)
Data bits:	8
Parity:	none
Stop bits:	1
Flow control:	off

Protocol

All sensors of the DM-Laser series are using a binary protocol. Alternatively they can be switched to an ASCII protocol. To get a fast communication the protocol has no additional overhead with CR, LR or ACK bytes.

ASCII protocol

To switch to the ASCII protocol please use the following command:

Decimal:	**131**
HEX:	**0x83**
Data, Answer:	**byte 1**
Result:	**0 – Binary protocol**
	1 – ASCII protocol

Saving of parameter settings

After power on of the DM-Laser sensor the flash mode is active. It means, changed parameter settings will be saved in the internal Flash-EEPROM and will be kept also after the sensor is switched off.
In case settings should be changed quite often or continuously the flash mode can be switched off by using the following command:

Decimal:	**112**
HEX:	**0x70**
Data, Answer:	**byte 1**
Result:	**1 – Data will not be written into the flash memory**
	2 – Data will be written into the flash memory

If the flash mode is deactivated, all settings will only be kept as long as the unit is powered. If the unit is switched off and powered on again all previous settings are lost.
The command 0x71 will poll the current status.

You will find a detailed protocol and command description on the software CD in the directory: **\Commands**.

Basics of Infrared Thermometry

Depending on the temperature each object emits a certain amount of infrared radiation. A change in the temperature of the object is accompanied by a change in the intensity of the radiation. For the measurement of “thermal radiation” infrared thermometry uses a wave-length ranging between 1 µ and 20 µm.
The intensity of the emitted radiation depends on the material. This material contingent constant is described with the help of the emissivity which is a known value for most materials (see enclosed table emissivity).

Infrared thermometers are optoelectronic sensors. They calculate the surface temperature on the basis of the emitted infrared radiation from an object. The most important feature of infrared thermometers is that they enable the user to measure objects contactless. Consequently, these products help to measure the temperature of inaccessible or moving objects without difficulties.
Infrared thermometers basically consist of the following components:

- lens
- spectral filter
- detector
- electronics (amplifier/ linearization/ signal processing)

The specifications of the lens decisively determine the optical path of the infrared thermometer, which is characterized by the ratio Distance to Spot size.
The spectral filter selects the wavelength range, which is relevant for the temperature measurement. The detector in cooperation with the processing electronics transforms the emitted infrared radiation into electrical signals.

Emissivity

Definition

The intensity of infrared radiation, which is emitted by each body, depends on the temperature as well as on the radiation features of the surface material of the measuring object. The emissivity (ε – Epsilon) is used as a material constant factor to describe the ability of the body to emit infrared energy. It can range between 0 and 100 %. A “blackbody” is the ideal radiation source with an emissivity of 1,0 whereas a mirror shows an emissivity of 0,1.
If the emissivity chosen is too high, the infrared thermometer may display a temperature value which is much lower than the real temperature – assuming the measuring object is warmer than its surroundings. A low emissivity (reflective surfaces) carries the risk of inaccurate measuring results by interfering infrared radiation emitted by background objects (flames, heating systems, chamottes). To minimize measuring errors in such cases, the handling should be performed very carefully and the unit should be protected against reflecting radiation sources.

Determination of unknown Emissivities

► First, determine the actual temperature of the measuring object with a thermocouple or contact sensor. Second, measure the temperature with the infrared thermometer and modify the emissivity until the displayed result corresponds to the actual temperature.

► If you monitor temperatures of up to 380°C you may place a special plastic sticker onto the measuring object, which covers it completely. Now set the emissivity to 0,95 and take the temperature of the sticker. Afterwards, determine the temperature of the adjacent area on the measuring object and adjust the emissivity according to the value of the temperature of the sticker.

► Cove a part of the surface of the measuring object with a black, flat paint with an emissivity of 0,98. Adjust the emissivity of your infrared thermometer to 0,98 and take the temperature of the colored surface. Afterwards, determine the temperature of a directly adjacent area and modify the emissivity until the measured value corresponds to the temperature of the colored surface.

CAUTION: On all three methods the object temperature must be different from ambient temperature.

Characteristic Emissivities

In case none of the methods mentioned above help to determine the emissivity you may use the emissivity tables
► **Appendix A and B**. These are average values, only. The actual emissivity of a material depends on the following factors:

- temperature
- measuring angle
- geometry of the surface
- thickness of the material
- constitution of the surface (polished, oxidized, rough, sandblast)
- spectral range of the measurement
- transmissivity (e.g. with thin films)

Appendix A – Emissivity Table Metals

Material		typical Emissivity			
Spectral response		**1,0 µm**	**1,6 µm**	**5,1 µm**	**8-14 µm**
Aluminium	non oxidized	0,1-0,2	0,02-0,2	0,02-0,2	0,02-0,1
	polished	0,1-0,2	0,02-0,1	0,02-0,1	0,02-0,1
	roughened	0,2-0,8	0,2-0,6	0,1-0,4	0,1-0,3
	oxidized	0,4	0,4	0,2-0,4	0,2-0,4
Brass	polished	0,35	0,01-0,05	0,01-0,05	0,01-0,05
	roughened	0,65	0,4	0,3	0,3
	oxidized	0,6	0,6	0,5	0,5
Copper	polished	0,05	0,03	0,03	0,03
	roughened	0,05-0,2	0,05-0,2	0,05-0,15	0,05-0,1
	oxidized	0,2-0,8	0,2-0,9	0,5-0,8	0,4-0,8
Chrome		0,4	0,4	0,03-0,3	0,02-0,2
Gold		0,3	0,01-0,1	0,01-0,1	0,01-0,1
Haynes	alloy	0,5-0,9	0,6-0,9	0,3-0,8	0,3-0,8
Inconel	electro polished	0,2-0,5	0,25	0,15	0,15
	sandblast	0,3-0,4	0,3-0,6	0,3-0,6	0,3-0,6
	oxidized	0,4-0,9	0,6-0,9	0,6-0,9	0,7-0,95
Iron	non oxidized	0,35	0,1-0,3	0,05-0,25	0,05-0,2
	rusted		0,6-0,9	0,5-0,8	0,5-0,7
	oxidized	0,7-0,9	0,5-0,9	0,6-0,9	0,5-0,9
	forged, blunt	0,9	0,9	0,9	0,9
	molten	0,35	0,4-0,6		
Iron, casted	non oxidized	0,35	0,3	0,25	0,2
	oxidized	0,9	0,7-0,9	0,65-0,95	0,6-0,95

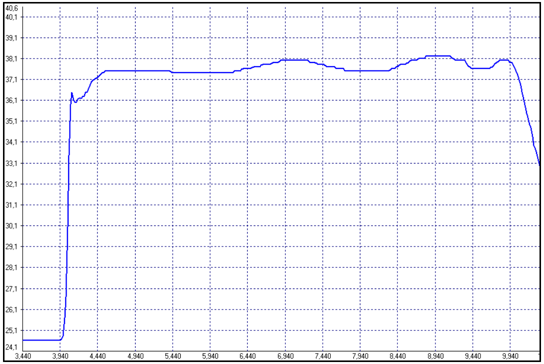
Material		typical Emissivity			
Spectral response		1,0 µm	1,6 µm	5,1 µm	8-14 µm
Lead	polished	0,35	0,05-0,2	0,05-0,2	0,05-0,1
	roughened	0,65	0,6	0,4	0,4
	oxidized		0,3-0,7	0,2-0,7	0,2-0,6
Magnesium		0,3-0,8	0,05-0,3	0,03-0,15	0,02-0,1
Mercury			0,05-0,15	0,05-0,15	0,05-0,15
Molybdenum	non oxidized	0,25-0,35	0,1-0,3	0,1-0,15	0,1
	oxidized	0,5-0,9	0,4-0,9	0,3-0,7	0,2-0,6
Monel (Ni-Cu)		0,3	0,2-0,6	0,1-0,5	0,1-0,14
Nickel	electrolytic	0,2-0,4	0,1-0,3	0,1-0,15	0,05-0,15
	oxidized	0,8-0,9	0,4-0,7	0,3-0,6	0,2-0,5
Platinum	black		0,95	0,9	0,9
Silver		0,04	0,02	0,02	0,02
Steel	polished plate	0,35	0,25	0,1	0,1
	rustless	0,35	0,2-0,9	0,15-0,8	0,1-0,8
	heavy plate			0,5-0,7	0,4-0,6
	cold-rolled	0,8-0,9	0,8-0,9	0,8-0,9	0,7-0,9
	oxidized	0,8-0,9	0,8-0,9	0,7-0,9	0,7-0,9
Tin	non oxidized	0,25	0,1-0,3	0,05	0,05
Titanium	polished	0,5-0,75	0,3-0,5	0,1-0,3	0,05-0,2
	oxidized		0,6-0,8	0,5-0,7	0,5-0,6
Wolfram	polished	0,35-0,4	0,1-0,3	0,05-0,25	0,03-0,1
Zinc	polished	0,5	0,05	0,03	0,02
	oxidized	0,6	0,15	0,1	0,1

Appendix B – Emissivity Table Non Metals

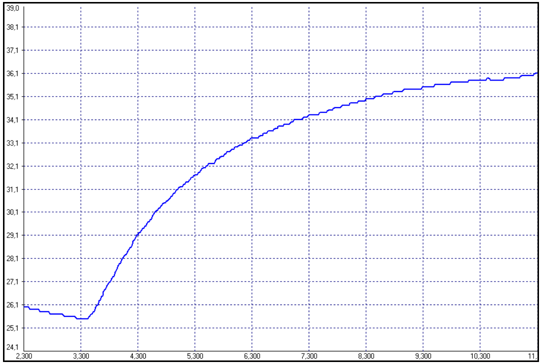
Material		typical Emissivity			
Spectral response		1,0 µm	2,2 µm	5,1 µm	8-14 µm
Asbestos		0,9	0,8	0,9	0,95
Asphalt				0,95	0,95
Basalt				0,7	0,7
Carbon	non oxidized		0,8-0,9	0,8-0,9	0,8-0,9
	graphite		0,8-0,9	0,7-0,9	0,7-0,8
Carborundum			0,95	0,9	0,9
Ceramic		0,4	0,8-0,95	0,8-0,95	0,95
Concrete		0,65	0,9	0,9	0,95
Glass	plate		0,2	0,98	0,85
	melt		0,4-0,9	0,9	
Grit				0,95	0,95
Gypsum				0,4-0,97	0,8-0,95
Ice					0,98
Limestone				0,4-0,98	0,98
Paint	non alkaline				0,9-0,95
Paper	any color			0,95	0,95
Plastic >50 µm	non transparent			0,95	0,95
Rubber				0,9	0,95
Sand				0,9	0,9
Snow					0,9
Soil					0,9-0,98
Textiles				0,95	0,95
Water					0,93
Wood	natural			0,9-0,95	0,9-0,95

Appendix C – Smart Averaging

The average function is generally used to smoothen the output signal. With the adjustable parameter time this function can be optimal adjusted to the respective application. One disadvantage of the average function is that fast temperature peaks which are caused by dynamic events are subjected to the same averaging time. Therefore those peaks can only be seen with a delay on the signal output.
The function **Smart Averaging** eliminates this disadvantage by passing those fast events without averaging directly through to the signal output.



Signal graph with Smart Averaging function



Signal graph without Smart Averaging function