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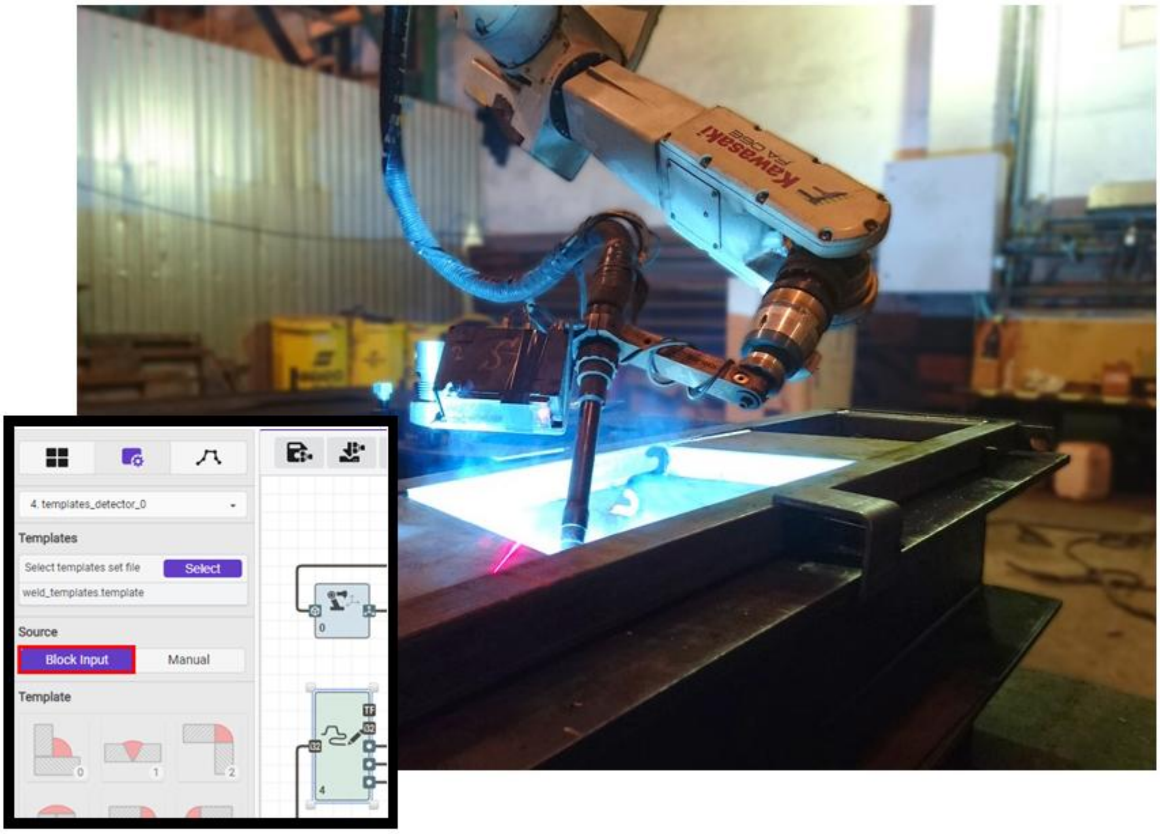

LASER SEAM TRACKING SYSTEM FOR WELDING AUTOMATION

RF627Smart-Weld Series

User's manual

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Certified according to ISO 9001:2015

Contents

1. General information

The laser tracking system is designed for use as part of industrial robotic welding systems and is intended for:

- Automatic control of the welding head position during the welding process.
- Visual control of the welding process.
- Measurement of geometric parameters of weld grooves.
- Measurement of geometric parameters of welds.

2. Safety precautions

- Use the supply voltage and interfaces given in the specifications.
- When connecting / disconnecting cables, the scanner and laptop must be powered off.
- To obtain stable results, wait about 20 minutes after turning on the power for the scanner to warm up evenly.
- All equipment must be properly grounded.

3. CE compliance

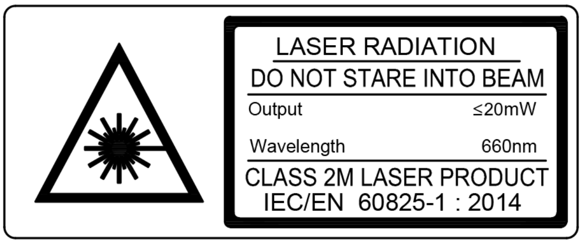
The system has been developed for use in industry and meets the requirements of the following Directives:

- EU directive 2014/30/EU. Electromagnetic compatibility (EMC).
- EU directive 2011/65/EU, “RoHS“ category 9.

4. Laser safety

Scanners belong to 2M laser safety class according to IEC/EN 60825-1:2014.

Scanners make use of an c.w. 660 nm or 450 nm wavelength semiconductor laser. Maximum output power is 20 mW. The following warning label is placed on the housing:



The following safety measures should be taken while operating the scanners:

- Do not target the laser beam to humans.
- Do not disassemble the scanner.
- Avoid staring into the laser beam.

5. Operating principle

5.1. Tracking

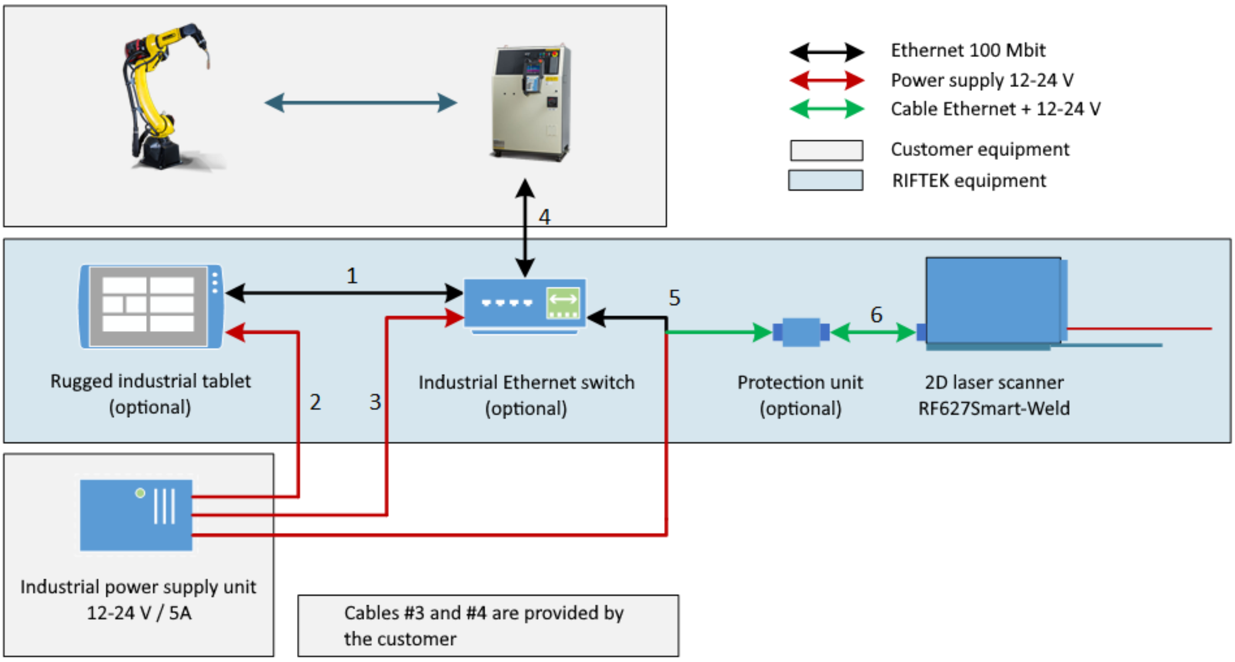
- The laser scanner is mounted on the robot flange next to the welding torch in such a way that during the welding process and movement along the welding groove, the scanner is ahead of the welding tool.
- The scanner is calibrated to obtain the coordinate transformation matrix. The calibration procedure is described in the User's Manual for RF627Smart: https://riftek.com/upload/iblock/65a/2D_Laser_Scanners_eng.pdf
- Using the web interface of the scanner, a computation graph is formed from the library of smart blocks (examples are given in this User's Manual), taking into account the specifics of the equipment, namely the robot type, communication protocol, groove type, geometric parameters of groove templates used to control the position and constraints applied to them, etc. If the supplied file does not contain the required groove template, the user can create a new template himself or with the support of the manufacturer using the provided template editor (see User's Manual for RF627Smart).
- The script for controlling the groove tracking block and the welding robot is being configured (examples of scripts are given in this User's Manual). The control script provides cyclic execution of the main stages of welding: placing the welding tool in the starting position, moving the tool in the direction of the beginning of the groove (search for the entry point into the groove), bringing the tool to the beginning of the groove and generating signals to external systems (welding controller) about the need for ignition and other actions, stopping the robot movement, transferring the coordinates to the robot for the movement of the tool along the welding groove, bringing the tool to the end of the groove and generating signals to external systems (welding controller) about the need to reduce the current or extinguish the arc (and other actions), bringing the tool to its original position.
- During operation, each profile received by the scanner is processed in accordance with the algorithm specified by the graph, and the following steps are performed: detecting the welding groove template in order to determine the exact coordinates in the scanner coordinate system (2D), transforming the coordinates from the scanner coordinate system to the robot coordinate system (3D), forming the trajectory of the tool in the robot coordinate system, transferring the coordinates to the robot for movement to the next position of the trajectory.

5.2. Geometry control

- The laser scanner is mounted on the flange of the robot or coordinate motion system.
- The geometry control procedure graph is created from the library of smart blocks using the web interface of the scanner. If the supplied file does not contain the required weld template, the user can create a new template himself or with the support of the manufacturer using the provided template editor (see User's Manual for RF627Smart).
- As the scanner moves along the weld, each profile received by the scanner is processed in accordance with the algorithm specified by the graph, geometric parameters are determined, tolerances are monitored, and a control protocol is generated.

6. Structure

The block diagram of the system:



The system includes the following main and optional components:

- Laser Scanner RF627Smart-Weld. Documentation for Laser Scanner RF627Smart (basic configuration) is available here: https://riftek.com/upload/iblock/65a/2D_Laser_Scanners_eng.pdf.
  RF627Smart-Weld differs from the basic configuration in the following options:
  - Built-in software packages for data exchange with robots and external industrial systems: RF627Smart-Industrial, RF627Smart-Robots.
  - Special design that provides protection against aggressive influences during welding, namely, a special body, replaceable protective glass, pneumatic shutter, protective cover; window blowing system.
  - Special equipment (taking into account the characteristics of the customer's system) for attaching the scanner to the welding robot. It is possible to equip the scanner with a pneumatic system for removing the scanner from the welding area.
  - Predefined set of working ranges that provide a solution to welding tasks.
  - Ready-to-use templates for the main types of welding grooves with the possibility to correct existing templates and add new ones.
- Rugged industrial tablet (optional) with pre-installed software designed to automatically search for a scanner on the network and open its web interface.
- Industrial Ethernet switch (optional).
- Scanner electrical protection unit (optional).
- Cables.

6.1. Laser scanner

The system includes 2D Laser Scanner RF627Smart-Weld Series.

The housing of the scanner is made of anodized aluminum. The front panel of the housing has two windows: the output window and the window for receiving radiation reflected from the object under control.

The scanner has one connector, **Reset** button and LED indicators. Pressing the **Reset** button for 5 seconds will restart the scanner. If you press the **Reset** button for 1 second, a broadcast Hello packet will be sent. Red LED indicates that the firmware is loading; green LED indicates that the Ethernet connection is established.

Laser scanners come with the following features by default:

- additional protective quick-change glass for scanner windows;
- a special fitting for supplying compressed air to protect the windows ("air knife" system);
- a protective cover;
- equipment for quick installation of the scanner.

Scanners can be supplied with the following laser wavelengths:

- red laser scanners, 660 nm;
- blue laser scanners (BLUE version), 450 nm.

Different lasers are used due to a wide range of applications. For example, the use of blue lasers instead of red ones is optimal for the control of shiny materials and high-temperature objects.

There are two operating modes in the full working range: Basic mode with the frequency of 484 Hz (profiles/second) and DS mode with the frequency of 921 Hz.

The ROI function has been implemented, which makes it possible to increase the working frequency of the scanner in the limited working range up to 4884 Hz in Basic mode and up to 6379 Hz in DS mode.

Specifications, working ranges and overall dimensions are given in the next sections.

6.1.1. Specification

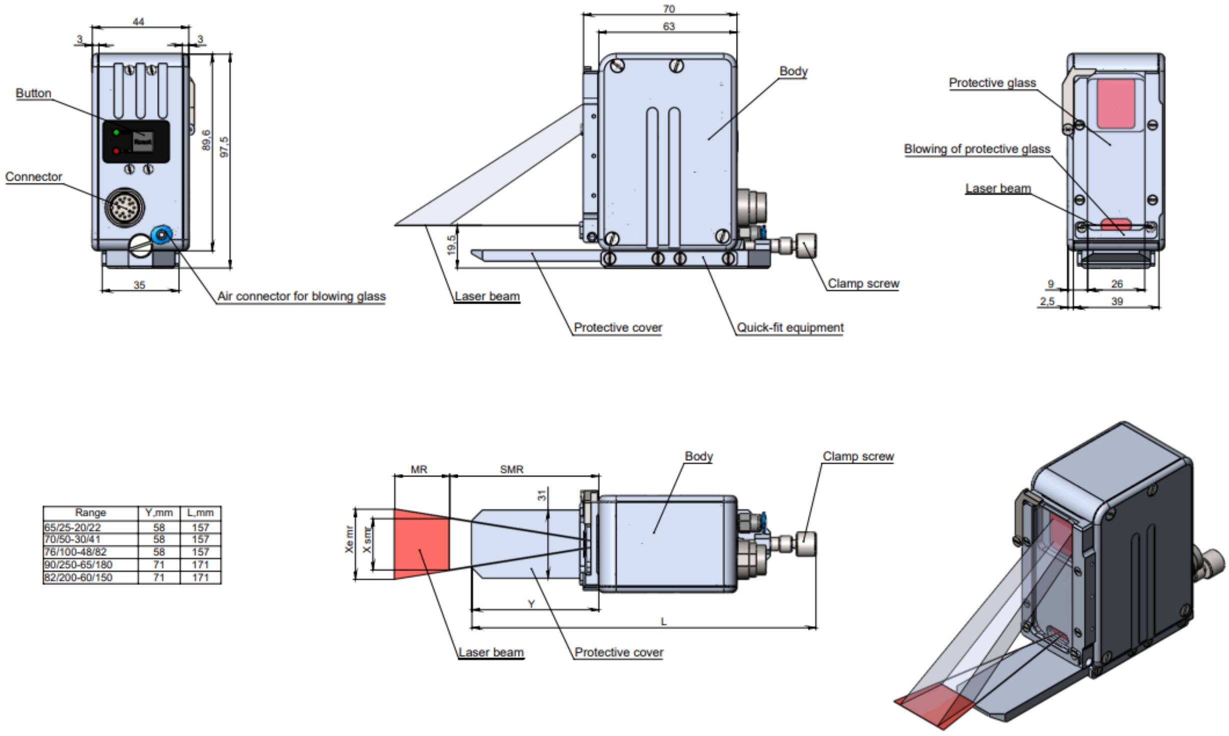
Sampling rate, accuracy, resolution	
Nominal sampling rate (full working range)	484 profiles/s (standard mode), 938 profiles/s (DS mode)
Maximum sampling rate (ROI mode)	4884 profiles/s, 6379 profiles/s (DS mode)
Linearity (measurement error), Z axis	±0.05% of the range (standard mode), ±0.1% of the range (DS mode)
Linearity (measurement error), X axis	±0.2% of the range
Resolution, Z axis	0.01% of the range (standard mode), 0.02% of the range (DS mode)
Resolution, X axis	648 or 1296 points (programmable value)
Laser	
660 nm or 450 nm Class 2M according to IEC/EN 60825-1:2014	
Interface	
Basic	Ethernet / 1000 Mbps
Synchronization inputs	RS422, 3 channels
Power supply	9...30 V or 12...36 V for scanners with Blue laser
Power consumption, not more	6 W (without a built-in heater)
Environmental resistance	
Enclosure rating	IP67
Vibration	20 g / 10...1000 Hz, 6 hours for each of XYZ axes
Shock	30 g / 6 ms
Operating ambient temperature	-20…+40°C or -20…+80°C for scanners with built-in air cooling system -20...+150°C for scanners with built-in water cooling system
Storage temperature	-20…+70°C
Relative humidity	5-95% (no condensation)
Housing/windows material	aluminum/glass
Replaceable protective windows	glass

6.1.2. Working ranges and overall dimensions

Range	MR, mm	SMR, mm	Xsmr, mm	Xemr, mm	Dimensions, figure	Weight, kg	Option: air or water cooling, figure	Option: shutter, figure
65/25-20/22	25	65	20	22	1	0.7	2	3
70/50-30/41	50	70	30	41	1	0.7	2	3
76/100-48/82	100	76	48	82	1	0.7	2	3
70/130-40/86	130	70	40	86	4	0.7	4	4
250/130-52/76	130	250	52	76	5	0.9	5	5
82/200-60/150	200	82	60	150	1	0.7	2	3
90/250-65/180	250	90	65	180	1	0.7	2	3

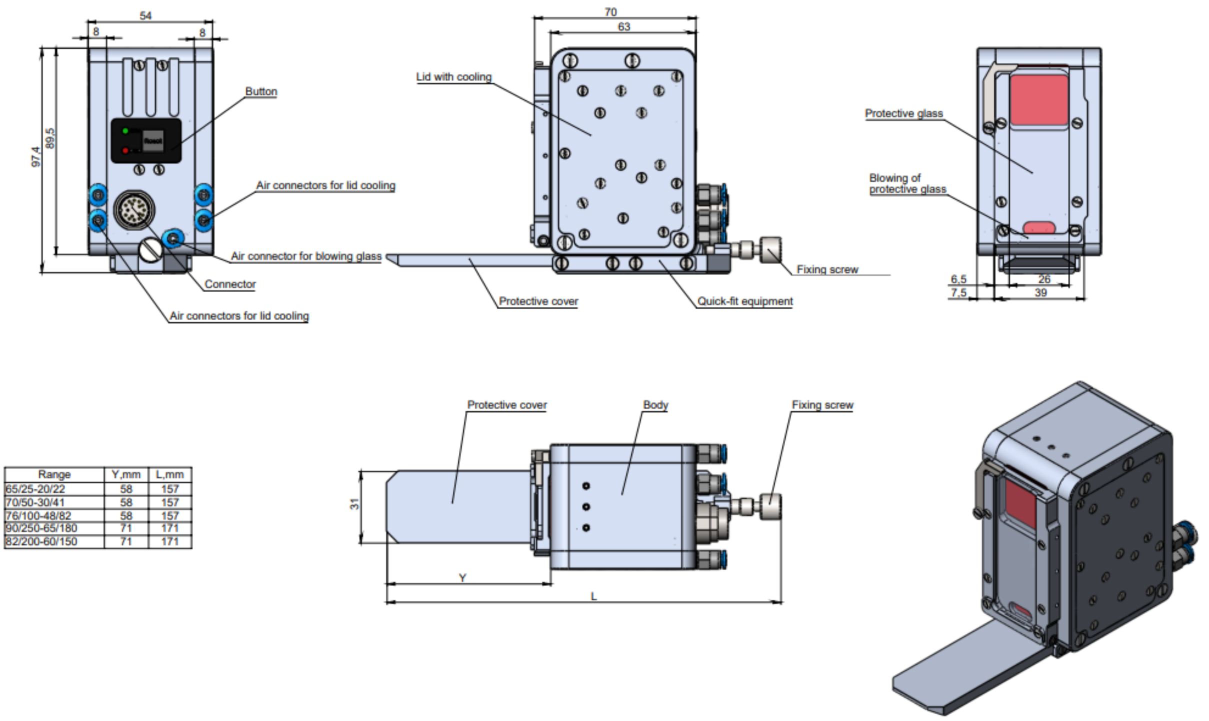
Detailed CAD documentation (2D and 3D) is available on request at info@riftek.com.

Overall and mounting dimensions of laser scanners:



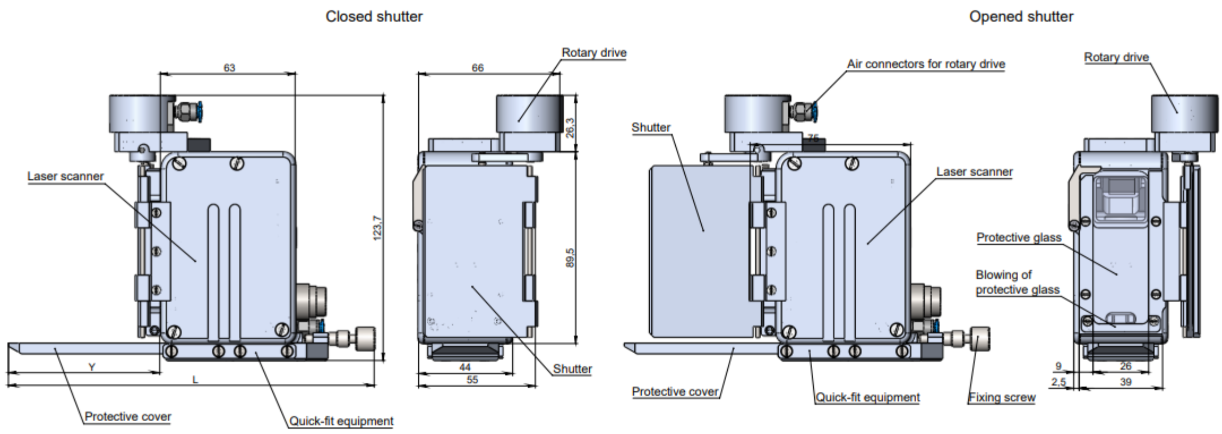
Range	Y,mm	L,mm
65/25-20/22	58	157
70/50-30/41	58	157
76/100-48/82	58	157
90/250-65/180	71	171
82/200-60/150	71	171

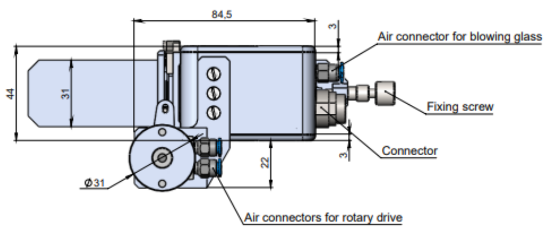
Figure 1



Range	Y,mm	L,mm
65/25-20/22	58	157
70/50-30/41	58	157
76/100-48/82	58	157
90/250-65/180	71	171
82/200-60/150	71	171

Figure 2





Range	Y,mm	L,mm
65/25-20/22	58	157
70/50-30/41	58	157
76/100-48/82	58	157
90/250-65/180	71	171
82/200-60/150	71	171

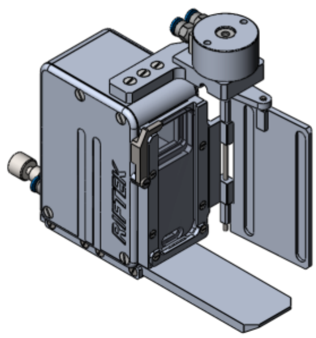


Figure 3

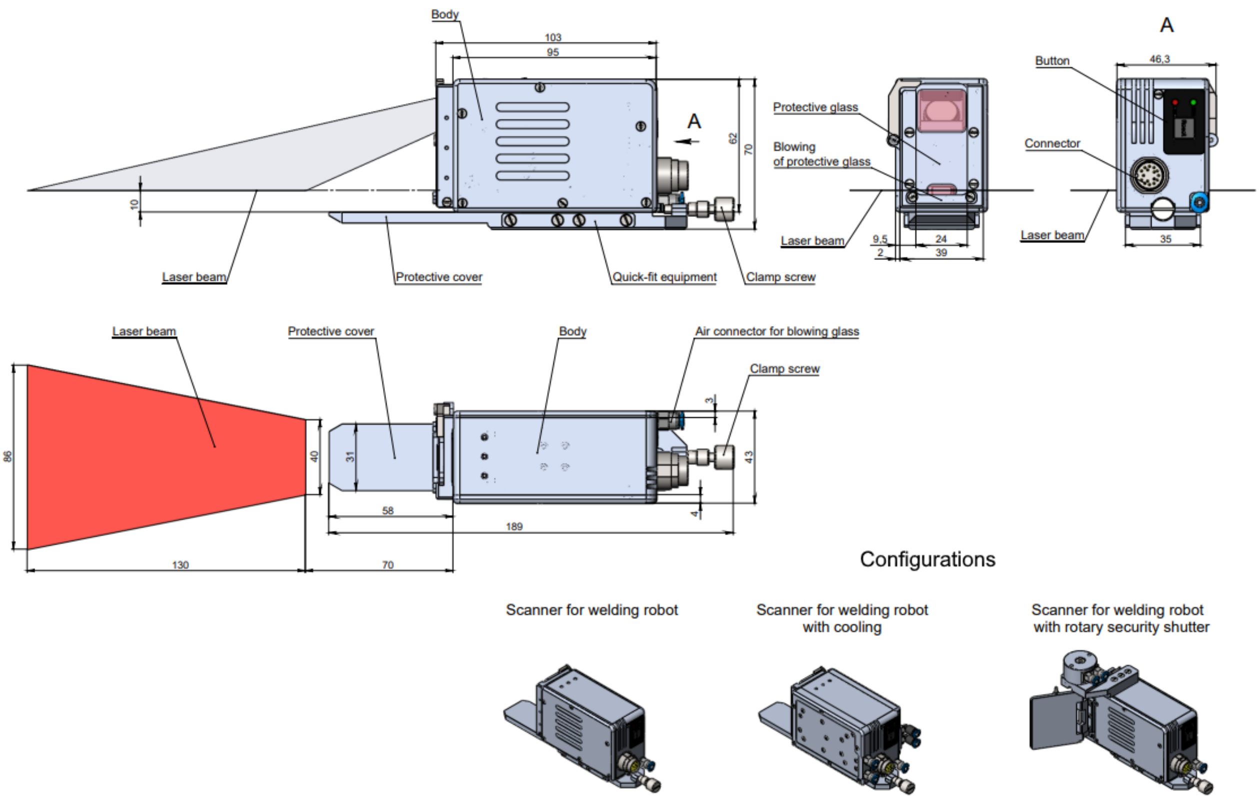


Figure 4

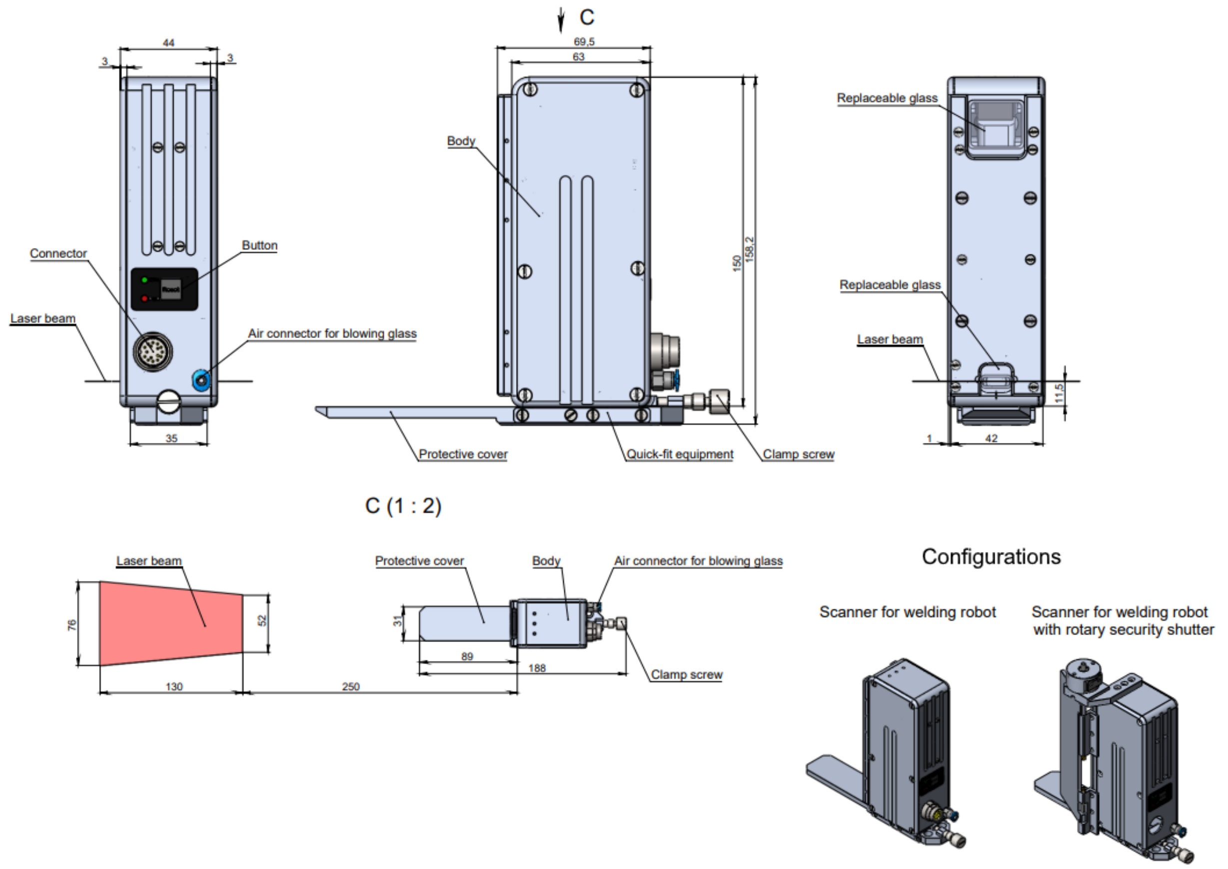


Figure 5

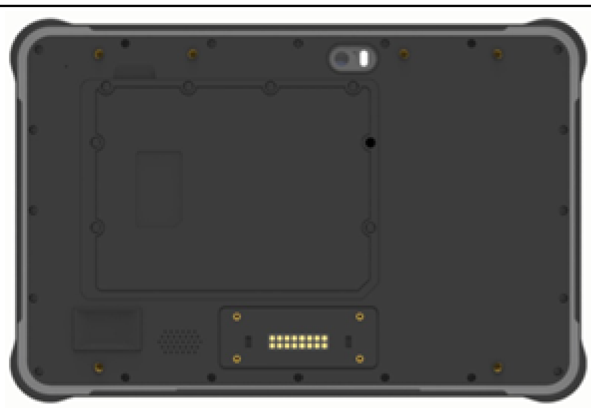
6.2. Rugged industrial tablet

The tablet is intended for the initial setup of the system by an engineer and subsequent control of the system operation by the adjuster and the operator of the welding robot.

The pre-installed software is designed to display the graphical interface and manage its settings, taking into account access control (engineer/adjuster/operator).

Since the tablet is for display, configuration and diagnostic purposes only (does not perform any calculations), the user may use other technical means (other types of tablets, personal or industrial computers). In the case of using other technical means, it is necessary to follow the instructions given in the documentation for the RF627Smart scanner.

6.2.1. Specification

	
Front view	**Back view**

Technical characteristics:

Parameter		Value
Architecture	CPU	Intel cherry trail Z8350, 1.44Ghz-1.92GHz
	OS	Windows 10 pro
	RAM/ROM	4GB+64GB
Display	Size	10.1"
	Resolution	1920x1200
Touch type		Capacitive
Interfaces	Type-A	USB2.0 x1
	Type-A	USB.0 x1
	MicroUSB	x1
	RJ45 Ethernet	10/100/1000M x1
	DB9 RS232	9-pin serial port x1
	DC power interface	DC 12V 2A x1
Enclosure rating	Degree of protection	Waterproof IP65, but in fact is IP67 design. Drop 1.2 m, 6 sides.
	Certification standards	Military 810G. EU CE, US FCC
	Operating Temperature	-20°C...60°C
Built-in battery	Battery type	Built-in removable Li-ion Polymer Battery
	Rated capacity	10500 mAh
Dimensions		275x180x20 mm

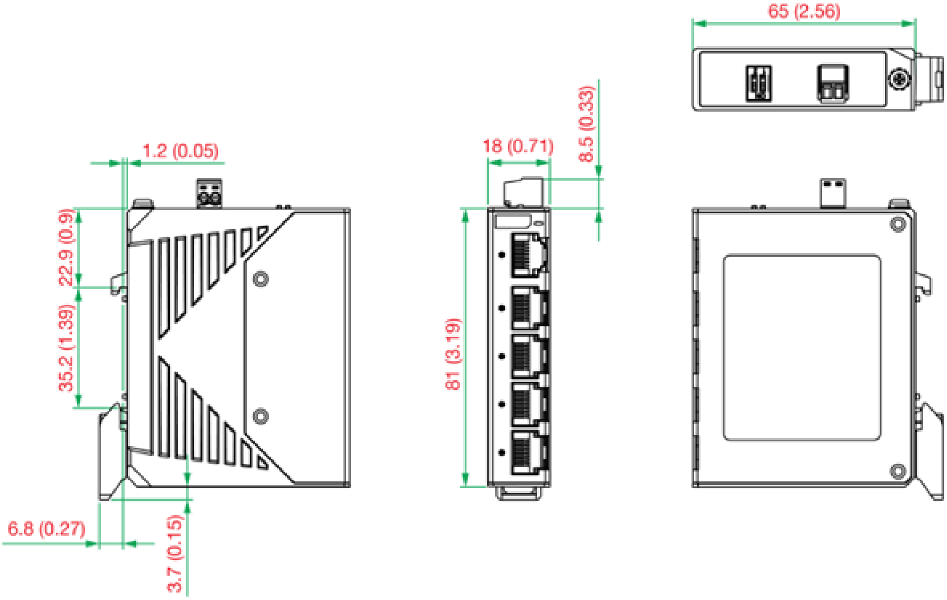
6.3. Industrial Ethernet switch

The switch is designed to provide network interaction between the tablet and the 2D scanner, as well as to exchange data with the robot controller.

It is allowed to use a standard network switch included in the welding kit (for example, between the robot and the controller). In this case, make sure the network settings are correct.

6.3.1. Specification

Parameter	Value
Network ports	5-RJ45-10/100/Mbps
Power supply	10...60V - 1.1W - 0.045A
Operating conditions	Temperature: -10...60°C Air humidity: 5...95%
Enclosure rating	IP40
Dimensions	see Figure



6.4. Protection unit

This unit provides power protection for the 2D laser scanner and includes a quick-change fuse.

6.5. Cables

The system comes with the following cables:

- Cable #1 - standard Ethernet cable Cat5e with RJ45 connectors on both ends (for connecting the industrial tablet to the network switch).
- Cable #2 - power cable for the tablet (included with the tablet).
- Cable #3 - two-core power cable for the network switch (voltage not less than 12V, current not less than 0.2A) - from the customer's equipment.
- Cable #4 - Ethernet cable with RJ45 crimp (for connecting the robot controller to the network switch) - from the customer's equipment.
- Cable #5 - Ethernet+power cable (for connecting the network switch to the protection unit).
- Cable #6 - Ethernet+power cable (for connecting the laser scanner to the protection unit).

7. Example of item designation when ordering

RF627Smart-Weld.(WAVE)-SMR/MR-Xsmr/Xemr-L1-L2-L5-L6(R)-PS-PB-Shutter-AC(WC)

Symbol	Description
(WAVE)	Laser wavelength: 660 nm – no symbol, 450 nm – BLUE.
SMR	Beginning of the measuring range for Z, mm.
MR	Measuring range for Z, mm.
Xsmr	Measuring range for X-coordinate at the beginning of the measuring range for Z-coordinate, mm.
Xemr	Measuring range for X-coordinate at the end of the measuring range for Z-coordinate, mm.
L1,L2,L5,L6	Cable length, m.
R	Robot-cable (option).
PS	Tablet (option).

PB	Protection unit (option).
Shutter	Controlled shutter.
AC	Built-in air cooling system.
WC	Built-in water cooling system.

NOTE. Default options: window blower, replaceable windows, shield, mounting bracket.
Example. RF627Smart-Weld.BLUE-90/250-65/180-3-3-3-10–PS-PB - Scanner with a blue laser, SMR - 90 mm, MR - 250 mm, Xsmr - 65 mm, Xemr - 180 mm, cable L1 = 3 m, cable L2 = 3 m, cable L5 = 3 m, cable L6 = 10 m, tablet, protection unit.

Product codes:

Name	Code
Tablet	P627A01
Network switch	P627B01
Protection unit	P627C01
Cable #1	EL04
Cable #2	P627A02
Cable #5 (for kit with protection unit)	E627E09
Cable #5 (for kit without protection unit)	E627E17
Cable #6	E627E18

8. Overall demands for mounting

The laser scanner is mounted on the robot flange next to the welding torch. The scanning area must be within the working range of the scanner. In addition, no foreign objects should be allowed to stay on the path of the incident and reflected laser radiation.

When scanning a surface with an intricate texture, the incidence of mirror component of the reflected radiation to the receiving window should be minimized.

> **ATTENTION!**
> The laser scanner and other equipment must be grounded.

9. Assembly and setup

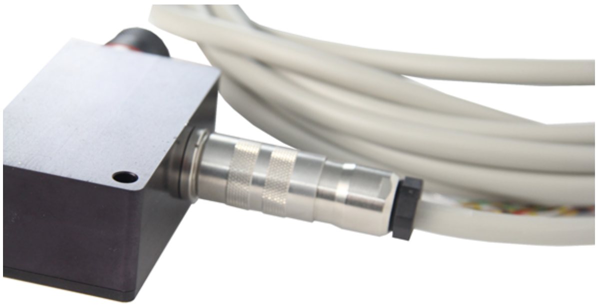
9.1. Assembling the system and mounting the elements

Assembly and installation should be carried out by a qualified person (usually an engineer) after studying the safety rules for working with electrical equipment.

General view:

The elements must be mounted using standard industrial solutions (DIN rail) and taking into account the connections shown on the block diagram of the system.

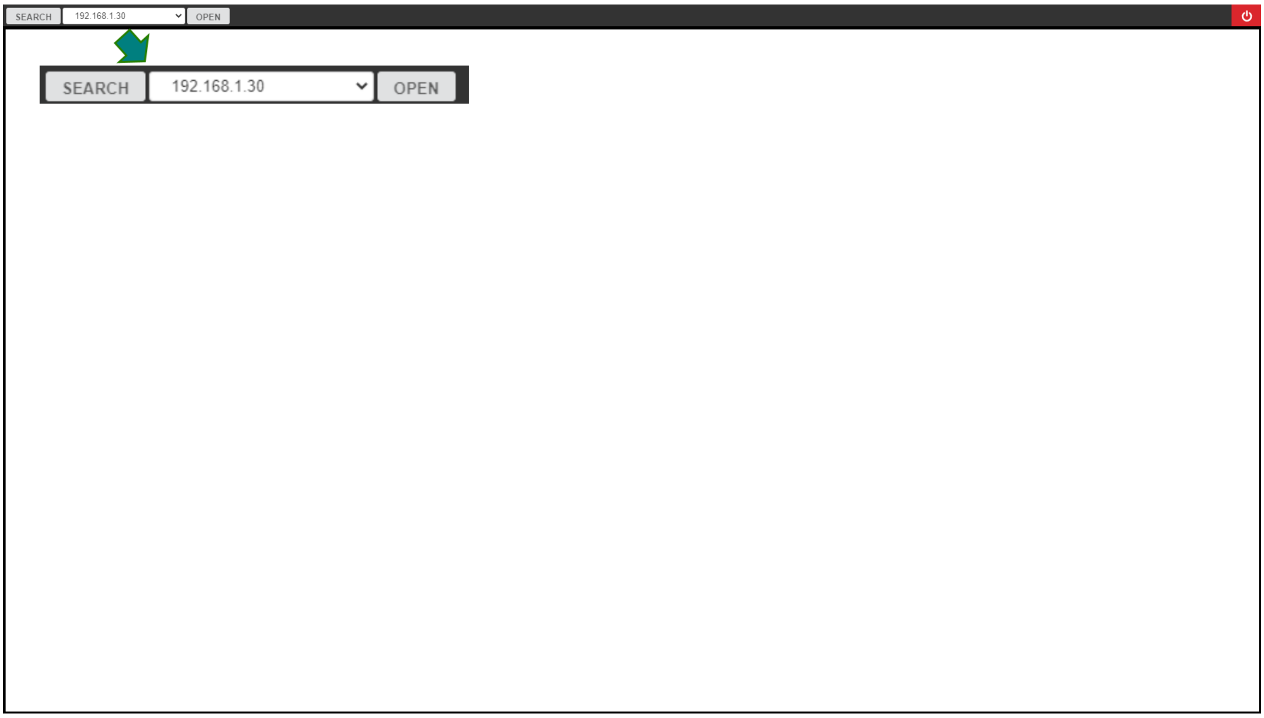
Procedure:

1. Connect the tablet (or other device) to the industrial switch using the Ethernet cable: 	2. Connect the RJ45 connector to the industrial switch: 
3. Connect Binder 423 99 5456 15 16 to the protection unit (if included): 	4. Connect the laser scanner to the protection unit: 
5. Connect the power cable of the tablet to the power source, and then connect it to the tablet (the power source must be disconnected from the mains): 	6. Connect the power cable of the industrial switch to the power source, and then connect it to the switch. 7. Connect free wires (red and blue) of the cable to the power source. 8. Connect the robot controller to the industrial switch using the cable with RJ45 connectors.

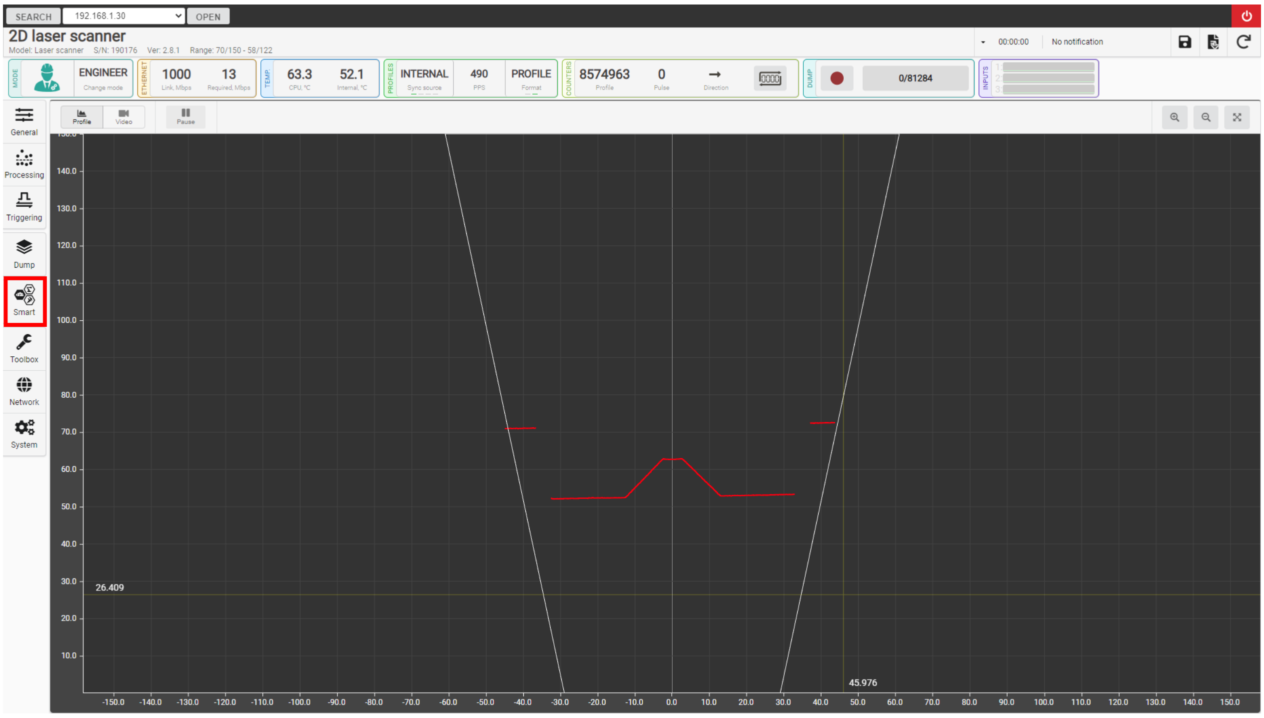
After assembly is completed, turn on the power supply to turn on the system.

9.2. Turning on the system

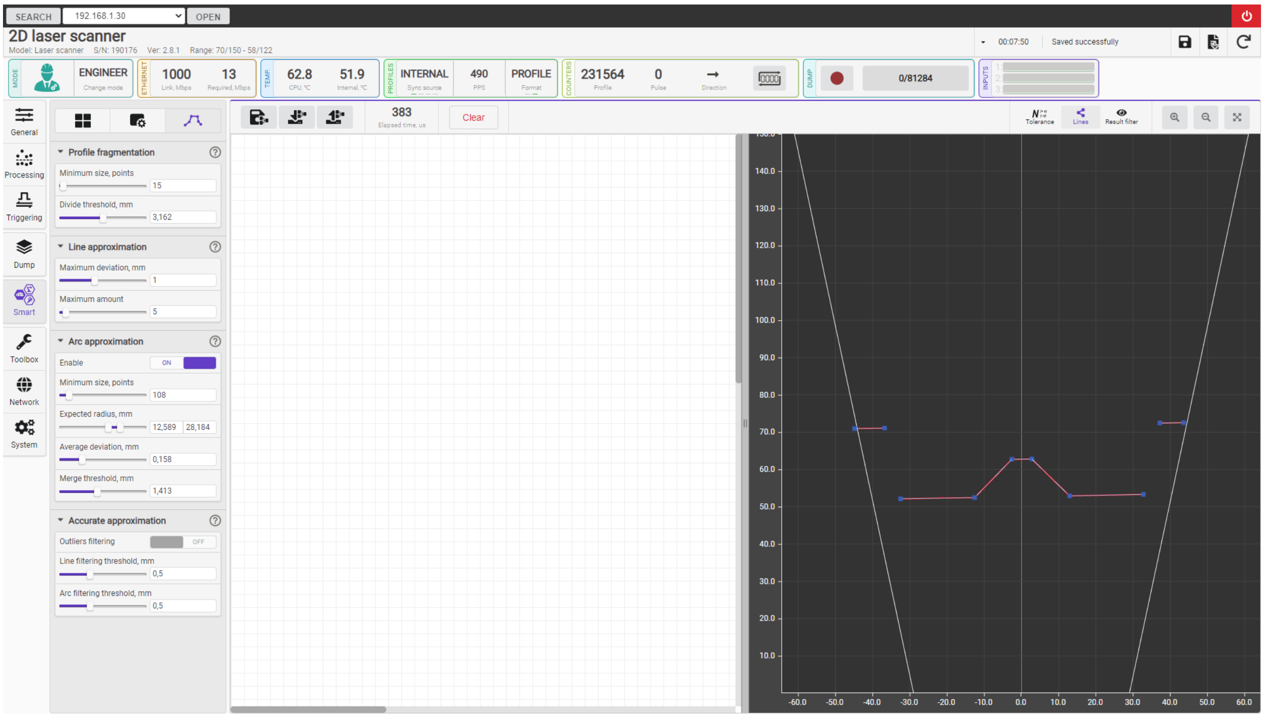
To turn on the system, it is necessary to supply voltage to its elements. The industrial tablet is turned on by pressing the power button. After turning on the tablet, specialized software automatically starts and searches for the connected scanner. When the scanner is detected, its IP address will be displayed:



The scanner is detected. Tap the **OPEN** button to connect to the scanner and open the web interface:



Go to the **Smart** tab to prepare the computation graph and configure smart blocks:



9.3. Setting up the system

The system is supplied without the computation graph (due to the wide variety of supported welding robots and data exchange protocols with them), so it is necessary to perform the initial (one-time) setup, which includes the following main steps:

- Building the computation graph.
- Calibrating the scanner relative to the robot (to perform the transformation of the 2D coordinates of the scanner to the 3D coordinates of the robot).
- Configuring the script for controlling the welding groove tracking block and the robot.
- Preparing custom templates (if necessary).
- Adjusting the robotic welding system on a mock-up.
- Testing the robotic welding system on mock-ups and real samples.

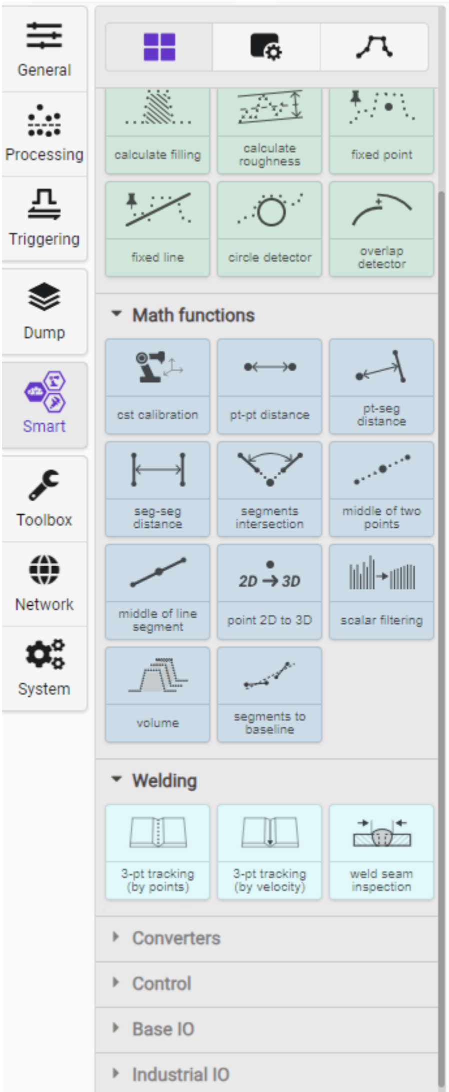
Examples are shown below.

10. Smart blocks

The computation graph is an ordered sequence of operations performed by the scanner. This sequence is represented in the form of smart blocks and connections between them. When changing the graph structure, the order of calculations will be determined automatically. Constraint: cyclic connections in the graph are not allowed. For more information about the graphs and smart blocks, please refer to the User's Manual for RF627Smart:

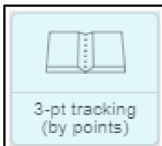
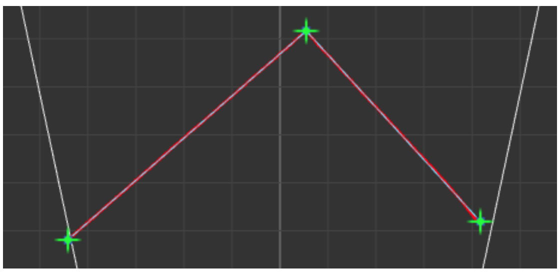
https://riftek.com/upload/iblock/922/9eiluol3mv65ulncgkfz4b11v43vksqw/2D_Laser_Scanners_eng.pdf

Smart blocks for tracking and control are located in the **Welding** group:



10.1. Smart blocks for seam tracking in real time

The following smart blocks are used for seam tracking in real time:

	"3-pt tracking (by points)" - tracking of the weld groove at three points formed by the profile:  **The output values of the smart block are the points and angles** (i.e. poses) to which the actuator (welding robot) must move in order to travel along the welding path. Points are issued sequentially, ahead of time. The tracking process is displayed in 3D in a special window, and this window can also be used for visual analysis of the weld groove. A detailed description of this smart block is given in the User's Manual for the "Laser Seam Tracking System for Welding Automation. RF627Weld-Smart.".		
Inputs:	"cst"	SDT_CST_3D	Data from the scanner calibration block with an actuator.
	"point #1"	SDT_POINT	"Left" point of the weld groove.
	"point #2"	SDT_POINT	"Central" point of the weld groove.

	“point #3”	SDT_POINT	"Right" point of the weld groove.
	“enabled”	SDT_BOOL	"Smart block enabled" flag.
	“accuracy”	SDT_FLOAT	Actuator movement accuracy (mm).
	“step”	SDT_FLOAT	Step of picking points along the weld groove and step of issuing points (mm).
	“torch offset”	SDT_FLOAT	Offset of the TCP relative to the weld groove in the direction perpendicular to the groove (offset from the groove) in mm.
	“torch rotation”	SDT_EULER_3D	Corrections to the angular position of the tool relative to the flange (in order to take into account the bending of the tool, for example, a burner) in rad.
Outputs:	“pose”	SDT_POSE_3D	Output poses for an actuator (for example, a welding robot).
	“detected”	SDT_BOOL	"Weld groove detected" flag.
	“tracking”	SDT_BOOL	"Weld groove tracking" flag. It is set to TRUE while the block is enabled and the block can issue the points to the robot, i.e. the end of the weld groove has not been reached.
	“3-pt tracking (by velocity)” - tracking of the weld groove at three points formed by the profile (similar to the “3-pt tracking (by points)” smart block). The output values of the smart block are the linear and angular velocities (in the form of a pose) with which the actuator (welding robot) must travel along the welding path. The tracking process is displayed in 3D in a special window, and this window can also be used for visual analysis of the weld groove.		
Inputs:	“cst”	SDT_CST_3D	Data from the scanner calibration block with an actuator.
	“point #1”	SDT_POINT	"Left" point of the weld groove.
	“point #2”	SDT_POINT	"Central" point of the weld groove.
	“point #3”	SDT_POINT	"Right" point of the weld groove.
	“enabled”	SDT_BOOL	"Smart block enabled" flag.
	“accuracy”	SDT_FLOAT	Actuator movement accuracy (mm).
	“step”	SDT_FLOAT	Step of picking points along the weld groove (mm).
	“torch offset”	SDT_FLOAT	Offset of the TCP relative to the weld groove in the direction perpendicular to the groove (offset from the groove) in mm.
	“torch rotation”	SDT_EULER_3D	Corrections to the angular position of the tool relative to the flange (in order to take into account the bending of the tool, for example, a burner) in rad.
Outputs:	“pose”	SDT_POSE_3D	Output velocities for an actuator (for example, a welding robot).
	“detected”	SDT_BOOL	"Weld groove detected" flag.
	“tracking”	SDT_BOOL	"Weld groove tracking" flag. It is set to TRUE while the block is enabled and the block can issue the points to the robot, i.e. the end of the weld groove has not been reached.

Key features of smart blocks:

- All calculations are performed by the scanner software in 3D space, which makes it possible to visualize all ongoing processes.
- Construction of the trajectory of the welding robot, taking into account the curvature of the groove.

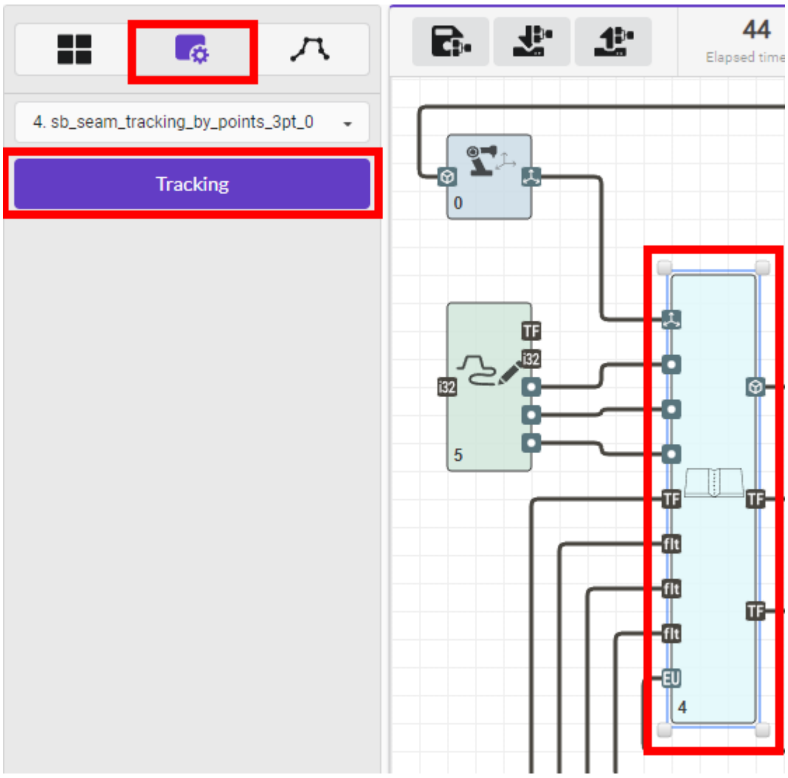
- Approximation of the trajectory, which makes it possible to issue control signals to the robot through equal distances even in difficult tracking conditions and ensure a stable speed of movement along the groove.
- Automatic prolongation of the trajectory in case of a short-term loss of the groove.
- Calculation and correction of the angular position of the welding torch relative to the groove.

The operation of smart blocks is based on the finite-state machine that has the following states:

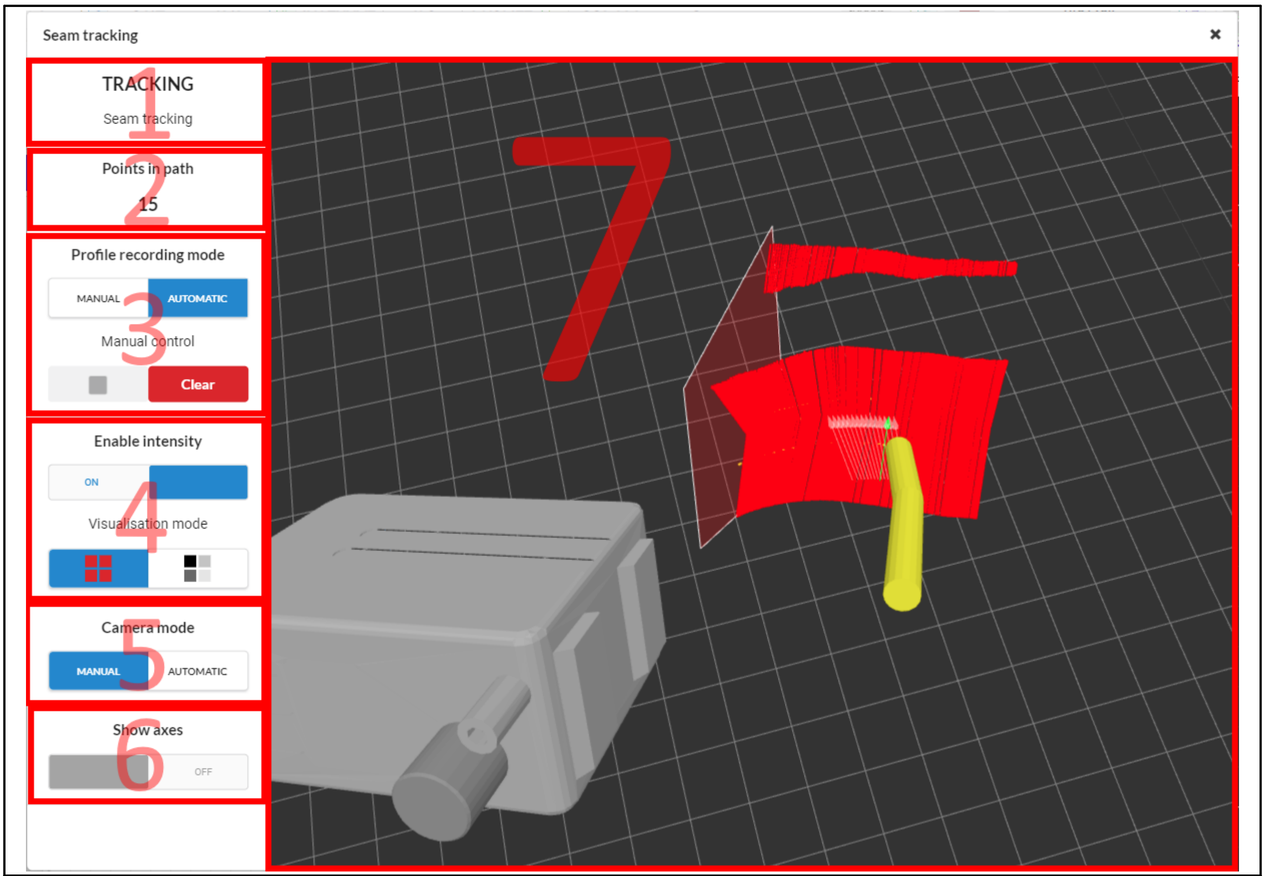
WAIT	Waiting for permission to work. No calculations are performed. The outputs have the following values: “pose” - not valid; “detected” - always “FALSE”; “tracking” - always “FALSE”.
SEARCH	Searching for a welding groove (in accordance with the data from the smart block for detecting templates). The outputs have the following values: “pose” - not valid; “detected” - “TRUE” if the template is detected, otherwise - “FALSE”; “tracking” - always “FALSE”.
BEGIN	Moving to the beginning of the welding groove. The outputs have the following values: “pose” - spatial and angular position of the TCP (for the “3-pt tracking (by points)” smart block) or components of velocities according to the corresponding coordinates (for the “3-pt tracking (by velocity)” smart block); “detected” - “TRUE” if the groove is detected, otherwise - “FALSE”; “tracking” - “TRUE” at the beginning of the groove, otherwise - “FALSE”.
TRACKING	Moving along the welding groove. The outputs have the following values: “pose” - spatial and angular position of the TCP (for the “3-pt tracking (by points)” smart block) or components of velocities according to the corresponding coordinates (for the “3-pt tracking (by velocity)” smart block); “detected” - “TRUE” if the groove is detected, otherwise - “FALSE”; “tracking” - “TRUE” during tracking process, “FALSE” when tracking is done.
DONE	Waiting for confirmation from the external system about the end of welding (removal of the signal from the “enabled” input). The outputs have the following values: “pose” - spatial and angular position of the last TCP (for the “3-pt tracking (by points)” smart block) or zero components of velocities according to the corresponding coordinates (for the “3-pt tracking (by velocity)” smart block); “detected” - always “FALSE”; “tracking” - always “FALSE”.

10.1.1. Visual control

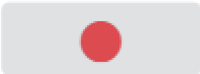
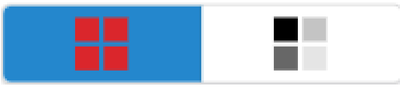
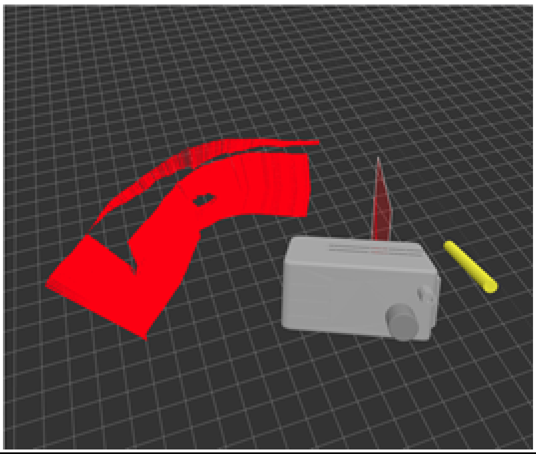
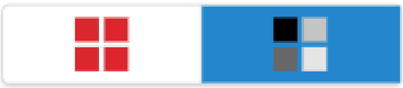
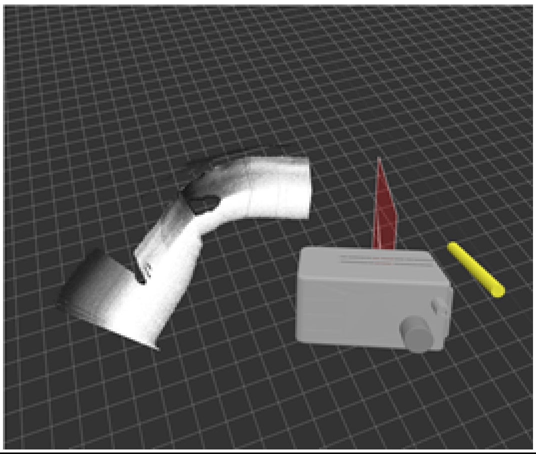
1. Visual control of the tracking process can be carried out by the adjuster or operator using a special interface available by pressing the **Tracking** button:



The interface contains the following areas:



1.	The area of the current state of the block. Possible states and their meaning are listed above.

2.	The number of points on the motion trajectory at the current time. During the movement of the robot, this value can increase or decrease (decreasing to 0 at the end of the welding groove).	
3.	Recording options:	
	MANUAL AUTOMATIC	Manual mode. The control is performed using the buttons located in the “Manual control” section.
	MANUAL AUTOMATIC	Automatic mode. Clearing is performed upon transition from the “WAIT” state to the “BEGIN” state. Recording is performed in the “BEGIN” and “TRACKING” states.
		Enabling and disabling profile recording in manual control mode.
	Clear	Deleting recorded profiles in all modes (clearing).
4.	Profile visualization parameters (with/without intensity):	
	ON	Turning on/off the transmission of the intensity for profile points. If the profiles are to be displayed with intensity, this parameter must be enabled.
		Recording profiles without intensity. The color of each point will be standard (red). 
		Recording profiles with intensity. 
5.	Camera control:	
	MANUAL AUTOMATIC	Manual mode. The camera is moved by the user.
	MANUAL AUTOMATIC	Automatic mode. Automatic control of the position and direction of the camera.
6.	Coordinate axes display:	

		Enabling/disabling display of coordinate axes.
7.	3D visualization area for welding groove, motion trajectory, TCP position, TCP orientation, etc.	

10.1.2. Algorithm for controlling tracking blocks

Algorithm for controlling smart blocks and applying the data received from them (practical examples are given below):

1. Setting parameters: “accuracy” - the required tracking accuracy in mm, “step” - the step of picking points along the groove in mm, “torch offset” - offset of the TCP from the groove in mm, “torch rotation” - corrections to the angular position of the tool relative to the groove.
2. Placing the TCP (tool) to its original position (can be done by the robot controller or the scanner).
3. Enabling the smart block by setting the “enabled” input of the block to “TRUE”.
4. Moving the TCP (tool) in the direction of the welding groove in order to detect its beginning. The movement is controlled by the robot controller or the scanner.
5. Waiting for "TRUE" on the "detected" output of the smart block, which will mean that the groove has been detected and the smart block can place the TCP to its beginning.
6. Switching to robot control. The position at the output of the smart block must be transmitted to the actuators of the robot, and the robot will move the TCP to the groove entry point.
7. Waiting for "TRUE" at the "tracking" output of the smart block, which will mean that the TCP is at the beginning of the groove and is ready to move along the groove. At this point, it is recommended to pause and perform the necessary actions: ignite the arc, heat up the weld pool, etc.
8. Cyclic transmission of data from the “pose” output of the smart block to the actuators of the robot to move it along the welding groove.
9. Waiting for “FALSE” at the “tracking” output of the smart block, which will mean the completion of movement along the welding groove (TCP is at the last point). At this point, it is recommended to pause in order to reduce the arc current, extinguish it and carry out other actions.
10. Setting the “FALSE” value at the “enabled” input of the smart block, which confirms the end of the welding cycle.
11. Going to step #2 if a new welding cycle is required.

The above algorithm can be fully implemented by the scanner using the “c-script” smart block.

10.2. Smart blocks for data exchange with robots and cobots

The smart blocks described below provide communication between the scanner and various industrial robots and cobots.

	“R691 protocol” - data exchange and control of Fanuc robots via the R691 (Universal sensor interface) protocol.		
Parameters:	“Listen port”	0…65535	The port number to be listen by the scanner to connect to the robot.
Inputs:	“point”	SDT_POINT	The point that is transmitted to the robot (for example, the specified point of the welding groove).

	“gap”	SDT_SCALAR	The gap measured for some types of welding grooves.
	“mismatch”	SDT_SCALAR	The mismatch measured for some types of welding grooves.
	“area”	SDT_SCALAR	The area measured for some types of welding grooves.
Outputs:	“laser en”	SDT_BOOL	Enabling laser emission.
	“track en”	SDT_BOOL	Enabling template detection (not used in the scanner).
	“template idx”	SDT_INT32	The number of the template to be detected.
	“state”	SDT_BOOL	Flag indicating the presence of communication with the robot.

	“KUKA RSI” - data exchange and control of KUKA robots via a customizable protocol with the RSI (Robot Sensor Interface) module. Examples of settings files are given below.		
Parameters:	“Listen port”	0…65535	The port number to be listen by the scanner to connect to the robot.
Inputs:	“tmplt_det”	SDT_BOOL	The template detection flag transmitted to the robot.
	“seam_touch”	SDT_BOOL	Flag indicating that the robot is at the beginning of the seam (can be used as a flag to start welding).
	“pose”	SDT_POSE_3D	Current corrections for the RSI module.
	“offs_x”	SDT_FLOAT	Correction for the "pose" output value on the X coordinate.
	“offs_z”	SDT_FLOAT	Correction for the "pose" output value on the Z coordinate.
	“tmplt_idx”	SDT_INT32	The number of the template to be detected.
	“state”	SDT_BOOL	Flag indicating the presence of communication with the robot.

	“Universal Robots RTDE” - data exchange and control of Universal Robots via the RTDE (Real-Time Data Exchange) protocol.		
Parameters:	“Robot IP”	XXX.XXX.XXX.XXX	The IP address of the robot.
	“Robot RTDE port”	1...65535	The network port number of the robot with which data should be exchanged.
Inputs:	“pose”	SDT_POSE_3D	The required pose of the robot.
Outputs:	“pose”	SDT_POSE_3D	The current pose of the robot.
	“state”	SDT_BOOL	Flag indicating the presence of communication with the robot.

	“JAKA” - data exchange and control of JAKA robots.		
Parameters:	“Robot IP”	XXX.XXX.XXX.XXX	The IP address of the robot.
	“Commands port”	1...65535	The network port number of the robot to which control commands are sent.
	“Realtime data port”	1...65535	The network port number of the robot from which data is received from the robot.

Inputs:	“pose”	SDT_POSE_3D	The required pose of the robot.
	“speed”	SDT_FLOAT	The required speed of the robot, mm/s.
	“accel”	SDT_FLOAT	The required acceleration of the robot, mm/s^2.
	“rel”	SDT_BOOL	Movement type: relative to the current position (TRUE) or absolute (FALSE).
Outputs:	“pose”	SDT_POSE_3D	The current pose of the robot (TCP position and tilt).
	“state”	SDT_BOOL	Flag indicating the presence of communication with the robot.

	“Rozum Robotics” - data exchange and control of Rozum Robotics robots.		
Parameters:	“Robot IP”	XXX.XXX.XXX.XXX	The IP address of the robot (or other device) with which data should be exchanged.
	“Robot port”	1...65535	The network port number of the robot (or other device) with which data should be exchanged.
Outputs:	“pose”	SDT_POSE_3D	The current pose of the robot (TCP position and tilt).
	“state”	SDT_BOOL	Flag indicating the presence of communication with the robot.

	“P3 protocol” - data exchange and control of robots via the P3 protocol (based on Ethernet/IP). A detailed description of the protocol is given in Annex 2.		
Inputs:	“pose”	SDT_POSE_3D	The required pose of the robot (converted to a 3D point of the welding groove, for example).
	“point”	SDT_POINT	A point in the scanner coordinate system.
Outputs:	“pose”	SDT_POSE_3D	The current pose of the robot (TCP position and tilt).
	“tmplt_idx”	SDT_INT32	The number of the template to be detected.
	“state”	SDT_BOOL	Flag indicating the presence of communication with the robot.

	“HND1 protocol” - data exchange with robots using the HND1 protocol. A detailed description of the protocol is given in Annex 1.		
Parameters:	“Destination IP	XXX.XXX.XXX.XXX	The IP address of the robot (or other device) with which data should be exchanged.
	“Destination port”	1...65535	The network port number of the robot (or other device) with which data should be exchanged.
	“Listen port”	1...65535	The network port number of the scanner to listen for incoming packets.
	“Swap X<->Y”	on/off	Swapping the X and Y coordinates of points.
	“Flip X-axis”	on/off	Flipping coordinates along the X axis (relative to 0). It is performed after applying the “Swap X<->Y” parameter.
	“Flip Y-axis”	on/off	Flipping coordinates along the Y axis (relative to 0). It is performed after applying the “Swap X<->Y” parameter.

	“Offset along X-axis, mm	-1000...1000	Offset of coordinates along the X axis. It is performed after applying the “Flip Y-axis” parameter.
	“Offset along Y-axis, mm	-1000...1000	Offset of coordinates along the Y axis. It is performed after applying the “Flip Y-axis” parameter.
Inputs:	“det”	SDT_BOOL	Boolean flag for template detection (correctness of all output points).
	“point #1”	SDT_POINT	Point #1, the coordinates of which are transmitted in the packet with the measurement results.
	“point #2”	SDT_POINT	Point #2, the coordinates of which are transmitted in the packet with the measurement results.
	“point #3”	SDT_POINT	Point #3, the coordinates of which are transmitted in the packet with the measurement results.
Outputs:	“idx”	SDT_INT32	The index of the welding template to be used.

	“CRobotP” - data exchange and control of CRP robots. They currently have limited functionality.		
Parameters:	“Listen port”	1...65535	The network port number of the scanner to listen for incoming packets.
Inputs:	“point”	SDT_POINT	Point coordinates in the scanner coordinate system to be transmitted to the robot.
Outputs:	“pose”	SDT_POSE_3D	The current pose of the robot (TCP position and tilt).
	“template idx”	SDT_INT32	The number of the template to be detected.
	"tracking en"	SDT_BOOL	Enabling the tracking process.
	"weld speed"	SDT_FLOAT	Welding speed.
	“state”	SDT_BOOL	Flag indicating the presence of communication with the robot.

10.3. Smart block for inspecting weld seam geometry

The **"weld seam inspection"** smart block is designed to analyze welds of various types: butt welds, corner welds, custom welds. The block automatically detects the position and boundaries of the weld and measures predefined geometric parameters for butt and fillet welds, as well as user-defined parameters for custom welds.

This smart block allows the user to view measurement results in real time, as well as accumulate measurements and view profiles.

Based on the results of the analysis of accumulated profiles, you can generate a report in the form of a PDF document or CSV table.

The block requires an activated **"Weld inspection"** license package.

	"weld seam inspection" – weld seam analysis block. The output values of the block are the results of calculating the geometric parameters of welds of various types.		
Parameters:	Left border	-100...-1	The boundary along the X axis to the right of which the weld should be located.
	Right border	1...100	The boundary along the X axis to the left of which the weld should be located.
Inputs:	"dump"	SDT_BOOL	Signal for controlling the accumulation of measurements in the internal memory.

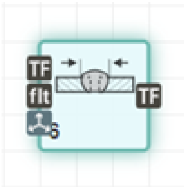
	"pos"	SDT_FLOAT	The absolute position of the positioning system or the encoder counter value when using a relative system.
	"cst"	SDT_CST_3D	Data from the calibration block.
Outputs:	"det"	SDT_BOOL	Weld detection signal.
	Dynamic outputs are added manually for the required measurements. Instructions for adding outputs are given in the detailed description of the block.		

10.3.1. Operating procedure

General procedure for working with the block:
1) Add a block to the graph.
2) Connect the inputs.
3) Select the weld type.
4) Configure weld detection (use deep debug mode if necessary).
5) Set tolerances.
6) Configure the outputs.
7) Connect the added outputs of the block to other blocks on the graph if necessary.
8) Make measurements.
9) View the results.
10) Generate a report.

10.3.2. Purpose and operating modes of the block inputs and outputs

A block located on the graph always contains three inputs and one output.



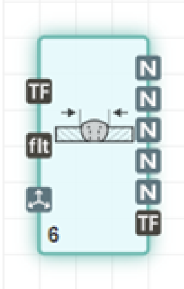
The **"dump"** input controls the accumulation of measurements into the internal memory. When set to TRUE, profiles are accumulated; when set to FALSE, accumulation is stopped. Changing from FALSE to TRUE resets previously accumulated profiles.

The **"pos"** input determines the position of the positioning system when constructing a 3D point cloud of the weld. The use of this input depends on the **"Position system type"** parameter. In the **"Linear, absolute"** and **"Radial, absolute"** modes, the input determines the coordinate of the positioning system. In the **"Linear, counter"** and **"Radial, counter"** modes, the input determines the value of the encoder counter, which, when multiplied by the value of the **"Positioner step"** parameter, forms the coordinate of the positioning system. In the **"Robot 3D coordinates"** mode, this input is not used.

The **"cst"** input determines the robot's position if the **"Position system type"** parameter is set to **"Robot 3D coordinates"** mode. Not used in all other modes.

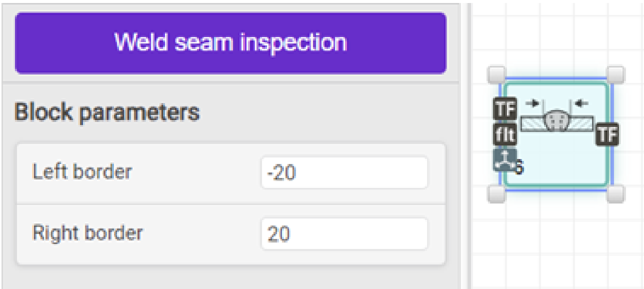
The **"det"** output indicates whether a weld is detected in the profile currently being analyzed. TRUE if a weld is detected, FALSE if it is not.

If you need to obtain measurements for output to the network or for subsequent processing on a graph, it is necessary to add dynamic outputs for each measurement. How to do this is described in par. "Outputs" mode. The type of all added outputs is SDT_SCALAR. Example of adding 4 dynamic outputs:

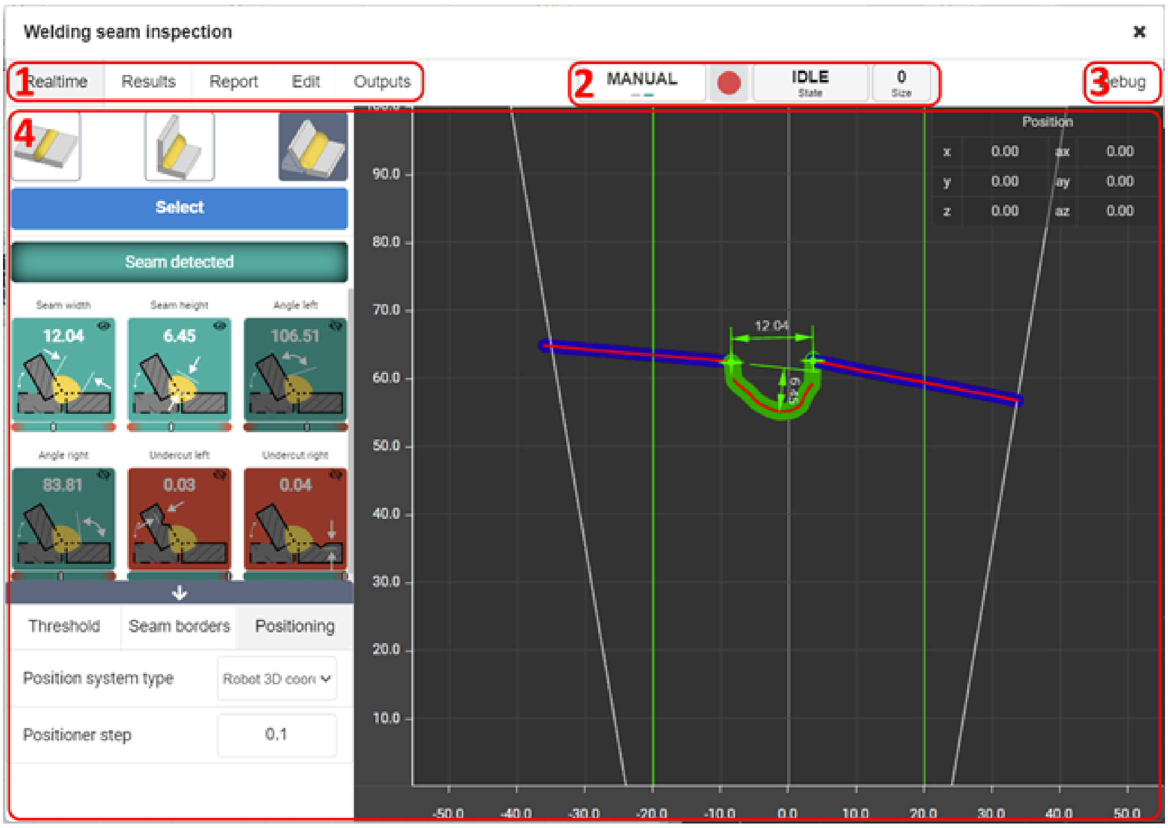


10.3.3. Main window

When you select a block on the graph, the **Left border** and **Right border** parameters are displayed on the block parameters tab, and a button for opening the main window for working with the block is displayed:



When you click on the **Weld seam inspection** button, the main program window appears:



1 - Operating modes.
2 - Profile accumulation controls.
3 - Switching to advanced debugging mode for weld detection.
4 - Current mode. The content of this area depends on the selected mode.

10.3.3.1. Operating modes

This area contains tabs for switching between five main operating modes:

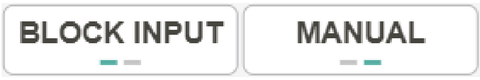
1 - **Realtime** – Viewing measurements in real time.
2 - **Results** – Viewing accumulated profiles and measurements.
3 - **Report** – Generating reports based on accumulated profiles.
4 - **Edit** – Editing tolerances.
5 - **Outputs** – Adding dynamic outputs for the required measurements.

10.3.3.2. Profile accumulation controls

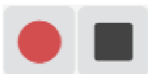
This area allows the user to start recording from the web interface or set the recording start mode.

Elements of this area:

1) Accumulation trigger selection. In **MANUAL** mode, accumulation is started using the manual start/stop button. In **BLOCK INPUT** mode, accumulation is started at the **"dump"** input.



2) Accumulation start/stop button.



3) Current state of accumulation: **IDLE** – accumulation is not performed; **RECORDING** – accumulation is in progress.

4) Counter of accumulated profiles.

Only those profiles on which a weld was detected are recorded.

10.3.3.3. Advanced debugging mode

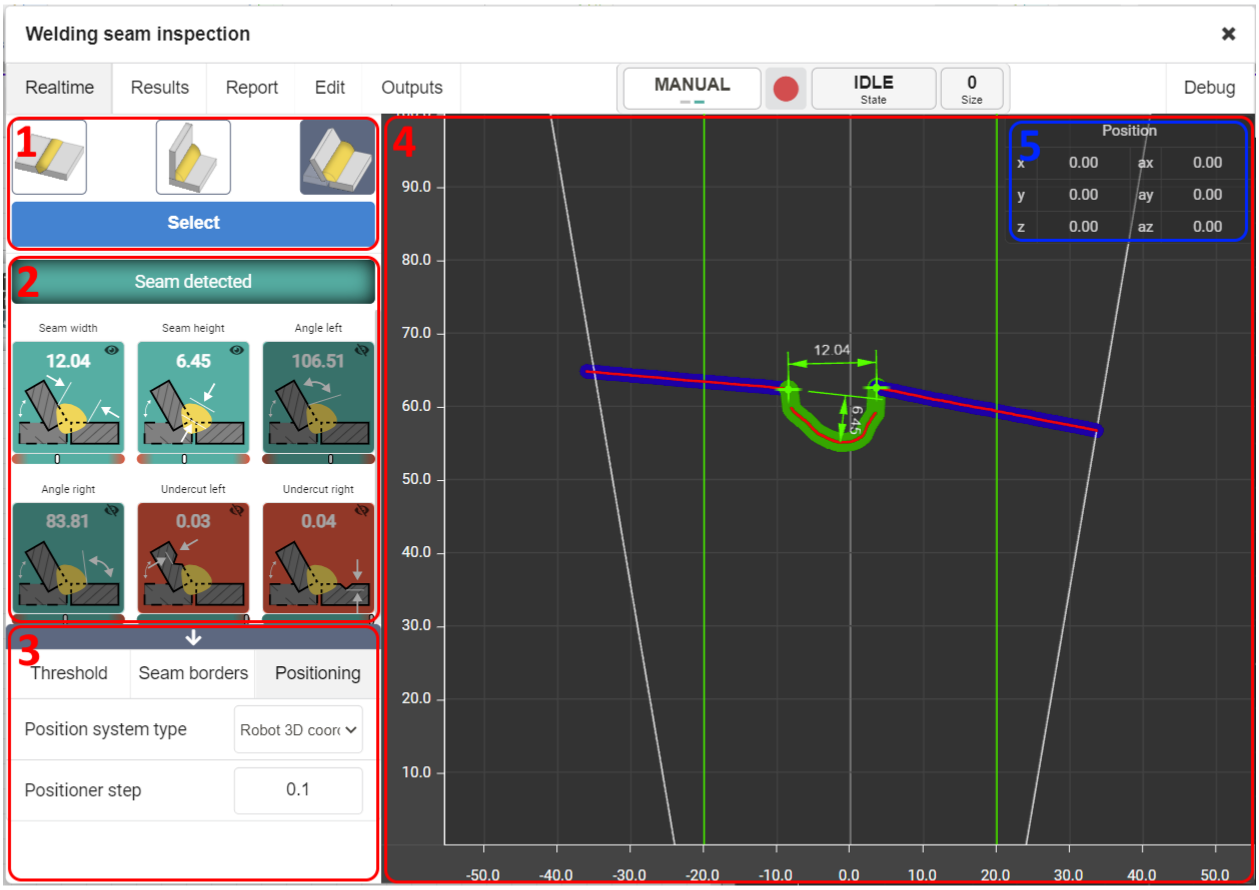
This tab switches the appearance of the window to a mode in which you can perform an in-depth analysis of weld detection. This mode allows you to adjust parameters based on visual characteristics in case of incorrect detection of weld boundaries.

10.3.3.4. Current mode

The content of this area depends on the selected operating mode.

10.3.4. "Realtime" mode

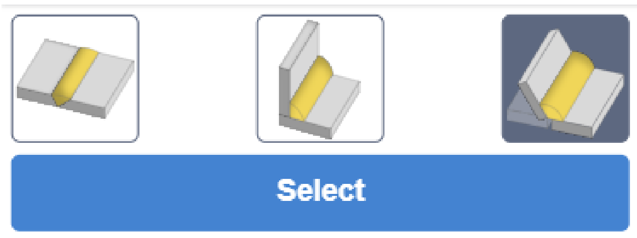
This mode is designed to view measurement results in real time.



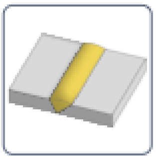
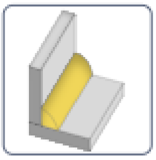
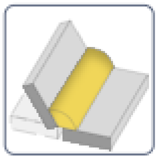
1 - Weld type selection.
2 - Measurement results.
3 - Block parameters.
4 - Display of profile, weld and measurements.
5 - Positioning system location.

10.3.4.1. Weld type selection

This panel allows you to select the type of weld currently being inspected.

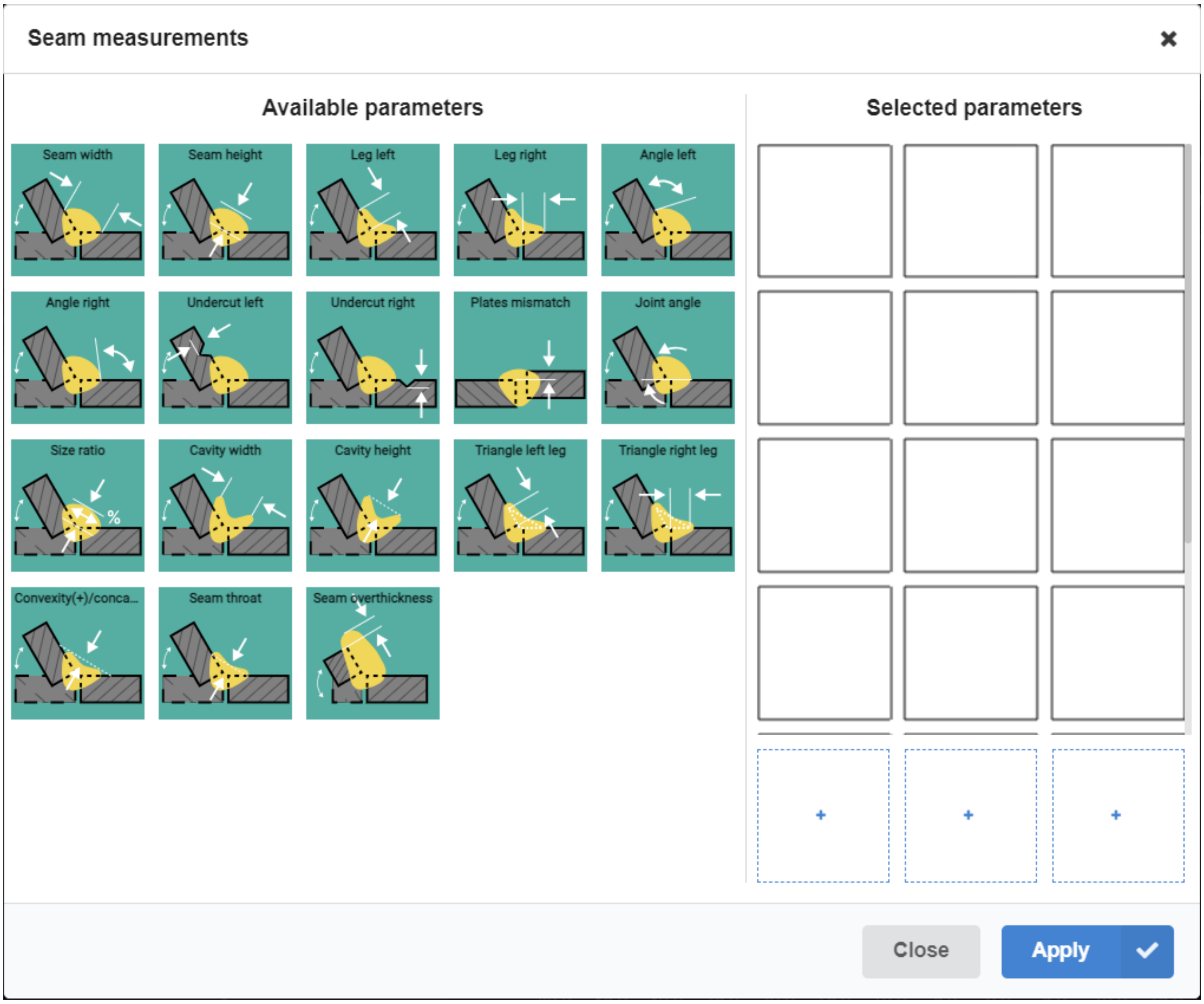


The following weld types are available:

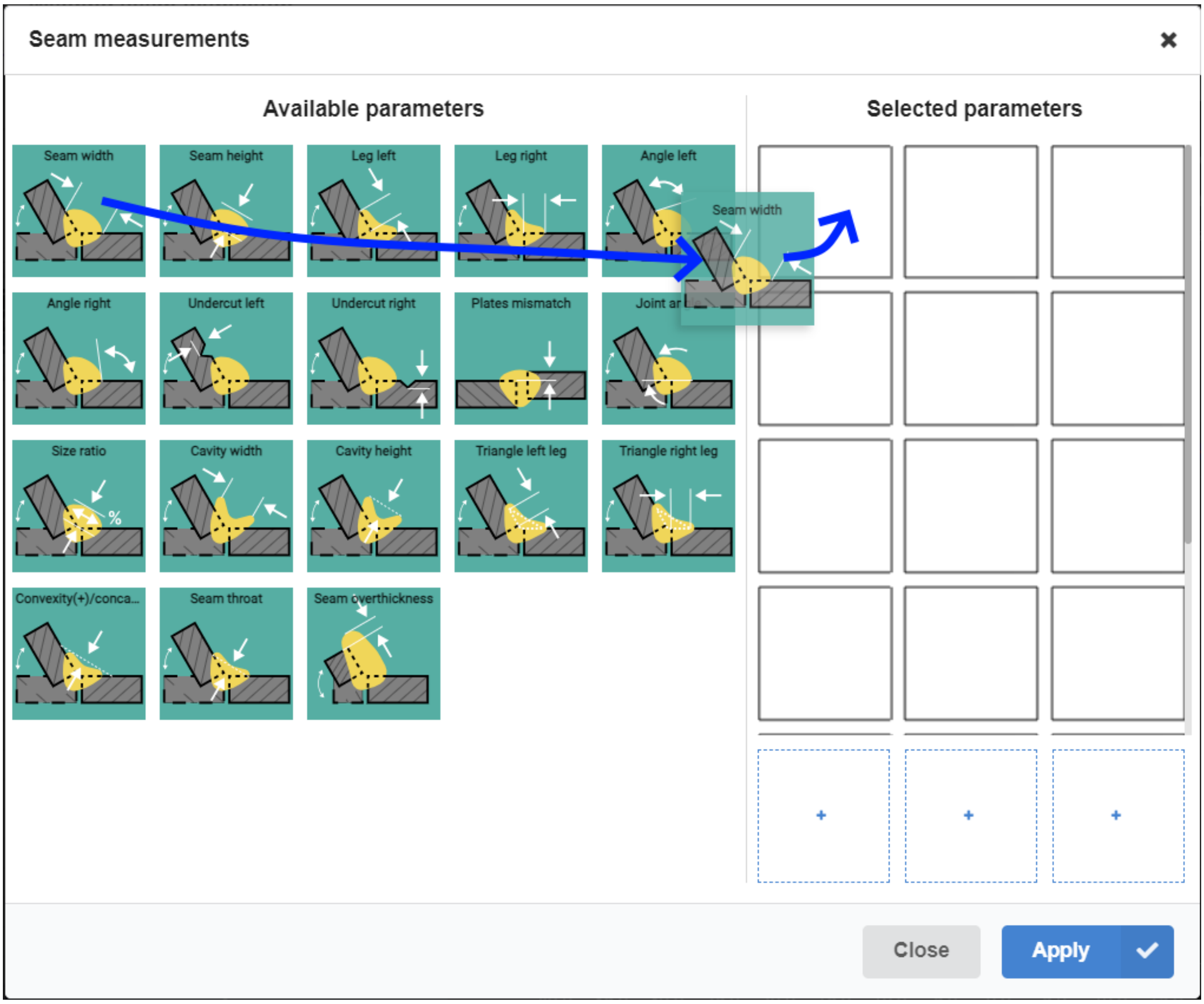
Butt weld	Fillet weld	Custom weld
		

For butt and fillet welds, the possible measurements are predefined.

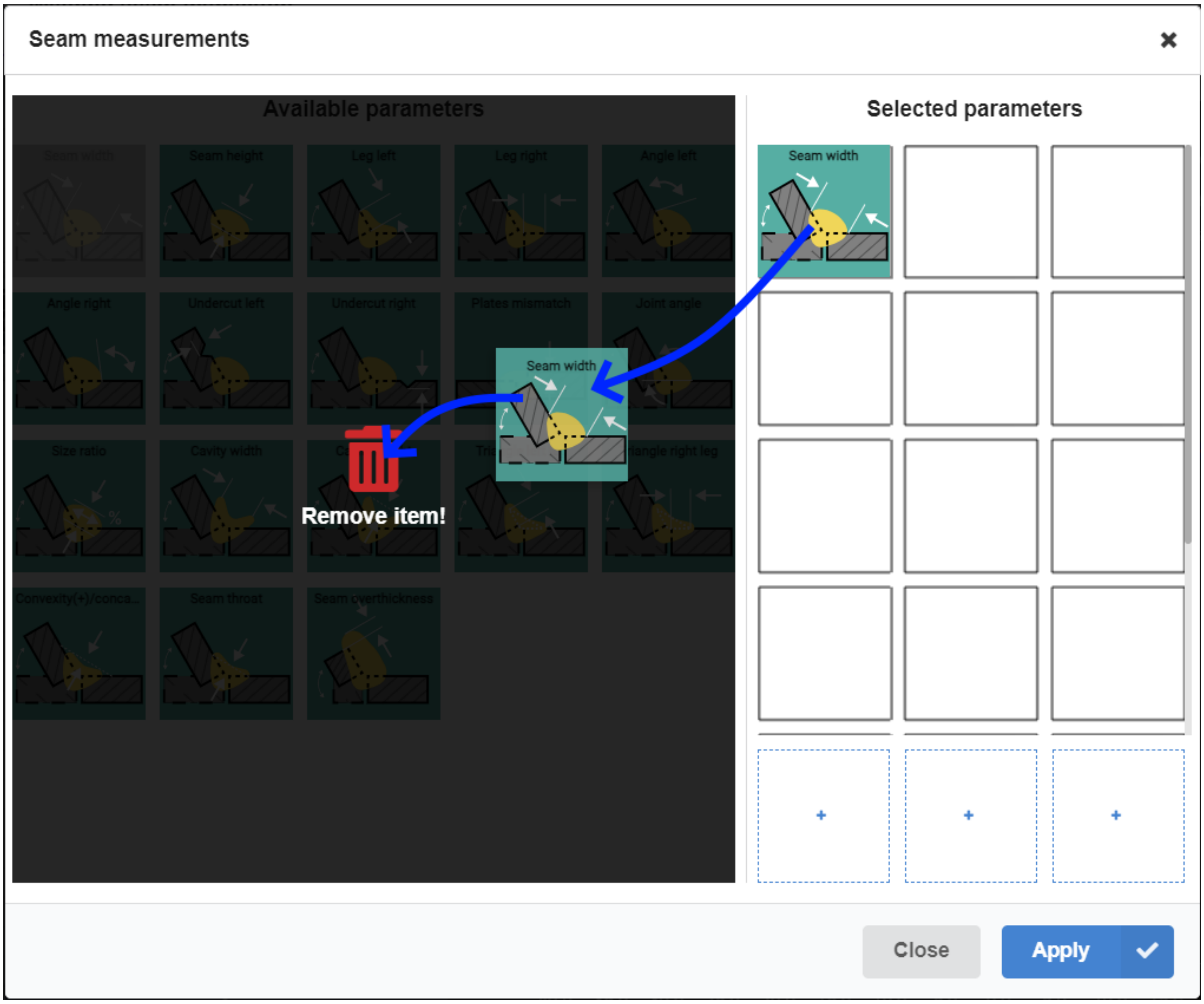
For a custom weld, you can select the required measurements by clicking the **Select** button.



The **Available parameters** area contains a list of all possible measurements. Adding is done by dragging the icon of the required parameter to the **Selected parameters** area.



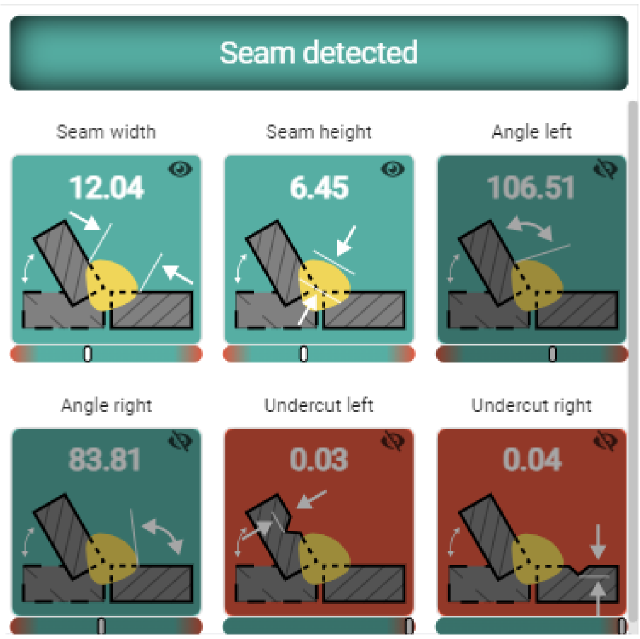
To remove a parameter, you need to drag the measurement icon from the **Selected parameters** area back to the **Available parameters** area.



In order to save the changes, it is necessary to click the **Apply** button and close the window by clicking the **Close** button.

The added parameters will appear in the measurement results area.

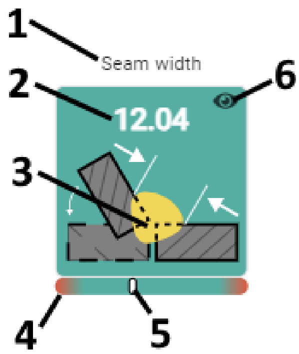
10.3.4.2. Measurement results



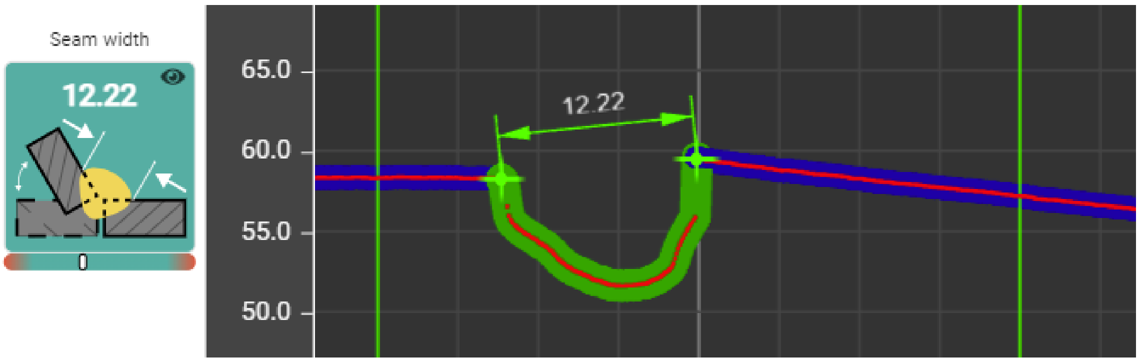
At the top there is a weld detection indicator.
Gray color means no weld was detected.

Green color means a weld has been detected.

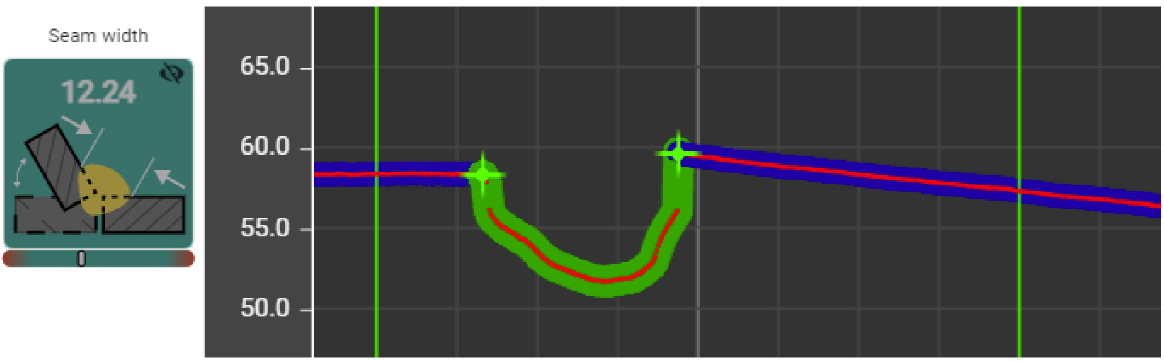
Below are the icons of measured parameters.



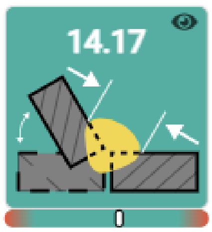
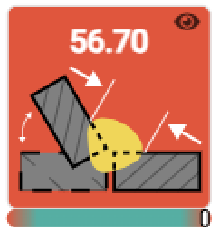
1 - Name of the measured parameter.
2 - Measurement result.
3 - Visualization of the measured parameter.
4 - Tolerance scale.
5 - Current position of the tolerance indicator.
6 - Button to enable/disable display of measurement results on the profile.
Display enabled:



Display disabled:



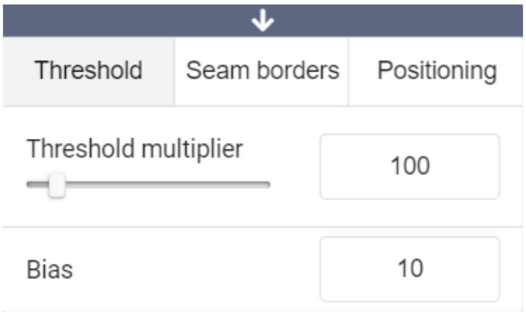
The background color of the icon determines whether the measured value is within the tolerance. The tolerance indicator shows in which direction the tolerance has been exceeded: at the lower limit or at the upper limit.

Within tolerance	Out of tolerance
	

10.3.4.3. Block parameters

This panel is designed to configure internal parameters of blocks. Internal parameters are divided into the following groups: **Threshold**, **Seam borders** and **Positioning**.

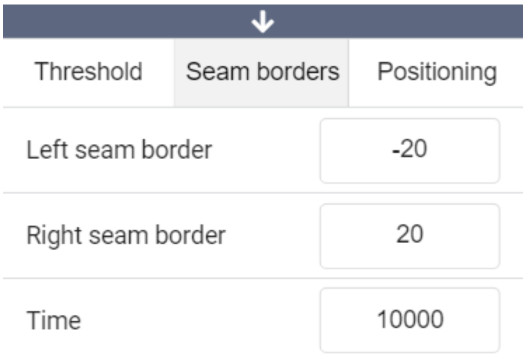
The **Threshold** group:



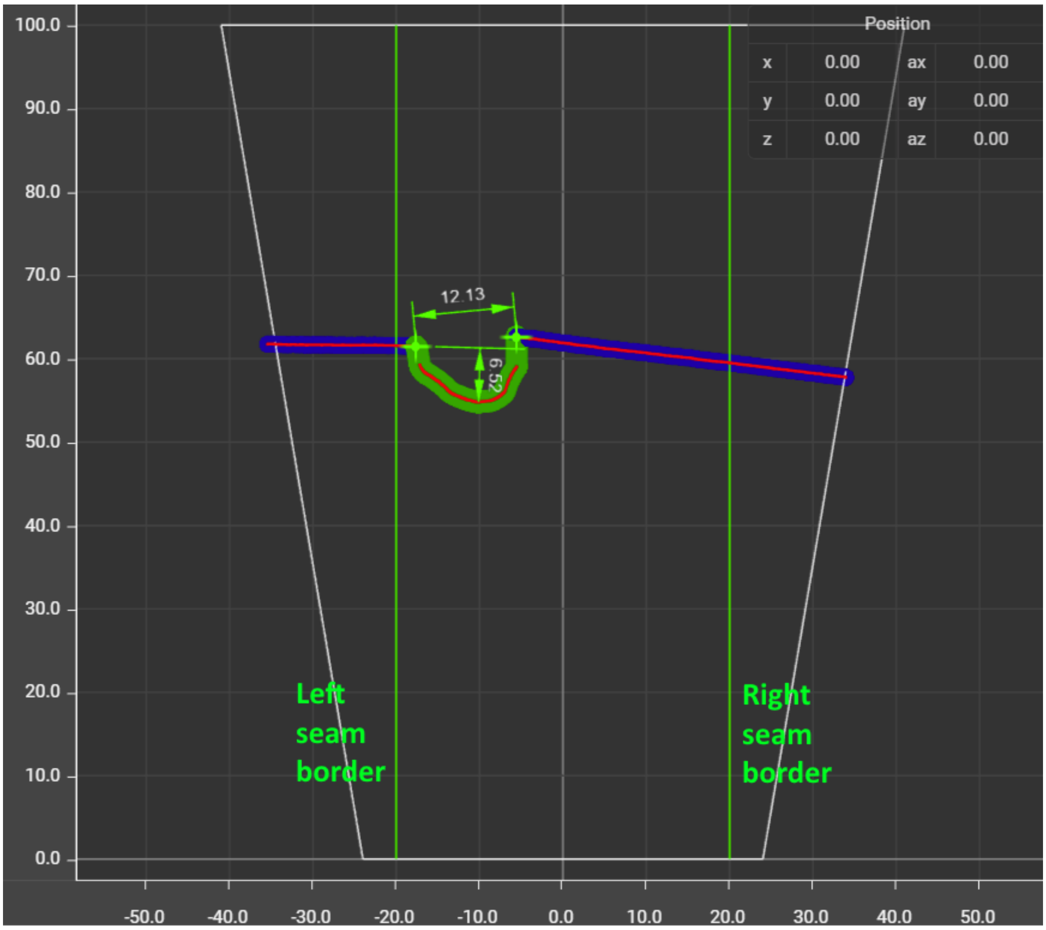
Threshold multiplier – a multiplier by which the average value of the lines of the plates being welded is multiplied. This parameter is described in detail in par. "Debug" mode.

Bias – if the average value for the sideplate lines is less than the **Bias** value, then the **Bias** value will be used to multiply by the **Threshold multiplier** value.

The **Seam borders** group:

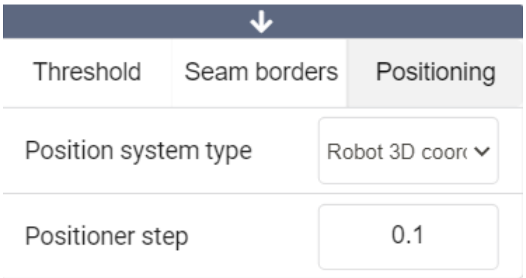


The **Left seam border** and **Right seam border** values determine the position of the vertical lines on the X axis, between which the weld should be located during the operation of the block.



Time – time step after which the results are saved to the internal memory during accumulation.

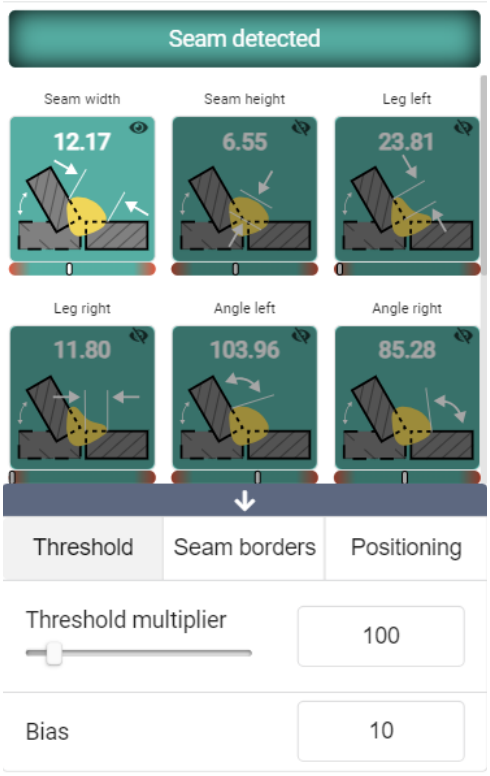
The **Positioning** group:

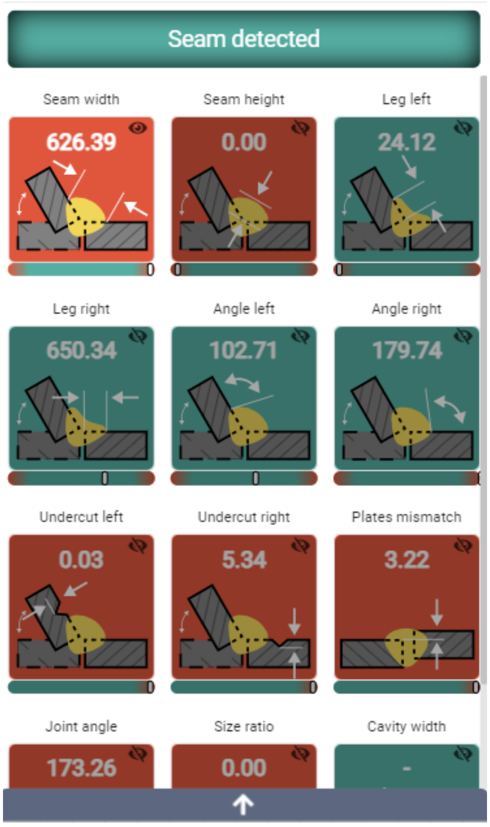


Position system type – the type of the positioning system. Possible options:

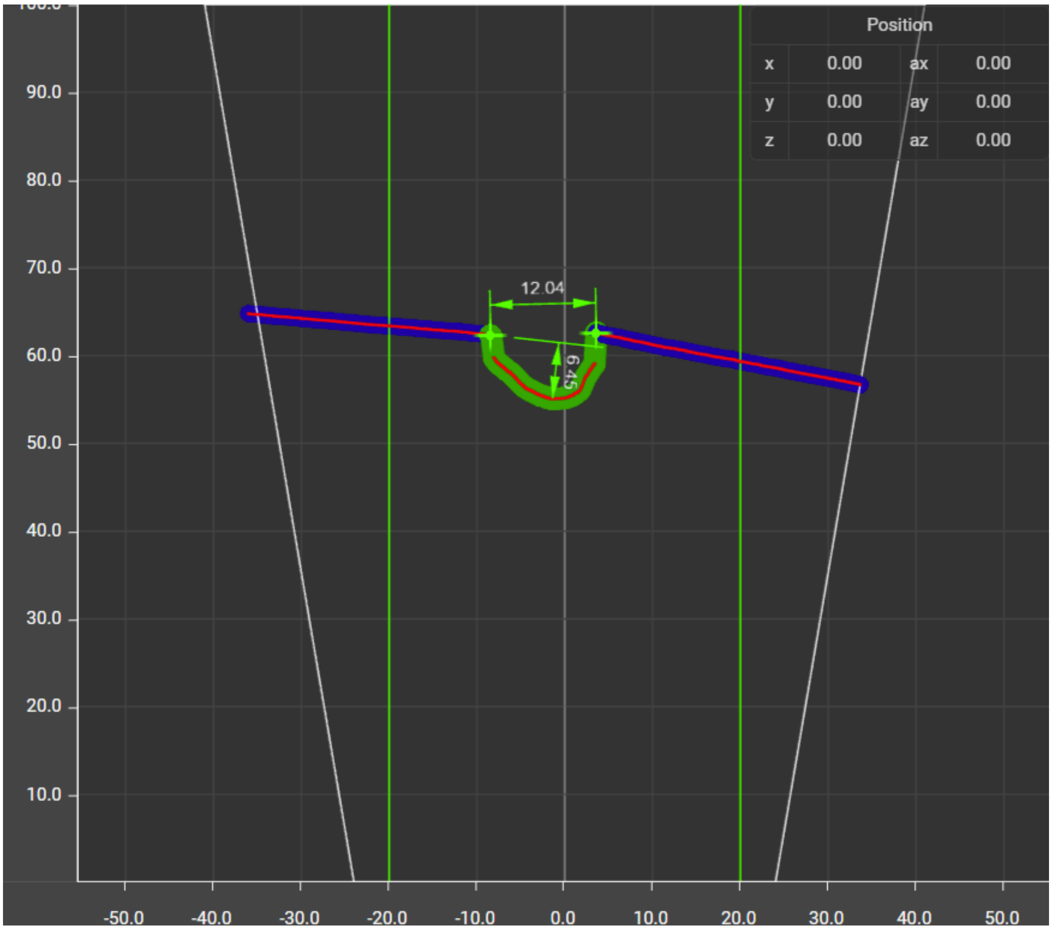
- **"Linear, absolute"** – a linear positioning system with absolute positioning. The **"pos"** input defines the coordinate value for each profile in mm.
- **"Linear, counter"** – a linear positioning system with positioning by encoder. The **"pos"** input defines the encoder counter value, which determines the position in mm when multiplied by the value of the **Positioner step** parameter.
- **"Radial, absolute"** – a radial positioning system with absolute positioning. The **"pos"** input defines a coordinate value for each profile in angular coordinates.
- **"Radial, counter"** – a radial positioning system with encoder positioning. The **"pos"** input defines the encoder counter value, which determines the position in angular coordinates when multiplied by the value of the **Positioner step** parameter.
- **"Robot 3D coordinates"** – a positioning system for robots in three-dimensional space. The **"cst"** input defines data from the calibration block.

This panel can be hidden to display more measurement icons:





10.3.4.4. Weld profile and measurements



This panel displays the profile divided into plates and weld. The plates are highlighted in blue. The weld is highlighted in green. The profile displays geometric interpretations of the selected measurements.

10.3.4.5. Positioning system

This panel is located in the profile display area. The content of this panel depends on the selected mode of the **Position system type** parameter.

With the **"Linear, absolute"** and **"Radial, absolute"** values only the current position is displayed. The counter value is not available.

Position	0
Counter	-

With the **"Linear, counter"** and **"Radial, counter"** values, the following parameters will be displayed: the encoder counter value and the recalculated value of the position taking into account the **Positioner step** parameter.

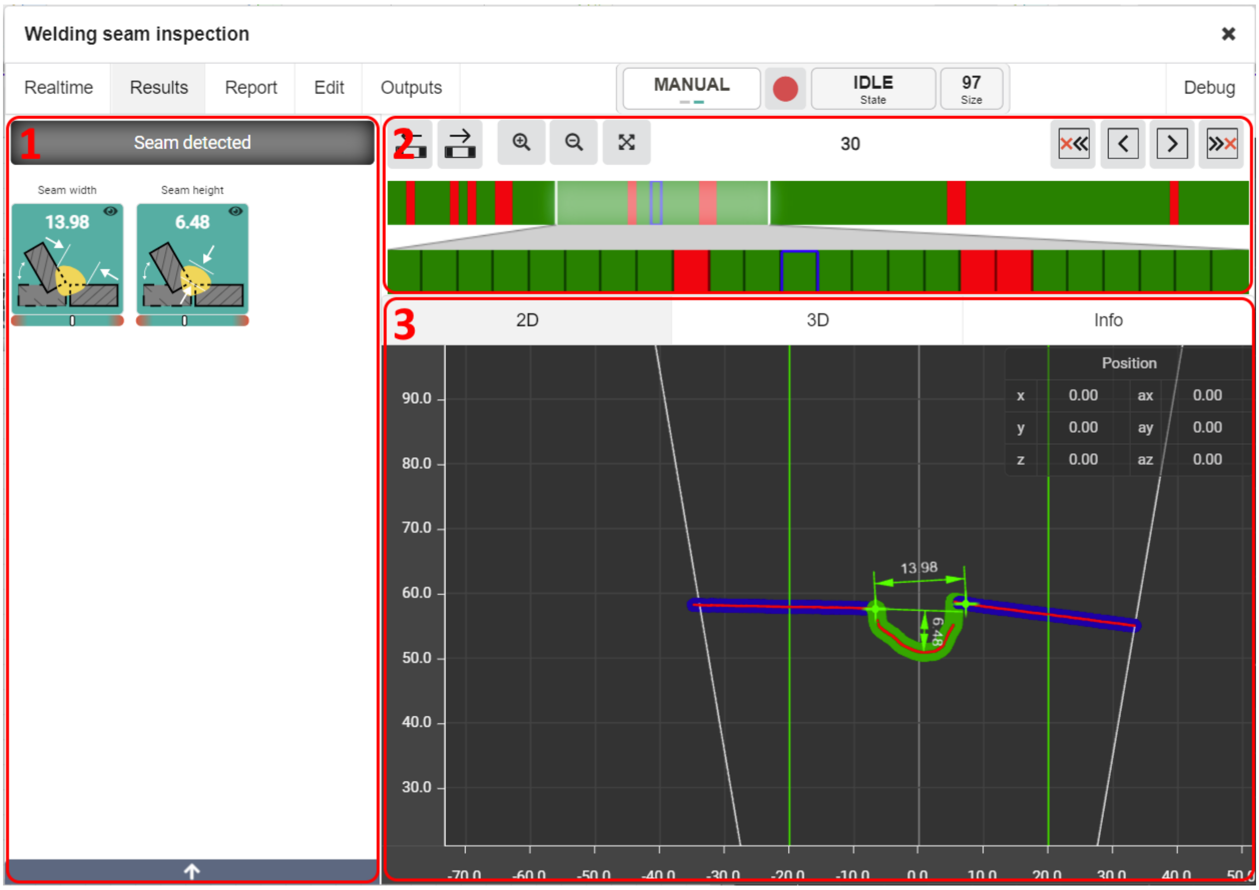
Position	0.00
Counter	0

When set to **"Robot 3D coordinates"**, the robot's position is displayed as three coordinates along the axes and three angles of rotation around the axes.

Position			
x	0.00	ax	0.00
y	0.00	ay	0.00
z	0.00	az	0.00

10.3.5. "Results" mode

This mode is designed to view accumulated measurement results.

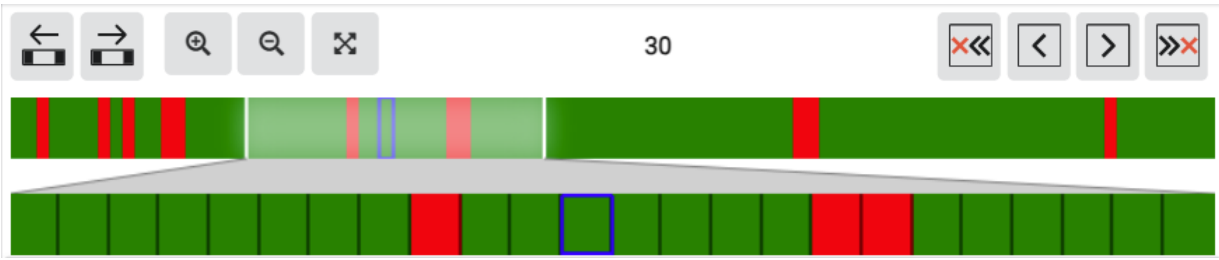


1 - Measurement icons. This panel is similar to that described in par. ["Realtime" mode](#).
2 - Profile selection.
3 - Display of profile, weld and measurements.

10.3.5.1. Profile selection

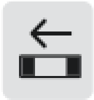
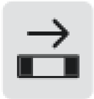
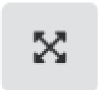
This area displays the status of accumulated profiles. The entire set of profiles is represented as a strip of cells, in which each profile is a separate cell. If all measurements for a given profile are within user-defined tolerances, the cell appears green. If the result of at least one measurement is out of tolerance, the cell turns red. The current profile is highlighted with a blue frame.

With a large number of profiles on a strip, the cells are too small to distinguish them, so there is a second strip below that allows you to view the area of interest.

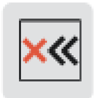
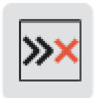
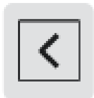
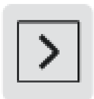


At the top there are controls for the area being viewed, an index of the selected profile, and navigation elements for the array of profiles.

Controls:

	Move the window to the left by 1 profile.
	Move the window to the right by 1 profile.
	Zoom in.
	Zoom out.
	Reset scaling.

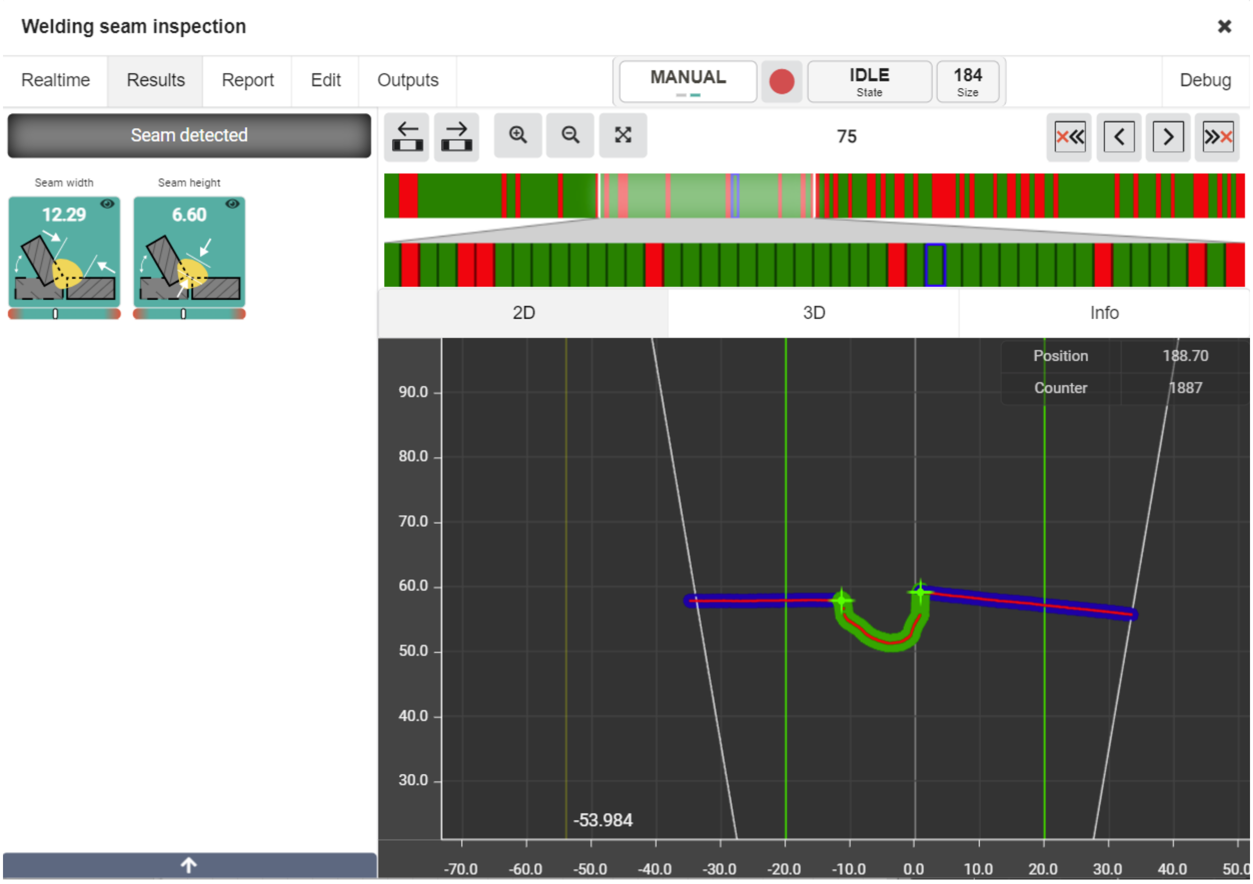
You can also move the window using the mouse.
Navigation elements:

	Go to the previous profile with defects.
	Go to the next profile with defects.
	Go to the previous profile.
	Go to the next profile.

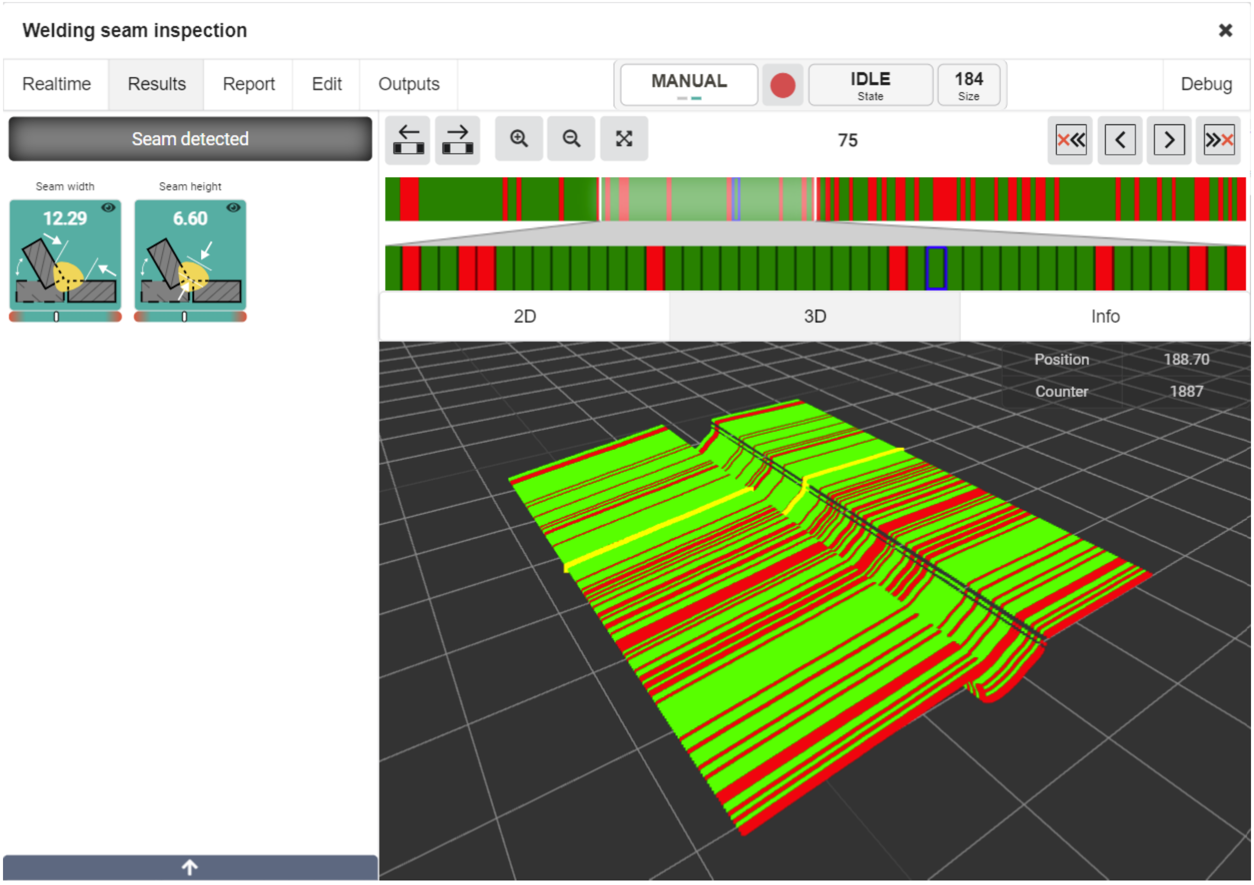
10.3.5.2. Display of profile, weld and measurements

There are two modes for displaying the results: **2D** and **3D**.

In **2D** mode, the viewing area is similar to that described in par. "Realtime" mode. The position and counter value are displayed for the selected profile.



In **3D** mode, all accumulated profiles are displayed as a point cloud. Each profile in the point cloud is colored green or red depending on whether the measurement results meet the specified tolerances. The selected profile will be highlighted in yellow.



When switching between **2D** and **3D** modes, the index of the selected profile is the same.

The **Info** tab displays information about the motion system.

2D	3D	Info

Positioning info

Position system type	Linear, counter

In robot mode, the calibration matrix is displayed.

2D	3D	Info

Positioning info

Position system type	Robot 3D coordinates

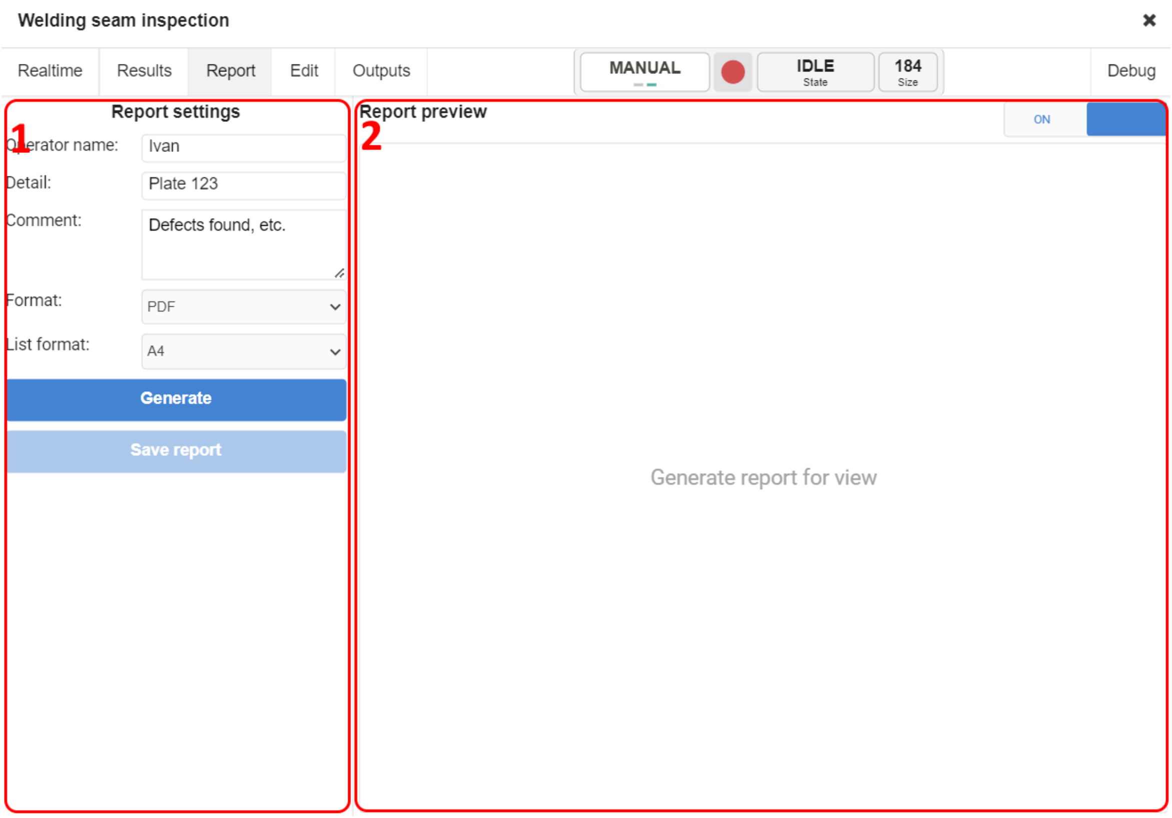
Sensor to flange matrix

0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0

10.3.6. "Report" mode

This mode allows you to generate a report.

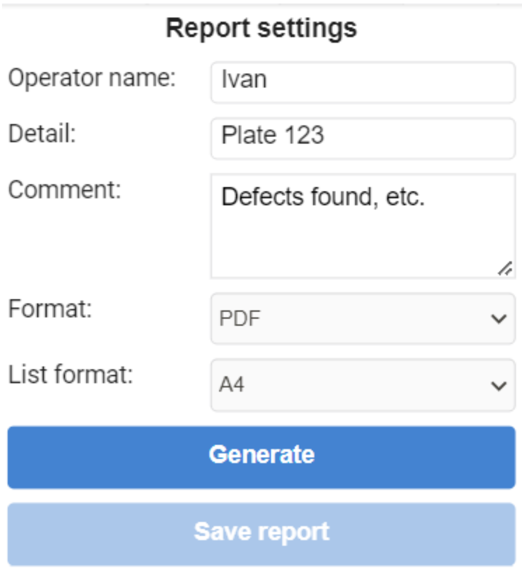
The **Report** mode:



1 - Report generation area.

2 - Preview area.

10.3.6.1. Report generation area



In this panel you can enter the following information for the report:

Format – Report format. Available formats: PDF and CSV.

Operator name – The name of the operator who performed the weld inspection (PDF only).

Detail – Name or code of the part being scanned (PDF only).

Comment – Operator's comment (PDF only).

List format – Sheet format. Available formats: A4, A3, A2 (PDF only).

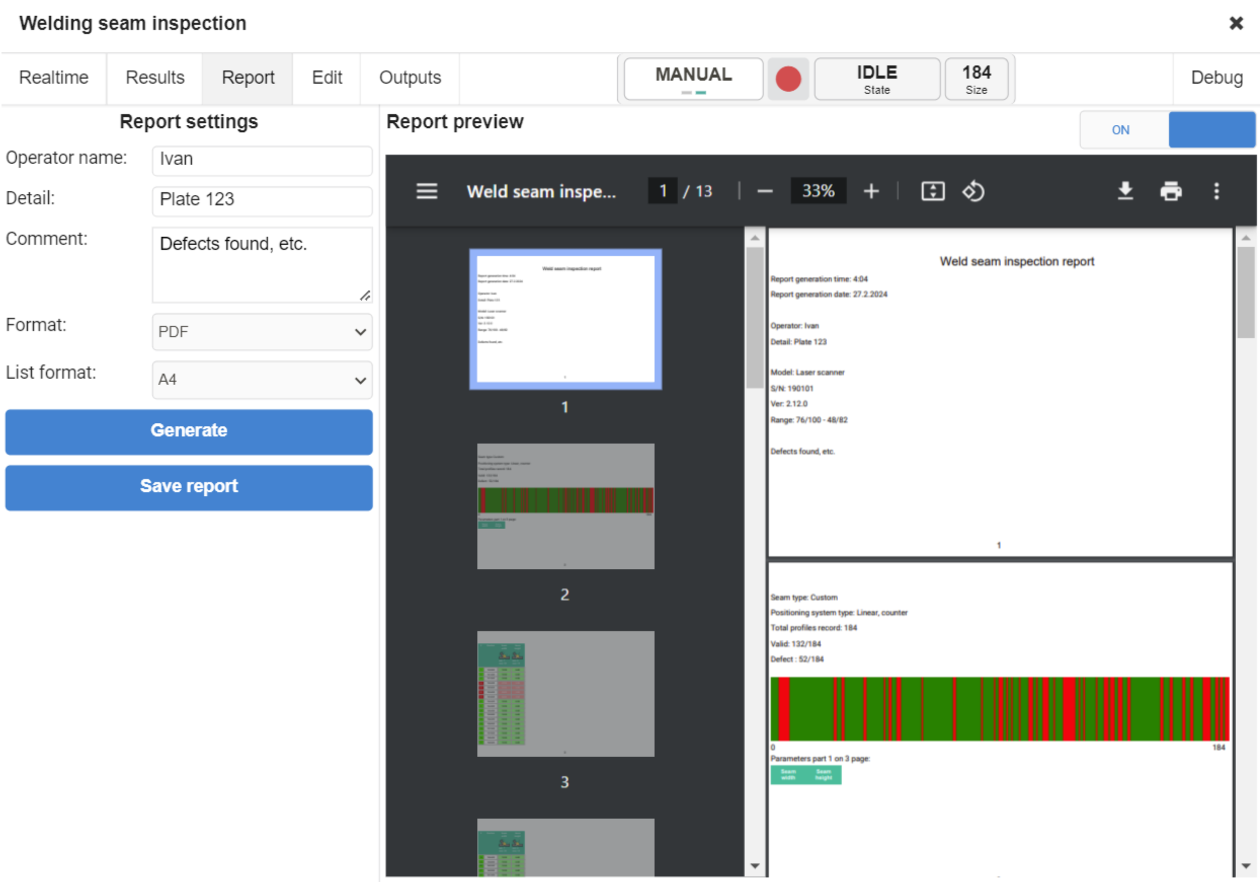
When you click the **Generate** button, the report is displayed in the preview area if the **Report preview** option is enabled.

You can download the report by clicking on the **Save report** button, which becomes active only after the report is generated.

10.3.6.2. Preview area

This area displays reports that appear after clicking the **Generate** button, provided that the **Report preview** option is enabled. For large reports, you can disable preview to save computer resources.

PDF report preview:



The first page of the PDF report contains the following information: date and time the report was generated, additional information entered by the operator, information about the scanner (model, serial number, software version, measuring range).

Weld seam inspection report

Report generation time: 4:04

Report generation date: 27.2.2024

Operator: Ivan

Detail: Plate 123

Model: Laser scanner

S/N: 190101

Ver: 2.12.0

Range: 76/100 - 48/82

Defects found, etc.

1

The second page of the report contains information about the total number of profiles and an indicator similar to that in the **Results** mode. A list of measured parameters is displayed below the indicator.

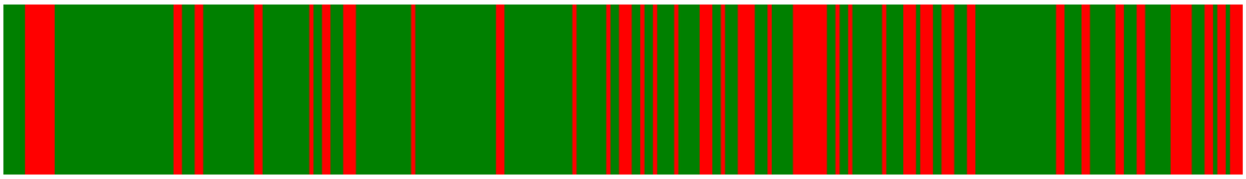
Seam type: Custom

Positioning system type: Linear, counter

Total profiles record: 184

Valid: 132/184

Defect : 52/184



0 184

Parameters part 1 on 3 page:

Seam width	Seam height

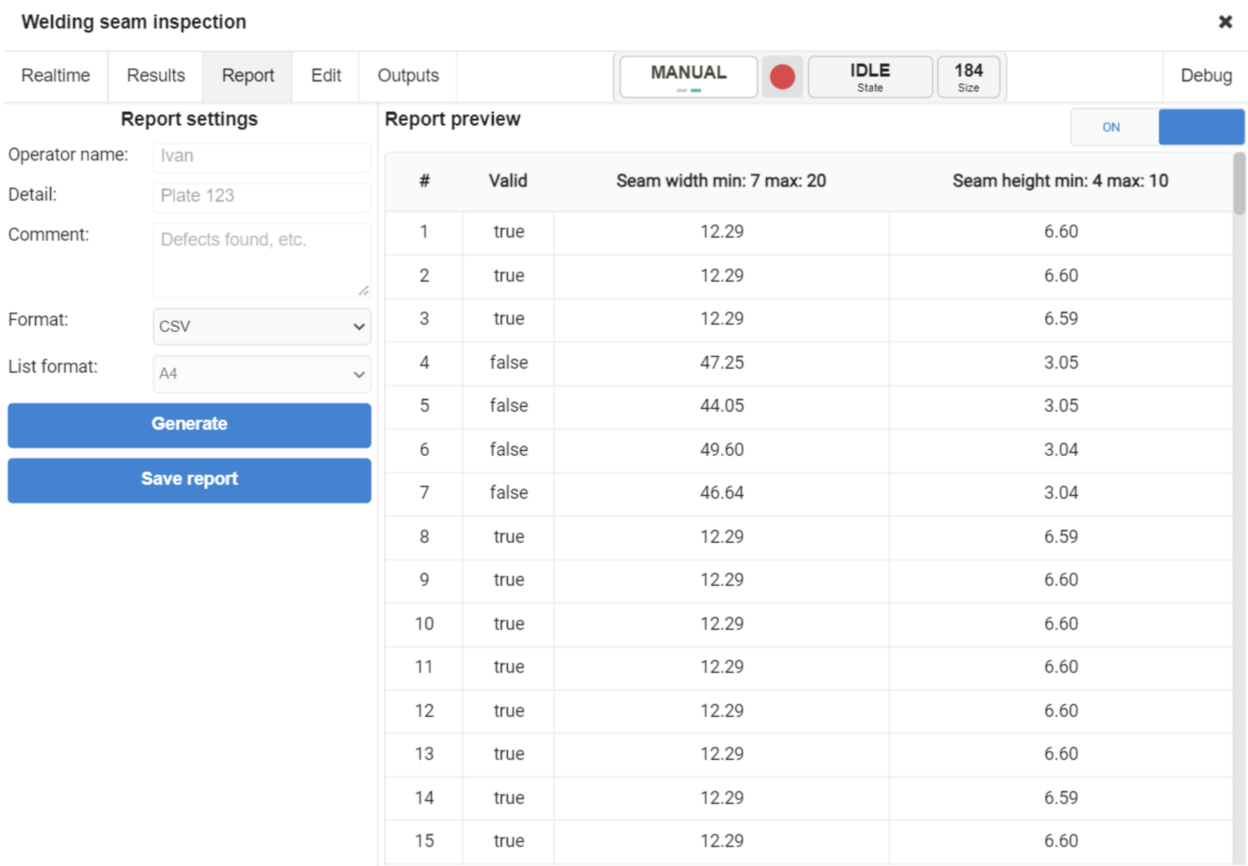
2

The following pages contain the measurement results for each profile:

#	Position	Seam width min: 7 max: 20	Seam height min: 4 max: 10
1	150.800	12.29	6.60
2	151.400	12.29	6.60
3	151.900	12.29	6.59
4	152.400	47.25	3.05
5	152.900	44.05	3.05
6	153.400	49.60	3.04
7	153.900	46.64	3.04
8	154.400	12.29	6.59
9	154.900	12.29	6.60
10	155.400	12.29	6.60
11	155.900	12.29	6.60
12	156.400	12.29	6.60
13	156.900	12.29	6.60
14	157.400	12.29	6.59
15	157.900	12.29	6.60
16	158.400	12.29	6.60
17	158.900	12.29	6.60

3

In CSV mode, the preview displays a table. Example of the report preview in CSV format:



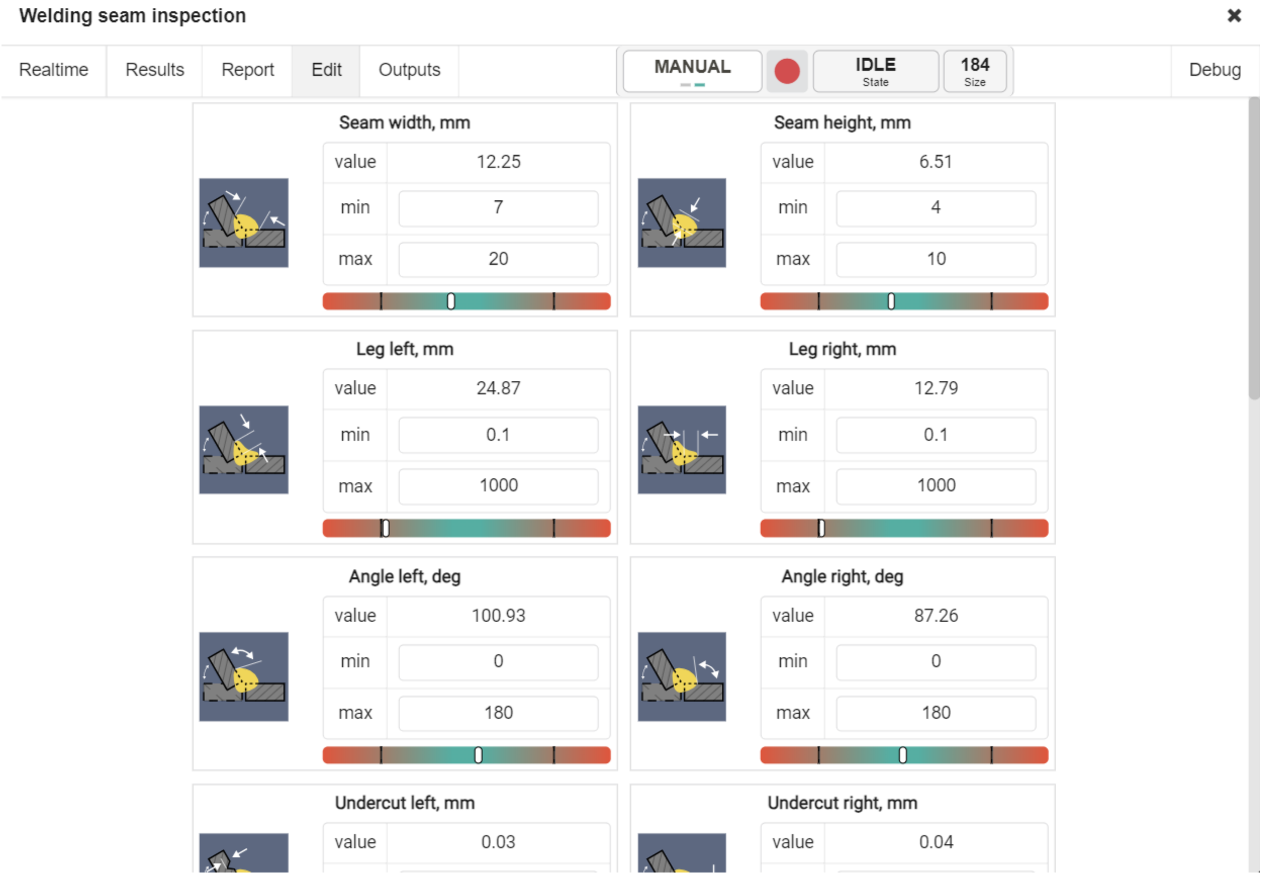
#	Valid	Seam width min: 7 max: 20	Seam height min: 4 max: 10
1	true	12.29	6.60
2	true	12.29	6.60
3	true	12.29	6.59
4	false	47.25	3.05
5	false	44.05	3.05
6	false	49.60	3.04
7	false	46.64	3.04
8	true	12.29	6.59
9	true	12.29	6.60
10	true	12.29	6.60
11	true	12.29	6.60
12	true	12.29	6.60
13	true	12.29	6.60
14	true	12.29	6.59
15	true	12.29	6.60

The first line of the CSV file is the parameters, the values of which are located in the corresponding columns. The **Valid** column is *false* if at least one measurement is out of tolerance.

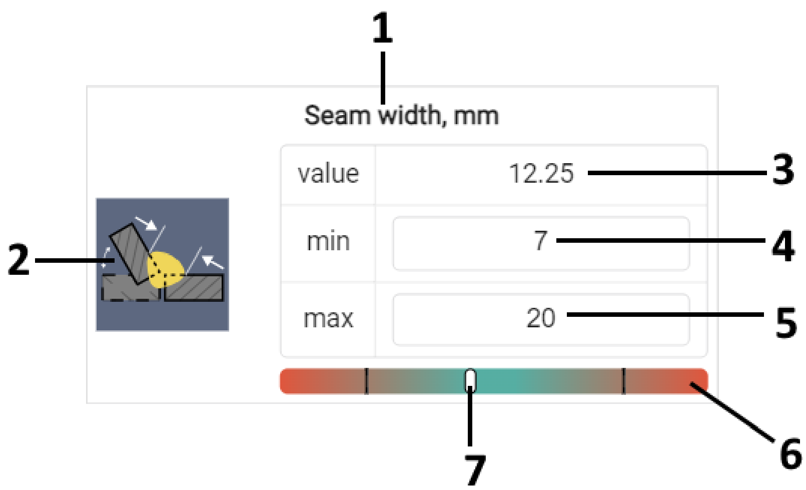
```
#,Valid,Seam width min: 7 max: 20,Seam height min: 4 max: 10
1,true,12.29,6.60
2,true,12.29,6.60
3,true,12.29,6.59
4,false,47.25,3.05
5,false,44.05,3.05
6,false,49.60,3.04
7,false,46.64,3.04
8,true,12.29,6.59
```

10.3.7. "Edit" mode

The **Edit** mode is designed to set tolerances for weld parameters.



An example:



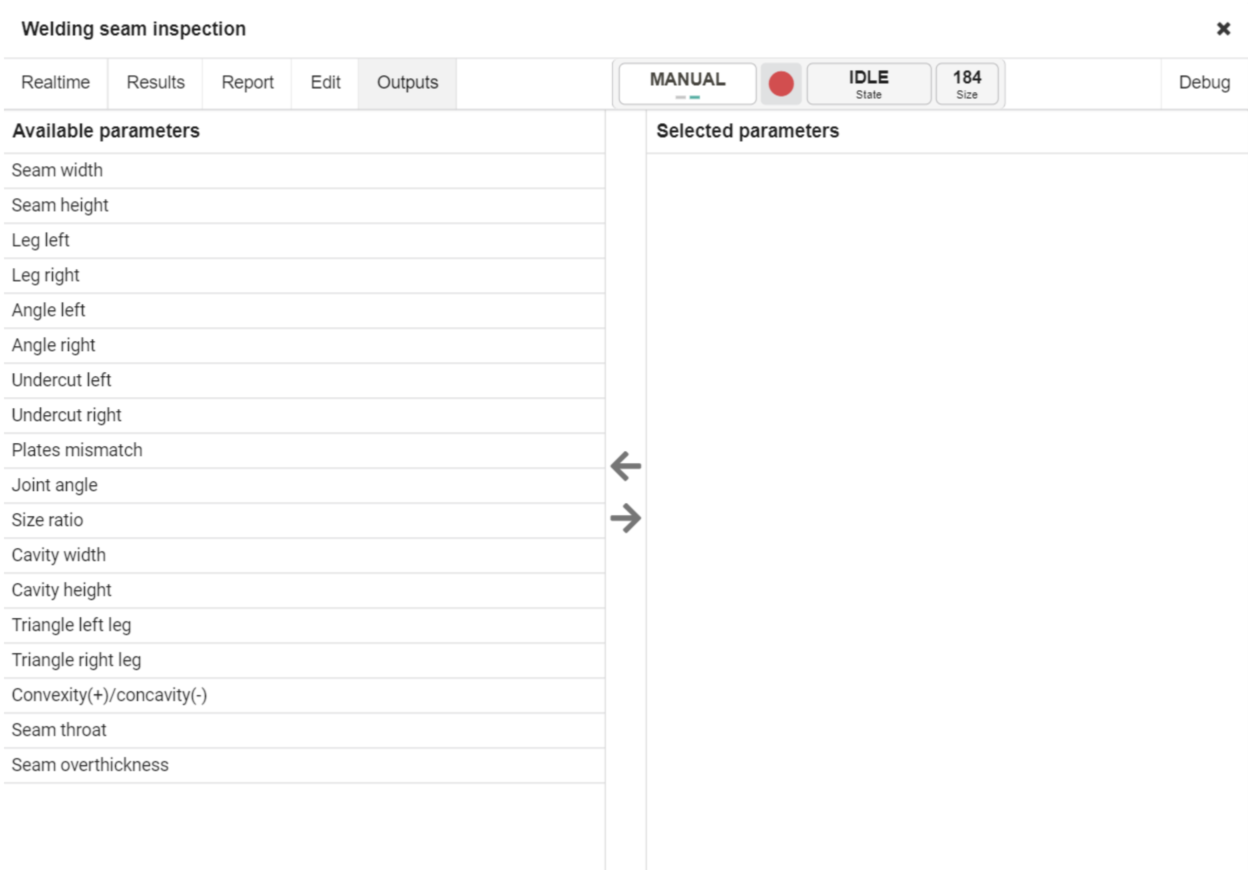
1 - Name of the measured parameter.
2 - Measurement icon.
3 - Current measured value.
4 - Lower tolerance limit.
5 - Upper tolerance limit.
6 - Tolerance indicator.
7 - The current position of the measured value.

The table contains icons for a custom weld because this weld type contains the largest set of measurements, including all measurements for a butt weld and all measurements for a fillet weld. Editing is available only when a weld is detected and if this measurement is possible for the specified weld type (the weld type is selected in **Realtime** mode).

Possible measurements for all available weld types are given in par. [List of measurements](#).

10.3.8. "Outputs" mode

This mode allows you to create dynamic outputs that determine what results can be obtained from the block outputs.



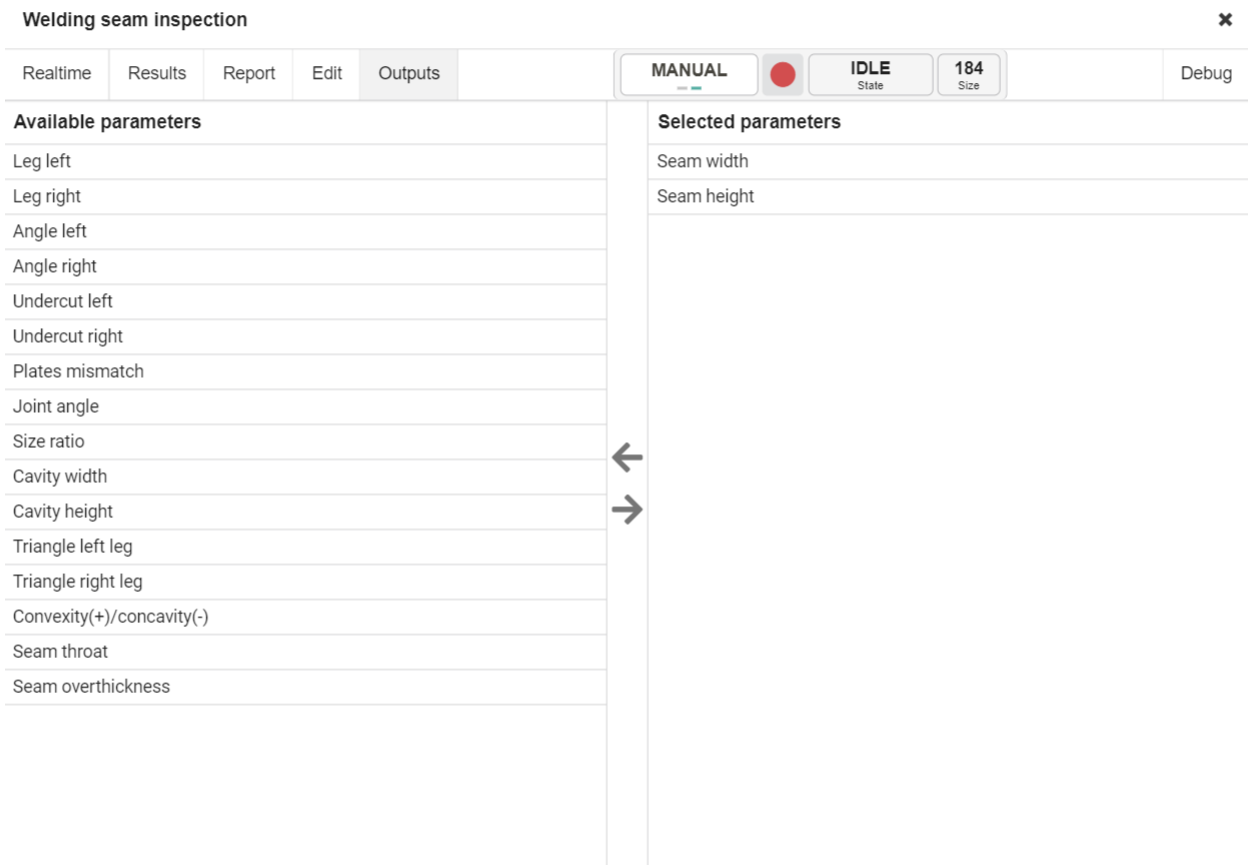
The list shows parameters for a custom weld because this weld type contains the largest set of measurements.

For example, if an output was created for the **Leg left** parameter, which is not possible for a butt weld, then when you switch to a butt weld, the output will not be valid, but will continue to exist.

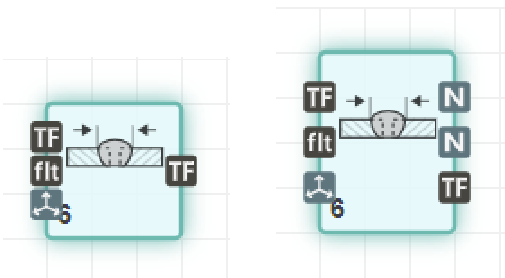
To add outputs, drag them from the **Available parameters** area to the **Selected parameters** area.

To remove parameters, drag it back from the **Selected parameters** area to the **Available parameters** area.

Example of adding multiple outputs:

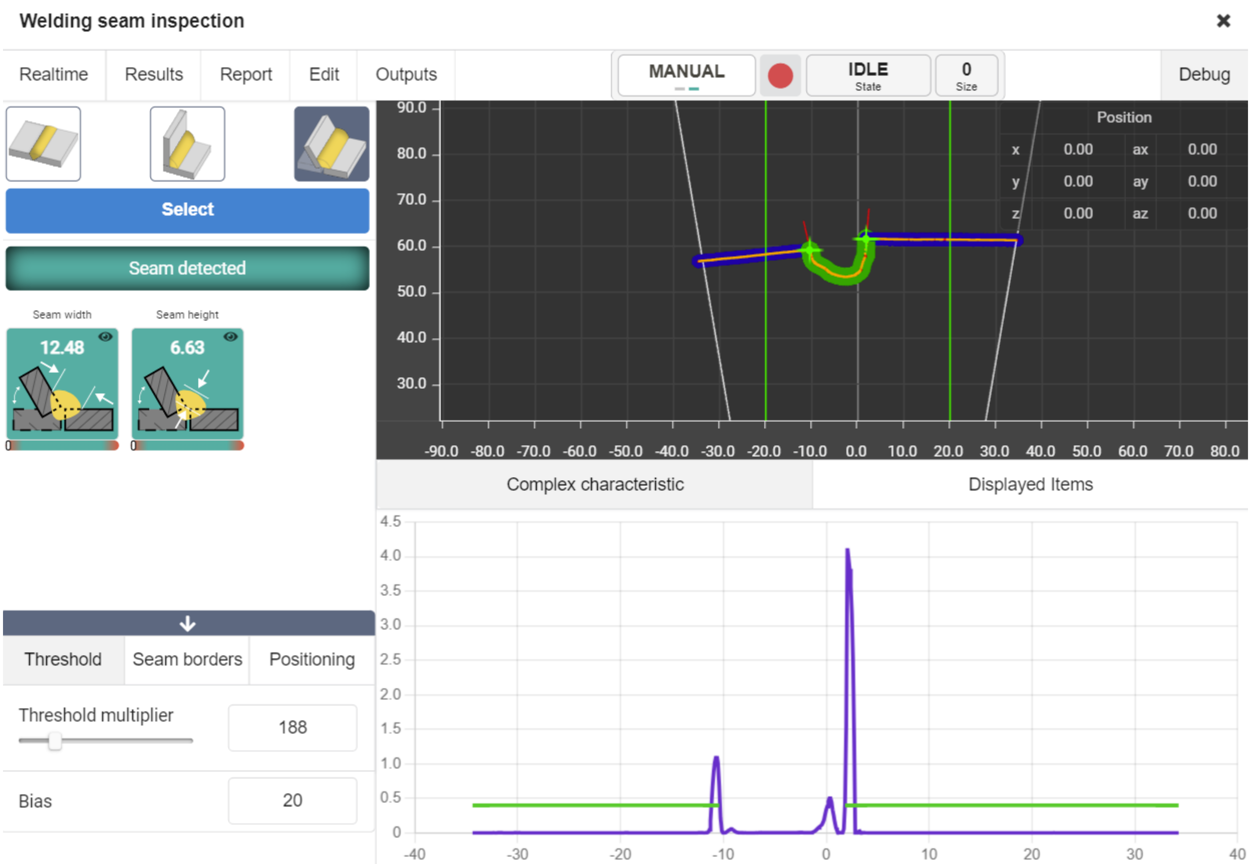


After closing the window, the outputs will appear on the block.



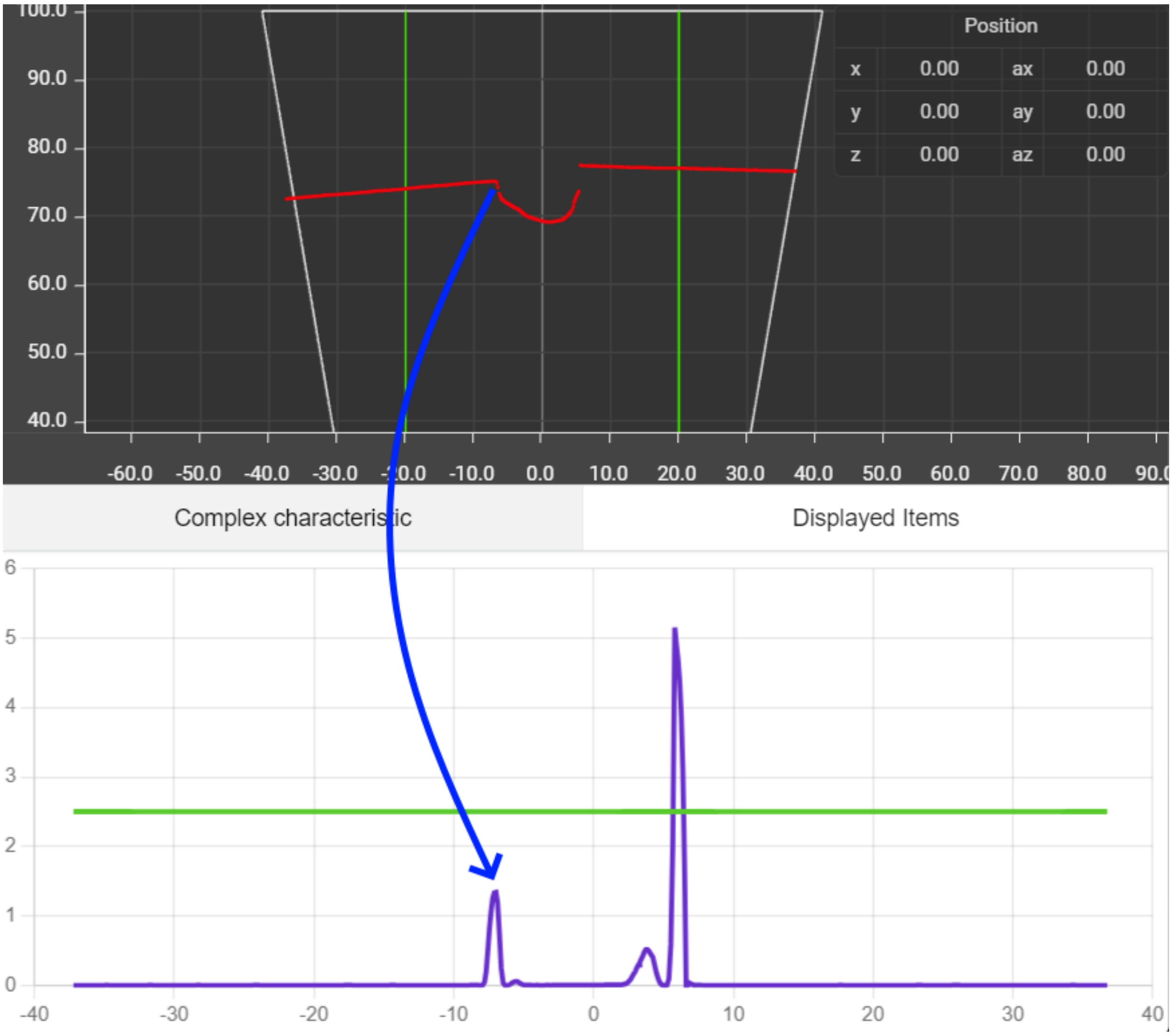
10.3.9. "Debug" mode

In this mode, you can view the complex characteristic by which the weld is detected.



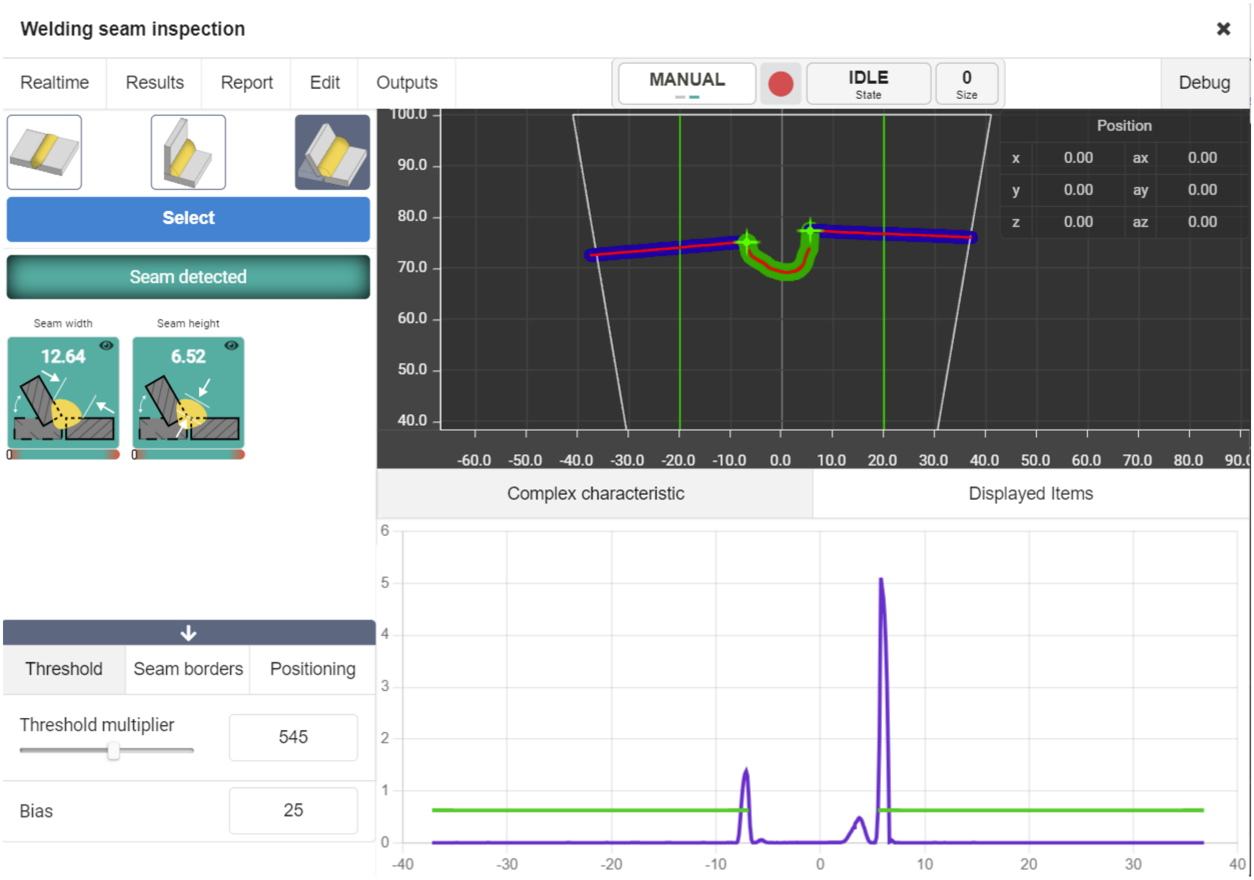
The **Debug** mode is similar to the **Realtime** mode, but has an additional area with a complex characteristic. This characteristic is created in such a way as to highlight the boundaries of the weld. Each peak in the characteristic corresponds to a certain bend of the profile. The greater the bend, the higher the peak. Specific peaks are isolated using separate thresholds.

If the thresholds are higher than the peak, the weld will not be detected correctly. In the screenshot below, the left peak is missing:



It is necessary to adjust the Threshold multiplier and Bias parameters so that the thresholds do not exceed the amplitude of the required peaks related to the edges of the weld, but at the same time they must be above the noise level.

It is necessary to adjust the **Threshold multiplier** and **Bias** parameters so that the thresholds do not exceed the amplitude of the required peaks related to the edges of the weld, but at the same time are above the noise level.

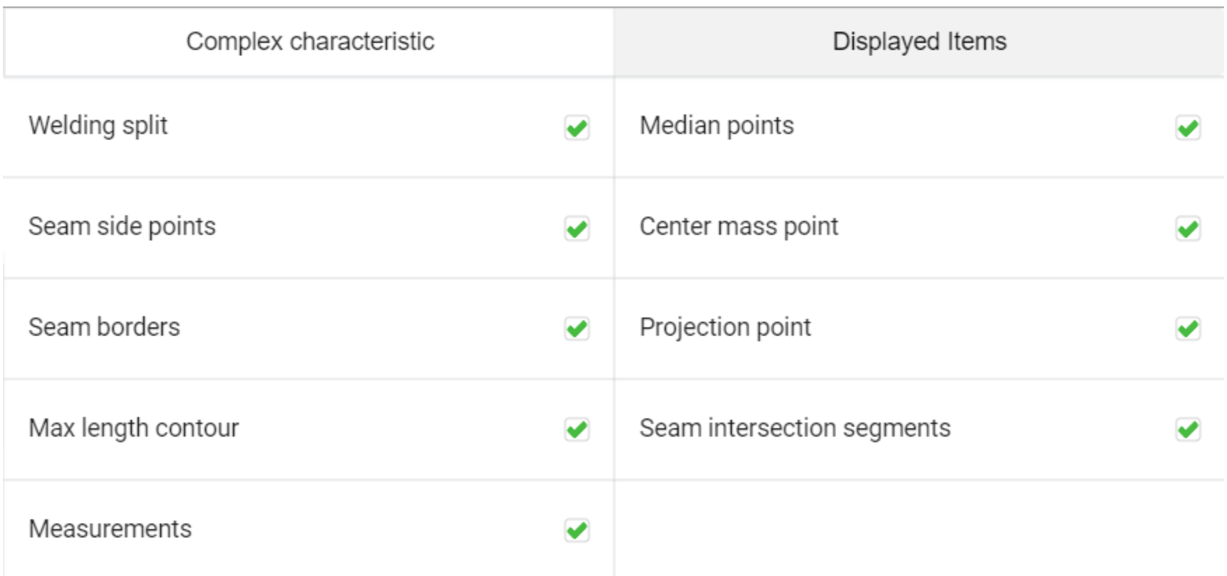


Peaks between detected boundaries are not taken into account. In the screenshot above, the peak located between the two main peaks defining the boundaries of the weld will be skipped, since the search for boundaries goes from the left to the first peak above the left threshold, and similarly from the right to the first peak above the right threshold.

Thresholds are calculated as the average line value multiplied by the **Threshold multiplier** factor.

If the average value for the lines of plates being welded is less than the **Bias** value, then the **Bias** value will be used to multiply by the **Threshold multiplier** factor.

On the **Displayed Items** tab, you can select the items for debugging:



Welding split – segmentation of the profile into plate areas and weld area.

Seam side points – extreme points of the weld (boundaries of the weld and plates).

Seam borders – vertical boundary lines along the X axis, within which the weld should be located when detected.

Max length contour – the longest contour, since weld detection is carried out only along the longest contour.

Measurements – displaying the results of selected measurements.

Median points – profile points after median filtering.

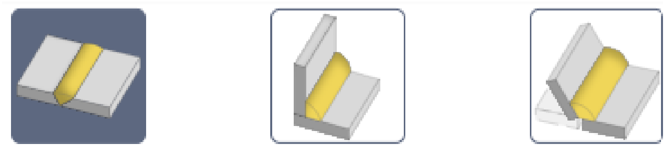
Center mass point – the center of mass of the detected weld.

Projection point – the point of projection of the center of mass onto the line between the boundaries of the plates.

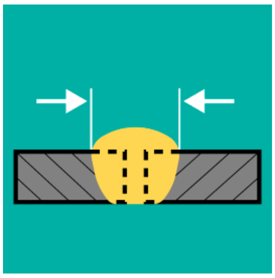
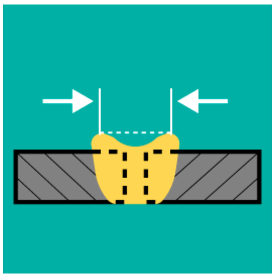
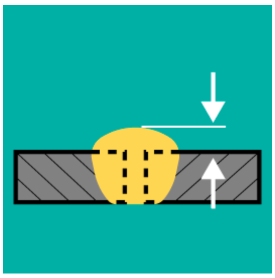
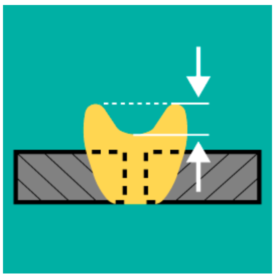
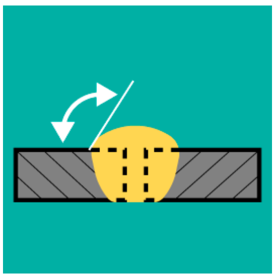
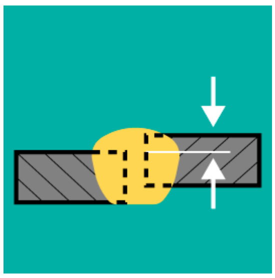
Seam intersection segments – lateral lines of the weld, along which the intersection with the plates is determined.

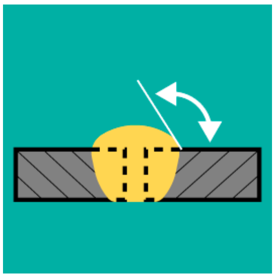
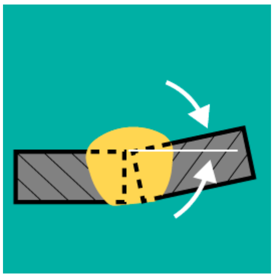
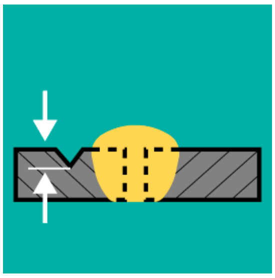
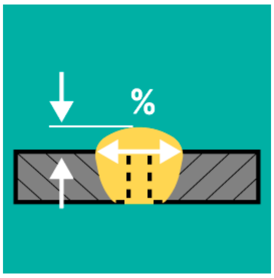
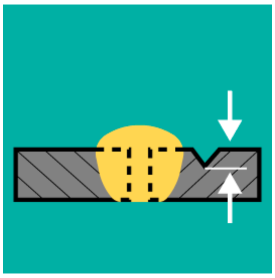
10.3.10. List of measurements

10.3.10.1. Butt weld

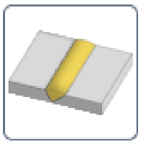
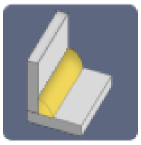
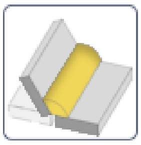


List of measurements:

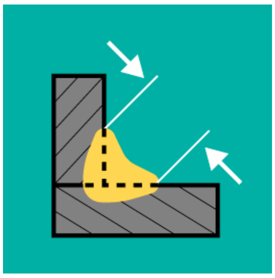
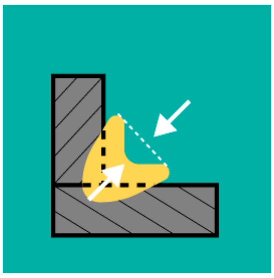
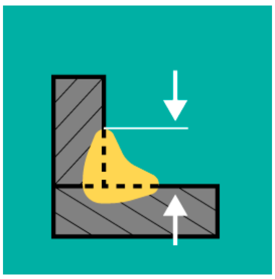
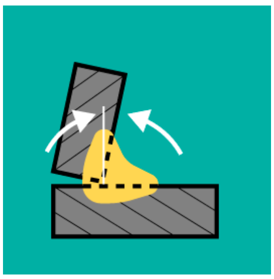
	Seam width		Cavity width
	Seam height		Cavity height
	Angle left		Plates mismatch

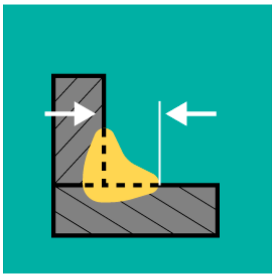
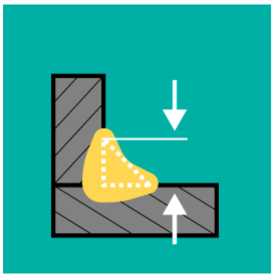
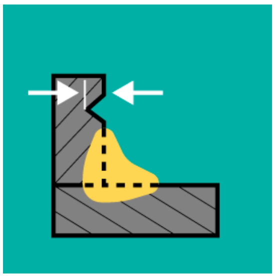
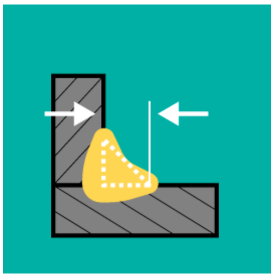
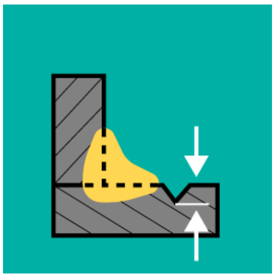
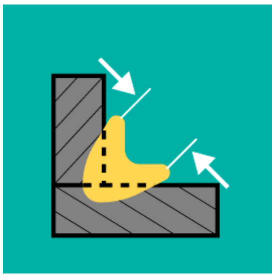
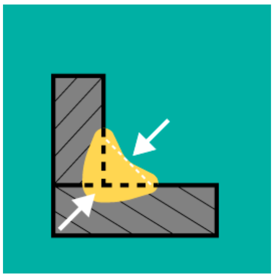
	Angle right		Joint angle
	Undercut left		Size ratio
	Undercut right		

10.3.10.2. Fillet weld

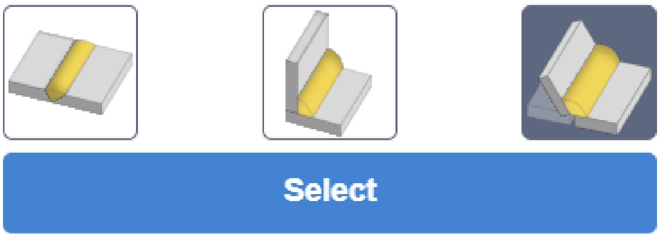
  

List of measurements:

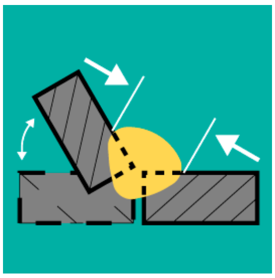
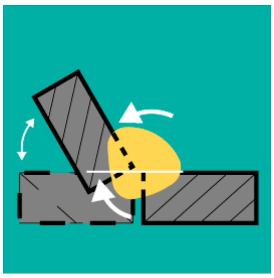
	Seam width		Cavity height
	Leg left		Joint angle

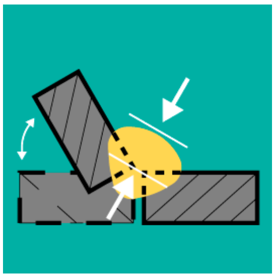
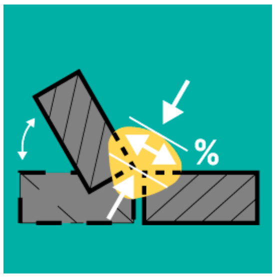
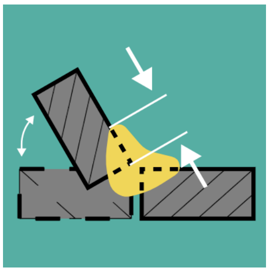
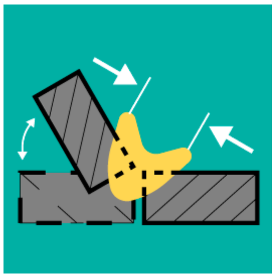
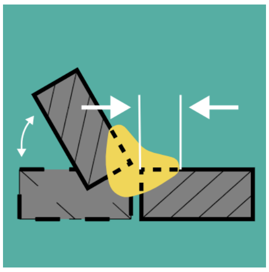
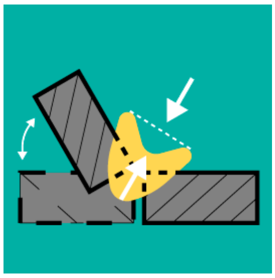
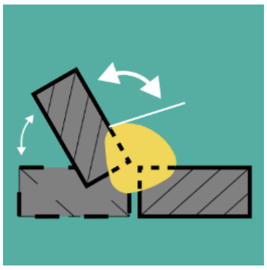
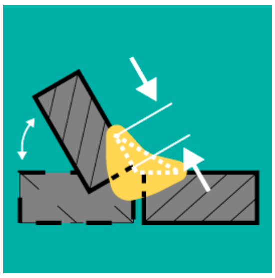
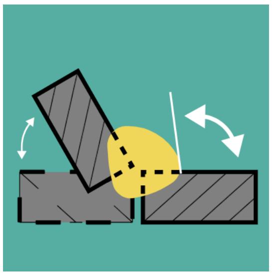
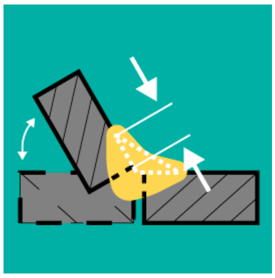
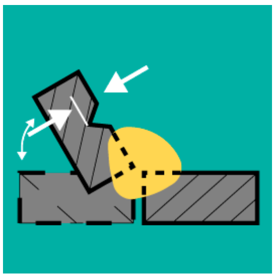
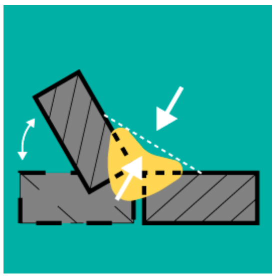
	Leg right		Triangle left leg
	Undercut left		Triangle right leg
	Undercut right		Convexity (+) / concavity (-)
	Cavity width		Seam throat

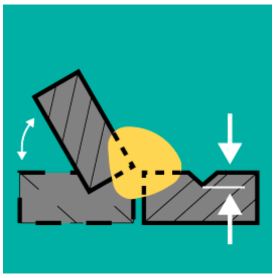
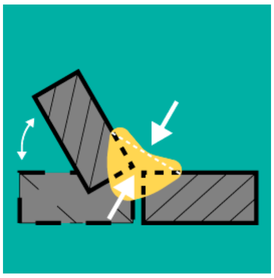
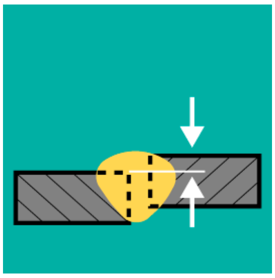
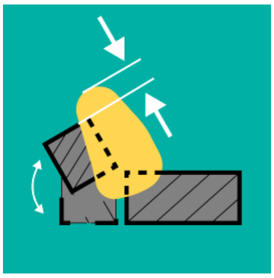
10.3.10.3. Custom weld



List of measurements:

	Seam width		Joint angle

	Seam height		Size ratio
	Leg left		Cavity width
	Leg right		Cavity height
	Angle left		Triangle left leg
	Angle right		Triangle right leg
	Undercut left		Convexity (+) / concavity (-)

	Undercut right		Seam throat
	Plates mismatch		Seam Overthickness

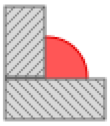
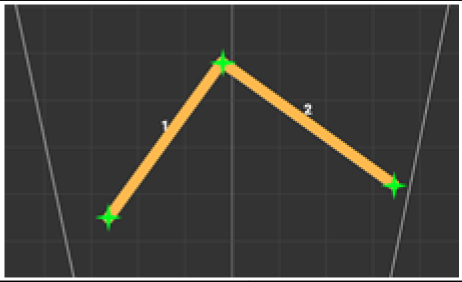
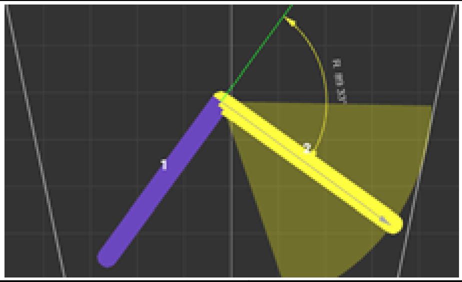
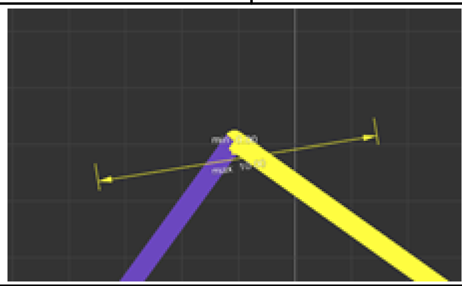
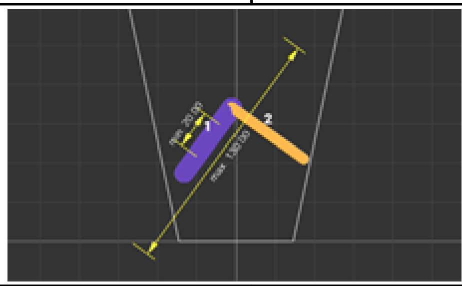
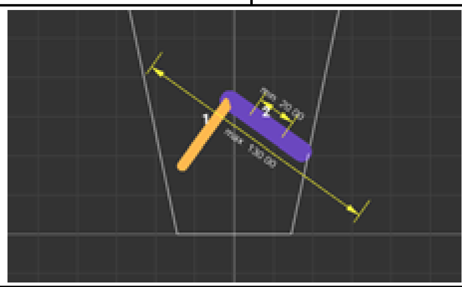
10.3.10.4. Types of welds and measurements

Measurement	Butt weld	Fillet weld	Custom weld
Seam width	+	+	+
Seam height	+		+
Leg left		+	+
Leg right		+	+
Angle left	+		+
Angle right	+		+
Undercut left	+	+	+
Undercut right	+	+	+
Plates mismatch	+		+
Joint angle	+	+	+
Size ratio	+		+
Cavity width	+	+	+
Cavity height	+	+	+
Triangle left leg		+	+
Triangle right leg		+	+
Convexity (+)/ concavity (-)		+	+
Seam throat		+	+
Seam Overthickness			+

11. Basic welding joints

The file contains templates created by RIFTEK for detecting standard welding grooves. New templates can be added by both RIFTEK and the user. To add new templates, you need to use the Template Editor, which is described in the User's Manual for RF627Smart. The file can be replicated, backed up and used with any other RF627Smart-Weld system.

By default, the file contains the following types of welding joints:

	**Tee joint**			
	Profile shape and points			
	Constraints	Angle between segments, deg	-90° ±35°	1-2
				
		Distance between the end of one segment and the beginning of another, mm	0...10	1-2
				
		Segment length, mm	20...130	1
				
		Segment length, mm	20...130	2
				

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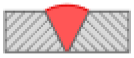
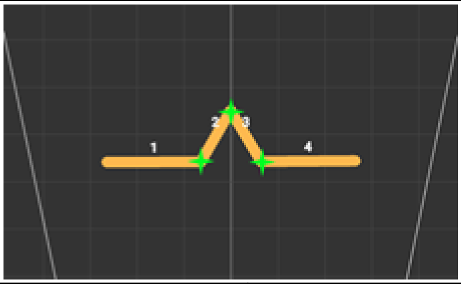
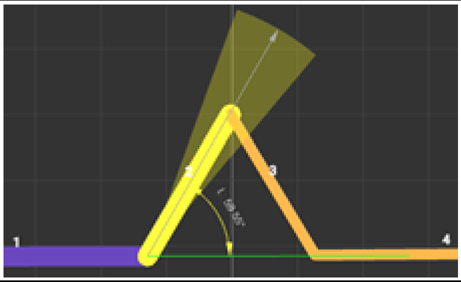
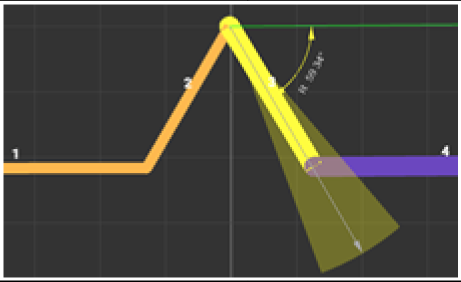
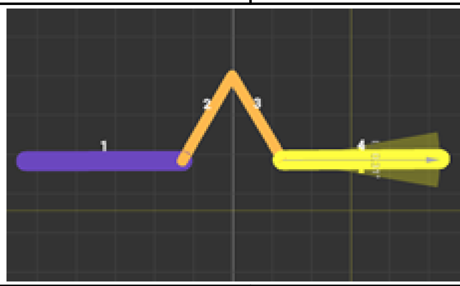
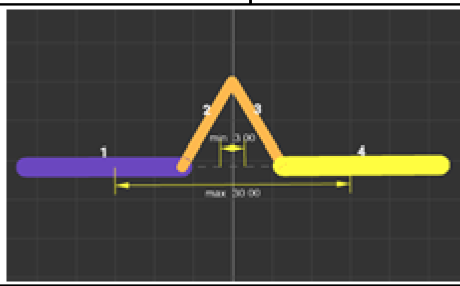
<tr><td rowspan="9"></td><td colspan="4">Groove joint</td></tr>
<tr><td colspan="2">Profile shape and points</td><td colspan="2"></td></tr>
<tr><td rowspan="8">Constraints</td><td rowspan="2">Angle between segments, deg</td><td>-60° ±10°</td><td>1-2</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td rowspan="2">Angle between segments, deg</td><td>-60° ±10°</td><td>3-4</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td rowspan="2">Angle between segments, deg</td><td>-0° ±10°</td><td>1-4</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td rowspan="2">Distance between the end of one segment and the beginning of another, mm</td><td>3...30</td><td>1-4</td></tr>
<tr><td></td><td colspan="2"></td></tr>
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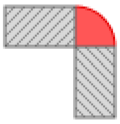
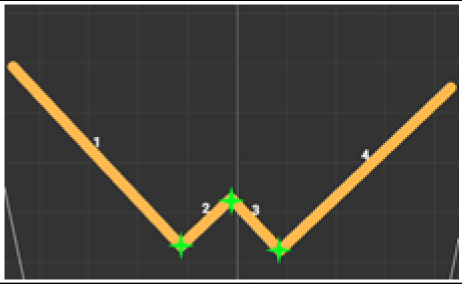
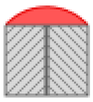
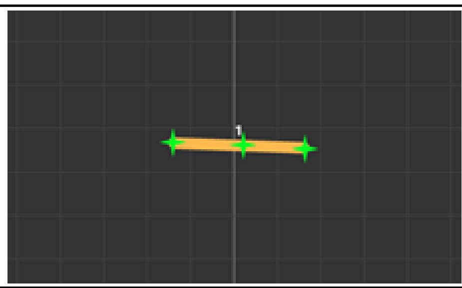
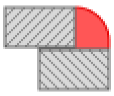
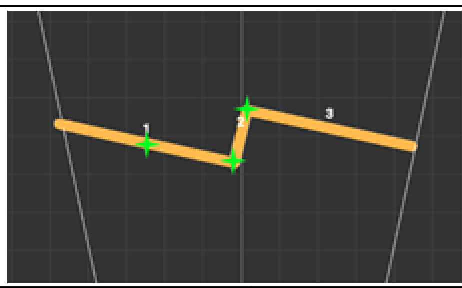
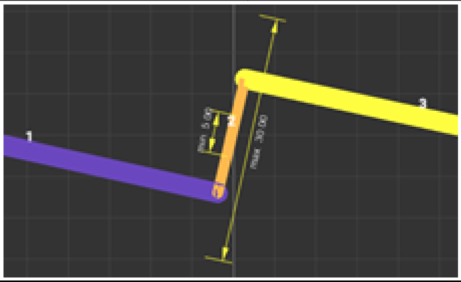
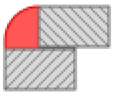
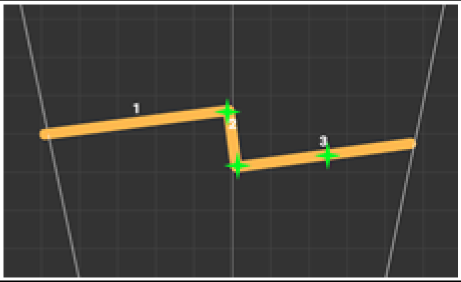
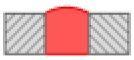
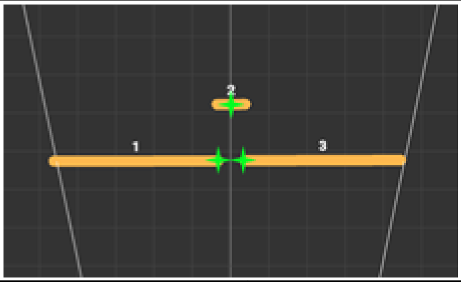
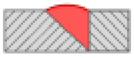
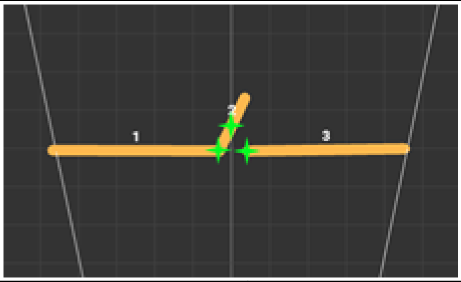
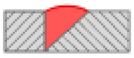
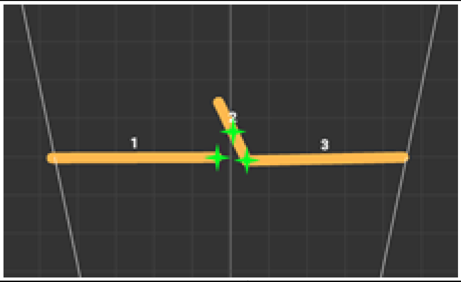
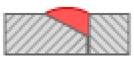
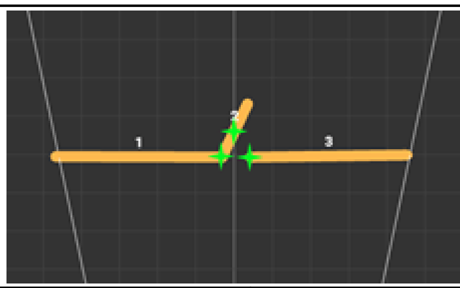
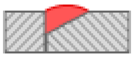
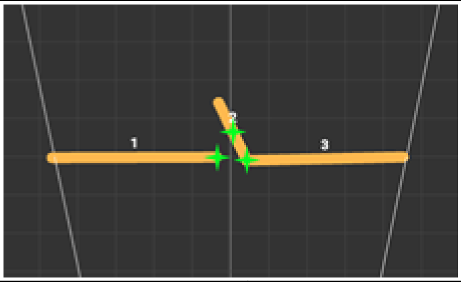
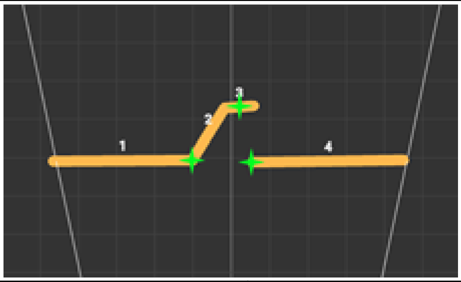
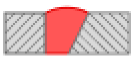
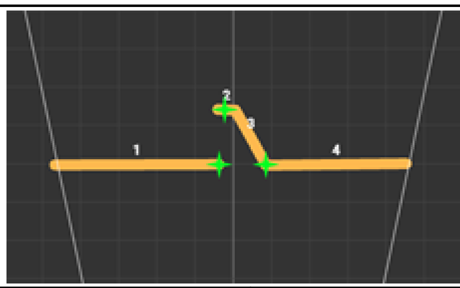
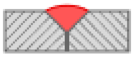
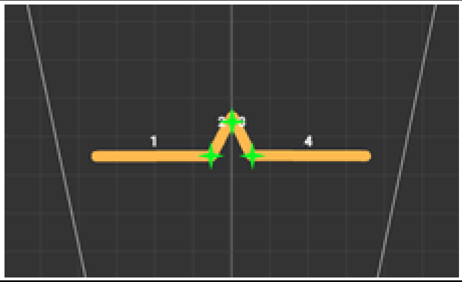
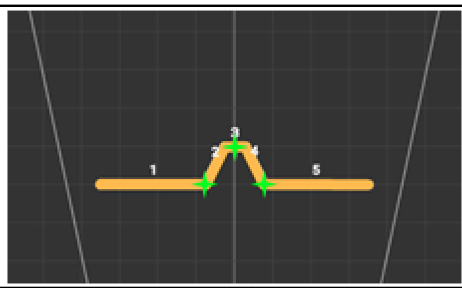
	**Corner joint**			
	Profile shape and points			
	Constraints	Angle between segments, deg	-90° ±10°	1-4
		Distance between the end of one segment and the beginning of another, mm	0...0	1-2
		Angle between segments, deg	-90° ±10°	1-2
		Distance between the end of one segment and the beginning of another, mm	0...5	2-3
		Angle between segments, deg	-90° ±10°	2-3
		Distance between the end of one segment and the beginning of another, mm	0...0	3-4
		Angle between segments, deg	-90° ±10°	2-3
		Distance between the end of one segment and the beginning of another, mm	5...50	1-4
	**Edge joint**			
	Profile shape and points			
	Constraints	Segment length, mm	5...30	1
	**Right lap joint**			
	Profile shape and points			
	Constraints	Distance between the end of one segment and the beginning of another, mm	0...0	1-2
		Angle between segments, deg	-90° ±10°	1-2
		Distance between the end of one segment and the beginning of another, mm	0...0	2-3
		Angle between segments, deg	-90° ±10°	2-3

		Perpendicular distance between segments, mm	5...30	1-3
				
	**Left lap joint**			
	Profile shape and points			
	Constraints	Distance between the end of one segment and the beginning of another, mm	0...0	1-2
		Angle between segments, deg	-90° ±10°	1-2
		Distance between the end of one segment and the beginning of another, mm	0...0	2-3
		Angle between segments, deg	-90° ±10°	2-3
		Perpendicular distance between segments, mm	5...30	1-3
	**Square groove joint**			
	Profile shape and points			
	Constraints	Distance between the end of one segment and the beginning of another, mm	3...30	1-3
		Angle between segments, deg	0° ±10°	1-2
		Perpendicular distance between segments, mm	0...10	1-3
		Perpendicular distance between segments, mm	0...30	2-2

	**Left bevel groove joint**			
	Profile shape and points			
	Constraints	Distance between the end of one segment and the beginning of another, mm	0...0	1-2
		Angle between segments, deg	45° ±10°	1-2
		Distance between the end of one segment and the beginning of another, mm	3...30	1-3
		Angle between segments, deg	0° ±10°	1-3
	**Right bevel groove joint**			
	Profile shape and points			
	Constraints	Distance between the end of one segment and the beginning of another, mm	0...0	2-3
		Angle between segments, deg	45° ±10°	1-2
		Distance between the end of one segment and the beginning of another, mm	3...30	1-3
		Angle between segments, deg	0° ±10°	1-3
	**Left bevel groove joint with broad root**			
	Profile shape and points			
	Constraints	Distance between the end of one segment and the beginning of another, mm	0...0	1-2
		Angle between segments, deg	45° ±10°	1-2
		Distance between the end of one segment and the beginning of another, mm	3...30	1-3
		Angle between segments, deg	0° ±10°	1-3

	**Right bevel groove joint with broad root**			
	Profile shape and points			
	Constraints	Distance between the end of one segment and the beginning of another, mm	0...0	2-3
		Angle between segments, deg	45° ±10°	1-2
		Distance between the end of one segment and the beginning of another, mm	3...30	1-3
		Angle between segments, deg	0° ±10°	1-3
	**Left steep flanked bevel groove joint**			
	Profile shape and points			
	Constraints	Distance between the end of one segment and the beginning of another, mm	3...30	1-4
		Angle between segments, deg	0° ±10°	1-4
		Perpendicular distance between segments, mm	3...30	1-2
		Angle between segments, deg	0° ±10°	1-2
		Distance between the end of one segment and the beginning of another, mm	0...0	3-4
		Angle between segments, deg	60° ±10°	3-4
	**Right steep flanked bevel groove joint**			
	Profile shape and points			
	Constraints	Distance between the end of one segment and the beginning of another, mm	3...30	1-4
		Angle between segments, deg	0° ±10°	1-4
		Perpendicular distance between segments, mm	3...30	3-4

		Angle between segments, deg	0° ±10°	3-4
		Distance between the end of one segment and the beginning of another, mm	0...0	1-2
		Angle between segments, deg	60° ±10°	1-2
	**V groove with broad root joint**			
	Profile shape and points			
	Constraints	Distance between the end of one segment and the beginning of another, mm	0...0	1-2
		Angle between segments, deg	60° ±10°	1-2
		Distance between the end of one segment and the beginning of another, mm	0...0	3-4
		Angle between segments, deg	60° ±10°	3-4
		Distance between the end of one segment and the beginning of another, mm	3...30	1-4
		Angle between segments, deg	0° ±10°	1-4
	**Steep flanked V groove joint**			
	Profile shape and points			
	Constraints	Distance between the end of one segment and the beginning of another, mm	0...0	1-2
		Angle between segments, deg	60° ±10°	1-2
		Distance between the end of one segment and the beginning of another, mm	0...0	4-5
		Angle between segments, deg	60° ±10°	4-5
		Distance between the end of one segment and the beginning of another, mm	3...30	1-5
		Angle between segments, deg	0° ±10°	1-5
		Angle between segments, deg	0° ±10°	1-3
		Perpendicular distance between segments, mm	3...30	1-3

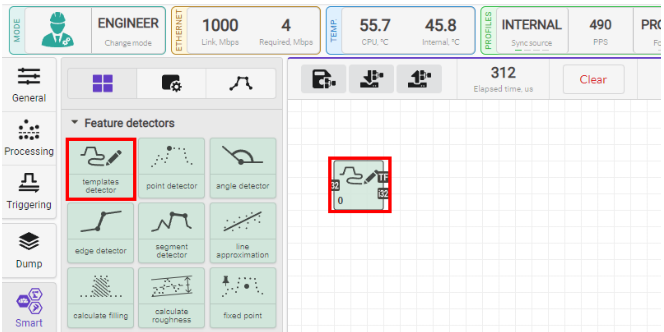
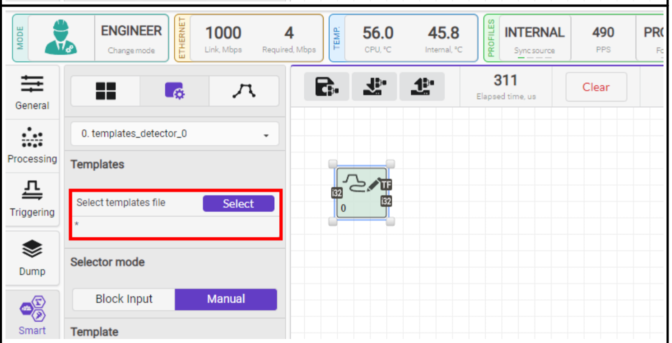
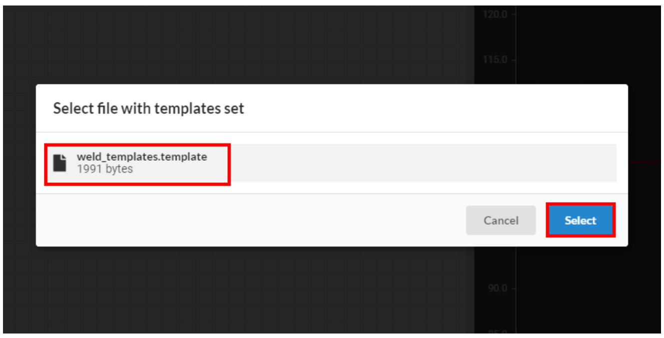
12. Examples of configuring the system for robots from different manufacturers

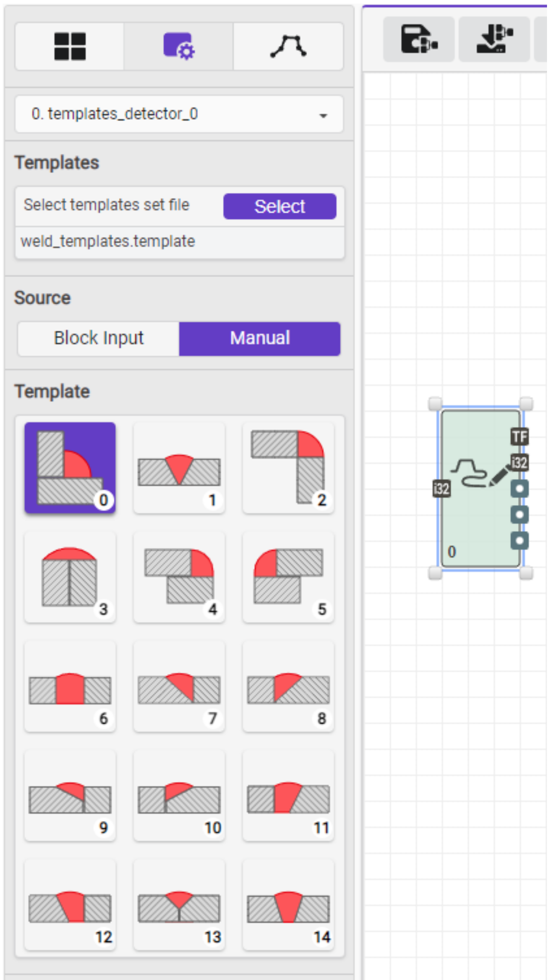
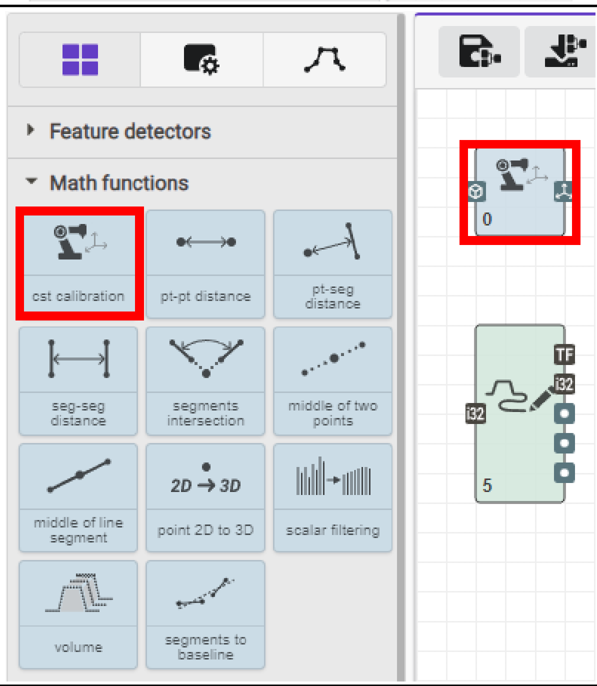
12.1. Kuka robots with RSI option

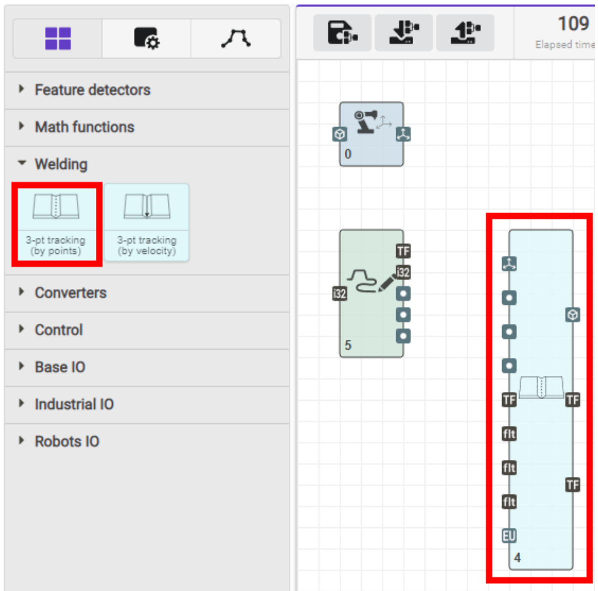
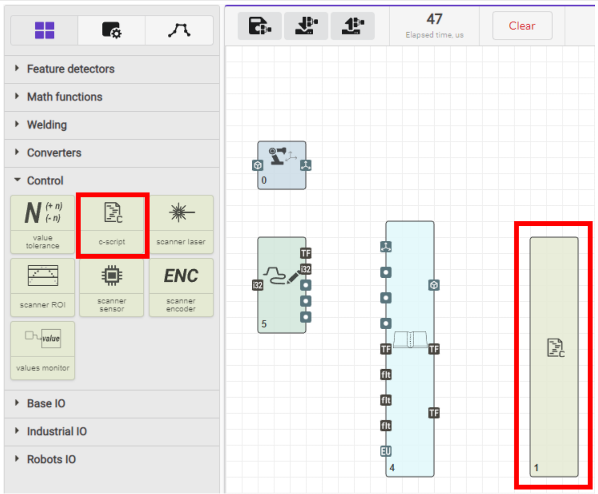
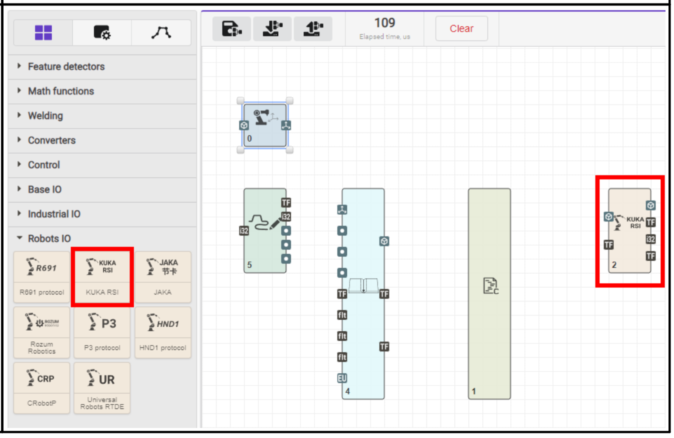
Data exchange and control of the robots is carried out using the **RSI** (Robot-Sensor Interface) option using the **KUKA RSI** smart block located in the **Robots IO** section.

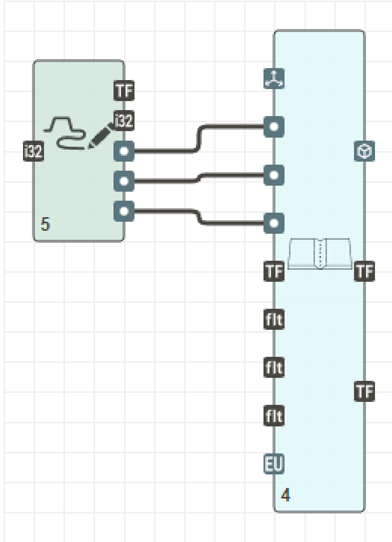
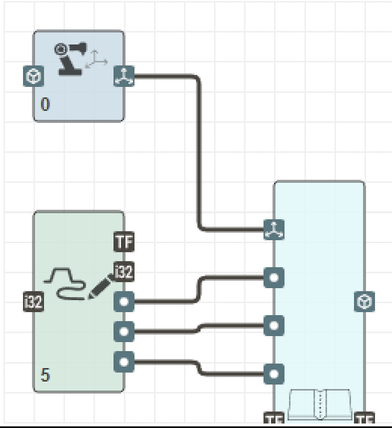
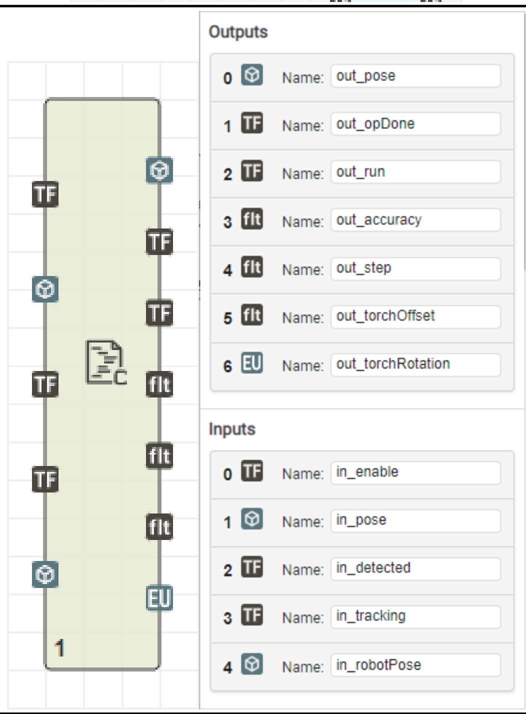
In accordance with the RSI specification, the following files are provided for fast pairing of scanners and robots: “riftek_sensor.src”, “riftek_sensor.dat”, “RSI_RIFTEK.xml”, “RSIContext.rsix”.

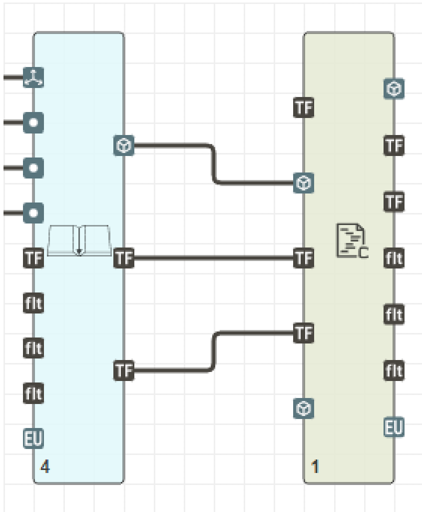
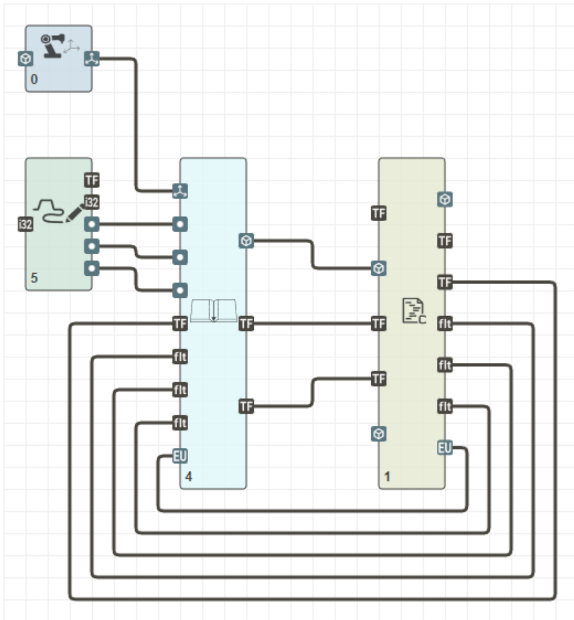
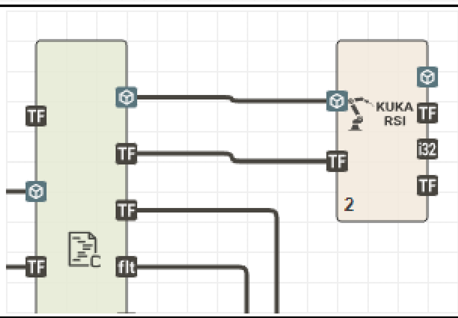
12.1.1. Preparing the computation graph

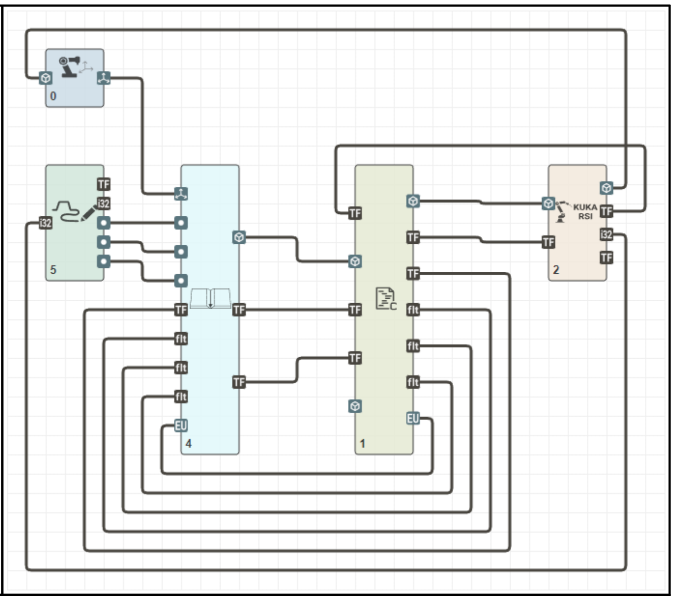
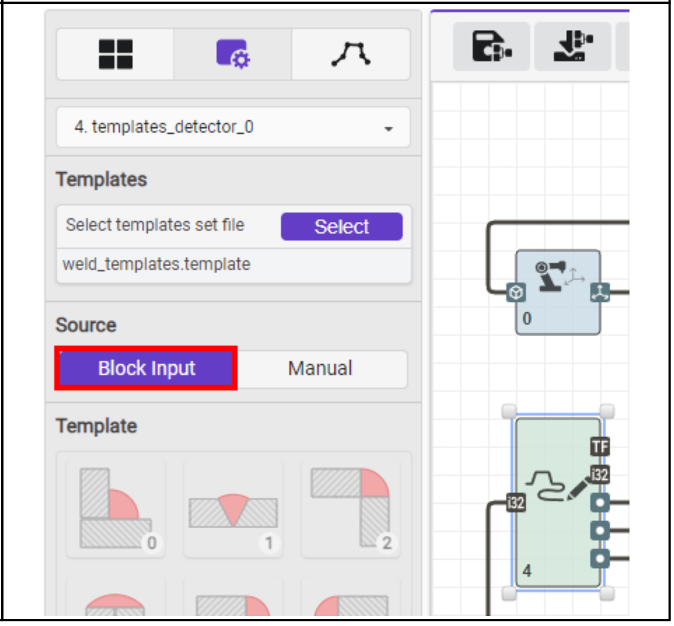
Place the "templates detector" block in the computation graph area.	
Select the templates file (the screenshot below shows the standard welding grooves contained in the templates file supplied with the system).	 

<table>
<tr>
<td></td>
<td>
</td>
</tr>
<tr>
<td>Place the "cst calibration" block.</td>
<td>
</td>
</tr>
</table>

Place the "3-pt tracking (by points)" block.	
Place the "c-script" block.	
Place the "KUKA RSI" block.	

<table>
<tr>
<td>Connect the outputs of the "templates detector" (output points detected on the welding groove) block with the inputs of the "3-pt tracking (by points)" block, thereby providing it with the initial data for tracking.</td>
<td></td>
</tr>
<tr>
<td>Connect the output of the "cst calibration" smart block to the input of the "3-pt tracking (by points)" smart block, thereby providing it with the data necessary to convert points from the 2D scanner coordinate system to the 3D robot coordinate system.</td>
<td></td>
</tr>
<tr>
<td>Add the inputs and outputs of the "c-script" smart block:
Inputs:
1. Bool,
2. 3D pose,
3. Bool,
4. Bool,
5. 3D pose
Outputs:
1. 3D pose,
2. Bool,
3. Bool,
4. Float,
5. Float,
6. Float,
7. 3D Euler angles
In the script editor, specify the names of the inputs and outputs, as shown in the screenshot.</td>
<td>
</td>
</tr>
</table>

Connect the outputs of the "3-pt tracking (by points)" smart block to the inputs of the "c-script" smart block.	
Connect the outputs of the "c-script" smart block to the inputs of the "tracking" smart block.	
Connect the outputs of the "c-script" smart block to the inputs of the "KUKA RSI" smart block.	

Connect the output of the "KUKA RSI" smart block to the inputs of the "cst calibration" smart block, the "c-script" smart block, and the "templates detector" smart block.	
In the parameters, select "Block Input" as the source of the template number (thus the robot program will be able to set the number of the detected template).	

12.1.2. Preparing the robot to work with the scanner via the RSI interface

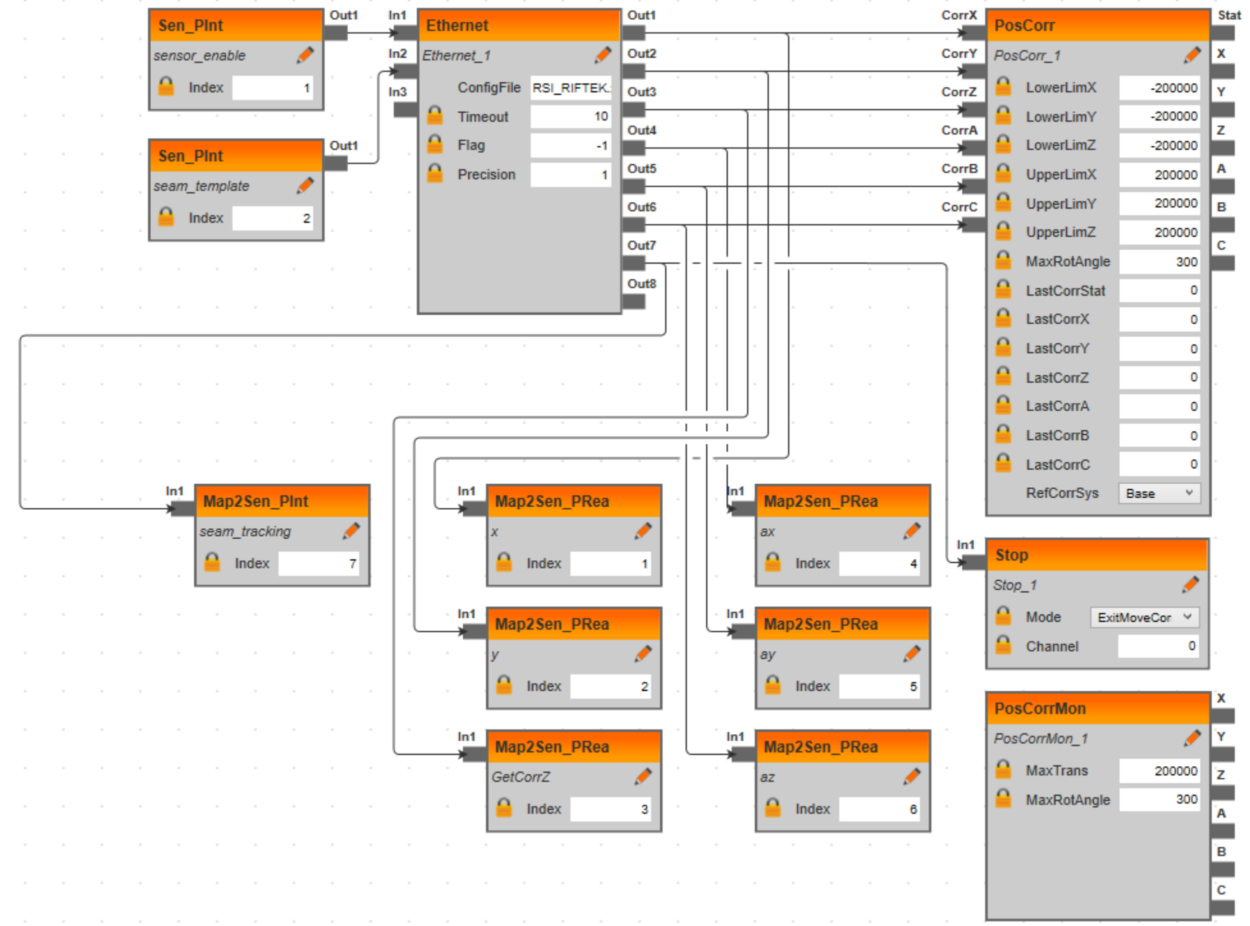
The robot must have the “RobotSensorInterface” and “Etehrnet KRL” options. The RSI interface must be configured according to the documentation, taking into account the files prepared for the scanner:

RSI_RIFTEK.xml

```
<ROOT>
  <CONFIG>
      <IP_NUMBER>192.168.2.30</IP_NUMBER>
      <!-- IP-number of the external socket -->
      <PORT>6008</PORT>
      <!-- Port-number of the external socket -->
      <SENTYPE>ImFree</SENTYPE>
      <!-- The name of your system send in <Sen Type="" > -->
      <ONLYSEND>FALSE</ONLYSEND>
      <!-- TRUE means the client don't expect answers. Do not send anything
to robot -->
  </CONFIG>
```

```
  <!-- RSI Data: TYPE=  "BOOL", "STRING", "LONG", "DOUBLE" -->
  <!-- INDX= "INTERNAL" switch on internal read values. Needed by DEF_... --
>
  <!-- INDX= "nmb" Input/Output index of RSI-Object / Maximum of RSI
Channels: 64  -->
  <!-- HOLDON="1", set this output index of RSI Object to the last value  --
>
  <!-- DEF_Delay count the late packages and send it back to server  -->
  <!-- DEF_Tech: .T = advance .C = main run / .T1 advance set function
generator 1 -->
<SEND>
      <ELEMENTS>
        <ELEMENT TAG="DEF_RIst" TYPE="DOUBLE" INDX="INTERNAL" UNIT="0" />
        <ELEMENT TAG="sensor_enable" TYPE="BOOL" INDX="1" UNIT="0" />
        <ELEMENT TAG="seam_template" TYPE="LONG" INDX="2" UNIT="0" />
      </ELEMENTS>
  </SEND>
  <RECEIVE>
      <ELEMENTS>
        <ELEMENT TAG="RKorr.X" TYPE="DOUBLE" INDX="1" UNIT="1" HOLDON="1" />
        <ELEMENT TAG="RKorr.Y" TYPE="DOUBLE" INDX="2" UNIT="1" HOLDON="1" />
        <ELEMENT TAG="RKorr.Z" TYPE="DOUBLE" INDX="3" UNIT="1" HOLDON="1" />
        <ELEMENT TAG="RKorr.A" TYPE="DOUBLE" INDX="4" UNIT="0" HOLDON="1" />
        <ELEMENT TAG="RKorr.B" TYPE="DOUBLE" INDX="5" UNIT="0" HOLDON="1" />
        <ELEMENT TAG="RKorr.C" TYPE="DOUBLE" INDX="6" UNIT="0" HOLDON="1" />
        <ELEMENT TAG="seam_tracking" TYPE="BOOL" INDX="7" UNIT="0"
HOLDON="1" />
      </ELEMENTS>
  </RECEIVE>

</ROOT>
```

RSIContext.rsix



riftek_sensor.src

```
&ACCESS RVP
&REL 13
&PARAM EDITMASK = *
&PARAM TEMPLATE = C:\KRC\Roboter\Template\vorgabe
&PARAM DISKPATH = KRC:\R1\Program
DEF riftek_sensor( )

; Declaration of KRL variables
DECL INT ret    ; Return value for RSI commands
DECL INT CONTID    ; ContainerID

;FOLD INI;%{PE}
  ;FOLD BASISTECH INI
    GLOBAL INTERRUPT DECL 3 WHEN $STOPMESS==TRUE DO IR_STOPM ( )
    INTERRUPT ON 3
    BAS (#INITMOV,0 )
  ;ENDFOLD (BASISTECH INI)
  ;FOLD USER INI
    ;Make your modifications here

  ;ENDFOLD (USER INI)
;ENDFOLD (INI)
```

```
; Forbid the preprocessor to execute commands following the cursor - this is
necessary to control the flags
$ADVANCE = 0

;FOLD PTP p1 Vel=30 % PDAT2 Tool[1]:tool1 Base[0] ;%{PE}
;FOLD Parameters ;%{h}
;Params IlfProvider=kukaroboter.basistech.inlineforms.movement.old;
Kuka.IsGlobalPoint=False; Kuka.PointName=p1; Kuka.BlendingEnabled=False;
Kuka.MoveDataPtpName=PDAT2; Kuka.VelocityPtp=30; Kuka.CurrentCDSetIndex=0;
Kuka.MovementParameterFieldEnabled=True; IlfCommand=PTP
;ENDFOLD
$BWDSTART = FALSE
PDAT_ACT = PPDAT2
FDAT_ACT = Fp1
BAS(#PTP_PARAMS, 30.0)
SET_CD_PARAMS (0)
PTP Xp1
;ENDFOLD

; Create RSI Context
ret = RSI_CREATE("RSIContext",CONTID,TRUE)
IF (ret <> RSIOK) THEN
  HALT
ENDIF

WAIT FOR (RSI_ON(#RELATIVE) == RSIOK)

; Select of the welding cut
$SEN_PINT[2] = 0

; Enable sensor
$SEN_PINT[1] = 1

; Movement to the beginning of the welding cut
RSI_MOVECORR()

; Perform some preparation for welding (arc ignition, bath formation, etc.)
;FOLD WAIT Time= 1.0 sec ;%{PE}
;FOLD Parameters ;%{h}
;Params IlfProvider=kukaroboter.basistech.inlineforms.logics.wait; Time=1.0
;ENDFOLD
WAIT SEC 1.0
;ENDFOLD
```

```
; Movement with welding
RSI_MOVECORR()

; Disable sensor
$SEN_PINT[1] = 0

; Complete welding (reduce current, etc.)
;FOLD WAIT Time= 1.0 sec ;%{PE}
;FOLD Parameters ;%{h}
;Params IlfProvider=kukaroboter.basistech.inlineforms.logics.wait; Time=1.0
;ENDFOLD
WAIT SEC 1.0
;ENDFOLD

; Turn off RSI
ret = RSI_OFF()
IF (ret <> RSIOK) THEN
  HALT
ENDIF

END
```

riftek_sensor.dat

```
&ACCESS RVP
&REL 13
&PARAM EDITMASK = *
&PARAM TEMPLATE = C:\KRC\Roboter\Template\vorgabe
&PARAM DISKPATH = KRC:\R1\Program
DEFDAT  riftek_sensor
;FOLD EXTERNAL DECLARATIONS;%{PE}%MKUKATPBASIS,%CEXT,%VCOMMON,%P
;FOLD BASISTECH EXT;%{PE}%MKUKATPBASIS,%CEXT,%VEXT,%P
EXT  BAS (BAS_COMMAND  :IN,REAL  :IN )
DECL INT SUCCESS
;ENDFOLD (BASISTECH EXT)
;FOLD USER EXT;%{E}%MKUKATPUSER,%CEXT,%VEXT,%P
;Make your modifications here

;ENDFOLD (USER EXT)
;ENDFOLD (EXTERNAL DECLARATIONS)
DECL E6POS XP1={X 180.004517,Y -184.731384,Z 161.211243,A 6.33770037,B
2.39791203,C 119.854492,S 2,T 3,E1 0.0,E2 0.0,E3 0.0,E4 0.0,E5 0.0,E6,0.0}
DECL FDAT FP1={TOOL_NO 1,BASE_NO 0,IPO_FRAME #BASE,POINT2[] " "}
```

```
DECL PDAT PPDAT1={VEL 30.0000,ACC 100.000,APO_DIST 500.000,APO_MODE
#CDIS,GEAR_JERK 100.000,EXAX_IGN 0}
DECL MODULEPARAM_T LAST_TP_PARAMS = {PARAMS[] "Kuka.PointName=p1;
Kuka.FrameData.base_no=0; Kuka.FrameData.tool_no=1;
Kuka.FrameData.ipo_frame=#BASE; Kuka.isglobalpoint=False;
Kuka.MoveDataPtpName=PDAT2; Kuka.MovementDataPdat.apo_mode=#CDIS;
Kuka.MovementDataPdat.apo_dist=500; Kuka.MovementData.vel=30;
Kuka.MovementData.acc=100; Kuka.MovementData.exax_ign=0;
Kuka.VelocityPtp=30; Kuka.BlendingEnabled=False; Kuka.APXEnabled=False;
Kuka.CurrentCDSetIndex=0; Kuka.MoveDataName=CPDAT1;
Kuka.MovementData.cb={AUX_PT {ORI #CONSIDER,E1 #CONSIDER,E2 #CONSIDER,E3
#CONSIDER,E4 #CONSIDER,E5 #CONSIDER,E6 #CONSIDER},TARGET_PT {ORI
#INTERPOLATE,E1 #INTERPOLATE,E2 #INTERPOLATE,E3 #INTERPOLATE,E4
#INTERPOLATE,E5 #INTERPOLATE,E6 #INTERPOLATE}};
Kuka.MovementData.apo_fac=50; Kuka.MovementData.apo_dist=500;
Kuka.MovementData.axis_acc=100; Kuka.MovementData.axis_vel=100;
Kuka.MovementData.circ_typ=#BASE; Kuka.MovementData.jerk_fac=50;
Kuka.MovementData.ori_typ=#VAR; Kuka.VelocityPath=0.05; Kuka.Logics.Io=1;
Kuka.Logics.IoName=; Kuka.Logics.State=True; Kuka.Logics.Cont=False;
Kuka.Logics.TriggerType=START; Kuka.Logics.Path=0; Kuka.Logics.Delay=0"}
DECL LDAT LCPDAT1={VEL 0.0500000,ACC 100.000,APO_DIST 500.000,APO_FAC
50.0000,AXIS_VEL 100.000,AXIS_ACC 100.000,ORI_TYP #VAR,CIRC_TYP
#BASE,JERK_FAC 50.0000,GEAR_JERK 100.000,EXAX_IGN 0,CB {AUX_PT {ORI
#CONSIDER,E1 #CONSIDER,E2 #CONSIDER,E3 #CONSIDER,E4 #CONSIDER,E5
#CONSIDER,E6 #CONSIDER},TARGET_PT {ORI #INTERPOLATE,E1 #INTERPOLATE,E2
#INTERPOLATE,E3 #INTERPOLATE,E4 #INTERPOLATE,E5 #INTERPOLATE,E6
#INTERPOLATE}}}
DECL FDAT FP2={TOOL_NO 1,BASE_NO 0,IPO_FRAME #BASE,POINT2[] " "}
DECL E6POS XP2={X 241.575836,Y -235.767456,Z 142.346405,A 136.503632,B
4.61282158,C 174.258,S 2,T 10,E1 0.0,E2 0.0,E3 0.0,E4 0.0,E5 0.0,E6 0.0}
DECL E6POS XP3={X 286.785492,Y -235.769958,Z 93.5453491,A 119.169380,B
39.6200676,C 138.546692,S 2,T 10,E1 0.0,E2 0.0,E3 0.0,E4 0.0,E5 0.0,E6 0.0}
DECL PDAT PPDAT2={VEL 30.0000,ACC 100.000,APO_DIST 500.000,APO_MODE
#CDIS,GEAR_JERK 100.000,EXAX_IGN 0}
DECL SParam_T SS2={OffsetX 0.0,VelX 10,OffsetZ 0.0,VelZ -10,Template 0}
ENDDAT
```

12.1.3. Calibrating the scanner

Calibration is intended to obtain the coordinate transformation matrix for converting points from the 2D coordinate system (scanner) to the 3D coordinate system (robot).

To perform calibration, it is necessary to execute the robot program (“riftek sencor.src”) up to the line “RSI_MOVECORR()” with disabled script execution. This will ensure the transfer of TCP coordinates from the robot to the scanner.

Further steps are described in Annex 3 of the User's Manual for RF627Smart.

12.1.4. Preparing the robot control script

Detailed information about "C_script" smart blocks can be found in the User's Manual for RF627Smart.

The control script generally ensures the execution of the welding cycle, which includes the following parts:

- Setting the initial values for the accuracy of the torch during the welding process, the trajectory construction step, the distance from the torch to the welding groove, the additional rotation of the torch.
- Performing the following actions in an infinite loop:
  - waiting for permission flag;
  - moving the robot in a specified direction to search for the welding groove (search for an “entry point”);
  - moving the torch to the beginning of the welding groove;
  - stopping the robot at the beginning of the welding groove, generating a signal for the robot to move to the beginning of the groove, pausing the robot to perform welding actions;
  - moving along the welding groove with simultaneous correction of the position of the torch and its inclination relative to the groove, lengthening the trajectory and maintaining a stable speed;
  - completing the movement at the end of the welding groove;
  - stopping the robot at the end of the welding groove, generating a signal for the robot about the end of the groove, pausing the robot to perform welding actions.
- Returning to the beginning of the cycle and waiting for the signal from the robot about the next work cycle.

An example of a script that executes a welding cycle (values may vary for different situations):

```
//Declaring variables used in the script
pose_3d_t       in_pose;
bool_t          in_enable   = 0;
pose_3d_t       out_pose;
pose_3d_t       start_pose;
bool_t          reached     = 0;
bool_t          seam_found  = 0;
bool_t          tracking    = 0;
pose_3d_t       rob_pose;
euler_3d_t      torch_rot;
m3d_euler_fill_zyx(0.0, 0.3, 0.0, &torch_rot);

//Setting initial parameters
//Torch accuracy
output_float("out_accuracy", 0.5, 1);
//Trajectory construction step
output_float("out_step", 2.0, 1);
//Distance from the torch to the welding groove
output_float("out_torchOffset", 30.0, 1);
//Angle of rotation of the torch relative to the robot flange
output_euler3d("out_torchRotation", &torch_rot, 1);
```

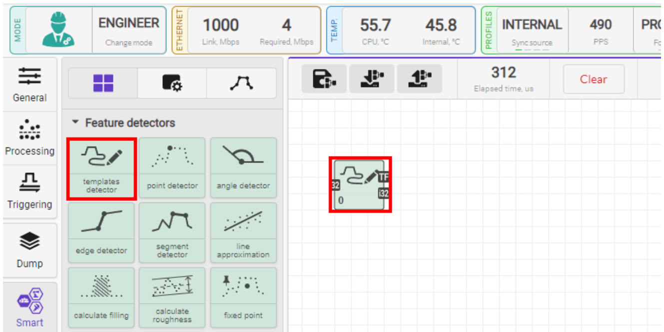
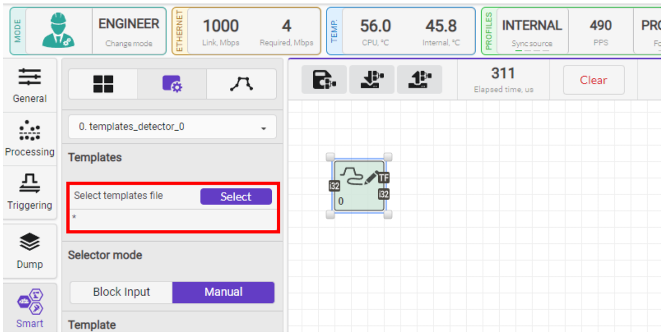
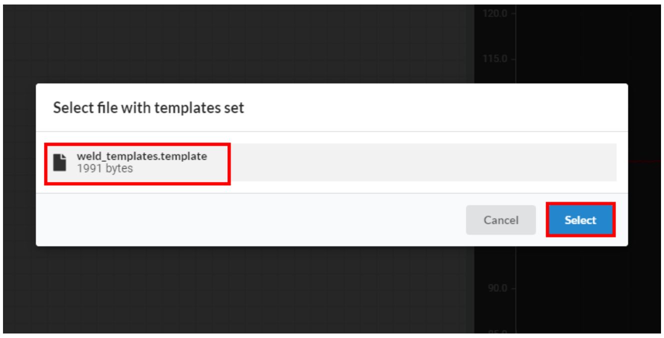
```
while (1)
{
    //Disabling tracking - it may remain enabled
    //after a reset or script crash
    output_bool("out_run", 0, 1);
    //Passing an invalid position to stop the robot
    output_pose3d("out_pose", &out_pose, 0);
    outputs_sync();

    //Waiting for permission to work from the robot
    do{
        inputs_sync();
        input_bool("in_enable", &in_enable);
    }while (in_enable == 0);


    //Enabling the search for the welding groove before the robot moves to
    //the beginning of the groove and waiting for detection, while
    //the position of the robot is controlled without tracking - it just
    //moves in a given direction
    output_bool("out_run", 1, 1);
    m3d_pose_fill_xyz_zyx(0.05, -0.1, 0.0, 0.0, 0.0, 0.0, &out_pose);
    do{
        output_pose3d("out_pose", &out_pose, 1);
        inputs_sync();
        input_bool("in_detected", &seam_found);
    }while (seam_found == 0);


    //Waiting for the robot to move to the beginning of the welding groove -
    //the "tracking" signal will be set - this means that the scanner can
    //guide the torch along the welding groove
    do{
        if (input_bool("in_enable", &in_enable) == 0)    break;
        if (in_enable == 0)                              break;

        if (input_pose3d("in_pose", &in_pose) == 1)
        {
            out_pose     = in_pose;
            m3d_pose_scale(&out_pose, 0.1, 0.001);
            output_pose3d("out_pose", &out_pose, 1);
            outputs_sync();
        }

        inputs_sync();
        input_bool("in_tracking", &tracking);
    }while (tracking == 0);

    //Stop the robot - send zero speeds to all coordinates
    m3d_pose_fill_xyz_zyx(0.0, 0.0, 0.0, 0.0, 0.0, 0.0, &out_pose);
    output_pose3d("out_pose", &out_pose, 1);
    output_bool("out_opDone", 1, 1);
    outputs_sync();
    sleep_us(10000);
```

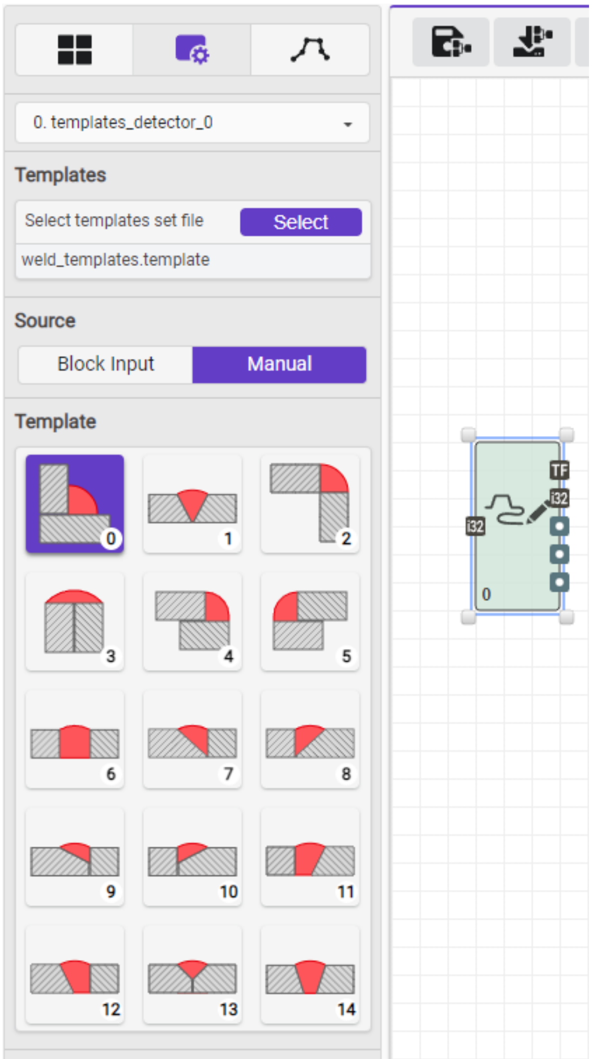
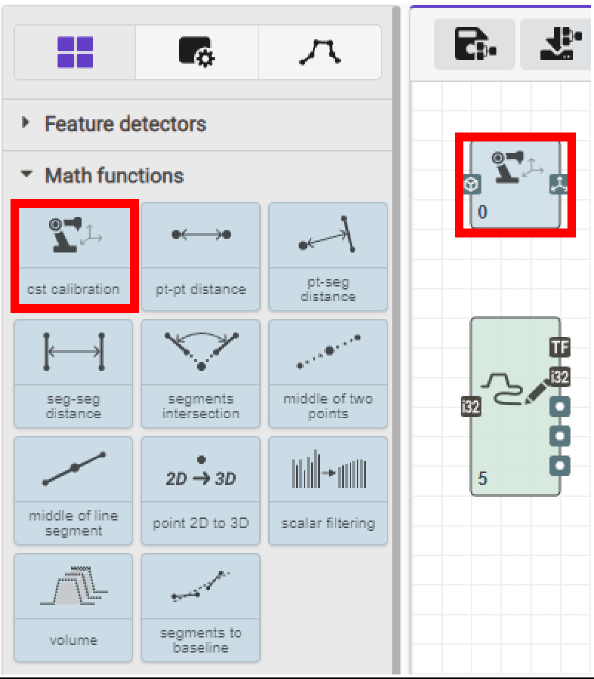
```
    output_bool("out_opDone", 0, 1);
    sleep_us(2000000);


    //Welding groove is found - start tracking
    do{
        if (input_bool("in_enable", &in_enable) == 0)   break;
        if (in_enable == 0)                             break;

        if (input_pose3d("in_pose", &in_pose) == 1)
        {
            out_pose    = in_pose;
            m3d_pose_scale(&out_pose, 0.05, 0.005);
            output_pose3d("out_pose", &out_pose, 1);
            outputs_sync();
        }

        input_bool("in_tracking", &tracking);

    }while (tracking != 0);

//Stop the robot - send zero speeds to all coordinates
    m3d_pose_fill_xyz_zyx(0.0, 0.0, 0.0, 0.0, 0.0, 0.0, &out_pose);
    output_pose3d("out_pose", &out_pose, 1);
    output_bool("out_opDone", 1, 1);
    outputs_sync();
    sleep_us(10000);
    output_bool("out_opDone", 0, 1);
    sleep_us(2000000);



    //Disable tracking - the block will return to its original state
    output_bool("out_run", 0, 1);
    //Stop the robot
    output_pose3d("out_pose", &out_pose, 0);
    outputs_sync();

    //Waiting for work permission from the robot
    do{
        inputs_sync();
        input_bool("in_enable", &in_enable);
    }while (in_enable == 1);

}//while (1)

return 0;
```

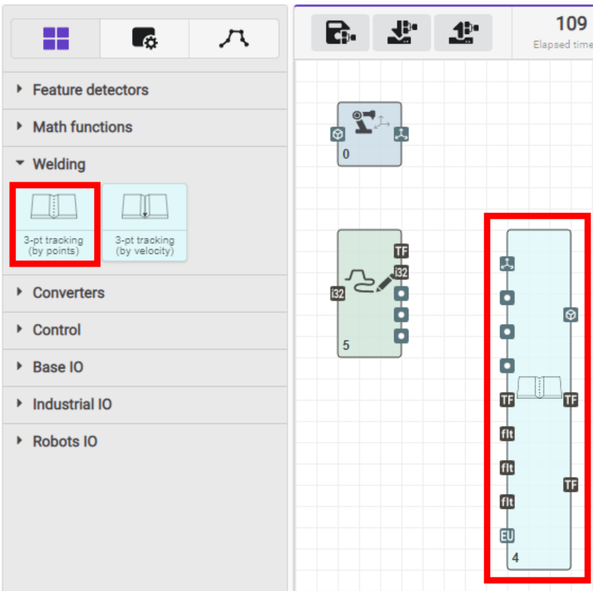
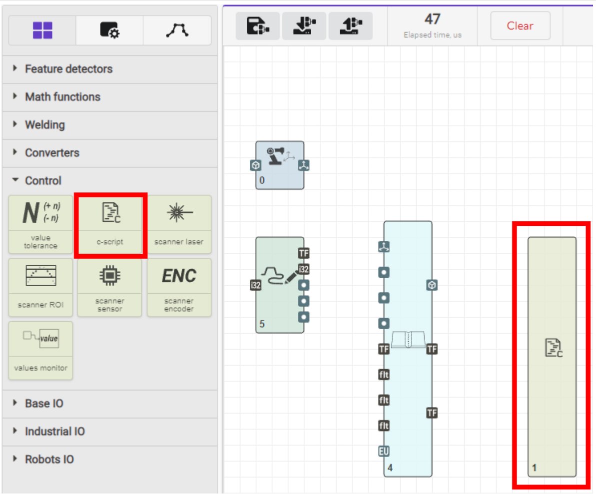
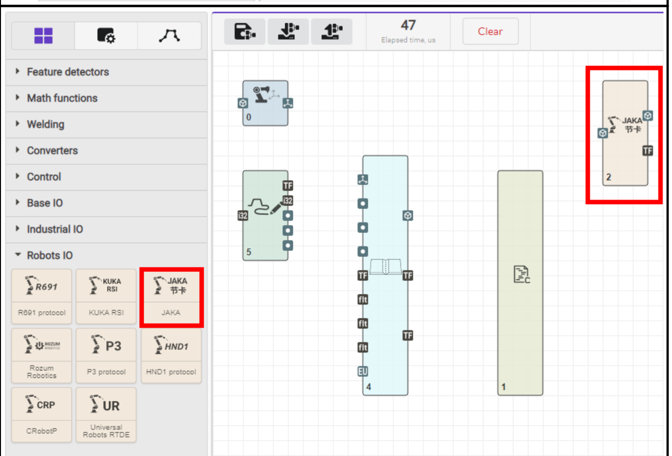
12.2. Jaka cobots

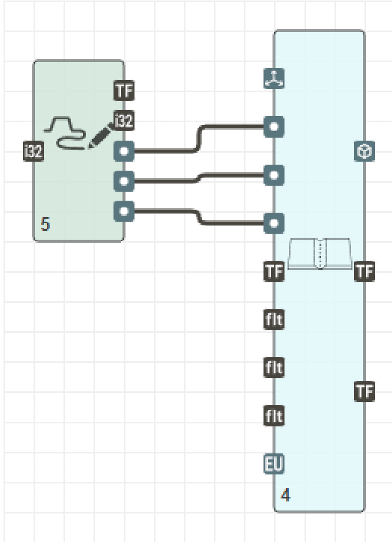
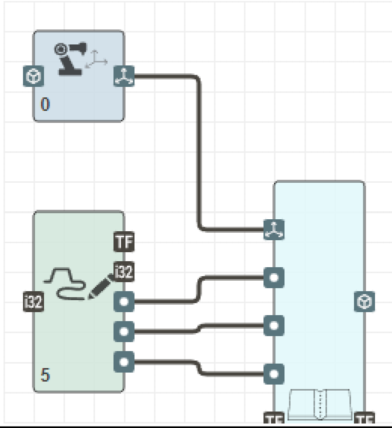
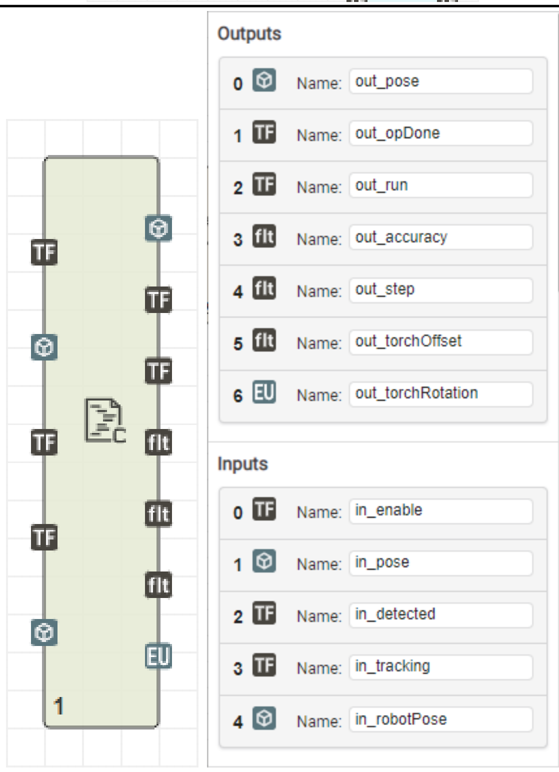
Data exchange and control of cobots is carried out via a proprietary protocol using the **JAKA** smart block located in the **Robots IO** section.

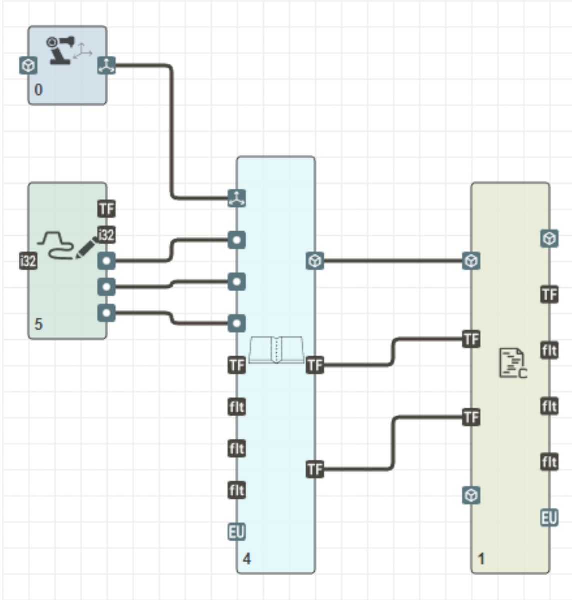
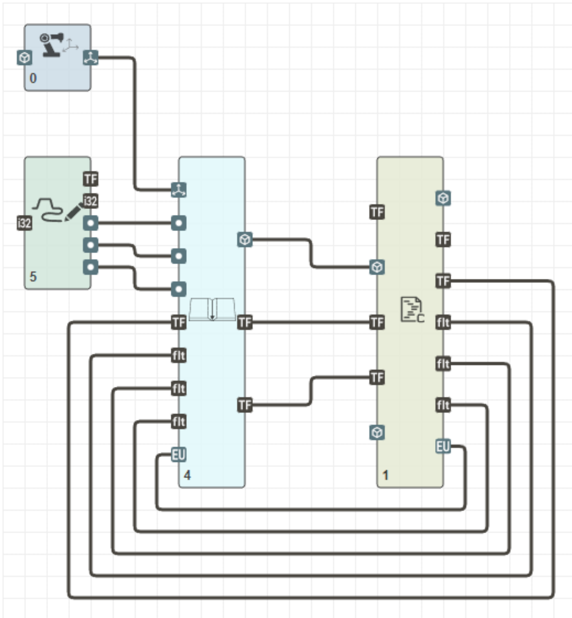
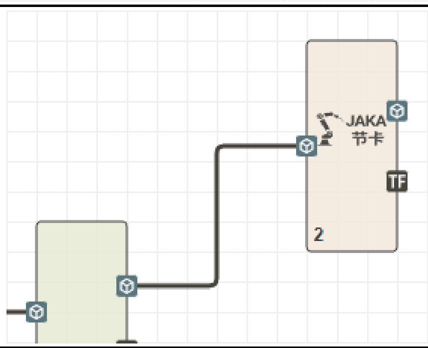
12.2.1. Preparing the computation graph

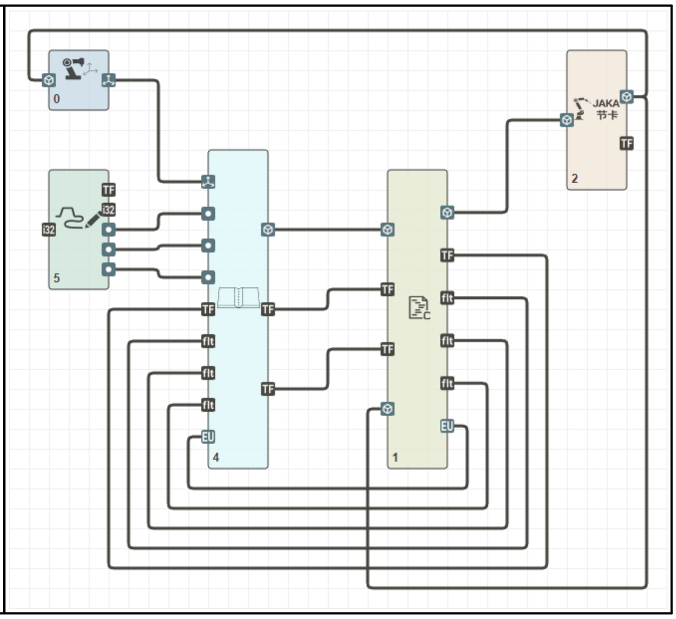
Place the "templates detector" block in the computation graph area.	
Select the templates file (the screenshot below shows the standard welding grooves contained in the templates file supplied with the system).	 

<table>
<tr>
<td></td>
<td>
</td>
</tr>
<tr>
<td>Place the "cst calibration" block.</td>
<td>
</td>
</tr>
</table>

Place the "3-pt tracking (by points)" block.	
Place the "c-script" block.	
Place the "JAKA" block.	

Connect the outputs of the "templates detector" (output points detected on the welding groove) block with the inputs of the "3-pt tracking (by points)" block, thereby providing it with the initial data for tracking.	
Connect the output of the "cst calibration" smart block to the input of the "3-pt tracking (by points)" smart block, thereby providing it with the data necessary to convert points from the 2D scanner coordinate system to the 3D robot coordinate system.	
Add the inputs and outputs of the "c-script" smart block: Inputs: 1. Bool, 2. 3D pose, 3. Bool, 4. Bool, 5. 3D pose Outputs: 1. 3D pose, 2. Bool, 3. Bool, 4. Float, 5. Float, 6. Float, 7. 3D Euler angles In the script editor, specify the names of the inputs and outputs.	

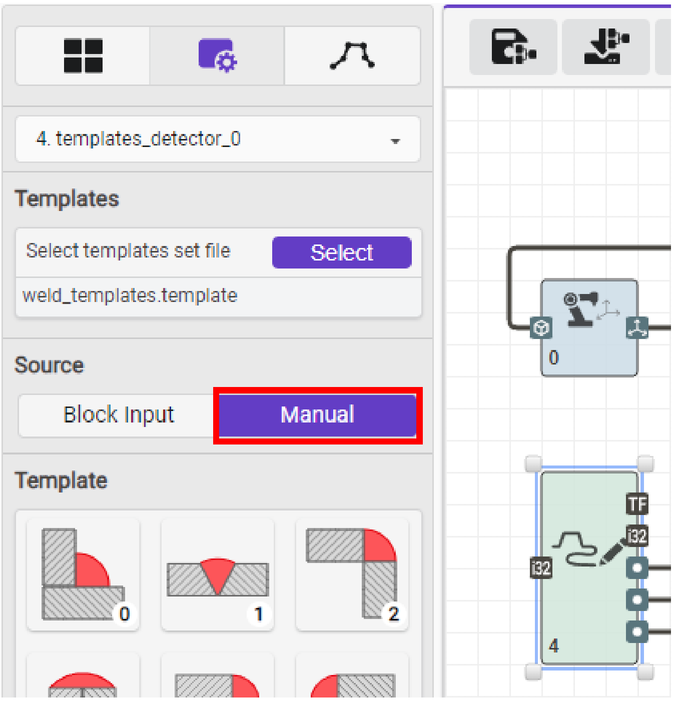
Connect the outputs of the "3-pt tracking (by points)" smart block to the inputs of the "c-script" smart block.	
Connect the outputs of the "c-script" smart block to the inputs of the "3-pt tracking (by points)" smart block.	
Connect the "out_pose" output of the "c-script" smart block to the "pose" input of the "JAKA" smart block.	

Connect the output of the "JAKA" smart block to the inputs of the "cst calibration" smart block, the "c-script" smart block, and the "templates detector" smart block.	

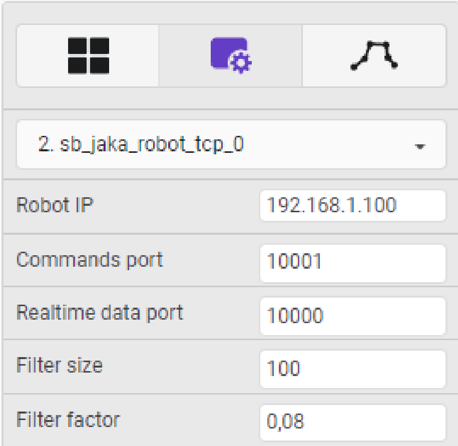
12.2.2. Configuring smart blocks

In this computation graph, it is necessary to set parameters for two smart blocks:

- “templates detector” - the “Source” parameter must be set to “Manual”, as it is assumed that the template is selected by the operator (or adjuster):



- “JAKA” - it is necessary to set the cobot's IP address on the Ethernet network, port numbers and filtering parameters. Default values:



12.2.3. Calibrating the scanner

Calibration is intended to obtain the coordinate transformation matrix for converting points from the 2D coordinate system (scanner) to the 3D coordinate system (robot).

The calibration procedure is described in Annex 3 of the User's Manual for RF627Smart.

12.2.4. Preparing the cobot control script

The control script generally ensures the execution of the welding cycle, which includes the following parts:

- Setting the initial values for the accuracy of the torch during the welding process, the trajectory construction step, the distance from the torch to the welding groove, the additional rotation of the torch.
- Moving the cobot to its initial position.
- Moving the cobot in a specified direction to search for the welding groove (search for an “entry point”).
- Moving the torch to the beginning of the welding groove, waiting for ignition and other actions.
- Moving along the welding groove with simultaneous correction of the position of the torch and its inclination relative to the groove, lengthening the trajectory and maintaining a stable speed.
- Stopping the movement at the end of the welding groove.
- Moving the robot to its initial position.

An example of a script that executes a welding cycle (values may vary for different situations):

```
//Declaring variables used in the script
pose_3d_t       in_pose;
pose_3d_t       out_pose;
pose_3d_t       start_pose;
bool_t          reached     = 0;
bool_t          seam_found  = 0;
bool_t          tracking    = 0;
pose_3d_t       rob_pose;
pose_3d_t       move_limit;
euler_3d_t      torch_rot;
```

```
m3d_pose_fill_xyz_zyx(20.0, 20.0, 20.0, 0.5, 0.5, 0.5, &move_limit);
m3d_euler_fill_zyx(0.0, -0.2, -0.2, &torch_rot);


//Forced disable tracking - for more safety
output_bool("out_enabled", 0, 1);
//Forced stop of the cobot - for more safety
output_pose3d("out_pose", &out_pose, 0);
outputs_sync();


//Setting initial parameters
//Torch accuracy, 0.5 mm
output_float("out_accuracy", 0.5, 1);
//Trajectory construction step, 2.0 mm
output_float("out_step", 2.0, 1);
//Distance from the torch to the welding groove, 2.0 mm
output_float("out_torchOfs", 2.0, 1);
//Angle of rotation of the torch relative to the robot flange
output_euler3d("out_torchRot", &torch_rot, 1);


//Placing the cobot to its initial position
m3d_pose_fill_xyz_zyx(-309.0, -114.0, 170.0, -2.02, -0.04, 1.29,
&start_pose);
//Waiting for the robot to return to the initial position
do{
    inputs_sync();
    if (input_pose3d("in_robPose", &rob_pose) == 0)
    {   output_pose3d("out_pose", &out_pose, 0);
        outputs_sync();
        return 0;
    }
    out_pose     = start_pose;
    m3d_pose_limit_movement(&rob_pose, &out_pose, &move_limit);
    output_pose3d("out_pose", &out_pose, 1);

    reached      = m3d_pose_isequal(&start_pose, &rob_pose, 1.0, 0.001);
}while (reached == 0);

//Enabling the search for the welding groove before the robot moves to
//the beginning of the groove and waiting for detection, while
//the position of the robot is controlled without tracking - it just
//moves in a given direction

output_bool("out_enabled", 1, 1);


outputs_sync();
do{
    out_pose.pos.x   -= 0.01;
    out_pose.pos.y   -= 0.01;
    output_pose3d("out_pose", &out_pose, 1);
```

```
    inputs_sync();
    input_bool("in_seamFound", &seam_found);
}while (seam_found == 0);

//Waiting for the robot to move to the beginning of the welding groove -
//the "tracking" signal will be set - this means that the scanner can
//guide the torch along the welding groove

do{
    if (input_pose3d("in_robPose", &rob_pose) == 0)
    {   output_pose3d("out_pose", &out_pose, 0);
        outputs_sync();
        return 0;
    }

    if (input_pose3d("in_pose", &in_pose) == 1)
    {
        out_pose    = in_pose;
        m3d_pose_limit_movement(&rob_pose, &out_pose, &move_limit);
        output_pose3d("out_pose", &out_pose, 1);
        outputs_sync();
    }

    inputs_sync();
    input_bool("in_tracking", &tracking);
}while (tracking == 0);


sleep_us(2000000);


//Welding groove is found - start tracking
do{
    if (input_pose3d("in_robPose", &rob_pose) == 0)
    {   output_pose3d("out_pose", &out_pose, 0);
        outputs_sync();
        return 0;
    }

    if (input_pose3d("in_pose", &in_pose) == 1)
    {
        out_pose    = in_pose;
        m3d_pose_scale_movement(&rob_pose, &out_pose, 2.5);
        m3d_pose_limit_movement(&rob_pose, &out_pose, &move_limit);
        output_pose3d("out_pose", &out_pose, 1);
        outputs_sync();
    }

    input_bool("in_tracking", &tracking);

}while (tracking != 0);
sleep_us(2000000);

//Placing the cobot to its initial position
```

```
m3d_pose_fill_xyz_zyx(-309.0, -114.0, 170.0, -2.02, -0.04, 1.29,
&start_pose);
//Waiting for the robot to return to the initial position
do{
    inputs_sync();
    if (input_pose3d("in_robPose", &rob_pose) == 0)
    {   output_pose3d("out_pose", &out_pose, 0);
        outputs_sync();
        return 0;
    }
    out_pose    = start_pose;
    m3d_pose_limit_movement(&rob_pose, &out_pose, &move_limit);
    output_pose3d("out_pose", &out_pose, 1);

    reached     = m3d_pose_isequal(&start_pose, &rob_pose, 1.0, 0.001);
}while (reached == 0);


//Disable tracking - the block will return to its original state
output_bool("out_enabled", 0, 1);
//Stop the robot
output_pose3d("out_pose", &out_pose, 0);
outputs_sync();
return 0;
```

13. Maintenance

Laser scanners are virtually maintenance free. As these are optical systems, they are sensitive to dust and sputter on the front windows. Cleaning is best done with a soft cloth. Do not use scratching cleaners or other aggressive media.

It is necessary to remove fingerprints from the windows, because fingerprints degrade the quality of profiles.

In order to remove fingerprints or grease, clean the windows with 20% alcohol and soft paper.

14. Warranty policy

Warranty assurance for the Laser Seam Tracking System for Welding Automation RF627Smart-Weld Series – 24 months from the date of shipping; warranty shelf-life – 12 months.

15. Technical support

Technical assistance related to incorrect operation of the system and problems with settings is provided free of charge by RIFTEK.

Technical support contacts:

- E-mail: support@riftek.com
- Skype: riftek_support

16. Revisions

Date	Revision	Description
27.09.2022	1.0.0	Starting document.
06.05.2024	1.1.0	Changes have been made to sections 5, 6, 7, 10.

17. Annex 1. HND1 protocol

Current version: 1.0.

17.1. Ethernet interface - link layer

The UDP transport layer protocol is used.

The scanner is usually connected to the robot controller or executive system and works as a slave device. Bidirectional data exchange is carried out by sending a command to the scanner by the master and sending a response by the scanner. There are commands that allow one-way exchange, namely the sending of the measurement results by the scanner until a stop command is sent.

Each command and response consists of a header (type of message (command) and the length of the subsequent data), followed by the data specific to that command. This sequence allows the transmission of commands and responses of variable length. In the future, it may be possible to send and receive multiple commands or responses in a single UDP packet in order to improve efficiency. The recipient will unpack and process each command in the order in which they are placed in the packet.

Words (16 or 32 bit values) are sent in “little endian” format.

17.2. Description of HND1 commands

Getting the protocol version

This command requests the protocol version supported by the scanner. The scanner will respond with the protocol version (two integers, major and minor version codes). The protocol version described in this document is indicated in the section title.

Command name: **MSG_GET_SENSOR_VERSION**

Scanner command:

Type		Length	
1	0	0	0

Parameters:
- none

Scanner response:

Type		Length		major		minor	
1	0	0	0	1	0	0	0

Parameters:
- major: major version code;
- minor: minor version code.

Setting the laser intensity

This command sets the current laser intensity. It is possible to change the intensity of up to 4 lasers. Each 16-bit field defines the intensity in % (0 - minimum intensity, 100 - maximum possible intensity). The value changed by this command is not saved in the nonvolatile memory of the scanner. If the laser is turned off, the intensity value will be applied and used the next time the laser is turned on.

Command name: **MSG_SET_LASERS_INTENSITY**

Scanner command:

Type		Length		intens0		intens1		intens2		intens3	
5	0	8	0	0	0	0	0	0	0	0	0

Parameters:
- intens0: the intensity of the first (main) laser;
- intens1: the intensity of the second (additional) laser;

- intens2: the intensity of the third (additional) laser;
- intens3: the intensity of the fourth (additional) laser.

Scanner response:

Type		Length	
5	0	0	0

Parameters:

- none.

Setting the exposure time

This command sets the exposure time of the frame by the CMOS sensor. The value must be transmitted in milliseconds. It is possible to set the exposure time up to 3 frames (in multiple exposure operation mode of the scanner).

Command name: **MSG_SET_SENSOR_EXPOSURE**

Scanner command:

Type		Length		exp0		exp1		exp2	
6	0	6	0	0	0	0	0	0	0

Parameters:

- exp0: exposure time for the first frame;
- exp1: exposure time for the second frame (in multiple exposure mode);
- exp2: exposure time for the third frame (in multiple exposure mode).

Scanner response:

Type		Length	
6	0	0	0

Parameters:

- none.

Turning on the laser

If the laser is already on, nothing will happen. The intensity specified in the scanner settings (using the MSG_SET_LASERS_INTENSITY command or some other way) will be applied. Please note that the forced shutdown of laser radiation for safety reasons (a special signal on the scanner connector) takes precedence over all other controls.

Command name: **MSG_SET_LASER_ON**

Scanner command:

Type		Length	
7	0	0	0

Parameters:

- none

Scanner response:

Type		Length	
7	0	0	0

Parameters:

- none.

Turning off the laser

If the laser is already off, nothing will happen.

Command name: **MSG_SET_LASER_OFF**

Scanner command:

Type		Length	
8	0	0	0

Parameters:
- none

Scanner response:

Type		Length	
8	0	0	0

Parameters:
- none.

Setting the region of interest (ROI)

This command allows the user to set the size and position of the working area of the CMOS sensor. Reducing the size of the area increases the operating frequency of the scanner.

The pair "X1, Y1" sets the top left position of the ROI, and the pair "X2, Y2" sets the bottom right position of the ROI.

Command name: **MSG_SET_SENSOR_ROI**

Scanner command:

Type		Length		X1		Y1		X2		Y2		NU		NU	
12	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0

Parameters:
- X1: the X coordinate of the top left point of the ROI - currently not used, will be ignored;
- Y1: the Y coordinate of the top left point of the ROI;
- X2: the X coordinate of the bottom right point of the ROI - currently not used, will be ignored;
- Y2: the Y coordinate of the bottom right point of the ROI;
- NU: not used.

Scanner response:

Type		Length	
12	0	0	0

Parameters:
- none.

Getting device status

This command is intended to get information about the status of the device.

Command name: **MSG_GET_SENSOR_STATUS**

Scanner command:

Type		Length	
8	0	0	0

Parameters:
- none

Scanner response:

Type		Length		mode		pad1[0]		...		pad1[15]		temp1		temp2	
15	0	2	50	0	0	0	0	...	0	0	0	0	0	0	

temp3		heater		pad2[0]		...		pad2[15]		gain		exp		NU	
0	0	0	0	0	0	...	0	0	0	0	0	0	0	0	

X1		Y1		X2		Y2		pad3[0]		...		pad3[15]		las		int0
0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	

int1	int2	int3	NU	NU	NU	NU	pad4[0]		...		pad4[15]		seam		NU	
0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	

NU[40]		pad5[0]		...		pad5[63]		NU		pad6[0]		...		pad6[127]	
0	0	0	....		0	0	0	0	0	0	...		0	0	

Parameters:
- mode: scanner operation mode (in the current version, it is always 0 - measurement output mode);
- pad1: separator-reserve;
- temp1: CPU temperature, the value is calculated as 100*(temperature in °C) + 10000;
- temp2: internal temperature of the scanner (sensor #1), the value is calculated as 100*(temperature in °C) + 10000;
- temp3: internal temperature of the scanner (sensor #2), the value is calculated as 100*(temperature in °C) + 10000;
- heater: heating state (in the current version - 0);
- pad2: separator-reserve;
- gain: amplification of the CMOS sensor signal (in the current version, it is always 0);
- exp: exposure time (for the first frame) in ms;
- NU: not used;
- X1: the X coordinate of the top left point of the ROI - currently not used, will be ignored;
- Y1: the Y coordinate of the top left point of the ROI;
- X2: the X coordinate of the bottom right point of the ROI - currently not used, will be ignored;
- Y2: the Y coordinate of the bottom right point of the ROI;
- pad3: separator-reserve;
- las: laser state (0 - off, 1 - on), this parameter is not affected by the hardware shutdown of the laser;
- int0: radiation intensity of laser #1 (main);
- int1: radiation intensity of laser #2 (additional);
- int2: radiation intensity of laser #3 (additional);;
- int3: radiation intensity of laser #4 (additional);
- pad4: separator-reserve;
- seam: template index;
- pad5: separator-reserve;
- pad6: separator-reserve.

Setting the welding template

This command sets the index of the template used for finding a welding joint and outputting its attributes.

Command name: **MSG_SET_BASIC_SEAM_TYPE**

Scanner command:

Type		Length		idx	
40	0	2	0	0	0

Parameters:
- idx: template id.

Scanner response:

Type		Length	
40	0	0	0

Parameters:
- none.

Getting the firmware version of the scanner

This command requests the firmware version of the scanner. The scanner will respond with the firmware version (three integers, major, minor and patch version codes).

Command name: **MSG_GET_FIRMWARE_VERSION**

Scanner command:

Type		Length	
100	0	0	0

Parameters:
- none.

Scanner response:

Type		Length		major		minor		patch	
100	0	6	0	2	0	3	0	3	0

Parameters:
- major: major version code;
- minor: minor version code;
- patch: patch version code.

Getting the temperature of the scanner

This command requests the internal temperature of the scanner. A sensor installed on the CPU is used, because the CPU is the most heat-generating element.

Command name: **MSG_GET_MAIN_BD_TEMP**

Scanner command:

Type		Length	
105	0	0	0

Parameters:
- none.

Scanner response:

Type		Length		temp	
105	0	2	0	0	0

Parameters:
- temp: CPU temperature, the value is calculated as 100*(temperature in °C) + 10000.

Start sending measurement results

This command allows sending measurement results (welding joint parameters). The index of the welding joint is specified by the MSG_SET_BASIC_SEAM_TYPE command. The list of parameters depends on the type of the selected joint. It is possible to send up to 16 points and 16 parameter values. Each point has a status indicating whether it is used for this type of joint and whether its data is valid.

Command name: **MSG_START_MEASUREMENT_SENDING_IN_MM**

Scanner command:

Type		Length	
150	0	0	0

Parameters:

- none.

Scanner response:

Type		Length	
150	0	0	0

Parameters:

- none.

Message from the scanner (sent after each measurement)

Type		Length		timestamp				pt[0].x				pt[0].y			
150	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

pt[0].st				...				pt[15].x				pt[15].y			
0	0	0	0	...	0	0	0	0	0	0	0	0			

pt[15].st				prm[0].val				prm[0].st				...			
0	0	0	0	0	0	0	0	0	0	0	0	...			

prm[15].val				prm[15].st				pad[0]		...				pad[63]	
0	0	0	0	0	0	0	0	0	0	...	0	0			

Parameters:

- timestamp: system timestamp of measurement results generation, ms;
- pt[0].x: X coordinate of point #1 (float, mm);
- pt[0].z: Z coordinate of point #1 (float, mm);
- pt[0].st: status of point #1;

...

- pt[15].x: X coordinate of point #16 (float, mm);
- pt[15].z: Z coordinate of point #16 (float, mm);
- pt[15].st: status of point #16;
- prm[0].val: value of parameter #1 (depends on the template) - not used in the current version;
- prm[0].st: status of parameter #1 - not used in the current version;

…

- prm[15].val: value of parameter #16 (depends on the template) - not used in the current version;
- prm[15].st: status of parameter #16 - not used in the current version;
- pad: separator-reserve.

Statuses (for the current version of the protocol): 0 - point/parameter data is up-to-date; 2 - point/parameter data is not up-to-date and should not be used.

Stop sending measurement results

This command stops sending measurement results.

Command name: **MSG_STOP_MEASUREMENT_SENDING_IN_MM**

Scanner command:

Type		Length	
151	0	0	0

Parameters:

- none.

Scanner response:

Type		Length	
151	0	0	0

Parameters:

- none.

18. Annex 2. P3 protocol

The protocol is designed for data exchange between the robot and the scanner and is based on EthernetIP.

EthernetIP parameters (scanner):

- assembly number for data transfer from the scanner to the robot: 101;
- assembly number for data transfer from the robot to the scanner: 102;
- configuration assembly (not used): 100;
- vendor id: 0x0634 (1588);
- device type: 0x2B (43);
- product code: 0x273 (627).

Transferred data:

- from the robot to the scanner:
  - coordinates of the current position of the robot TCP in the world coordinate system (in the base coordinate system), each value is 16 bits: X, Y, Z, W, P, R;
  - packet counter (8 bits);
  - control command (8 bits): 0x01 - turn on laser radiation, 0x02 - turn off laser radiation, other values are ignored;
  - template set selection (8 bits) - currently not used;
  - selection of a template for detection (8 bits).
- from the scanner to the robot:
  - point coordinates in the world coordinate system of the robot, each value is 16 bits: X, Y, Z;
  - packet counter value received from the robot (8 bits);
  - reserved value (8 bits);
  - P-coordinate for the robot (16 bits);
  - R-coordinate for the robot (16 bits);
  - point coordinates in 2D space of the scanner, each value is 16 bits: X, Z.

Coordinate value representation format:

- bit 15 - value sign: positive - 0, negative - 1;
- bits 14-0 - modulo value.

19. Annex 3. R691 USI protocol

The R691 Universal Sensor Interface protocol provides communication between the scanner and the welding robot and is based on a client-server architecture, where the scanner acts as a server (waits for connection to the port specified in the smart block settings), and the robot acts as a client and must connect to the network address of the scanner and port specified in the smart block settings.

To use this protocol, the robot must meet the following requirements:

- R30iA Robot Controller;
- Arc tool Software V7.30P9 or higher;
- Software Option R691 Universal Sensor Interface;
- Software Option R648 User Socket Messaging.

Requests and commands from the robot to the scanner

The robot sends commands and data requests to the scanner in TCP packets of at least 3 bytes in size (each packet is a separate protocol message).

The first byte indicates the message type:

- 0x02 - command to the scanner;
- 0x01 - data request.

The second byte indicates the number of commands or data in the message and is usually 0x01.

The third byte indicates the command type (turn on/off the laser, set the welding groove type, etc.) or the type of data requested (point coordinates, status, etc.).

The current version of the protocol supports the following messages:

#	Protocol message	Message type	Number of commands / data	Command / data type	Value
1	Sensor ON	0x02	0x01	0x13	0x01
2	Sensor OFF	0x02	0x01	0x06	0x00
3	Start track (laser on and measure)	0x02	0x01	0x06	0x01
4	End track	0x02	0x01	0x06	0x00
5	Set joint ID 0xXX - template number for detection	0x02	0x01	0x10	0xXX
6	Request joint data*	0x01	0x06	0x08 0x09 0x0A 0x0B 0x0C 0x0D	-
7	Request status	0x01	0x01	0x06	-
8	Request joint idx	0x01	0x01	0x10	-

The robot must wait for a response from the scanner for at least 80 ms (usually the scanner responds to a message within no more than 5 ms), after which it sends a second message. If no response is received from the scanner within 300 ms, a “Timeout Alarm” is set.

* on the “Request joint data” request, the data about the detected welding groove is sent in the following order (the format is described below), the request is sent by the robot every 50 ms:

X	Y (not used)	Z	GAP	MISMATCH	AREA

Responses from the scanner to the robot

The scanner responds to commands 1-5 with one byte 0x82, which means that the command has been received and executed.

The scanner responds to data requests 6-8 with a message in which the first byte is 0x82, the second byte contains the error code, followed by two-byte data.

Error codes (not currently used, provided for reference):

1	External alarm	7	Incorrect message
2	Checksum error	8	Unknown parameter
3	Correction	9	Setup error
4	Timeout error	10	Temperature alarm
5	Sensor error	11	Value out of range
6	Bad end	12	Data not available

They occupy 1 byte, if the value is 0x00, then there is no error (in the current version, this value is always transmitted).

Scanner status

For request 7, a two-byte value of the current state of the scanner is returned, which is a set of bits:

Bit 0	No alarm	1
Bit 1	No external alarm	2
Bit 2	No temperature larm	4
Bit 3	Not too cold	8
Bit 4	Not too hot	16
Bit 5	No shutdown	32
Bit 6	Laser Off	64
Bit 7	Laser Down	128
Bit 8	Laser power control disabled	256
Bit 9	Flash checksum invalid	512
Bit 10	Calibration table error	1024
Bit 11	Laser Ready	2048
Bit 12	Laser On	4096
Bit 13	Reserved	8192
Bit 14	Reserved	16384
Bit 15	Reserved	32768

In the current version of the protocol, bit 11 (“Laser ready”) is always set, and bits 6 (“Laser off”) and 12 (“Laser on”) indicate the actual state of the laser.

Coordinate representation format

Each coordinate transmitted in response to request 7 is transmitted as 2 bytes in two's complement format. The first byte is the most significant, the sign bit is the most significant in the most significant byte. Coordinate values and other metric values are transmitted multiplied by 0.01 mm (which means that 9.51 mm will be transmitted as 951).

Data exchange example

Scanner status request from robot: [0x01] [0x01] [0x06]
Scanner response to robot: [0x82] [0x00] [0x08] [0x40]
where:
[0x82] - scanner response;
[0x00] - no error;
[0x08] - high byte of status 0x08 * 256 = 2048 - laser ready
[0x40] - high byte of status 0x40 = 64 - laser off

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