3D LASER SCANNING KIT

Shtrikh-2M

User's manual

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1. Safety precautions

- In connection/disconnection of cables, the power must be switched off.
- Do not use the kit in locations close to powerful light sources.
- To obtain stable results, wait about 20 minutes after turning on the power for the sensor to warm up evenly.
- Check the grounding of the CNC machine before connecting the kit to the machine.
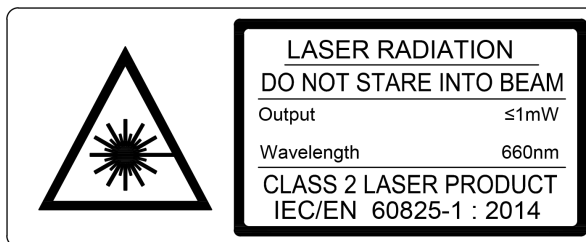
2. CE compliance

The kit 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.

3. Laser safety

The kit contains a laser sensor that complies with laser safety class 2 according to IEC/EN 60825-1:2014.

The sensor makes use of an c.w. 660 nm wavelength semiconductor laser. The maximum output power is 1 mW. The following warning label is placed on the body:

```
                    LASER RADIATION
                 DO NOT STARE INTO BEAM
           Output                    ≤1mW

           Wavelength                660nm
           CLASS 2 LASER PRODUCT
           IEC/EN  60825-1 : 2014
```

The following safety measures should be taken:
- Do not target the laser beam to humans.
- Do not disassemble the sensor.
- Avoid staring into the laser beam.

4. General information

The kit is designed for non-contact laser scanning of objects to obtain a three-dimensional model and generate files suitable for further use in CNC machines. The kit includes a laser sensor, a synchronization module and a software package and can be installed on CNC routers, milling and engraving machines with any type of control.

5. Structure and operating principle

The laser sensor is installed on the motion system of the machine. In scanning mode, the CNC system moves the sensor line by line ("snake") over the prototype of the product. The sensor measures the distance (Z coordinate) to the product surface. Data readout from the sensor is synchronized with its movement (XY coordinates), and the result is transmitted to the PC via the Ethernet port. Thus, an array of XYZ coordinates of the surface is formed, i.e. a digitized model of the prototype. This model is saved as a point cloud and also in STL format suitable for further use in CNC systems.
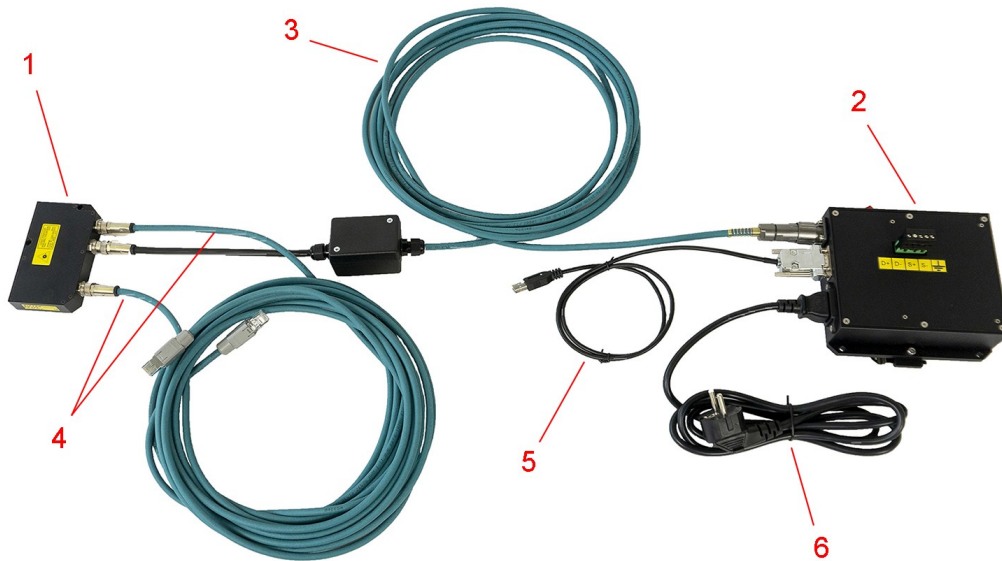
The main components of the kit:

Figure 1. Main components

Designations:

1 - Laser sensor (RF603 or RF603B, in the figure - RF603B).

2 - Synchronization unit.

3 - Cable for connecting the laser sensor to the synchronization unit.

4 - Ethernet cables for connecting the laser sensor to the PC (in the version with RF603 - one Ethernet cable).

5 - USB-RS485 cable for connecting the synchronization unit to the PC.

6 - Power cable 220 V.

NOTE: For the version of the kit with a binocular laser sensor (RF603B), a network switch and a patch cable are also supplied.

6. Basic technical data

6.1. Scan parameters

Parameter	Value
Scanned materials	any *
Scan grid, XY	arbitrary
Scan field, XY	arbitrary
Scan depth, mm	100 or by order **
Average scanning speed, points/s	4500

* When scanning transparent and specular materials, apply a special laser scanning spray to the surface.
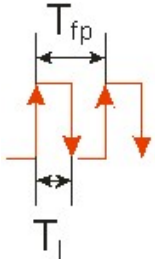
** The scan depth is determined by the working range of the laser sensor (see par. 6.4.).

It is possible to equip the kit with a sensor with a different working range (RF603 Series, see https://riftek.com/products/laser_triangulation_sensor/).

6.2. Acceptable synchronization methods

Sync source	Signal level value
Stepper drive direct control signals, X-axis	CMOS/TTL
X-axis encoder with pulse output (differential or non-differential)	2,5…30V
X-axis encoder with sinusoidal output (differential or non-differential)	2,5…30V

6.3. Dynamic characteristics of STEP input signal

Sygnal	Parameter	Symbol	Environmental conditions	Min.	Norm.	Max.
T_{fp} T_I	STEP signal period, µs	Tfp	Ambient temp. - 25°C	125	222	-
	Time of STEP signal active level, µs	Ti	Ambient temp. - 25°C	10	25	-

> **ATTENTION!**
> In the case of using the **Mach3** program (and the like), be careful when setting the STEP pulse duration - it should not be shorter than the Ti time indicated in the table.

6.4. Laser sensors RF603 and RF603B

Parameter	Value
Base distance, mm	140*
Working range, mm	100*
Height from machine table, mm	240*
Linearity, mm	±0.1*
Resolution, mm	0.01*
Maximum speed, points/sec	9400
Laser type	1 mW, 660 nm wavelength
Enclosure rating	IP67
Operating temperature, °C	-10…+60
Continuous operating time	unlimited
Dimensions, mm	RF603 - Fig. 3, RF603B - Fig. 5
Weight, gram	RF603 - 100, RF603B - 220

* It is possible to equip the system with a laser sensor with a different working range and base distance (RF603 Series, see https://riftek.com/products/laser_triangulation_sensor/).

> **IMPORTANT!**
> The accuracy and resolution of laser sensors are directly proportional to the working range of the sensor. Therefore, for maximum scanning accuracy, choose a sensor with the working range comparable to the height of the scanned objects.

> **IMPORTANT!**
> The use of the binocular sensor (RF603B) can significantly improve the quality of scanning, especially for objects with deep relief. Unlike a standard sensor, the binocular sensor contains two input windows, located symmetrically relative to the laser beam, which makes it possible to scan the areas inaccessible to the standard sensor, see Fig. 2, 4.
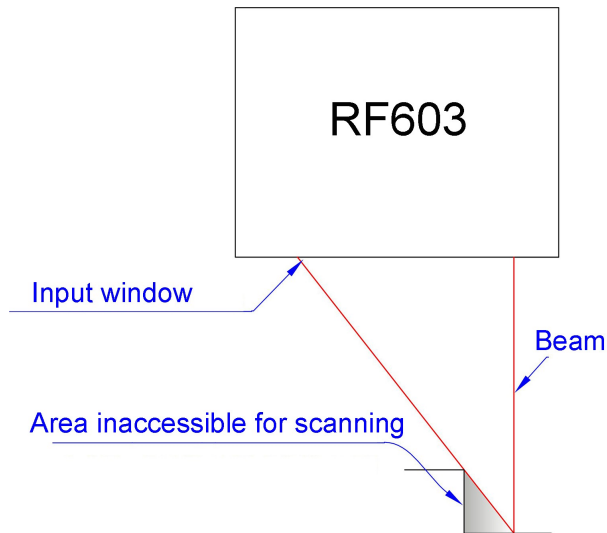
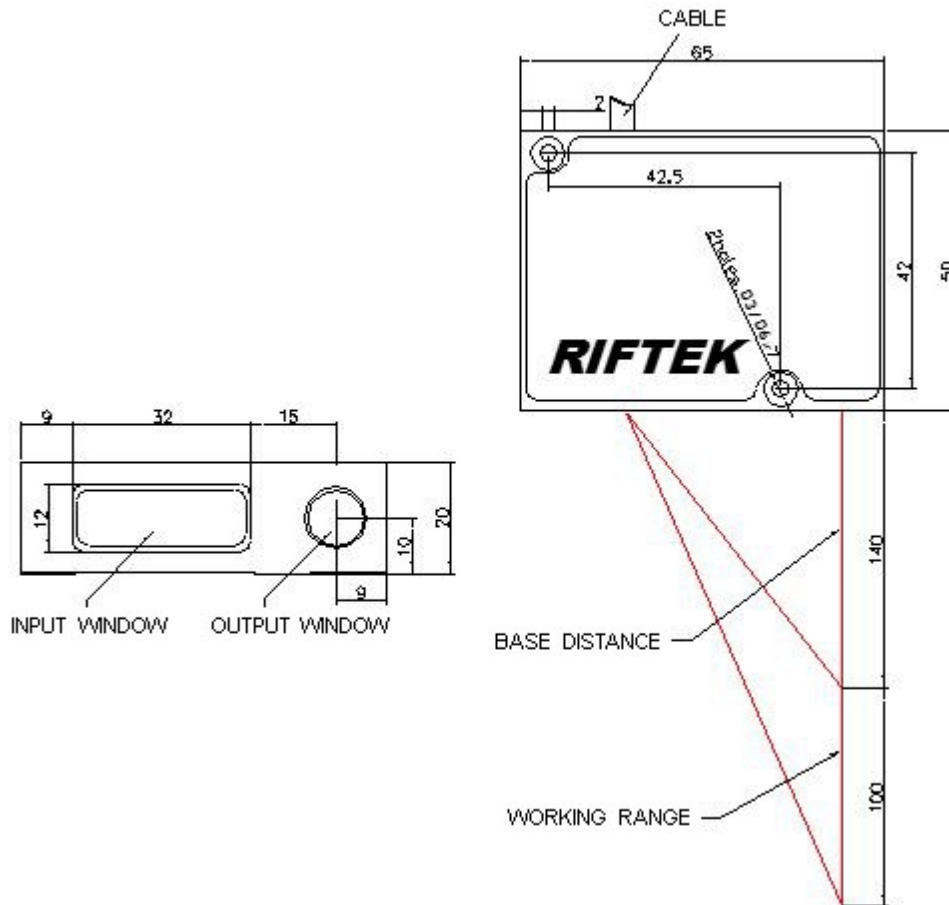**Figure 2. The principle of operation of the RF603 sensor**

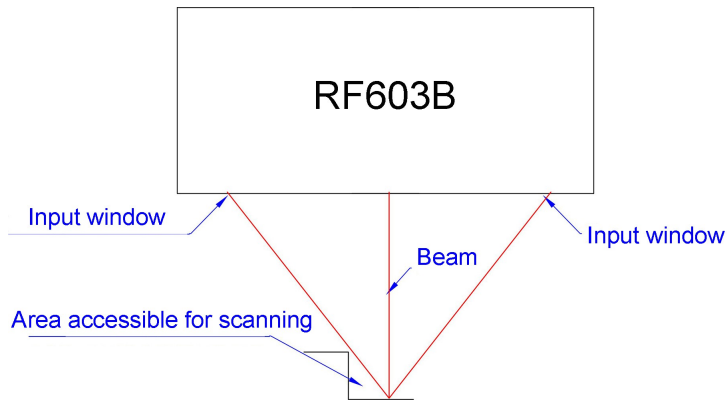**Figure 3. Overall and mounting dimensions of the RF603 sensor**

Figure 4. The principle of operation of the RF603B sensor
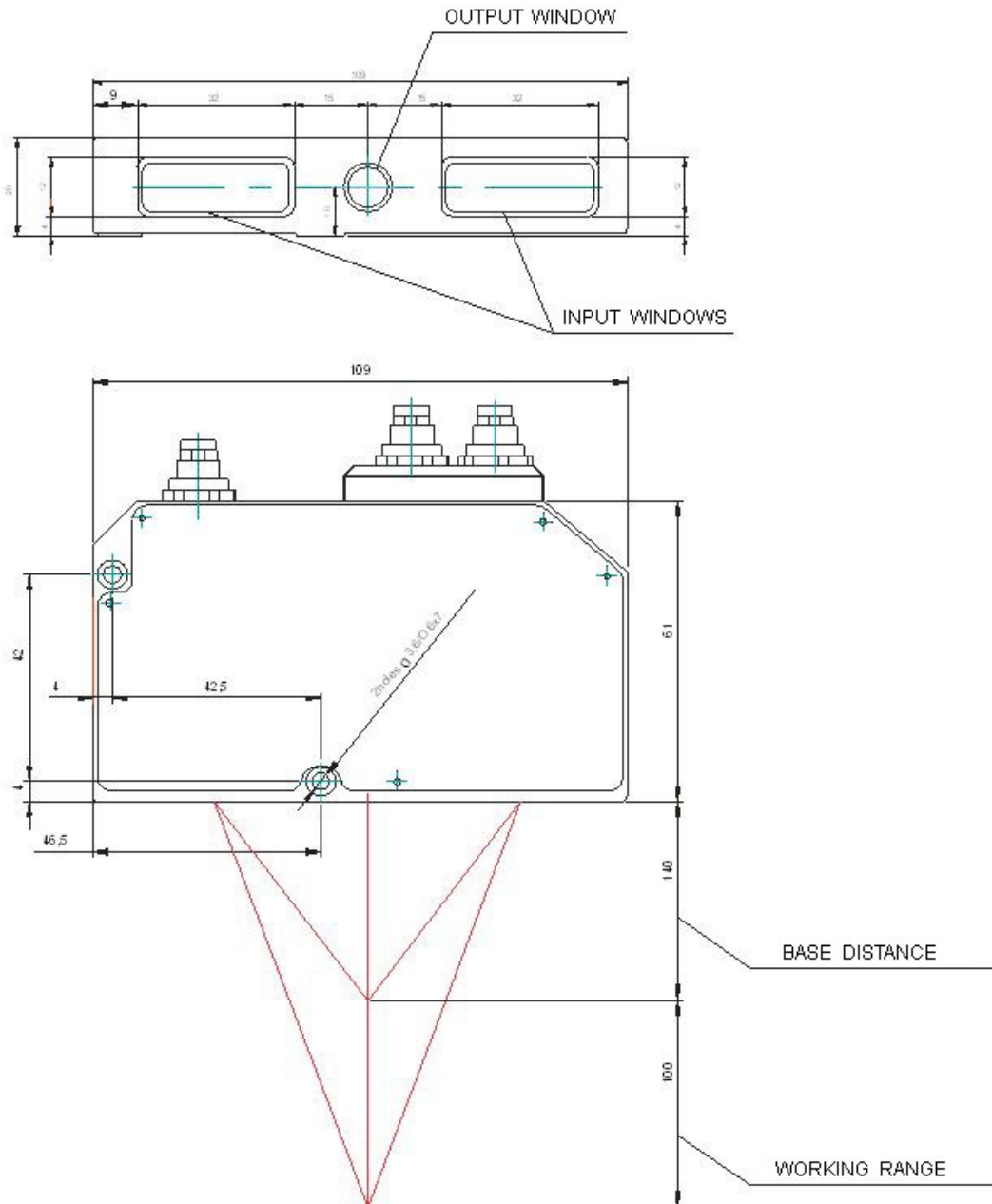
Figure 5. Overall and mounting dimensions of the RF603B sensor

6.5. Synchronization unit

Parameter	Value
Interface for PC	USB 2.0
Power supply, V	220
Enclosure rating	IP67
Operating temperature, ºC	-10…+60
Dimensions, mm	Fig. 6

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A (1.5 : 1)
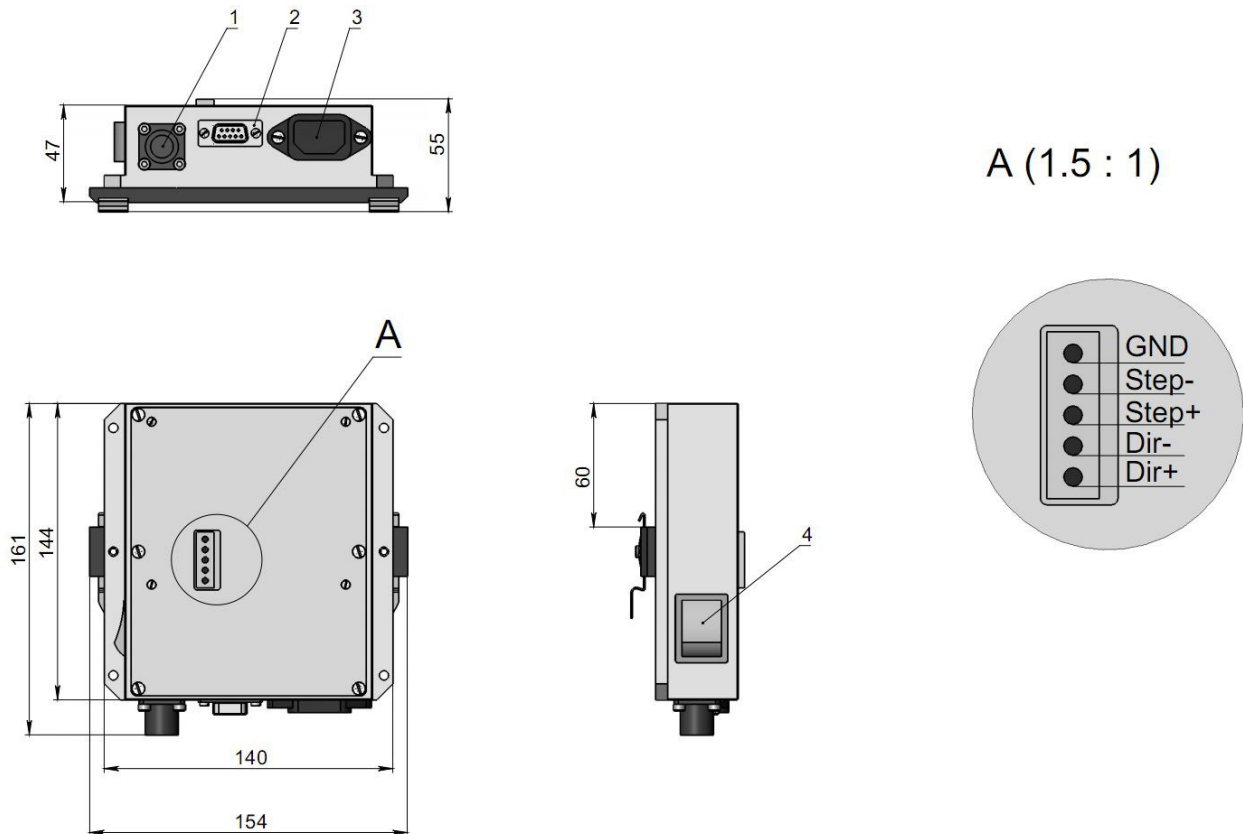
Figure 6. Overall and mounting dimensions of the synchronization unit

6.5.1. Pin assignment

?	Assignment
1	Connector for the laser sensor.
2	USB cable for connecting the system to a PC.
3	Connector for power supply (220V).
4	Power button.
A	Connector for connecting to the machine.

> **ATTENTION!**
> The sensor and the synchronization unit must be grounded (connected to the ground of the machine).

7. Example of designation when ordering

Shtrikh-2M-D-B/R-L1/L2

Symbol	Description
Shtrikh-2M	Series name.
D	Sensor type: 0 – Standard sensor RF603. 1 – Binocular sensor RF603B.
B	Base distance of the laser sensor.
R	Working range of the laser sensor.
L1	Length of the cable between the laser sensor and the synchronization unit.
L2	Ethernet cable length.

Example: Shtrikh-2M-1-140/100-5/6 – 3D Laser Scanning Kit Shtrikh-2M with a binocular sensor RF603B-140/100 (base distance - 140 mm, working range - 100 mm), length of the cable between the laser sensor and the synchronization unit - 5 m, Ethernet cable length - 6 m.
Note: The standard cable length is 5 meters. The length exceeding the standard is charged additionally.

8. Complete set to be supplied

8.1. RF603 version

Name	Description	Quantity
RF603	Laser triangulation sensor.	1
RF033.001.000	Synchronization unit.	1
-	Power cable 220V 1.8 m (SCZ-1 BM).	1
RF019.00.058	Cable for connecting the laser sensor to the synchronization unit.	1
RF333.90.001-001	Ethernet cable for connecting the laser sensor to a PC.	1
RF333.80.012-001	USB-RS485 cable for connecting the synchronization unit to a PC.	1
-	USB flash drive with Software.	1
Shtrikh-2M-UM	User's manual.	1

8.2. RF603B version

Name	Description	Quantity
RF603B	Binocular laser triangulation sensor.	1
RF033.001.000	Synchronization unit.	1
-	Power cable 220V 1.8 m (SCZ-1 BM).	1
RF019.00.058	Cable for connecting the laser sensor to the synchronization unit.	1
RF333.90.001-001	Ethernet cable for connecting the laser sensor to a PC.	2
RF333.80.012-001	USB-RS485 cable for connecting the synchronization unit to a PC.	1
-	Network switch (D-Link 5-Port 10/100 DES-1005A).	1
-	Patch cable (UTP Patch Cable Cat.5e).	1
-	USB flash drive with Software.	1
Shtrikh-2M-UM	User's manual.	1

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9. Connection

9.1. General information

Before connecting:
- Study the circuit diagram of the machine.
- Study this User's Manual.

> ⚠️ **IMPORTANT!**
> Ground the machine bed and the cabinet in which the motor drivers are located (combine them into one ground). If the spindle is not grounded, connect it to a common ground as well.

- Connect the 3D scanning kit to the machine (it connects only to the X coordinate) and check the functionality.

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9.2. Connection (standard laser sensor)

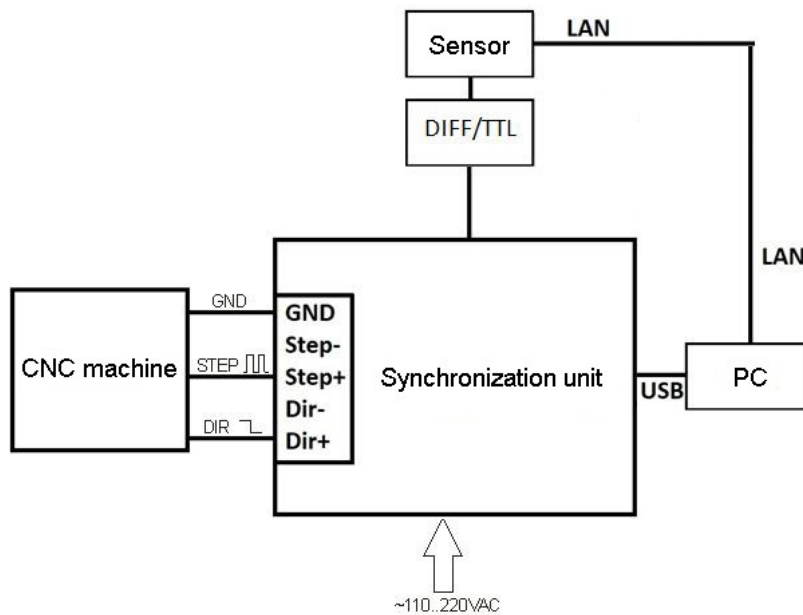### 9.2.1. Connection to machines with direct stepper motor control

Figure 7. Connection diagram

Designations:
LAN - RF333.90.001-001.
DIFF/TTL - RF019.00.058.
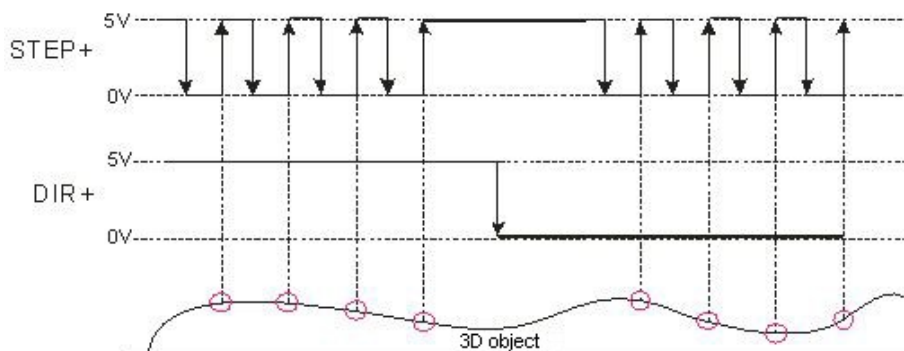**USB** - RF333.80.012-001.

Figure 8. Control signals diagram

9.2.2. Connection to machines with encoder pulses

Figure 9. Connection diagram

Designations:
LAN - RF333.90.001-001.
DIFF/TTL - RF019.00.058.
USB - RF333.80.012-001.

Figure 10. Control signals diagram

9.2.3. Connection to machines with pulse control signals, or with an encoder with a differential input
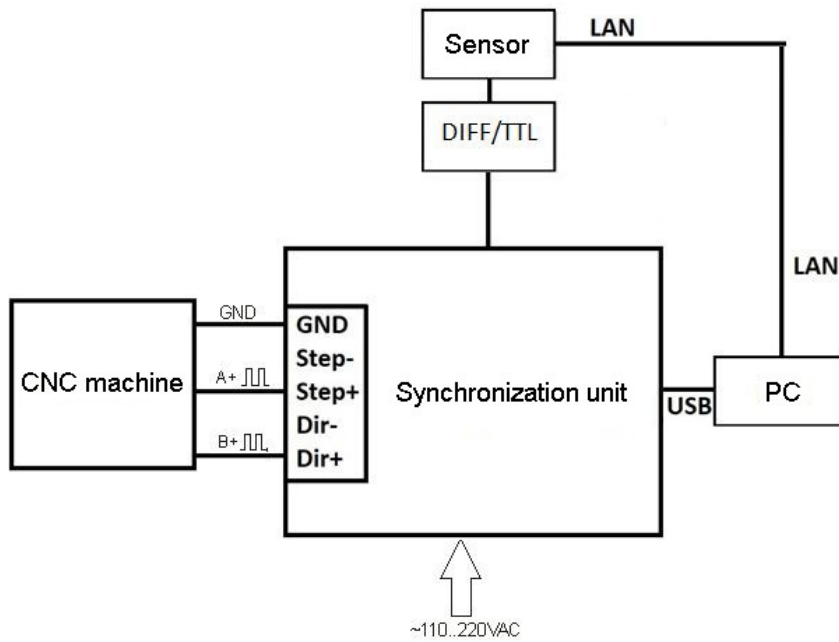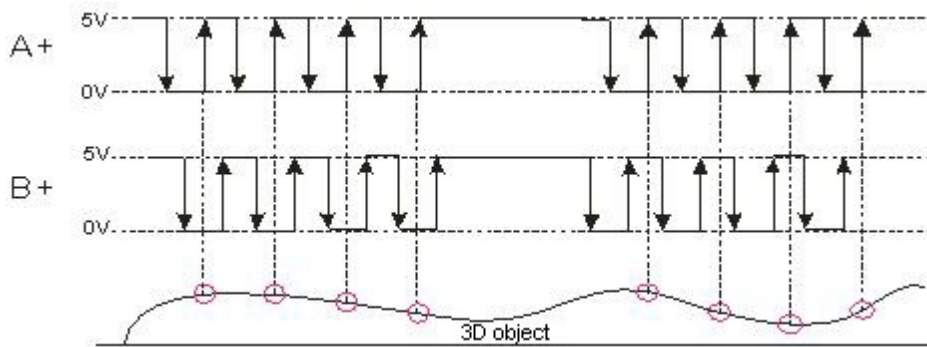

Figure 11. Connection diagram

Designations:
LAN - RF333.90.001-001.
DIFF/TTL - RF019.00.058.
USB - RF333.80.012-001.
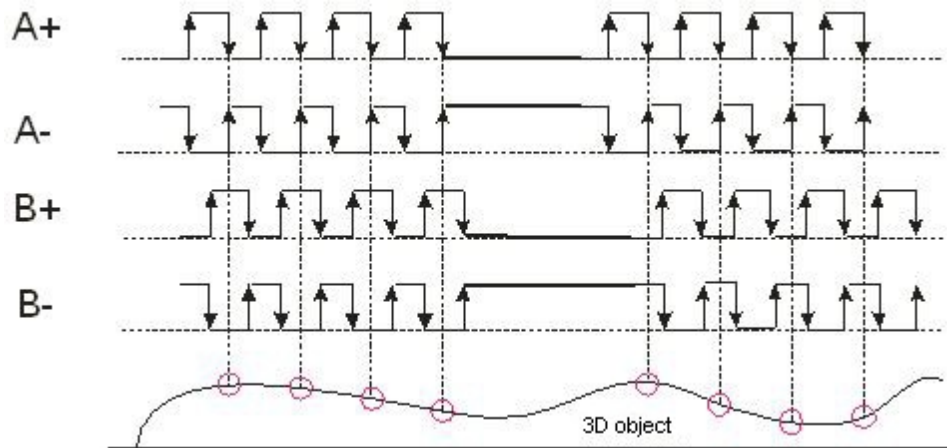
Figure 12. Control signals diagram

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9.2.4. Connection to machines with sinusoidal encoder signals (3 wires)

Figure 13. Connection diagram

Designations:
LAN - RF333.90.001-001.
DIFF/TTL - RF019.00.058.
USB - RF333.80.012-001.

Figure 14. Control signals diagram

9.2.5. Connection to machines with sinusoidal and differential encoder signals (5 wires)
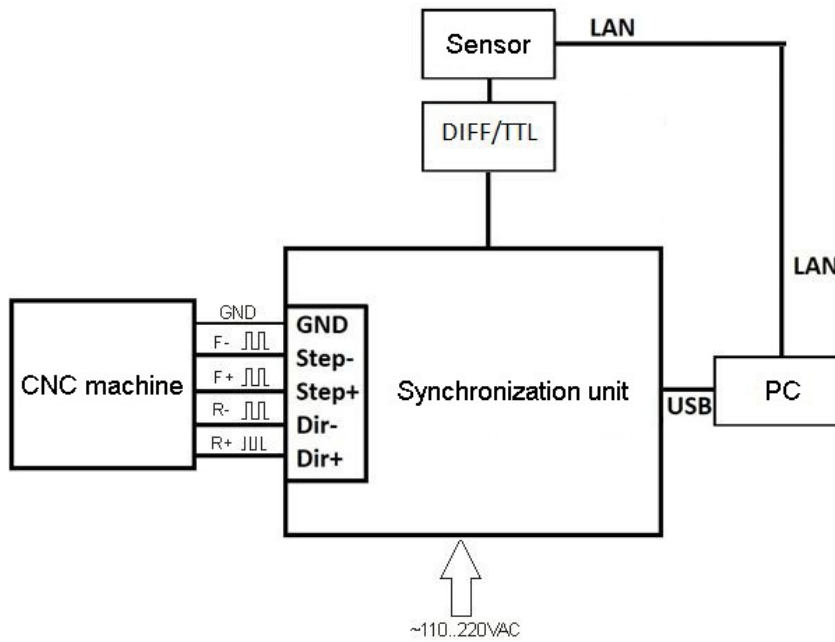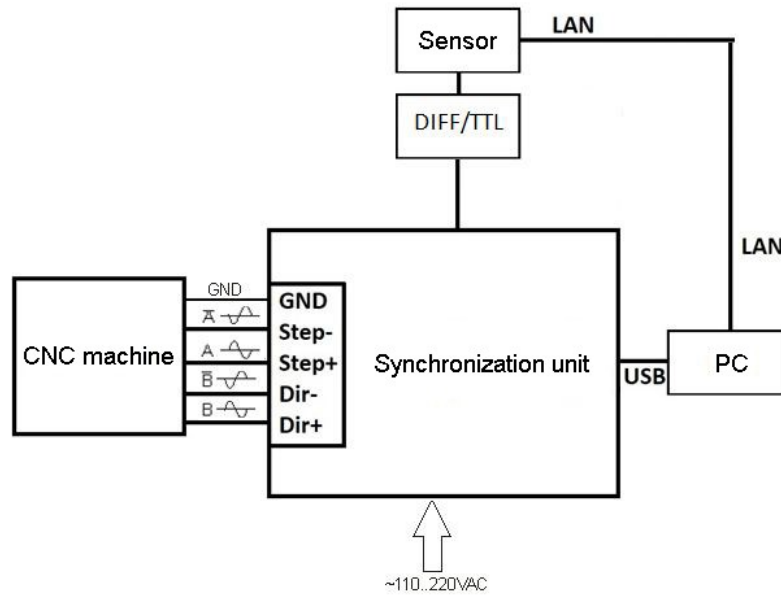

Figure 15. Connection diagram

Designations:
LAN - RF333.90.001-001.
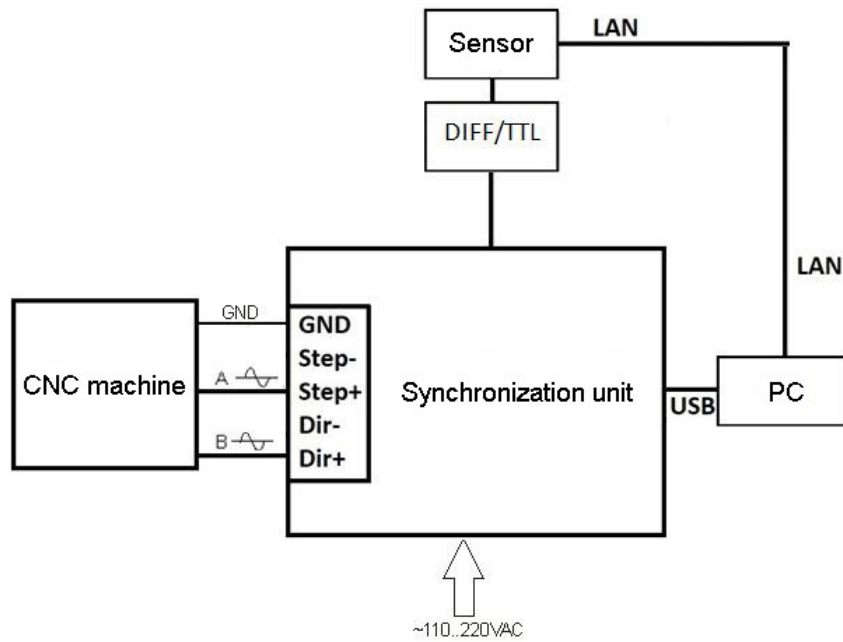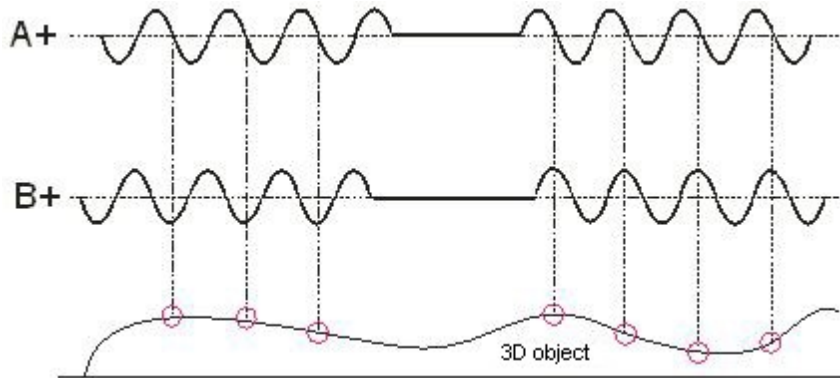**DIFF/TTL** - RF019.00.058.
USB - RF333.80.012-001.
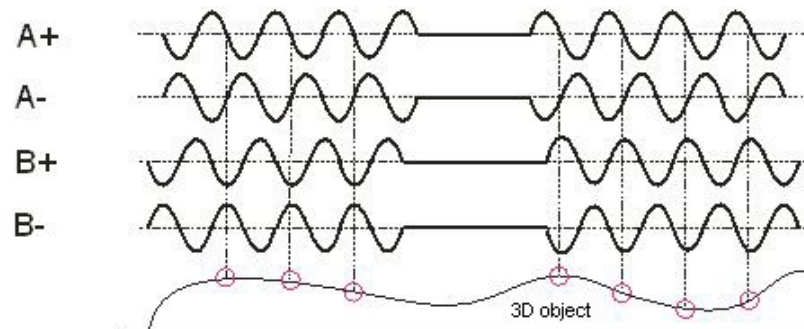
Figure 16. Control signals diagram

9.3. Connection (binocular laser sensor)

The connection procedure is similar to that described in par.
Data transmission from the binocular sensor is carried out via two LAN lines.

10. Software

10.1. Purpose

The software is intended for:
- Generating a line-by-line scan file for the CNC system (G-codes), including setting the size of the scan area, setting the sampling step along the Y coordinate.
- Receiving data from a laser sensor.
- Data visualization.
- Filtering and smoothing results.
- Generating files of standard formats .stl, .pcd.

10.2. System requirements

Operating system	Windows 10, 64 bit
RAM	At least 8 GB
Display resolution	At least 1280 x 1024
USB port	1
Ethernet port	1

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10.3. Starting the program

To start the program, go to the folder with the program and run **rf019.exe**.

10.4. User interface

10.4.1. Main window

The main window of the program:

Interface elements:
1. Menu.
2. Toolbar.
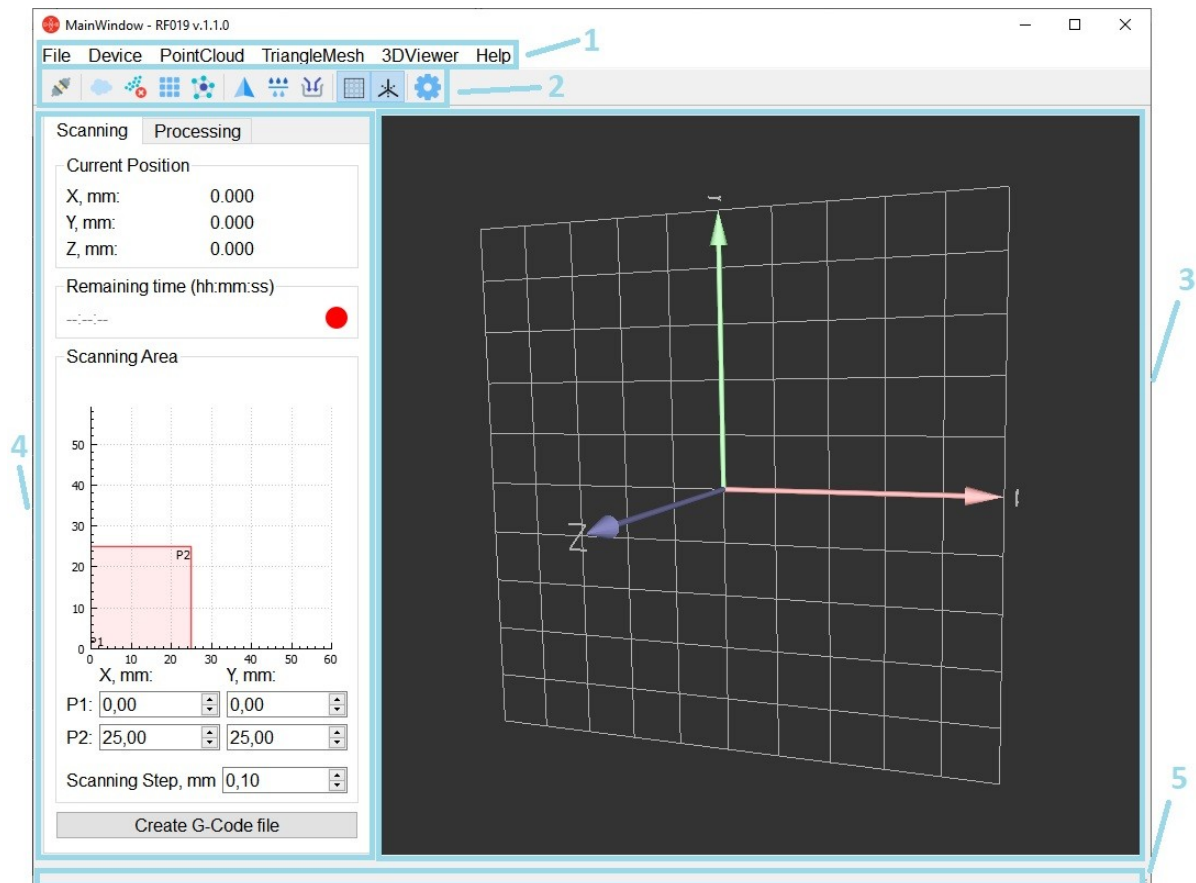3. Scanning and processing results display area.
4. Scanning and model processing settings area.
5. Status bar.

10.4.2. Menu and toolbar

The toolbar duplicates some of the frequently used menu items. If the item is not available, the icon is shown in gray.

Name	Keyboard shortcuts	Icon	Description
File			
New	Ctrl + N	-	Prepare the program for a new scan.
Save	Ctrl + S	-	Save a point cloud or a model to the program folder in a file with the standard name.
Save as...	Ctrl + Shift + N	-	Save a point cloud or a model to the specified location in a file with the specified name.
Open...	Ctrl + O	-	Load a point cloud to the display area.
Exit	Ctrl + Q	-	Exit the program.
Device			
Connect	-		Connect to equipment.
PointCloud			
Reset	-		Return to the raw point cloud.
Outlier Remove	-		Remove points that are located farther from their neighbors than the others in the point cloud (see par. 10.7.4.).
Downsample	-		Smooth a point cloud (see par. 10.7.4.).
Triangulate	-		Build a model from a point cloud (see par. 10.7.4.).
TriangleMesh			
Reset	-		Remove all model transformations.
Filter	-		Smooth a model.
Simplify	-		Reduce the number of triangles in the model to the specified number (see par. 10.7.4.).
3DViewer			
Enable Grid	G		Disable/enable the grid in the display area.
Enable Axes	A		Disable/enable coordinate axes in the display area.
Help			
About program	-		Information about the program.
Help	F1		User's manual.
Settings			Open the Settings window.

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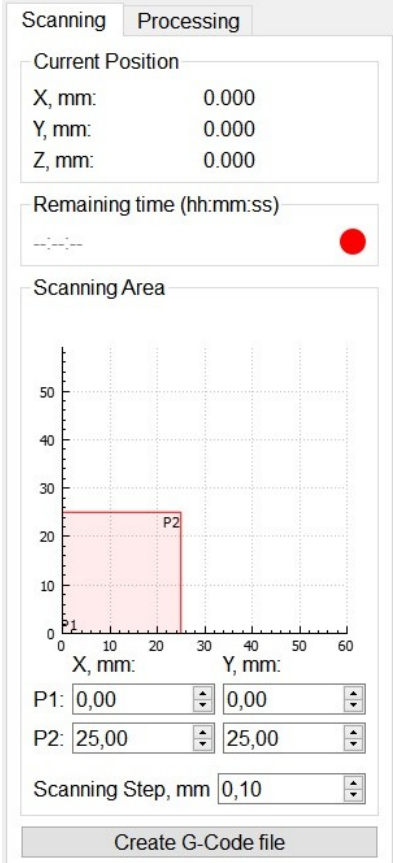
10.4.3. Scanning and processing results display area

This area displays the results of scanning and processing the model in real time. Using the mouse, the operator can move the camera (by holding down the right mouse button), zoom in/out (by rotating the mouse wheel) and rotate (by holding down the left mouse button). If necessary, the coordinate axes and the grid can be disabled/enabled.

10.4.4. Scanning and model processing settings area

This area contains the **Scanning** tab and the **Processing** tab.
The **Scanning** tab:

The **Scanning** tab is used to configure scanning parameters and contains the following sections:

- "Current Position" section. This section displays the coordinates corresponding to the last measurement received from the sensor.
- "Remaining Time" section. The approximate time remaining until scanning is complete. This section also contains an indicator: during scanning, the indicator is green, but if there have been no signals from the sensor for the last three seconds, the indicator turns red.
- "Scanning Area" section. This section contains scanning parameters and displays the scan area relative to the available area. In this section, the user can also specify the start point (P1) and end point (P2), scanning step (along the Y axis). The section contains the **Create G-Code file** button, which is used to generate a file with G-code commands for passing the specified area along the route ("snake").

The **Processing** tab contains two tabs: **Point Cloud** and **Triangle Mesh**:
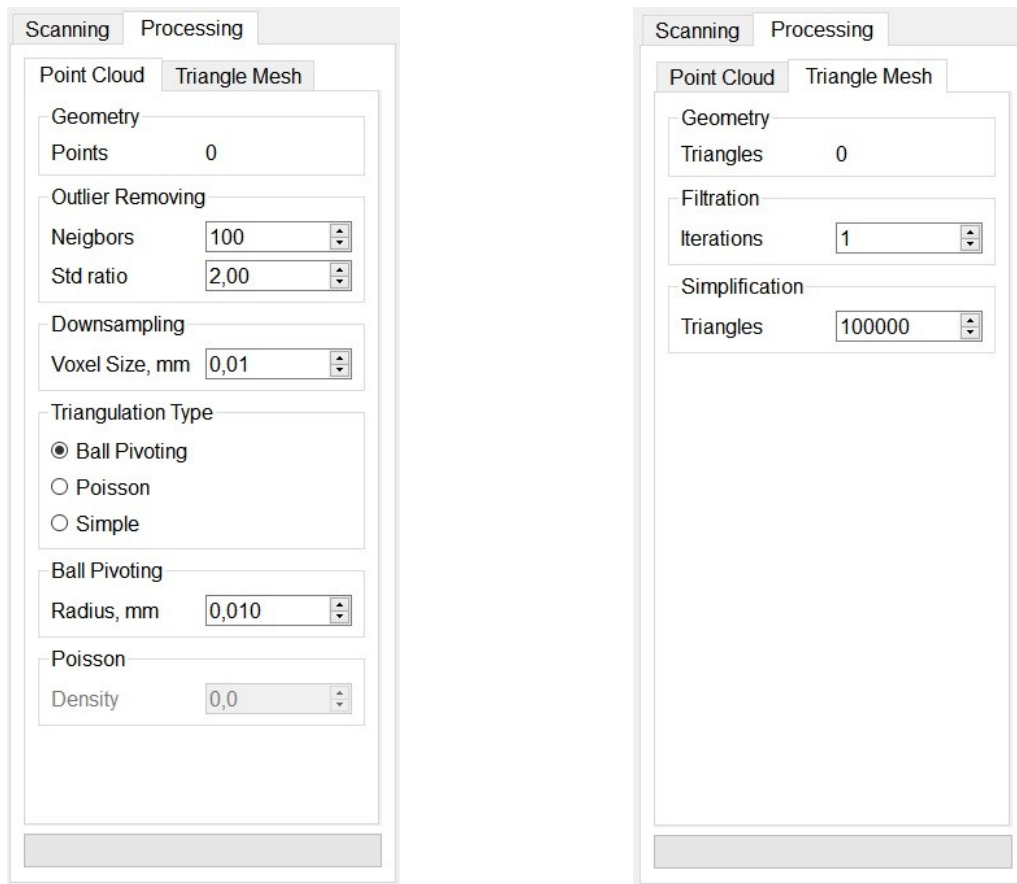
The **Processing** tab is used to set the parameters for processing the model.

The **Points** parameter shows the number of points in the point cloud. The **Triangles** parameter shows the number of triangles in the model. The rest of the parameters are described in par. 10.7.4.

10.4.5. Status bar

This panel displays messages about the results of various operations (connecting to equipment, saving a file, etc.).

10.5. "Settings" window

To open the **Settings** window, click ⚙ on the toolbar. To apply the specified settings, click **Apply**. To keep the current settings unchanged, click **Cancel**.

The **Settings** window is not available if the sensor is already connected.

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10.5.1. "Language settings" section

In this section, the user can select the interface language. The software supports Russian and English languages.

10.5.2. "Movement settings" section

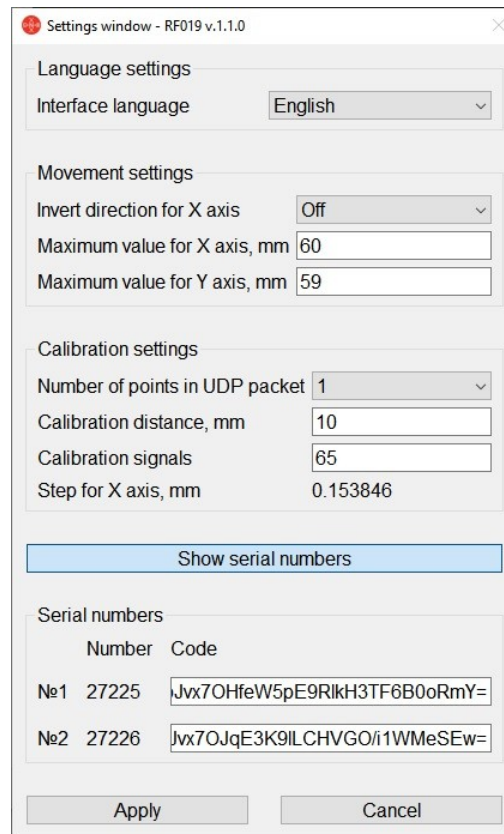In this section, the user can invert the direction of movement along the X axis (if needed), as well as specify the maximum ranges of movement along the X and Y axes.

10.5.3. "Calibration settings" section

This section contains the calibration settings.

Number of points in UDP packet - this parameter determines how many measurements from the packet are used to build the model.

When connected via UDP, the sensor sends data in packets of 100 measurements. The clarity of the model can be increased by processing all measurements from the packet, because it increases the number of points in the model. But more points require more computer resources to build and process the surface, as well as to store the model.

Valid values for this parameter: 1, 10, 100.

Changing this parameter will require adjusting the **Calibration signals** parameter (see par.). For example, if this parameter is increased from 1 to 10 points, the number of calibration signals for the same calibration distance will also increase by 10 times.

This section also displays the current step along the X axis in mm.

10.5.4. "Serial numbers" section

This section becomes available after clicking the **Show serial numbers** button. The section contains encoded serial numbers of the sensors for which this copy of the program is intended.

The code is entered only when the system is supplied or when the sensor is replaced. Entering the wrong code will make it impossible to work with the program until the correct code is entered.

10.6. Sensor connection

To connect to the sensor, select the **Connect** item in the menu or click   on the toolbar. For a successful connection, the sensor and the switch must be configured as follows:

- IP port to which the switch is connected must have the following address: 192.168.0.2.
- Sampling mode: trigger (by external input), the division ratio is 1.
- It is also recommended to set the **Maximum Exposure Time Allowed** parameter to 110 µs. In this case, the sensor will perform measurements as quickly as possible.

NOTE: The system comes with the settings listed above.

The sensor settings can be changed using the "RF60x Setup" software available for download at the RIFTEK official website https://www.riftek.com/.

10.7. Operating procedure

10.7.1. Preparation

Before starting work, it is necessary to configure some parameters in the **Settings** window.

First, you need to specify the maximum movement values along the X and Y axes.

If necessary, enable the inversion of the direction of movement along the X axis.

Then it is necessary to carry out the calibration procedure, which is needed to determine which linear displacement (in mm) one sync signal corresponds to. To do this, run the program and connect to the sensor. After that, specify the movement along the X axis - the **Calibration distance** parameter. It is recommended to specify at least 30 mm. Then move the machine in the opposite direction along the X axis. When changing the direction, the program displays the number of sync signals received during moving in the previous direction. This value must be entered in the **Calibration signals** field.

Based on this data, the program will automatically calculate how far along the X axis the machine has moved when one sync signal is received.

10.7.2. Generating a G-Code file

1. Run the program.
2. In the **Scanning Area** section, set the following parameters: start point (**P1**), end point (**P2**), scanning step along the Y axis (**Scanning Step, mm**).
3. Click the **Create G-Code file** button and select a location to save the file. As a result, the program creates a file with a description of the route of the machine.

10.7.3. Scanning procedure

1. Set the machine to the starting position. Generate a G-Code file. Transfer this G-Code file to the machine.
2. Run the program.
3. In the **Scanning Area** section, set the following parameters: start point (**P1**), end point (**P2**), scanning step along the Y axis (**Scanning Step, mm**).
4. Click **Connect**.
5. Start the machine operation in accordance with the G-Code file.

6. Upon receipt of the first measurement packet, the serial number of the sensor will be checked. If the serial number of the sensor is not in the list of serial numbers in the **Settings** window, then further operation of the program will be blocked.

NOTE: The scan results are displayed on the screen in real time.

10.7.4. Processing scan results

As a result of scanning, a point cloud is obtained. By carrying out certain operations, it is possible to build a 3D model from this point cloud. Point cloud processing functions are available in the menu or on the toolbar. Parameters are available on the **Point Cloud** tab of the **Processing** tab.

Outlier Removing – makes it possible to remove points that are located farther from their neighbors than the average in the point cloud. The **Neighbors** parameter shows how many neighbors were taken to calculate the average distance for a specific point. The **Std ratio** parameter is used to set a threshold based on the standard deviation of the average distances in the point cloud. The lower this parameter, the harder the filter.

Downsampling – gives uniformity to the point cloud. The algorithm consists of two steps: first, the points are distributed across voxels (cubes), then one point is generated in each occupied voxel by averaging all points inside the voxel. The **Voxel Size** parameter defines the length of the voxel side.

Triangulation Type – reconstructs a surface from a point cloud. The following methods can be used for reconstruction:

- **Ball Pivoting**. The **Radius** parameter sets the radius of the sphere used for surface reconstruction. This parameter should not be less than the scan step along the Y axis and the scan step along the X axis, otherwise the surface will not be created. The method does not use extrapolation, the resulting model is relatively small. The disadvantage of this method is the possibility of gaps on the surface in places with complex relief.
- **Poisson**. This method uses extrapolation, which can lead to the appearance of surfaces in the model that are absent in the real object. The **Density** parameter determines which vertices should be left in the model. If the density of points in the point cloud for a given vertex is less than the specified one, then the vertex will not be used. The method constructs a surface without gaps, the resulting model is relatively small.
- **Simple**. This method uses a simple triangulation model by connecting adjacent points. The resulting model has no gaps. The method does not use extrapolation, but the model is large and contains many triangles. When this method is selected, the point cloud preprocessing functions (**Outlier Removing** and **Downsampling**) are not available.

After construction, the model is colored depending on the relative height of each vertex. The highest vertices are red. As the height decreases, the color of the lowest vertices changes to purple.

The model can be processed by various methods. Processing functions are available in the menu or on the toolbar. Parameters can be found on the **Triangle Mesh** tab of the **Processing** tab.

Filtration – makes the model smoother, but less precise. The **Iterations** parameter determines how many times the filter will be applied to the model.

Simplification – reduces the number of triangles in the model to the number specified by the **Triangles** parameter. With this method, the clarity of the model slightly decreases, but at the same time, the amount of computer resources required to work with the model decreases as well.

The figures below show the result of scanning two objects.

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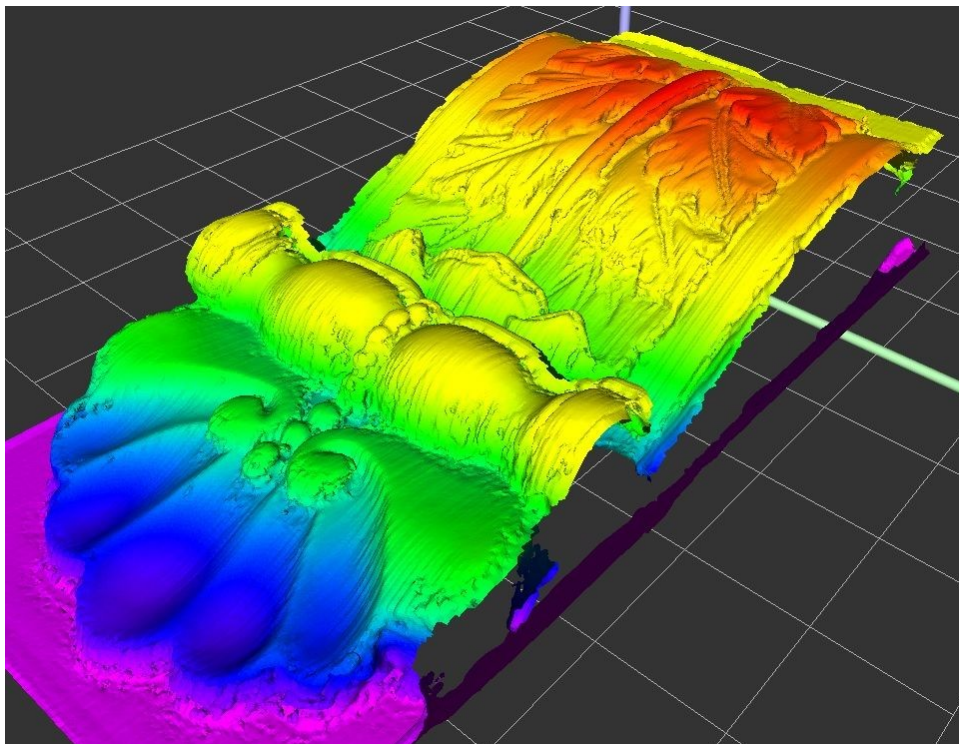
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10.8. Notes

- After scanning is complete, it is recommended to stop all movements of the machine, because the program reads the measurements from the sensor during all movements, including those that occur during the return of the machine to the zero position.
- When choosing the scanning step, consider the following:

- decreasing the scanning step leads to an increase in the scanning time;

- when creating a surface, the **Radius** parameter in the **Point Cloud** tab of the **Processing** tab must not be less than the scanning step along the Y axis and the step along the X axis, otherwise the surface will not be created.

Thus, it makes no sense to make the step along the Y axis less than the step along the X axis. The step along the X axis is displayed in the auxiliary window when the program starts. It depends on the number of sync signals from the machine and the **Number of points in UDP packet** parameter in the settings window.

11. Technical support

Technical assistance related to incorrect work of the kit and to problems with settings is free. Requests for technical assistance should be addressed at support@riftek.com.

12. Warranty policy

Warranty assurance for the 3D Laser Scanning Kit Shtrikh-2M – 24 months from the date of shipping; warranty shelf-life – 12 months.

13. Revisions

Date	Revision	Description
25.01.2021	1.0.0	Starting document.
05.04.2021	1.1.0	Changes have been made to Section 10 "Software".