Operators Manual

Bottom-Up GIS
640i G7 and 450i G7

Glass Inspection System

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Table of contents

Table of contents **3**

1 General notes **6**

1.1 Intended use 6

1.2 Warranty 7

1.3 Scope of supply 8

2 Technical Data **9**

2.1 Bottom-Up GIS 9

2.2 Factory default 14

2.3 Optical specifications 15

2.3.1 Camera 15

2.3.2 Pyrometer 19

3 Installation 21

3.1 Hardware installation 21

3.1.1 Scan line and FOV 23

3.1.2 Camera positioning 26

3.1.3 Shutter adjustment 28

3.1.4 Installation control cabinet 29

3.2 Software Installation 33

3.2.1 Set up of the USB-Server 33

3.2.2 Installation PIX Connect 33

3.2.3 Set up of the Software PIX Connect 34

3.2.4 Fine tuning of the Software PIX Connect 38

3.3 Electrical Installation 40

4 Operation 42

4.1 Maintenance 45

4.2 Glass breakage sensor CTL 4M 46

5 Basics of glass measurement 47

5.1 Reflection and transmission 47

5.2 Influence of different measuring wavelengths 49

5.3 Hardening of glass sheets 50

5.4 Angle dependency 50

Appendix A – Control cabinet 52

1 General notes

1.1 Intended use

Thank you for choosing the **optris®** **B**ottom **U**p **G**lass **I**nspection **S**ystem **(BUGIS)**.

This compact system is ideal for measuring glass and can be used for process control in glass tempering machines. This system consists of several components which are already pre-wired and ready for immediate use. The entire system is supplied with 24 V and is connected to a PC via an Ethernet cable. With the license free analysis software PIX Connect and a predefined layout the system can be used directly.

Features:

- Bottom-Up system with additional breakage detection sensor
- **D**igital **c**ontrolled **l**ens **p**rotection system (**DCLP**) avoids additional air purge and protects the camera lens
- Automatic calculation of the glass surface
- Automatic Adjustment of the scan line (**A**utomatic **L**ine **A**djustment – **ALA**)
- Pre-assembled system for easy installation as retrofit on glass tempering furnaces

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.

1.2 Warranty

Each single product passes through a quality process. Nevertheless, if failures occur please contact the customer service at once. The warranty period covers 24 months starting on the delivery date. After the warranty is expired the manufacturer guarantees additional 6 months warranty for all repaired or substituted product components. Warranty does not apply to damages, which result from misuse or neglect. The warranty also expires if you open the product. The manufacturer is not liable for consequential damage 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 supply

- 2x PI 640i G7 with 90° FOV or 2x PI 450i G7 with 80° FOV
- CTLaser 4M pyrometer for the breakage detection with electronic box
- 2x Shutter systems with mounting bracket and electronic box
- 2x USB-Server Gigabit 2.0 and 1x Ethernet switch
- Control cabinet (pre-assembled and pre-wired) with 10m cable set and 24V Power supply
- 2x Industrial Process Interface (PIF)
- Remote control (for trigger signal of shutter)
- USB stick with Software, Layout and calibration files
- Operators manual

2 Technical Data

2.1 Bottom-Up GIS

System	640i G7	450i G7
Temperature range	150-900°C or 200-1500°C	
Spectral range	breakage sensor: 2,2-6 µm Imager: 7,9 µm	
Optical resolution	640x480 Pixel VGA Up to 1600 points/line	382x288 Pixel Up to 955 points/line
Accuracy	± 2°C or ± 2%	
Frame rate / Scan speed	32Hz / 125 Hz @ 640x120 Pixel	80 Hz / switchable to 27 Hz
NETD / Temperature resolution	80 mK	150 mK
Ambient temperature camera	0 - 50 °C	0 - 70 °C
Ambient temperature pyrometer	0 - 70 °C	
Ambient temperature control cabinet	0 - 50 °C	

In- and Outputs	0-10 V Inputs, digital input, 3x 0/4-20 mA output or alarm-/Relais outputs
Interface	Integrated TCP/IP Ethernet interface via USB Server
Environmental rating	IP67
Dimensions:	Shutter: 116 x 57 x 121 mm control cabinet: 400 x 200 x 155 mm CTlaser 4M Pyrometer: L=100mm, Ø=55mm
Weight (complete system)	16,5 kg
Material	Stainless steal
Warm-up time	10 min

Table 1: Technical Data of Bottom Up GIS

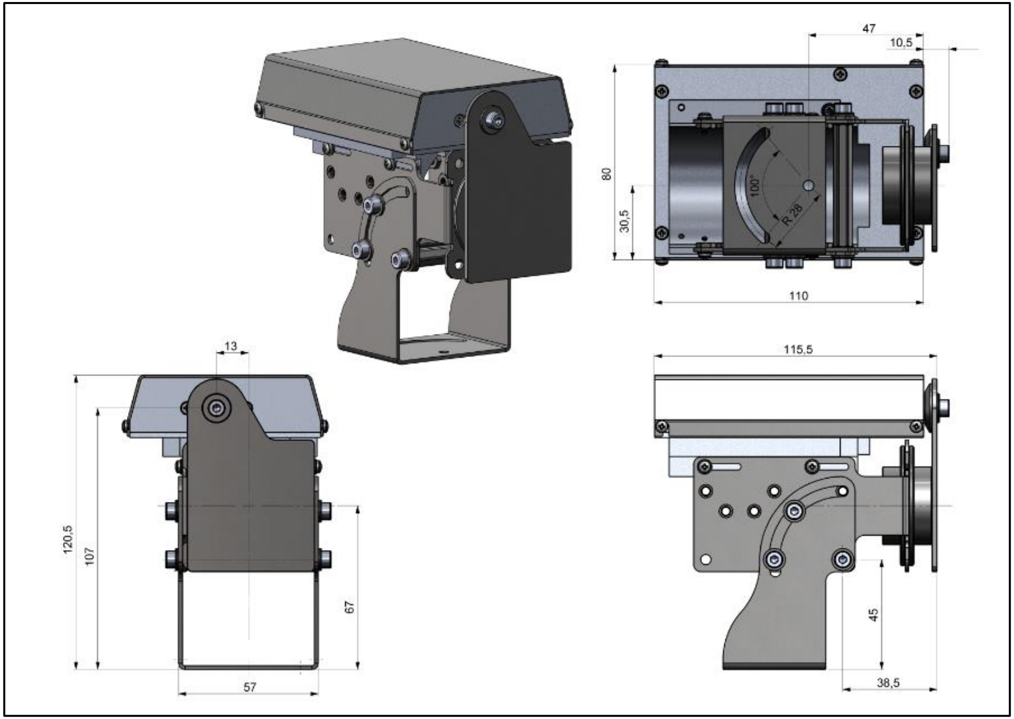


Figure 1: Dimensions [mm], shutter system

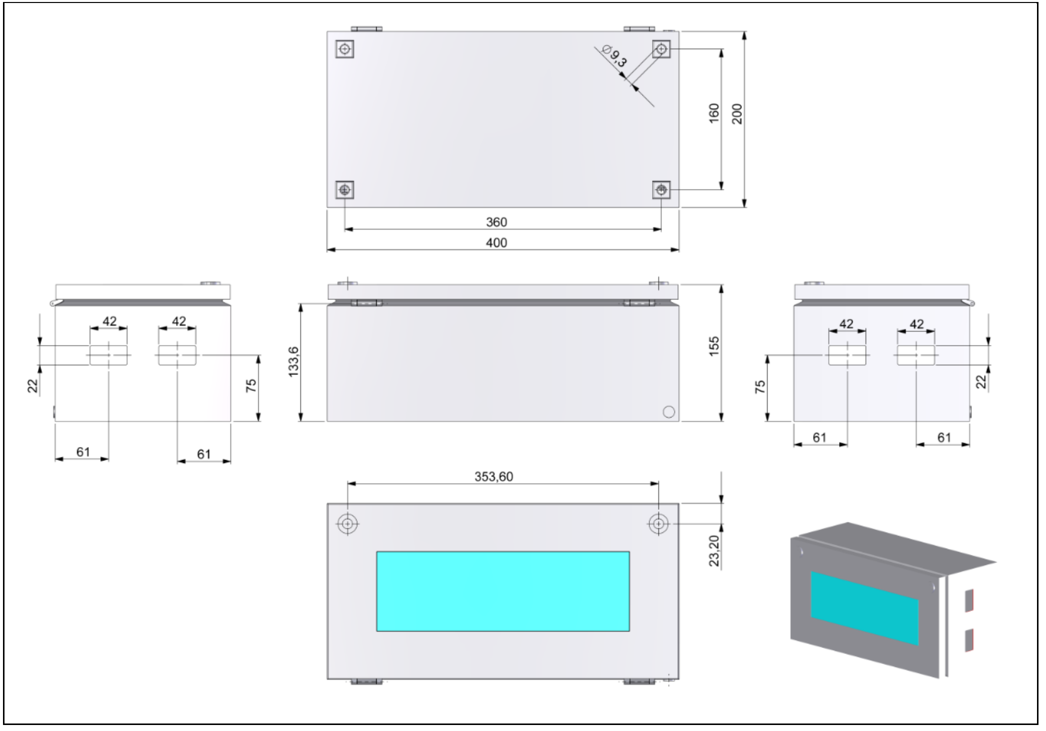


Figure 2: Dimensions [mm], control cabinet

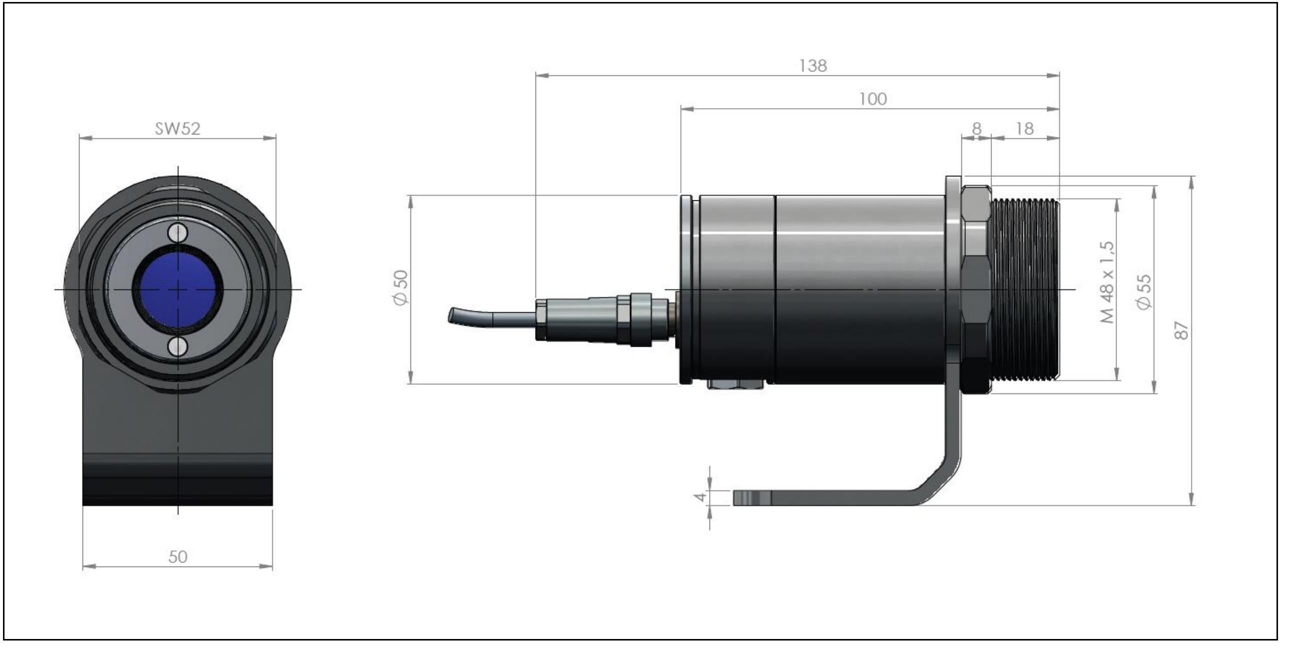


Figure 3: Dimensions [mm], CTL 4M

2.2 Factory default

The CTL 4M pyrometer is delivered with the following factory settings:

Emissivity	1,00
Exposure time (90%) [µs]	90
Averaging (AVG)	inactive
Lower limit temperature range [°C]	0
Upper limit temperature range [°C]	500
alarm limit (AL2) [°C]	300
Alarm source and alarm mode	Tproc - normally open
Temperature unit	°C
Baud rate [kBaud]	921,6

You can change the settings either directly with the CompactPlusConnect software or via the programming keys on the electronics box

2.3 Optical specifications

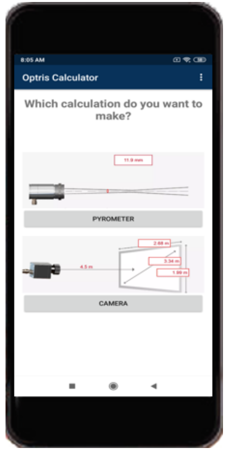
2.3.1 Camera

Make sure that the focus of thermal channel is adjusted correctly. If necessary, focus the thermal imaging camera with the optics (**Figure 4**). The turning out of the optics leads to the focus setting "near" and the turning in of the lens to the focus setting "infinity".

Note: The focus of the optics is set at the factory to an object distance of 90 cm (camera lens to measurement object - **A** in **Figure 7**). The optics only must be focused if the distance is not equal to 90 cm. When refocusing the optics, the shutter must also be adjusted (see **chapter 3.1.3** on page **28**).

Figure 4: Focusing by turning the exterior lens ring of camera

The following table with examples shows 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 PIX Connect has an algorithm which corrects this distortion. As an alternative to the tables below, the optics calculator can also be used on the optris website or via the optris calculator app. The app can be downloaded for free from the Google Play Store (see QR code).



PI 640i / PI 640i G7 640 x 480 px	**Focal length [mm]**	**Minimum measurement distance***	**Angle**	**Distance to measurement object [m]**												
					0.05	**0.1**	**0.2**	**0.3**	**0.5**	**1**	**2**	**4**	**6**	**10**	**30**	**100**
O33 Standard lens	19	0.2 m	33°	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	28.0	93.3
O15 Telephoto lens	42	0.5 m	15°	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
O60 Wide angle lens	11	0.2 m	60°	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
O90 Super wide angle lens	8	0.2 m	90°	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

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

PI 400i / 450i PI 450i G7 382 x 288 px	Focal length [mm]	Minimum measurement distance*	Angle	Distance to measurement object [m]												
					0.05	0.1	0.2	0.3	0.5	1	2	4	6	10	30	100
O29 Standard lens	13	0.35 m	29°	HFOV [m]		0.060	0.11	0.17	0.27	0.53	1.06	2.1	3.2	5.3	15.8	52.5
			22°	VFOV [m]		0.044	0.083	0.12	0.20	0.39	0.78	1.5	2.3	3.9	11.6	38.5
			37°	DFOV [m]		0.075	0.14	0.21	0.34	0.66	1.31	2.6	3.9	6.5	19.5	65.1
			1.4 mrad	IFOV [mm]		0.2	0.3	0.4	0.7	1.4	2.8	5.5	8.3	13.8	41.2	137.4
O18 Telephoto lens	20	0.5 m	18°	HFOV [m]				0.102	0.16	0.33	0.66	1.3	2.0	3.3	9.8	32.5
			14°	VFOV [m]				0.076	0.13	0.25	0.50	1.0	1.5	2.5	7.4	24.7
			23°	DFOV [m]				0.127	0.21	0.41	0.83	1.6	2.5	4.1	12.3	40.9
			0.9 mrad	IFOV [mm]				0.3	0.4	0.86	1.7	3.4	5.1	8.5	25.6	85.2
O53 Wide angle lens	8	0.25 m	53°	HFOV [m]	0.059	0.107	0.21	0.31	0.51	1.01	2.0	4.0	6.0	10.0	29.9	99.5
			38°	VFOV [m]	0.041	0.076	0.14	0.21	0.35	0.70	1.4	2.8	4.2	6.9	20.8	69.2
			65°	DFOV [m]	0.072	0.131	0.25	0.37	0.62	1.23	2.4	4.9	7.3	12.1	36.4	121.2
			2.7 mrad	IFOV [mm]	0.2	0.3	0.5	0.8	1.3	2.6	5.2	10.5	15.7	26.1	78.2	260.5
O80 Super wide angle lens	6	0.2 m	80°	HFOV [m]	0.093	0.17	0.33	0.49	0.81	1.6	3.2	6.5	9.8	16.6	49.9	166.4
			54°	VFOV [m]	0.059	0.11	0.21	0.31	0.52	1.0	2.0	4.1	6.1	10.2	30.6	101.9
			96°	DFOV [m]	0.110	0.21	0.39	0.58	0.96	1.9	3.8	7.7	11.6	19.5	58.5	195.1
			4.2 mrad	IFOV [mm]	0.2	0.5	0.9	1.3	2.1	4.2	8.5	17.0	25.7	43.6	130.7	435.5

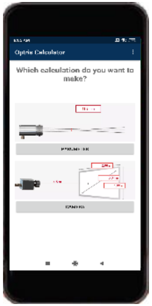
** Note: The accuracy of measurement can be outside of the specifications for distances below the defined minimum distance.*

2.3.2 Pyrometer

The following optical chart show the diameter of the measuring spot in dependence on the distance between measuring object and sensing head. The spot size refers to **90 % of the radiation energy**.

The distance is always measured from the front edge of the sensing head.

As an alternative to the optical diagrams, the spot size calculator can also be used on the Optris website or via the Optris calculator app. The app can be downloaded for free from the Google Play store (see QR code).



D = Distance from front of the sensing head to the object

S = Spot size

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

CTL 4M (FF optics)

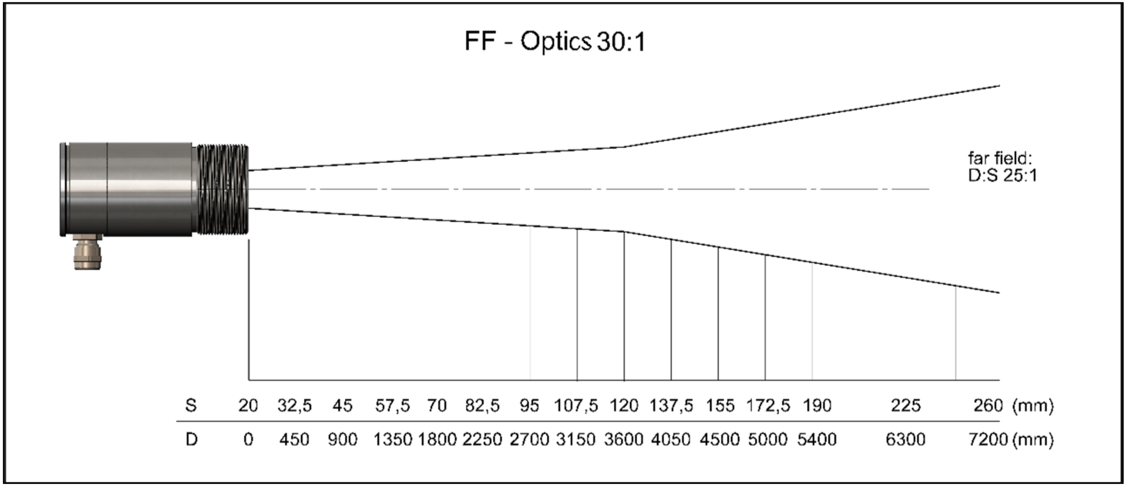


Figure 5: spot size diagram

3 Installation

3.1 Hardware installation

Basically the whole system consists of three main components:

- Temperature measuring system 1: 2 cameras with shutter (measurement from underneath)
- Glass breakage detection: high performance pyrometer (measurement from the side)
- Switch cabinet with complete electronic unit and remote control

Hardware and software recommendations:

- Computer with OS Windows 10 or higher
- i7 Processor 10th Generation with 2,6GHz or higher
- 16 GB RAM or higher

Note:

- The camera must be focused if the distance between the camera lens and the object (see **A** in **Figure 7**: schematic representation of the distances) is not equal to 90cm.
- After focusing the camera, the shutter must be adjusted (s. **Chapter 3.1.3** on **page 28**)
- Note the distance between the cameras (see **Figure 10** and **d** in **Figure 7**: schematic representation of the distances)
- Consider the minimum distance of the selected optics.
- For installation, the components must be detached from the profiles.

All components must be correctly positioned for the first commissioning of the entire system. Since all components are already pre-wired, they only have to be brought into the correct position. A suitable position for glass measurement is between the furnace and the immediately following annealing furnace. In most cases, there is a small slot there, which allows a contactless temperature measurement. The glass is transported on horizontal rollers. **Figure 6** shows a classical glass tempering process.

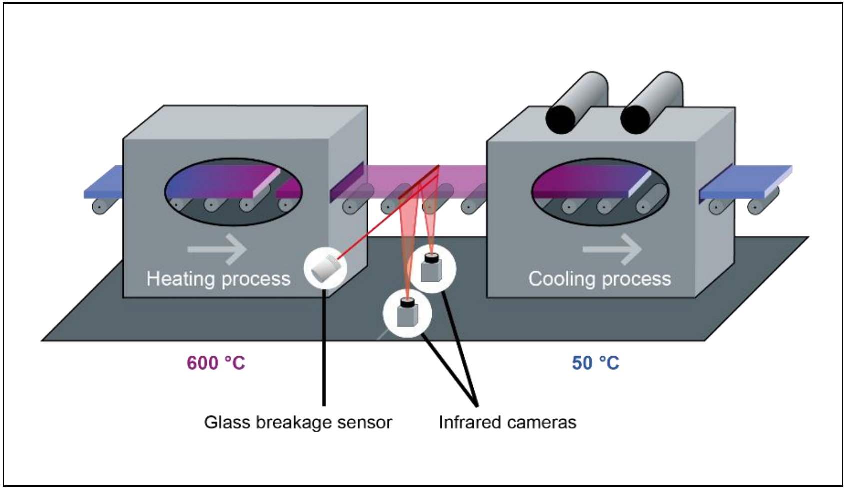


Figure 6: Process of glass production

After leaving the furnace, the glass must be cooled down after a relatively short time. The annealing furnace follows the heating furnace at a very short distance. Since glass is coated on the top size in most cases, a measurement from below has advantages. On this side the glass is uncoated. Two thermal imaging cameras are required to display the individual glass sheets in a complete image. This is positioned on the floor as shown in **Figure 6**. More about this in chapter **5 Basics of glass measurement**. The software PIX Connect uses the Linescan and the Merge function to display a complete image although only one line is scanned.

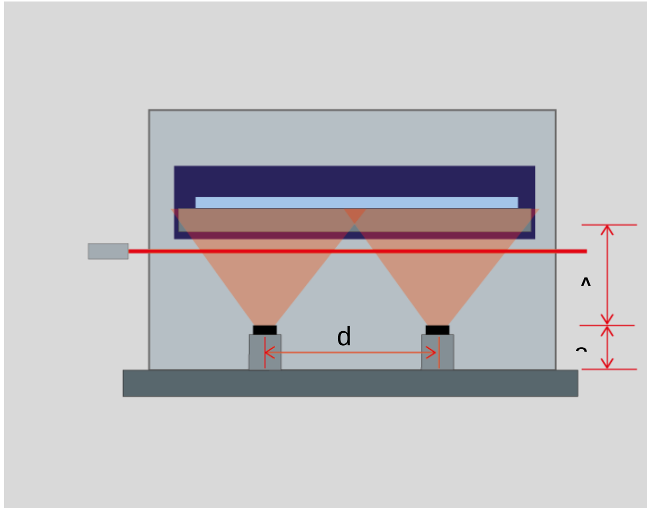


Figure 7: schematic representation of the distances

3.1.1 Scan line and FOV

The scan line is an important tool to display the thermal image and calculate the produced glass area. Detailed instructions for setting up the line scanning function can be found in the folder *Documentation/ Manuals/ PIX Connect-MA-E20xx-xx-X.pdf*

The width of the glass surface or the width of the oven should be covered by the scan line completely. The maximum width of the scan line depends on the distance between the camera lens and the measurement object (**A** in **Figure 7**) and on the selected configuration – diagonal or horizontal setup.

The diagonal setup increases your scan line (black line in **Figure 8**) and your field of view (**FOV** – **F**iled **o**f **V**iew)**.**

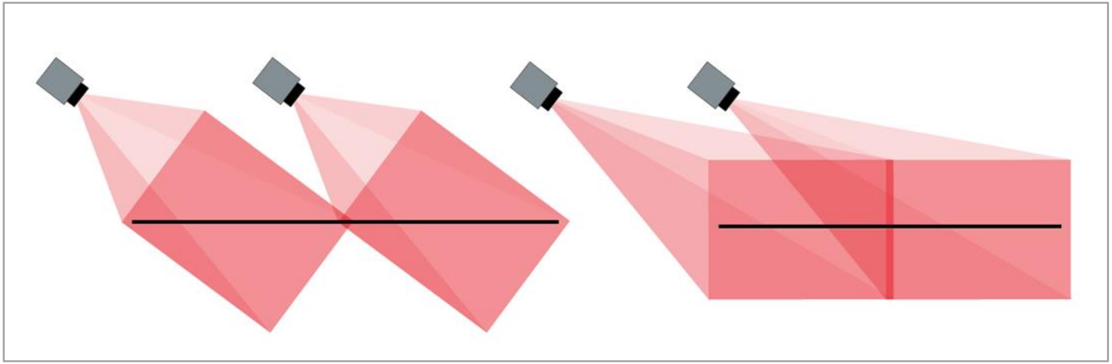


Figure 8: camera setup; left: diagonal; right: horizontal

The following diagram shows the maximum scan line width as a function of the distance from the ground to the object (a distance from the ground to the camera lens **a** in **Figure 7** of 155mm was assumed) and depending of a chosen system.

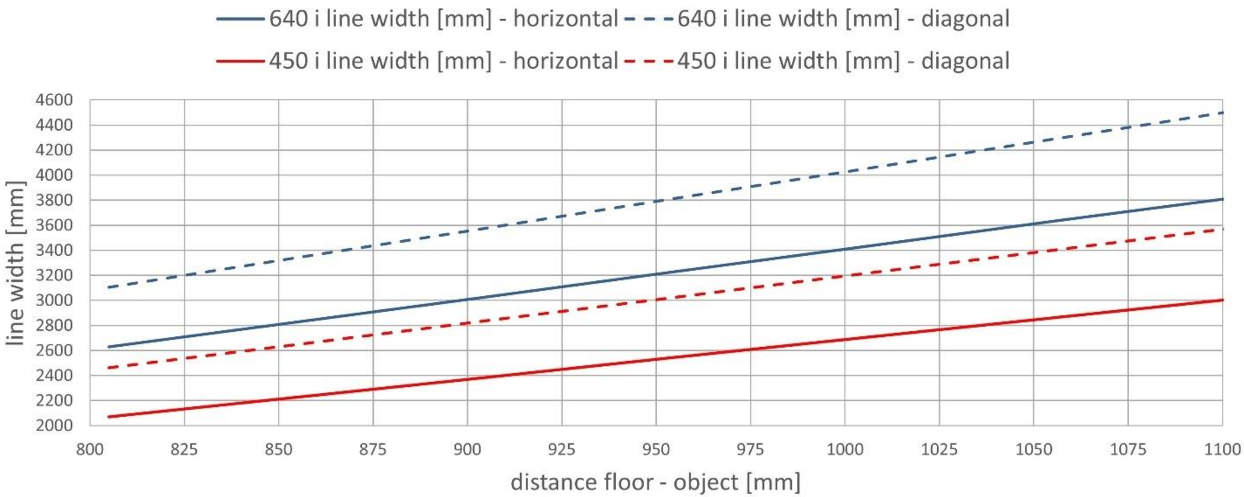


Figure 9: maximum line width

3.1.2 Camera positioning

For the positioning of the cameras, the following diagram (see **Figure 10**) showing the distance between the cameras (**d** in **Figure 7**) depending on the chosen system (640i G7 vs. 450i G7 or horizontal vs. diagonal setup) and the distance ground to object (**a+A** in **Figure 7**) is used.

Once the cameras are positioned, they must be focused to the object. Focusing is not required at the object distance camera lens to measurement object (**A** in **Figure 7**) of 90cm, this distance is factory-focused.

As soon as the camera has been focused, the shutter must be readjusted, see **Chapter 3.1.3** on **page 28**. The fine-adjustment of the camera position is carried out later when the PIX Connect software will be started up.

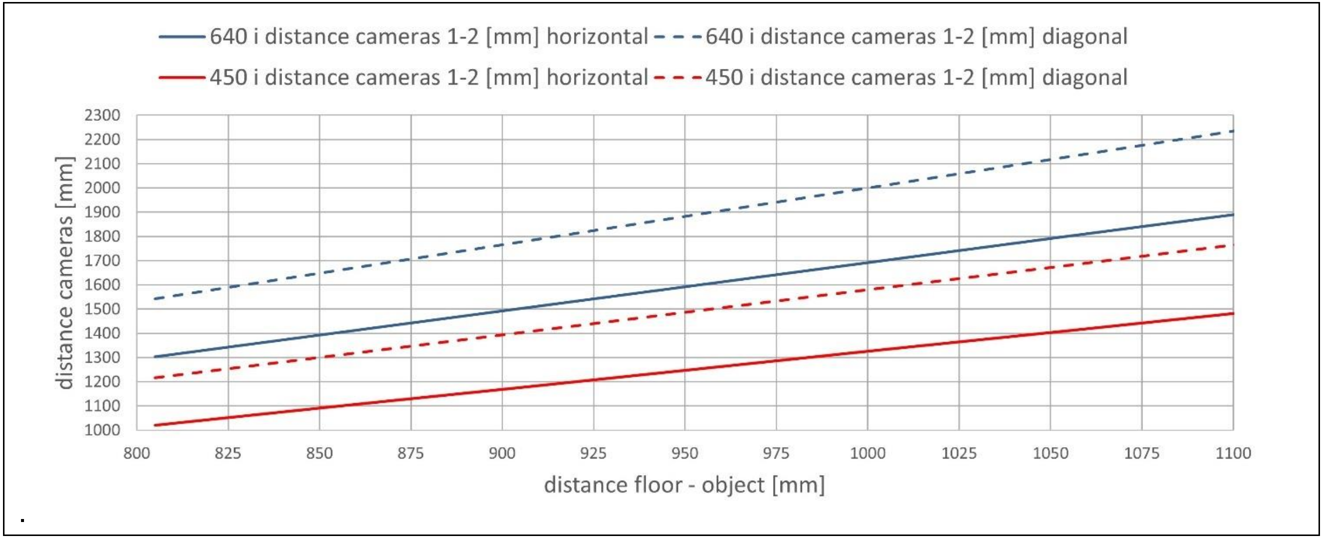


Figure 10: camera distance

3.1.3 Shutter adjustment

Open the shutter via the remote control. If necessary, readjust the focus.

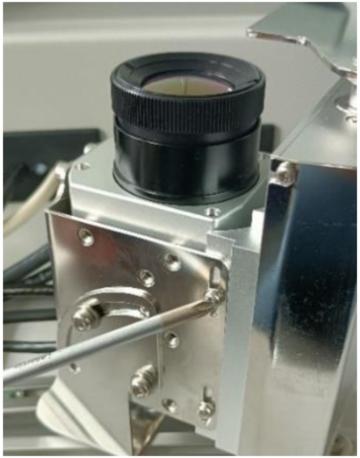


Figure 11: Shutterhousing left side

Loosen the screws on both sides of the shutter housing (see pictures on the right and left).

It is not necessary to unscrew these screws completely.

Lift the shutter housing and close the shutter via the remote control above the lens.

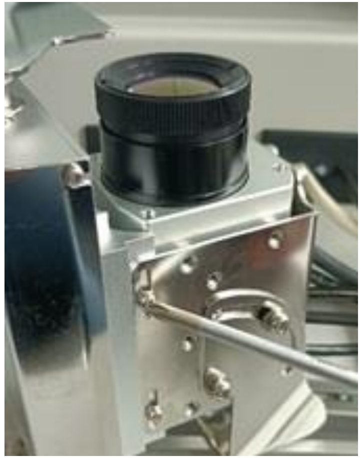


Figure 12: Shutterhousing right side

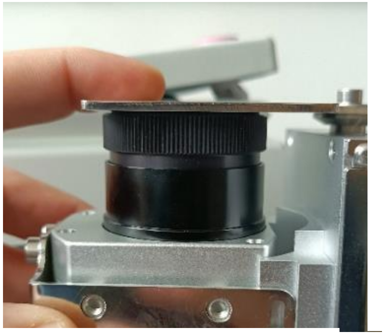


Figure 13: Gap between shutter and lens

Sink the shutter housing above the lens and tighten the screws.

There must not be any gap between lens and shutter (see **Figure 13**)

Now the shutter is adjusted.

3.1.4 Installation control cabinet

Now the control cabinet (**Figure 14**) must be moved to a suitable position. The individual cable lengths are 10 m. Therefore, make sure that the switch cabinet is no further than 10 m from the cameras or breakage sensor. Furthermore, make sure that it is not mounted in the immediate vicinity of hot ambient temperatures. Furthermore, it should be easily accessible, because the trigger signal from the oven must be connected here.

Figure 14: **Control cabinet**

The cables of the cameras, the pyrometer and the shutter boxes can be disassembled for easier cable laying. The cables on the cameras and pyrometer are screwed and can be easily unscrewed for disassembly. When reassembling the cables, make sure that the master and slave of the cameras are not mixed up.

The cables are marked according to the wiring diagram and, for better orientation, blue color marks the master and the red color marks the slave.

To dismantle the cables on the shutter box, loosen the four screws on the shutter box housing (it is not necessary to loosen the screws completely). Remove the cover of the shutter housing by tilting it backwards and pulling upwards. Now the end of the cable (**Figure 15** in red) can be seen on the shutter box. Now loosen the screw for the strain relief under the cover and pull out the slide (**Figure 15** in blue). Now you can unscrew the shutter cable and, after laying the cable, reassemble it in the reverse order.

Figure 15: cables access inside the shutterbox

Now that the three main components have been successfully assembled, two connections must be connected. The first connection is the Ethernet cable to a computer or switch. The second connection is the power supply. The entire system is supplied with 24 V. The power supply unit is included in the delivery.

If your machine has a power supply of 24 V DC with a current of at least 3A, the entire system can be supplied by the machine and the power pack can be omitted.

Another component of the system is the remote control. With this unit the shutters can be opened and closed again. During the first installation it is necessary to align the devices. This can only be done when the shutters are open.

When the system is powered, the yellow LED is on and the shutters are closed. When the button is pressed, the shutters are opened and the LED goes off.

Figure 16: Remote control

Further notes and information on glass measurement can be found in chapter **5 Basics of glass measurement**.

3.2 Software Installation

After having connected your Hardware, you can start with the configuration in the PIX Connect software.

The steps in **chapters 3.2.1** to **3.2.3** are mandatory and the steps in **chapter 3.2.4** are optional and is only used to calculate the produced glass area.

Now that you have successfully connected your hardware, you can start with the configuration in the PIX Connect software.

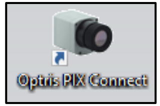
3.2.1 Set up of the USB-Server

But before you start the PIX Connect, you must first set up the USB server. On the supplied USB stick, in the folder USB Sever, you will find two software programs (**WuTility** and **USB Redirector**) that are required for the installation of the whole system. Detailed instructions for setting up the server can be found in the folder *Documentation/ Manuals/ ACPIUSBSGB-QSG-Dxxxx-xx-x*.

3.2.2 Installation PIX Connect

After successful integration of the USB server on your computer, the software PIX Connect can be installed. This software is also on the USB stick and can also be downloaded here. To install the software, open the **Setup.exe**.

After the installation the software can be opened. When using the camera for the first time, the calibration files must be downloaded from the Internet. This happens automatically, your PC hast to be connected to the internet. Alternatively, they can also be downloaded from the USB stick.



3.2.3 Set up of the Software PIX Connect

The software starts with a so-called standard layout. There are two special predefined layouts included in the software package. These are already customized for the glass system and contain all the necessary settings. To load them, you must first import them from the stick into the software. In the menu, go to **Tools → Layouts → Layots import/export → Layouts import** and select the two pre-configured layouts from the stick.

The software already contains two predefined layouts called "**BUGIS_Operation**”, “**BUGIS_Demo**” and “**BUGIS_Setup**”. You can load these layouts in the menu under **Tools** and **Load layout** and use it as a presetting.

The layout named " **BUGIS_Setup**" is used for aligning the cameras and **BUGIS_Demo** for demonstration and is set to be used for temperatures from 0 to 250°C.

The layout named " **BUGIS_Operation**" has been configured for the actual glass measurement. Here the temperature range of 150-900 °C is set.

Start the software PIX Connect and load the layout **BUGIS_Setup.**

Now the cameras can be fine-tuned. To do this, place a hot object in the center of the merged image so that the overlap of the two cameras captures that object. Adjust the camera positions so that the object appears correctly and is not distorted or duplicated.

In this setup the merged image from the two cameras with an overlap of 12 pixels is shown.

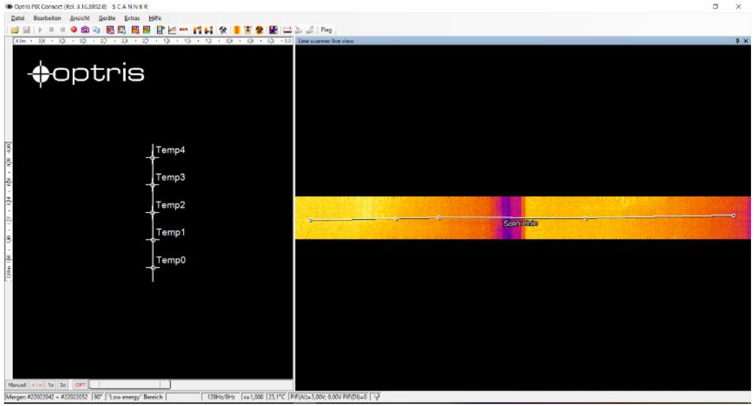


Figure 17: Layout BUGIS_Setup

The scan line can also be used as an aid to aligning the cameras to the glass between the rollers.

Later the scan line has to be set in the **BUGIS_Operation** layout

The scan line in the layout BUGIS_Setup is used for orientation and camera positioning. The final scan line will be adjusted, if necessary in the BUGIS_Operation layout.

Now start the layout BUGIS_Operation. The shutters must be open for this step. To do this, go to the Line scanner configuration via **Tools - Line scanner mode - Line scanner settings** under the tab *General* click on the *Continuous* mode. After the fine adjustment set the Line scanner configuration mode back to *External triggered.*

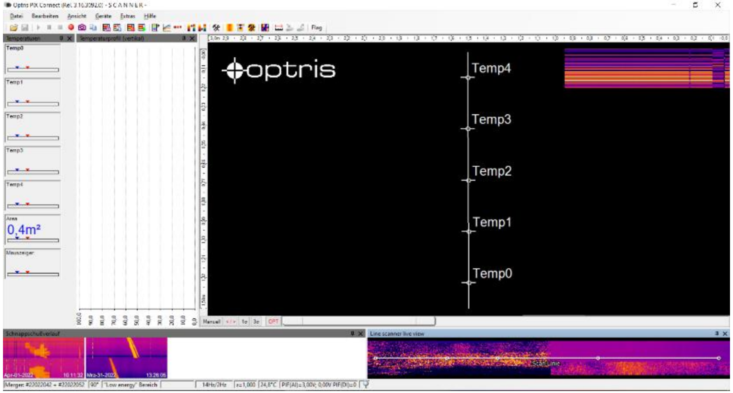


Figure 18: Layout BUGIS_Operation

Now a few settings have to be made. The scan line must be positioned correctly. The scan line can be moved in the lower right window (line scanner live view) in the specified 5 points by clicking and dropping. Alternatively, coordinates can also be entered via the line scan camera configuration via Line scanner configuration.

Make absolutely sure that the width of the scan line is at least as wide as the glass passes through. This ensures that the entire glass is scanned.

Take care to position of the scan line between the rollers of the conveyor system to avoid possible reflections.

You can use the **A**utomatic **L**ine **A**djustment (**ALA**) function. The scan line is automatically set over the temperature for the entire scan width. There must be a hot object (e.g., glass) on the rollers in the scan line field. Detailed instructions for setting up the line scanning function can be found in the folder *Documentation/ Manuals/ PIX Connect-MA-E20xx-xx-X.pdf*

The system is now ready and can be operated.

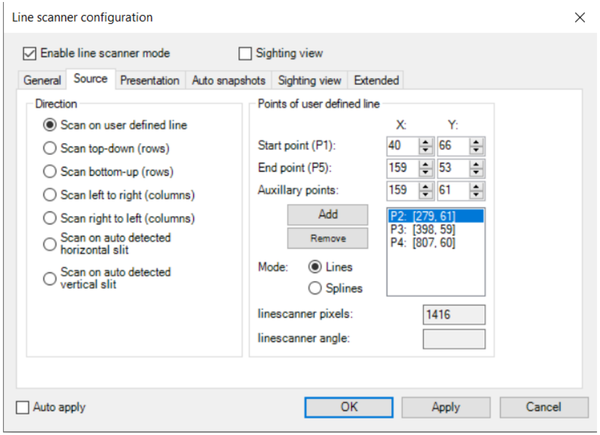


Figure 19: Line scanner settings

Additional settings, described in **3.2.4**, are required for the correct and undistorted display of the glass surfaces and the calculation of the glass surfaces.

Now you can use the system and start your temperature measurement.

3.2.4 Fine tuning of the Software PIX Connect

If you want to use the area calculation of the glass surfaces via the PIX Connect software or your thermal image of the glass is distorted, some modifications to the PIX Connect software are necessary.

Rectification of the IR image

The linescan is displayed in a metric format. The furnace is displayed in its dimension. This means that the length and width of the furnace must be specified in the software. To do this, go to the menu **Tools**, **Line scanner mode** and select **Line scanner settings**. A new window opens. Under the tab **Presentation** the parameters can be entered (see **Figure 20**).

Under **Width (Length of line)** and **Length (of scan)** the two parameters can be entered. To obtain an undistorted representation of the product at the end of a linescan, the **Feed rate** of the furnace is still required. This must also be entered. Then click on **OK**.

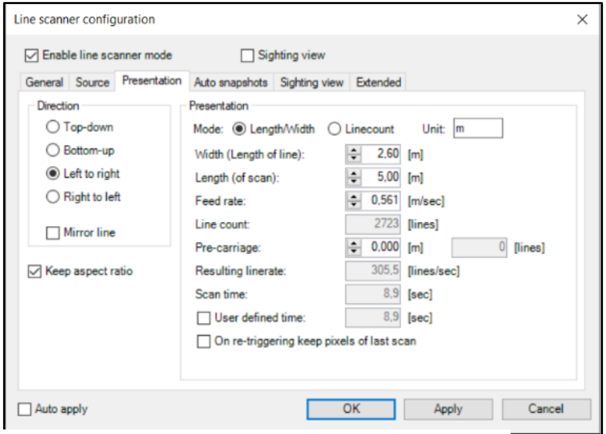


Figure 20: Line scanner settings

. Now the picture is shown undistorted.

Calculation of produced glass area

With the new specification of these values, the calculated produced glass area must still be adjusted. This indicates how much material is generated in one scan pass. To do this, go to **Tools** and **Configuration** in the menu. In the tab **Measuring area** click on the measuring area **Area**. On the right side under **Total area** you can enter the new value.

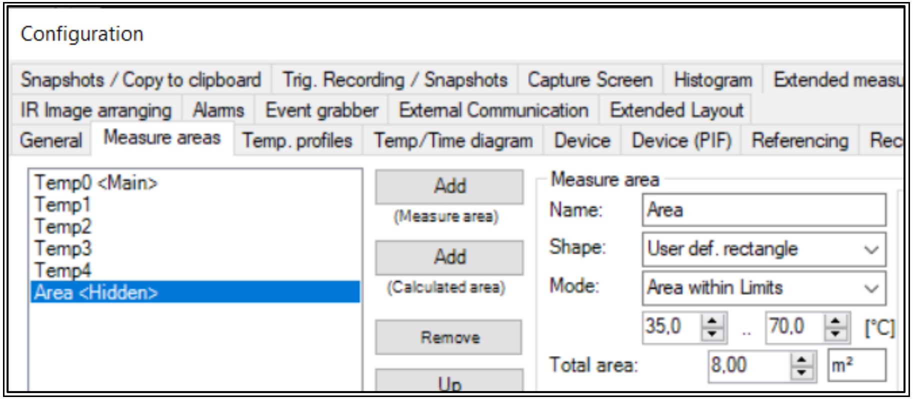


Figure 21: setup the of the calculation area

Now you can use the system and start your temperature measurement and calculation of produced glass area.

3.3 Electrical Installation

The delivered glass system is already pre-wired and is ready for operation without any additional electrical installation.

To integrate the input signal from the furnace with the glass inspection system, you must open the control cabinet. On the left side is a terminal block, which is connected to different colors of wires. These are labeled as follows (**Figure 23**).

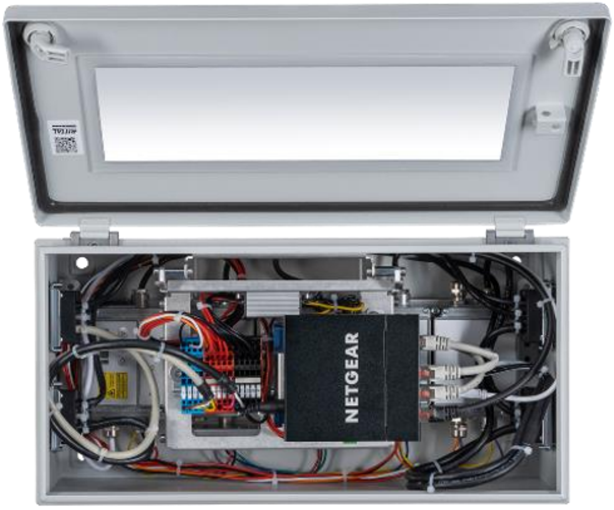


Figure 22: Control cabinet open

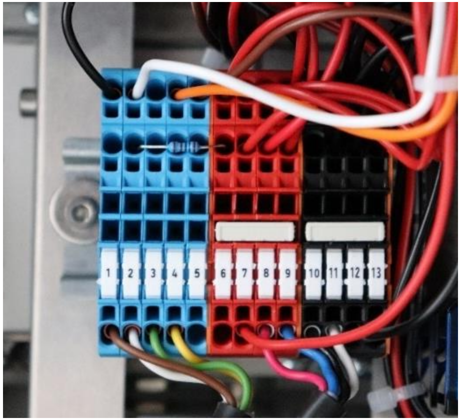


Figure 23: Terminal block

Designation

1. Ground
2. Shutter Status LED
3. Not assigned
4. Analog Input for the shutters – remote control
5. Analog Input for the shutters – external trigger
6. to 9: 24 V DC Power supply
10. to 13: Ground

The wiring of the furnace signal on the control cabinet is done under connection 5 (Input) and connection 10 (ground).

The input voltage range is 0 / max. 24 V. An open input is interpreted as a high signal. The signal must be switched to ground (0 V). If your system provides an open input as a low signal, the alarm mode must be changed from normally open to normally closed on the CTL 4M via CompactPlusConnect and the system must be restarted.

4 Operation

After successful hardware and software configuration and electrical installation, the operation of the system is very simple. With the existing layout and the signal of the furnace, the system runs autonomously.

The process procedure is as follows: The glass system gets the signal from the furnace: the signal opens the two shutters and the actual process starts. The software starts the linescan with 125 Hz and builds up the image line by line. In the end, a complete image of the product is created and automatically saved as a snapshot. Since each pixel is saved as a temperature value, an exact analysis can be performed afterwards.

In addition to maintaining the correct temperature, the software also displays the temperature distribution as a profile. Here it can be seen exactly how good the temperature distribution is on the glass and inhomogeneities can be easily detected.

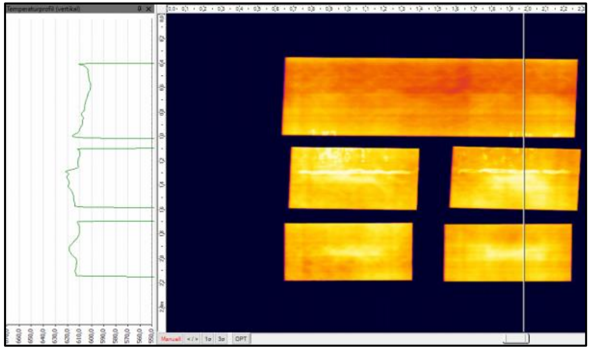


Figure 24: Temperature profile vertical

Furthermore, the amount of glass produced can be displayed in the software. In this way, it is possible to see how much glass has been produced in a linescan pass. This information can be found in the digital display group.

It is also possible to get the value of the calculated glass area via the analog output. In addition, the separately snapshots are saved after each scan and can subsequently be evaluated in terms of temperature and the produced glass area.

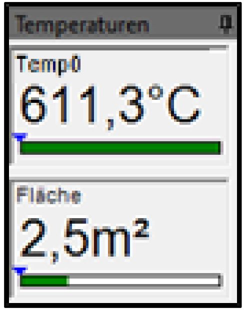


Figure 25: Digital display group

Another component of the system is the remote control. With this unit the shutters can be opened and closed again. During the first installation it is necessary to align the devices. This can only be done when the shutters are open.

When the system is powered, the yellow LED is on and the shutters are closed. When the button is pressed, the shutters are opened and the LED turns off.

Figure 26: Remote control

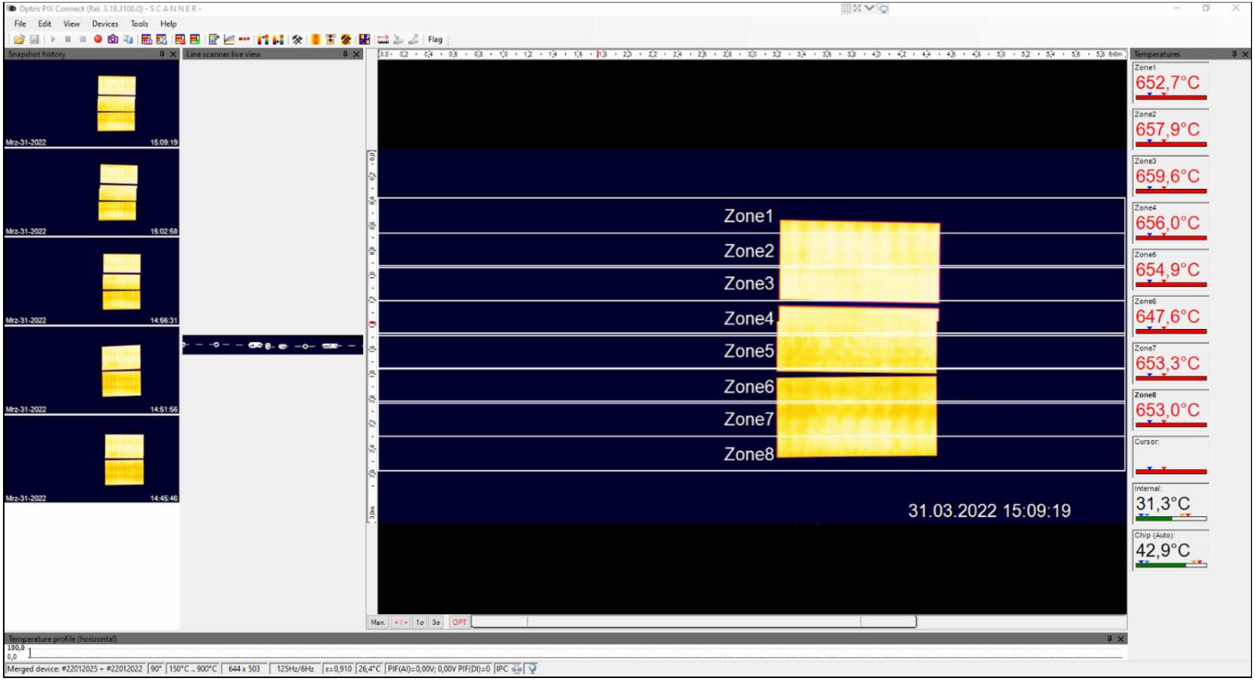


Figure 27: Linescan in PIX Connect software (customized Layout)

4.1 Maintenance

The system requires a maintenance check at regular intervals. Here, it should be checked whether the optics of the camera are clean, correctly focused and whether the shutter systems still function properly. This includes a complete opening and closing of the shutters. These points must be observed, as they have a direct influence on the temperature measurement.

Figure 28: Shutter open camera

Figure 29: Shutter closed camera

Figure 30: breakage sensor

Never use cleaning compounds which contain solvents (neither for the lens nor for the housing). The lens surface can be cleaned with a soft, humid tissue (moistened with water) or a lens cleaner (e.g. Purosol or B+W Lens Cleaner).

4.2 Glass breakage sensor CTL 4M

To protect the cameras, the glass inspection system is delivered with a glass breakage detection. For this purpose, the pyrometer CTL 4M is set up just below the scan line between the rollers. If a glass breaks into pieces and these fall between the rollers, the pyrometer recognizes this because of the ultra-fast reaction time of 90 µs and gives the shutters a signal to close.

The shutters are operated here in the so-called *fast mode*, so that the closing time is approx. 100ms. This prevents broken glass from damaging the camera lens. Furthermore, a signal can be output that a glass is broken.

5 Basics of glass measurement

In general, non-contact temperature measurement on glass is very suitable. However, the following points should be considered:

- Angle of view
- Emissivity
- Coatings
- Correct sensors
- Heat and dust

Also pay attention to the measuring depths:

- 1,0 to 3.9 µm for deep layers
- 5.0 and 7.9 µm for surface

5.1 Reflection and transmission

Reflection and transmission must be considered:

- For long wavelength devices 8-14 µm (LT) the emissivity ε is about 0.85.

- For devices with a wavelength range of 5.0 µm (G5) or 7.9 µm (G7) the emissivity ε is > 0.90 and there is a low angular dependence of the reflectivity ρ

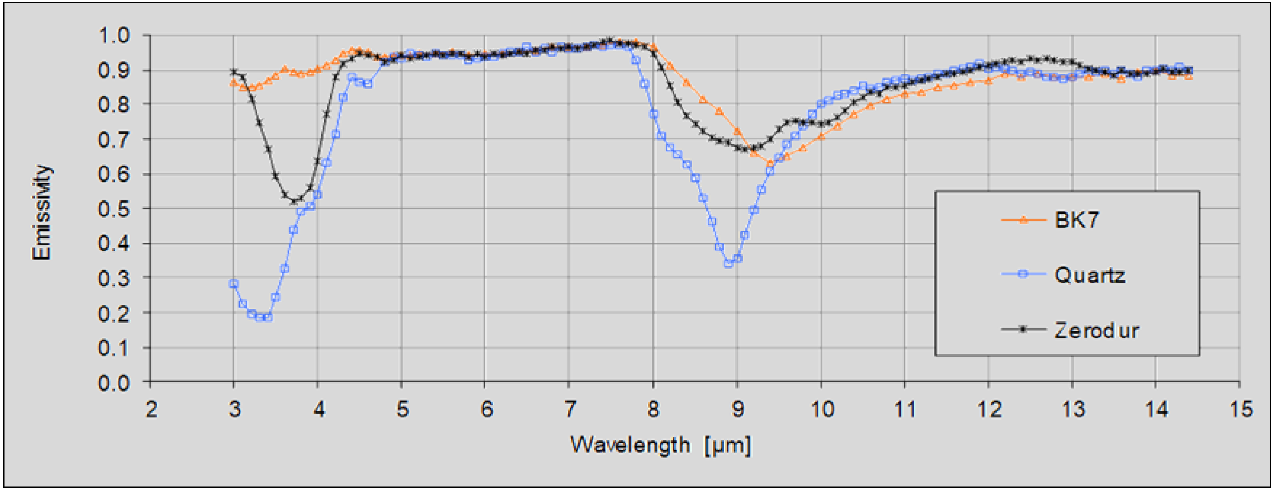


Figure 31: Representation of the emissivity over the wavelength for different glass types

The figure shows how the dependence of the emissivity of different types of glass behaves with respect to the wavelength. A good emissivity is present in the wavelength range 5.0 µm and 7.9 µm and is preferred for measurements on glass.

5.2 Influence of different measuring wavelengths

Spectral range	Sensor (Examples)	Purpose
8 - 14 µm	PI 640i, Xi 400	Low temperature, uncoated glass
7.9 µm	PI 640i G7, CTlaser G7	High temperature, coated glass
5.0 µm	CTlaser G5	
1.0 µm	PI 1M	molten glass, looking in/through glass

The table gives an overview for which purpose which wavelength and therefore which sensor must be used. This depends, among other things, on the material, the temperature and the coating.

5.3 Hardening of glass sheets

- Temperature has a direct influence on glass quality
- Testing for the heating profile (temperature distribution)

Linescan function (line scanning) with PI camera from below.

Direct effects: Defective or inhomogeneous surfaces can be detected by the measurement.

Tempering: Change of the heating/cooling degree depending on the temperature distribution

5.4 Angle dependency

The angle dependence is another important factor to be considered when measuring temperature.

On the uncoated side the values are constant up to an angle of 45°.

On the coated side (low-E) the 60° optics is preferred, since the influence of the emissivity change is negligible here.

The following two figures show the emissivity as a function of angle (G5, G7, LT) for Low-E glass at 250 °C. Once for coated glass and once for uncoated glass.

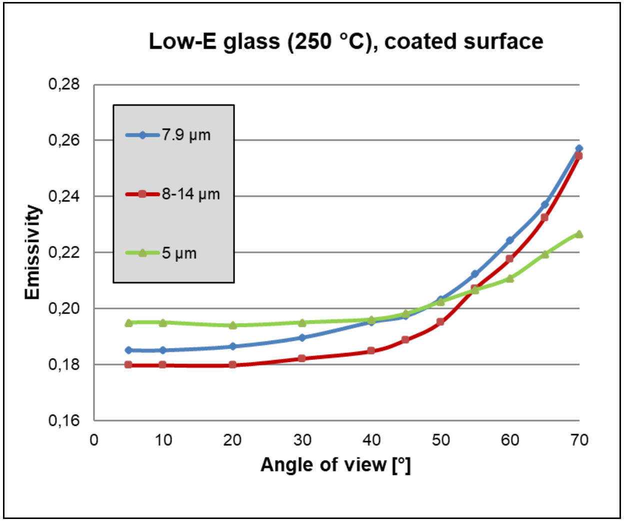


Figure 32: Angle dependency of Low-E glass, coated surface

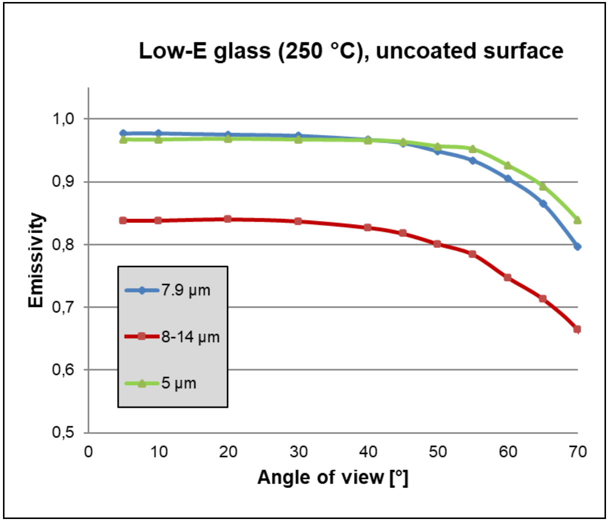


Figure 33: Angle dependency of Low-E glass, uncoated surface

Appendix A – Control cabinet

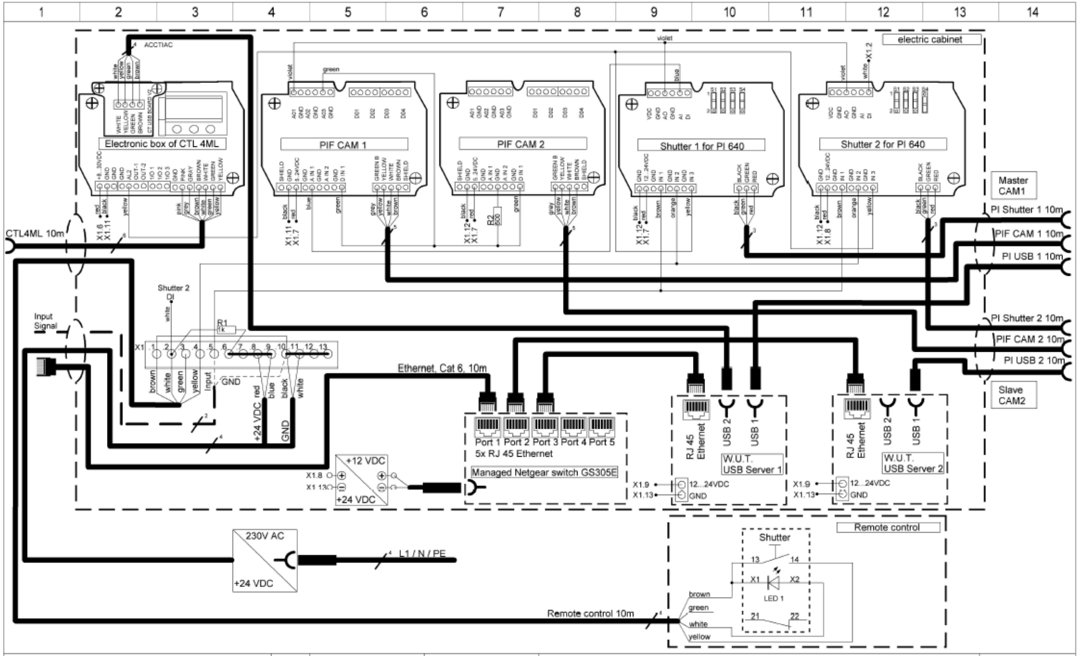


Figure 34: Wiring diagram of control cabinet

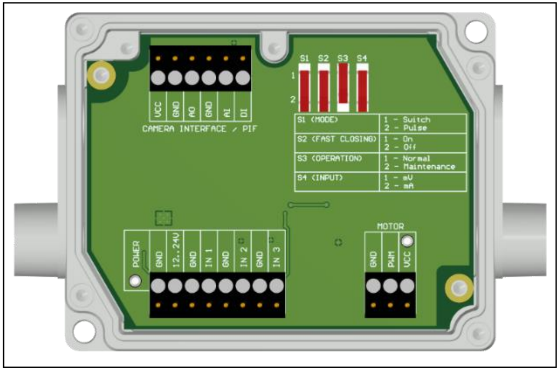


Figure 35: Control box of shutter (opened)

Power supply: 12-24 V

Upper terminal screw Connection for Process Interface (PIF)

Switch for different operation modes:

S1: Switching between switch operation and pulse operation
S2: Activation/deactivation of fast-closing mode
S3: Only for factory calibration (Switch must be at Normal)
S4: Switching between mV or mA input

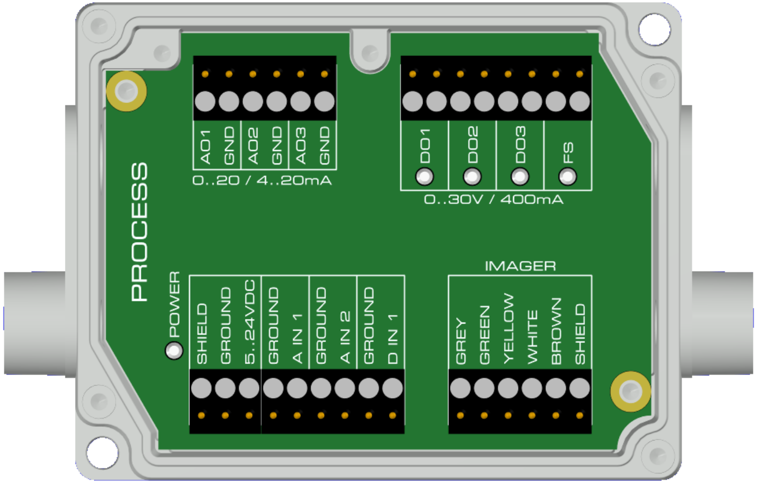
> The S4 position is on the control box shutter 1 on 1 and on the control box shutter 2 on 2

Lower screw terminal: Connection for power supply, Inputs (Start/Stop signal) and Motor

Inputs (Start/Stop signal, max. 24 V, input is active LOW (open input = HIGH))**:**

IN 1: Trigger input for normal operation (S1)
IN 2: Currently no usage
IN 3: Trigger input for fast-closing mode (S2)

Pin assignment PIF electronic box (industrial process interface)



GREY	Interrupt
GREEN	SCL (I^2C)
YELLOW	SDA (I^2C)
WHITE	3,3 V
BROWN	GND
SHIELD	GND

Figure 36: Connections of the industrial Process Interface (PIF)

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 [2]
D IN 1	Digital input (active-low = 0…0,6 V)	24 V
AO1 / 2 / 3	Analog output 1, 2 and 3 Alarm output 1, 2 and 3	0/4-20 mA
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

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

Designation CT electronic box

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

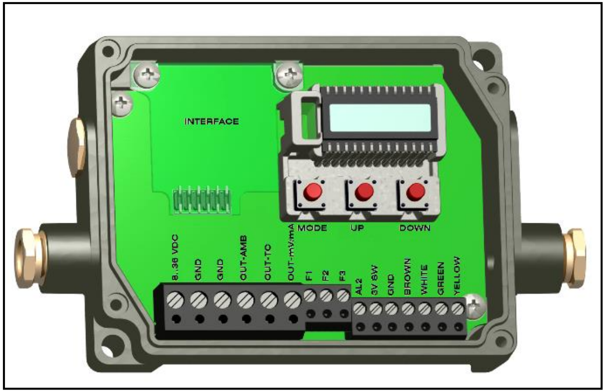


Figure 37: Opened electronic box with terminal connections