



ОБЩЕСТВО С ОГРАНИЧЕННОЙ ОТВЕТСТВЕННОСТЬЮ
ИНФОРМАЦИОННО-ПРОМЫШЛЕННАЯ КОМПАНИЯ

«ИНКОМ»



INSTRUCTIONS FOR CREATING A 3D LASER SCANNER BASED ON A CNC MACHINE (SERIES LDx.2 SENSORS)

Version 0.2

Features of 3D scanning systems:

- Ability to work on any CNC machine with 2 mutually perpendicular axes of movement and CNC signals: DIR, STEP (laser machine, milling machine, 3D printer ...);
- Easy to connect to the machine's CNC system (just connect 2 signals: DIR, STEP);
- High measurement frequency up to:
 - 25,00kHz
- Digital interfaces for connecting to a computer:
 - USB 10Mb (Virtual COM port)
 - Ethernet 100Mb
 - RS485 (up to 10Mb)
- 3D file formats: STL, ASC (point cloud), SRS (source file of the scanned object);
- Support for plugins for processing / exporting scanned data;
- Ability to develop your own plugins, which allows you to integrate into the program your own algorithms for processing and exporting scanned data;

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1 INTRODUCTION

This manual describes the stages of creating a 3D laser scanner based on the CNC machine using triangulation laser sensors of the series LD1, LD2, LD3, LD4.

Before mounting the sensor, it is necessary to read this instruction manual and also the operating instructions for the sensor. Compliance with the operating rules set out in this manual and the operating instructions ensures trouble-free operation of the sensor over the entire service lifetime.

The manufacturer reserves the right to make schematic and design changes that are not reflected in the operating documentation guaranteed they do not degrade the technical characteristics of the product.

2 PRECAUTIONS



When working with the sensor, observe the following precautions:

- ✓ do not point the laser beam to your eyes;
- ✓ use protective glasses when working with the sensor;
- ✓ avoid direct or reflected laser radiation to the eyes;
- ✓ when connecting / disconnecting the electrical connector the sensor power must be turned off;
- ✓ the machine and the computer must have a common earthing to eliminate possible potential differences between them;

3 BRIEF DESCRIPTION OF LDx SERIES SENSORS

1) Laser triangulation sensors (series LD1)

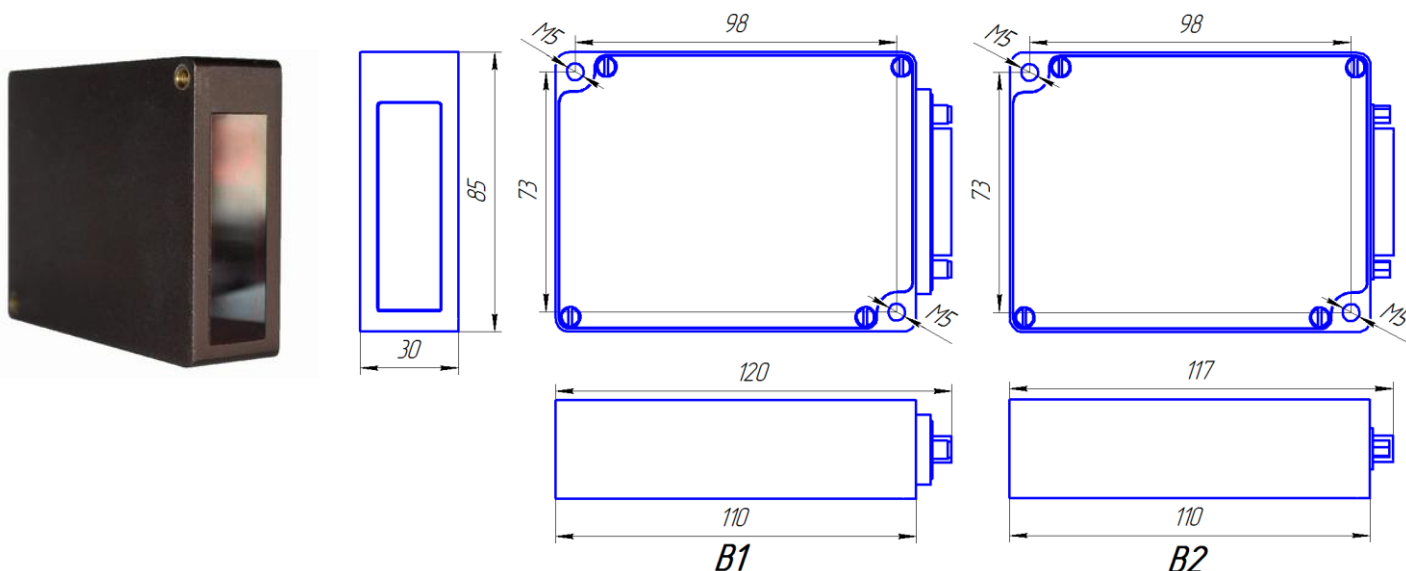


Figure 1. Overall dimensions of the LD1 sensor with a D-SUB44 connector.
B1 - IP67 housing; B2 – IP50 housing;

A series of universal monocular laser sensors, contains a wide variety of operating ranges.

2) Binocular laser triangulation sensors (series LD2)

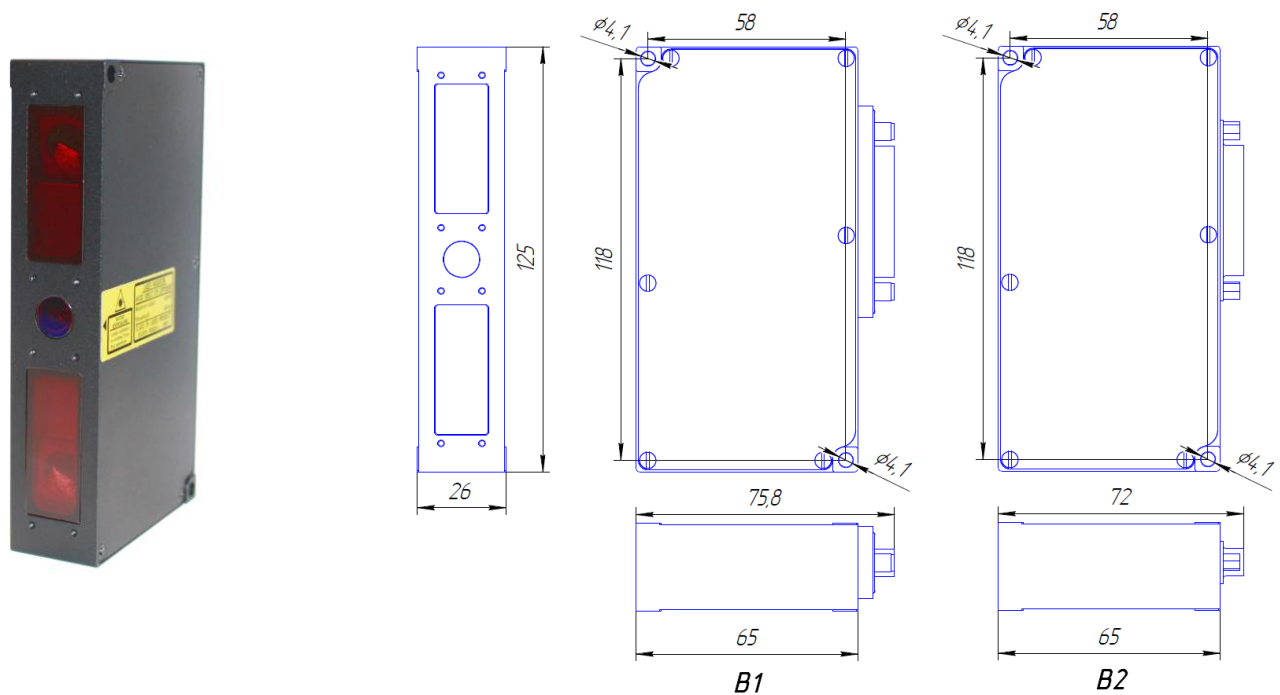


Figure 2. Overall dimensions of the LD2 sensor with a D-SUB44 connector.
B1 - IP67 housing; B2 – IP50 housing;

A special series of sensors for working with complex surface relief. Owing to two sensors symmetrically positioned relative to the laser beam, the binocular laser sensor, unlike monocular laser sensors is able to work with a deeper relief without signal loss.

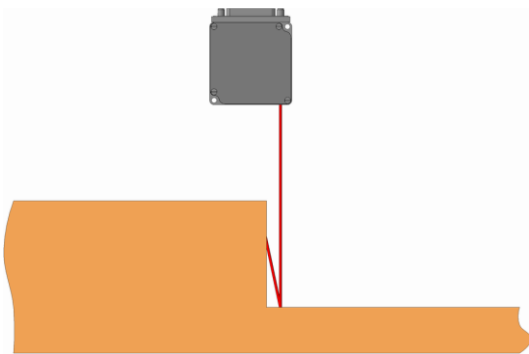


Figure 3. The monocular sensor is unable to detect object position

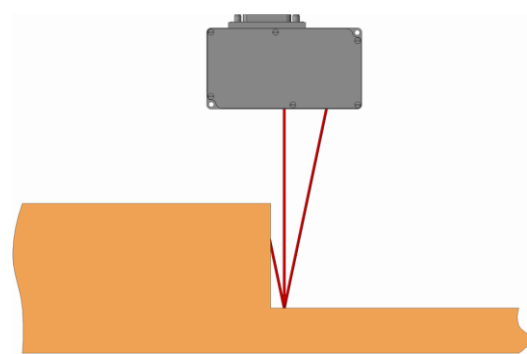


Figure 4. Owing to the second sensor, the binocular detector is able to determine object position

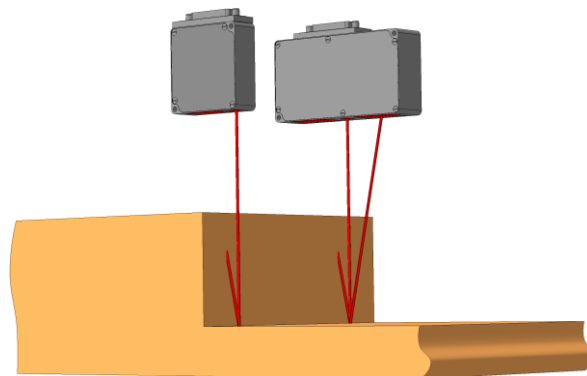


Figure 5. General view of the function of the sensors with a deep relief

3) Laser triangulation sensors (series LD3)

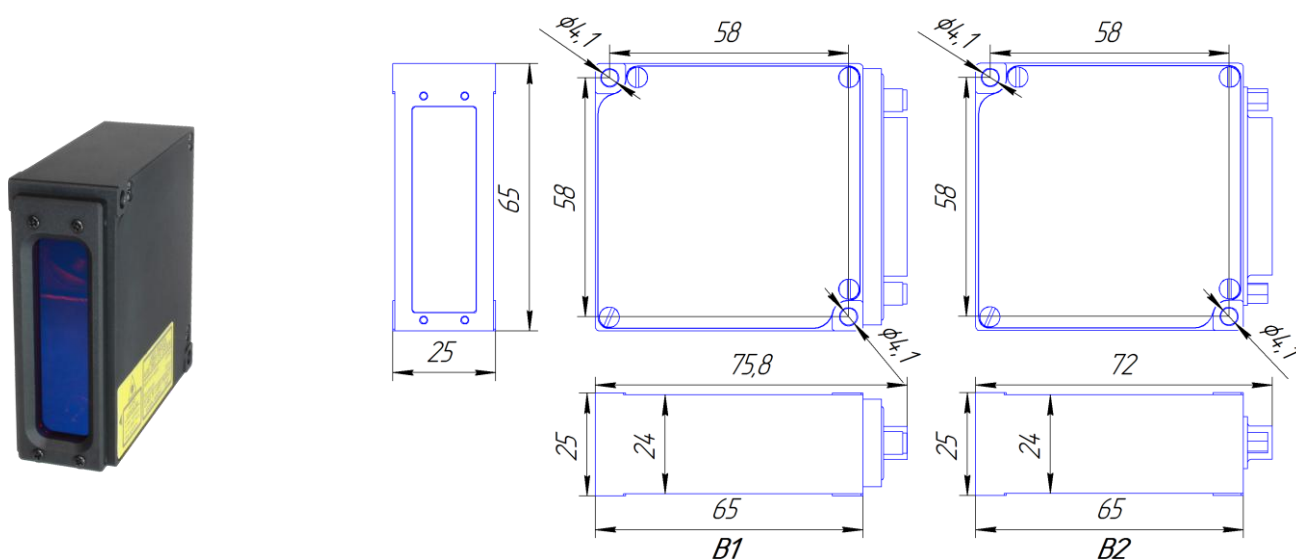


Figure 6. Overall dimensions of the LD3 sensor with a D-SUB44 connector.
B1 - IP67 housing; B2 – IP50 housing;

A special series of small-sized monocular sensors designed for tasks where light weight and size of the device is required.

4) Laser triangulation sensors (series LD4)

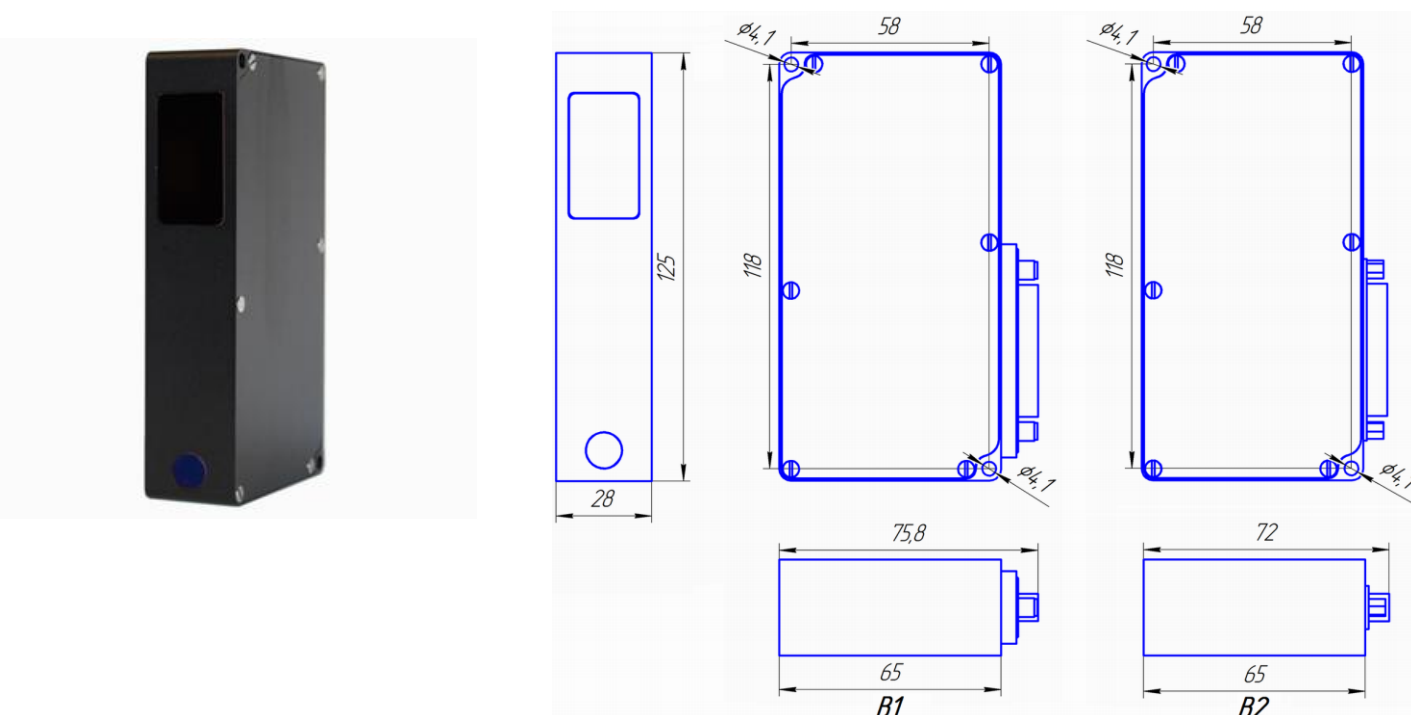


Figure 7. Overall dimensions of the LD4 sensor with a D-SUB44 connector.
B1 - IP67 housing; B2 – IP50 housing;

A special monocular series of sensors with an increased value of the start of measuring range, for situations when the sensor, for certain reasons cannot be installed close to the measured object.

For a more detailed description of the sensors refer to the "**User manual**".

4 ORDERING INFORMATION

LDx.2-SMR/MR-WL-AO-Ethernet-RS485-HEAT-IPxx

LDx.2	Sensor series LDx.2
SMR	Start of measuring range, mm
MR	Measuring range, mm
WL	Laser type: LR - red 650nm; LB - blue 405nm;
AO	Analogous output: TAO - sensor with analogous output; FAO - sensor without an analogous output;
Ethernet	Ethernet interface: TE - sensor with Ethernet interface; FE - sensor without Ethernet interface;
RS485	RS485 interface: T485 - sensor with RS485 interface; F485 - sensor without RS485 interface;
HEAT	Built-in automatic heating: TH - sensor with heating; FH - sensor without heating;
IPxx	Protection rating: IP67; IP50;

Example: LD2.2-190/350-LR-FAO-TE-F485-FH-IP50

- sensor series LD2;
- start of measuring range: 190mm;
- measuring range: 350mm;
- red laser 650nm;
- sensor without analog output;
- sensor with Ethernet interface;
- sensor without RS485 interface;
- sensor without heating;
- protection rating: IP50;

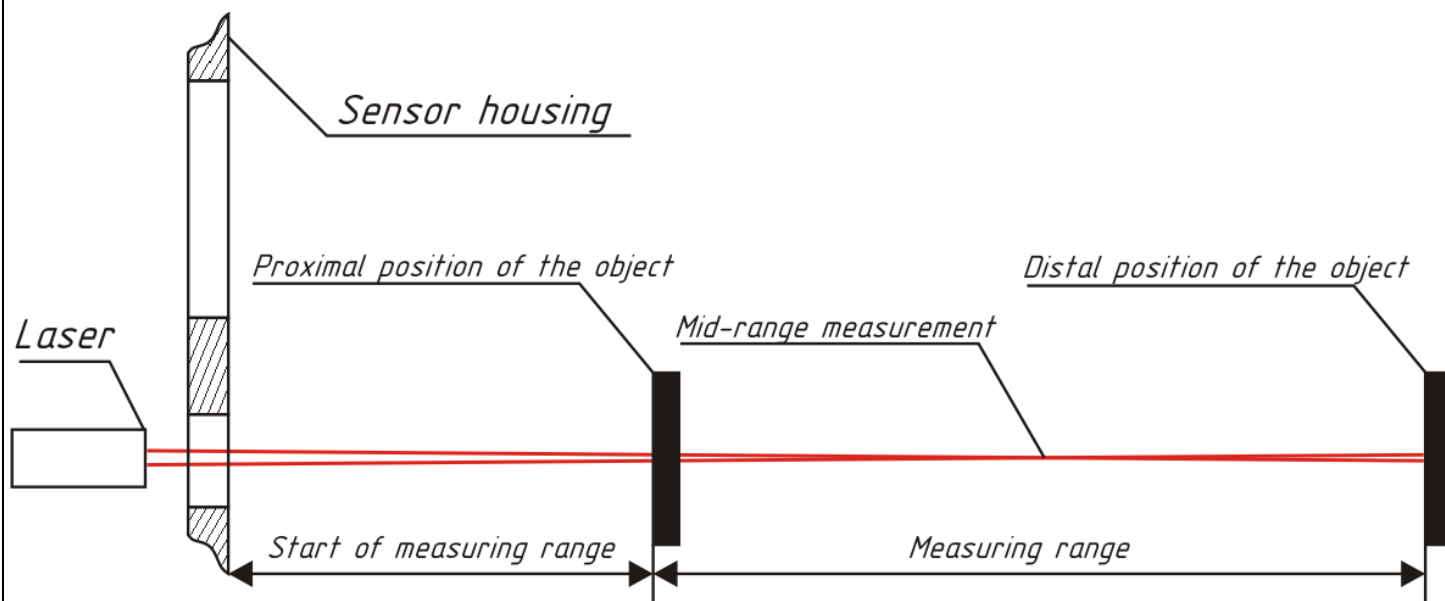


Figure 8. Scheme showing the position of the object of measurement

The choice of the measuring range of the sensor depends on the maximum height of the scan object along the Z axis and the required accuracy of the sensor measurement. For example, a sensor with a measuring range of 200 mm is capable of scanning an object with a height of up to 200 mm and an accuracy of ± 0.2 mm, and a sensor with a measuring range of 300 mm is capable of scanning an object with a height of 300 mm and an accuracy of ± 0.3 mm.

5 BRIEF DESCRIPTION OF THE 3D SCANNER OPERATION ALGORITHM

Depending on the selected scan settings: length, width and step of scanning along the axes, the sensor program generates a control program file for the CNC machine in G codes. According to this control program, the machine will move the sensor line-by-line above the object being scanned, while the sensor will determine the current position according to DIR STEP signals from the axis which makes periodic movement in one direction and the other.

6 STEP-BY-STEP INSTRUCTION FOR CREATING A 3D SCANNER

6.1 Mounting the sensor on the machine

Mount the sensor on the machine in such a way that it should be able to move along the 2 mutually perpendicular axes of the machine (as a rule, in most cases these are the X and Y axes);

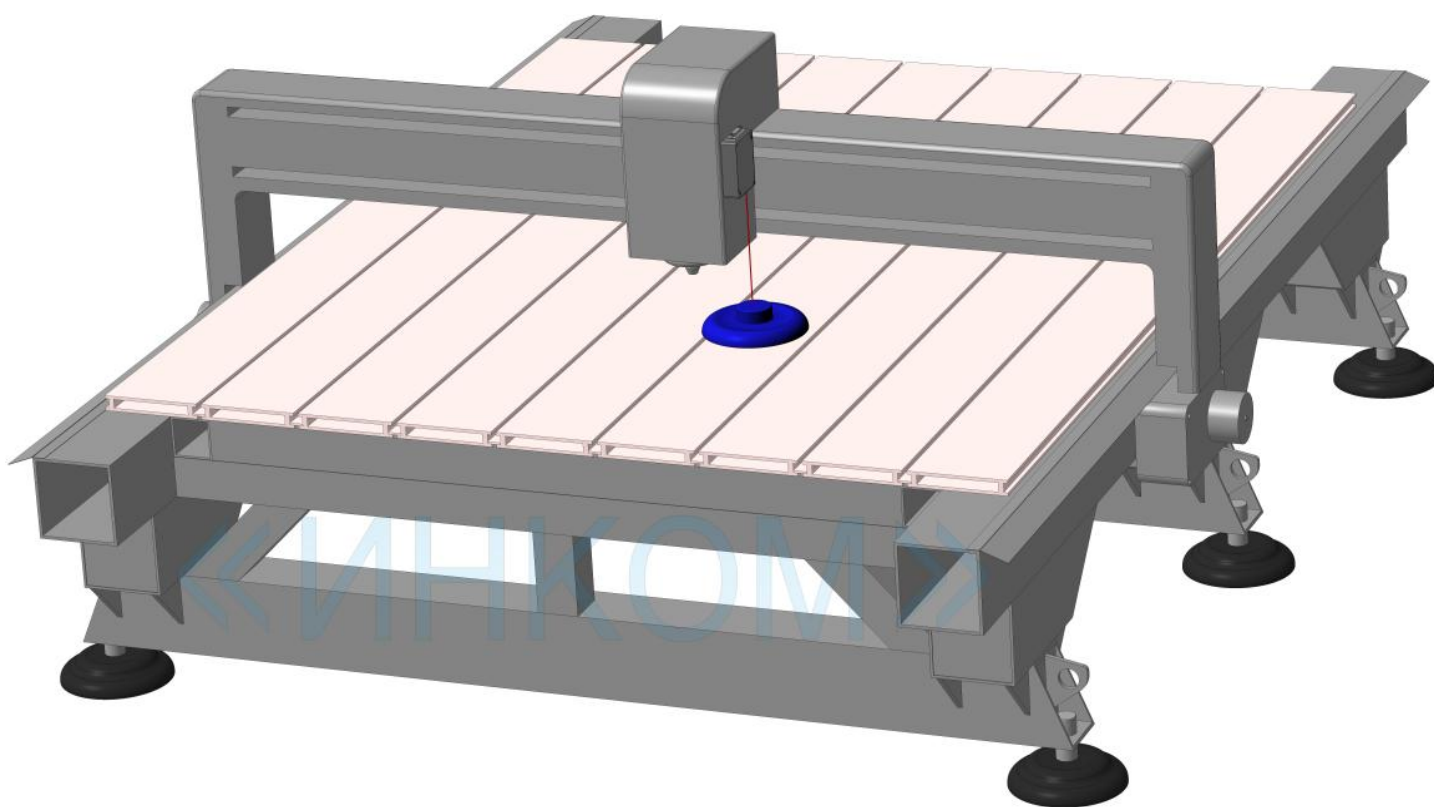


Figure 9. An example of mounting the sensor on a milling machine



ATTENTION!!!

The product must be installed on a flat surface to avoid bending forces on the housing relative to the attachment points.

Figure 10 shows an example of optimal height sensor installation.

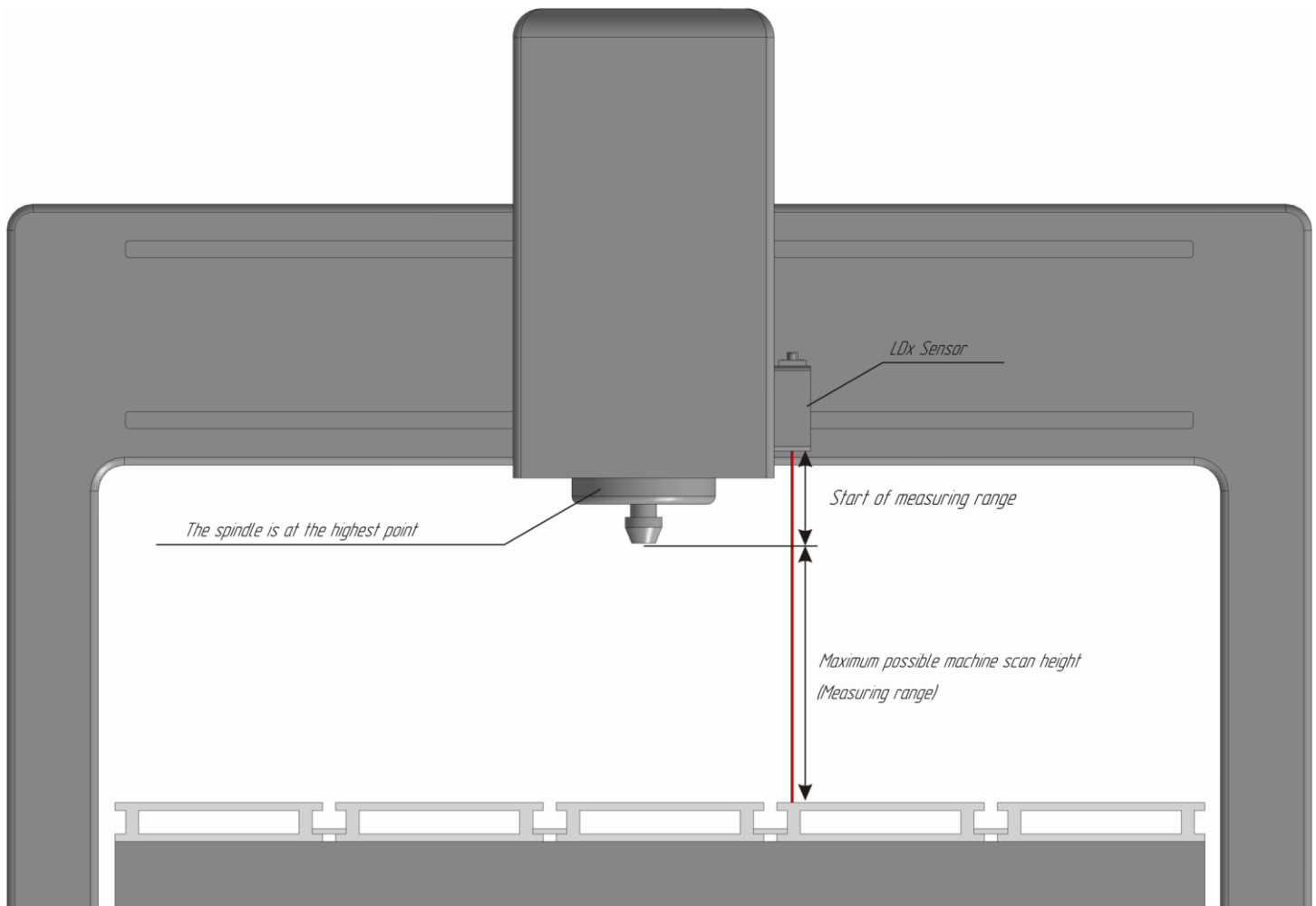



Figure 10. An example of optimal installation of the sensor in height.

It is advisable to choose the measuring range of the sensor based on the maximum possible scanning height of your CNC machine.

6.2 Connecting the sensor to the CNC system

There are two options for connecting the sensor to the machine:

- 1) Connection to the signals of the CNC controller: DIR / STEP;
- 2) Connection to the signals of the quadrature encoder axis: A / B;

 When using encoder signals, the model is obtained better, because in the system of DIR / STEP signals and the real position of the motor, as a rule, there is a delay link;

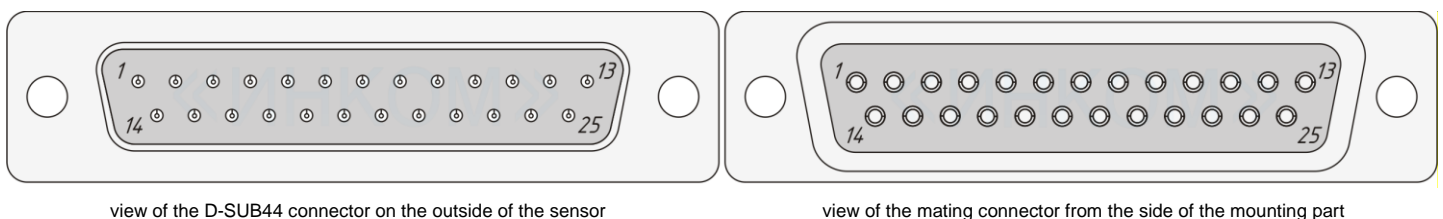


Figure 11. Pin numbering of the sensor connector.

Option for connecting to DIR / STEP signals of the CNC controller

Connect to the sensor connector the second signals: DIR and STEP from the axis of the CNC controller, which should then perform periodic movement in one direction and the other, scanning the object line by line.
The STEP signal (i.e. PULSE) is connected to the DI1 digital input of the sensor.
The DIR signal is connected to the DI2 digital input.

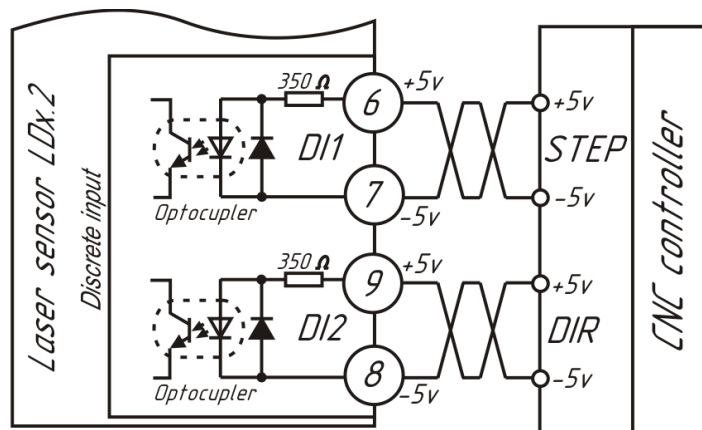


Figure 12. Diagram showing connection of the laser sensor to the CNC system

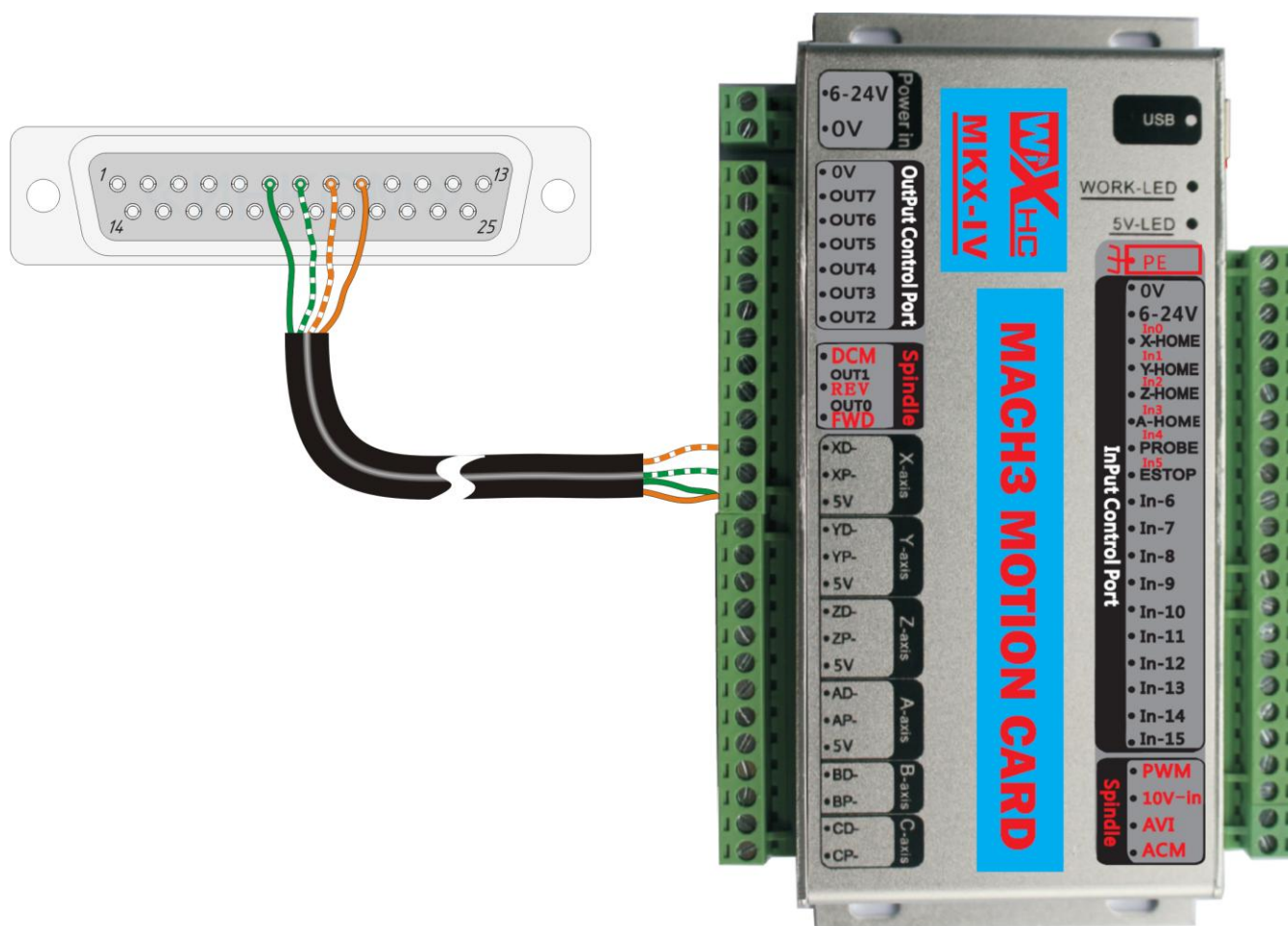


Figure 13. Example of connecting to the X axis of the Mach3 controller

In this example, the X axis will perform periodic movements to one side and the other, scanning the object line by line.

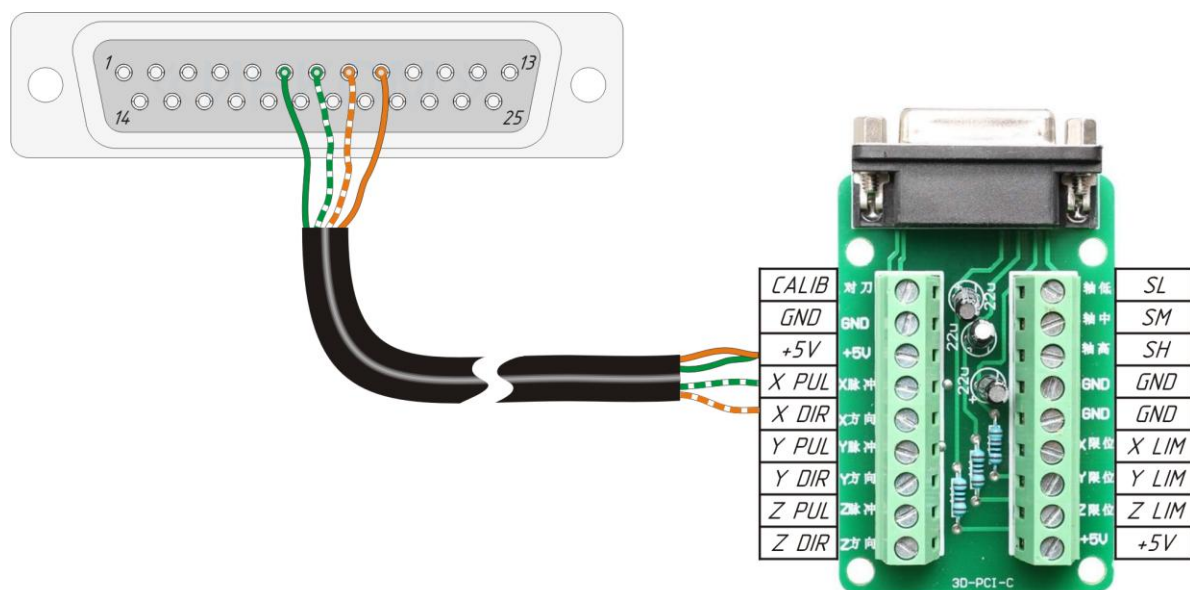


Figure 14. Example of connecting to the X axis of the NC Studio controller

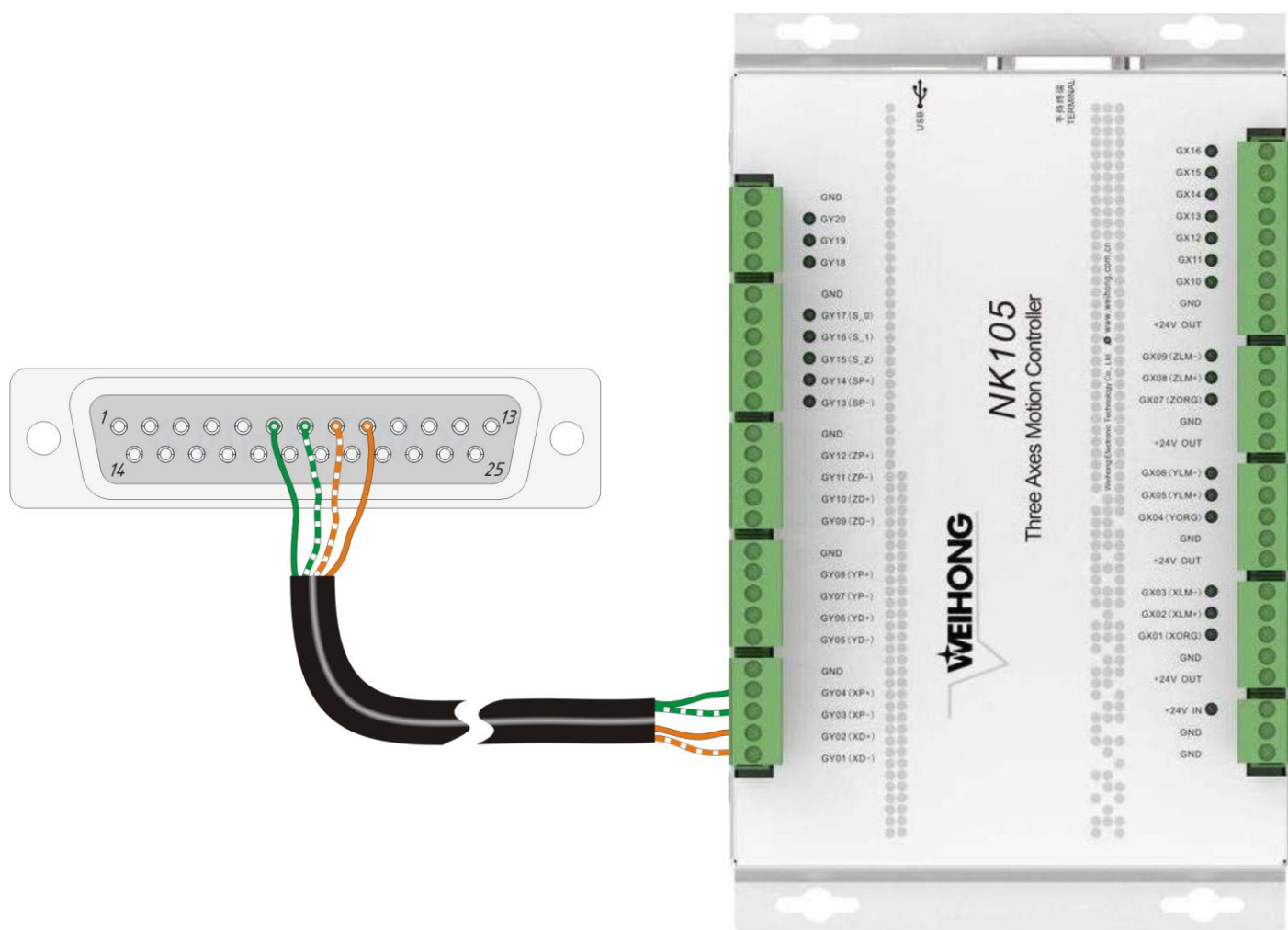


Figure 15. Example of connecting to the differential signals of the X-axis of the WEIHONG NK105 controller

Option for connecting to quadrature encoder A / B signals

Connect to the sensor connector two signals: A and B from the quadrature encoder of the machine axis, which should then perform periodic movement in one direction and the other, scanning the object line by line.

Signal A is connected to the digital input of the DI1 sensor: connector pins: 25, 26;

Signal B is connected to the digital input of the DI2 sensor: connector pins: 23, 24;.

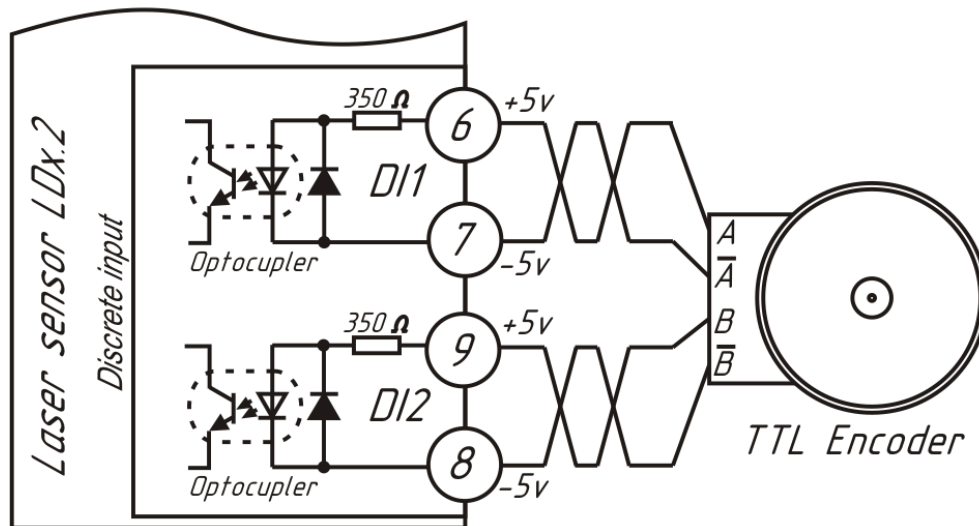


Figure 16. Connection diagram of the laser sensor to the quadrature encoder

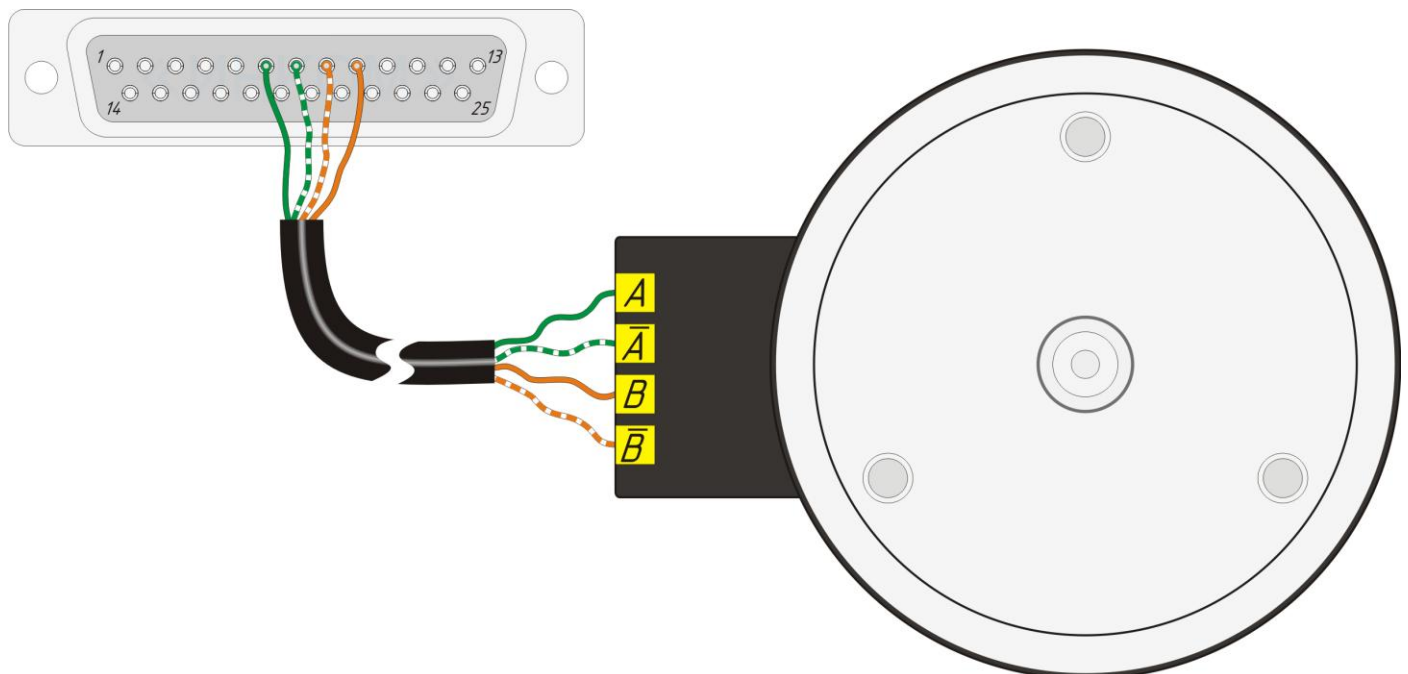


Figure 17. Example of connecting to the quadrature encoder of the machine

6.3 Power connection

The sensor can be powered either from a USB port or from an external power supply

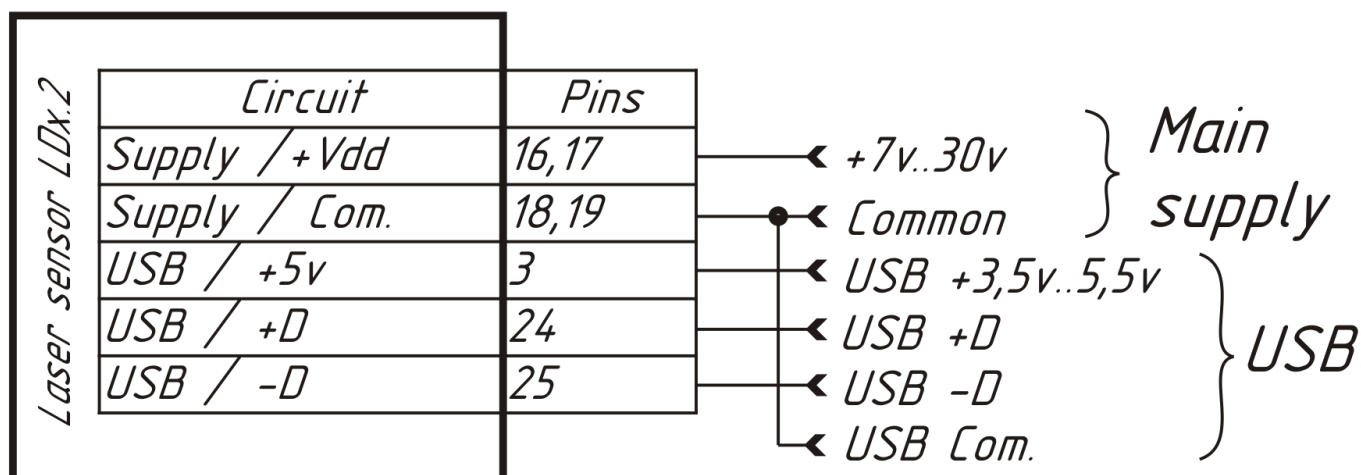


Figure 18. Connecting the sensor power supply

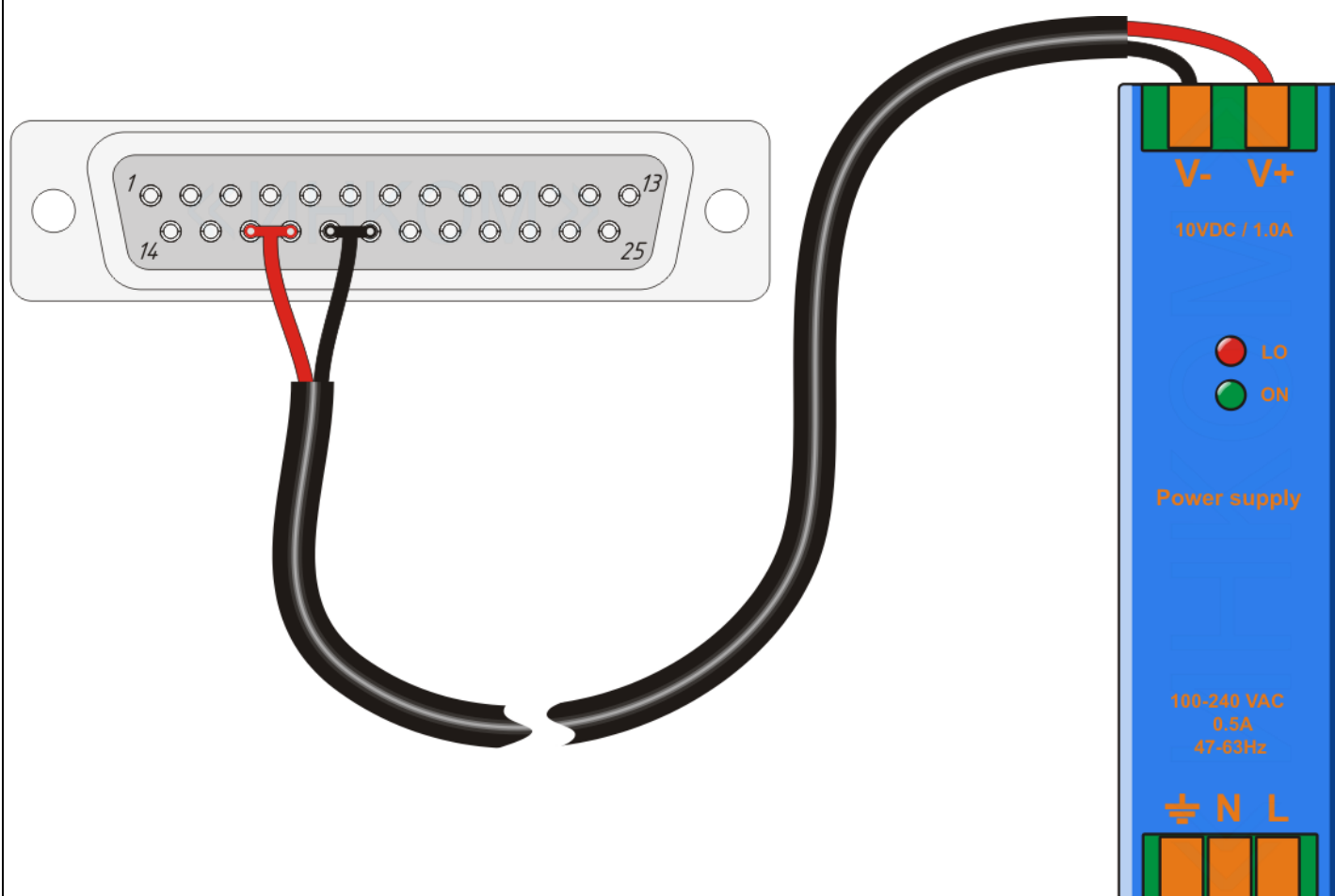


Figure 19. Example of connecting to a power source

6.4 Connecting the sensor to the computer

For scanning, it is preferable to establish a sensor connection via a USB virtual COM port, or an Ethernet port, since they have the fastest bit rate.

- The advantages of Ethernet are its highest bit rate, long connection cable and a galvanic isolation of the port and as a result, decoupling of the computer from the CNC machine.
- The advantage of the USB virtual COM port is its connection convenience - no external power is necessary, the sensor is powered by a USB port, but it is necessary to have a common earthing of the impulsive power supplies to avoid potential differences between the machine body and the computer case. The length of the cable according to the USB specification is up to 5 meters.

Connecting via USB

1. Connect the USB cable to the sensor connector according to the scheme:

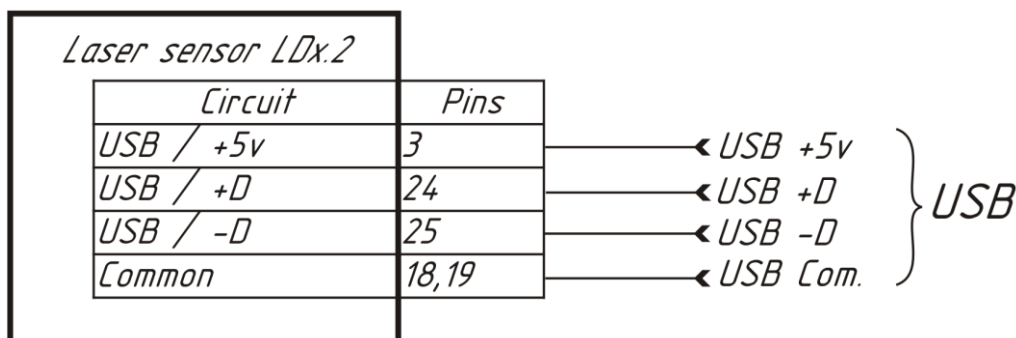


Figure 20. USB connection

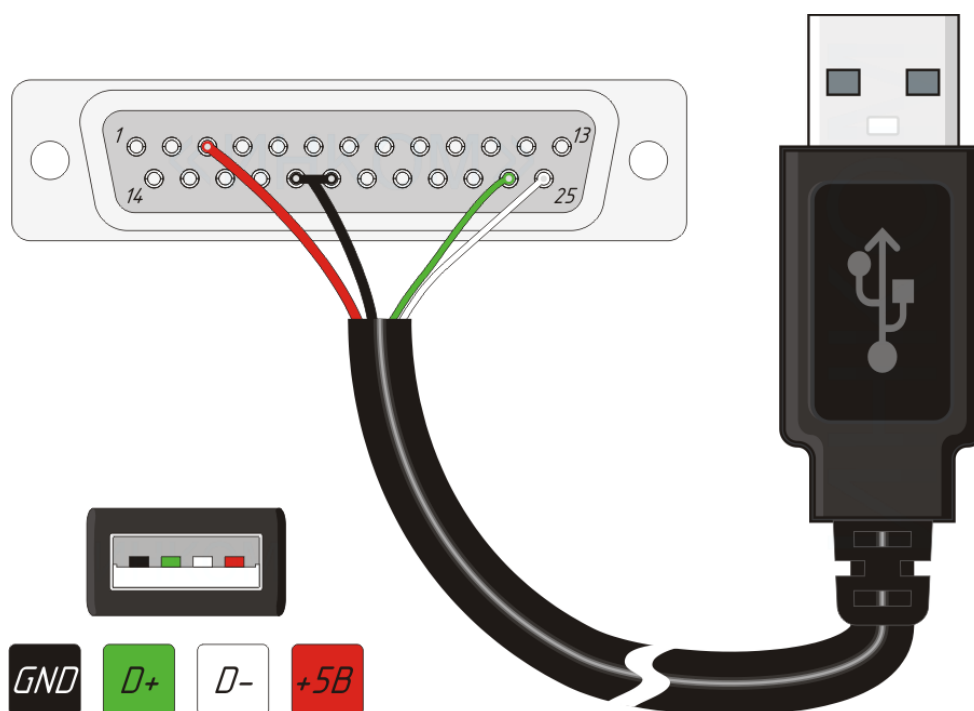


Figure 21. Example of connecting to the USB connector

2. Install the Windows driver:

When you connect the sensor to the computer for the first time, Windows will ask you to install the driver for the sensor, specify the path for installing the driver from the "USB Driver" folder that is included with the program.

Connecting via Ethernet

Connect the Ethernet cable to the sensor connector according to the scheme:

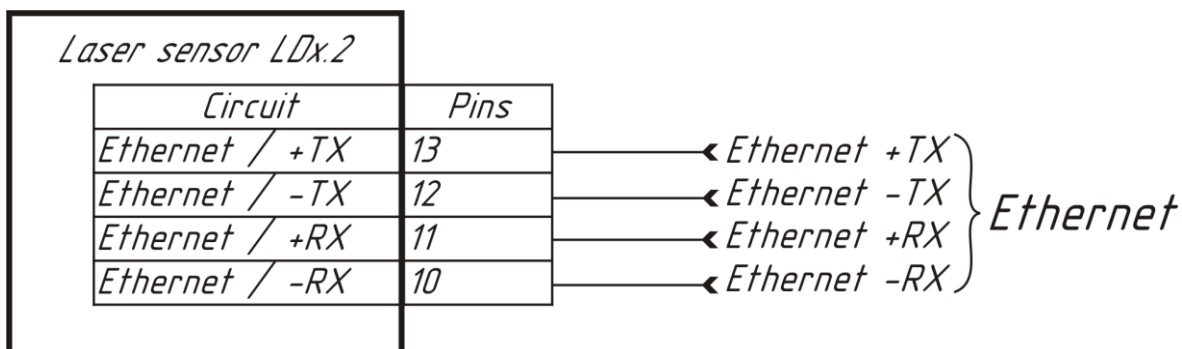


Figure 22. Ethernet connection

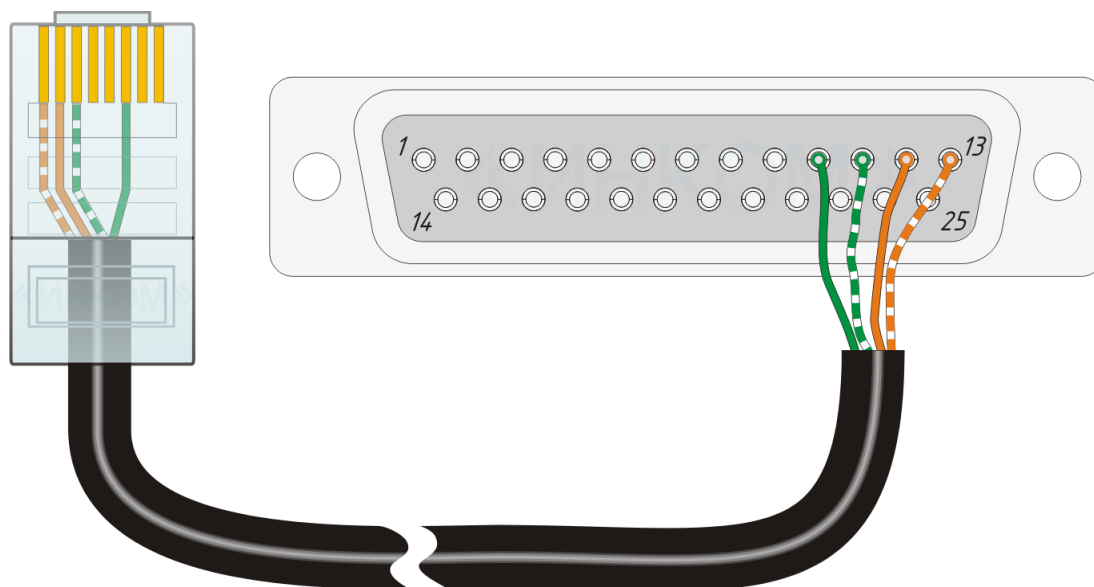


Figure 23. Example of connecting to the Ethernet connector

Connecting via RS485

To connect the sensor to the computer via RS485 an interface converter will be needed: USB-> RS485 or RS232-> RS485

Connect the RS485 port cable from the converter to the sensor connector according to the scheme:

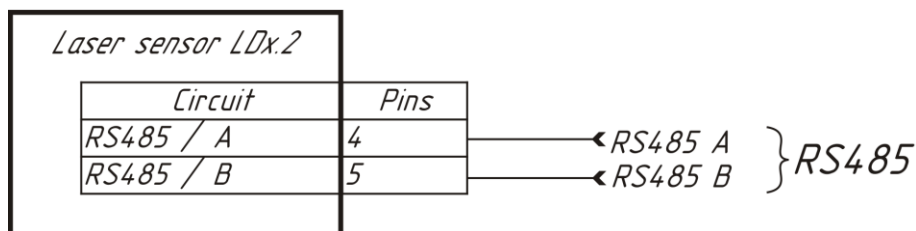


Figure 24. RS485 connection

6.5 Establishing a connection with the sensor

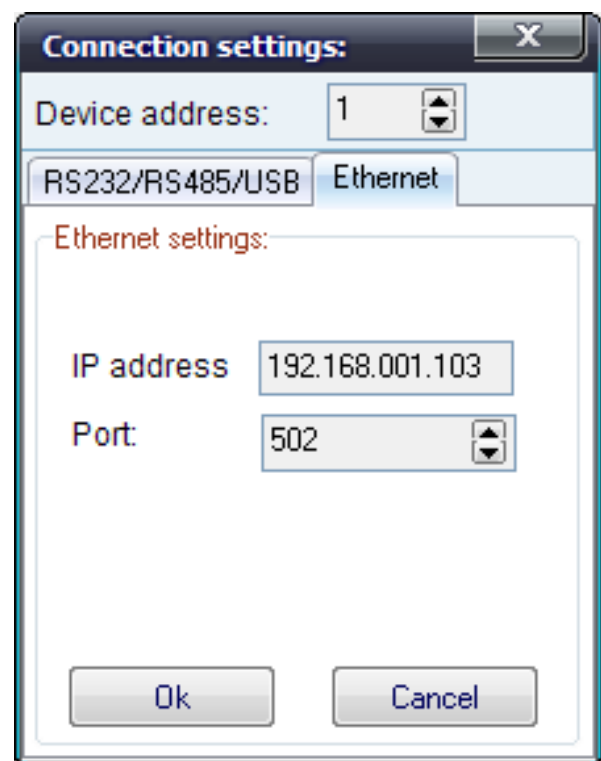
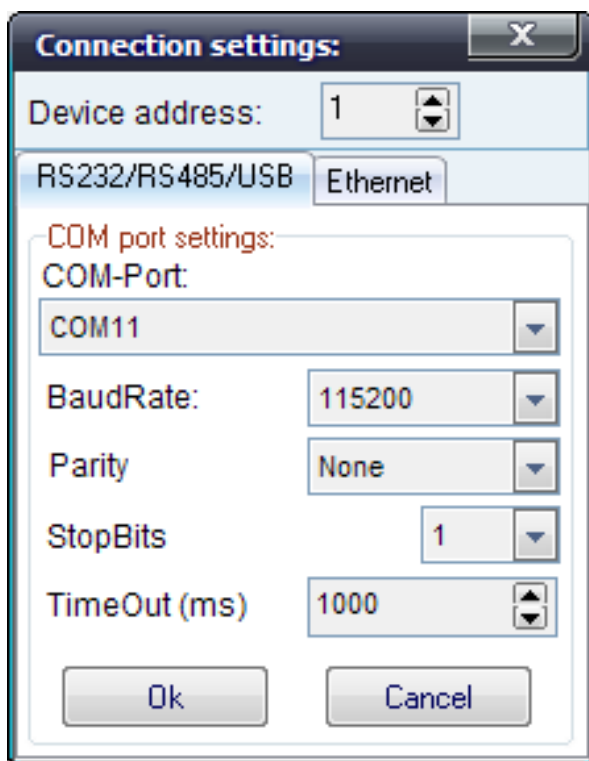
- 1 Start the program by double-clicking on the program icon



- 2 Click on the "Connect" button.



- 3 In the "Connection settings:" window that appears, select the "RS232/RS485/USB" tab if you want to connect via a serial COM port of the computer or the USB virtual COM port, or select the "Ethernet" tab if you want to connect via Ethernet:



Specify the required connection parameters, and click the "Ok" button.

For a USB virtual COM port, the speed settings, parity and the number of stop bits are not important, with the device address set to 1.

6.6 Scan program setup

On the "Configuration and scanning" tab, check the box "Configuring the sensor connection:".

☒ Configuring the sensor connection:
 Control signals:
 DIR/STEP
 X-Axis (num. of pulse p 1 mm): 800
 Binding the sensor axis to X: X
 Binding the sensor axis to Y: Y
 Extension of the CNC file: nc

1 "Control signals:"

Select the type of sensor connection: DIR / STEP or "A / B encoder, depending on your type of connection.

2 "X-Axis (num. of pulse p 1 mm):"

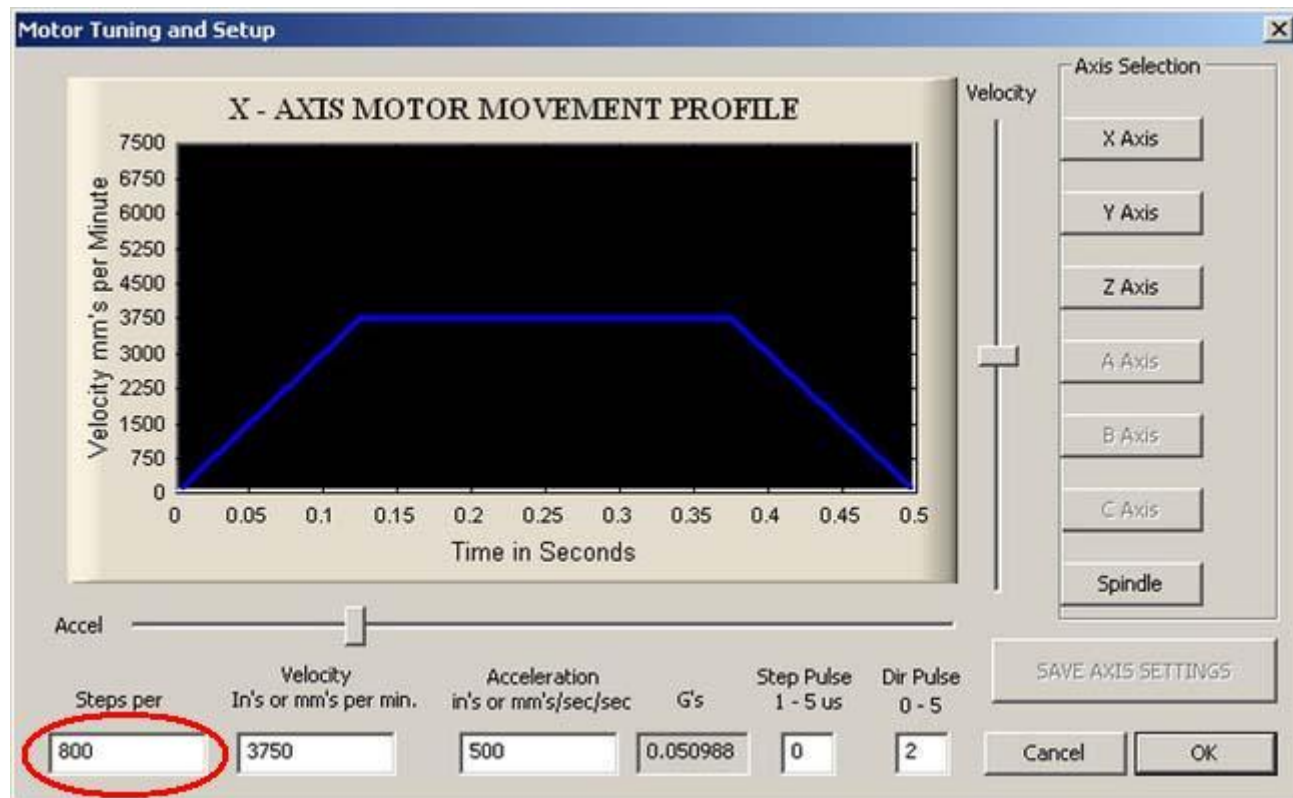
Set the parameter of the number of pulses per 1 mm of movement of the machine axis connected to the sensor. This parameter must be determined based on the configuration of the drive and the mechanics of your machine. Or this parameter can be found in the CNC system settings.

Parameter definition example for CNC: **DSP RichAuto A11**

Press the MENU button on the remote control, then -> Machine setup -> Pulse Equiv

Parameter definition example for CNC: **Mach3**

Go to the menu "Motor Tuning and Setup"



Parameter definition example for CNC: **NC Studio**

Trace Log Manager **Params** Editor IOState

Machining

Manufactory

"Set the workbench dimensions, which decide when the system raises an out-of-limit alarm after the mechanical coordinate has become effective."

Start (Mechanical) Coord.

X: 0 mm

Y: 0 mm

Z: -80 mm

End (Mechanical) Coord.

X: 600 mm

Y: 900 mm

Z: 0 mm

Note: Please restart after changing above

Mobile Calibrator:

Thickness of the 10 mm

Motor Parameter rate of z axis:

X: 0.003125 mm/pulse

Y: 0.00625 mm/pulse

Z: 0.003125 mm/pulse

Start-up Feedrate:

300 mm/min

the maxium feedrate of z axis:

1500 mm/min

In NC Studio, this parameter is presented in millimeters per 1 pulse, i.e. to obtain the required value of pulses per 1 mm of movement, it is necessary to divide the 1 by the number specified in the NC Studio program.

For example, if the value of the NC Studio program = 0.003125, then we get: $1 / 0.003125 = 320$ pulse on 1 mm displacement.

3 "Binding the sensor axis to X:"

This parameter binds the axis of the X sensor to the required machine axis: (X, Y, Z, A, B, C), in fact, we set the axis to which the sensor was connected.

4 " Binding the sensor axis to Y:"

This parameter binds the axis of the Y sensor to the required machine axis: (X, Y, Z, A, B, C).

5 "Extension of the CNC file:"

Select the type of extension for the control program of your CNC system.

For example: for the CNC system Mach - type of extension of the control program: "tap";
for CNC system DSP RichAuto - type of extension of the control program: "nc";

The setting can be considered complete, now you can uncheck the "Configuring the sensor connection:" box to hide this information.

7 STEP-BY-STEP INSTRUCTIONS FOR THE SCANNING PROCESS

- 1 Start the program and connect the program with the sensor.
(For a detailed description, see section **6.5 Establishing a connection with a sensor**).
- 2 Set the object to be scanned on the machine, set the sensor relative to the start of the object scan and reset the machine position along the sensor displacement axes (in most cases, the X and Y axes);
- 3 Set the required scan settings in the "Configuration and scanning" tab;

Configuration and scanning

Configure scan settings:

X-Axis (pulse-divider): 300

Actual scanning step (mm): 0.3000000

Y-Axis scanning step (mm): 0,3

Scan length X (mm): 100

Scan length Y (mm): 100

Scanning speed (mm / min): 5000

☐ X axis inversion

☐ Y axis inversion

☒ Z axis inversion

Minimum scan time: 00:06:40

Create CNC file

Scanning

Number of line: 0

(For a detailed description of the parameters, see section **9.2 Description of the 3D Scanning Function**).

- 4 After establishing all the settings, create a control program by clicking on the "Create CNC file" button and transfer it to the CNC controller of the machine;
- 5 Press the "Scanning" button in the program and only after that start the previously transferred control program on the machine;
- 6 Wait until scanning is complete;
- 7 Unpress the "Scanning" button, after which the program will build a 3D model of the object for further processing and saving it to a file;

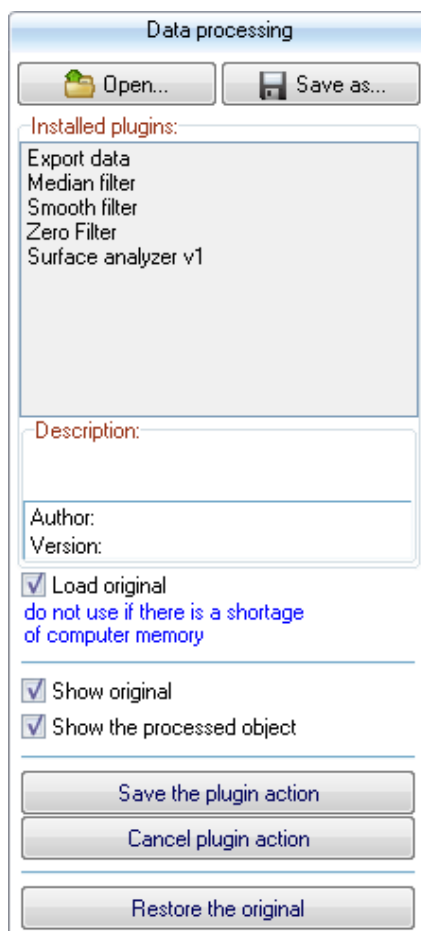


It is recommended to save the original scanned view of the model in *.srs format before processing and filtering, this format contains all information about the scanned model and will allow to restore its initial state if necessary.

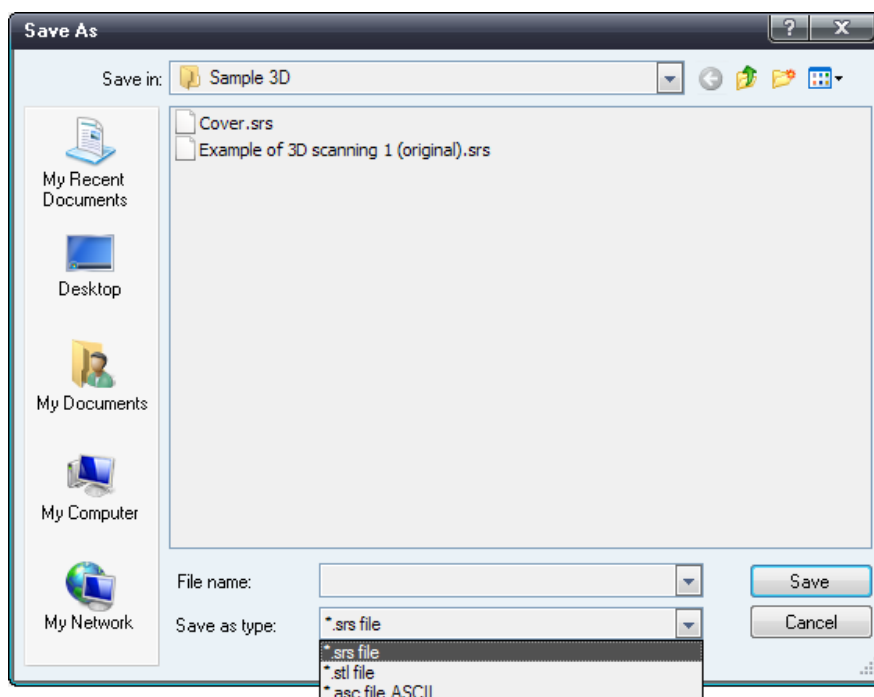
- 8 Process and filter the scanned model;
(For a detailed description, see section **10 EXAMPLE OF PROCESSING OF THE SCANNED MODEL**).

9 Save the result to disk in the required file format: *.srs, *.stl, *.asc;

To do this on the "Data processing" tab:



you need to click the "**Save as ...**" button and in the resulting menu select the required file format (*.srs, *.stl, *.asc), specify the file name and click the "**Save**" button.



8 GUIDELINES FOR USING THE SENSOR AS A 3D SCANNER

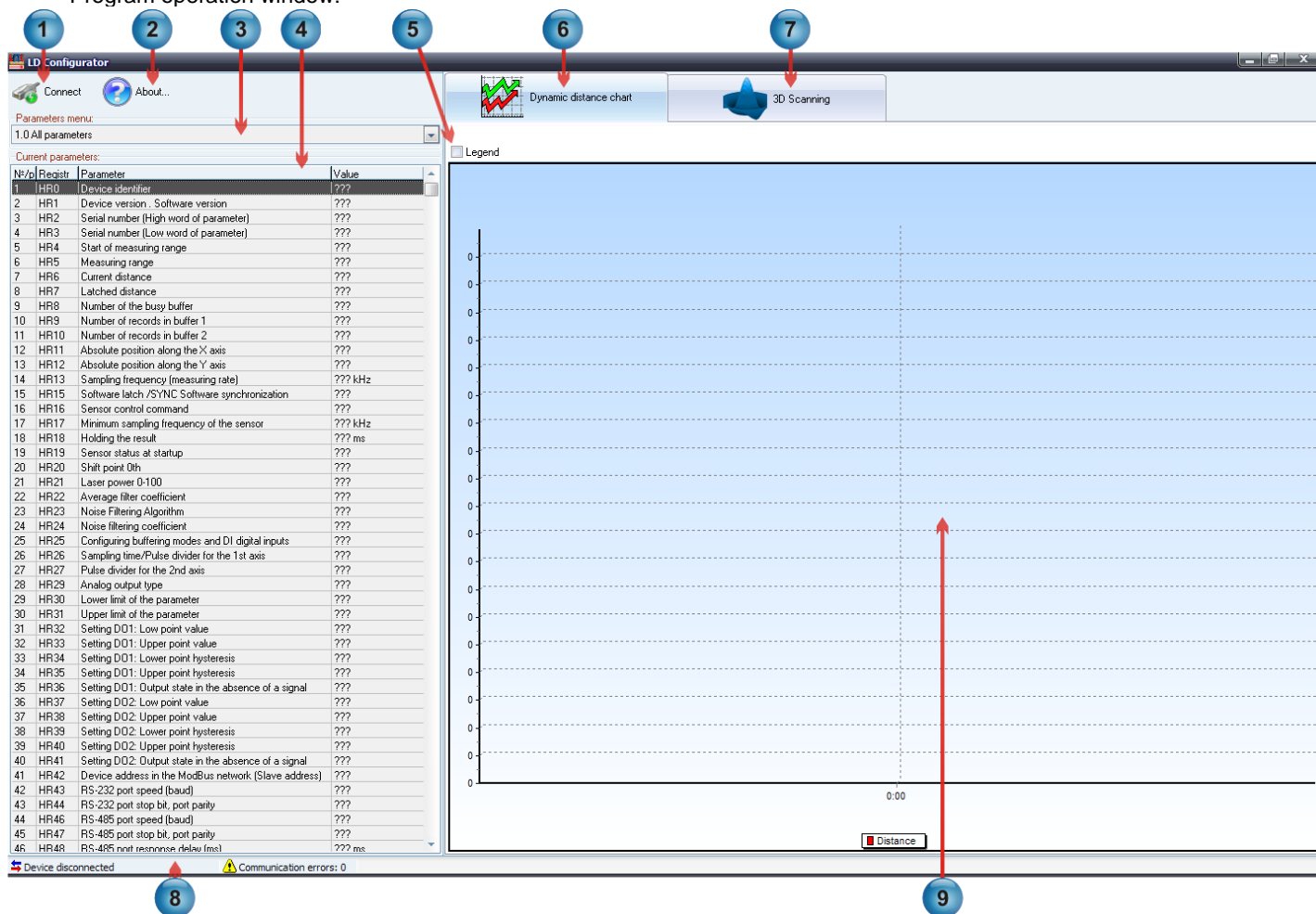
- ✓ To obtain stable results measurement, it is necessary to wait for 10-20 minutes after power on, to evenly warm the sensor.
- ✓ Do not use the sensors near powerful light sources.
- ✓ Prior to scanning multicolored, shiny or transparent objects, it is necessary to use a special spray on the object or a light matte paint - this is due to the fact that in order to obtain a good quality of the scan, the object must have a uniform matte color.
- ✓ The lighter color the object of scanning, the higher the speed of the measurement of the sensor, and accordingly the scan can be performed at higher speeds.
- ✓ The accuracy of the triangulation laser sensors is minimal at the end of the measuring range and is maximum at the beginning. Consider this fact when positioning the object of scanning in height, to achieve a better result.

9 DESCRIPTION OF THE CONFIGURATION PROGRAM

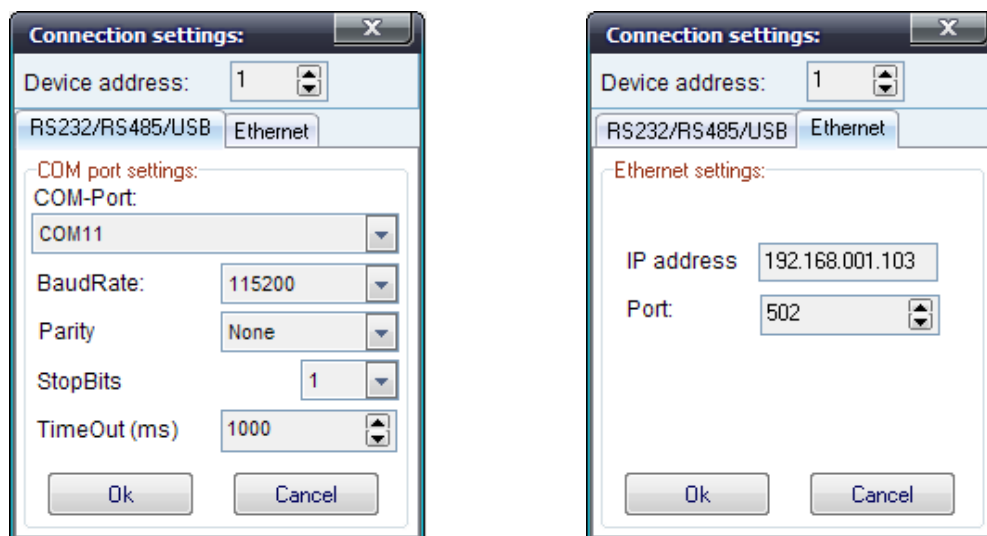
The program is designed for configuring the sensor parameters. Additionally, in order to demonstrate the operation of the sensor as a laser scanner, the program implements the 3D scanning, visualization and data processing function.

9.1 Description of the main elements of the program

Program operation window:

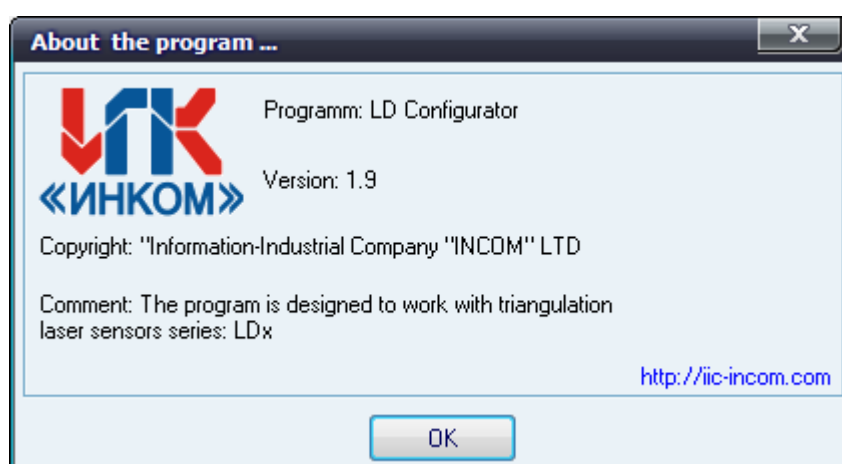


- 1) The **"Connect"** button - calls up the **"Connection settings:"** menu:

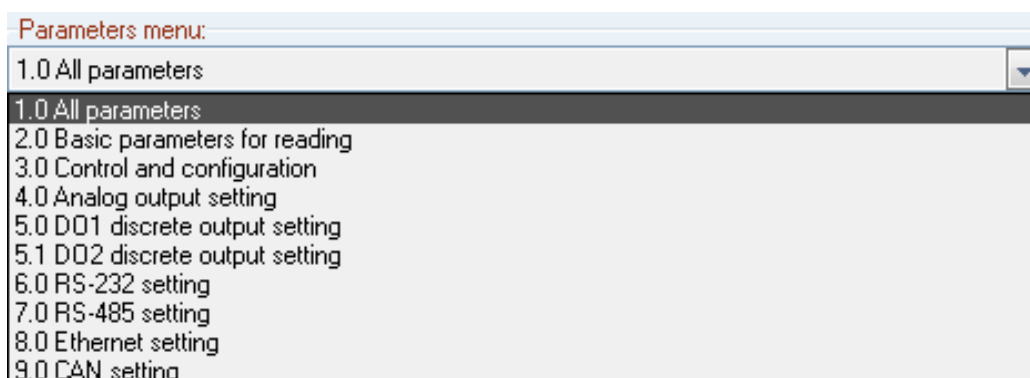


In this menu, the type of connection and its settings are selected. For a virtual COM port, speed settings, parity and the number of stop bits are irrelevant.

- 2) **"About the program..."** button - opens a window for the description of the program version:

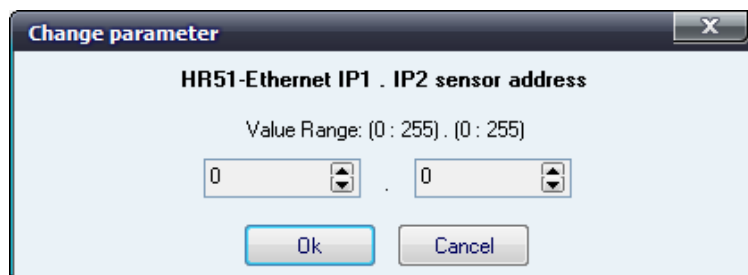
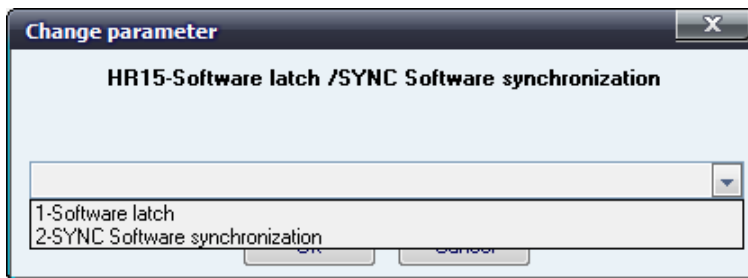
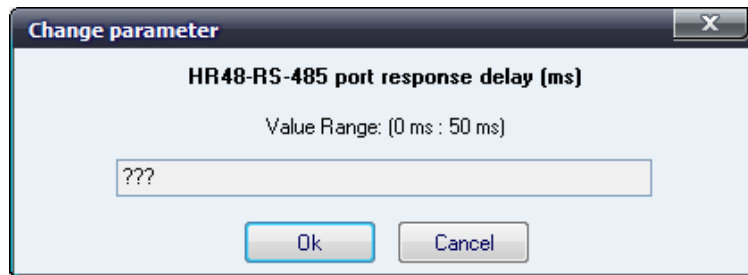


- 3) **"Parameters menu:"** - contains a grouped menu of sensor registers:

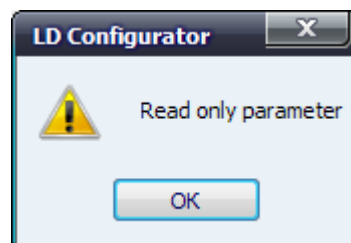


if changed, the table **"Current parameters:"** (4) changes its content. This is done for the convenience of searching and displaying the required registers.

4) **"Current parameters:"** table - displays the names of the parameters and their values. Double-clicking a parameter with read and write access depending on the type of parameter (numeric, enumerated or high / low bytes) brings up one of the three parameter editing windows:



if the parameter has read-only access, then an information window appears:



5) **"Legend"** - shows / hides the values of points on a dynamic chart.

6) The **"Dynamic distance chart"** tab - this tab contains a dynamic distance graph, created to demonstrate the operation of the sensor.

7) **"3D Scanning"** tab - this tab is intended for using the sensor as a 3D scanner.

8) **Status Bar** - this line displays the communication status of the sensor.

9) **Dynamic graph** - displays the current distance change depending on a certain time range.

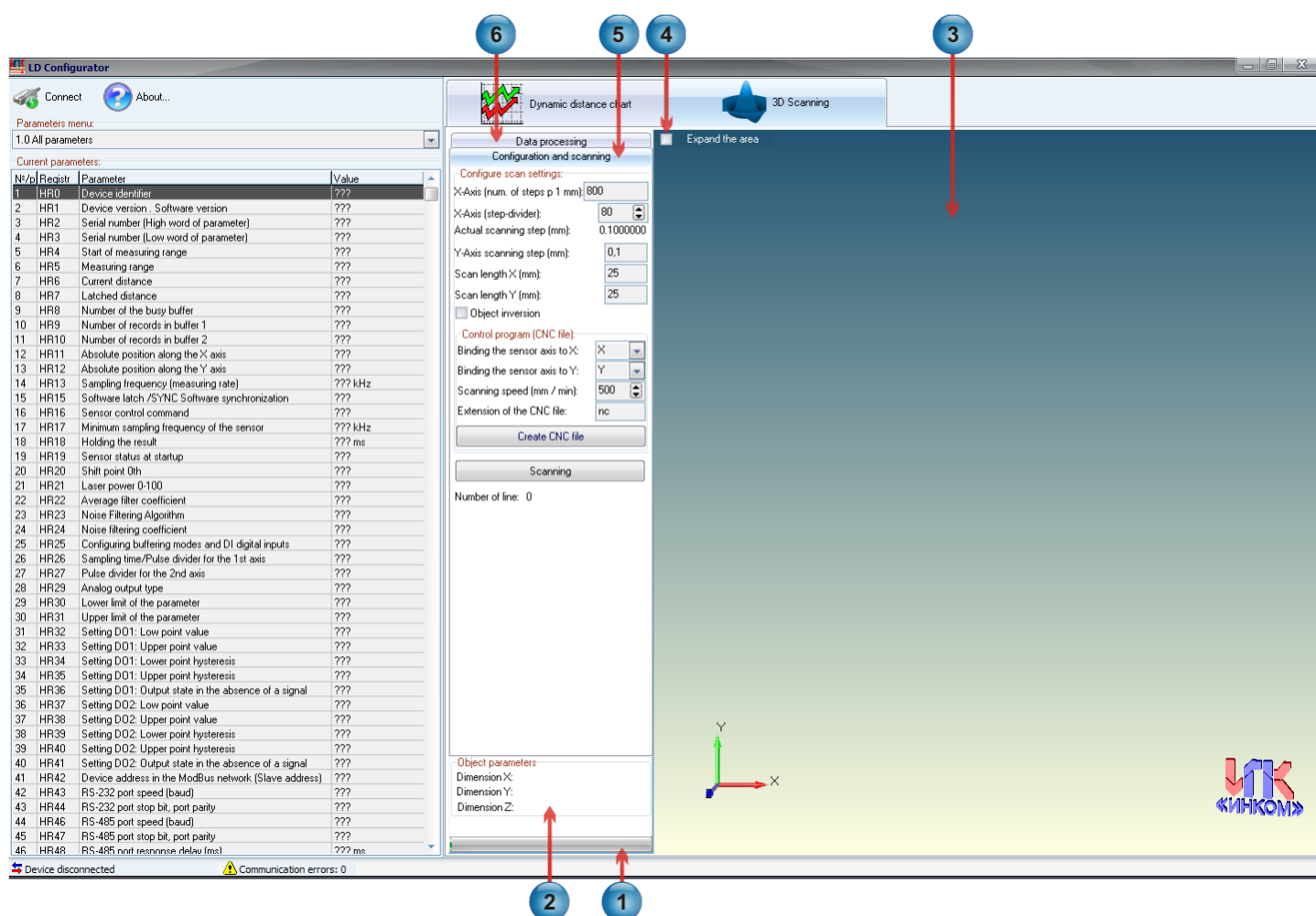
9.2 Description of the 3D Scanning function

The "3D Scanning" function in the configuration program is implemented to demonstrate the capabilities of the sensor.

This software feature allows to:

- view and edit scanned models in the form of *.srs files, as well as viewing *.stl files without the possibility of editing;
- create a control program (row-wise scan) for machine tools under control of G codes;
- scan objects;
- produce software processing and filtering of the scanned model;
- save the scanned model as *.srs, *.stl files or as a point cloud *.asc;
- owing to the built-in plugin support, it is possible to create your own custom filtering and data processing, as well as saving the data in the required format;

"3D Scanning" tab outward appearance:



Description of the main elements of the "3D Scanning" tab:

- 1) Task execution indicator - informs about the progress of file downloads, the scanning process, data processing;
- 2) Information menu "Object parameters" - displays the geometric dimensions of the scanning object;

- 3) 3D model viewing area - created to visualize the object in the form of a 3D model. With the help of a computer mouse, it is possible to rotate, move and scale the model.
- 4) The tab **"Expand the area"** - allows you to increase the width of the viewing area of the 3D model for easy visualization;
- 5) The **"Configuration and scanning"** tab is used to configure scan settings:

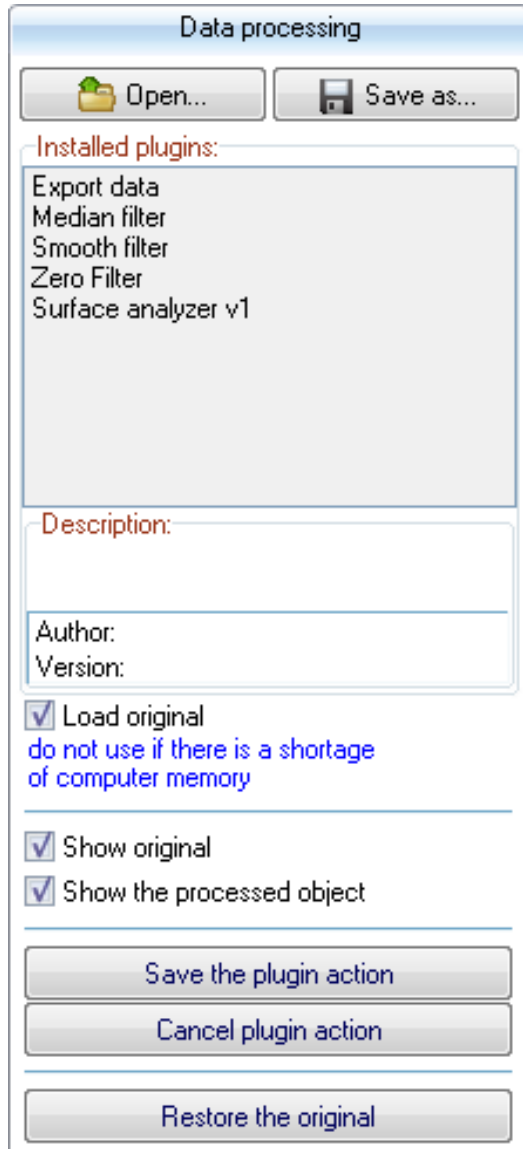
Description of the main elements of the **"Configuration and scanning"** tab:

- **"X-Axis (step-divider):"** – specifies the actual scanning pitch in the X-axis;
- **"Actual scanning step (mm):"** – shows the actual scanning pitch along the X axis in millimeters;
- **"Y-Axis scanning step (mm):"** – specifies the scanning pitch on the Y-axis in millimeters;
- **"Scan length X (mm):"** – specifies the scan length along the X axis in millimeters;
- **"Scan length Y (mm):"** – specifies the scanning length along the Y axis in millimeters;
- **"Scanning speed (mm / min):"** – sets the scanning speed;
- **"X,Y,Z axis inversion"** – sets the scan mode in normal or inverted form;
- **"Create CNC file"** – pressing this button generates a CNC control program for the machine controller of the G-code;
- **"Scanning"** – once this button is pressed, the scan mode starts, and the sensor parameters are configured according to the preset settings. Press the button again to turn off the scan mode;
- **"Number of lines:"** – shows the current number of scanned lines along the Y axis;
- **"X-Axis (number of pulse p 1 mm):"** – specifies the number of impulses issued by the CNC controller for 1 millimeter of movement along the X axis;
- **"Binding the sensor axis to X:"** – binds the axis of the sensor along X to the required machine axis: (X, Y, Z, A, B, C) in fact, we set the axis to which the sensor was connected;

- **"Binding the sensor axis to Y:"** – binds the sensor axis along the Y axis to the required machine axis: (X, Y, Z, A, B, C);
- **"Extension of the CNC file:"** – allows you to specify the extension of the control program;

6) **"Data processing"** tab - is intended for software processing, filtering and subsequent saving to the disk of the scanned model.

All data processing is implemented in the form of plugins, and hence it is possible to develop and connect to the program own plugins, with the required algorithms for processing and / or saving the scanned data (see section **8.3 Brief description of plugins operation**).



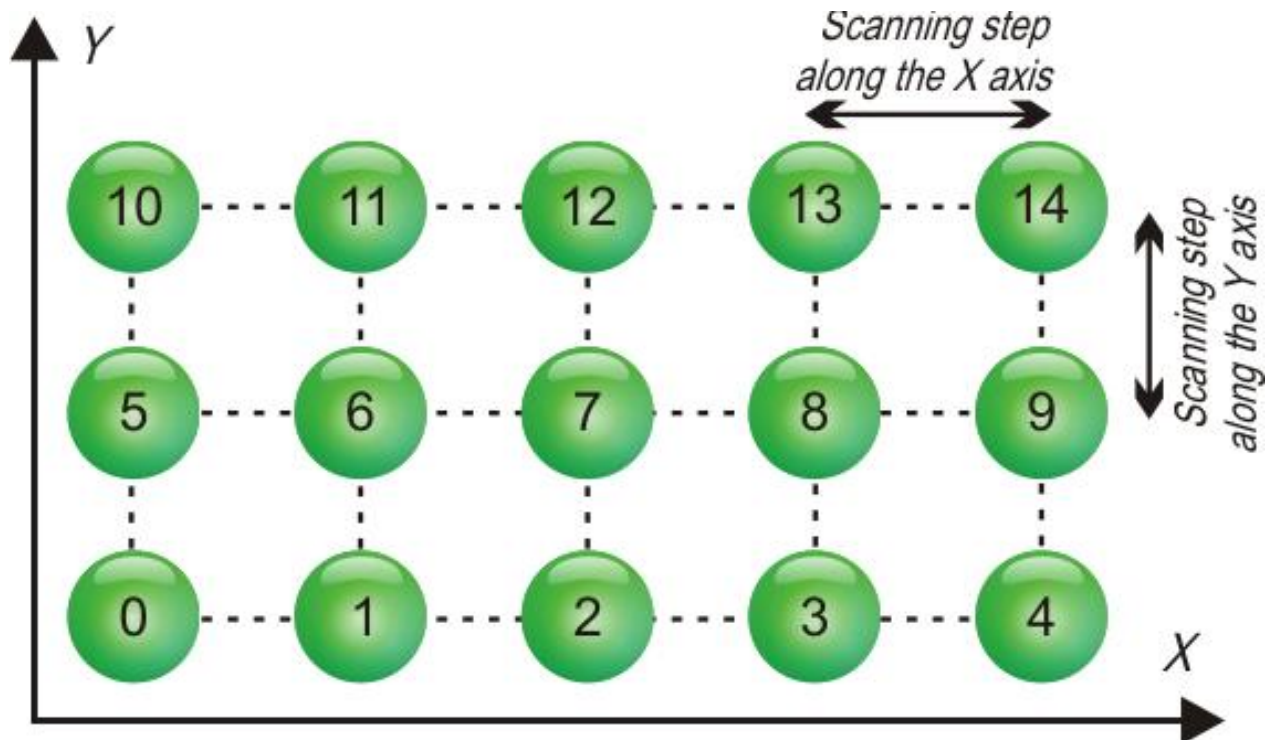
Description of the main elements of the tab **"Data processing"**:

- **"Open..."** – this button allows you to open a previously saved file of the scanned 3D model (extension *.srs) for viewing and editing. In addition, it is possible to open the *.stl extension files for viewing, while editing and saving to other formats is not supported.
- **"Save as..."** – this button allows saving the scanned model in *.srs, *.stl, *.asc format (ASCII point cloud).
- **"Installed plugins:"** – window for selecting the required plugin. To start the plugin, double-click on the required plugin;
- **"Description:"** – contains information about the description, version and author of the selected plugin;
- **"Load original"** – additionally loads the original model of the 3D object over the processed model, this allows you to visually control the geometry of the processed object relative to the original one;
- **"Show original"** – shows / hides the original scanned 3D model of the object;
- **"Show the processed object"** – show / hide the processed 3D model of the object;
- **"Save the plugin action"** – this button saves the changes that the plugin made;
- **"Cancel plugin action"** – this button cancels the changes made by the plugin;
- **"Restore the original"** – this button restores the original model;

9.3 Brief description of plugins operation

This description is intended for those who have experience in programming in the Delphi environment and want to write their own plugin processing of scanned data.

The program passes to the plugin a pointer on the dynamic array of coordinates of the points:



Each scanned point is specified by 3 coordinates: X, Y and Z height.

The plugin receiving this pointer can process this data: filter the data on the Z axis or save the received data in the required format or perform other operations required by the user.

After making changes to the dynamic array along the Z axis, there is the possibility to:

- update the 3D model image according to the edited dynamic array;
- restore the data in the array, as it were before;
- save data for further use;

For this purpose, there is a mechanism for exchanging commands and data between the program and plugins:

Messages sent from the plugin to the main program:

procedure CallBack(TypeD:Integer; var Data);

TypeD = 0: - update the 3D model image according to dynamic array

TypeD = 1: - restore the data of the dynamic array

TypeD = 2: - save data

TypeD = 10: - command to set the position of the task execution indicator

TypeD = 11: - update window program command

Data - has no significance

Data - has no significance

Data - has no significance

Data = 0..100

Data - has no significance

Messages received by the plugin from the main program:

procedure ReceiveData (TypeD:Integer; var Data);

TypeD = 0: - clearing of the dynamic array

TypeD = 1: - start the Data plugin

TypeD = 2: - update pointer

Data - has no significance

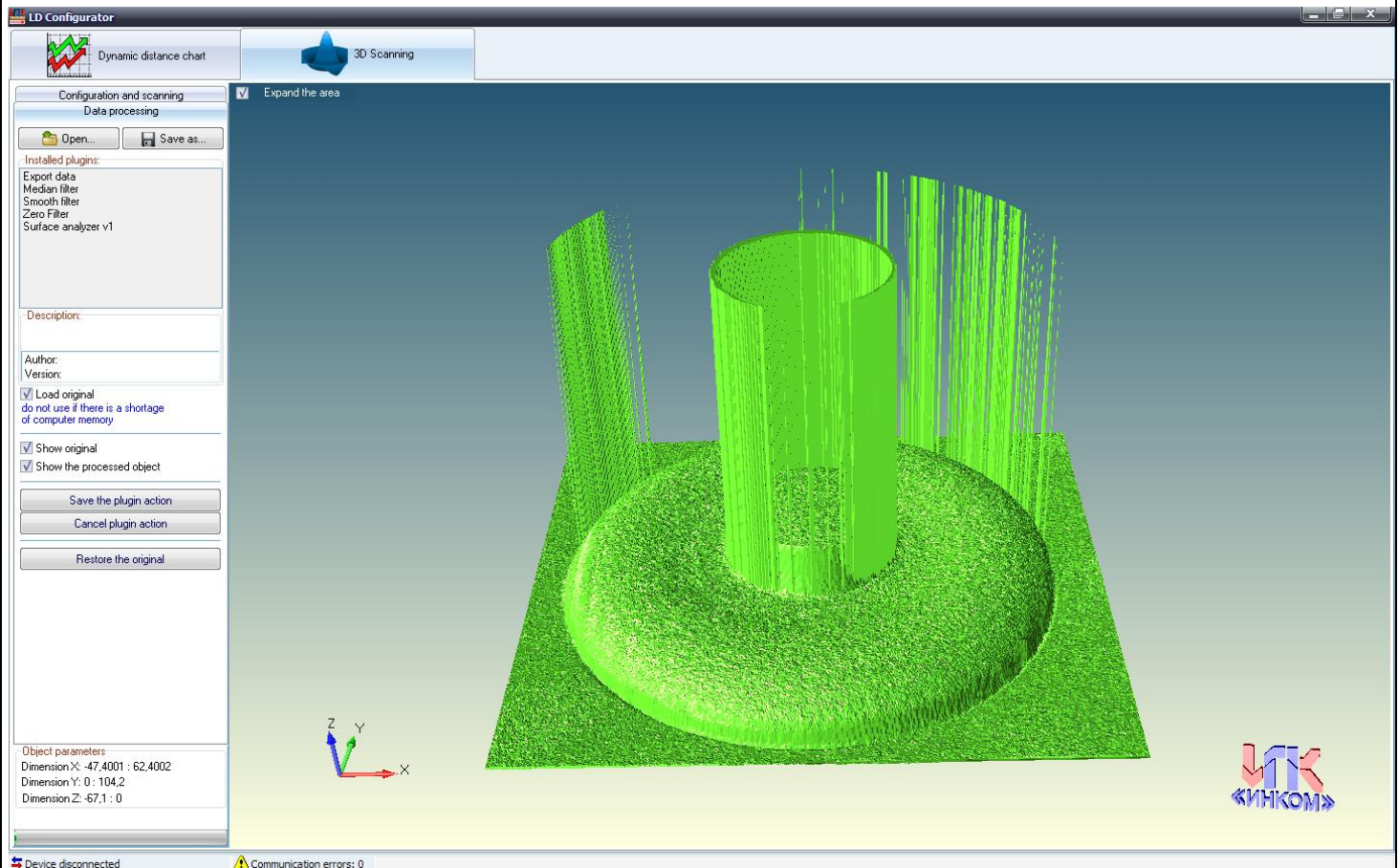
Data - pointer to dynamic array

Data - pointer to dynamic array

For a more detailed introduction on writing plugins, see examples of plugins written in the Delphi programming language in the **Source Code\Plugins** folder.

10 EXAMPLE OF PROCESSING OF THE SCANNED MODEL

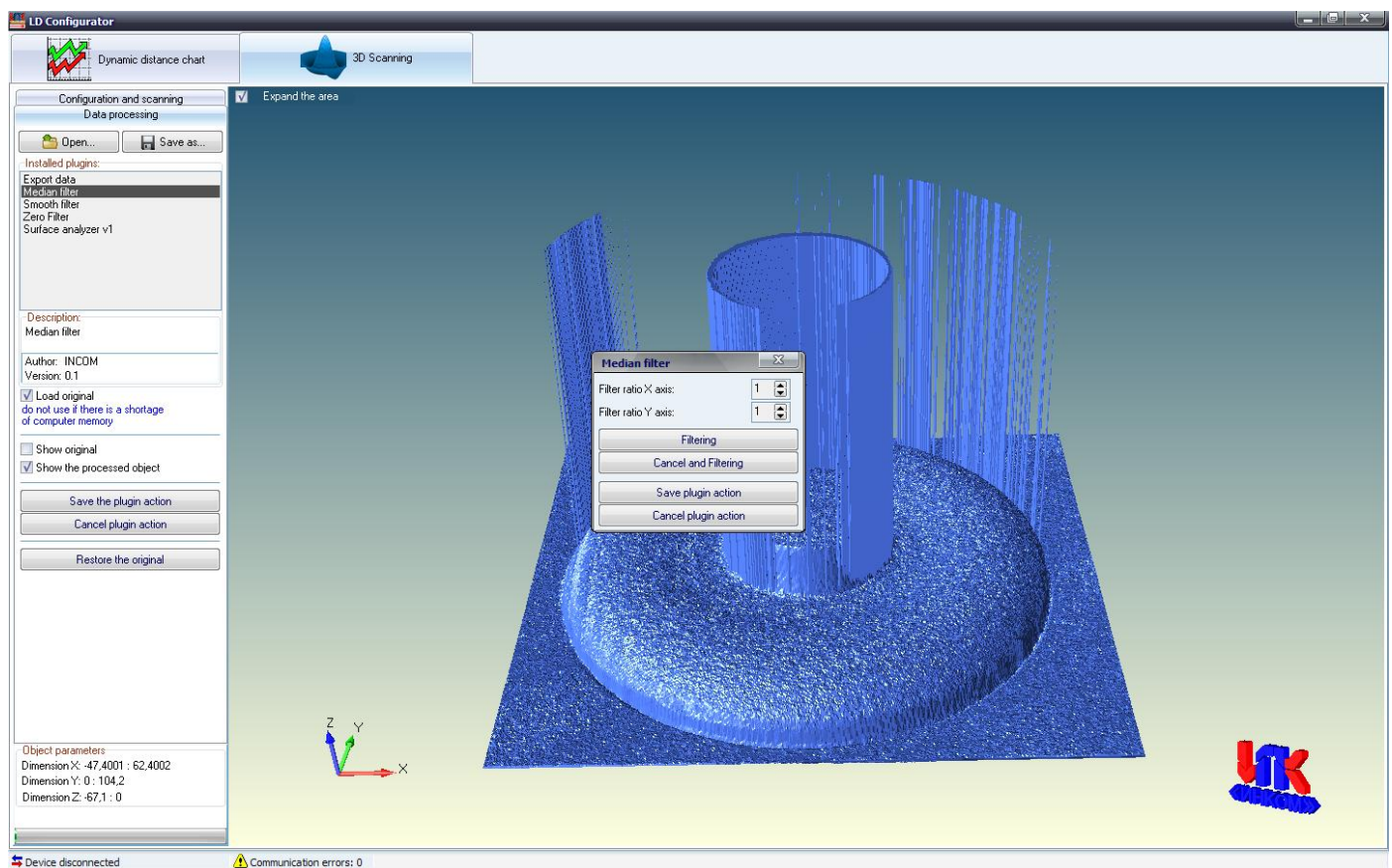
For a preliminary review of the processing, open the file Cover.srs located in the **Sample 3D** folder:



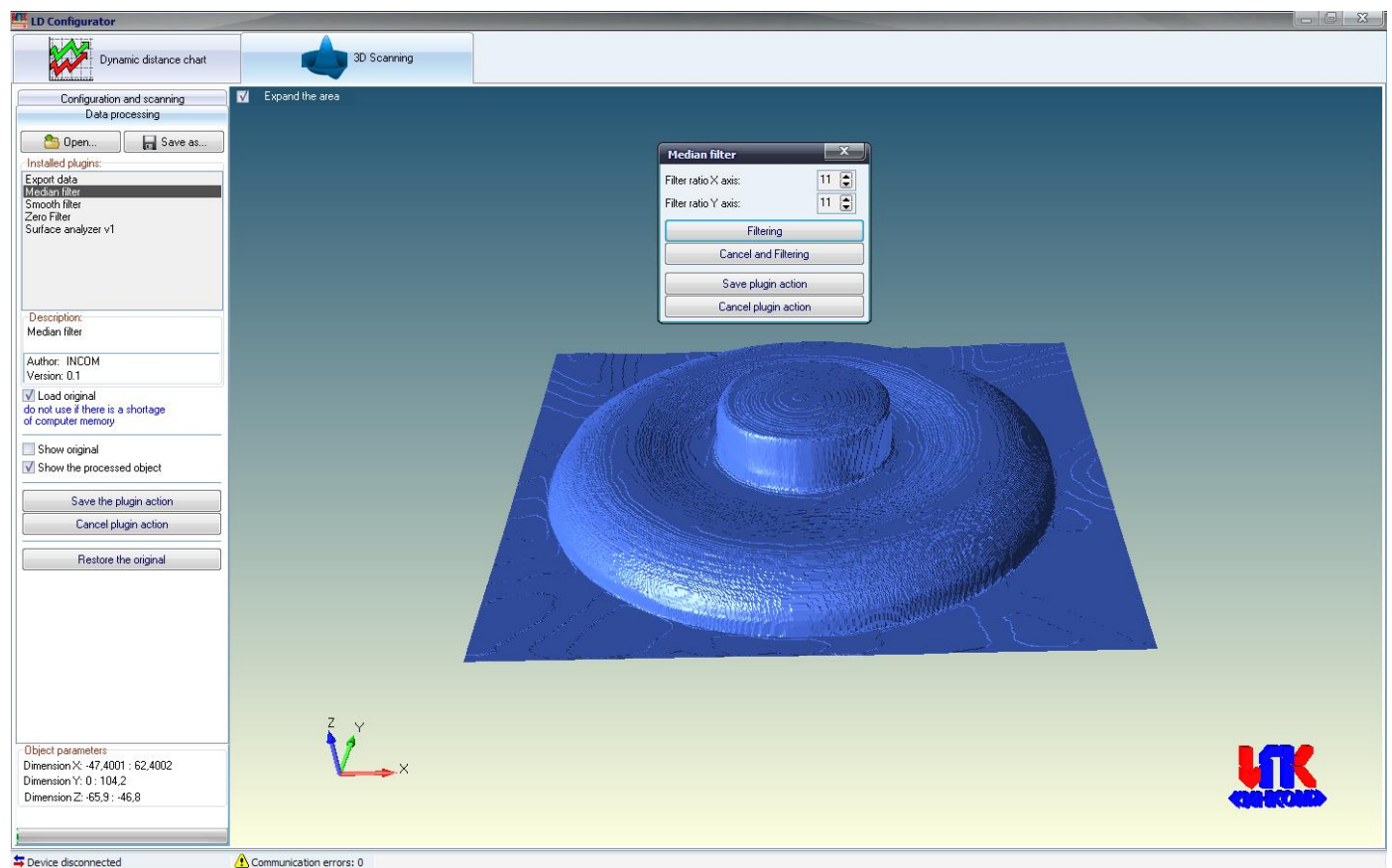
The scanning of this model occurred at high speed and there are many areas where the sensor could not determine the position of the object. In addition, since a sensor with a large measuring range was used, the roughness of the model surface is strongly noticeable.

Green color shows the original model before processing, if you un-check the **Show original** checkbox, the blue model will be visible - this is the model that will be processed, so it is possible to apply 2 models before and after processing to control the geometry of the processed model.

To filter the sections of the model where the sensor was unable to determine the position, the median filter is well suited. For now, let us turn off the visualization of the original model while unchecking the **Show original** checkbox and double-clicking on the **Median filter** label with the left mouse button, and bring up the median filter plugin:

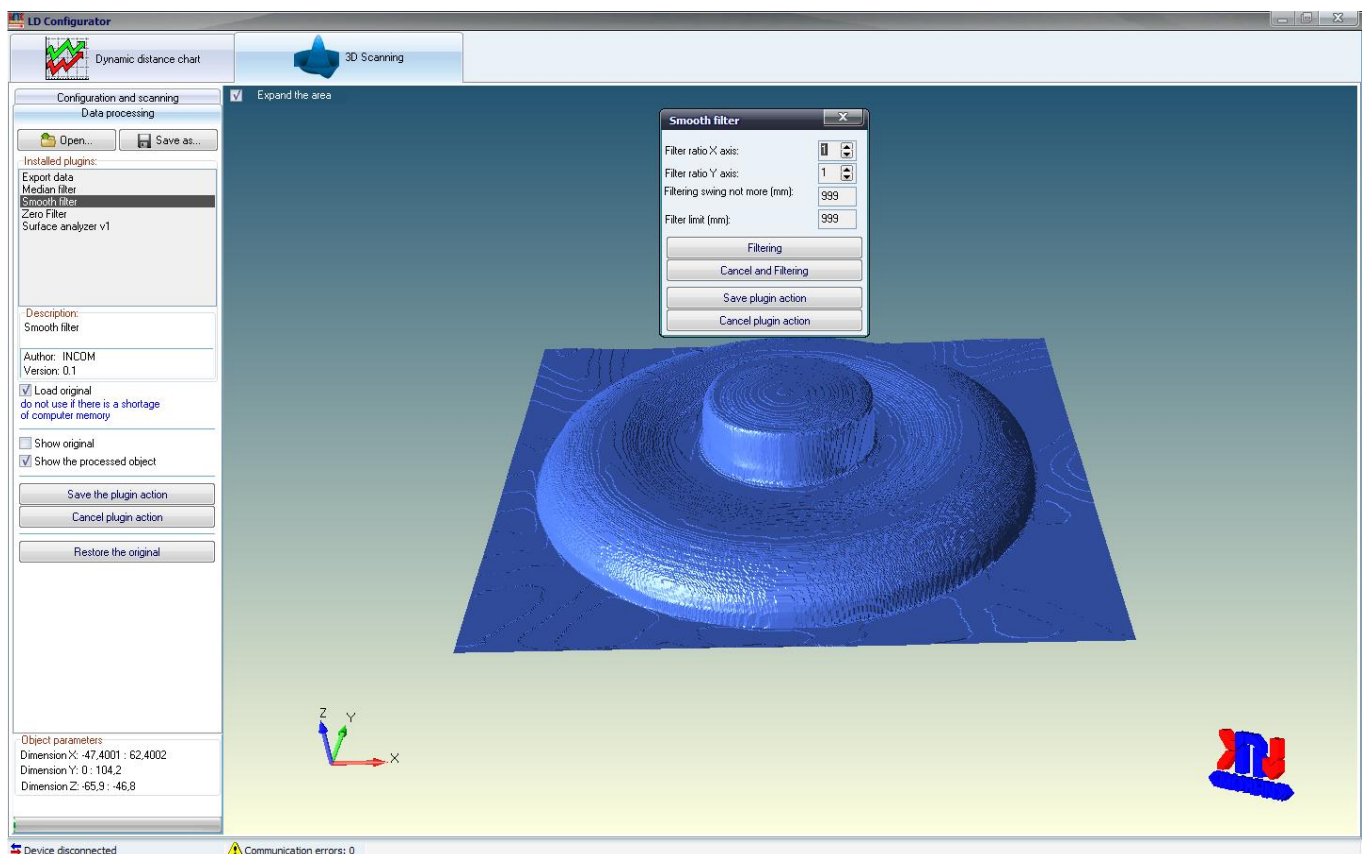


Now let's set filter coefficient to 11 and click the **"Filtering"** button:

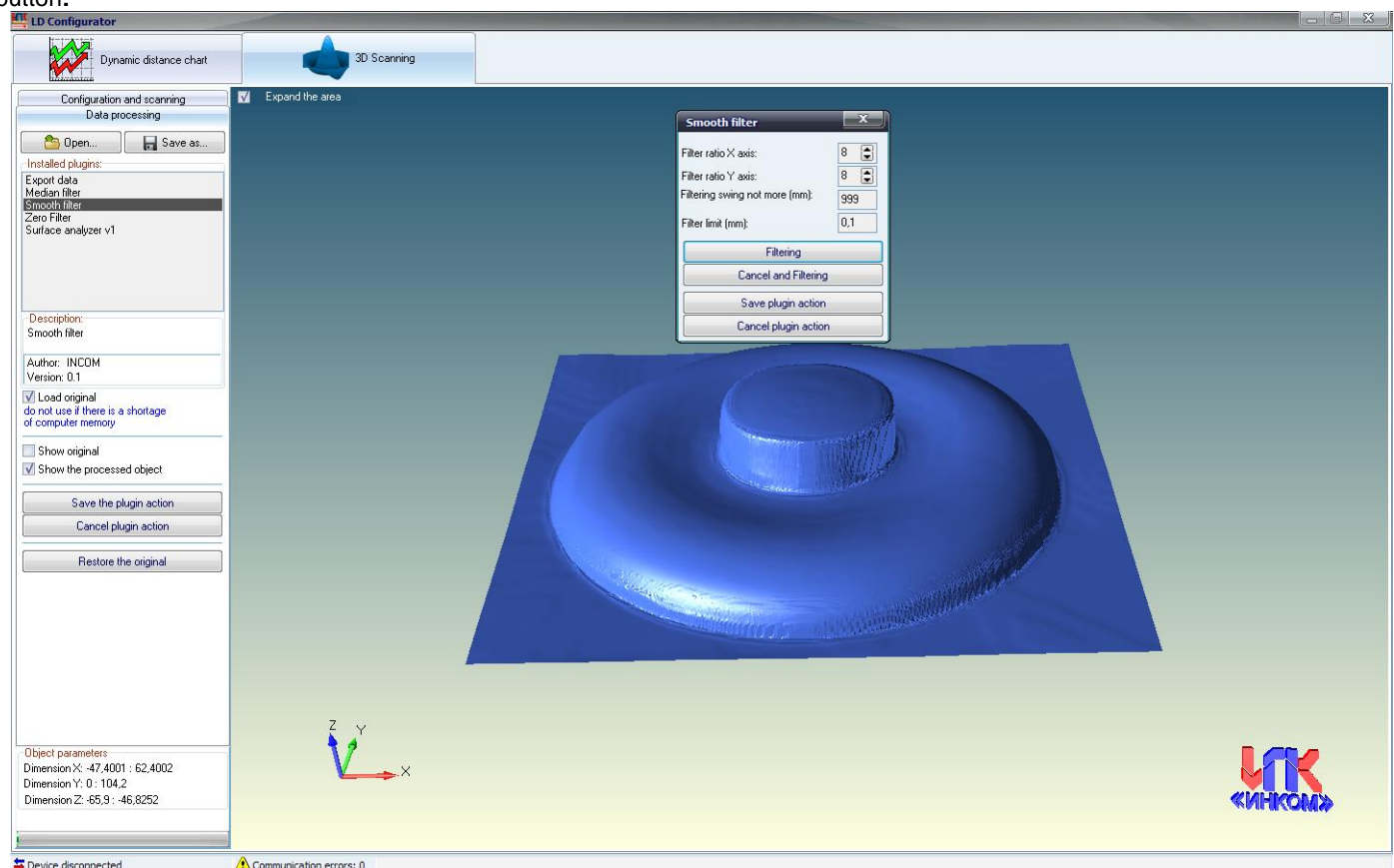


The filter with this coefficient filtered out all the "peaks", so to save the result, let's click the **"Save the plugin action"** button.

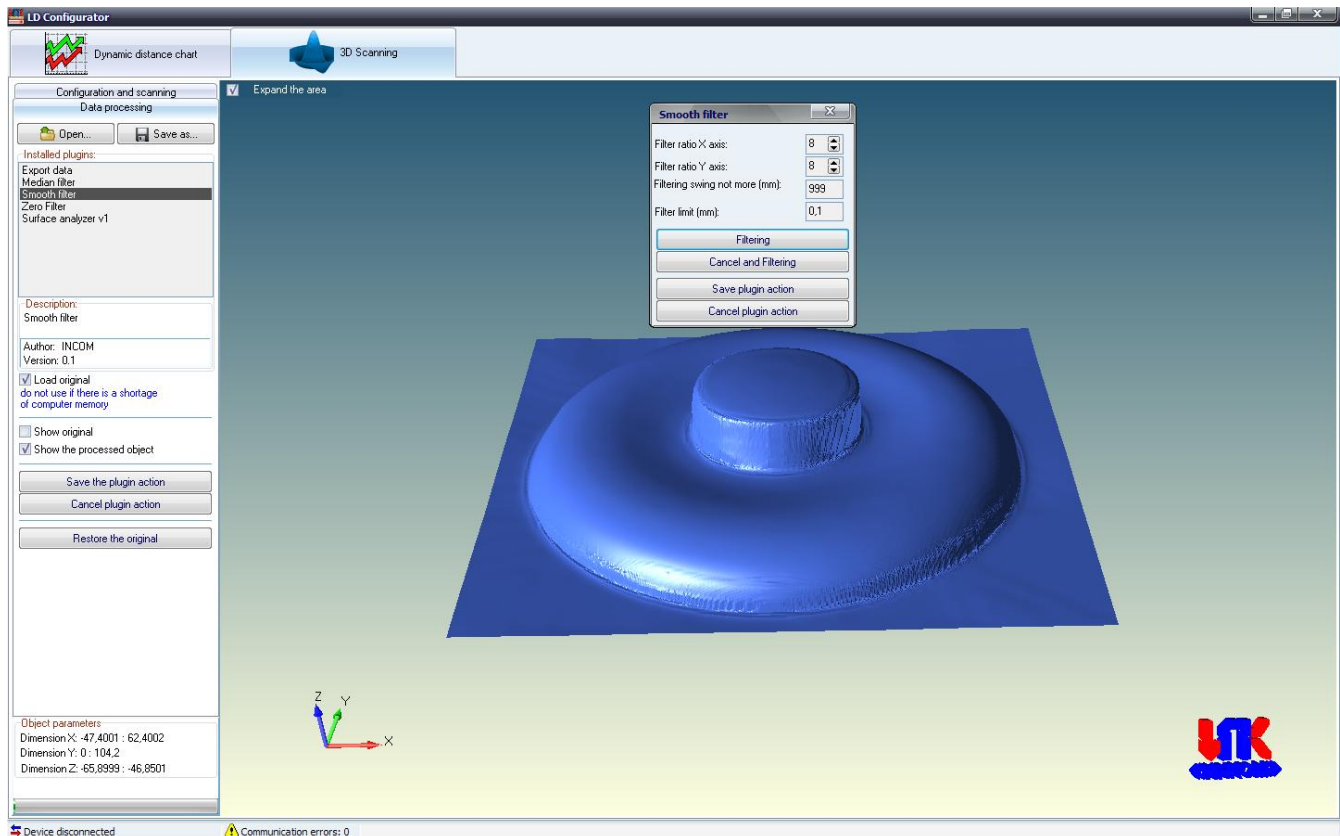
Next, let's remove the excess roughness of the model and smooth out the sharp contours, to do this, double click on the **"Smooth filter"**, bringing up the smoothing filter plugin:



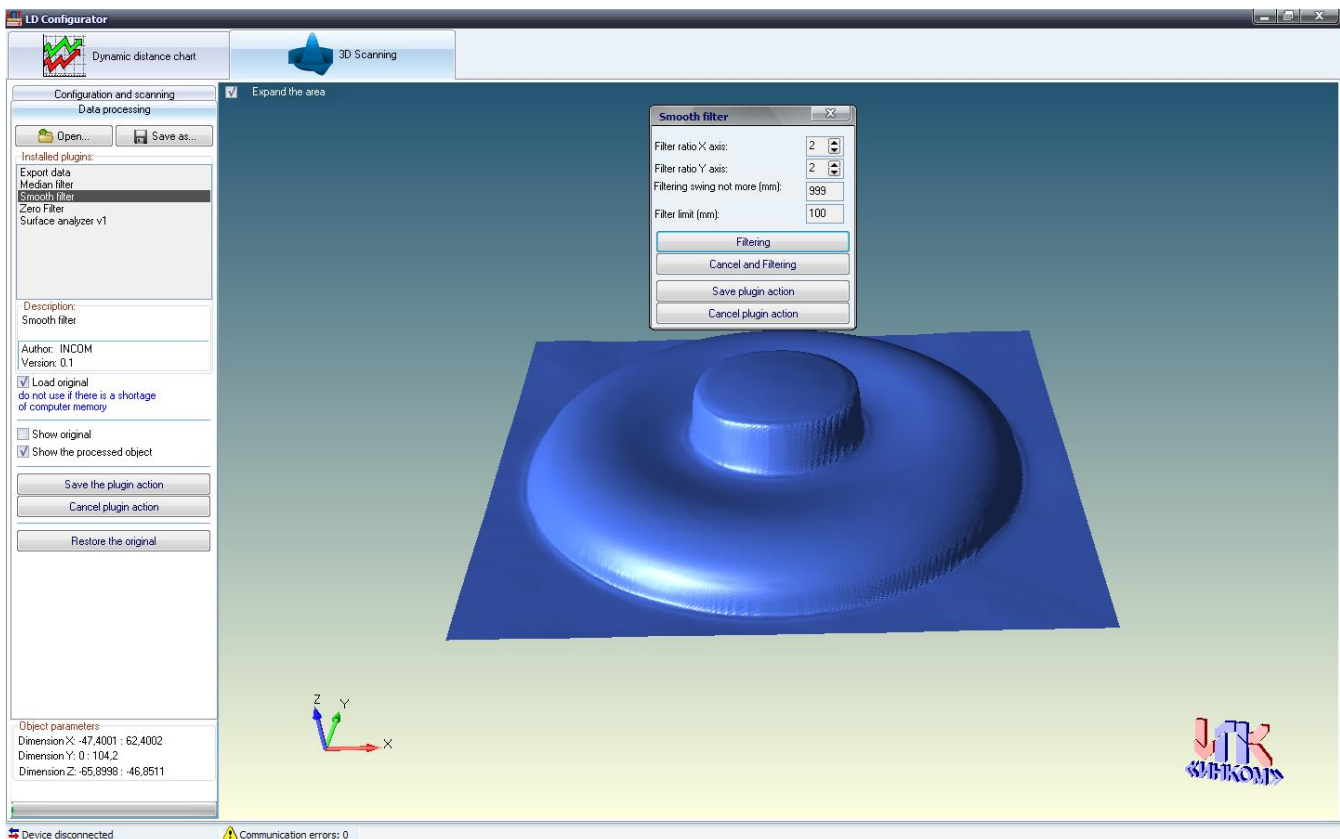
Firstly, we will remove the roughness by setting the window factor to 8, the filter limit to 0.1mm, and then click the **"Filtering"** button:



The model has become smoother, but small surface irregularities are still present, so repeat the previous procedure by pressing the **"Filtering"** button again:

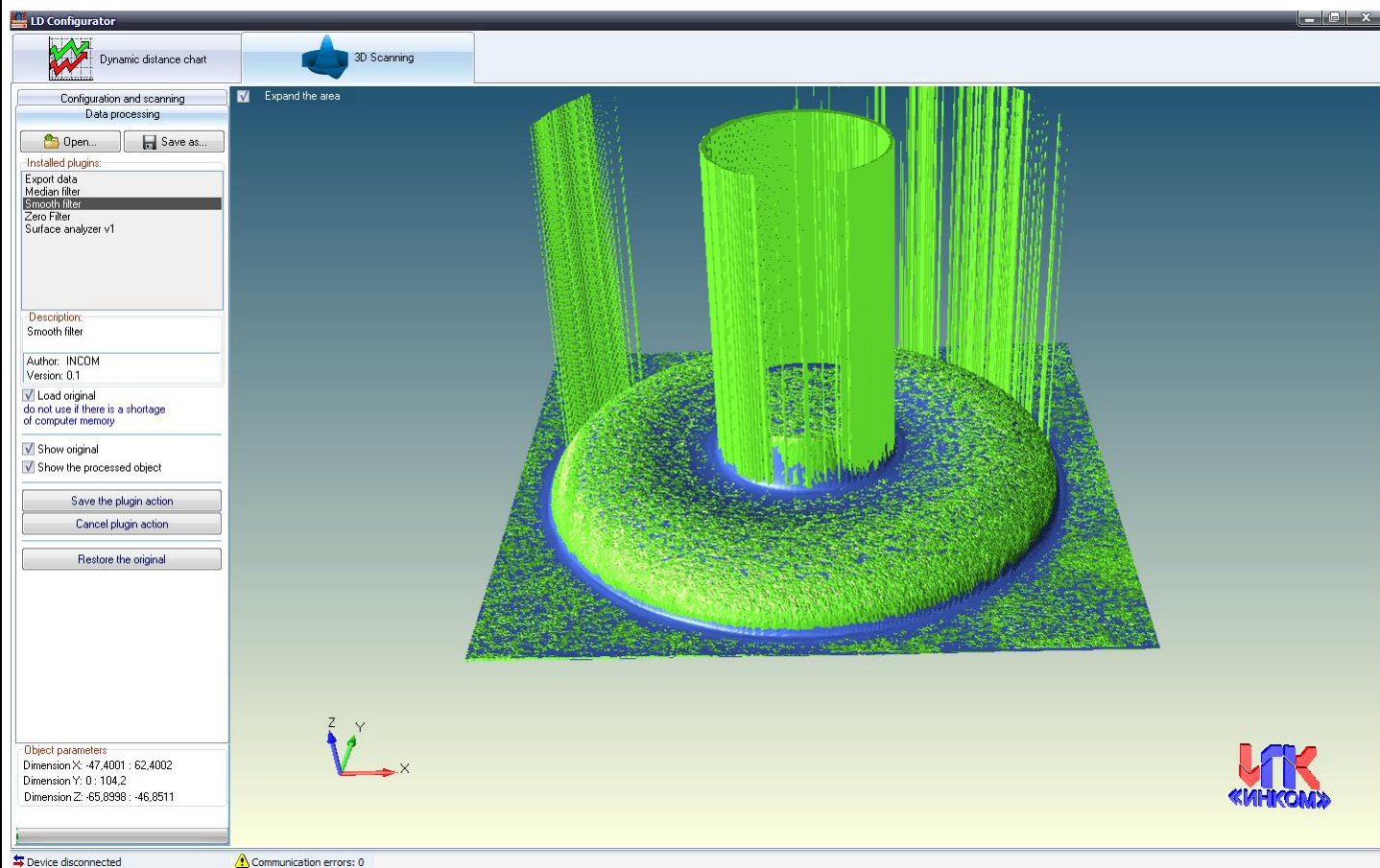


We shall now smooth out the sharp contours of the model, for this we set the window coefficient to 2, remove the filter limit by setting it to a value greater than the model size - 100mm, and click the **"Filtering"** button:

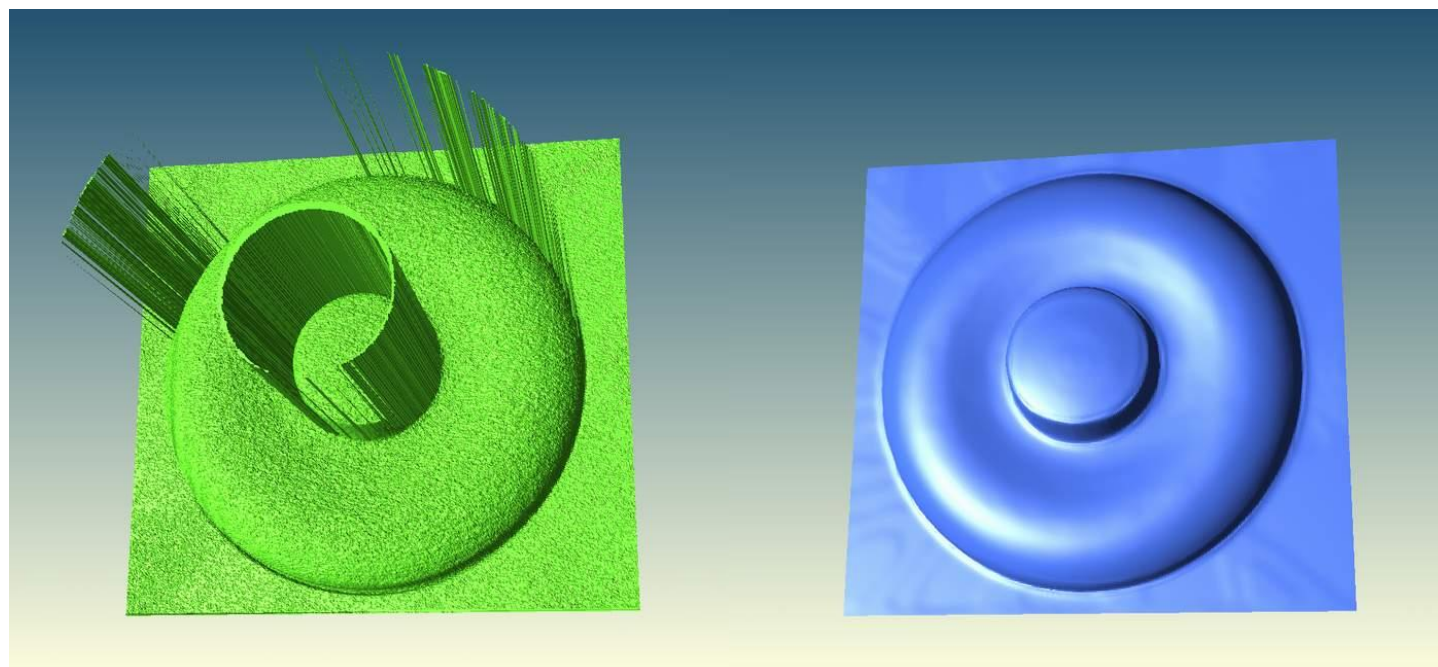


Save the result by clicking the **"Save the plugin action"** button.

To control the geometry we will superimpose two models:



Processing result:



After processing, the model can be saved in the format *.srs, *.stl, *.asc (ASCII point cloud), to do this click the **"Save As..."** button, and select the desired file format.

11 SDK LIBRARY AND EXAMPLES OF THE OPEN SOURCE CODE FOR WORKING WITH THE SENSOR

For developers, the package contains in addition to the survey and configuration program in the Source code folder, a number of open source programs written in the Delphi and C++ programming language:

- An example of using the SDK library to work with the sensor;
- Examples of plugins for 3D scanning:
 - Plugin for data export as a point cloud;
 - Plugin for removing all zero Z points;

12 MAINTENANCE AND REPAIR

Technical maintenance of the sensor entails:

- periodic inspection of its housing and connector for mechanical damage;
- cleaning the contacts of the plugs and the outlet from possible contamination, oxidation and moisture;
- cleaning the sensor from dust and dirt without opening it;
- checking the connecting cable;

The sensor should be repaired at the factory

13 STORAGE AND TRANSPORTATION

The product should be stored on shelves in consumer packaging at an ambient temperature of + 5 ° C to + 40 ° C and a relative humidity of not more than 80%.

The ambient air in the storage place should not contain acidic, alkaline or other aggressive impurities, vapors and gases that cause corrosion, as well as conductive dust.

Transportation of the sensor should be carried out in a transport container using closed transport of any kind.

When transporting by air, the sensor should be placed in heated sealed compartments.

The sensor in the transport packaging on vehicles must be fixed so that there are no displacements and impacts on other cargo and on the walls of the vehicle along the way.