Operator's Manual

PI

160/ 200/ 230/ 400/ 450/ 450G7/ 640/ 1M

Infrared camera

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1 General Notes

1.1 Intended use

The PI calculates the surface temperature based on the emitted infrared energy of objects [►**6 Basics of Infrared Thermometry**]. The two-dimensional detector (FPA - focal plain array) allows a measurement of an area and will be shown as thermal image using standardized palettes. The radiometric processing of the picture data enables the user to do a comfortable detailed analysis with the software PI Connect.

The PI is a precise instrument and contains a sensitive infrared detector and a high-quality lens. The alignment of the camera to intensive energy sources (high power laser or reflections of such equipment, e.g.) can have effect on the accuracy of the measurement or can cause an irreparable defect of the infrared detector.

- Avoid abrupt changes of the ambient temperature.
- Avoid static electricity, arc welders, and induction heaters. Keep away from very strong EMF (electromagnetic fields).
- In case of problems or questions which may arise when you use the infrared camera, please contact our service department.

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.

► All accessories can be ordered according to the referred part numbers in brackets [ ].

1.2 Warranty

Each single product passes through a quality process. Nevertheless, if failures occur 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 or in case of a non-intended use of the product.

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.

1.3 Scope of delivery

Standard version

- PI160, PI200, PI230, PI400, PI450, PI450G7, PI640 or PI1M incl. 1 lens
- USB cable (1 m[1)])
- Table tripod
- Process interface cable incl. terminal block (1 m)
- Software package PI Connect

- Operators manual
- Aluminum case
- PI450/ 640 only: Hard transport case (IP 67)
- PI200/ 230 only: focusing tool for VIS camera

Thermal Analysis Kit

- PI160 or PI200
- 3 lenses (23°, 6° and 41°, incl. calibration certificate)
- USB cable (1 m[1)] and 10 m)
- Tripod (20 - 63 cm)
- Process interface cable incl. terminal block (1 m)
- Software package PI Connect
- Operators manual
- Aluminum case
- PI200/ 230 only: focusing tool for VIS camera

[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.*

1.4 Maintenance

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

1.4.1 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.

1.5 Model overview

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

Modell	Model code	Measurement range	Spectral response	Typical applications
PI 160	IR	-20 to 900 °C 200 to 1500 °C (optional)	7.5-13 µm	Exact measurements of metallic and non-metallic surfaces
PI 200/ Pi 230	BI-SPEKTRAAL	-20 to 900 °C 200 to 1500 °C (optional)	7.5-13 µm	Synchronous recording of VIS and IR videos and images
PI 400/ PI 450	IR	-20 to 900 °C 200 to 1500 °C (optional for PI 400)	7.5-13 µm	Real-time thermographic images in high speed; Detection of smallest temperature differences (PI450)
PI 450 G7	IR	200 to 1500 °C	7.9 µm	Measurement of glass with Line-Scanning mode
PI 640	IR	-20 to 900 °C	7.5-13 µm	Pin-sharp radiometric recordings in real time
PI 1M	IR	450 to 1800 °C	0.92-1.1 µm	Measurement of metallic surfaces, graphite or ceramics with short wavelengths

Table 1: Model overview

2 Technical Data

2.1 General specifications

Environmental rating:	IP67 (NEMA-4)
Ambient temperature:	0...50 °C (0...70 °C [PI 450/ PI 450 G7])
Storage temperature:	-40...70 °C (-40...85 °C [PI 450/ PI 450 G7])
Relative humidity:	10...95 %, non-condensing
Material (housing):	Aluminum, anodized
Dimensions:	PI160/ PI200/ PI230: 45 x 45 x 62 - 65 mm (depending on lens) PI400/ 450/ 640/1M: 46 x 56 x 86 - 90 mm (depending on lens)
Weight:	PI160: 195 g, PI200/ 230: 215 g, PI400/ PI450/ PI640/PI1M: 320 g
Cable length (USB 2.0):	1 m (standard), 5 m, 10 m, 20 m
Vibration[1)]:	IEC 60068-2-6 (sinus shaped) IEC 60068-2-64 (broadband noise)
Shock[1)]:	IEC 60068-2-27 (25 g and 50 g)

[1)] Used standards for vibration and shock:

IEC 60068-1:1988 + **Corr.** 1988 + **A1**: 1992 **DIN EN 60068-1**:1995-03
„Umweltprüfungen - Teil 1: Allgemeines und Leitfaden"

IEC 60068-2-6:2007 **DIN EN 60068-2-6; VDE 0468-2-6**:2008-10
„Umgebungseinflüsse - Teil 2-6: Prüfverfahren - Prüfung Fc: Schwingen (sinusförmig)"

IEC 60068-2-27:2008 **DIN EN 60068-2-27; VDE 0468-2-27**:2010-02
„Umgebungseinflüsse - Teil 2-27: Prüfverfahren - Prüfung Ea und Leitfaden: Schocken"

IEC 60068-2-47:2005 **DIN EN 60068-2-47**:2006-03
„Umgebungseinflüsse - Teil 2-47: Prüfverfahren - Befestigung von Prüflingen für Schwing-, Stoß- und ähnliche dynamische Prüfungen"

IEC 60068-2-64:2008 **DIN EN 60068-2-64; VDE 0468-2-64**:2009-04
„Umgebungseinflüsse - Teil 2-64: Prüfverfahren - Prüfung Fh: Schwingen, Breitbandrauschen (digital geregelt) und Leitfaden"

Figure 1: Used standards

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 two 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 range	10-2000 Hz		

Acceleration	39.3 m/s2	(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)	

2.2 Electrical specifications

Power Supply:	5 VDC (powered via USB 2.0 interface)
Current draw:	Max 500 mA
Output Process Interface (PIF out)	0-10 V (Main area temperature, internal temperature, flag status, alarm) [▶ Appendix F – Wiring diagrams PIF]
Input Process Interface (PIF in)	0-10 V (Emissivity, ambient temperature, reference temperature, flag control, triggered recording, triggered snapshots, triggered line-scanner, uncommitted value) [▶ Appendix F – Wiring diagrams PIF]
Digital Input Process Interface	Flag control, triggered video or triggered snapshots, triggered line-scanner [▶ Appendix F – Wiring diagrams PIF]
Digital interface:	USB 2.0

2.3 Measurement specifications

	PI 160	PI 200[1)]	PI 230[1)]
Temperature ranges	20...100 °C; 0...250 °C; 150...900 °C; Option: 200…1500°C		
Spectral range	7.5-13 µm		
Detector	UFPA, 160 x 120 pixel@120 Hz	UFPA, 160 x 120 pixel@128 Hz[3)] 640 x 480 pixel (visual Camera)	UFPA, 160 x 120 pixel@128 Hz[3)] 640 x 480 pixel (visual Camera)
Lenses (FOV)	23° x 17°; 6° x 5°; 41° x 31°; 72° x 52°		
System accuracy[2)]	±2°C or ±2 %		
Temperature resolution (NETD):	0.08 K with 23°; 0,3 K with 6°; 0.1 K with 41° and 72°		
Warm-up time	10 min		
Emissivity	0.100...1.100		
Software	PIConnect		

[1)] *For an ideal combination of IR and VIS image we recommend the 41° lens for PI200 and the 23° lens for PI230*
[2)] *At ambient temperature 23±5 °C; whichever is greater*
[3)] *The following options can be set: Option 1 (IR with 96 Hz at 160 x 120 px; VIS with 32 Hz at 640 x 480 px); Option 2 (IR with 128 Hz at 160 x 120 px; VIS with 32 Hz at 596 x 447 px)*

	PI 400	PI 450	PI 450G7
Temperature ranges	20...100 °C; 0...250 °C; 150...900 °C; Option: 200…1500°C	-20...100 °C; 0...250 °C; 150...900 °C	200…1500°C
Spectral range	7.5-13 µm	7.5-13 µm	7.9 µm
Detector	UFPA, 382 x 288 pixel@80 Hz (switchable to 27 Hz)	UFPA, 382 x 288 pixel@80 Hz (switchable to 27 Hz)	UFPA, 382 x 288 pixel@80 Hz (switchable to 27 Hz)
Lenses (FOV)	38° x 29°; 62° x 49°; 13° x 10°	38° x 29°; 62° x 49°; 13° x 10°	38° x 29°; 62° x 49°
System accuracy[2)]	±2°C or ±2 %		
Temperature resolution (NETD):	0.08 K[1)] with 38° and 62°; 0.1 K[1)] with 13°	0.04 K[1)] with 38° and 62°; 0.06 K[1)] with 13°	130 mK
Warm-up time	10 min		
Emissivity	0.100...1.100		
Software	PI Connect		

[1)] Value is valid at 40 Hz and 25°C room temperature

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

	PI 640	PI 1ML	PI 1MH
Temperature ranges	-20...100 °C; 0...250 °C; 150...900 °C	450…1400 °C (500…1400 °C@1kHz)	700…1800 °C
Spectral range	7.5-13 µm	0.92-1.1 µm	
Detector	UFPA, 640 x 480 pixel@32 Hz	UFPA, 382 x 288 pixel@80 Hz (switchable to 27 Hz) 72x56 pixel@1000 Hz	UFPA, 768 x 480 pixel@32 Hz 382 x 288 pixel@80 Hz (switchable to 27 Hz) 72x56 pixel@1000 Hz
Lenses (FOV)	33° x 25°	FOV@382x288 px: 51°x 39°, 26°x 20°, 20°x 15°, 13°x 10°, 6,2°x 4,7°, 4,0°x 3,0°	FOV@768x480 px: 39°x 25°, 20°x 13°, 15°x 9°, 9,6°x 6°, 4,7°x 2,9°, 3,0°x 1,9°
System accuracy[2)]	±2°C oder ±2 %		
Temperature resolution (NETD):	0.075 K[1)] with 33°	< 1K (700 °C), < 2K (1000 °C)	
Warm-up time	10 min		
Emissivity	0.100...1.100		
Software	PI Connect		

[1)] *Value is valid at 40 Hz and 25°C room temperature*
[2)] *At ambient temperature 23±5 °C; whichever is greater*

2.4 Optical specifications

Make sure that the focus of thermal channel and visual channel (PI200/ 230 only) is adjusted correctly. For focusing the thermal camera turn the lens in right direction for “close” and to the left for “infinite” (**Figure 2)**, as well as focusing the visual camera with the focusing tool supplied in the scope of delivery (**Figure 3).**

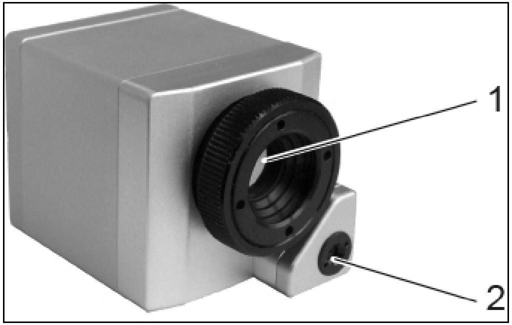

Figure 2: PI 200 with visual camera

1 IR channel **2** VIS channel

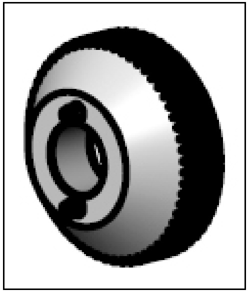

Figure 3: Focusing tool for VIS camera

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 (**Table 2**).

With the help of BI-SPECTRAL technology at PI200/ 230, a visual image (VIS) can be combined with a thermal image (IR). Both can be finally captured time synchronously:

PI 160/200/230 160 x 120 px	Focal length	Angle	Minimum distance*	Distance to object [m]												
					0.02	0.1	0.2	0.3	0.5	1	2	4	6	10	30	100
O23 Standard lens	10 mm	23°	0.2 m	HFOV [m]	0.008	0.04	0.08	0.12	0.20	0.40	0.81	1.61	2.42	4.0	12.1	40.3
		17°		VFOV [m]	0.006	0.03	0.06	0.09	0.15	0.30	0.60	1.20	1.79	3.0	9.0	29.9
		29°		DFOV [m]	0.010	0.05	0.10	0.15	0.26	0.51	1.02	2.04	3.06	5.1	15.3	51.1
		2.52 mrad		IFOV [mm]	0.1	0.3	0.5	0.8	1.3	2.5	5.0	10.1	15.1	25.2	75.6	252.0
O6 Tele lens	35.5 mm	6°	0.5 m	HFOV [m]					0.06	0.11	0.23	0.45	0.68	1.1	3.4	11.3
		5°		VFOV [m]					0.04	0.08	0.17	0.34	0.50	0.8	2.5	8.4
		8°		DFOV [m]					0.07	0.14	0.28	0.56	0.84	1.4	4.2	14.1
		0.71 mrad		IFOV [mm]					0.4	0.7	1.4	2.8	4.2	7.1	21.2	70.5
O48 Wide angle lens	5.7 mm	41°	0.2 m	HFOV [m]	0.015	0.08	0.15	0.23	0.38	0.76	1.51	3.02	4.53	7.6	22.7	75.6
		31°		VFOV [m]	0.011	0.05	0.11	0.16	0.27	0.55	1.09	2.19	3.28	5.5	16.4	54.7
		52°		DFOV [m]	0.019	0.10	0.19	0.29	0.49	0.97	1.95	3.90	5.85	9.7	29.2	97.5
		4.72 mrad		IFOV [mm]	0.09	0.5	0.9	1.42	2.4	4.7	9.5	18.9	28.3	47.2	141.7	472.3
O72 Wide angle lens	3.3 mm	72°	0.2 m	HFOV [m]	0.029	0.15	0.29	0.44	0.73	1.45	2.91	5.81	8.72	14.5	43.6	145.3
		52°		VFOV [m]	0.020	0.10	0.20	0.29	0.49	0.98	1.95	3.90	5.85	9.80	29.3	97.5
		95°		DFOV [m]	0.043	0.22	0.43	0.65	1.09	2.17	4.34	8.68	13.02	21.7	65.1	217.0
		9.08 mrad		IFOV [mm]	0.2	0.9	1.8	2.7	4.5	9.1	18.2	36.3	54.5	90.8	272.5	908.2

Table 2: Table 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 PIConnect has an algorithm which corrects this distortion.

** Note: The accuracy of measurement can be outside of the specifications for distances below the defined minimum distance.*

PI400/450 382 x 288 px	Focal length	Angle	Minimum distance*	Distance to object [m]												
					0.02	0.1	0.2	0.3	0.5	1	2	4	6	10	30	100
O38 Standard lens	15 mm	38°	0.2 m	HFOV [m]	0.014	0.07	0.14	0.21	0.35	0.69	1.39	2.77	4.16	6.9	20.8	69.3
		29°		VFOV [m]	0.010	0.05	0.10	0.15	0.25	0.51	1.02	2.03	3.05	5.1	15.2	50.8
		49°		DFOV [m]	0.018	0.09	0.18	0.28	0.46	0.92	1.84	3.68	5.52	9.2	27.6	92.0
		1.81 mrad		IFOV [mm]	0.1	0.2	0.4	0.5	0.9	1.8	3.6	7.3	10.9	18.1	54.4	181.3
O13 Tele lens	41 mm	13°	0.5 m	HFOV [m]					0.12	0.23	0.47	0.94	1.40	2.3	7.0	23.4
		10°		VFOV [m]					0.09	0.17	0.35	0.70	1.05	1.7	5.2	17.5
		17°		DFOV [m]					0.15	0.29	0.58	1.17	1.75	2.9	8.8	29.2
		0.61 mrad		IFOV [mm]					0.3	0.6	1.2	2.5	3.7	6.1	18.4	61.2
O62 Wide angle lens	8 mm	62°	0.5 m	HFOV [m]	0.024	0.12	0.24	0.36	0.60	1.20	2.40	4.80	7.20	12.0	36.0	119.9
		49°		VFOV [m]	0.018	0.09	0.18	0.27	0.45	0.90	1.80	3.60	5.41	9.0	27.0	90.1
		74°		DFOV [m]	0.030	0.15	0.30	0.45	0.75	1.50	3.00	6.00	8.99	15.0	45.0	149.9
		3.14 mrad		IFOV [mm]	0.1	0.3	0.6	0.9	1.6	3.1	6.3	12.6	18.8	31.4	94.2	314.0
PI 640 O33 Standard lens 640 x 480 px	18.4 mm	33°	0.2 m	HFOV [m]	0.012	0.06	0.12	0.18	0.30	0.60	1.19	2.37	3.55	5.9	17.8	59.2
		25°		VFOV [m]	0.009	0.04	0.09	0.13	0.22	0.44	0.89	1.77	2.66	4.4	13.3	44.3
		41°		DFOV [m]	0.015	0.07	0.15	0.22	0.37	0.75	1.20	2.99	4.49	7.5	22.4	74.8
		0.93 mrad		IFOV [mm]	0.02	0.1	0.2	0.3	0.5	0.9	1.9	3.7	5.6	9.3	27.8	92.6

Table 3: Table 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 PIConnect has an algorithm which corrects this distortion.

** Note: The accuracy of measurement can be outside of the specifications for distances below the defined minimum distance.*

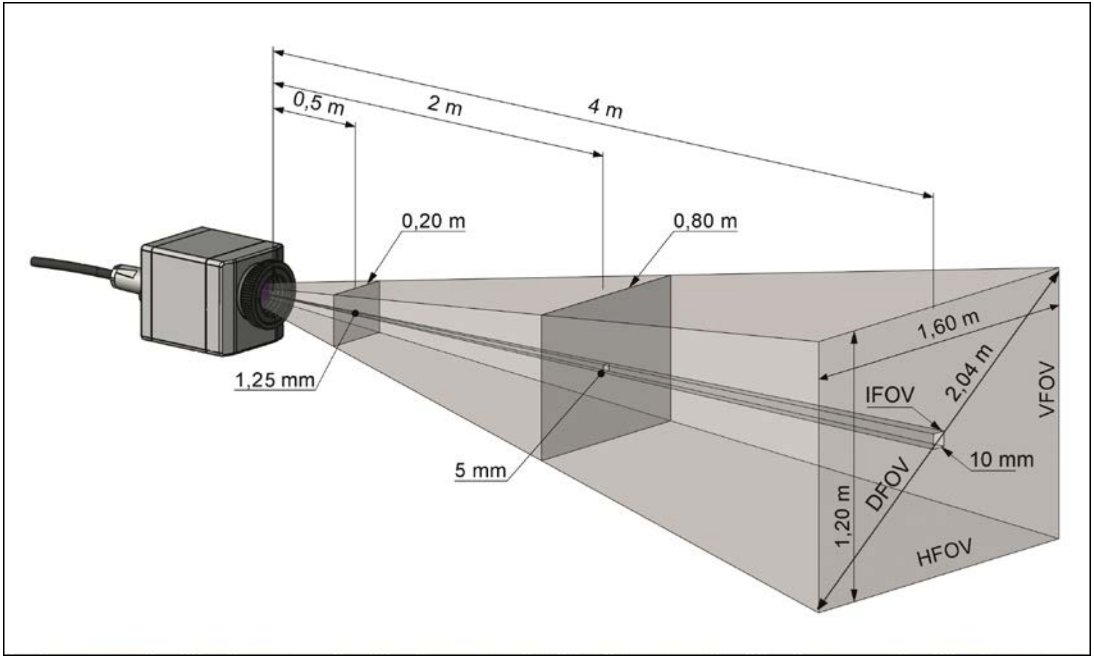

Figure 4: Measurement field of the infrared camera PI representing the 23° x 17° lens

- **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

3 Mechanical Installation

3.1 Dimensions

The PI 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).

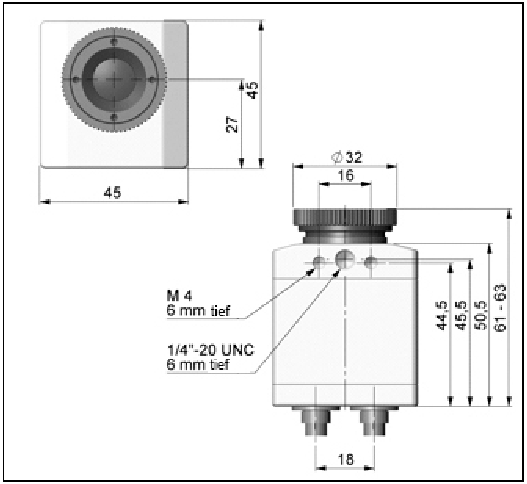

Figure 5: PI160, dimensions [mm]

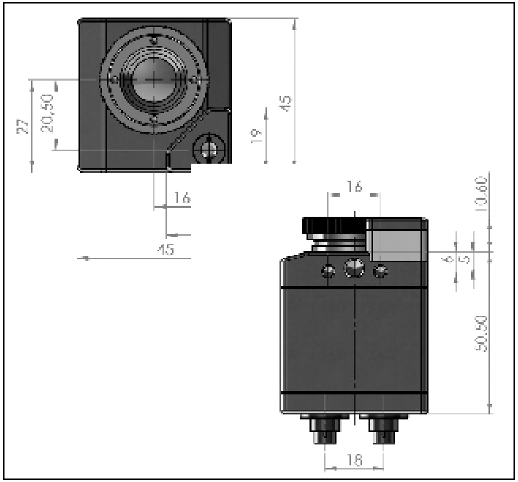

Figure 6: PI200/ 230, dimensions [mm]

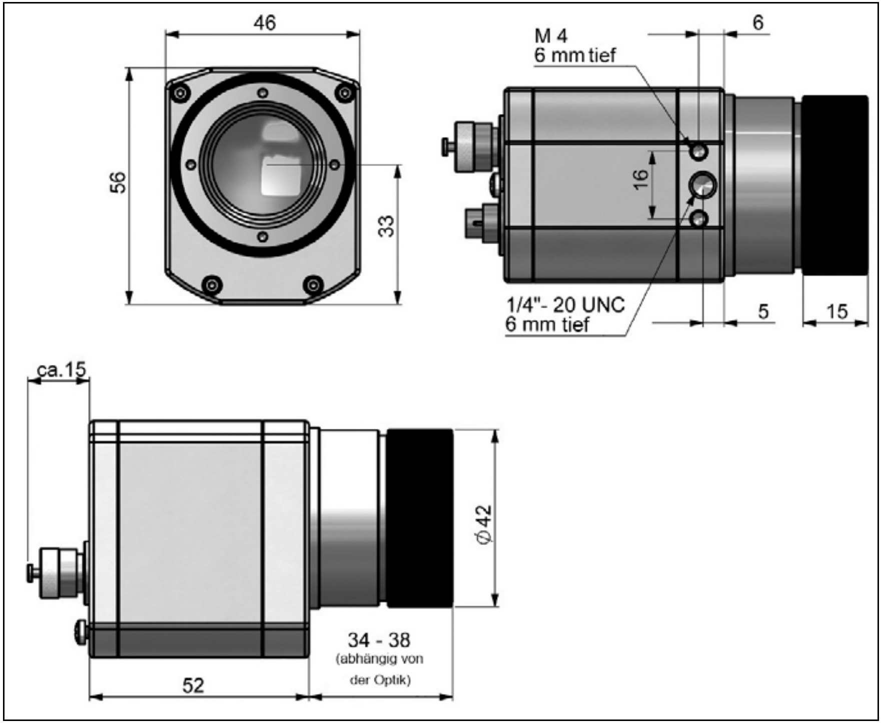

Figure 7: PI400/ PI450/ PI450G7/ PI640/ PI1M, dimensions [mm]

3.2 Mounting accessories (optional)

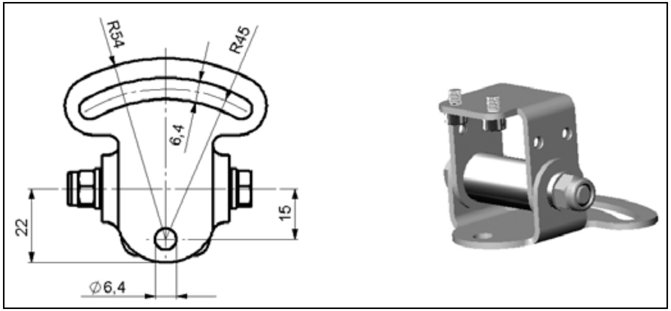

Figure 8: Mounting base, stainless steel, adjustable in 2 axes [**Part No.: ACPIMB**]

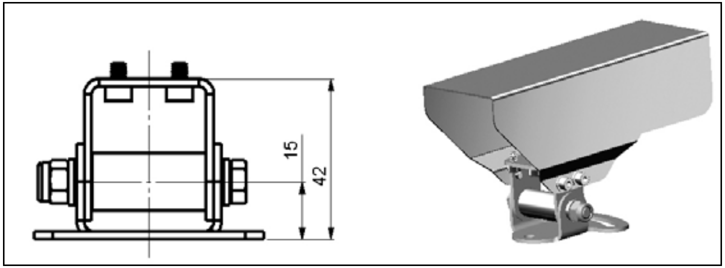

Figure 9: Protective housing, stainless steel, Incl. Mounting base [**Part No.: ACPIPH**]

3.3 High temperature accessories

3.3.1 Cooling Jacket

- The IR camera can be used at ambient temperature up to 50 °C (up to 70 °C with PI450/ PI450G7). For higher temperatures (up to 240 °C) the Cooling Jacket is provided.

- For detailed information see installation manual.

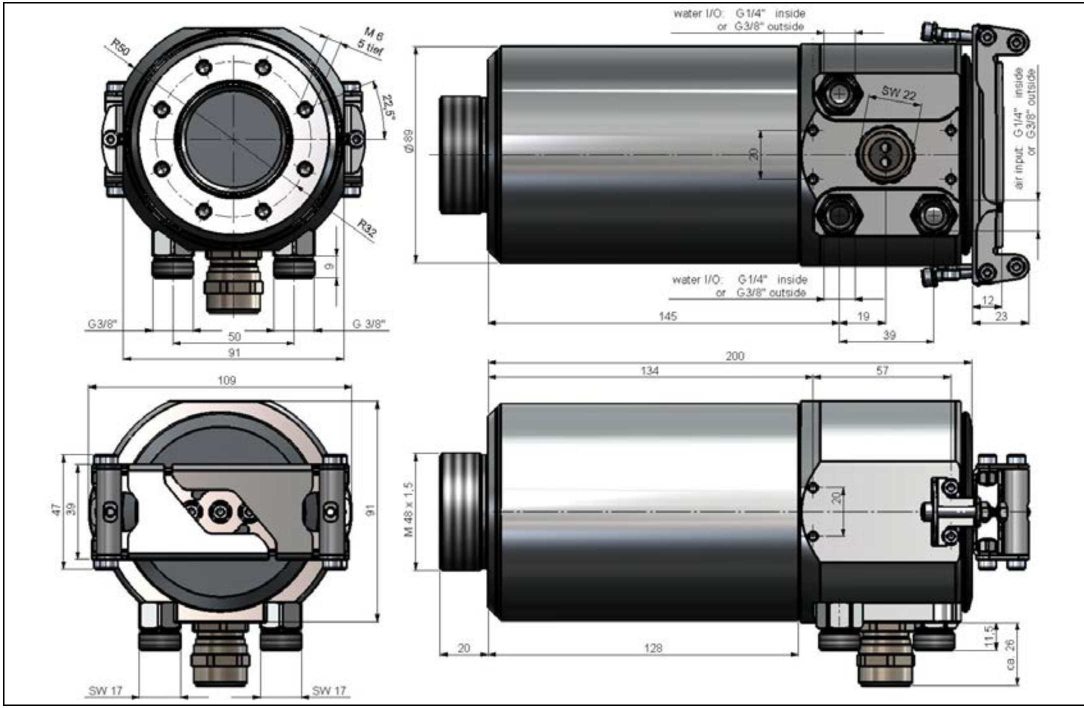

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Figure 10: Cooling Jacket - Dimensions

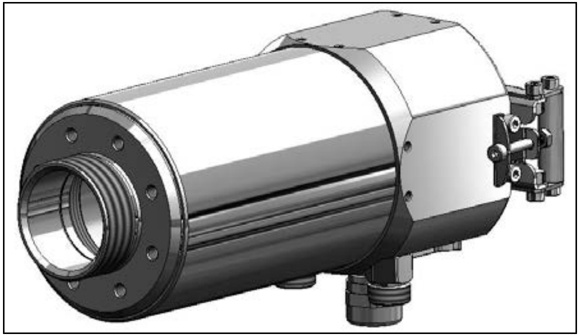


Figure 11: Cooling jacket for PI [**Part No.: ACPIxxxCJ**]

Figure 12: Cooling jacket with mounting bracket

3.3.2 Cooling Jacket Advanced

- 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 PI450/ PI450G7). For higher temperatures (up to 300 °C) the Cooling Jacket Advanced is provided.
- For detailed information see installation manual.

Standard Version

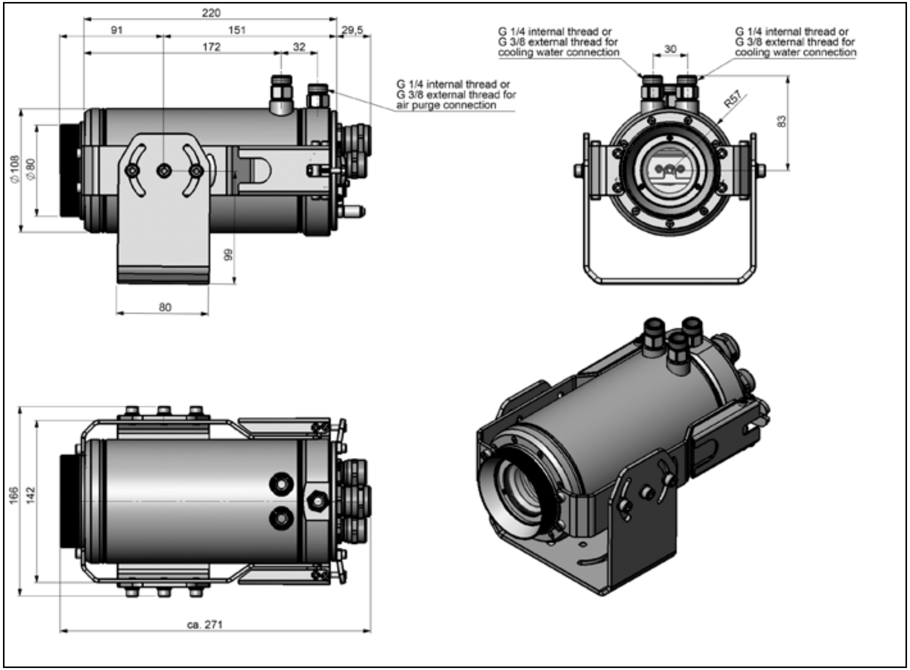


Figure 13: Cooling Jacket Advanced [**Part No.: ACPIxxxCJAS**], Standard Version, 38°/ 62° optics - Dimensions

Extended Version

- The Extended Version is provided for applications of the PI series with the PI Netbox and industrial PIF or the USB Server Gigabit and industrial PIF.

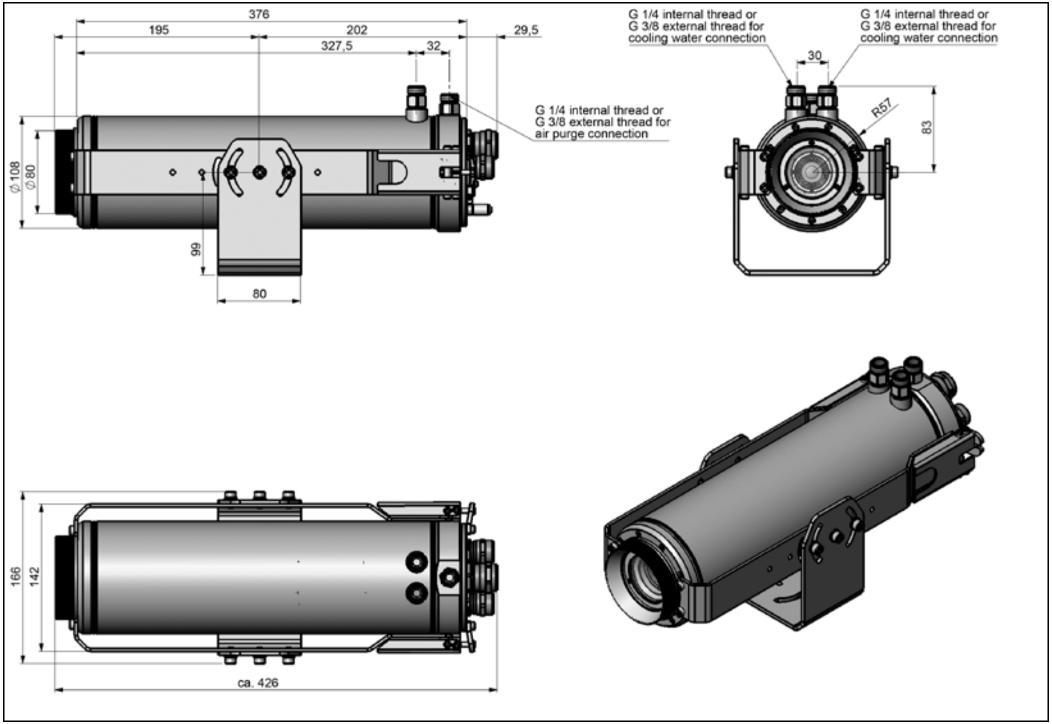


Figure 14: Cooling Jacket Advanced [**Part No.: ACPIxxxCJAE**], Extended Version, 38°/ 62° optics - Dimensions

4 Electrical Installation

At the back side of the PI there are the two connector plugs. The left plug is for the USB cable. The right connector plug is only used for the process interface.

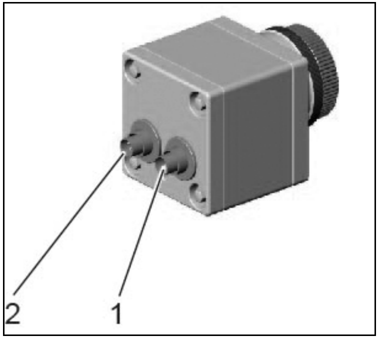


Figure 15: Backside of the camera with connectors

1 Plug for PIF cable

2 Plug for USB cable

4.1 Process interface

The process interface (electronics within cable as well as industrial interface) must be powered separately (5-24 VDC). Before switching on the power the PIF cable must be connected to the camera.

The PI 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.

The process interface can be activated choosing the following options:

Analog Input (AI):	Emissivity, ambient temperature, reference temperature, flag control, triggered recording, triggered snapshots, triggered line-scanner, uncommitted value
Analog Output (AO):	Main area temperature, internal temperature, flag status, alarm
Digital Input (DI):	Flag control, triggered recording, triggered snapshots, triggered line-scanner

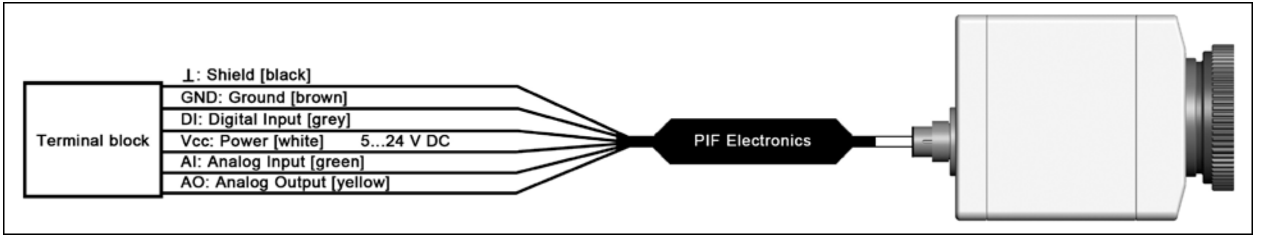


Figure 16: Configuration Standard Process Interface (PIF)

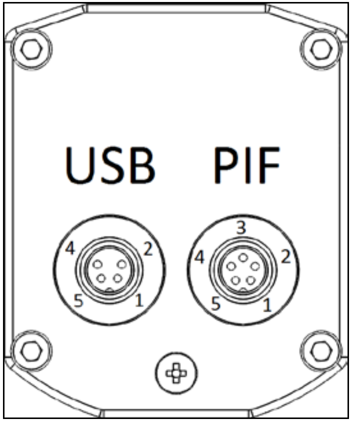
The standard process interface provides the following inputs and outputs:

Name	Description	max range[1]/ status
AI	Analog input	0-10 V
DI	Digital input	24 V
AO	Analog output Alarm output	0-10 V 0/ 10 V

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

4.1.1 PIN allocation

> **!** Consider that the input of the PIF is not protected if there is a direct PIF connection!
> A voltage > 3 V on the INT pin will destroy the device!



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

Figure 17: Rear side of the camera

If the process interface of the camera is directly connected to external hardware[1] (without using the supplied PIF cable) an activation of the field „**`Support proprietary PIF cable`**" in the menu **`Tools/ Configuration/ Device (PIF)`** in the PIConnect software is necessary.

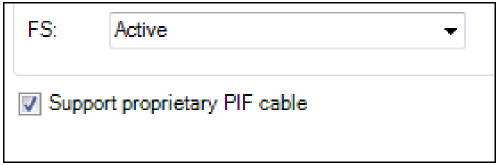


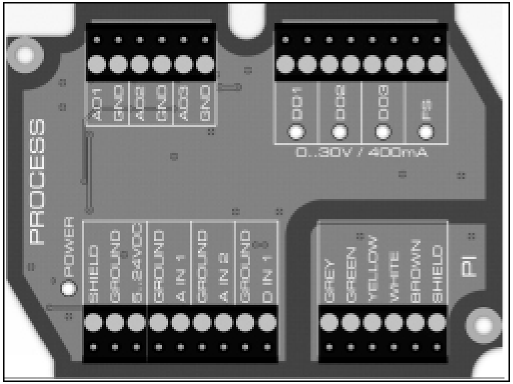
Figure 18: Support proprietary PIF cable

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

4.1.2 Industrial Process Interface (optional)

For use in industrial environment the industrial process interface with 500 VAC$_{RMS}$ isolation voltage between PI and process is available (connection box with IP65, 5 m, 10 m or 20 m standard or high temperature cable for camera connection, terminal for process integration). **[►Appendix F – Wiring diagrams PIF]**

Pin assignment PIF cable (industrial process interface)



GREY	Interrupt
GREEN	SCL (I²C)
YELLOW	SDA (I²C)
WHITE	3.3 V
BROWN	GND
SHIELD	GND

Figure 19: Connections of the industrial Process Interface

The industrial process interface provides the following inputs and outputs:

Name	Description	max range[1]/ status
A IN 1 / 2	Analog input 1 and 2	0-10 V
D IN 1	Digital input	24 V
AO1 / 2 / 3	Analog output 1, 2 and 3 Alarm output 1, 2 and 3	0-10 V 0/ 10 V
DO1 / 2/ 3	Relay output 1, 2 and 3 [2]	open/ closed (red LED on) / 0...30 V, 400 mA
FS	Fail-safe relay	open/ closed (green LED on)/ 0...30 V, 400 mA

[1] *depending on supply voltage; for 0-10 V on the AO the PIF has to be powered with min. 12 V.*
[2] *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.

Controlled conditions on camera and software	Standard Process interface ACPIPIF	Industrial Process interface ACPIPIF500V2CBxx
Interruption USB cable to camera	√	√
Interruption data cable camera - PIF	√	√
Interruption power supply PIF	√	√
Shut-down of PIConnect software	√	√
Crash of PIConnect software	-	√
Fail-Safe-Output	0 V at analog output (AO)	open contact (fail-safe relay)/ green LED off

4.2 Example for a Fail-Safe monitoring of the PI with a PLC

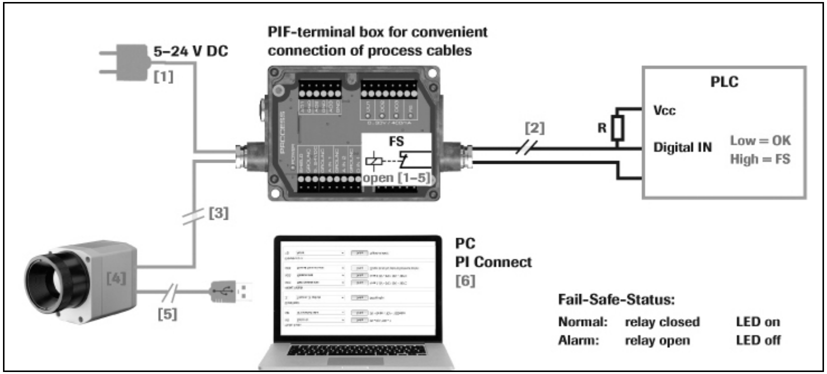


Figure 20: Fail-Safe monitoring states

Fail-Safe monitoring states

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

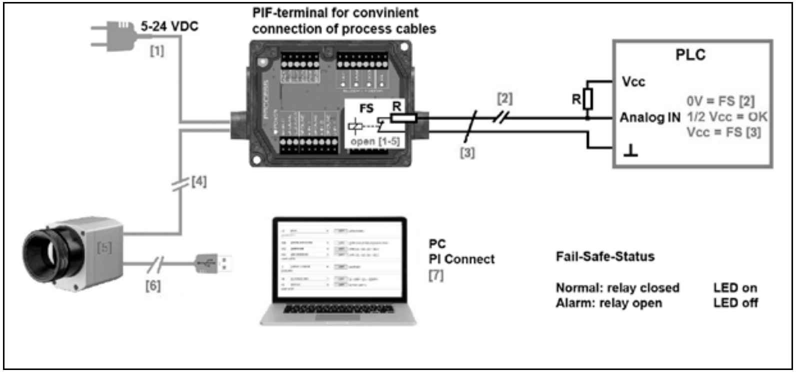


Figure 21: Fail-Safe monitoring states

Fail-Safe monitoring states

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

4.3 USB cable extension

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

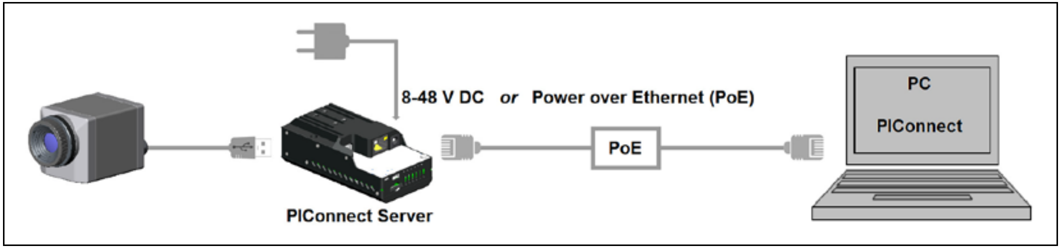


Figure 22: Ethernet direct communication with PI Netbox

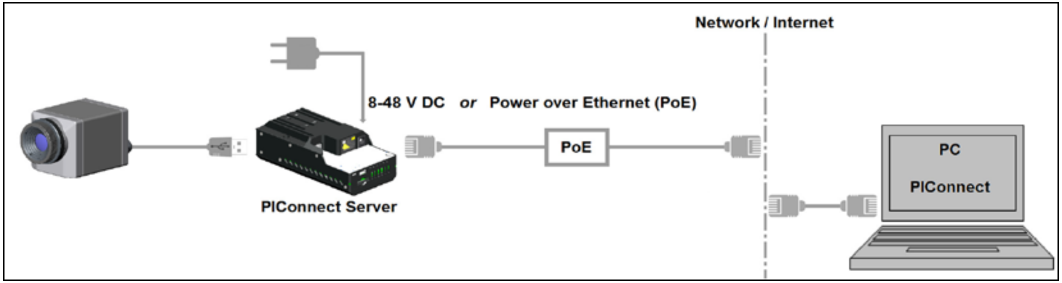


Figure 23: Ethernet network communication with PI Netbox

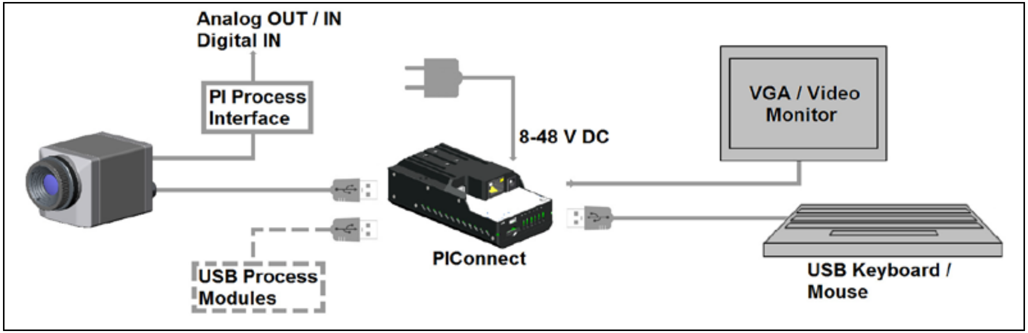


Figure 24: Stand-Alone operation with PI Netbox

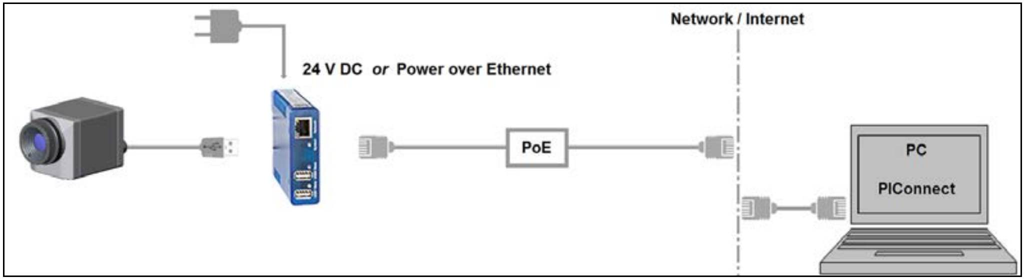


Figure 25: USB Server Gigabit

5 Software PIConnect

Minimum system requirements:

- Windows Vista, Windows 7, Windows 8
- USB interface
- Hard disc with at least 30 MByte of free space
- At least 128 MByte RAM
- CD-ROM drive

A detailed description is provided in the software manual on the software CD.

5.1 Installation and initial start-up

Uninstall previous versions of the PI Connect before installing the new software. To uninstall the software from your system use the **Uninstall** icon in the start menu.

1. Insert the installation CD into the according drive on your computer. If the **autorun option** is activated the installation wizard will start automatically.

2. Otherwise start **`setup.exe`** from the CD-ROM. 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\PIConnect`

To uninstall the software from your system use the **`uninstall`** icon in the start menu.

1. To connect the camera to the PC, plug the USB cable to the camera first. Afterwards connect it with the PC.

2. To disconnect the camera and the computer remove the USB cable from the computer first and then disconnect it from the camera.

After the software has been started the live image from the camera is shown inside a window on your PC screen.

3. Install the calibration data at first start of the software (supplied on the CD).

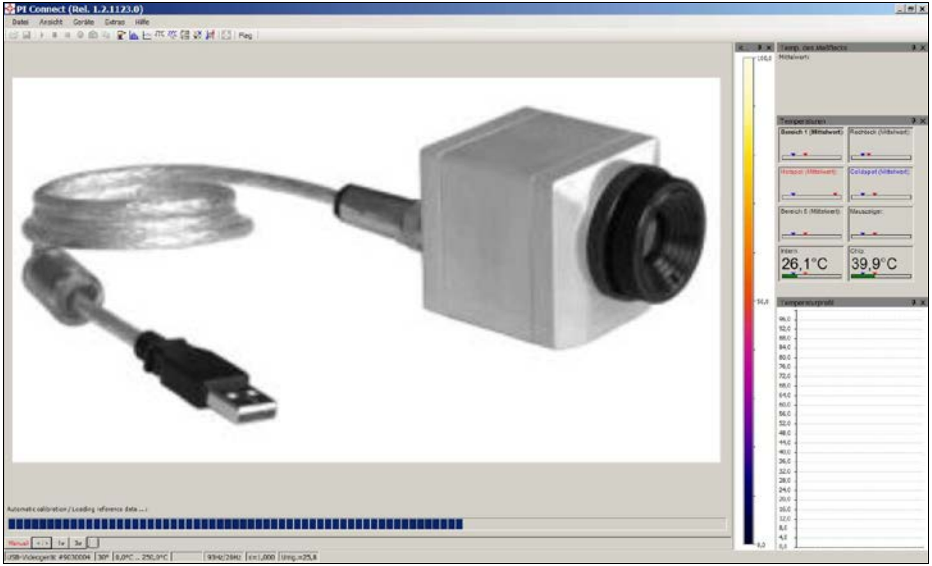


Figure 26: Calibration data transfer

4. If necessary adjust the sharpness of the image by turning the exterior lens ring at the camera.

5.2 Software window

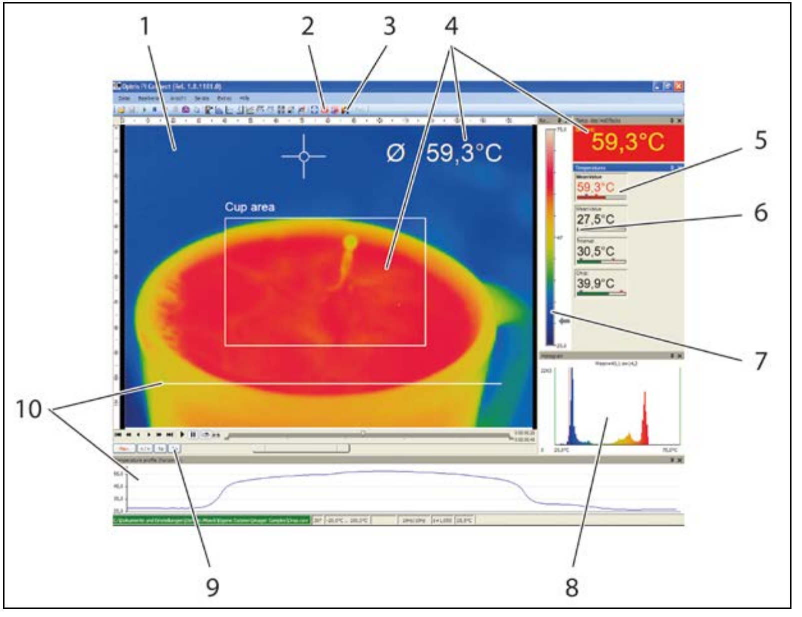


Figure 27: Software window

1 IR image from the camera

2 Icon for quick access to Image subtraction function

3 Icon enabling switching between color palettes

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 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 Control displays: Displays all temperature values in the defined measure areas like Cold Spots, Hot Spots, temperature at cursor, internal temperature and chip temperature

7 Reference bar: Shows the scaling of temperature within the color palette

8 Histogram: Shows the statistic distribution of single temperature values

9 Automatic/ manual scaling of the palette (displayed temperature range): Man., </> (min, max),
1**σ** : 1 Sigma, 3**σ** : 3 Sigma

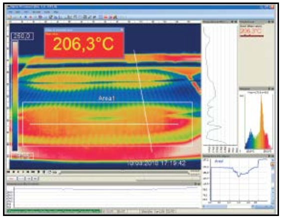
10 Temperature profile: Shows the temperatures along max. 2 lines at any size and position in the image

5.2.1 Basis features of the software PIConnect

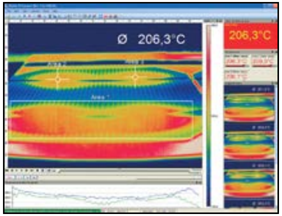
Extensive infrared camera software

- 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 Vista, 7 and 8

High level of individualization for customer specific display



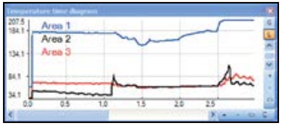
- Various language option including a translation tool
- Temperature display in °C or °F
- Different layout options for an individual setup (arrangement of windows, toolbar)
- Range of individual measurement parameter fitting for each application
- Adaption of thermal image (mirror, rotate)
- Individual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



Video recording and snapshot function (IR or BI-SPECTRAL)

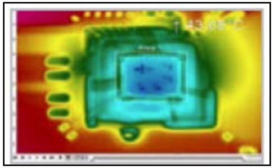
- Recording of video sequences and detailed frames for further analysis or documentation
- BI-SPECTRAL video analysis (IR and VIS) in order to highlight critical temperatures
- Adjustment of recording frequency to reduce data volume
- Display of snapshot history for immediate analysis

Extensive online and offline data analysis



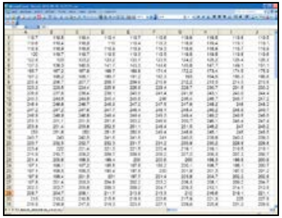
- Analysis supported by measurement fields, hot and cold spot searching, image subtraction
- Real time temperature information within main window as digital or graphic display (line profile, temperature time diagram)
- Slow motion repeat of radiometric files and analysis without camera being connected
- 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
- BI-SPECTRAL process monitoring (IR and VIS) for easy orientation at point of measurement
- Definition of visual or acoustic alarms and analog data output
- Analog and digital signal input (process parameter)
- External communication of software via Comports 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 Photoshop or Windows Media Player (*.avi, *.tiff)
- Data transfer in real time to other software programs DLL or Comport interfaces

6 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.

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

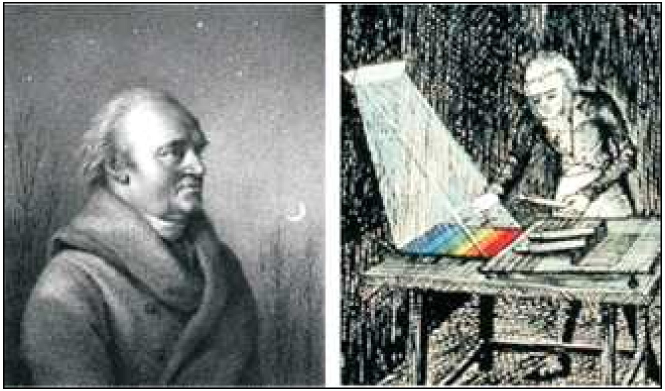


Figure 28: William Herschel (1738-1822)

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”.

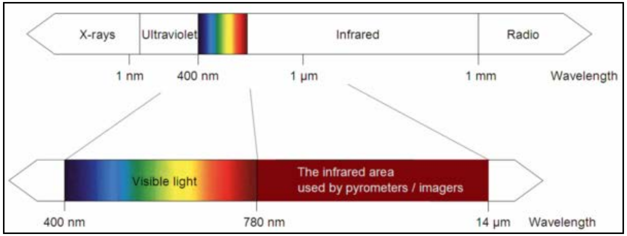


Figure 29: The electromagnetic spectrum and the area used for temperature measurement

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.

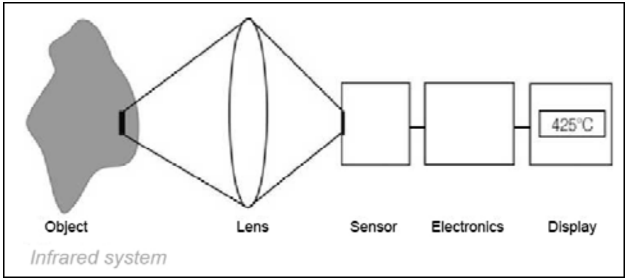


Figure 30: Main principle of noncontact thermometry

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.

The advantages of noncontact thermometry 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

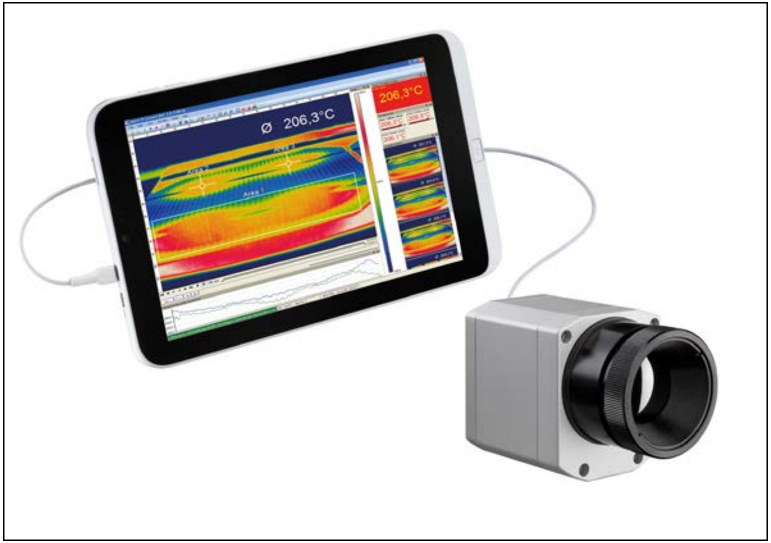
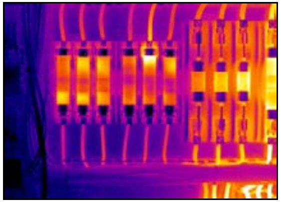
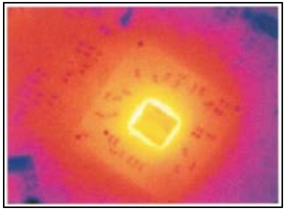


Figure 31: Non-contact thermometry

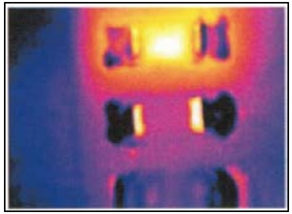
Application field:



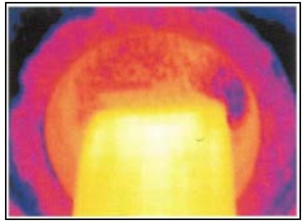
Monitoring of electronic cabinets



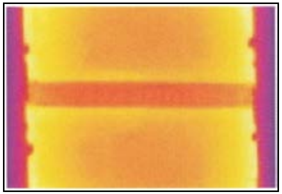
R&D of electronics



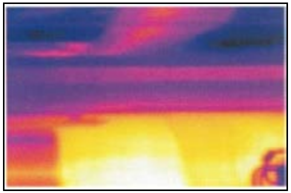
R&D of electronic parts



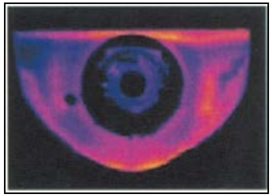
Process control extruding plastic parts



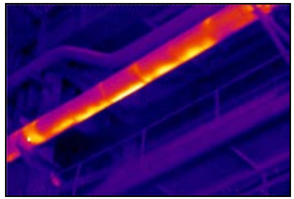
Process control manufacturing solar modules



Process control at calendering



R&D of mechanical parts

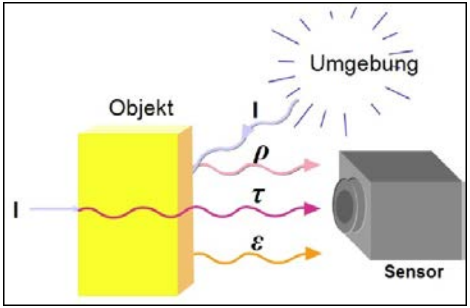


Monitoring of cables

7 Emissivity

7.1 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.



I Passed radiation

ε Reflection

ρ Transmission

τ Emissivity=Absorption

$$\varepsilon + \rho + \tau = 1$$

Figure 32: Capability of an object to emit radiation

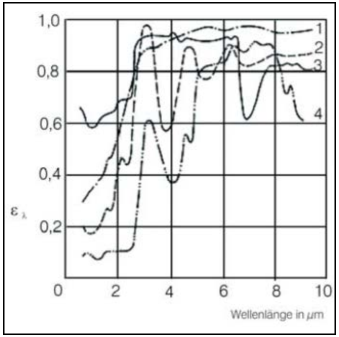


Figure 33: Spectral emissivity of several materials: **1** Enamel, **2** Plaster, **3** Concrete, **4** Chamotte

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.

7.2 Determination of unknown emissivity

► 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 (emissivity dots – **Part No.: ACLSED**) onto the measuring object, which covers it completely.

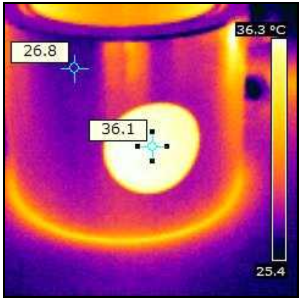


Figure 34: Plastic sticker at metal surface

1. Set the emissivity to 0.95 and take the temperature of the sticker.

2. 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. 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.

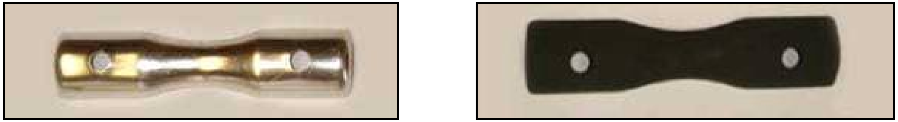


Figure 35: Shiny metal surface **left** and blackened metal surface **right**

4. 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.

7.3 Characteristic emissivity

In case none of the methods mentioned above help to determine the emissivity you may use the emissivity table ►**Appendix A** and **Appendix 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)

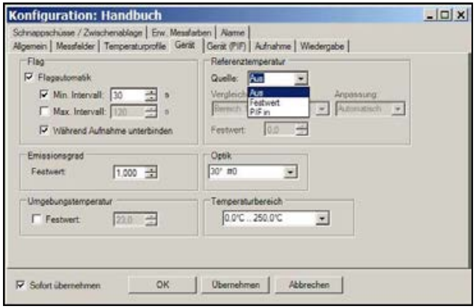


Figure 36: Adjustment of the emissivity in the software PI Connect (menu **Configuration/ Device**)

Appendix A – Table of emissivity for 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 – Table of emissivity for 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 – Quick start for serial communication

Introduction

One special feature of the PI Connect software contains the possibility to communicate via a serial comport interface. This can be a physical comport or a Virtual Comport (VCP). It must be available on the computer where the PI connect software is installed.

Setup of the interface

1. Open the **`Options`** dialog and enter the tab “**`Extended Communication`**” to enable the software for the serial communication.

2. Select the mode “**`Comport`**” and choose the appropriate port.

3. 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).

These parameters are used in many other communication devices too. The other station must support 8 bit data.

4. Connect the computer with the communication device. If this is a computer too, use a null modem cable.

Command list

The command list is provided on the software CD. Every command must expire with CR/LF (0x0D, 0x0A).

Appendix D – Interprocess Communication (IPC)

The description of the initialization procedure as well as the necessary command list is provided on the CD.

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 **ImagerIPC.dll** are designed for Windows Vista/ 7/ 8 only. The application must support call-back functions.

The **ImagerIPC.dll** will export a bunch of functions that are responsible for initiating the communication, retrieving data and setting some control parameters.

Appendix E – PI Connect Resource Translator

A detailed tutorial is provided on the CD.

PI Connect is a **`.Net Application`**. Therefore it is ready for localization. Localization as a Microsoft idiom means a complete adaption of resources to a given culture. Learn more about the internationalization topics consult Microsoft's developer documentation on

http://msdn.microsoft.com/en-us/goglobal/bb688096.aspx.

If desired the localization process can be illustrated in detail. Also the resizing of buttons or other visible resources and the support of right-to-left-languages are supported. Experts who have the appropriate tools should handle it. Nevertheless we have developed the small tool "**`Resource Translator`**" to make the translation of the resources of the PI Connect application possible for everybody.

This tool helps to translate any visible text within the PI Connect application.

Appendix F – Wiring diagrams PIF

Analog Output:

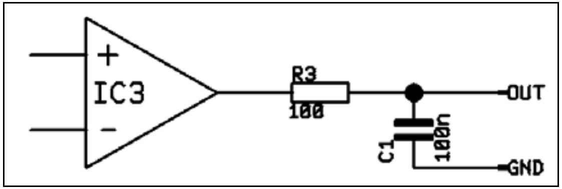


Figure 37: Analog output

For voltage measurements the minimum load impedance must be 10KOhm.

The analog output can be used as a digital output too. The voltage for “**`no alarm`**” and “**`alarm on`**” is set within the software. The analog output (0 … 10 V) has a 100 Ohm resistor in series. With a maximum current of 10 mA the voltage drop is 1 V.

To use an alarm LED with a forward voltage of 2 V the analog output value for “**`alarm on`**” must be 3 V as maximum.

Digital Input:

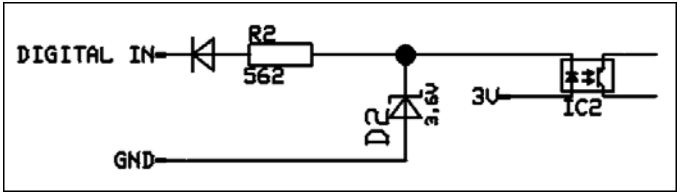


Figure 38: Digital input

The digital input can be activated with a button to the PI GND-Pin or with a low level CMOS/TTL signal: Low level 0…0.6 V; High level 2…24 V

Example Button:

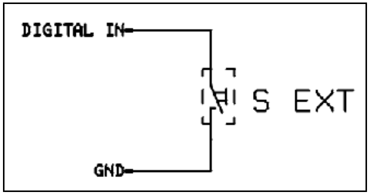


Figure 39: Button

Analog input (usable voltage range: 0 … 10 V):

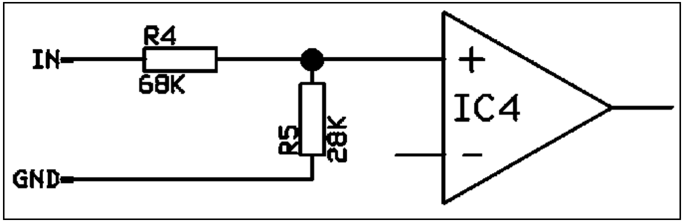


Figure 40: Analog input

Relay output at industrial PIF [Part No.: ACPIPIF500V2CBxx]

The analog output must be set to “Alarm”. The voltage level for AO1-AO3 can be set in the software (no alarm: 0 V/ alarm: 2-10 V)

REL1-3 (DO1-DO3): U_{max} = 30 VDC

I_{max} = 400 mA

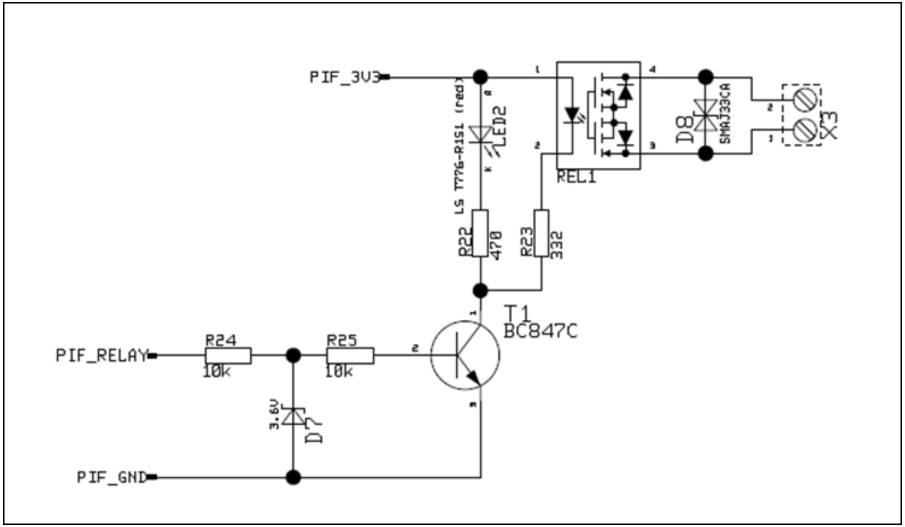


Figure 41: Relay output at industrial PIF

Appendix G – CE Conformity

optris infrared thermometers

EG-Konformitätserklärung
EU Declaration of Conformity

Wir / We

Optris GmbH
Ferdinand Buisson Str. 14
D-13127 Berlin

erklären in alleiniger Verantwortung, dass
declare on our own responsibility that

die Produktserie optris PI
the product group optris PI

den Anforderungen der EMV-Richtlinie **2004/108/EG** und der Niederspannungsrichtlinie **2006/95/EG** entspricht.
meets the provisions of the EMC Directive **2004/108/EG** and the Low Voltage Directive **2006/95/EG**.

Angewandte harmonisierte Normen:
Applied harmonized standards:

EMV Anforderungen / EMC General Requirements:

EN 61326-1:2006 (Grundlegende Prüfanforderungen / Basic requirements)
EN 61326-2-3:2006

Gerätesicherheit von Messgeräten / Safety of measurement devices:

EN 61010-1:2010
EN 60825-1:2007 (Lasersicherheit / Laser safety)

Dieses Produkt erfüllt die Vorschriften der Richtlinie **2011/65/EU** des Europäischen Parlaments und des Rates vom 8. Juni 2011 zur Beschränkung der Verwendung bestimmter gefährlicher Stoffe in Elektro- und Elektronikgeräten.
This product is in conformity with Directive **2011/65/EU** of the European Parliament and of the Council of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment.

Berlin, 18.09.2014

Ort, Datum / place, date

Dr. Ulrich Kienitz
Geschäftsführer / General Manager