



Operating Instructions
thermoIMAGER TIM

TIM 160S

TIM QVGA
TIM QVGA-HD
TIM QVGA-G7

TIM VGA
TIM VGA G7

TIM M-1
TIM M-05

Infrared camera

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1. Safety

System operation assumes knowledge of the operating instructions.

1.1 Symbols Used

The following symbols are used in the operating instructions.



Indicates a hazardous situation which, if not avoided, may result in minor or moderate injury.



Indicates a situation that may result in property damage if not avoided.



Indicates a user action.



Indicates a tip for users.

Measure

Indicates hardware or a software button/menu.

1.2 Warnings



Connect the power supply and the display/output device according to the safety regulations for electrical equipment.

- > Risk of injury
- > Damage to or destruction of the camera



Avoid the alignment of the camera to intensive energy sources (e.g. devices which emit laser radiation or reflections of such equipment). This is also valid if the camera is switched off.

- > Effect on the accuracy of the measurement
- > Irreparable defect of the infrared detector

Avoid static electricity, arc welders, and induction heaters. Keep away from very strong EMF (electromagnetic fields).

- > Damage to or destruction of the camera

Avoid shocks, impacts and vibration to the camera.

- > Damage to or destruction of the camera

The supply voltage must not exceed the specified limits.

- > Damage to or destruction of the camera

No solvent-based cleaning agents may have an effect on the camera (neither for the optics nor the housing).

- > Damage to or destruction of the camera

Avoid abrupt changes of the ambient temperature.

- > Incorrect display of the device

Do not mount the camera with external mounting devices (thread/ tripod connection).

- > Damage to the camera (thread)

Protect the USB cable against damage.

- > Failure of the camera

1.3 Notes on CE Marking

The following apply to the thermoIMAGER TIM:

- EU Directive 2014/30/EU
- EU Directive 2011/65/EU

Products which carry the CE mark satisfy the requirements of the EU directives cited and the relevant applicable harmonized European standards (EN). The measuring system is designed for use in industrial and laboratory applications.

The EU Declaration of Conformity and the technical documentation are available to the responsible authorities according to EU Directives.

1.4 Intended Use

- The thermoIMAGER TIM is designed for use in industrial and laboratory applications. It is used for measuring the surface temperature based on the emitted energy of objects, [see 10](#).
- The system must only be operated within the limits specified in the technical data, [see 2](#).
- The system must be used in such a way that no persons are endangered or machines and other material goods are damaged in the event of malfunction or total failure of the system.
- Take additional precautions for safety and damage prevention in case of safety-related applications.

1.5 Proper Environment

- Protection class: IP67 (NEMA-4)
- Operating temperature:
 - TIM 160S/TIM QVGA/TIM VGA/TIM VGA-G7: 0 ... +50 °C (+32 ... +122 °F)
 - TIM QVGA-HD/TIM QVGA-G7: 0 ... +70 °C (+32 ... +158 °F)
 - TIM M-1/TIM M-05: +5 ... +50 °C (+41 ... +122 °F)
- Storage temperature:
 - TIM 160S/TIM QVGA/TIM VGA: -40 ... +70 °C (-40 ... +158 °F)
 - TIM QVGA-HD/TIM QVGA-G7: -40 ... +85 °C (-40 ... +185 °F)
 - TIM M-1/TIM M-05/TIM VGA-G7: -40 ... +70 °C (-40 ... +158 °F)
- Relative humidity: 20 ... 80 %, non-condensing

NOTICE

Avoid abrupt changes of the ambient temperature.

> Incorrect display of the device

2. Technical Data

2.1 Functional Principle

The thermoIMAGER TIM calculates the surface temperature based on the emitted infrared energy of objects, [see 10](#). The two-dimensional detector (FPA - focal plain array) allows a measurement of an area and will be shown as thermographic image using standardized palettes. The radiometric processing of the picture data enables the user to do a comfortable detailed analysis with the software TIM Connect.

2.2 Model Overview

The cameras of the TIM series are available in the following basic versions:

Model	Type	Temperature range	Spectral range	Frame rate	Typical applications
TIM 160S	IR	-20 to 900 °C 200 to 1500 °C (optional)	8 - 14 μm	120 Hz	Surface measurements in industrial application
TIM QVGA / TIM QVGA-HD	IR	-20 to 900 °C 200 to 1500 °C (optional)	8 - 14 μm	80 Hz	Real-time thermographic images in high speed; Detection of smallest temperature differences (TIM QVDA-HD)
TIM VGA	IR	-20 to 900 °C 200 to 1500 °C (optional)	8 - 14 μm	32 Hz	Pin-sharp radiometric recordings in real time, detection of smallest temperature differences
TIM QVGA-G7	IR	200 to 1500 °C 150 to 900 °C	7.9 μm	80 Hz/ 27 Hz	Measurement of glass (with Line-Scanning mode)
TIM VGA-G7				32 Hz	
TIM M-1	IR	450 to 1800 °C	0.85 - 1.1 μm	Up to 1 kHz	Measurement of metallic surfaces, graphite or ceramics with short wavelengths
TIM M-05		900 to 2450 °C	500 - 540 nm		

2.3 General Specifications

Model TIM	160S	QVGA	QVGA-HD	QVGA-G7	VGA	VGA G7	M-1	M-05
Protection class	IP67 (NEMA-4) ¹							
Operating temperature	0 ... 50 °C (+32 ... +122 °F)		0 ... 70 °C (+32 ... +158 °F)		0 ... 50 °C (+32 ... +122 °F)		5 ... 50 °C (+412 ... +122 °F)	
Storage temperature	-40 ... 70 °C (-40 ... +158 °F)		-40 ... 85 °C (-40 ... +185 °F)		-40 ... 70 °C (-40 ... +158 °F)			
Relative humidity	10 ... 95 %, con condensing							
Material (housing)	Aluminum, anodized/ plastic							
Dimensions	45 x 45 x 60 - 76 mm (depending on the lens and focus position)	46 x 56 x 68 - 77 mm (depending on the lens and focus position)			46 x 56 x 76 - 100 mm (depending on the lens and focus position)		46 x 56 x 88 - 129 mm (depending on the lens and focus position)	
					TIM VGA microscope optics: 46 x 56 x 119 - 126 mm (depending on focus position)			
Weight (inclusive lens)	195 g	237 - 252 g			269 - 320 g		245 - 311 g	
					TIM VGA microscope optics: 370 g			
Cable length (USB)	1 m (standard), 3 m, 5 m, 10 m, 20 m							
Vibration	IEC 60068-2-6: (sinus shaped), see 2.4 IEC 60068-2-64 (broadband noise), see 2.4							
Shock	IEC 60068-2-27: 25 g and 50 g, see 2.4							

1) Only with 5, 10, 20 m USB cable. The camera plug of USB cable (1 m) does not feature an IP67 protection class.

2.4 Vibration / Shock

2.4.1 Used Standards

IEC EN 60068-1:1988 + Corr. 1988 + A1: 1992 / DIN EN 60068-1: 1995-03

Environmental testing - Part 1: General and guidance

IEC 60068-2-6:2007 / DIN EN 60068-2-6; VDE 0468-2-6:2008-10

Environmental testing - Part 2-6: Tests - Test Fc: Vibration (sinusoidal)

IEC 60068-2-27:2008 / DIN EN 60068-2-27; VDE 0468-2-27:2010-02

Environmental testing - Part 2-27: Test Ea and guidance: Shock

IEC 60068-2-47:2005 / DIN EN 60068-2-47:2006-03

Environmental testing - Part 2-47: Mounting of specimens for vibration, impact and similar dynamic tests

IEC 60068-2-64:2008 / DIN EN 60068-2-64; VDE 0468-2-64:2009-04

Environmental testing - Part 2-64: Tests - Tests Fh: Vibration, broadband random and guidance

2.4.2 Stress Program (Camera in Operation)

Shock, half sinus 25 g – testing Ea 25 g (acc. IEC 60068-2-27)		
Acceleration	245 m/s ²	(25 g)
Pulse duration	11 ms	
Number of directions	6	(3 axes with 2 directions each)
Duration	600 shocks	(100 shocks each direction)
Shock, half sinus 50 g – testing Ea 50 g (acc. IEC 60068-2-27)		
Acceleration	490 m/s ²	(50 g)
Pulse duration	11 ms	
Number of directions	6	(3 axes with 2 directions each)
Duration	18 shocks	(3 shocks each direction)

Vibration, sinus shaped – testing Fc (acc. IEC60068-2-6)			
Frequency range	10 - 500 Hz		
Acceleration	29.42 m/s ²	(3 g)	
Frequency change	1 octave/ min		
Number of axes	3		
Duration	1:30 h	(3 x 0.30 h)	
Vibration, broadband noise – testing Fh (acc. IEC60068-2-64)			
Frequency change	10 - 2000 Hz		
Acceleration, effective	39.3 m/s ²	(4.01 g _{RMS})	
Frequency spectrum	10 - 106 Hz	0.9610 (m/s ²) ² /Hz	(0.010 g ² /Hz)
	106 - 150 Hz	+6 dB/ octave	
	150 - 500 Hz	1.9230 (m/s ²) ² /Hz	(0.020 g ² /Hz)
	500 - 2000 Hz	-6 dB/ octave	
	2000 Hz	0.1245 (m/s ²) ² /Hz	(0.00126 g ² /Hz)
Number of axes	3		
Duration	3 h	(3 x 1 h)	

2.5 Electrical Specifications

Model TIM	160S	QVGA	QVGA-HD	QVGA-G7 ¹	VGA	M-1	M-05
Power supply	5 VDC (powered via USB 2.0 interface)						
Current draw	max. 500 mA						
Output Standard Process Interface (PIF out)	0 - 10 V (Main measure area, measure area, internal temperature, flag status, recording status, line scan status, alarm, frame sync, fail-safe, external communication), see A 11						
Input Standard Process Interface (PIF in)	0 - 10 V (Emissivity, ambient temperature, reference temperature, uncommitted value, flag control, triggered snapshots, triggered recording, triggered linescanner, triggered event grabber, reset peak-/value-hold, switch temperature range), see A 11						
Digital Input Standard Process Interface	Flag control, triggered snapshots, triggered recording, triggered linescanner, triggered event grabber, reset peak-/value-hold, switch temperature range						
Digital interface	USB 2.0						

2.6 Measurement Specifications

Modell TIM	160S
Temperature range (scalable)	-20 ... 100 °C; 0 ... 250 °C; 20 (150) ... 900 °C ¹ ; additional temperature range: 200 ... 1500 °C (optional)
Spectral range	8 - 14 μm
Detector	UFPA 160 x 120 Pixel@120 Hz
Lenses (FOV)	12° x 9° FOV / f = 13 mm or 30° x 23° FOV / f = 5 mm or 55° x 40° FOV / f = 3 mm or 80° x 54° FOV / f = 2 mm
System accuracy ²	±2°C or ±2 %
Temperature resolution (NETD) ³	80 mK with 30° FOV 100 mK with 55° and 80° FOV 300 mK with 12° FOV
Warm-up time	10 min
Emissivity	0.100 ... 1.100
Software	TIMConnect

1) For the range (20) 150 up to 900 °C, the accuracy specification applies from 150 °C

2) At ambient temperature 23±5 °C; whichever is greater.

3) Values apply with 40 Hz and 25 °C room temperature

Model TIM	QVGA	QVGA-HD	QVGA-G7 ¹
Temperature ranges (scalable)	-20 ... 100 °C; 0 ... 250 °C; (20) 150 ... 900 °C ¹ ; Option: 200 ... 1500 °C		200 ... 1500 °C 150 ... 900 °C
Sighting range / low energy range ²	-		0 ... 250 °C
Spectral range	8 - 14 μm		7.9 μm
Detector	UFPA, 382 x 288 Pixel@80 Hz (switchable to 27 Hz)		
Lenses (FOV)	18° x 14° / f = 20 mm or 29° x 22° / f = 12.7 mm or 53° x 38° / f = 7.7 mm or 80° x 54° / f = 5.7 mm		
System accuracy ²	±2 °C or ±2 %		
Temperature coefficient ⁴	±0,05 %/K		
Temperature resolution (NETD)	75 mK ⁵ with 29°, 53° and 80°; 0.1 K ⁵ with 18°	40 mK ⁵ with 29°, 53° and 80°; 60 mK ⁵ with 18°	150 mK (T _{obj} = 650 °C) with 29°, 53°, 80° 175 mK (T _{obj} = 650 °C) with 18°
Warm-up time	10 min		
Emissivity	0.100 ... 1.100		
Software	TIMConnect		

1) Accuracy statement effective from 150 °C.

2) The sighting range is used to align the G7 cameras; at $\epsilon < 1$ and activation of the extended temperature range a temperature measurement up to 1500 °C is possible.

3) At ambient temperature 23 ± 5 °C; whichever is greater

4) For $T_{Amb} 10 \dots 50$ °C und $T_{Obj} \leq 500$ °C; otherwise $\pm 0,1$ K/K or 0,1 %/K (whichever is greater)

5) Value is valid at 40 Hz and 25 °C room temperature

Model TIM	VGA	VGA-G7
Temperature range (scalable)	20 ... 100 °C; 0 ... 250 °C; (20) 150 ... 900 °C ¹ Option: 200 ... 1500 °C	200 ... 1500 °C 150 ... 900 °C
Sighting range / low energy range ²	-	0 ... 250 °C
Spectral range	8 - 14 μm	7.9 μm
Detector	UFPA, 640 x 480 Pixel@32 Hz 640 x 120 Pixel@125 Hz	
Lenses (FOV)	33° x 25° 60° x 45° 90° x 64° 15° x 11°	
System accuracy ³	±2 °C or ±2 %	
Temperature coefficient ⁴	±0,05 %/K	
Temperature resolution (NETD)	40 mK with 33°, 60° and 90° 60 mK with 15° / 80 mK with 12°	80 mK (T _{obj} = 650 °C) with 33°, 60°, 90° 120 mK (T _{obj} = 650 °C) with 15°
Warm-up time	10 min	
Emissivity	0.100 ... 1.100	
Software	TIMConnect	

1) Accuracy statement effective from 150 °C.

2) The sighting range is used to align the G7 cameras; at $\varepsilon < 1$ and activation of the extended temperature range a temperature measurement up to 1500 °C is possible.

3) At ambient temperature 23 ± 5 °C; whichever is greater

4) For T_{Amb} 10 ... 50 °C und $T_{Obj} \leq 500$ °C; otherwise $\pm 0,1$ K/K or 0,1 %/K (whichever is greater)

Model TIM	M-1	M-05
Temperature range (scalable)	450 ¹ ... 1800 °C (27 Hz mode) 500 ¹ ... 1800 °C (80 Hz-Modus and 32 Hz mode) 600 ¹ ... 1800 °C (1 kHz mode)	900 ... 2450 °C (27 Hz mode) 950 ... 2450 °C (80 Hz and 32 Hz mode) 1100 ... 2450 °C (1 kHz mode)
Spectral range	0.85 - 1.1 μm	500 - 540 nm
Detector	CMOS, 764 x 480 Pixel@32 Hz 382 x 288 Pixel@80 Hz (switchable to 27 Hz) 72 x 56 Pixel@1 kHz (1 ms real-time analog output (0 - 10 V) from 8x8 pixel (freely selectable)) 764 x 8 Pixel@1 kHz (fast line scanning-mode, 1 ms real-time analog output (0 - 10 V) from 8x8 Pixel (freely selectable))	
Lenses (FOV)	FOV@382x288 px: 20 ° x 15 °, 13 ° x 10 °, 7 ° x 5 °, 4 ° x 3 ° FOV@764x480 px: 39 ° x 25 ° (F-number = 1.4), 26 ° x 16 ° (F-number = 1.4), 13 ° x 8 ° (F-number = 2.4), 9 ° x 5 ° (F-number = 2.8)	FOV@382x288 px: 13 ° x 10 ° FOV@764x480 px: 26 ° x 16 ° (F-number = 1.4)
System accuracy ²	For object temperature < 1400 °C: ± 1 % of reading for 27/32/80 Hz ± 1.5 % of reading for 1 kHz For object temperature < 1600 °C: ± 2 % of reading for 27/32/80 Hz ± 2.5 % of reading for 1 kHz	For object temperature < 2000 °C: ± 1 % of reading for 27/32/80 Hz ± 1.5 % of reading for 1 kHz For object temperature > 2000 °C: ± 2 % of reading for 27/32/80 Hz ± 2.5 % of reading for 1 kHz
Temperature resolution (NETD) ³	< 2 K (< 900 °C) < 4 K (< 1400 °C)	< 2 K (< 1400 °C) < 4 K (< 2100 °C)
Warm-up time	10 min	
Emissivity	0,100...1,100	
Software	TIMConnect	

1) 2 + 75 °C start temperature for optics with focal length $f = 50$ mm and $f = 75$ mm

2) At an ambient temperature of 25 °C

3) Specified NETD value applies to all frequencies.

2.7 Microscope Lenses

Model	TIM VGA
Optical resolution	640 x 480 Pixel @ 32 Hz 640 x 120 Pixel @ 125 Hz
Temperature ranges (scalable)	-20 to 100°C, 0 to 250 °C, (20)150 to 900 °C ¹
Spectral range	8 to 14 μm
Frame rate	125 Hz (switchable to 32 Hz)
System accuracy	± 2 °C or ± 2 %, whichever is greater
Microscope lens (FOV)	12° x 9° (F = 1.1) / f = 44 mm
Smallest spot size (IFOV)	28 μm
MFOV	85 μm ²
Focus adjustment	80 to 100 mm
Thermal sensitivity (NETD)	80 mK mit 12°
Detector	UFPA – uncooled micro bolometer
Outputs/digital	USB 2.0
Standard Process interface (PIF)	0 - 10 V input, digital input (max. 24 V), 0 - 10 V output
Industry Process interface (IPIF)	2 x 0 -10 V input, digital input (max. 24 V), 3 x 0(4) - 20 V output , 3 x Relay (0 - 30 V / 400 mA), fail-safe relay
Cable length (USB)	1 m (standard), 3 m, 5 m, 10 m, 20 m
Power supply	USB powered
Tripod mount	1/4-20 UNC
Protection class	IP67
Ambient temperature range	0 °C ... 50 °C
Storage temperature	-40 °C ... 70 °C
Relative humidity	10 ... 95 %, non-condensing

Model	TIM VGA
Shock / Vibration ³	IEC 60068-2
Housing (size) ³	46 mm x 56 mm x 90 mm
Weight	370 g, incl. lens
Emissivity	0,100 ... 1,10

1) Accuracy statement effective from 150 °C.

2) MFOV on TIM 450 is 2 x 2 pixels; on TIM VGA 3 x 3 pixels

3) For more information, [see 2.3](#), [see 2.4](#)



If you already have a TIM VGA, the accessories kit without cameras is optionally available.

3. Delivery

3.1 Unpacking

- 1 thermoIMAGER TIM inclusive 1 lens
- 1 USB cable (1 m¹)
- 1 Table tripod
- 1 Process Interface cable inclusive terminal block (1 m)
- 1 TIM Connect software on a USB stick
- 1 Operating Instructions
- 1 Aluminum case

- ➡ Carefully remove the components of the measuring system from the packaging and ensure that the goods are forwarded in such a way that no damage can occur.
- ➡ Check the delivery for completeness and shipping damage immediately after unpacking.
- ➡ If there is damage or parts are missing, immediately contact the manufacturer or supplier.

1) The camera plug of USB cable (1 m) does not feature an IP67 protection class. For industrial applications there are cables with IP67 available, starting at 5 m.

3.2 Storage

- Storage temperature:
 - TIM 160S/TIM QVGA/TIM VGA/TIM M-1/TIM M-05/TIM VGA-G7: -40 ... +70 °C (-40 ... +158 °F)
 - TIM QVGA-HD/TIM QVGA-G7: -40 ... +85 °C (-40 ... +185 °F)
- Relative humidity: 10 ... 95 %, non-condensing

4. Optical Charts

4.1 Notes on Focusing

i Make sure that the focus of thermal channel is adjusted correctly.

➡ If necessary, focus the thermal imaging camera with the optics, [see Fig. 1](#).

The turning out of the optics leads to the focus setting *near* and the turning in of the lens to the focus setting *infinity*.



Fig. 1 Focusing by turning the exterior lens ring of camera



Fig. 2 TIM M-05 / TIM M-1

i For the TIM M-1 respectively TIM M-05 camera, you must first unscrew the protective tube in order to be able to focus the camera, [see Fig. 2](#).

The variety of different lenses offers the possibility to precisely measure objects in different distances. We offer lenses for close, standard distances and large distances. Different parameters are important if using infrared cameras. They display the connection between the distance of the measured object and the size of the pixel, [see 4.2 et seq.](#)

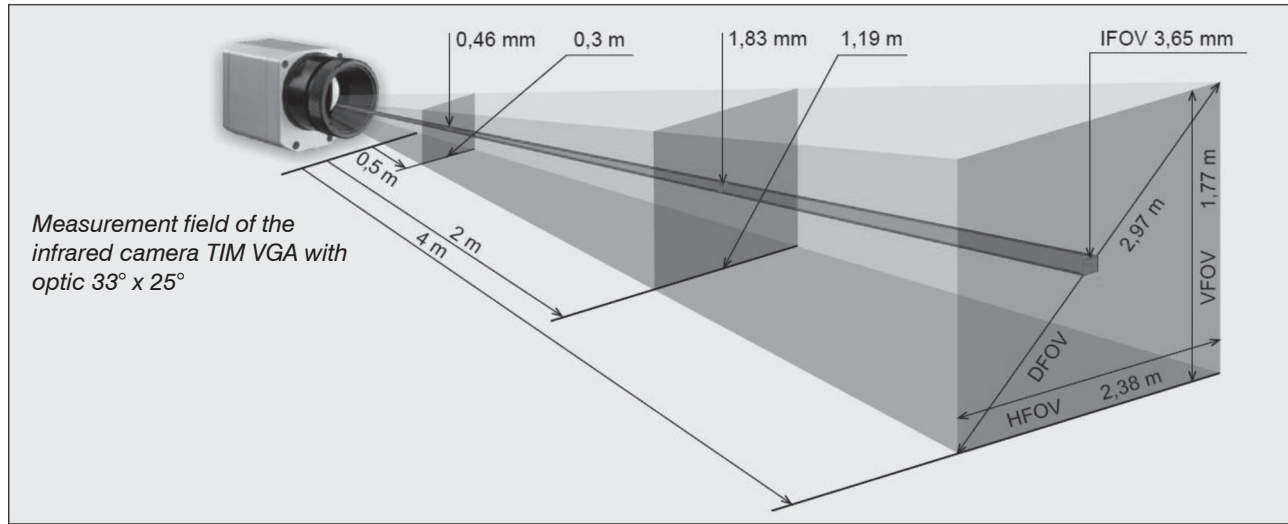


Fig. 3 Measurement field of the infrared camera TIM VGA representing the 33° x 25° lens

HFOV	Horizontal enlargement of the total measuring at object level
VFOV	Vertical enlargement of the total measuring at object level
IFOV	Size at the single pixel at object level
DFOV	Diagonal dimension of the total measuring field at object level
MFOV	Recommended, smallest measured object size of 3 x 3 pixel

Geometric resolution for ideal temperature measurement

When designing optics for measuring IR cameras, special attention must be paid to the quality of detail contrast with which an object can be represented in the image. This is described by the modulation transfer function (MTF). Since in contrast to visual cameras, with IR cameras the thermal contrast is of more interest, this is used together with the slit response function (SRF). The result is determined by the number of pixels an object needs to fill to allow its temperature to be measured exactly. In high-performance infrared optical systems, this is 3×3 pixels, with lower quality optical systems, in some circumstances as many as 10×10 pixels may be required, to receive 90% of the energy. A high-performance camera lens also allows a larger measuring distance with the same number of pixels of the detector, or the precise temperature measurement of smaller structures and objects. The 3×3 pixel geometry is described as MFOV (measurement field of view) - one single pixel on the object surface is described as IFOV (instantaneous field of view). The MFOV is comparable with the measuring spot definition with infrared thermometers.

The following tables with examples showing what spot sizes and pixel sizes will be reached in which distance. For individual configuration there are different lenses available. Wide angle lenses have a radial distortion due to their large opening angle; the software TIM Connect has an algorithm which corrects this distortion.

4.2 Lenses thermoIMAGER TIM 160S

TIM 160S	Focal length [mm]	Angle	Minimum measurement distance*	Distance to measurement object [m]													
					0.05	0.1	0.2	0.3	0.5	1	2	4	6	10	30	100	
160 x 120 px																	
30° Standard lens	5	30° 23° 38° 3.33 mrad	0.2 m	HFOV [m]	0.032	0.057	0.109	0.160	0.263	0.542	1.08	2.15	3.22	5.4	16.1	53.6	
				VFOV [m]	0.024	0.044	0.083	0.122	0.201	0.397	0.79	1.57	2.36	3.9	11.8	39.2	
				DFOV [m]	0.040	0.072	0.137	0.201	0.330	0.672	1.34	2.66	3.99	6.6	19.9	66.4	
				Ifov [mm]	0.17	0.33	0.67	1.0	1.7	3.3	6.7	13.3	20.0	33.3	100.0	333.3	
12° Telephoto lens	13	12° 9° 15° 1.33 mrad	0.3 m	HFOV [m]	0.021		0.042	0.063	0.105	0.211	0.421	0.841	1.26	2.1	6.3	21.0	
				VFOV [m]	0.016		0.032	0.048	0.079	0.158	0.315	0.630	0.94	1.6	4.7	15.7	
				DFOV [m]	0.027		0.053	0.079	0.132	0.263	0.526	1.051	1.58	2.6	7.9	26.3	
				Ifov [mm]	0.13		0.27	0.40	0.66	1.3	2.7	5.3	8.0	13.3	39.8	132.8	
55° Wide angle lens	3	55° 40° 68° 5.57 mrad	0.2 m	HFOV [m]	0.058	0.110	0.214	0.318	0.527	1.05	2.09	4.17	6.25	10.4	31.2	104.1	
				VFOV [m]	0.040	0.077	0.149	0.221	0.366	0.73	1.45	2.90	4.35	7.2	21.7	72.4	
				DFOV [m]	0.125	0.241	0.384	0.615	1.172	2.34	4.66	7.52	12.15	32.9	108.7	104.1	
				Ifov [mm]	0.28	0.56	1.1	1.7	2.8	5.6	11.1	22.3	33.4	55.7	167.2	557.4	
80° Super wide angle lens	2	80° 54° 96° 7.73 mrad	0.2 m	HFOV [m]	0.088	0.169	0.331	0.492	0.816	1.63	3.25	6.48	9.72	16.2	48.6	162.0	
				VFOV [m]	0.056	0.107	0.210	0.313	0.518	1.03	2.06	4.12	6.17	10.3	30.8	102.8	
				DFOV [m]	0.104	0.200	0.391	0.583	0.967	1.93	3.84	7.68	11.52	19.2	57.6	191.8	
				Ifov [mm]	0.39	0.77	1.5	2.3	3.9	7.7	15.5	30.9	46.4	77.3	231.8	772.7	

FOV: Horizontal expansion of the total measuring field at the object level; VFOV: Vertical expansion of the total measuring field at the object level;

DFOV: Diagonal expansion of the total measuring field at the object level; Ifov: Size of the individual pixels at the object level

* Please note: The measurement accuracy of the camera may lie outside of the specifications for distances below the defined minimum measurement distance.

4.3 Lenses thermoIMAGER TIM QVGA / TIM QVGA-HD / TIM QVGA-G7

TIM QVGA / QVGA-HD / QVGA-G7	Focal length [mm]	Angle	Minimum measurement distance*	Distance to measurement object [m]													
					0.05	0.1	0.2	0.3	0.5	1	2	4	6	10	30	100	
382 x 288 px																	
29° Standard lens	13	29° 22° 37° 1.3 mrad	0.35 m	HFOV [m]		0.057	0.111	0.16	0.27	0.53	1.06	2.1	3.2	5.3	15.7	52.5	
				VFOV [m]		0.042	0.081	0.12	0.20	0.40	0.80	1.6	2.4	4.0	11.9	39.6	
				DFOV [m]		0.071	0.137	0.20	0.34	0.67	1.32	2.6	4.0	6.6	19.7	65.7	
				IFOV [mm]		0.1	0.3	0.4	0.7	1.3	2.7	5.4	8.0	13.4	40.2	133.9	
18° Telephoto lens	20	18° 14° 23° 0.9 mrad	0.45 m	HFOV [m]			0.066	0.099	0.16	0.33	0.65	1.3	1.9	3.2	9.7	32.4	
				VFOV [m]			0.050	0.075	0.12	0.25	0.49	1.0	1.5	2.5	7.4	24.6	
				DFOV [m]			0.083	0.124	0.20	0.41	0.82	1.6	2.4	4.1	12.2	40.7	
				IFOV [mm]			0.2	0.3	0.4	0.9	1.7	3.5	5.2	8.6	25.9	86.3	
53° Wide angle lens	8	53° 38° 66° 2.2 mrad	0.25 m	HFOV [m]		0.103	0.20	0.30	0.50	1.0	2.0	4.0	5.9	9.9	29.6	98.6	
				VFOV [m]		0.073	0.14	0.21	0.35	0.70	1.4	2.8	4.1	6.9	20.7	68.9	
				DFOV [m]		0.127	0.25	0.37	0.61	1.22	2.4	4.8	7.2	12.0	36.1	120.3	
				IFOV [mm]		0.2	0.4	0.7	1.1	2.2	4.4	8.8	13.2	21.9	65.8	219.4	
80° Super wide angle lens	6	80° 54° 96° 3.0 mrad	0.2 m	HFOV [m]	0.087	0.17	0.33	0.49	0.82	1.7	3.3	6.7	10.0	16.6	49.9	166.4	
				VFOV [m]	0.056	0.11	0.21	0.31	0.51	1.0	2.0	4.1	6.1	10.2	30.6	101.9	
				DFOV [m]	0.103	0.20	0.39	0.58	0.97	2.0	3.9	7.8	11.7	19.5	58.5	195.1	
				IFOV [mm]	0.2	0.3	0.6	0.9	1.5	3.0	6.0	12.0	18.1	30.1	90.3	300.9	

FOV: Horizontal expansion of the total measuring field at the object level; VFOV: Vertical expansion of the total measuring field at the object level;

DFOV = diagonal expansion of the total measuring field at the object level; IFOV: Size of the individual pixels at the object level

* Please note: The measurement accuracy of the camera may lie outside of the specifications for distances below the defined minimum measurement distance.

4.4 Lenses thermoIMAGER TIM VGA / TIM VGA-G7

TIM VGA / TIM VGA-G7	Focal length [mm]	Angle	Minimum measurement distance*	Distance to measurement object [m]												
				0.05	0.1	0.2	0.3	0.5	1	2	4	6	10	30	100	
640 x 480 px	19	33°	0.2 m	HFOV [m]		0.064	0.12	0.18	0.30	0.60	1.20	2.4	3.6	6.0	17.9	59.7
		25°		VFOV [m]		0.047	0.09	0.14	0.23	0.45	0.9	1.8	2.7	4.5	13.4	44.5
		42°		DFOV [m]		0.079	0.15	0.23	0.38	0.75	1.5	3.0	4.5	7.5	22.4	74.5
		0.9 mrad		IFOV [mm]		0.1	0.2	0.3	0.5	0.9	1.9	3.7	5.6	9.3	28	93.3
15° Telephoto lens	42	15°	0.5 m	HFOV [m]					0.14	0.27	0.53	1.0	1.6	2.6	7.8	26.2
		11°		VFOV [m]					0.10	0.20	0.40	0.8	1.2	2.0	5.9	19.6
		19°		DFOV [m]					0.17	0.33	0.66	1.3	2.0	3.3	9.8	32.7
		0.4 mrad		IFOV [mm]					0.2	0.4	0.8	1.6	2.4	4.1	12.3	40.9
60° Wide angle lens	11	60°	0.2 m	HFOV [m]	0.07	0.13	0.24	0.35	0.60	1.2	2.3	4.7	7.0	11.7	34.9	116.4
		45°		VFOV [m]	0.05	0.09	0.17	0.26	0.42	0.8	1.7	3.3	5.0	8.3	24.9	82.9
		75°		DFOV [m]	0.09	0.16	0.30	0.44	0.73	1.4	2.9	5.7	8.6	14.3	42.9	142.9
		1.9 mrad		IFOV [mm]	0.1	0.2	0.4	0.6	0.9	1.8	3.7	7.3	10.9	18.2	54.6	182
90° Super wide angle lens	8	90°	0.2 m	HFOV [m]	0.11	0.22	0.42	0.62	1.0	2.0	4.0	8.1	12.1	20.2	60.4	201.4
		64°		VFOV [m]	0.07	0.14	0.26	0.39	0.6	1.3	2.5	5.0	7.6	12.6	37.7	125.7
		110°		DFOV [m]	0.14	0.26	0.49	0.73	1.2	2.4	4.8	9.5	14.2	23.8	71.3	237.4
		3.2 mrad		IFOV [mm]	0.2	0.3	0.7	1.0	1.6	3.2	6.3	12.6	18.9	31.5	94.4	315

FOV = Field of view; HFOV = horizontal view; VFOV = vertical view; DFOV = Diagonal dimension of the total measuring field at the object level;

IFOV = Indicated field of view

Table with examples showing which measuring field sizes and pixel sizes are reached at which distance. Various lenses are available for optimal configuration of the camera. Wide angle lenses have radial distortion due to the angle of their aperture. The TIMConnect software has an algorithm which corrects this distortion.

* Please note: The measurement accuracy of the camera may lie outside of the specifications for distances below the defined minimum measurement distance.

4.5 Microscope Optics TIM VGA

TIM VGA	Focal length [mm]	Angle	Minimum measurement distance*	Distance to measurement object [m]			
				0.08	0.09	0.1	
640 x 480 px							
F44 Mikroscope optics	44.2	12° 9° 15° 0.36 mrad	0.08 m	HFOV [m] VFOV [m] DFOV [m] IFOV [mm]	0.018 0.014 0.023 0.028	0.021 0.016 0.026 0.032	0.023 0.017 0.029 0.036

* Please note: The measurement accuracy of the camera may lie outside of the specifications for distances below the defined minimum measurement distance.

4.6 Lenses thermoIMAGER TIM M-1 / TIM M-05

TIM M-1 / TIM M-05 ¹⁾	Focal length [mm]	Angle	Minimum measurement distance*	Distance to measurement object [m]												
					0.1	0.2	0.3	0.5	1	2	4	6	10	30	100	
382 x 288 px																
f = 16 mm Wide angle lens	16	20°	0.2 m	HFOV [m]		0.07	0.11	0.18	0.36	0.72	1.43	2.15	3.6	10.7	35.8	
		15°		VFOV [m]		0.05	0.08	0.14	0.27	0.54	1.08	1.62	2.7	8.1	27.0	
		25°		DFOV [m]		0.09	0.13	0.22	0.45	0.90	1.79	2.69	4.5	13.5	44.9	
		0.94 mrad		IFOV [mm]		0.2	0.3	0.5	0.9	1.9	3.8	5.6	9.4	28.1	93.8	
f = 25 mm Standard lens	25	13°	0.5 m	HFOV [m]	0.023	0.05	0.07	0.11	0.23	0.46	0.92	1.38	2.3	6.9	22.9	
		10°		VFOV [m]	0.017	0.03	0.05	0.09	0.17	0.35	0.69	1.04	1.7	5.2	17.3	
		16°		DFOV [m]	0.029	0.06	0.09	0.14	0.29	0.57	1.15	1.72	2.9	8.6	28.7	
		0.60 mrad		IFOV [mm]	0.1	0.1	0.2	0.3	0.6	1.2	2.4	3.6	6.0	18.0	60.0	
f = 50 mm Telephoto lens	50	7°	1.5 m	HFOV [m]				0.06	0.11	0.23	0.46	0.69	1.1	3.4	11.5	
		5°		VFOV [m]				0.04	0.09	0.17	0.35	0.52	0.9	2.6	8.6	
		8°		DFOV [m]				0.07	0.14	0.29	0.57	0.86	1.4	4.3	14.4	
		0.30 mrad		IFOV [mm]				0.2	0.3	0.6	1.2	1.8	3.0	9.0	30.0	
f = 75 mm Super telepho- to lens	75	4°	2.0 m	HFOV [m]					0.08	0.15	0.31	0.46	0.8	2.3	7.6	
		3°		VFOV [m]					0.06	0.12	0.23	0.35	0.6	1.7	5.8	
		5°		DFOV [m]					0.10	0.19	0.38	0.57	1.0	2.9	9.6	
		0.20 mrad		IFOV [mm]					0.2	0.4	0.8	1.2	2.0	6.0	20.0	

¹⁾ TIM M-05 only available with OF25 lens | Please note: the camera provides 382 x 288 px in the 80 Hz mode.

* Please note: The measurement accuracy of the camera may lie outside of the specifications for distances below the defined minimum measurement distance.

4.7 Lenses thermoIMAGER TIM M-1 / TIM M-05 with VGA Resolution

TIM M-1 / TIM M-05 ¹⁾ with VGA resolution 764 x 480 px	Focal length [mm]	Angle	Minimum measurement distance*	Distance to measurement object [m]											
				0.1	0.2	0.3	0.5	1	2	4	6	10	30	100	
f = 16 mm Wide angle lens	16	39° 25° 46° 0.94 mrad	0.2 m	HFOV [m]		0.14	0.21	0.36	0.72	1.43	2.87	4.30	7.2	21.5	71.6
				VFOV [m]		0.09	0.14	0.23	0.45	0.90	1.80	2.70	4.5	13.5	45.0
				DFOV [m]		0.17	0.25	0.42	0.85	1.69	3.38	5.08	8.5	25.4	84.6
				IFOV [mm]		0.2	0.3	0.5	0.9	1.9	3.8	5.6	9.4	28.1	93.8
f = 25 mm Standard lens	25	26° 16° 30° 0.60 mrad	0.5 m	HFOV [m]	0.046	0.09	0.14	0.23	0.46	0.92	1.83	2.75	4.6	13.8	45.8
				VFOV [m]	0.029	0.06	0.09	0.14	0.29	0.58	1.15	1.73	2.9	8.6	28.8
				DFOV [m]	0.054	0.11	0.16	0.27	0.54	1.08	2.17	3.25	5.4	16.2	54.1
				IFOV [mm]	0.1	0.1	0.2	0.3	0.6	1.2	2.4	3.6	6.0	18.0	60.0
f = 50 mm Telephoto lens	50	13° 8° 15° 0.30 mrad	1.5 m	HFOV [m]				0.11	0.23	0.46	0.92	1.38	2.3	6.9	22.9
				VFOV [m]				0.07	0.14	0.29	0.58	0.86	1.4	4.3	14.4
				DFOV [m]				0.14	0.27	0.54	1.08	1.62	2.7	8.1	27.1
				IFOV [mm]				0.2	0.3	0.6	1.2	1.8	3.0	9.0	30.0
f = 75 mm Super telephoto lens	75	9° 5° 10° 0.20 mrad	2.0 m	HFOV [m]					0.15	0.31	0.61	0.92	1.5	4.6	15.3
				VFOV [m]					0.10	0.19	0.38	0.58	1.0	2.9	9.6
				DFOV [m]					0.18	0.36	0.72	1.08	1.8	5.4	18.0
				IFOV [mm]					0.2	0.4	0.8	1.2	2.0	6.0	20.0

¹⁾ TIM M-05 only available with OF25 lens | Please note: the camera provides 764 x 480 px in the 32 Hz mode

* Please note: The measurement accuracy of the camera may lie outside of the specifications for distances below the defined minimum measurement distance.

5. Mechanical Installation

The thermoIMAGER TIM is equipped with two metric M4 thread holes on the bottom side (6 mm depth) and can be installed either directly via these threads or with help of the tripod mount (also on bottom side).

- **i** The tightening torque of the M4 screws for mounting the TIM camera should be between 1 ... 1.5 Nm and must not exceed 2 Nm.

5.1 Dimensional Drawings

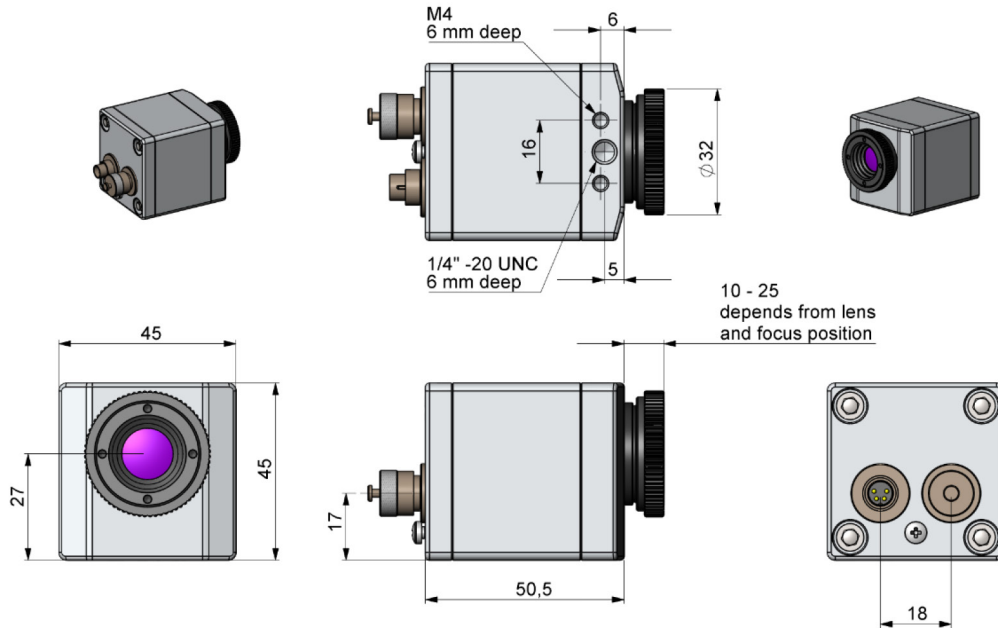


Fig. 4 Dimensional drawing TIM 160S, dimensions in mm (inches)

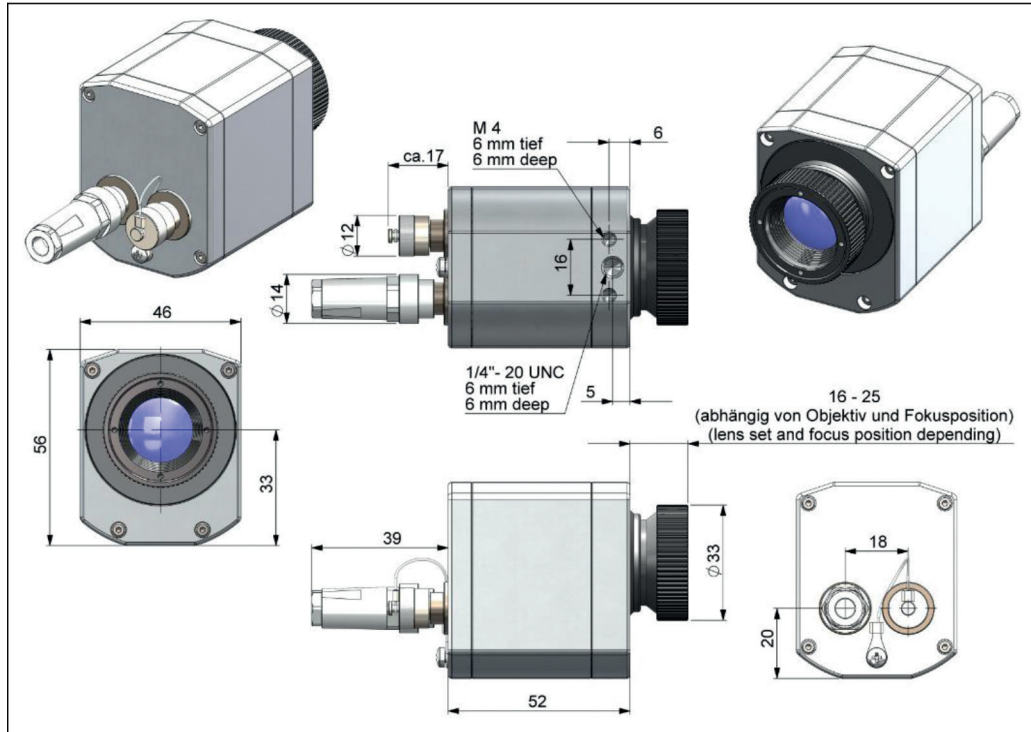


Fig. 5 Dimensional drawing TIM QVGA / TIM QVGA-HD / TIM QVGA-G7, dimensions in mm (inches)

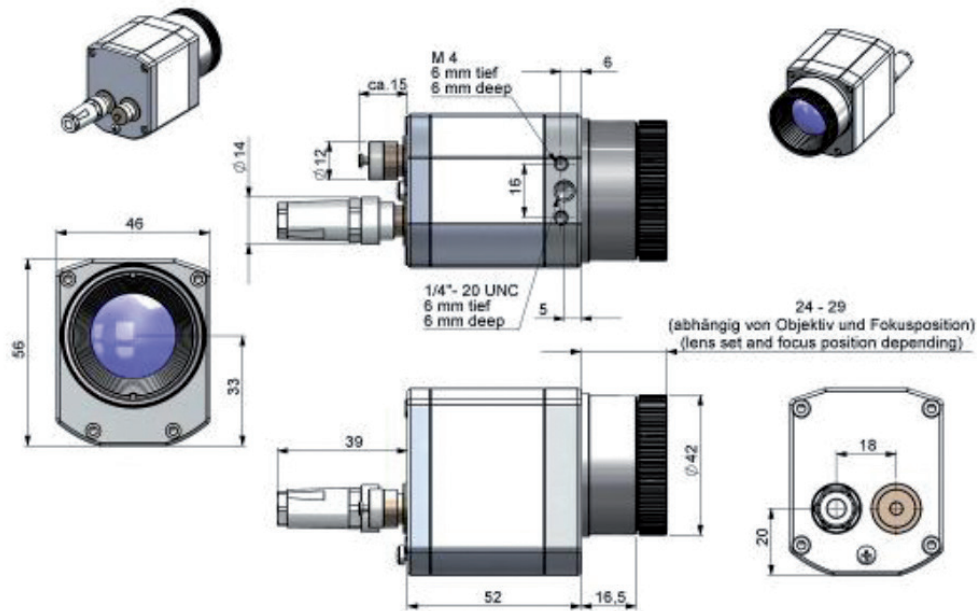


Fig. 6 Dimensional drawing TIM VGA / TIM VGA-G7, optics 29°/33° & 53°/60°, dimensions in mm (inches)

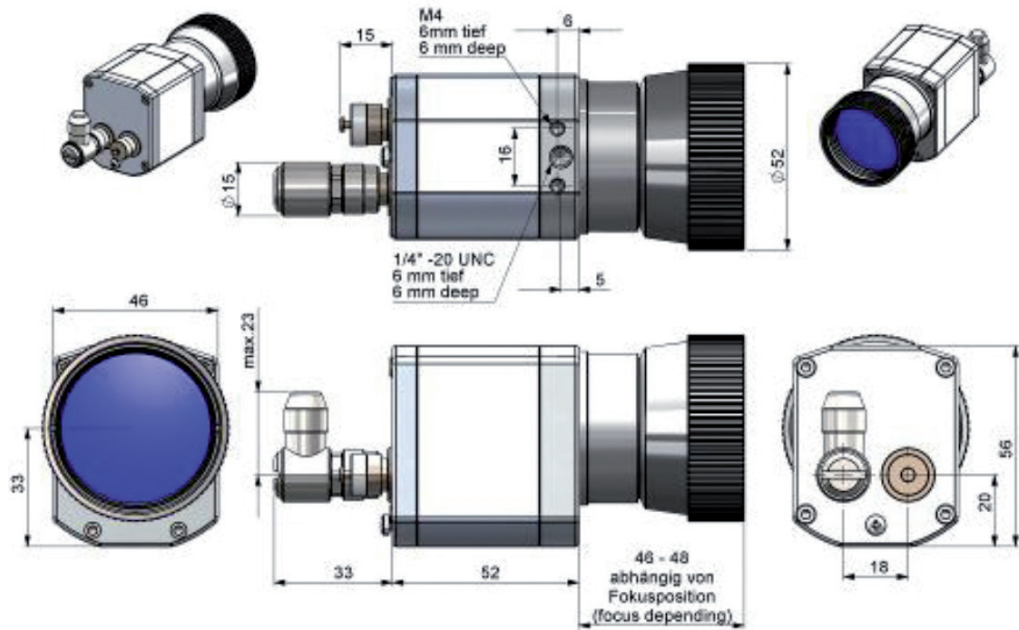


Fig. 7 Dimensional drawing TIM VGA / TIM VGA-G7, optics 13°/15°, dimensions in mm (inches)

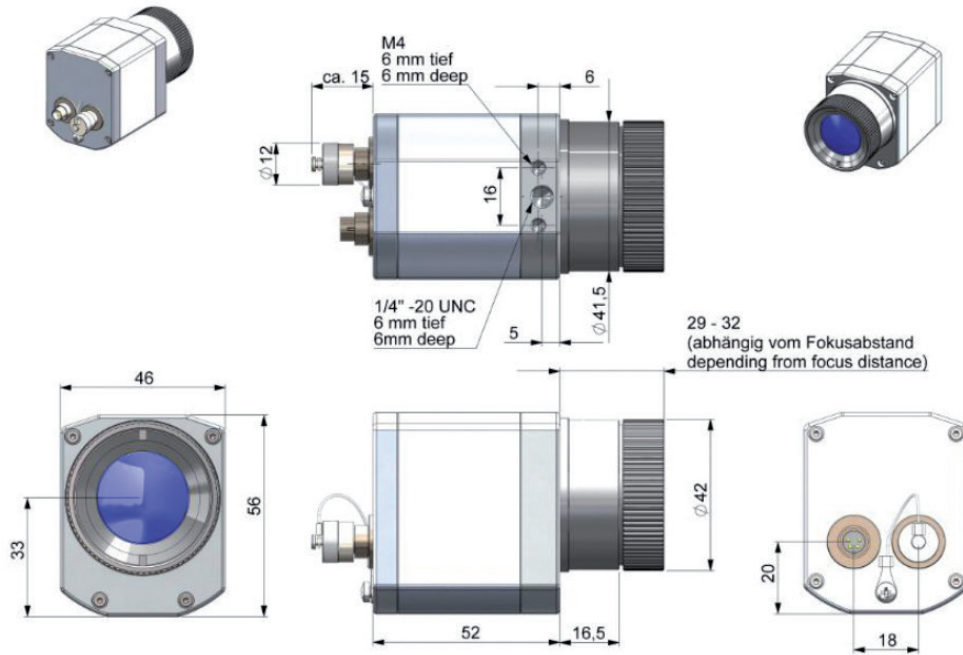


Fig. 8 Dimensional drawing TIM VGA / TIM VGA-G7, optics 80°/90°, dimensions in mm (inches)

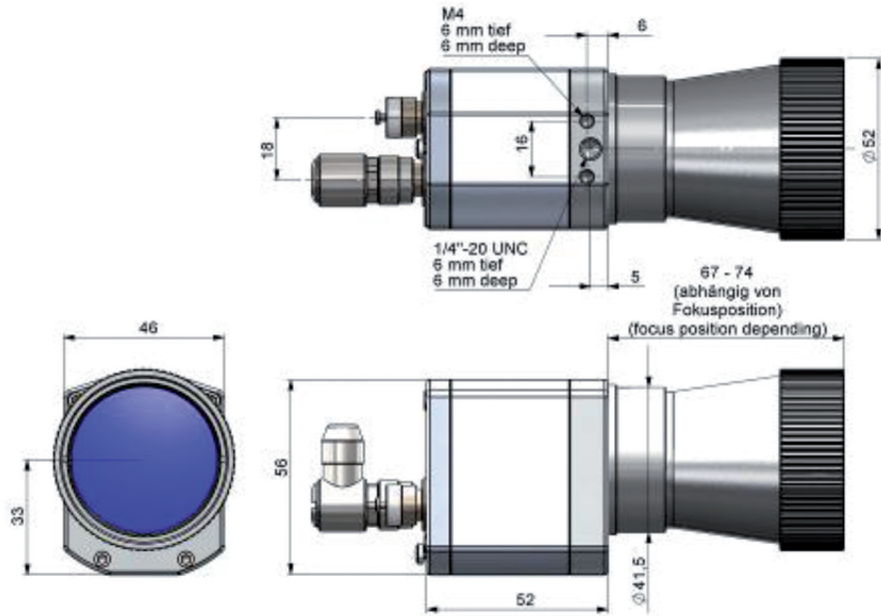


Fig. 9 Dimensional drawing TIM VGA, microscope optics 10°/12°, dimensions in mm (inches)

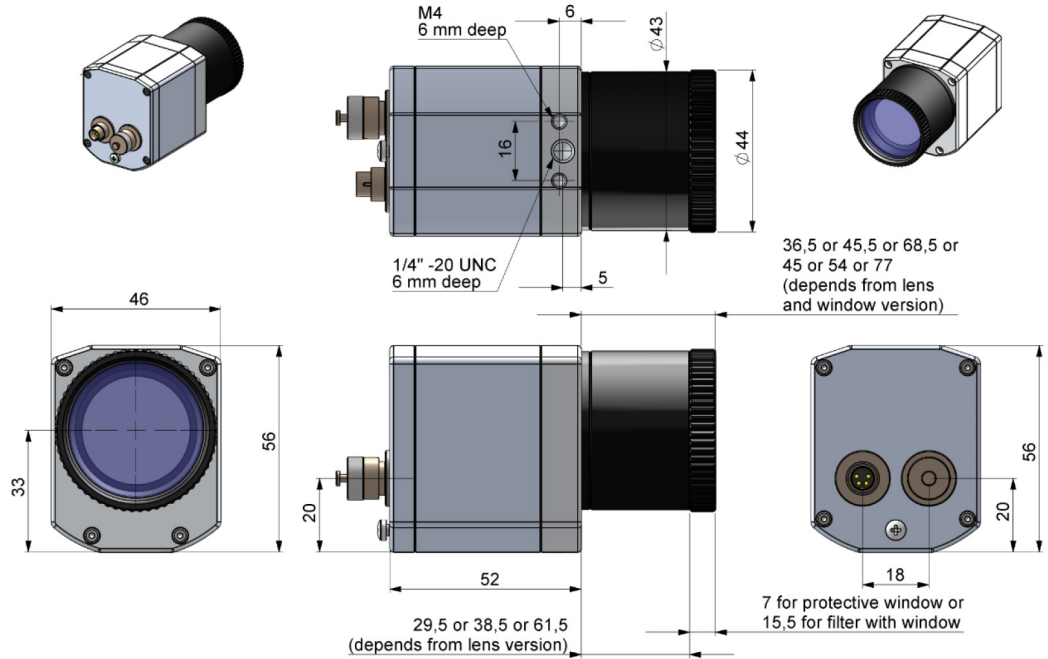


Fig. 10 Dimensional drawing TIM M-1, TIM M-05, dimensions in mm (inches)

5.2 High Temperature Accessories - Cooling Jacket Advanced

i The Cooling Jacket Advanced is available as Standard Version and Extended Version. The IR camera can be used at ambient temperature up to 50 °C (up to 70 °C with TIM QVGA-HD / TIM QVGH-G7). For higher temperatures (up to 315 °C) the Cooling Jacket Advanced is provided. For detailed information see appendix, [see A 1](#), [see A 2](#) and installation manual.

5.3 Changing the Lens

The thermoIMAGER TIM camera is offered with several different lenses ¹ (lenses depending on the camera variant).

➡ To change a lens, rotate it as shown below.

➡ For the TIM M-1 and TIM M-05, first remove the the protective tube of TIM M-1 and TIM M-05 off , [see Fig. 12](#).



Fig. 11 Change lens for TIM 160S / TIM QVGA/ TIM VGA



Fig. 12 Change lens for TIM M-1 and TIM M-05

To achieve the best possible measurements, make sure when inserting the lens into the camera housing that the label on the lens is screwed in parallel to the label of the housing.

1) An additionally purchased lens for the TIM M-05 / TIM M-1 includes the corresponding protective tube.

5.4 Fixing the Focus of the Lens (only for TIM M-1 and TIM M-05)

With the TIM M-1 and TIM M-05, it is possible to fix the focus of the lens. To do this, unscrew the protective tube of the camera, see Fig. 2. There are three small holes on the lens.

➡ Take the three screws that are included and attach them to the three holes.

The focus of the lens is now fixed. Alternatively, the two knurled screws supplied can also be used.



Fig. 13 Lens for TIM M-1 and TIM M-05



Fig. 14 Fixing the focus for thermoIMAGER TIM M-1 and TIM M-05

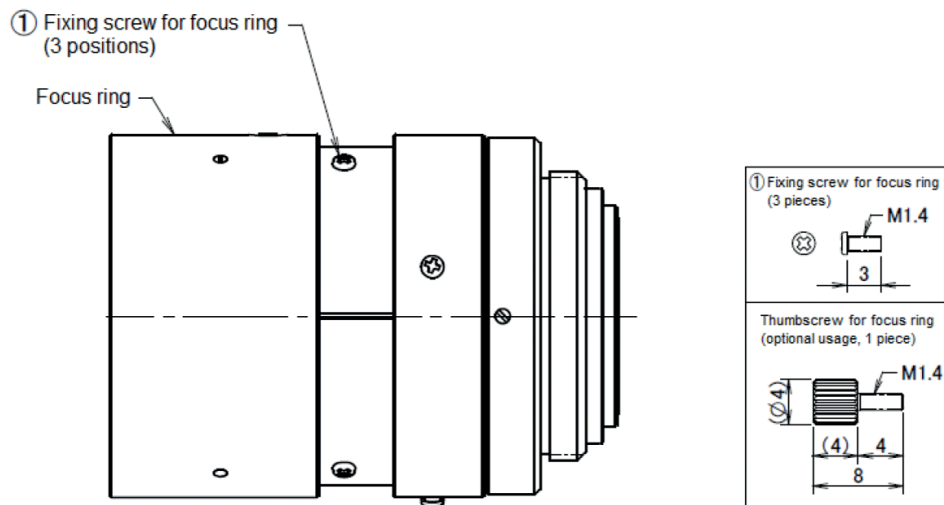


Fig. 15 Focusing screws for focus ring

6. Electrical Installation

At the back side of the thermoIMAGER TIM you will find two connector plugs.

➡ Please connect the supplied USB cable with the left plug.

The right connector plug is only used for the Process Interface.

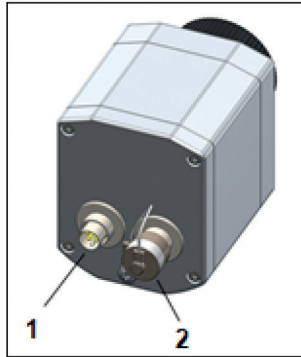
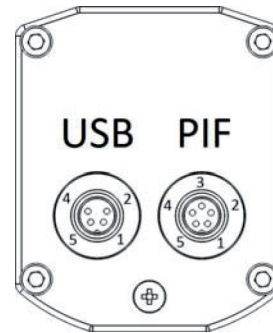


Fig. 16 Rear side of camera with connectors

- 1 Plug for USB cable
- 2 Plug for PIF cable

6.1 PIN Assignment of Connectors

PIF	1	INT
	2	SDA (I ² C)
	3	SCL (I ² C)
	4	DGND
	5	3.3 V (Out)
USB	1	VCC
	2	GND
	4	D-
	5	D+



View on connector side

Fig. 17 Pin assignment of rear side of camera

⚠ CAUTION

In case of working with a direct PIF connection the input of the PIF is not protected!
A voltage > 3 V on the INT pin will destroy the device!

In case you would like to connect the Process Interface of the camera directly to external hardware ¹ (without using the supplied PIF cable) you should activate the field “Support proprietary PIF cable” in the menu Tools/ Configuration/ Device (PIF) in the TIM Connect software.

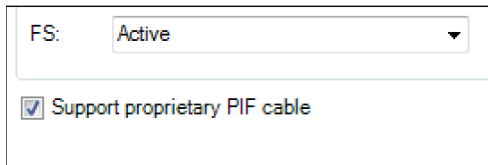


Fig. 18 Screen Support proprietary PIF cable

1) We recommend using only a switching contact between INT and DGND as external hardware (button, relay).

6.2 Process Interface

The TIM is equipped with a Process Interface (cable with integrated electronics and terminal block), which can be programmed via the software as an Analog Input (AI) and Digital Input (DI) in order to control the camera or as an Analog Output (AO) in order to control the process. The signal level is always 0 - 10 V (DI = 24 V).

NOTICE

Please make sure that the Process Interface (electronics within cable as well as industrial interface) is powered separately (5 - 24 VDC).

> With no external power supply the PIF will not work



Fig. 19 Prozess interface

➡ Connect the PIF cable to the camera before switching on the power.

The Process Interface can be activated choosing the following options:

- | | |
|---------------------|---|
| Analog Input (AI): | Emissivity, ambient temperature, reference temperature, uncommitted value, flag control, triggered recording, triggered snapshots, triggered linescanner, triggered event grabber, reset peak-/value-hold, switch temperature range |
| Analog Output (AO): | Main measure area, measure area, internal temperature, flag status, recording status, line scan status, alarm, frame sync, fail-safe, external communication |
| Digital Input (DI): | Flag control, triggered snapshots, triggered recording, triggered linescanner, triggered event grabber, reset peak-/value-hold, switch temperature range |

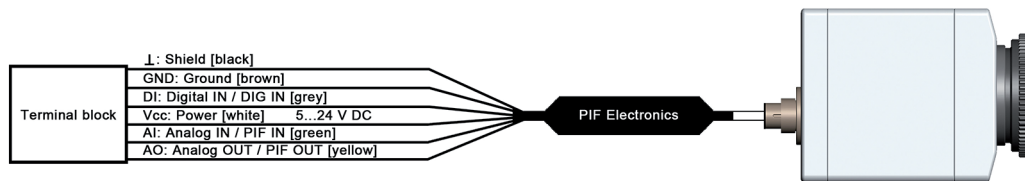


Fig. 20 Configuration Process Interface (PIF)

The standard Process Interface offers the following inputs and outputs:

Designation	Description	max. range ^{1/} status
AI	Analog input	0 - 10 V ²
DI	Digital input	24 V
AO	Analog output	0 - 10 V
	Alarm output	0/ 10 V

The voltage levels for the DI are: LOW = 0 ... 0.6 V / HIGH = 2 ... 24 V.

6.3 Industrial Process Interface (Optional)

For use in industrial environment an industrial Process Interface with 500 VAC_{RMS} isolation voltage between TIM and process is available (connection box with IP 65, 5 m, 10 m or 20 m standard or high temp cable for camera connection, terminal for process integration), [see A 6](#) (Industrial Process Interface).

6.4 USB Cable Extensions

The maximum USB cable length is 20 m. For greater distances between TIM and computer or for stand-alone solutions you should use the optional TIM NetBox or the USB-Server Industry Isochron, [see A 7](#).

1) Depending on supply voltage; for 0 - 10 V on the AO the PIF has to be powered with min. 12 V.

2) The AI is designed for max. 24 V, the voltage level above 10 V is not interpreted.

7. Installation and Commissioning

i All drivers are booted via Windows OS automatically. A driver installation is not necessary. By default the program starts automatically in the installed language.

- ➡ 1. Insert the included USB stick into the according port on your computer.
- ➡ 2. Please start `Setup.exe`. Follow the instructions of the wizard until the installation is finished.

The installation wizard places a launch icon on the desktop and in the start menu: `Start\Programs\TIM Connect`.

- ➡ 3. To connect the camera to the PC, plug the USB cable to the camera first. Afterwards connect it with the PC. To disconnect the camera and the computer remove the USB cable from the computer first and then disconnect it from the camera.
- ➡ 4. Start the software.

At the initial start the software asks for the calibrations files which are available via internet or on the USB stick.

- ➡ 5. Install the calibration files at first start of the software.

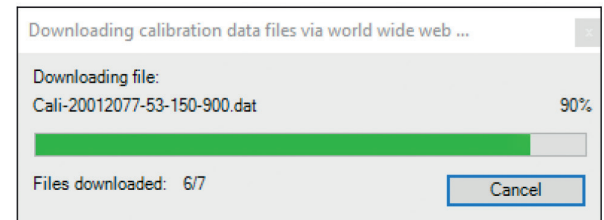
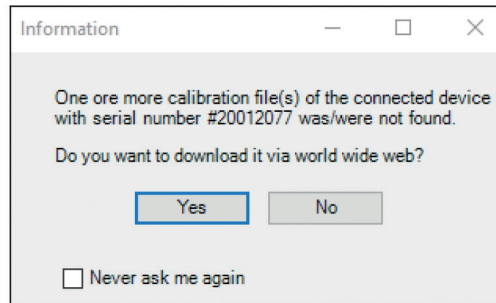


Fig. 21 Calibration data transfer

After the calibration files have been installed the live image from the camera is shown inside a window on your PC screen.



6. Choose the desired language in the menu `Tools > Language`.



7. Adjust the focus of the image by turning the exterior lens ring at the camera.

8. Instructions for Operation / Cleaning

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.

NOTICE

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

> Destruction of the sensor and/or the controller

9. Software TIM Connect

9.1 Properties

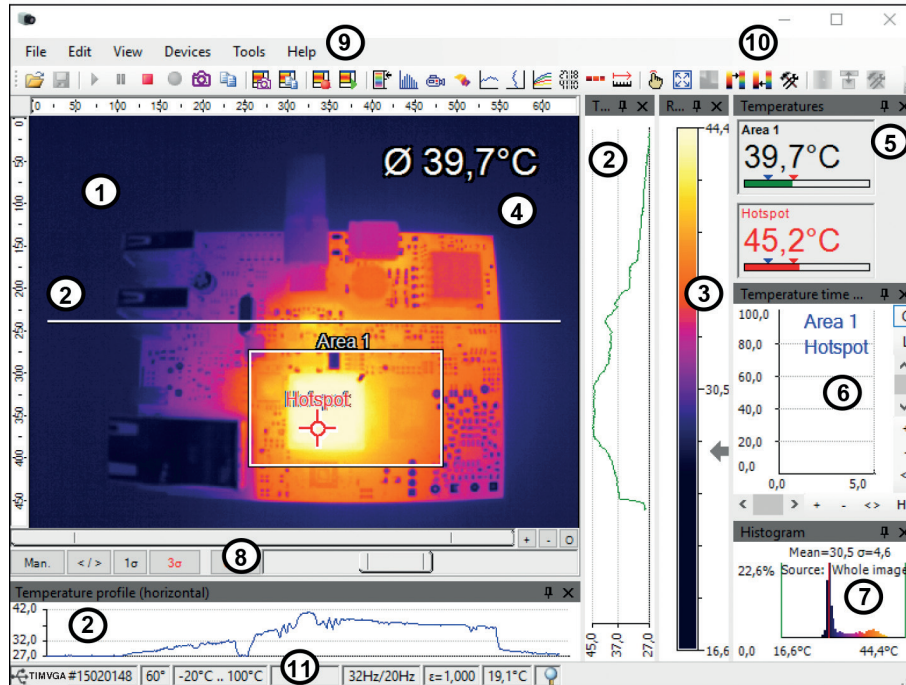


Fig. 22 Example window

1	IR image from the camera
2	Temperature profile: Shows the temperatures along max. 2 lines at any size and position in the image.
3	Reference bar: Shows the scaling of temperature within the color palette.
4	Temperature of measure area: Analyses the temperature according to the selected shape, e.g. average temperature of the rectangle. The value is shown inside the IR image and the control displays.
5	Control displays: Displays all temperature values in the defined measure areas like Cold Spots, Hot Spots, temperature at cursor, internal temperature and chip temperature. Alarm settings: Bar showing the defined temperature thresholds for low alarm value (blue arrow) and high alarm value (red arrow). The color of numbers within control displays changes to red (when temperature above the high alarm value) and to blue (when temperature below the low alarm value).
6	Temperature time diagram: Shows the temperature curves over time for selectable region of interest (ROI)
7	Histogram: Shows the statistic distribution of single temperature values.
8	Automatic / manual scaling of the palette (displayed temperature range): Man., </> (min, max), 1 σ : 1 Sigma, 3 σ : 3 Sigma, OPT: Palette optimization
9	Menu and Toolbar (Icons)
10	Icon enabling switching between color palettes
11	Status bar: Serial number, optic, temperature range, cursor position, device framerate/ display framerate, emissivity, ambient temperature, flag status

i Further information regarding software installation as well as software features you will find in the operation instructions.

They are available online at:

<http://www.micro-epsilon.de/download/manuals/man--thermoIMAGER-TIM-Connect--en.pdf>

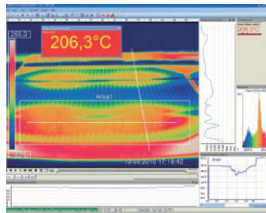
9.2 Basic Features of Software TIM Connect

Extensive infrared camera software



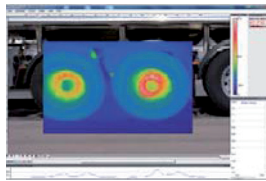
- No restrictions in licensing
- Modern software with intuitive user interface
- Remote control of camera via software
- Display of multiple camera images in different windows
- Compatible with Windows 7, 8 and 10

High level of individualization for customer specific display



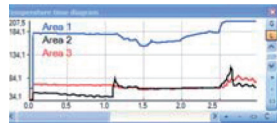
- Various language option including a translation tool
- Temperature display in °C or °F
- Different layout options for an individual setup (arrangement of windows, toolbar)
- Range of individual measurement parameter fitting for each application
- Adaption of thermal image (mirror, rotate)
- Individual start options (full screen, hidden, etc.)

Video recording and snapshot function



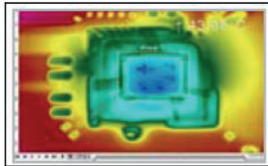
- Recording of video sequences and detailed frames for further analysis or documentation
- Adjustment of recording frequency to reduce data volume
- Display of snapshot history for immediate analysis

Extensive online and offline data analysis



- Analysis supported by measurement fields, hot and cold spot searching, image subtraction
- Real time temperature information within main window as digital or graphic display (line profile, temperature time diagram)
- Slow motion repeat of radiometric files and analysis without camera being connected
- Editing of sequences such as cutting and saving of individual images
- Various color palettes to highlight thermal contrasts

Automatic process control



- Individual setup of alarm levels depending on the process
- Definition of visual or acoustic alarms and analog data output
- Analog and digital signal input (process parameter)
- External communication of software via COM-Ports and DLL
- Adjustment of thermal image via reference values

Temperature data analysis and documentation

- Triggered data collection
- Radiometric video sequences (*.ravi) radiometric snapshots (*.tiff)
- Text files including temp. information for analysis in Excel (*.csv, *.dat)
- Data with color information for standard programmes such as Photo-shop or Windows Media Player (*.wmv, *.tiff)
- Data transfer in real time to other software programmes via DLL or COM-Port interfaces

10. Basics of Infrared Thermometry

10.1 Introduction

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.

Searching for new optical material William Herschel by chance found the infrared radiation in 1800.

He blackened the peak of a sensitive mercury thermometer. This thermometer, a glass prism that led sun rays onto a table made his measuring arrangement.

With this, he tested the heating of different colors of the spectrum. Slowly moving the peak of the blackened thermometer through the colors of the spectrum, he noticed the increasing temperature from violet to red.

The temperature rose even more in the area behind the red end of the spectrum. Finally he found the maximum temperature far behind the red area.

Nowadays this area is called “infrared wavelength area”.

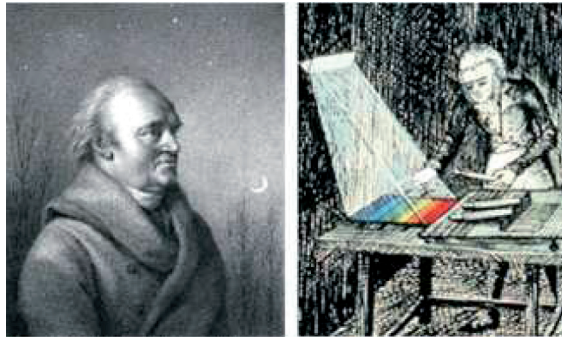


Fig. 23 William Herschel (1738 – 1822)

For the measurement of “thermal radiation” infrared thermometry uses a wave-length ranging between 1μ and $20 \mu\text{m}$.

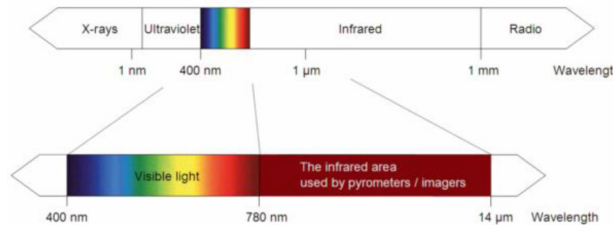


Fig. 24 The electromagnetic spectrum and the area used for temperature measurement

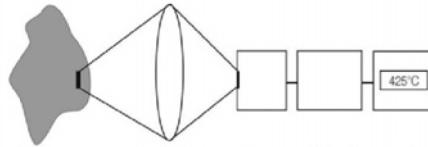
The intensity of the emitted radiation depends on the material. This material contingent constant is described with the help of the emissivity which is a known value for most materials, [see 11](#).

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 (sensor)
- 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.



Object Lens Sensor Electronics Display
Infrared system

Fig. 25 Optical path

The advantages of non-contact temperature measurement are clear - it supports:

- temperature measurements of moving or overheated
- objects and of objects in hazardous surroundings
- very fast response and exposure times
- measurement without inter-reaction, no influence on the
- measuring object
- non-destructive measurement
- long lasting measurement, no mechanical wear

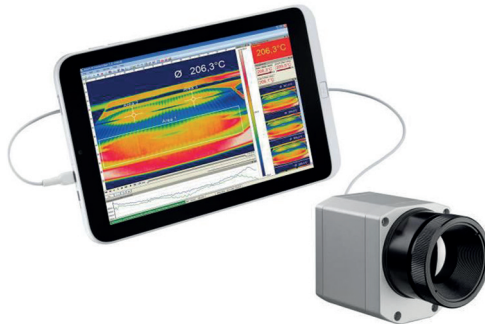
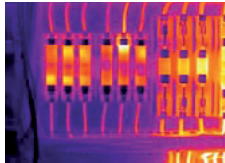
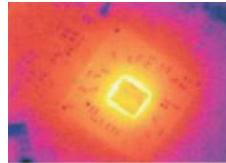


Fig. 26 TIM with tablet PC

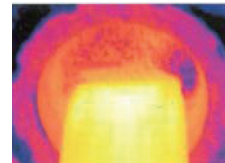
10.2 Application Examples



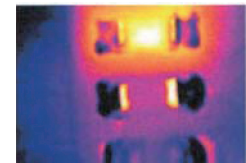
Monitoring of electronic cabinets



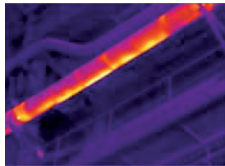
Electronic development



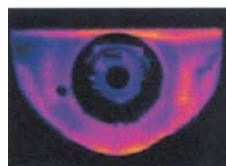
Process control extruding plastic parts



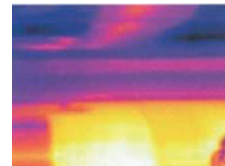
Development of electronic components



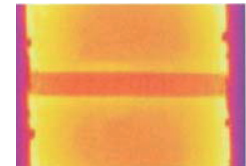
Monitoring of cables



Development of mechanical parts



Process control at calendaring



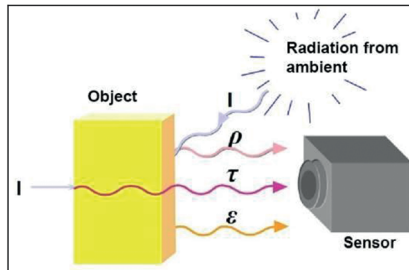
Process control in solar cell production

11. Emissivity

11.1 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.



I = IR radiation
 ρ = Reflection
 τ = Transmission
 ϵ = Emission

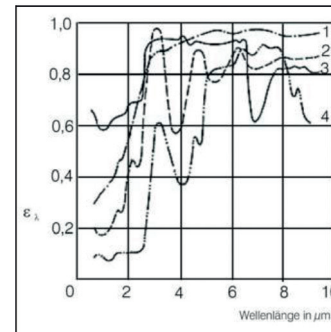


Fig. 27 Spectral emissivity of some materials ¹

Fig. 28 Capability of an object to emit radiation 1) 1 = Enamel, 2 = Plaster, 3 = Concrete, 4 = Chamotte

11.2 Determination of Unknown Emissivity

3 methods:

- 1 First of all, determine the current temperature of the measuring object with a thermocouple or contact sensor. The second step is to measure the temperature with the infrared thermometer and modify the emissivity until the displayed measuring value corresponds to the current temperature.
- 2 If you monitor temperatures of up to 380 °C you may place a special plastic sticker (Part number: TM-ED-LS emissivity dots) onto the measuring object, which covers it completely.

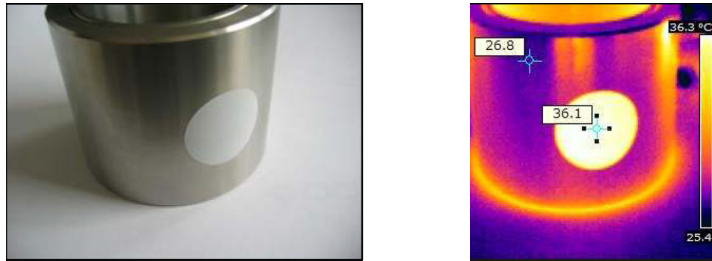


Fig. 29 Plastic sticker at metal surface

- ➡ 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.
- 3

➡ Cover 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.



Fig. 30 Shiny metal surface



Fig. 31 Blackened metal 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.

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

11.3 Characteristic Emissivity

In the case that none of the methods mentioned above help to determine the emissivity you may use the emissivity tables, [see A 4](#), [see A 5](#). These are only average values. The actual emissivity of a material depends on the following factors:

- Temperature
- Measuring angle
- Geometry of the surface (smooth, convex, concave)
- Thickness of the material
- Constitution of the surface (polished, oxidized, rough, sandblast)
- Spectral range of the measurement
- Transmissivity (e.g. with thin films)

Fixed radiometric values

Emissivity:	1,000
Transmissivity: (IR-window compensation)	1,000
Ambient temperature:	<input type="checkbox"/> 23,0

Fig. 32 Adjustment of the emissivity in the software TIM Connect under the menu item Tools / Configuration / Device

12. Disclaimer

All components of the device have been checked and tested for functionality in the factory. However, should any defects occur despite careful quality control, these shall be reported immediately to MICRO-EPSILON or to your distributor / retailer.

MICRO-EPSILON undertakes no liability whatsoever for damage, loss or costs caused by or related in any way to the product, in particular consequential damage, e.g., due to

- non-observance of these instructions/this manual,
- improper use or improper handling (in particular due to improper installation, commissioning, operation and maintenance) of the product,
- repairs or modifications by third parties,
- the use of force or other handling by unqualified persons.

This limitation of liability also applies to defects resulting from normal wear and tear (e.g., to wearing parts) and in the event of non-compliance with the specified maintenance intervals (if applicable).

MICRO-EPSILON is exclusively responsible for repairs. It is not permitted to make unauthorized structural and / or technical modifications or alterations to the product. In the interest of further development, MICRO-EPSILON reserves the right to modify the design.

In addition, the General Terms of Business of MICRO-EPSILON shall apply, which can be accessed under Legal details | Micro-Epsilon <https://www.micro-epsilon.com/impressum/>.

For translations into other languages, the German version shall prevail.

13. Service, Repair

If the camera is defective, please send us the affected parts for repair or exchange.

If the cause of a fault cannot be clearly identified, please send the entire measuring system to:

For customers in USA applies:

Send the affected parts or the entire measuring system back to:

For customers in Canada or South America applies:

Please contact your local distributor.

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Fax +1 919 / 787-9706
me-usa@micro-epsilon.com
www.micro-epsilon.com

14. Decommissioning, Disposal

In order to avoid the release of environmentally harmful substances and to ensure the reuse of valuable raw materials, we draw your attention to the following regulations and obligations:

- Remove all cables from the sensor and/or controller.
- Dispose of the sensor and/or the controller, its components and accessories, as well as the packaging materials in compliance with the applicable country-specific waste treatment and disposal regulations of the region of use.
- You are obliged to comply with all relevant national laws and regulations.

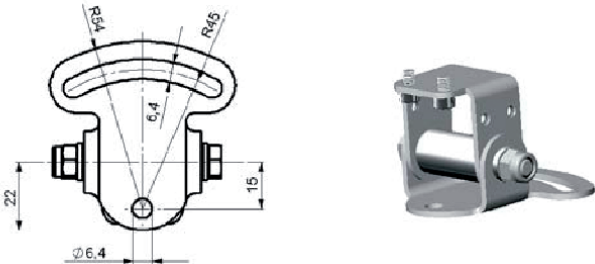
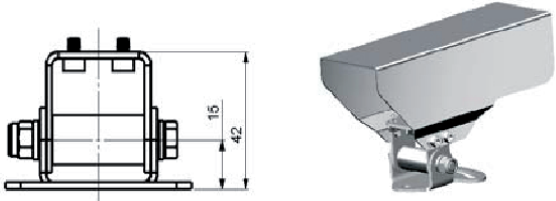
For Germany / the EU, the following (disposal) instructions apply in particular:

- Waste equipment marked with a crossed garbage can must not be disposed of with normal industrial waste (e.g. residual waste can or the yellow recycling bin) and must be disposed of separately. This avoids hazards to the environment due to incorrect disposal and ensures proper recycling of the old appliances.
- A list of national laws and contacts in the EU member states can be found at https://ec.europa.eu/environment/topics/waste-and-recycling/waste-electrical-and-electronic-equipment-weee_en. Here you can inform yourself about the respective national collection and return points.
- Old devices can also be returned for disposal to MICRO-EPSILON at the address given in the imprint at <https://www.micro-epsilon.de/impressum/>.
- We would like to point out that you are responsible for deleting the measurement-specific and personal data on the old devices to be disposed of.
- Under the registration number WEEE-Reg.-Nr. DE28605721, we are registered at the foundation Elektro-Altgeräte Register, Nordostpark 72, 90411 Nuremberg, as a manufacturer of electrical and/or electronic equipment.

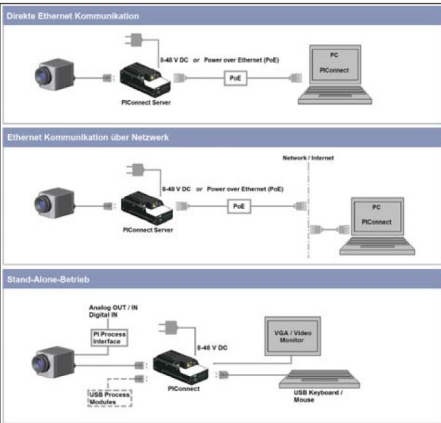
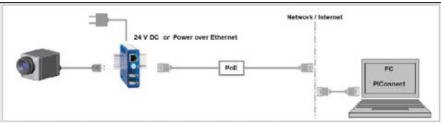



Appendix

A 1 Optional Accessories

TM-MB-TIM		Mounting base, adjustable in two axes
TM-PH-TIM		Protective housing, stainless steel, inclusive mounting base
TM-CJAxxxx	Further information on request, see 13 Dimensional drawing, see A 2	Cooling Jacket Advanced

Dimensions in mm (inches)

<p>TM-NETBox-TIM</p>		<p>Miniature PC for standalone installation of TIM systems</p>
<p>TM-USB-SGB-TIM</p>		<p>USB server for cable extension via Ethernet</p>
<p>TM-OPH24F-TIM</p>		<p>Outdoor protective housing for TIM (suitable for optics up to 90° FOV) with foils window</p>
<p>TM-OPH24GE-TIM</p>		<p>Outdoor protective housing for TIM (suitable for optics up to 90° FOV) with GE window</p>

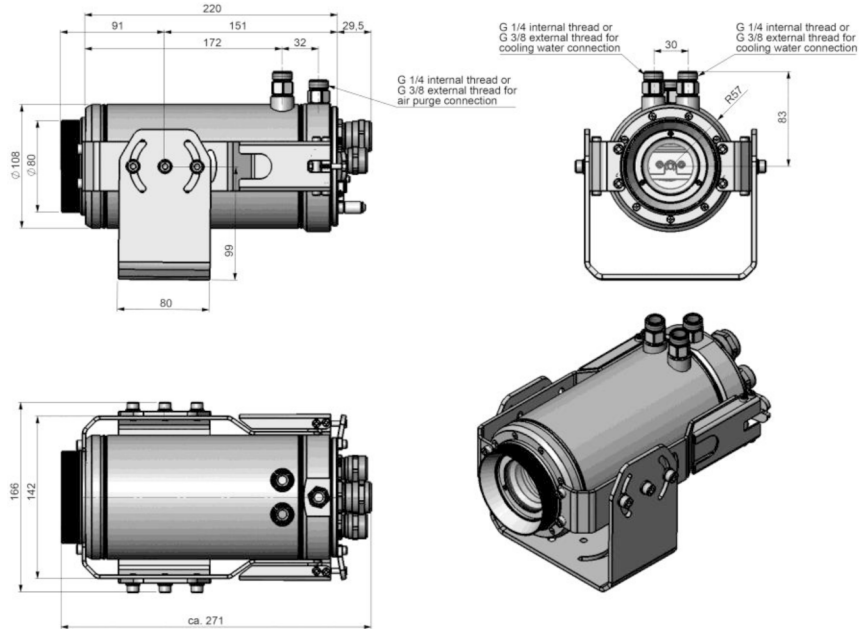
Other versions on request

- **i** The infrared camera TIM and the USB server can also be used for outdoor applications by using the outdoor protective housing. The outdoor protective housing can be used for any TIM camera (lenses up to 90 ° FOV). In addition, the industrial PIF can be installed as an accessory without housing. For detailed information see installation manual.

A 2 Dimensions Cooling Jacket Advanced

The Cooling Jacket Advanced is available as a standard version and as an extended version.

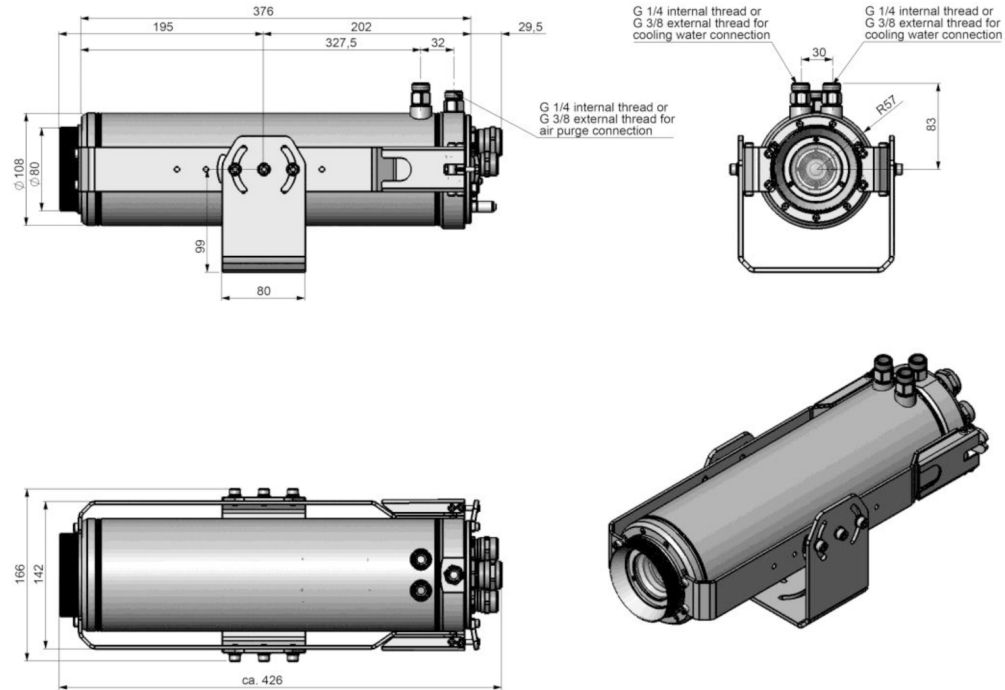
A 2.1 Standard Version



Dimensions in mm (inches)

A 2.2 Extended Version

The Extended Version is provided for applications of the TIM series with the TIM NetBox and industrial PIF or the USB Server Gigabit and industrial PIF. Both TIM NetBox and industrial PIF or USB Server Gigabit and industrial PIF can be integrated in the Cooling Jacket Advanced.



Dimensions in mm (inches)

A 2.3 Laminar Air Purge for Cooling Jacket

Laminar air purge for front mounting of the Cooling Jacket Advanced (Standard and Extended). Two different versions are available: One for standard IR camera applications (order no. TM-CJAAPLS-TIM, see Fig. 34) and the other for line scanning applications (order no. TM-CJAAPLL, see Fig. 33).



Fig. 33 TM-CJAAPLL



Fig. 34 TM-CJAAPLS-TIM

Those two versions are fitting to all focusing units with production date \geq 01/2018. A protective window (67 x 3 mm) has to be ordered separately. If you like to mount the air purge on an older CJ, the focusing unit should be exchanged to the current version.

A 3 Factory Settings

The devices have following presettings at time of delivery:

Temperature range	-20 ... 100 °C
Emissivity	1.000
Process Interface (PIF)	inactive
Interprocess Communication (IPC)	inactive
Measurement function	Rectangle measure area

A 4 Emissivity Table Metals

Material		Typical Emissivity			
		1.0 μm	1.6 μm	5.1 μm	8 - 14 μm
Aluminum	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

Material		Typical Emissivity			
		1.0 μm	1.6 μm	5.1 μm	8 - 14 μm
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
	Forget, 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
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

Material		Typical Emissivity			
Spectral response		1.0 μm	1.6 μm	5.1 μm	8 - 14 μm
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	0.9 - 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

A 5 Emissivity Table Non Metals

Material Spectral response	Typical Emissivity			
	1.0 μm	2.3 μm	5.1 μm	8 - 14 μm
Asbest	0.9	0.8	0.9	0.95
Aphalt			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
Carborundum	0.4	0.8 - 0.95	0.8 - 0.95	0.95
Cement	0.65	0.9	0.9	0.95
Ceramic	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

Material	Typical Emissivity			
Spectral response	1.0 μm	2.3 μm	5.1 μm	8 - 14 μm
Sand			0.9	0.95
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

A 6 Industrial Process Interface (Optional)

For use in industrial environment an industrial Process Interface with 500 VAC_{RMS} isolation voltage between TIM and process is available (connection box with IP65, 5 m, 10 m or 20 m standard or high temp cable for camera connection, terminal for process integration).

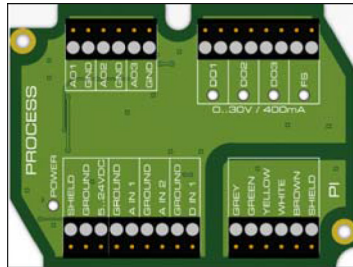


Fig. 35 Connections of the industrial Process Interface

Color	Designation
Gray	Interrupt
Green	SCL (I ² C)
Yellow	SDA (I ² C)
White	3,3 V
Brown	GND
Shield	GND

Fig. 36 Pin assignment connection cable industrial PIF

The industrial Process Interface offers the following inputs and outputs:

Designation	Description	max. range ¹ / status
A IN 1 / 2	Analog input 1 und 2	0 - 10 V ²
D IN 1	Digital input (active-low = 0 ... 0.6 V)	24 V
AO1 / 2 / 3	Analog output 1, 2 and 3	0/4 - 20 mA
	Alarm output 1, 2 and 3	
DO1 / 2 / 3	Relay output 1, 2 and 3 ³	open/ closed (red LED on) / 0 ... 30 V, 400 mA
FS	Fail-safe relay	open/ closed (green LED on) / 0 ... 30 V, 400 mA

! The alarm output can be configured as a threshold between 0 - 4 mA for no alarm and between 10 - 20 mA as alarm. For values outside the respective range, the relay does not switch on a DO.

1) Depending on supply voltage; for 0 - 20 mA on the AO the PIF has to be powered with $\min. 5 \text{ V} < (1.5 + \text{working resistance} * 0.021) < 24 \text{ V}$; Example: $R_{\text{Load}} = 500 \text{ ohm} \rightarrow U_{\text{min}} = 1.5 + 500 * 0.021 = 12 \text{ V}$, $R_{\text{Load}} = 100 \text{ ohm} \rightarrow U_{\text{min}} = 1.5 + 100 * 0.021 = 3.6 \text{ V} \rightarrow \min. 5 \text{ V}$

2) The AI is designed for max. 24 V, the voltage level above 10 V is not interpreted.

3) Active if AO1, 2 or 3 is/ are programmed as alarm output.

The Process Interface has an integrated fail-safe mode. This allows to control conditions like interruption of cables, shut-down of the software etc. and to give out these conditions as an alarm. The time constant of the fail-safe is 1.5 seconds.

Controlled conditions on camera and software	Standard Process Interface TM-PIF-TIM	Industrial Process Interface TM-PIFCxx-TIM
Interruption USB cable to camera	✓	✓
Interruption data cable camera - PIF	✓	✓
Interruption power supply - PIF	✓	✓
Shut-down of TIM Connect software	✓	✓
Crash of TIM Connect software	-	✓
Fail-safe output	0 V at analog output (AO)	Open contact (Fail-safe relay)/ green LED off

A 6.1 Examples for a Fail-Safe Monitoring of the TIM with a PLC

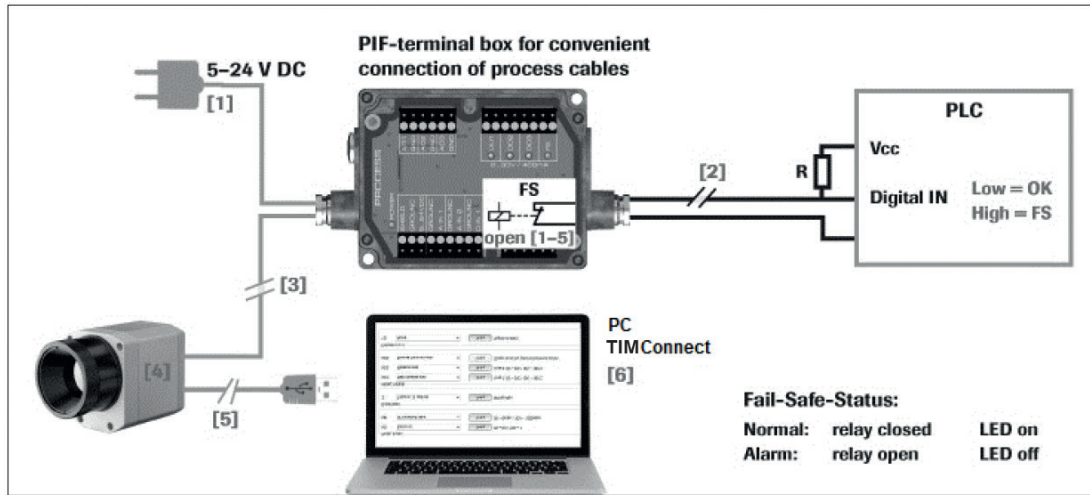


Fig. 37 Fail-Safe monitoring states

Fail-Safe monitoring states

- [1] Breakdown of PIF power supply
- [2] Cable break of fail-safe cable
- [3] Interruption of cable TIM-PIF
- [4] Malfunction of camera
- [5] Breakdown of TIM power supply/ interruption of USB cable
- [6] Malfunction of TIM Connect software

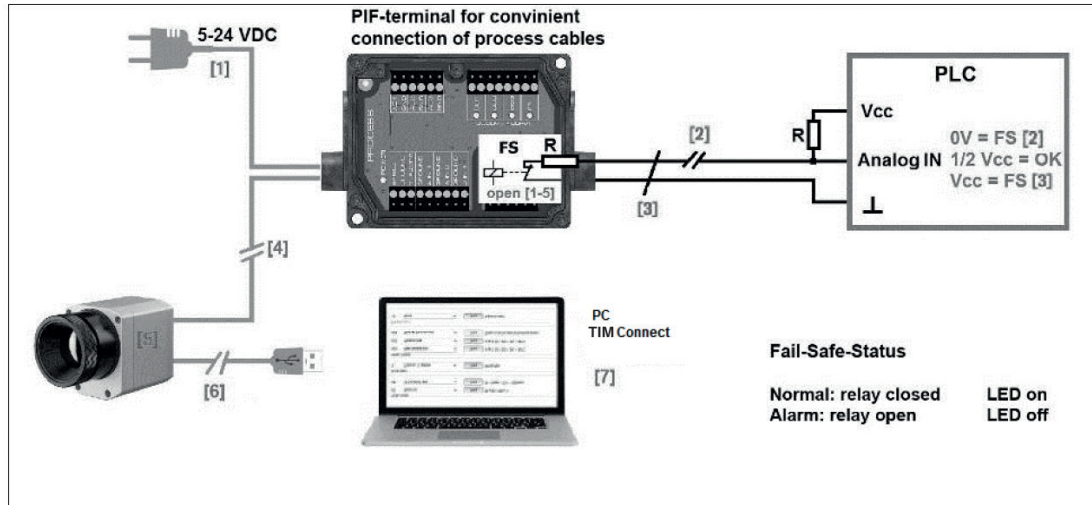


Fig. 38 Fail-Safe monitoring status

Fail-Safe monitoring status

- [1] Breakdown of PIF power supply
- [2] Cable break of fail-safe cable
- [3] Short circuit of fail-safe cable
- [4] Interruption of cable TIM PIF
- [5] Malfunction of camera
- [6] Breakdown of TIM power supply/ interruption of USB cable
- [7] Malfunction of TIM Connect software

A 7 USB Cable Extensions

The maximum USB cable length is 20 m. For greater distances between TIM and computer or for stand-alone solutions the optional TIM NetBox or the USB-Server Gigabit is provided:

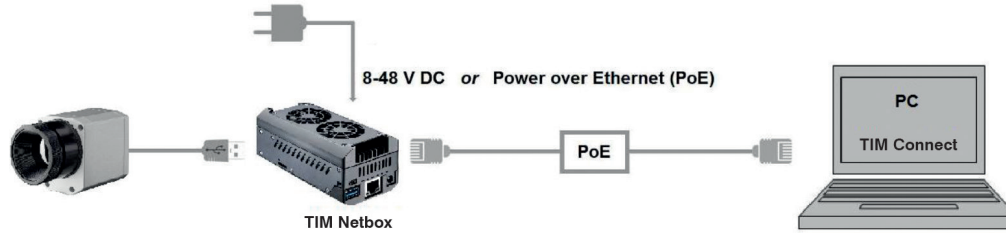


Fig. 39 Ethernet direct communication with TIM NetBox

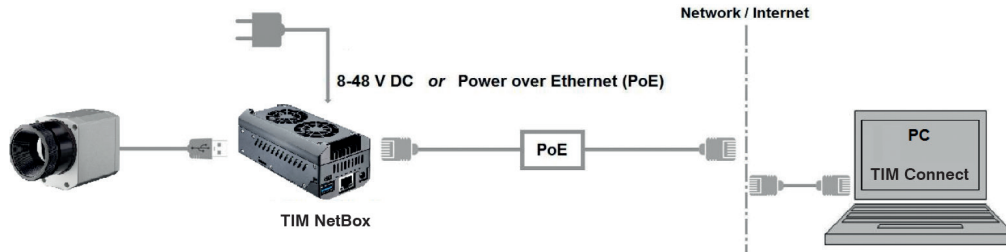


Fig. 40 Ethernet network communication with TIM NetBox

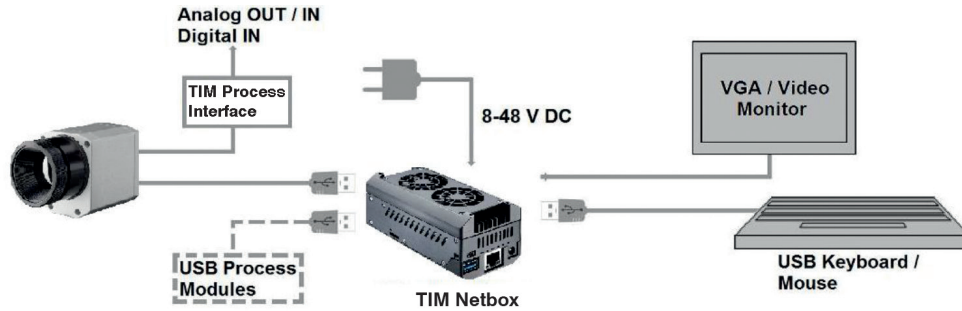


Fig. 41 Stand-Alone operation with TIM NetBox

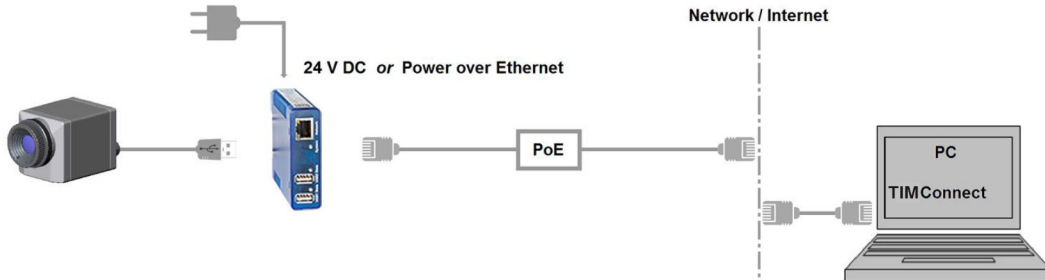


Fig. 42 USB Server Gigabit

A 8 A Brief Overview to Serial Communication

A 8.1 Introduction

One of the features of the thermoIMAGER TIM Connect software is the ability to communicate via a serial COM-Port interface. This can be a physical COM-Port or a Virtual Comport (VCP). It must be available on the computer where the TIM connect software is installed.

A 8.2 Setup of the Interface

- ➡ To enable the software for the serial communication open the Options dialog and enter the tab `Extended Communication`.
- ➡ Choose the mode `COM-Port` and select the port you want to use.
- ➡ Also select the baud rate that matches the baud rate of the other communication device.

The other interface parameters are 8 data bits, no parity and one stop bit (8N1). This is mostly used on other communication devices too. The other station must support 8 bit data.

- ➡ Now you have to connect the computer with your other communication device.
- ➡ If this is a computer too you will have to use a null modem cable.

A 8.3 Command List

- **i** You will find the command list on the USB stick provided and in the TIM Connect software (`Help > SDK`).
Each command must end with a `CR / LF (0x0D, 0x0A)`.

A 9 A Brief Overview to DLL Communication (IPC)

i The description of the initialization procedure as well as the necessary command list is provided on the USB stick and in the TIM Connect software under `Help > SDK`.

2 SDK packages are available. These can be found on the included USB stick:

- Connect SDK: requires the TIM Connect software
- Direct SDK: no TIM Connect software required, supports Linux and Windows

The communication to the process imager device is handled by the PI Connect software (`Imager.exe`) only. A dynamic link library (`ImagerIPC2.dll`) provides the interprocess communication (IPC) for other attached processes. The DLL can be dynamically linked into the secondary application. Or it can be done static by a lib file too. Both `Imager.exe` and `ImagerIPC2.dll` are designed for Windows 7, Windows 8 and Windows 10 only. The application must support call-back functions and polling mode.

The `ImagerIPC2.DLL` will export a bunch of functions that are responsible for initiating the communication, retrieving data and setting some control parameters.

The main difference to the former Version 1 (`ImagerIPC.dll`) is the support of more than one TIM cameras via multiple instances of TIM Connect.

A 10 thermoIMAGER TIM Connect Resource Translator

thermoIMAGER TIM Connect is a .Net Application. Therefore it is ready for localization. Localization as a Microsoft idiom means the complete adaption of resources to a given culture. If you want to learn more about the internationalization topics please consult Microsoft's developer documentation <http://msdn.microsoft.com/en-us/goglobal/bb688096.aspx>.

If needed the localization process can be very detailed. Also the resizing of buttons or other visible resources and the support of right-to-left languages is supported. This can be a huge effort and should be done by experts who have the appropriate tools. To limit this effort and to enable anybody to translate the resources of the TIM Connect application

Micro-Epsilon has developed the small tool `Resource Translator`. This tool helps to translate any visible text within the thermoIMAGER TIM Connect application.

i You will find a detailed tutorial on the USB stick provided.

A 11 Process Interface

A 11.1 Analog Output

The maximum load impedance is 500 Ohm.

The analog output can be used as a digital output too. The current value for `no alarm` and `alarm on` is set within the software.

A 11.2 Digital Input

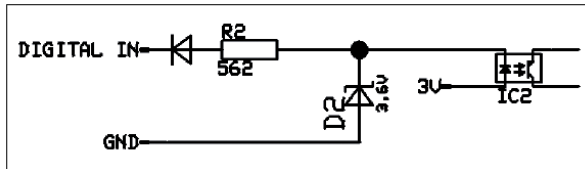


Fig. 43 Digital input

The digital input can be activated with a button to the TIM GND-Pin or with a low level CMOS/TTL – signal:

- Low level 0 ... 0.6 V
- High level 2 ... 24 V

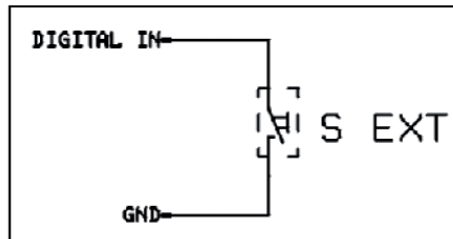


Fig. 44 Digital input - button example

A 11.3 Analog Input (Usable Voltage Range: 0 ... 10 V)

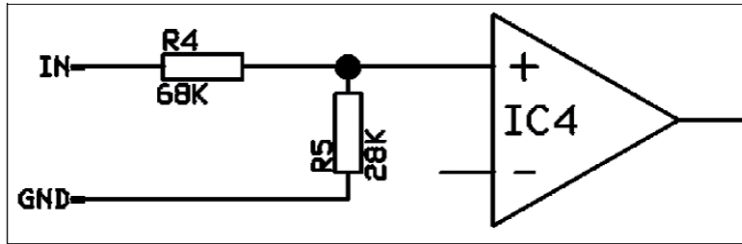


Fig. 45 Analog input

A 11.4 Relay Output at Industrial PIF (Part No.: TM-PIFCxx-TIM)

The analog output must be set to Alarm. The range for A01 - A03 can be set in the software:

- No Alarm: 0 - 4 mA
- Alarm: 10 - 20 mA

REL1-3 (DO1-DO3): $U_{\max} = 30 \text{ VDC}$
 $I_{\max} = 400 \text{ mA}$

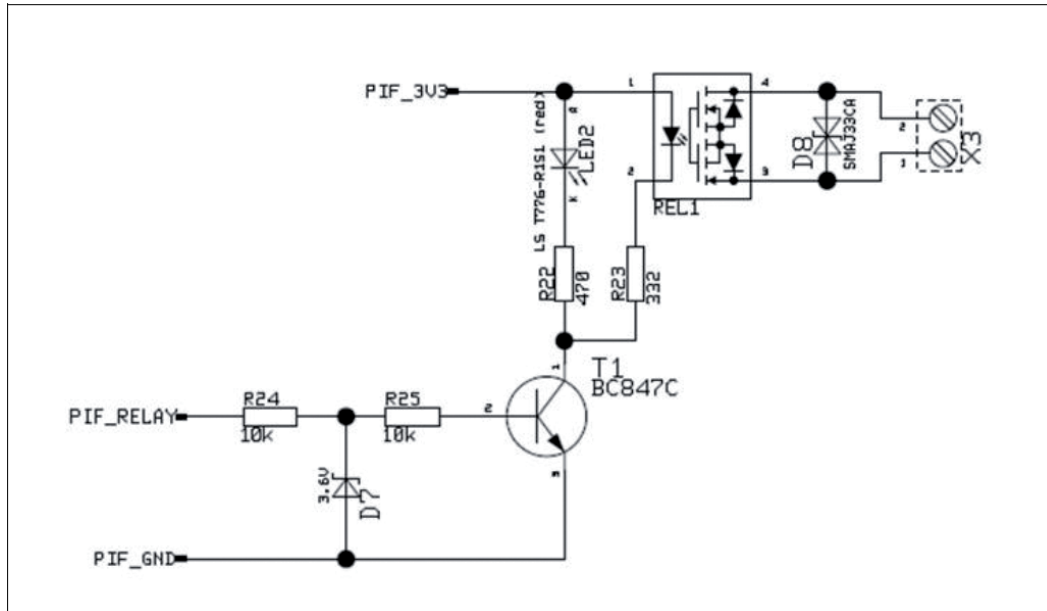


Fig. 46 Relay output at industrial PIF



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