LS5 Laser triangulation sensors

Technical description

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2021

CONTENTS

Features:

- **High resolution (up to 0.1 µm)**
- **Measurement frequency 1000 Hz**
- **High interference resistance**
- **Work with a wide variety of surfaces**
- **Two programmable NPN outputs**
- **Digital (RS-485/232, Ethernet, CAN) and analog (4-20 mA, 0-20 mA, 0-10 V) interfaces**
- **Robust metal case**
- **Power supply voltage from 5 to 36 V**

1. OVERVIEW

The **LS5** is an optical position sensor with a set-in microprocessor control system. The **LS5** measures with high accuracy the distance to a monitored object with no mechanical contact. Ideal for the industrial control systems of dimensions and parameters calculated based on them.

The LS5 sensors use the triangulation principle (see the fig. 1.1). The laser emitter creates a light mark on the object's surface. The light spot is projected onto a linear CMOS photodetector. When changing the distance from the sensor to the object, the light spot moves in the photodetector's plane. The microprocessor calculates the coordinates of the image. The coordinates of the image are used to determine the distance to the object. During the measurement, the reflected light power is dynamically controlled and the backlight is suppressed.

The registration number of the LS5 laser sensors in the National Register of Measuring Equipments of the Russian Federation is 41773-09.

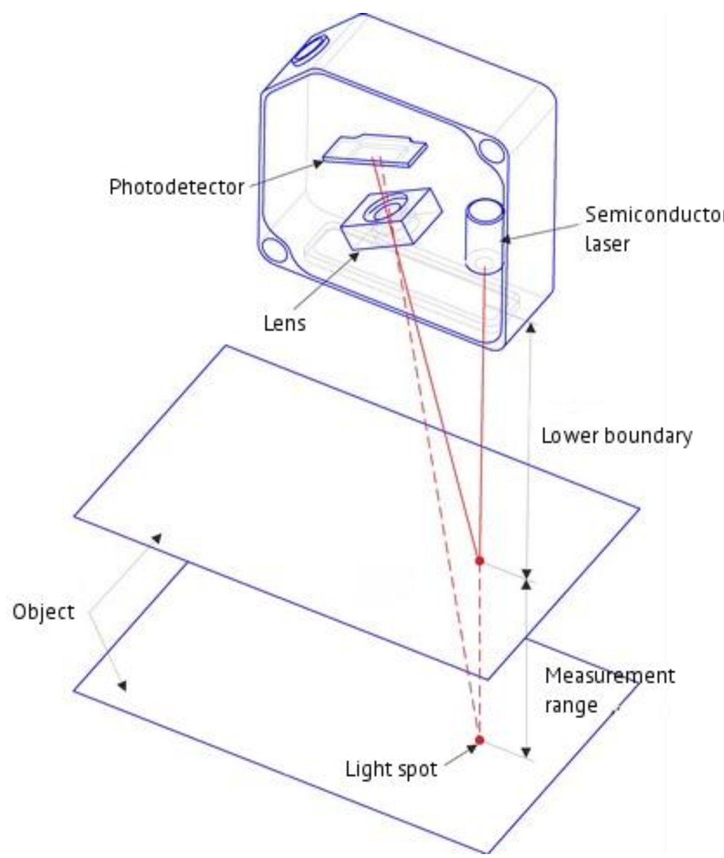
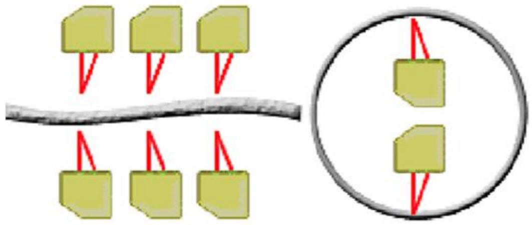
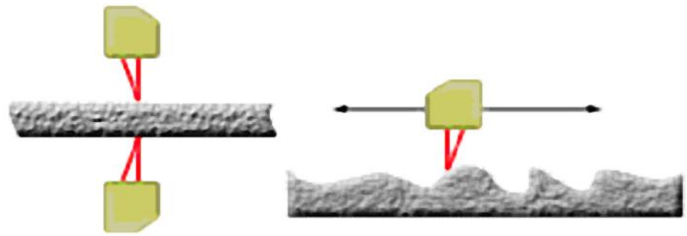


Figure 1.1 – Structure and operating principle of the LS5 sensor

1.1. Typical application



Measurement of the nonlinearity and the diameter



Measurement of the product thickness and profile

Measurement of the beats of the rotation bodies – the sensors are fixed at a 10-100 mm from one another, they measure the distance to the rotation body for an entire revolution. Using the digital processing of measures, the beat value is calculated as the largest differential between the maximum and the minimum distances measured by each sensor.

Measurement of the internal diameters of pipes – sensors move along the rail inside the pipe and measure the distances to its internal walls and to the starting point of the measurement along the movement. Using digital measurement processing, the dynamics of the measurements of the internal pipe diameter is determined in the longitudinal sections corresponding to the position of the sensors.

Measurement of the distance to an object.

Registration of the number of items and the number of visitors. The key part of such systems is the algorithm for the measurements processing.

The automatic control systems can be built for various processes (product correction, sheet material rolling, etc.) based on the LS5 laser sensors. You can find the similar systems on the website http://www.prizmasensors.ru

2. SAFETY MEASURES

During the operation, the maintenance and verification, it is necessary to follow the requirements of the GOST 12.3.019-80, "Guidelines for the operation of electric installations of consumers", "Guidelines for the labour protection during operation of consumer electrical installations" and the GOST IEC 60825-1-2013.

Only the engineers and technicians who have been specially instructed and studied this technical description are admitted to the work with the sensors.

Any connection to the sensor and its maintenance should only be performed when the power supply is switched off.

2.1. Laser safety

The LS5 sensor uses a semiconductor laser with continuous radiation, maximum output power – 500 mW. According to the GOST IEC 60825-1-2013, it corresponds to the class 3B.

ATTENTION! When working with sensors at a distance of less than 2 meters, please, avoid the direct or mirror laser radiation in the eyes.

Each sensor has the following marks on the case according to the GOST IEC 60825-1-2013 (see the fig. 2.1):

- laser hazard sign;
- explanatory sign with the inscription:

LASER APERTURE

- explanatory sign with the inscription:

LASER RADIATION

AVOID EXPOSURE TO BEAM

CLASS 3B LASER PRODUCT

indicating the wavelength and maximum radiation power of the laser used, the name of GOST IEC 60825-1-2013, and the information about the manufacturer.

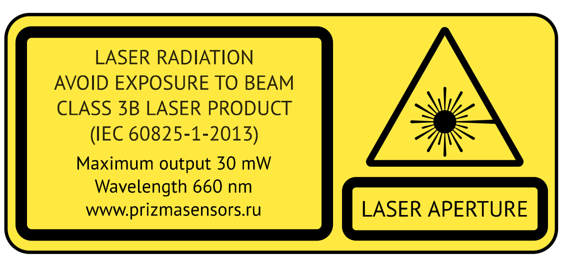


Figure 2.1 – Example of marking on the case laser sensor of the class 3B

When working with a laser sensor of the class 3B, it is forbidden to direct the laser beam at people or look at the laser beam through the optical tools.

When working with a laser sensor of the class 3B, it is recommended to use safety goggles.

3. SPECIFICATIONS

Table 3.1 – Main parameters and characteristics of the sensors

Name of the parameters and characteristics	Value
Measurement range, D, mm	2 – 2000[1]
Discreteness depending on the measurement range, mm:	0.01 % of D
– up to 10 mm inclusive	0.0001
– over 10 to 100 inclusive	0.001
– over 100 to 1000 inclusive	0.01
– more than 1000 mm	0.1
Limit of the relative error reduced to the measurement range, %:	
- for the digital interface	±0.15[2]
- for the analog interface	±0.25
Digital interface[3]	RS-232, or RS-485, or RS-485 and Ethernet 10/100, two discrete programmable outputs with open collector (OC)[4]
Analog output range	4 – 20 mA, 0 – 20 mA or 0 – 10 V
Sync input	logic level 2 – 5 V, triggering on the rising edge
Rated DC power supply voltage, V	5 – 36
Power consumption, no more than, W	4
Operating temperature range, °C	+10 … +35
Maximum operating temperature range, °C	-20 … +60
Continuous working time	unlimited
Probability of fault-free performance of the sensor during 2000 hours of work, at least	0.95
Average service life, at least, years	5

Notes:

[1] Made at the customer's request.

[2] For example, for a sensor with a range of 5 mm, the digital interface error will be 5 mm · 0.0015 = 0.0075 mm.

[3] At the customer's request the sensor can be equipped with a CAN interface converter.

[4] The availability of the programmable outputs with an open collector allows you to create a system based on a single sensor that sends control signals to the actuators. The programming is performed using the software provided with the sensor.

Table 3.2 – The LS5 sensor laser diode specifications

Name of parameter	Value
Laser type	semiconductor
Wavelength of radiation, nm	400 – 660
Output power, no more than, mW	500
Generation mode	continuous
Beam divergence, level e^{-2}	from 25° to 61°
Laser safety class (according to GOST IEC 60825-1-2013)	3B
Associated hazardous and harmful factors	direct and diffusely-reflected laser radiation

4. DESIGN SPECIFICATIONS

The design parameters of the sensor are shown in the table 4.1 and in the figures 4.1 – 4.5. At the customer's request, sensors with a case type A can be equipped with a cooling casing (see the fig. 4.6) or a thermoregulation casing (see fig. 4.7).

Table 4.1 – Design parameters of the sensor

Case type	Name of the indicator	
	Overall dimensions, mm	Weight, no more than, g
A (see fig. 4.1)	60×60×20	150
A2 (see fig. 4.2)	75×60×20	200
B (see fig. 4.3)	84×34×20	150
C (see fig. 4.4)	118×50×25	240
D (see fig. 4.5)	180×50×25	300
E	at the customer request	

Notes:

1. At the customer's request, sensors with a case type A or B can be completely sealed (IP67 protection).
2. The case A2 is only used for sensors with an Ethernet interface.

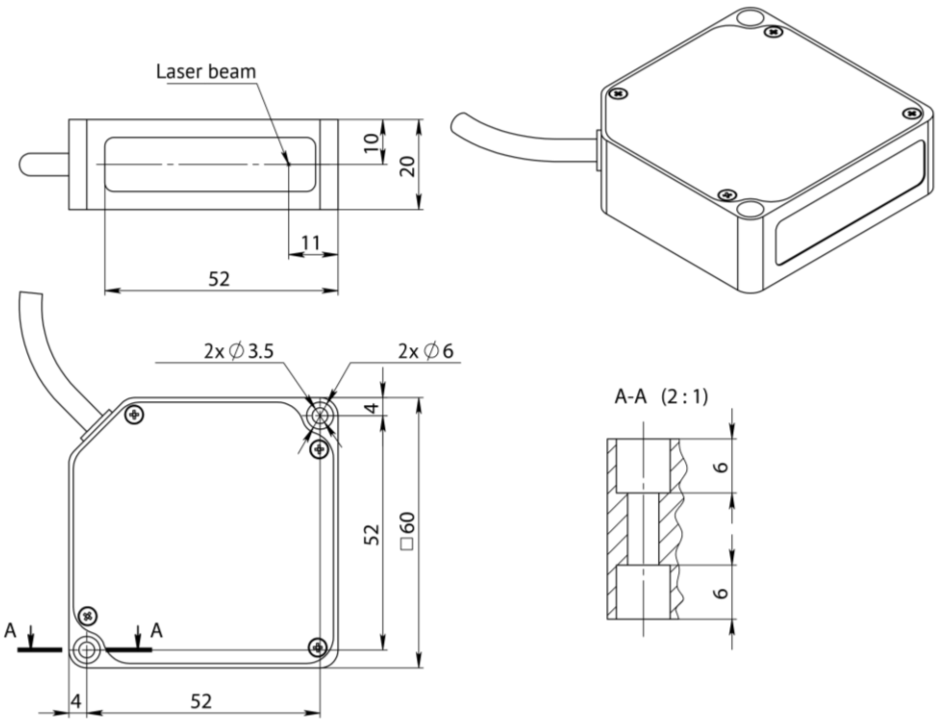


Figure 4.1 – The case A

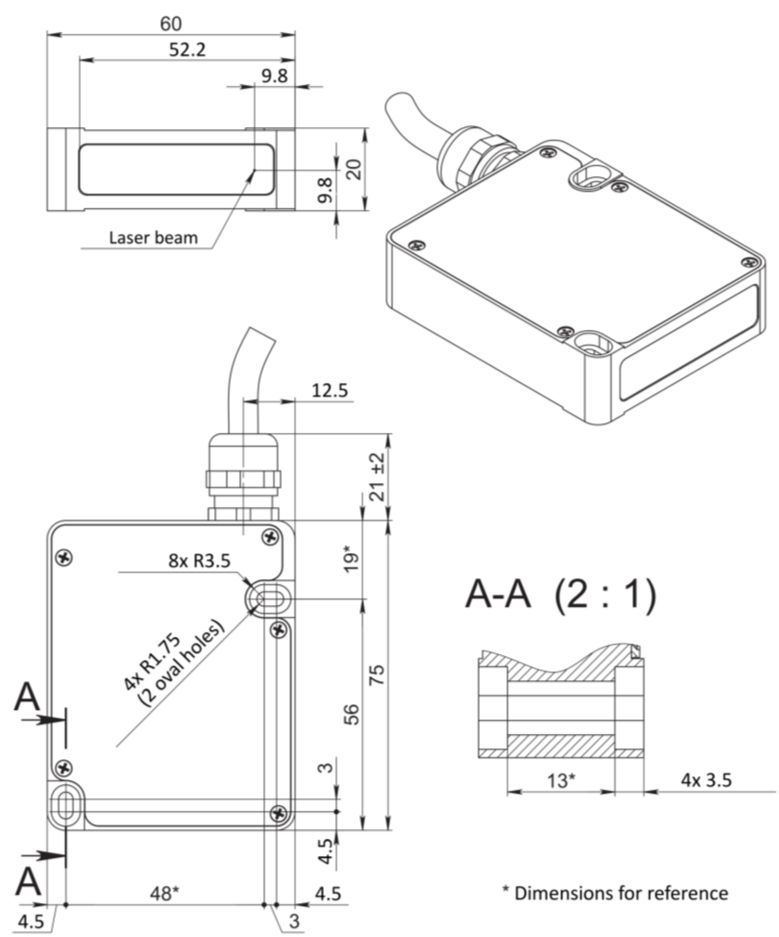


Figure 4.2 – The case A2

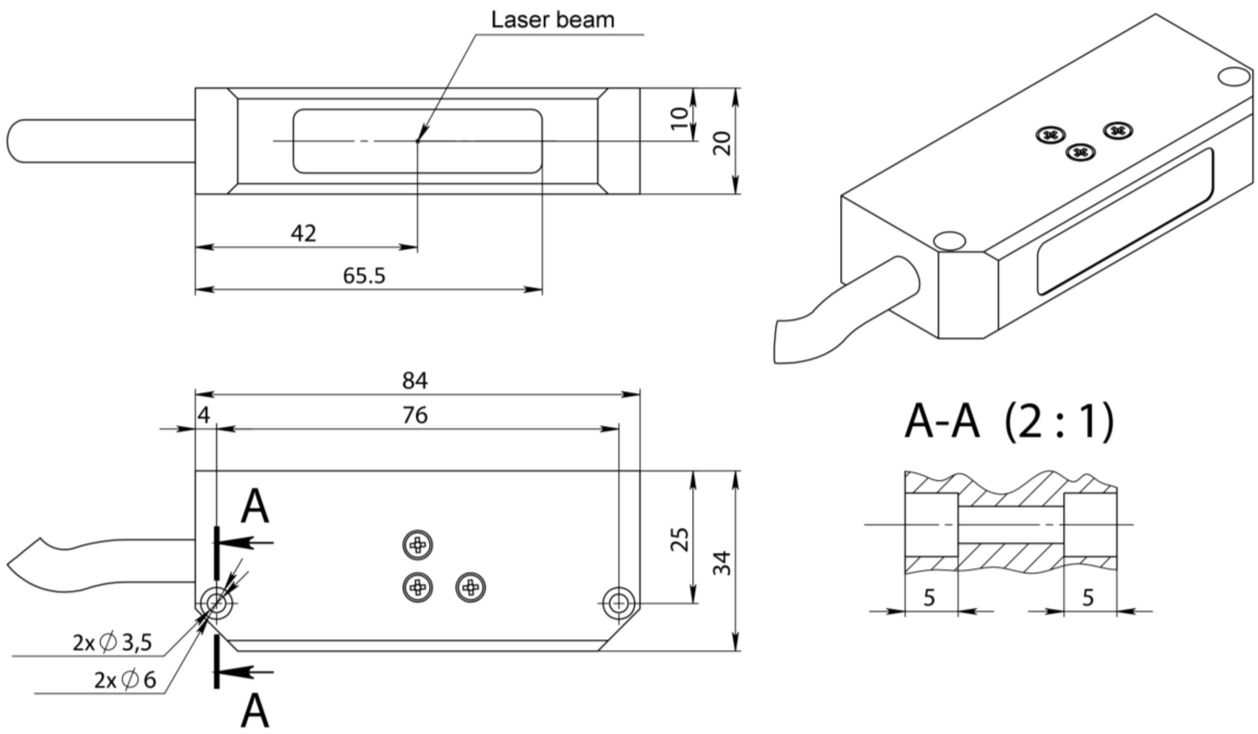


Figure 4.3 – The case B

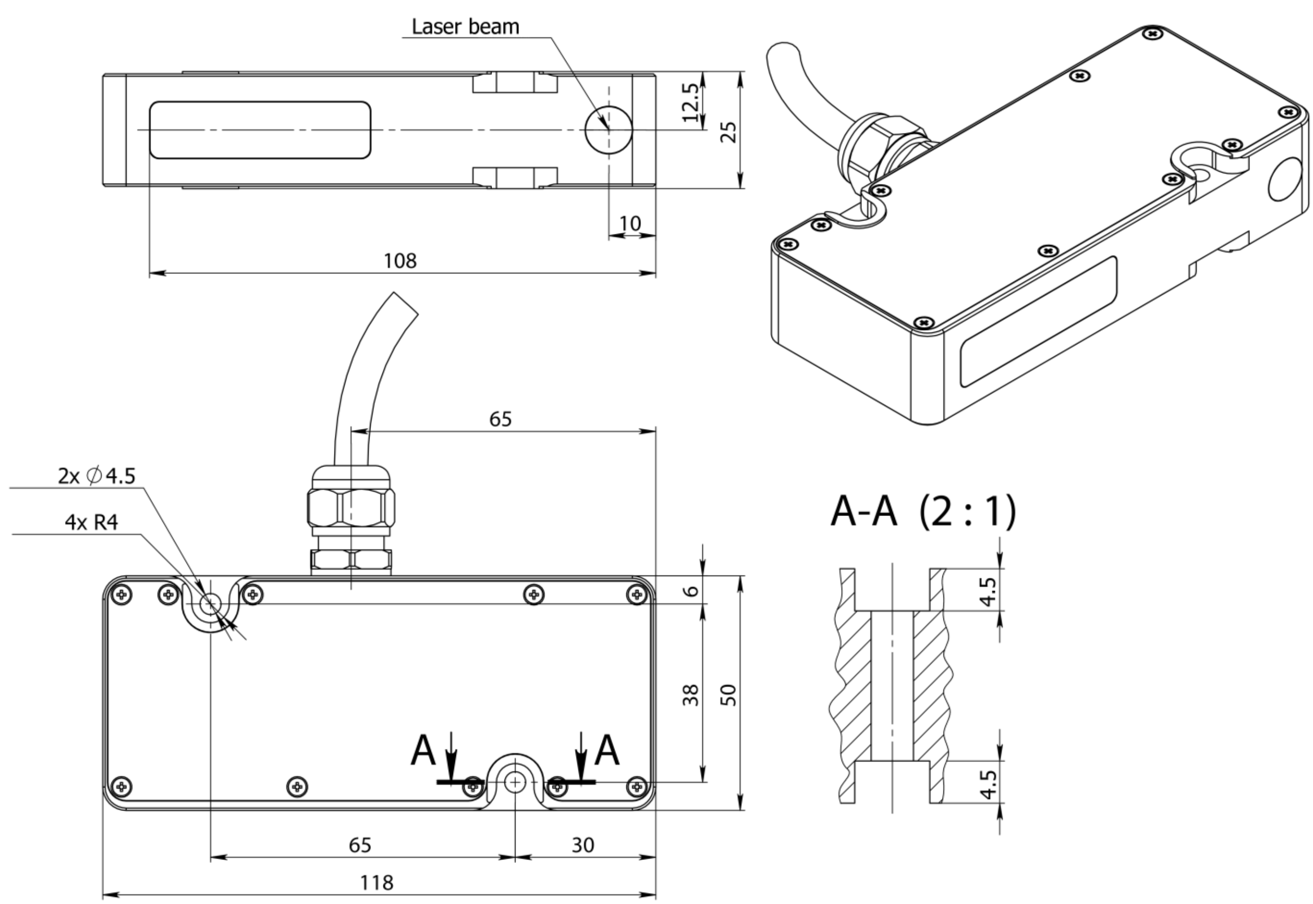


Figure 4.4 – The case C

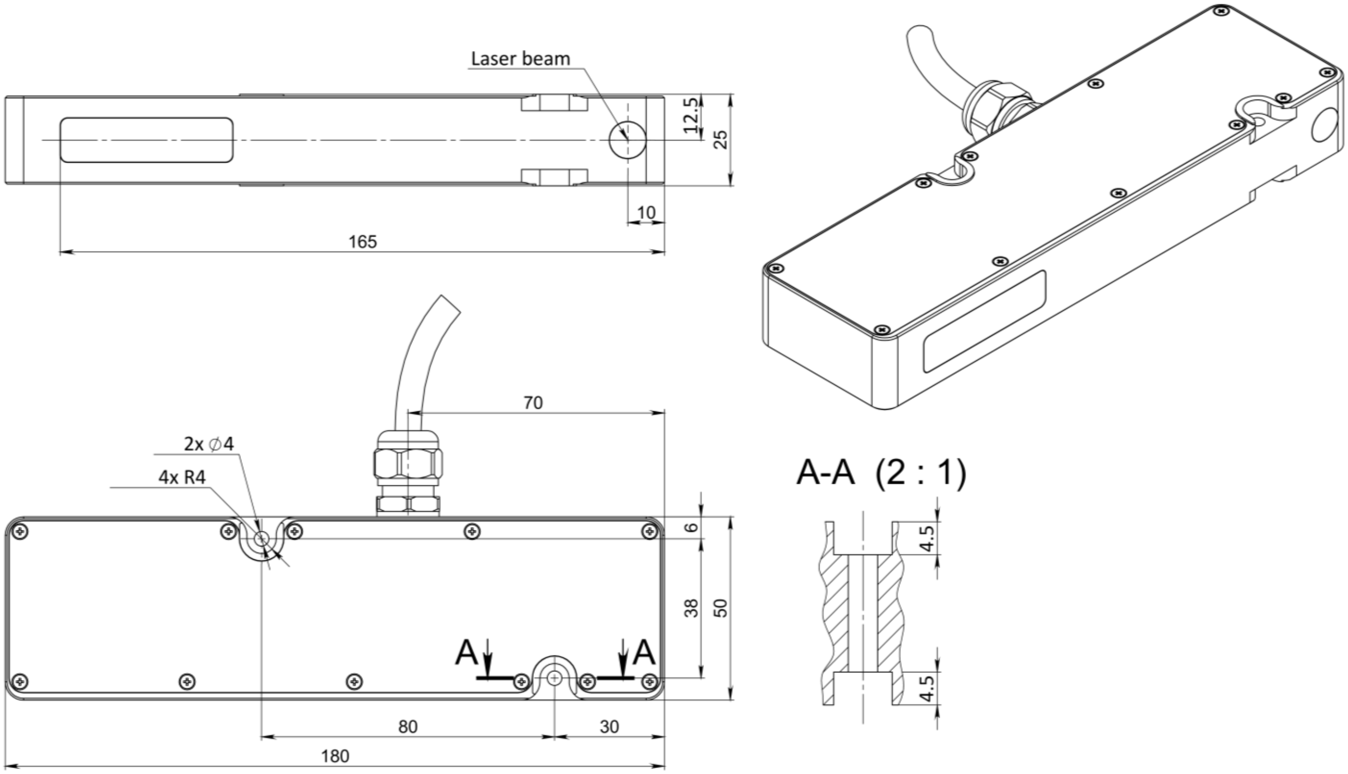


Figure 4.5 – The case D

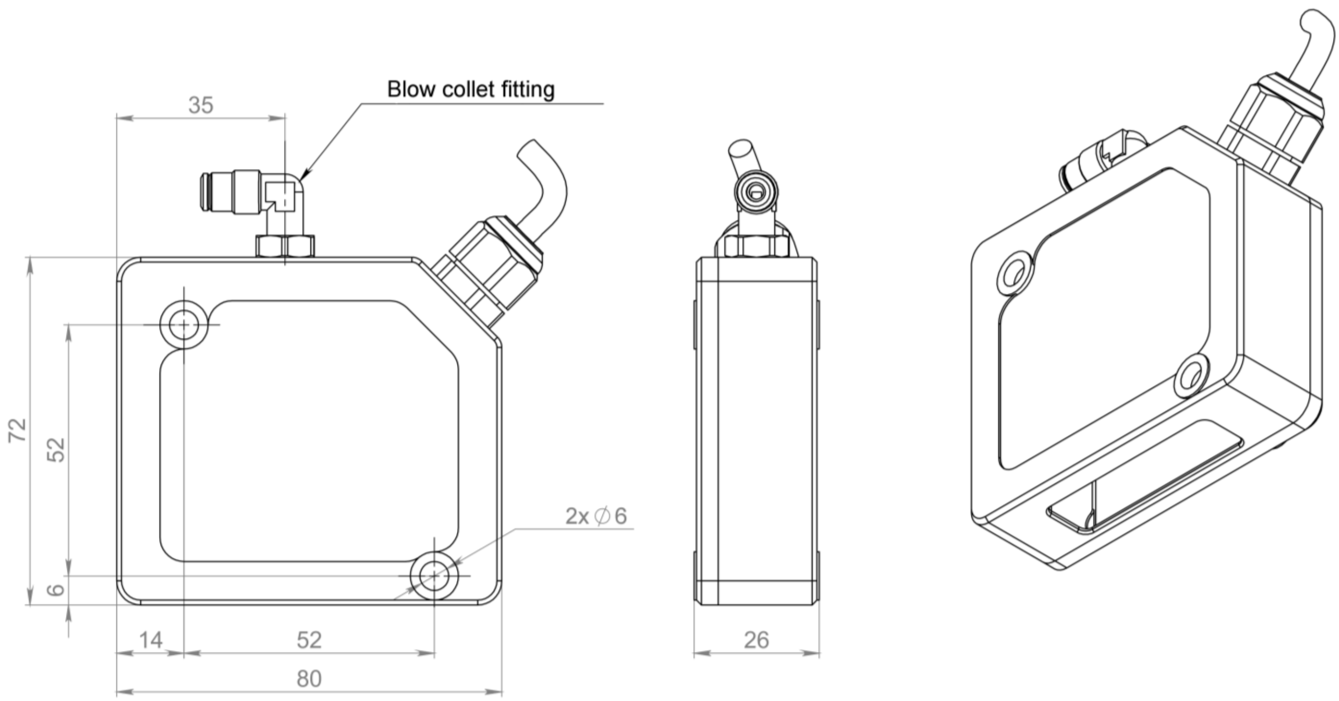


Figure 4.6 – Cooling casing for a case A

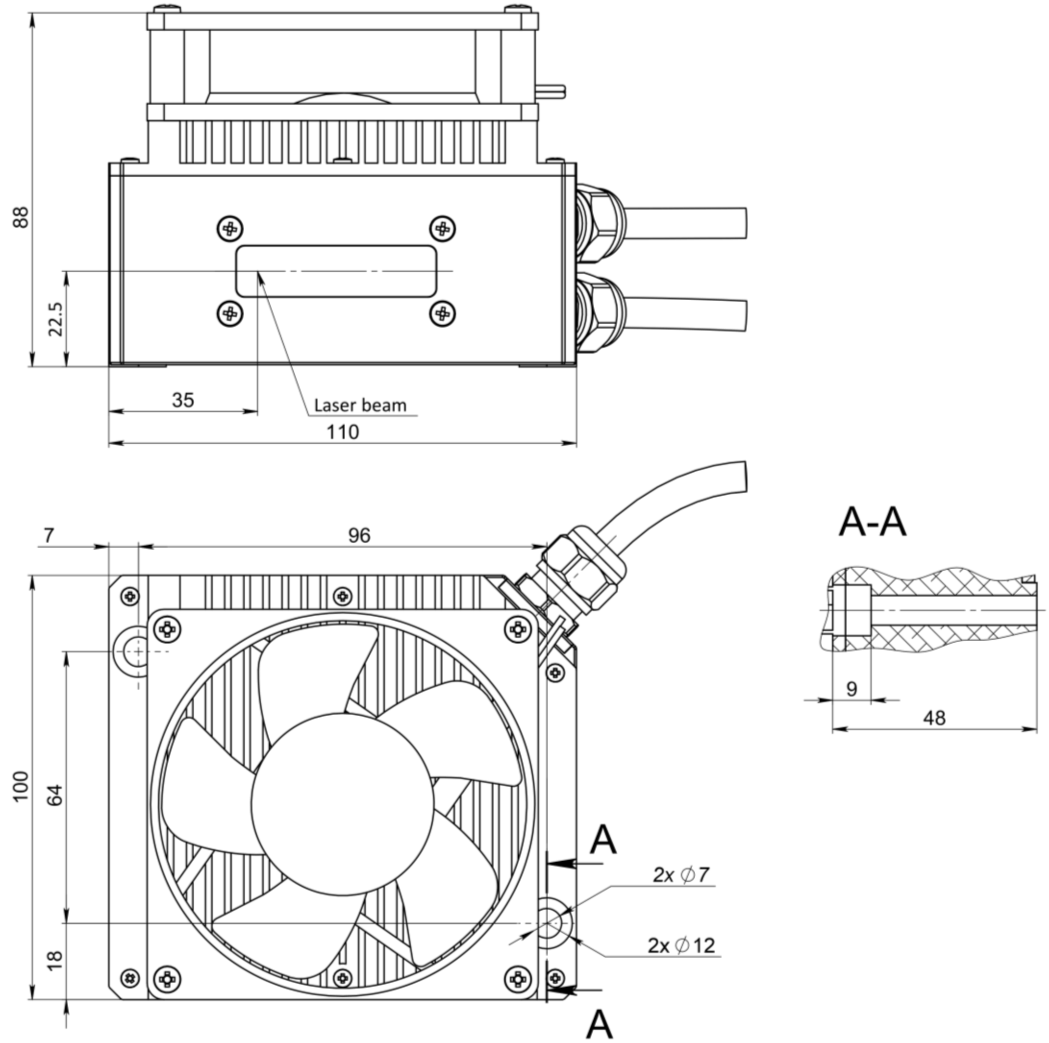


Figure 4.7 – Thermoregulation casing for a case A

5. ORDERING INFORMATION

When ordering, please, adhere the following conventions:

LS5-XX/XX-XXX-XX-X-XX-X TU 443130-001-72884111-2009

- Sensor type
- Lower boundary, mm
- Measurement range, mm
- Digital interface:
  - **232** – RS-232
  - **485** – RS-485
  - **485/E** – RS-485 and Ethernet
- Analog output range:
  - **I0** – 0...20 mA
  - **I4** – 4...20 mA
  - **V** – 0...10 V
- Number of digital outputs:
  - **1** – one
  - **2** – two
- Power supply voltage:
  - **5** – 5 V
  - **12** – 12 V
  - **24** – 24 V
- Case type (dimensions in mm):
  - **A** – 60×60×20
  - **A2** – 75×60×20
  - **B** – 84×34×20
  - **C** – 118×50×25
  - **D** – 180×50×25

Example of a symbol:

LS5-100/200-485/E-I4-2-12-A TU 443130-001-72884111-2009

Decryption:	
laser sensor LS5	
lower boundary, mm	100
measurement range, mm	200
digital interface	RS-485 and Ethernet
analog output range, mA	4 … 20
number of discrete outputs, pcs	2
power supply voltage, V	12
case size, mm	60×60×20

When ordering the sensor take a look at the table 5.1

Table 5.1 – List of commonly used sensors (standard ranges)

Model LS5-	**Lower boundary, mm**	**Measurement range, mm**	**Discreteness, mm**	**Measurement error, no more than, mm**	**Laser spot size[1], µm**	**Case type**
0.5/5	0,5	5	0.0001	±0.0075	75	A, A2, B
2/6	2	6	0.0001	±0.009	77	
0.5/10	0,5	10	0.001	±0.015	78	
5/10	5	10	0.001	±0.015	84	
2/15	2	15	0.001	±0.023	83	
20/15	20	15	0.001	±0.023	108	
0.5/20	0,5	20	0.001	±0.03	84	
5/20	5	20	0.001	±0.03	90	
10/20	10	20	0.001	±0.03	97	
30/20	30	20	0.001	±0.03	130	
2/25	2	25	0.001	±0.038	90	
5/30	5	30	0.001	±0.045	97	
10/30	10	30	0.001	±0.045	105	
30/30	30	30	0.001	±0.045	135	
10/40	10	40	0.001	±0.06	110	
30/40	30	40	0.001	±0.06	145	
40/40	40	40	0.001	±0.06	165	
20/50	20	50	0.001	±0.075	135	
40/50	40	50	0.001	±0.075	175	
10/60	10	60	0.001	±0.09	130	
40/60	40	60	0.001	±0.09	185	
40/70	40	70	0.001	±0.11	195	
20/80	20	80	0.001	±0.12	165	
50/80	50	80	0.001	±0.12	225	
20/100	20	100	0.01	±0.15	185	
30/100	30	100	0.01	±0.15	205	
50/100	50	100	0.01	±0.15	250	
80/100	80	100	0.01	±0.15	320	
30/120	30	120	0.01	±0.18	225	
50/120	50	120	0.01	±0.18	270	
30/140	30	140	0.01	±0.21	250	
60/150	60	150	0.01	±0.23	330	
90/150	90	150	0.01	±0.23	410	
30/160	30	160	0.01	±0.24	270	
60/170	60	170	0.01	±0.26	360	
30/180	30	180	0.01	±0.27	300	
60/190	60	190	0.01	±0.29	380	
30/200	30	200	0.01	±0.3	320	
100/200	100	200	0.01	±0.3	500	

Model LS5-	Lower boundary, mm	Measurement range, mm	Discreteness, mm	Measurement error, no more than, mm	Laser spot size[1], µm	Case type
60/210	60	210	0.01	±0.32	410	A, A2, B
60/230	60	230	0.01	±0.35	440	
60/250	60	250	0.01	±0.38	460	
60/270	60	270	0.01	±0.41	490	
110/300	110	300	0.01	±0.45	670	A, A2,C
500/300	500	300	0.01	±0.45	1600	A, A2,C, D
70/320	70	320	0.01	±0.5	590	A, A2,C
70/350	70	350	0.01	±0.6	630	
110/350	110	350	0.01	±0.53	740	
70/400	70	400	0.01	±0.7	700	
110/400	110	400	0.01	±0.65	810	
200/400	200	400	0.01	±0.6	1000	A, A2,C, D
500/400	500	400	0.01	±0.55	1700	C, D
70/450	70	450	0.01	±0.9	770	A, A2,C
110/450	110	450	0.01	±0.68	880	A, A2,C, D
300/450	300	450	0.01	±0.63	1200	
600/450	600	450	0.01	±0.6	1900	C, D
110/500	110	500	0.1	±0.8	1000	A, A2,C, D
600/500	600	500	0.1	±0.75	1900	C, D
120/600	120	600	0.1	±1	1100	A, A2,C, D
300/600	300	600	0.1	±0.9	1500	C, D
700/600	700	600	0.1	±0.8	2300	
150/700	150	700	0.1	±1.1	1300	
300/700	300	700	0.1	±0.9	1600	
700/700	700	700	0.1	±1	2500	
170/800	170	800	0.1	±1.2	1500	
300/800	300	800	0.1	±1.1	1700	
700/800	700	800	0.1	±1.1	2700	
180/900	180	900	0.1	±1.35	1600	
300/900	300	900	0.1	±1.2	1800	
700/900	700	900	0.1	±1.2	3000	
250/1000	250	1000	1	±1.5	1800	
300/1000	300	1000	1	±1.5	2000	
700/1000	700	1000	1	±1.4	3300	

Note:

[1] The average spot size in the center of the measurement range is indicated. Size can be adjusted at the customer's request.

6. INSTRUCTIONS FOR THE SENSOR INSTALLATION

Installation of the sensor in the equipment is done in the way the monitored object is located in the operating range of the sensor. No foreign objects should in the area of the radiation beam falling on the object and reflected from it.

It is recommended that laser sensor class 3B be installed so that the laser beam is above or below eye level.

When monitoring objects of complex shape and texture, it is necessary to minimize the penetration of the mirror component of reflected radiation into the sensor lens.

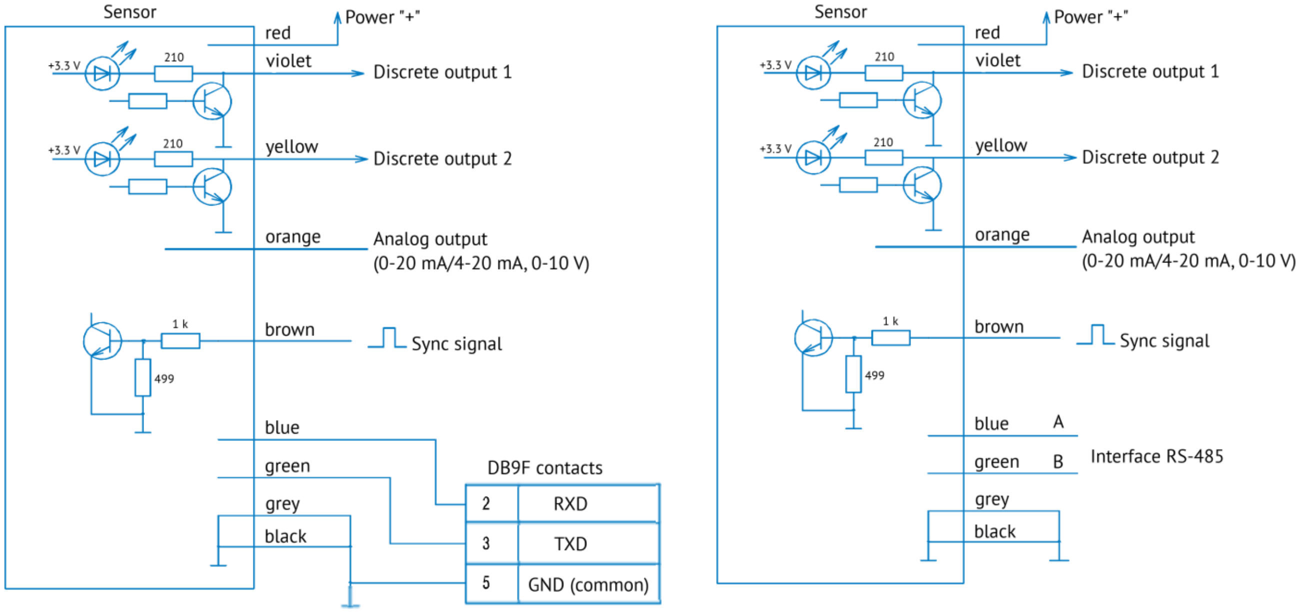
Do not install the sensor in the humidity condensation areas on the optical surfaces of the sensors or where direct sunlight or artificial light enters the aperture of the receiving lens. It can cause errors in the measurements.

7. CONNECTION OF THE SENSORS

The connection of sensors with digital interfaces RS-232, RS-485 is made according to the table 7.1 and figure 7.1.

Table 7.1 – The typical wire desoldering for connecting the sensor with digital interfaces RS-232, RS-485

Wire colour	Name of the output	DB9F contacts
red	Power «+»	–
blue	RS-485 A	–
	RS-232 output	2
green	RS-485 B	–
	RS-232 input	3
orange	analog output	–
violet	discrete output 1 (OC1)	–
yellow	discrete output 2 (OC2)	–
brown	Sync input	–
gray black	case	5



a *b*

a – Connecting the sensor with the RS-232 interface; *b* – Connecting the sensor with the RS-485 interface

Figure 7.1 – Typical sensor connection options

When using the current loop as an analog output, the minimum load resistance R_L must be correctly calculated in order to avoid failure of the built-in current generator in the sensor:

$$R_L > \frac{I_{MAX} \cdot U_P - 0.125\ W}{I_{MAX}^2},$$

where I_{MAX} is the maximum current (20 or 24 mA);

U_P is the power supply voltage applied to the current generator (usually coincides with the power supply voltage of the sensor).

So, for the 0...20 mA interface, the load resistance must be:

when U_P = 12 V – more than 288 Ohm;

when U_P = 15 V – more than 438 Ohm;

when U_P = 24 V – more than 888 Ohm;

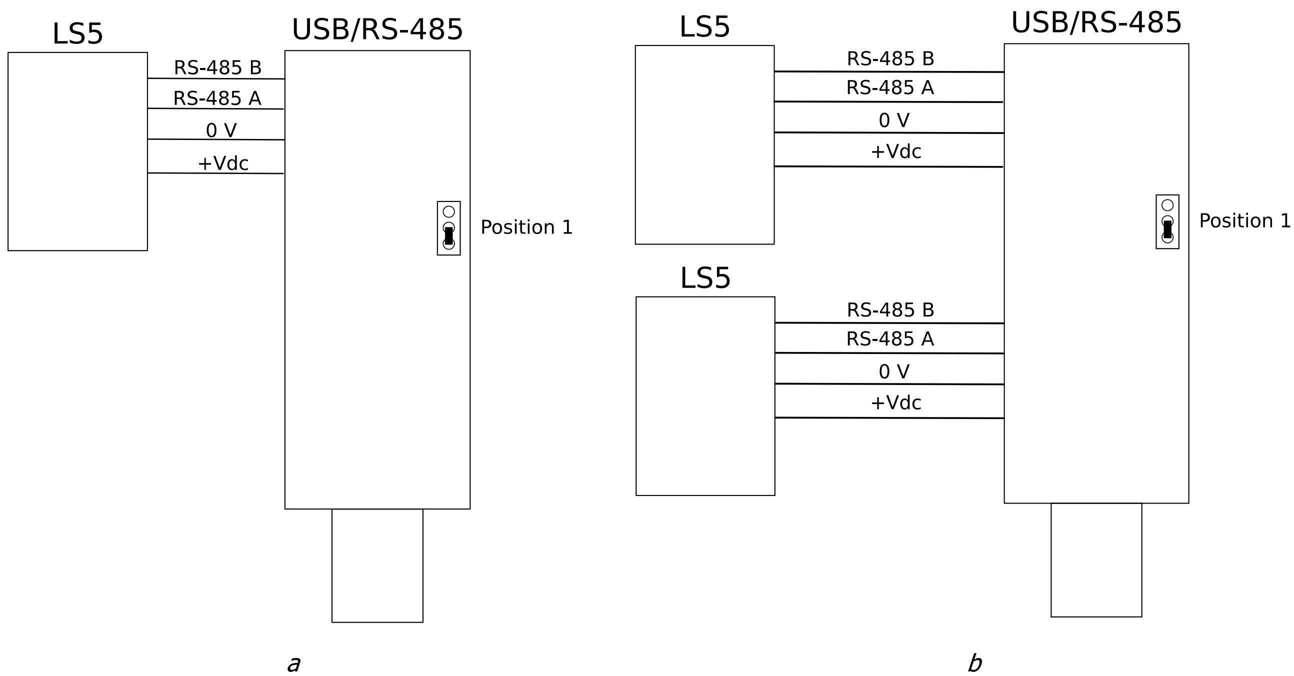
when U_P = 36 V – more than 1488 Ohm.

If the current loop resistance of the receiver is smaller than the calculated one, a resistor with resistance $R_L - R_R$ must be added in series in the circuit,

where R_L is the calculated minimum resistance;

R_R is the input resistance of the receiver.

When using the RS-485 digital interface, the outputs of the RS-485 A and RS-485 B sensor should be connected to the corresponding outputs of the interface adapter or converter, for example, USB/RS-485 by OOO "NPP "Prisma" (see the fig. 7.2, 7.3)



a – Connection for one LS5 sensor; *b* – Connection for two LS5 sensors

Figure 7.2 – Connecting LS5 sensors to the converter USB/RS-485 (sensors powered by USB, with 5V → 12V conversion, i.e. +Vdc = 12 V)

When connecting the LS5 sensors to the USB/RS-485 interfaces converter by OOO "NPP "Prisma", the sensor outputs "Power +" and "Power –" should be connected to the terminals of the converter connector "+Vdc" and "0 V" respectively (see the fig. 7.2, 7.3). If the interface converter jumper is in position 1, the sensors are powered by the internal voltage of the interface converter of 12 V (see the fig. 7.3).

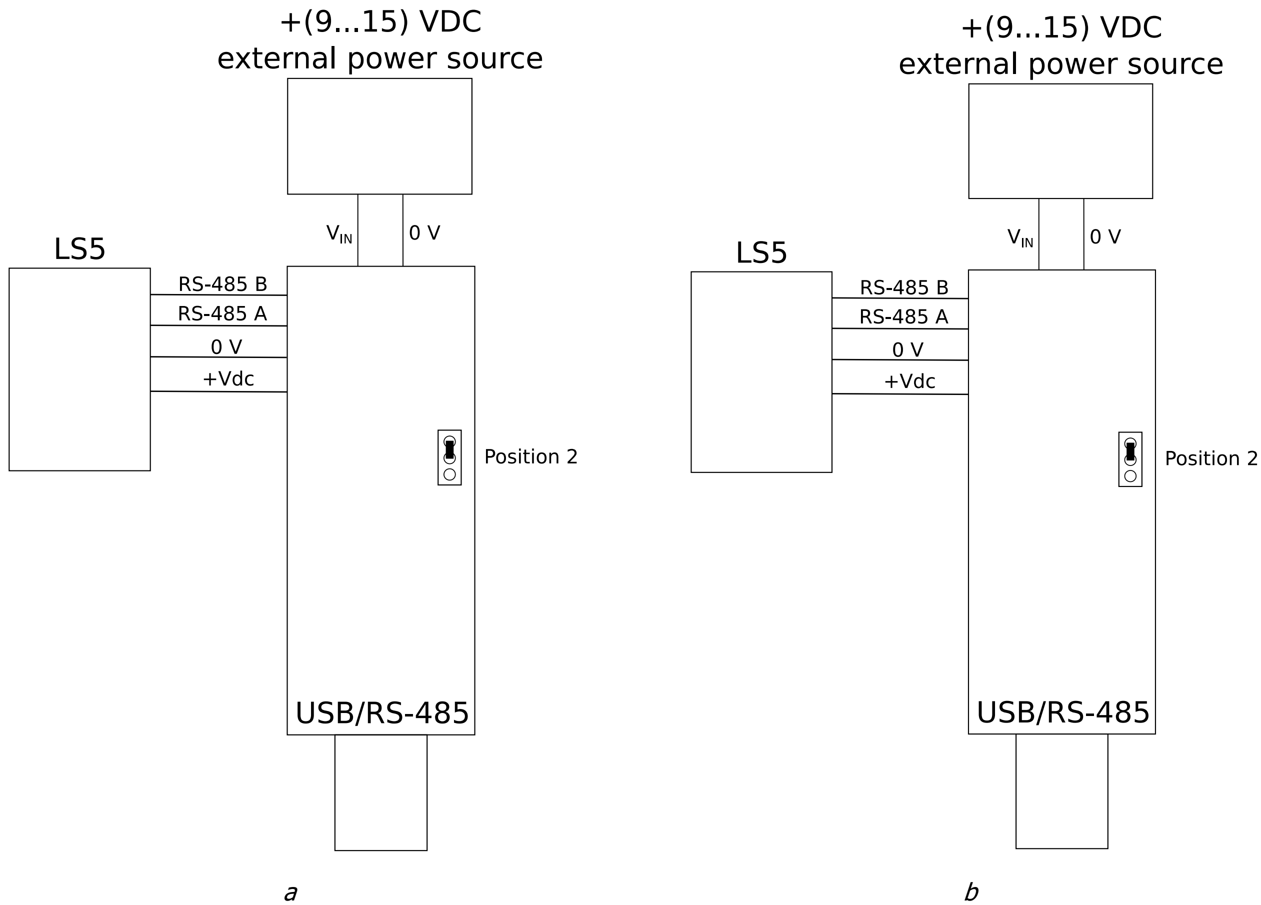


Figure 7.3 – Connecting LS5 sensors to a converter USB/RS-485 (sensors are powered by an external voltage source V_{IN})

When connecting the LS5 sensors according to the scheme shown in the figure 7.3, the LS5 sensors will be powered from an external source with the voltage V_{IN}, the interface converter jumper is in position 2.

The connection of the sensor to the equipment with a digital Ethernet interface is made according to the table 7.2 and figure 7.4.

Table 7.2 – The typical wire desoldering for connecting the sensor with digital interface Ethernet

Wire colour	**Name of the output**	**RJ-45 contacts**
white	Power «+»	–
brown	Power «–»	–
red-blue	RS-485 A	–
	RS-232 output	
gray-pink	RS-485 B	–
	RS-232 input	
black	analog output	–
gray	Ethernet TX+	1
pink	Ethernet TX-	2
green	Ethernet RX+	3
yellow	Ethernet RX-	6
blue	discrete output 1 (OC1)	–
violet	discrete output 2 (OC2)	–
red	Sync input	–
braid	case	–

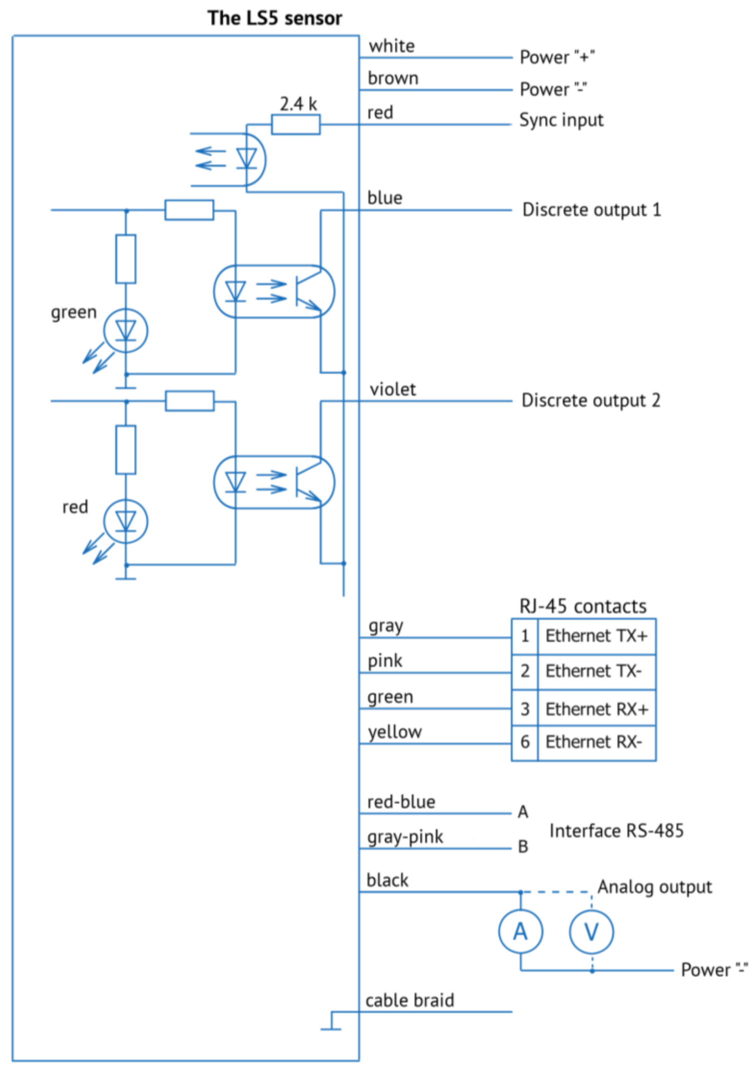


Figure 7.4 – The typical connecting the sensor with the digital interface Ethernet

8. SENSOR PARAMETERS AND TERMS FOR EXPLANATION

8.1. Network address

The network address is an address where the information exchange with the sensor goes through the serial interface. When connecting several sensors, each of them must have a unique address. The initial address set at the manufacturer is 01. If you need to send a single command to several sensors (a broadcast request), the network address 00 is used. The network address is stored in the sensor memory cell with address 01 (see the table 9.2).

8.2. The sensor is on/off. Sensor status when power is on

You can determine that the sensor is on by the presence of a red laser glow in the window. In this case the device is in constant measurement mode (according to the settings), i.e. the discrete outputs are updated, the analog output status is updated (if it is available and enabled), and the results output in a stream over the serial interface (if the stream is started). When enabled, the sensor always scans the network for commands.

If the sensor is off (not the power turned off, but a command), the device will switch to energy-saving mode, in which there is no irradiation of the measured object (there is no red glow) and no measurements are made. The sensor scans the network only for commands. When turned off, the discrete outputs are reset to zero, and the analog output remains in the state corresponding to the last measurement (if the sensor had made at least one measurement), or in the state of no result (the minimum value of current or voltage – for example, for a 4-20 mA setting, this is 4 mA).

Turning off the device also extends its service life, since the resource of the light-emitting component is not consumed. However, to make precise measurements, it is necessary to warm up the device after switching on, which is not always possible with frequent switching on/off.

In addition, new versions of LS5 sensors (starting from version LS5.6.0, the version can be recognized at identification) have some specific settings that may not allow the correct information exchange with the sensor over the serial interface on outdated hardware. These parameters include the serial interface settings (baud rate, byte format)[1]. For this case, a standby mode is provided when the sensor is powered on. The transition to this mode occurs if the value of baud rate more than 115200 baud is written in the non-volatile memory. In this mode, the following happens:

- when the power is turned on the laser lights up immediately;
- within 4 seconds, the sensor is initialized (internal settings, reading the parameters from the non-volatile memory);
- the sensor sets the serial interface to a simplified mode (19200 baud rate, no parity, 8 bits, 1 stop bit), the emitter is turned off;
- the sensor waits for 5 seconds for any commands to arrive (you can change the parameters "Baud rate" and "Byte format");
- the emitter lights up and the sensor sets up according to the saved parameters;
- 0.5 seconds after the last actuation of the irradiator, the sensor switches to operating mode.

The parameter "Sensor on/off when power is supplied" is stored in the sensor memory and can be changed at address 02 (see the table 9.2).

[1] See the table 9.2

8.3. The byte formats

The byte format for serial protocol operation specifies the availability of parity/odd control and the number of stop bits. This parameter is stored in the sensor memory and can be changed at address 04 (see the table 9.2).

8.4. Sensor measurement period and data output period

The sensor measurement period, t – the time interval between neighbouring measurements (see the figure 8.1).

A coefficient of the data stream thinning, n is the number of the results decimation in the data stream. When the stream is running, data is sent to the sensor output with a period $T=n\times t$ (see the figure 8.1). Note that the data transfer time is limited by the specified baud rate. For example, it is only possible to get a 1 kHz speed when the stream is started and 8-bit data format is set without parity and parity control if the baud rate is 115200 baud or higher. (Calculation: the data packet contains 7 bytes when the stream is running (see the table 9.1); it requires 10 bits to transmit one byte (start-bit, 8 data bits, stop-bit). 7·10·1/115200 = 0.61 ms; the baud rate of 57600 baud is no longer enough for 1 kHz: 7·10·1/57600 = 1.2 ms.)

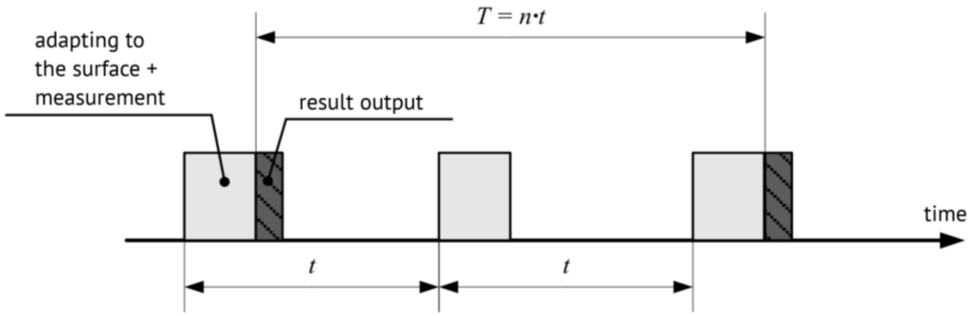


Figure 8.1 –Measurement period and coefficient of the data stream thinning for the case n=2

These two parameters are stored in the sensor memory and can be changed (see the table 9.2).

8.5. Maximum exposure time, measurement frequency priority and sensitivity priority [1]

As for any devices with photosensitive elements, it is fair to use the term exposure time (photodetector illumination) for LS5 sensors. To detect a signal from an object that is far from the sensor, the one which reflects the light weakly, it will take a longer exposure time than to detect a close and bright object, i.e. the longer the exposure time, the more sensitive the sensor is. When working, the sensor automatically adjusts the exposure time to get the highest signal-to-noise ratio.

Obviously, increasing the exposure time reduces the sensor's performance. Therefore, you have to choose a compromise between the desired measurement frequency and the sensitivity of the LS5. To achieve this, the exposure time is limited to a certain maximum exposure time, which is explicitly set as a parameter.

The default sensor setting is optimal for the majority of measurement tasks. However, for more fine-tuning, the sensors have the option to set either the measurement frequency priority or the sensitivity priority. When setting the frequency priority, the sensor is automatically adjusted to provide the specified measurement frequency (set by the parameter «Sensor measurement period»), the sensitivity (the exposure time) in this case is a secondary factor. When setting the sensitivity priority, the sensor tries to provide the best sensitivity, limiting only the maximum exposure time and neglecting the

[1] Available in sensors with firmware version "LS5.7.0" and higher.

specified measurement period, and only when the signal level is good, the sensor starts working at the specified frequency.

The parameters "Maximum exposure time" and "The measurement frequency/sensitivity priority" are stored in the sensor memory (see the table 9.2) and can be changed.

8.6. Acceptable time of signal absence

No signal – the state of the sensor when no result had been obtained during the measurement. The absence of a signal can be considered normal if there is no object in the measurement field. In all other cases, the absence of a signal is an operational error and it can be corrected. These cases include:

1) the shading in the area of the signal reflection (you should position the sensor so that the signal reflected from the object can falls freely into the lens);
2) a too dark (weakly reflects the light) or mirrored object is being measured. It can be corrected by setting more Maximum exposure time, but at the expense of the performance;
3) the sensor is used in poor conditions (dust, condensation of moisture on the glass of the device). In such situations, you should periodically wipe the sensor glass and monitor the cleanliness of the workspace.

Acceptable time of signal absense, τ – the time during which, in the absence of a signal, the result remains equal to the last measured value in the range. Configuring the τ parameter allows you to avoid the registration of the accidental signal absences when it is impossible to achieve good measurement conditions. The advantages of this method are illustrated in the fig. 8.2. This parameter is stored in the sensor memory (see the table 9.2) and can be changed.

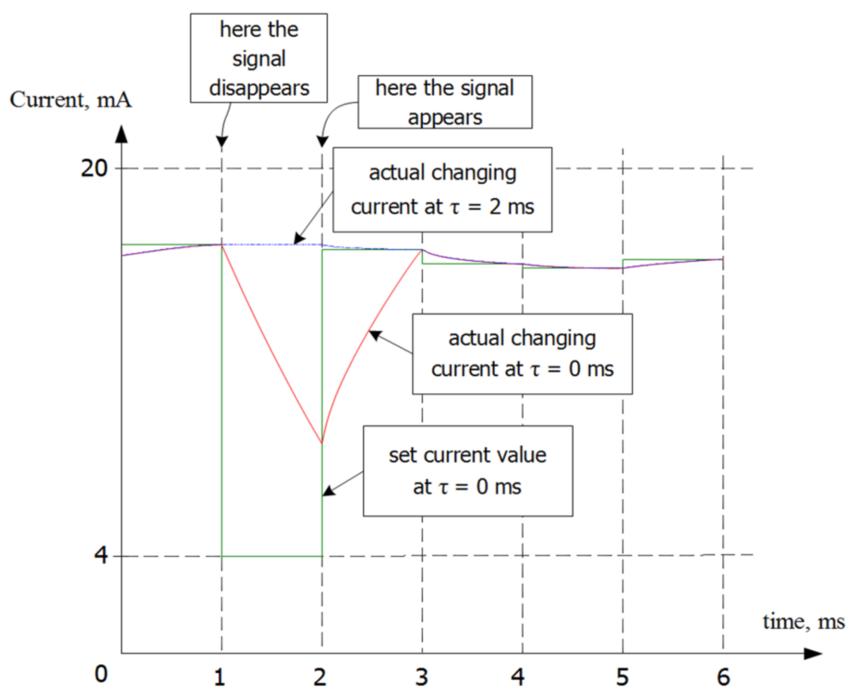


Figure 8.2 – Applying acceptable time of result absense on the example of the time diagram of analog output current (the analog output is set to a range of 4-20 mA, the measurement period is 1 ms, τ is the acceptable time of result absense)

8.7. The data pre-filtering

The data filtering is used to improve the accuracy of the sensor readings.

The **«Data pre-filtering type»** parameter sets the filter type: moving average filter or median filter. The figure 8.3 clearly shows the features of both filters.

The moving average filter is a linear filter and acts like a low-frequency filter.

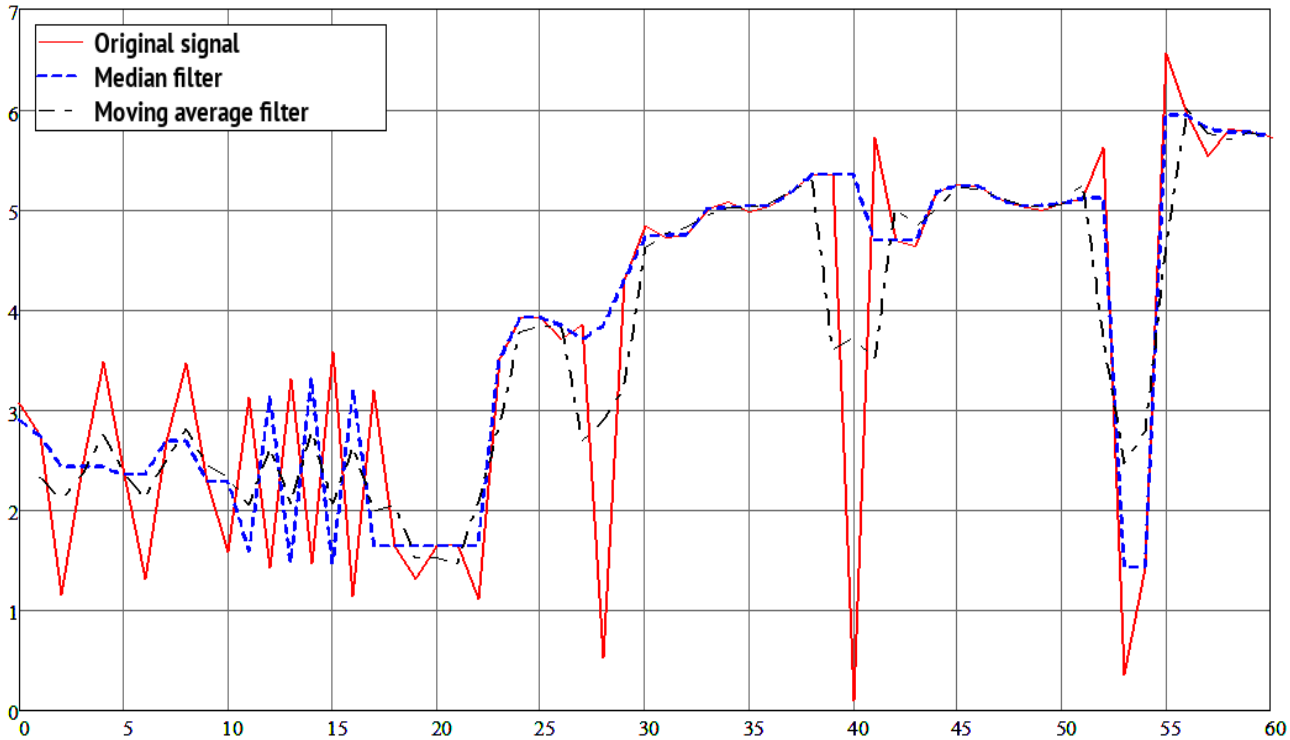


Figure 8.3 – Filtering the data array with a moving average filter (window k = 5) and a median filter (window m = 5)

A median filter with an optimally selected aperture can preserve sharp object boundaries without distortion, effectively suppressing uncorrelated or poorly correlated noise and small-sized details. This property allows you to apply median filtering to eliminate abnormal values in data arrays, reduce outliers, and reduce pulse noise. The median filter does not change step functions. This filter is non-linear and suppresses white and Gaussian noise less effectively than linear filters. The weak filter efficiency is also observed at the fluctuation noise filtration.

Number of averaging points, *k* – parameter for the moving average filter sets the degree of smoothing of the signal output by the sensor.

Number of points of the median filter, *m* – window (aperture) of the median filter, sets the filtration level

These parameters are stored in the sensor memory (see the table 9.2) and can be changed.

8.8. Type of preliminary result[1]

The "Type of preliminary result" parameter switches the possibility of the result output either in a net form (distance from the beginning of the range), or as a derivative of the distance (see the fig. 8.4).

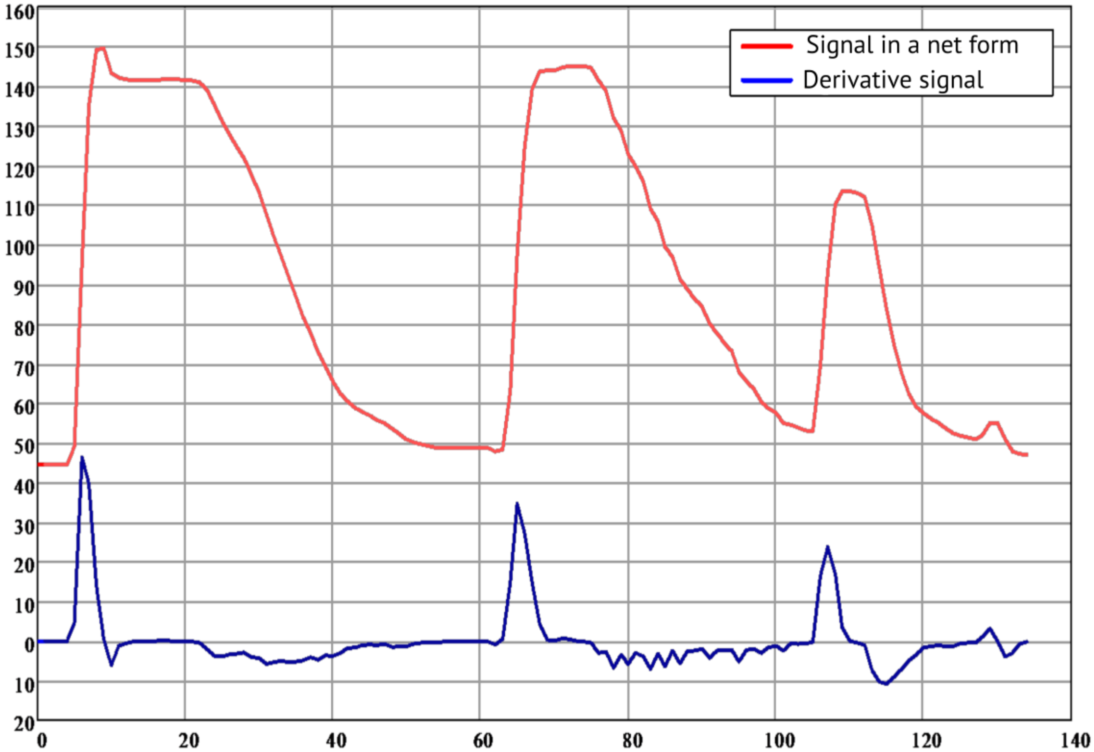


Figure 8.4 – Output by the sensor of results in a pure form and in the form of a derivative

This type of result processing is primary, i.e. the result obtained at this stage is the subject to the further processing according to the specified allowed time of the signal absence, filtering (see p. 8.7), and only then is output via digital and analog interfaces and to discrete outputs.

A derivative is the difference between the current and previous results. The derivative is convenient to use, for example, for controlling the discrete outputs as synchronizing signals.

The type of the preliminary result is selected in the memory cell of the sensor with the address `0E`. By default, the sensor is set to the "in its pure form" output mode (see the table 9.2).

8.9. The interpretation of the output result

Through the digital interface, the sensor measurement result is output as a code in the range from 0 to 50000. The code 0...50000 is also used when working with some sensor parameters related to the output result. Depending on the set parameter «Type of preliminary result», the code 0...50000 must be interpreted differently:

1) if the parameter «Type of preliminary result» equals 0x00 (the result is issued in the net form).

[1] This parameter is used in the upgraded versions of the sensors, starting from version LS5.8.0.

The number 0 is the starting point of the range, and the number 50000 is the end point. To calculate the actual range value relative to the starting point of the range, use the formula (8.1):

$$distance = range \cdot \frac{code}{50000}, \quad (8.1)$$

where the $code$ is the result issued by the sensor;

2) if the parameter «Type of preliminary result» equals 0x01 (the result is issued as a derivative of the distance).

The number 0 corresponds to the minimum value of the derivative, the number 50000 – the maximum value of the derivative, and the number 25000 – the zero value of the derivative. To calculate the actual value of the distance derivative, use the following formula:

$$distance\ derivate = range \cdot \frac{code - 25000}{50000}, \quad (8.2)$$

where the $code$ is the result issued by the sensor.

The result code is passed in five bytes of the ASCII code, i.e. from '00000' to '50000' (for more information, see section 9).

In addition to the range 0...50000, two special values are used:

65534 – to indicate that the sensor has not made any measurements yet and there is nothing to output yet;

65535 – to indicate that there is no signal.

8.10. Analog output

The range of the analog output, defined by the lower and upper bounds, specifies the range of sensor readings within its limits the signal on the analog output changes from minimum to maximum. The formula 8.3 mathematically expresses the relationship between the analog output readings, the sensor readings, and the «**Upper limit of the analog output**» и «**Lower limit of the analog output**» parameters.

$$A = \begin{cases} A_{\min} + (A_{\max} - A_{\min}) \cdot \dfrac{K - K_n}{K_v - K_n}, \text{ if } \left[\begin{array}{l} \begin{cases} K_n \le K \le K_v, \\ K_n < K_v \end{cases} \\ \text{or} \\ \begin{cases} K_v \le K \le K_n, \\ K_v < K_n \end{cases} \end{array} \right. \\ A_{\min}, \text{ if } \left[\begin{array}{l} \begin{cases} K \le K_n, \\ K_n < K_v \end{cases} \\ \text{or} \\ \begin{cases} K \le K_v, \\ K_v < K_n \end{cases} \\ \text{or} \\ K_v = K_n \end{array} \right. \\ A_{\max}, \text{ if } \left[\begin{array}{l} \begin{cases} K \ge K_v, \\ K_n < K_v \end{cases} \\ \text{or} \\ \begin{cases} K \ge K_n, \\ K_v < K_n \end{cases} \end{array} \right. \end{cases}, \quad (8.3)$$

where A is an analog output indication;

$A_{\min}$ – the minimum possible reading on the analog output (for example, for a 4-20 mA current output, it's 4 mA);

$A_{\max}$ – the maximum possible reading on the analog output (for example, for a 4-20 mA current output, it's 20 mA);

K – sensor reading in the code 0...50000;

K_n – the lower limit of the analog output (in the code 0...50000);

K_v – the upper limit of the analog output (in the code 0...50000).

The values of the lower and upper bounds can only be in the range 0÷50000. It is possible to invert the analog output (when $K_v < K_n$). To indicate the status «No signal» on the analog output, the setting to the extreme position is applied depending on the last measured value.

The figure 8.5 clearly describes the principle of scaling of the analog output. Another example of working with the analog output is illustrated in the p. 9.5.

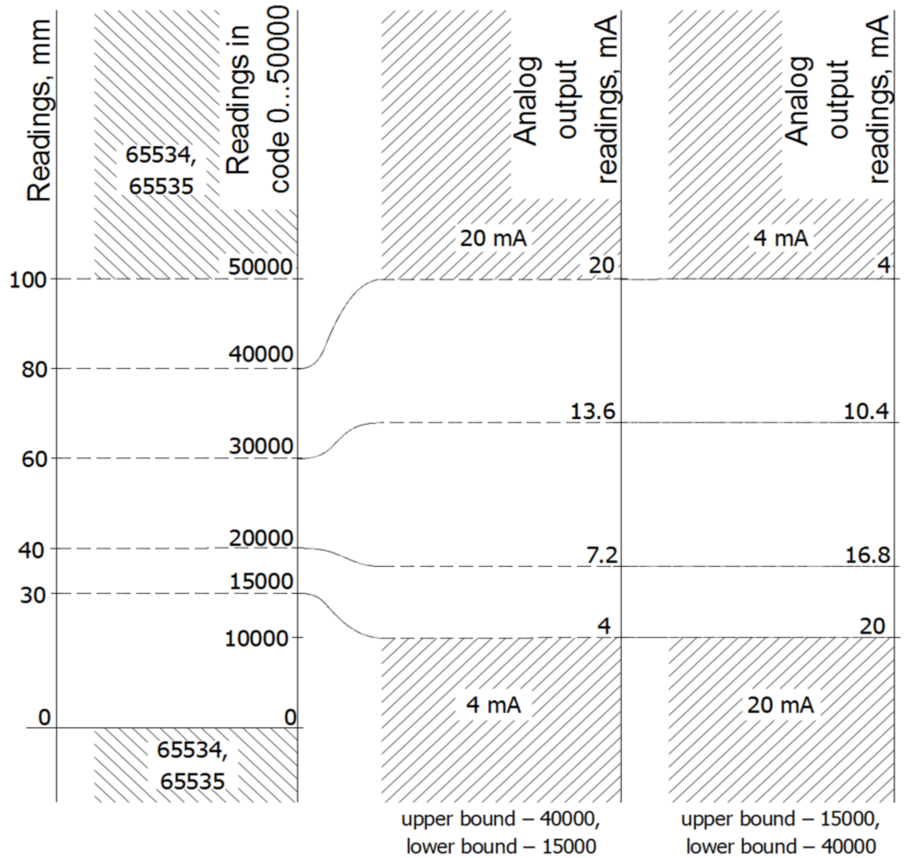


Figure 8.5– Scaling of the analog output for a sensor with a range of 100 mm. In this example, the current output of 4-20 mA is considered.

The analog output can be enabled or disabled by controlling the corresponding parameter (see the table 9.2).

If the analog output is disabled, its value remains the same as it was at the last measurement before the output was disabled.

The "Fixed range of analog output" parameter is only used at latching (see p. 8.14).

8.11. Parameters of discrete outputs

The LS5 sensors have 2 independent discrete NPN outputs (with an open collector) that can be used to control external devices. Each of the outputs has an initial value and the range, within its limits the output changes its value. The range is set by the setting of the first and second swing.

The first and second swing of the discrete output[1] – are two values (in the code 0...50000), when "skipping" them, the discrete output changes its state.

The initial value of the discrete output – is the value ("0" or "1") that it will accept for results below the level of the first swing or above the level of the second swing. For results which values are between the first and second levels of swings, the discrete output takes the level opposite to its "initial value of the discrete output". Thus, when the initial value of the discrete output is changed to the opposite, the switching characteristic of the discrete output is inverted. You can mathematically describe the state of the discrete output using the formula 8.4 (see also the figure 8.6):

[1] See the parameters "First swing of the first discrete output", "Second swing of the first discrete output", "First swing of the second discrete output" and "Second swing of the second discrete output" in the table 9.2

$$OC = \begin{cases} not(N), & if \quad K_{OC1} \le K \le K_{OC2}, \\ N, & if \quad K < K_{OC1} \ or \ K > K_{OC2} \end{cases}, \qquad (8.4)$$

where OC is the state of the discrete output;

K – sensor reading in the code 0...50000;

K_{OC1} – value of the first swing (in the code 0...50000);

K_{OC2} – value of the second swing (in the code 0...50000);

N – initial value of the discrete output;

not – inversion operator (the opposite value).

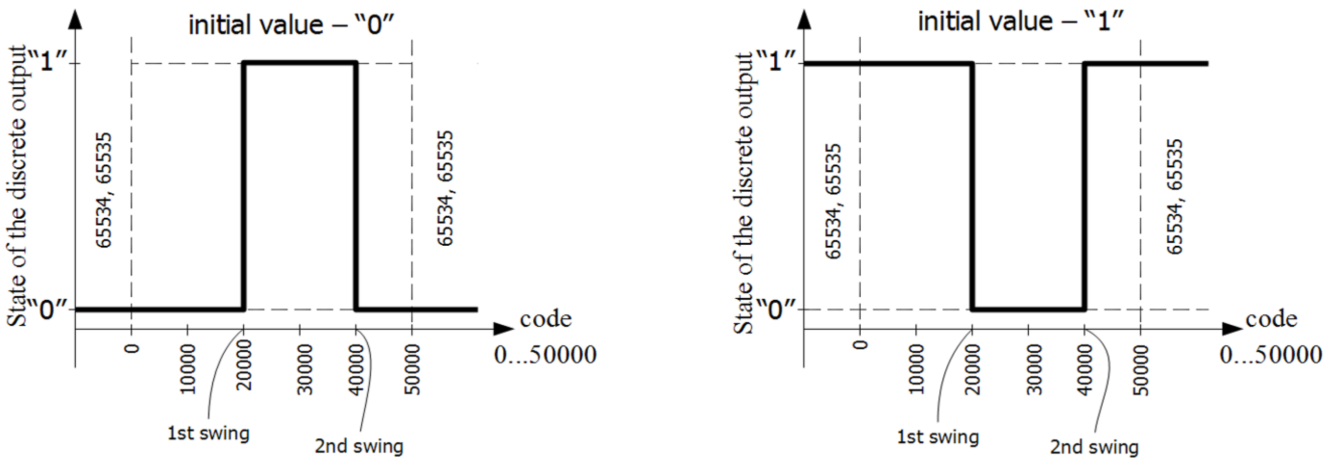


Figure 8.6 – The principle of operation of a discrete output with a value of the first swing 20000, the second swing – 40000.

The values of the lower and upper swings can only be in the range 0÷50000. The first swing of the discrete output must be less than (or equal to) the second swing of the same output. Otherwise, the functioning of the discrete output will be incorrect. In case of the signal loss (when the result code becomes 65535), the formula 8.4 is valid.

The "Fixed range of the discrete outputs" parameter is only used when latching (see p. 8.14).

8.12. The sequence of processing the result

The functional diagram in the figure 8.7 shows the sequence of applying filters and parameters used in the sensor for processing the measurement result.

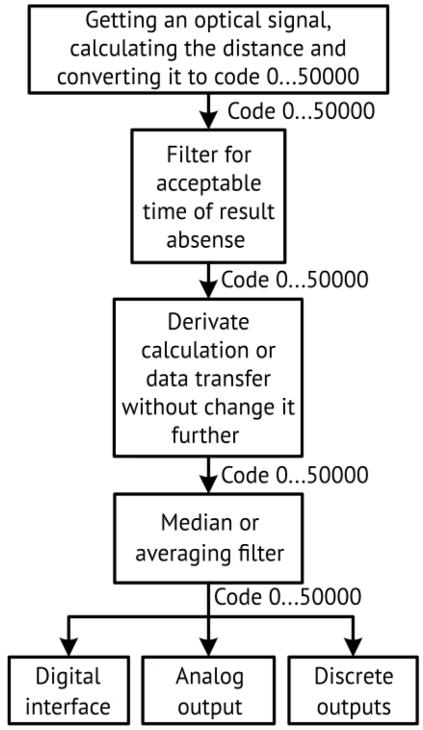


Figure 8.7 – Functional diagram of the sequence of preliminary processing of the measurement result

Note: After each measurement cycle, the result is saved in RAM, at the next measurement the old result is erased by the new one.

8.13. The measurements results output, triggering, latching

LS5 sensors provide the following methods for the measurement results output:

- continuously in the stream, after a single query (see the "Start the result stream" and "Stop the stream" commands in the table 9.1);
- request for a single output of the current result (see the "Read the last result" command in the table 9.1). The current result is updated with each measurement cycle;
- request for a single output of a latched result (a sequence of commands "Latch the result" and "Read the latched result" (see the table 9.1));
- a separate data stream over the Ethernet interface (in addition to the standard interface), if available (see the parameter "UDP data auto-stream" in the table 9.2 and section 10);
- through the analog output;
- indirectly – by swings in logical levels on pins with an open collector (see the figure 9.1).

The "Triggering" parameter specifies the method of the measurement's triggering:

– internal timer (according to the specified measurement period);

– the signal received at the external synchronization input (clocking).

When triggered by an internal timer, the sensor measures according to the set parameter "The sensor measurement period" (see the p. 8.4).

When triggered by an external signal, the sensor measures on a rising edge of the signal at the sync input. If the clock frequency exceeds the stated measurement frequency, the sensor will "skip" the clock cycles.

The "Triggering" parameter is stored in the sensor memory and can be changed at address 1E (see the table 9.2).

The sync input can also perform a latching (double the "Latch the result" command (see the table 9.1)). To do this, the "Latching" parameter must be bigger than 0 for any valid value of the "Triggering" parameter. The measurement process with subsequent latching will be triggered by the rising edge of the signal at the synchronization input, regardless of what operations were performed before in the sensor.

Consider an ambiguous situation when:

– the "Triggering" parameter is equal to 1 (clock on the external sync input);

– the "Latching" parameter is not equal to 0;

– the data stream is running (the command "Start the result stream" was sent).

In this case, each sync pulse will launch a single measurement with subsequent latching, there will be no data output in the stream, and the result can only be read with the commands "Read the latched result" or "Read the last result".

If the "Triggering" parameter is set to 0 under the same conditions, the sync signal will likewise start the measurement with a latching, and this process will take the priority over the processes controlled by the internal timer. In addition, there will be data output in the stream, controlled by an internal timer, but there may be delays or interruptions in data packets (the latching signal interrupts all processes and starts a new measurement).

If you want to obtain data in a stream with clock over the sync input, the "Latch" parameter must be set to 0. In this case, the latching can only be performed by sending the "Latch the result" command via the digital interface (see the table 9.1).

8.14. The latching with recalculation of the analog and discrete outputs limits

Starting from the "LS5.9.0" version, the sensors now have the capability to recalculate automatically the limits of the analog and discrete outputs.

The use of automatic recalculation allows you to abandon the computer or other microprocessor devices during the operation of automated control systems in conjunction with LS5 sensors. Recalculated values of the limits of a particular parameter, depending on the value of the parameter «Latching» can be automatically written to non-volatile memory, which also eliminates the need to send the sensor the command "Store current parameters to FLASH" using the other devices.

To automatically recalculate the limits of the analog and discrete outputs, the sensor must receive a sync input signal or a "Latch the result" command. The following parameters must be pre-set: «Latching» (set the desired value from 02 to 09), «Fixed range of the analog output» or «Fixed range of the discrete outputs» (see the table 9.2).

To convert the distance values to the sensor code from 0 to 50000 use the formula:

$$code = \frac{\text{distance}}{range} \cdot 50000, \tag{8.5}$$

where *distance* is the value of the distance to be represented in the sensor code from 0 to 50000, mm;

range – the measurement range of the sensor, mm.

The limits of the fixed range of the analog or discrete output are recalculated using the following formulas:

$$G_{\min} = \begin{cases} \operatorname{int}\left(K - \dfrac{D}{2}\right), \text{ if } 0 \le \operatorname{int}\left(K - \dfrac{D}{2}\right) \le 50000 \\ \text{or} \\ 0, \text{ if } \operatorname{int}\left(K - \dfrac{D}{2}\right) < 0 \\ \text{or} \\ 50000, \text{ if } \operatorname{int}\left(K - \dfrac{D}{2}\right) > 50000 \end{cases}, \quad (8.6)$$

$$G_{\max} = \begin{cases} \operatorname{int}\left(K + \dfrac{D}{2}\right), \text{ if } 0 \le \operatorname{int}\left(K + \dfrac{D}{2}\right) \le 50000 \\ \text{or} \\ 0, \text{ if } \operatorname{int}\left(K + \dfrac{D}{2}\right) < 0 \\ \text{or} \\ 50000, \text{ if } \operatorname{int}\left(K + \dfrac{D}{2}\right) > 50000 \end{cases}, \quad (8.7)$$

where $G_{\min}$ и $G_{\max}$ are the lower and upper limits of the required parameter, respectively;

K – the result of the measurement at latching (in the code 0...50000);

D – «Fixed range of the analog output» или «Fixed range of the discrete outputs» (in the code 0...50000);

int – mathematical rounding operator to the nearest integer.

Here is an example of setting up an automatic welding head positioning system based on the LS5 sensor (see the figure 8.8).

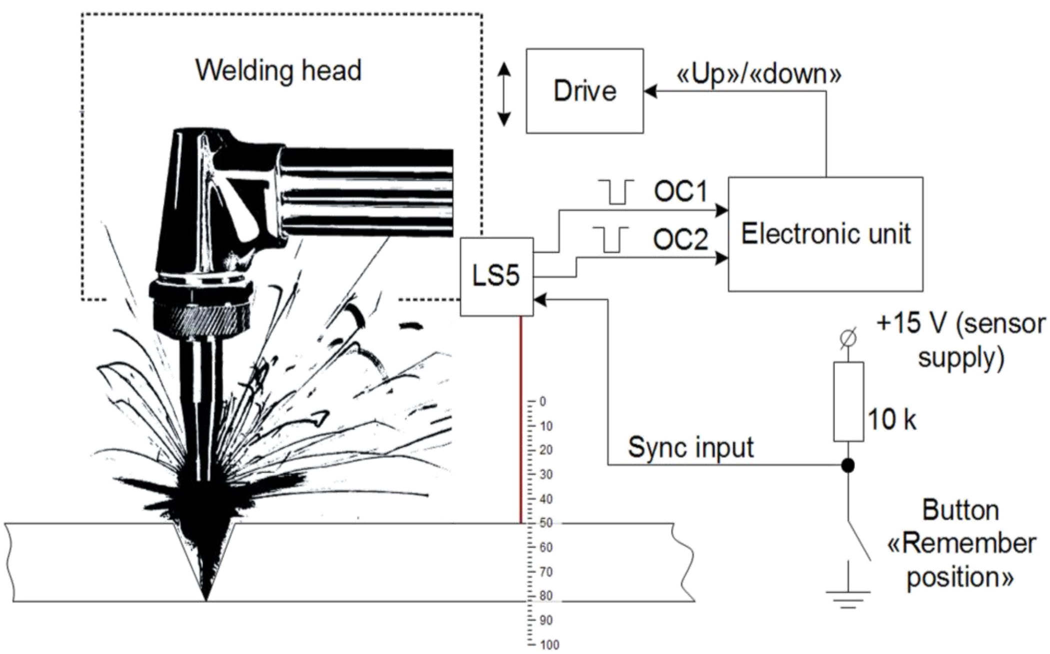


Figure 8.8 – Functional diagram of the automatic system welding head positioning

There is an installation where it is necessary to maintain the height of the welding head above the object in a specified range of distances (for example, ±10 mm) when moving along the weld. The burner can be positioned vertically using a drive. How automatize this process using a minimum of circuit technique? It is enough to attach a laser sensor LS5 with a range of 100 mm to the burner so that the plane with the welded objects is approximately in the middle of its working range. A button with a pull-up on the "plus" power supply is connected to the sync input of the sensor. Discrete outputs with an open collector "OC1" and "OC2" together with the simplest logic electronic unit send commands "Up", "Down", "In range" or "Out of range".

According to the formula (8.5) the parameter «Fixed range of the discrete outputs» for a sensor with a measuring range of 100 mm and a permissible height deviation of ±10 mm (i.e., in a span of 20 mm) should be equal to $\frac{20\ \text{mm}}{100\ \text{mm}} \cdot 50000 = 10000$.

Let’s assume that when the "Latch the result" command is given, the sensor has saved the code 25000.

Then the lower limit of the fixed range of discrete outputs is $G_{\min}$ by the formula (8.6):

$G_{\min} = 25000 - \frac{10000}{2} = 20000$ =4E20(HEX), and the upper limit of $G_{\max}$ by the formula (8.7):

$G_{\min} = 25000 + \frac{10000}{2} = 30000$ =7530(HEX).

The diagram of operation of discrete outputs should look like this:

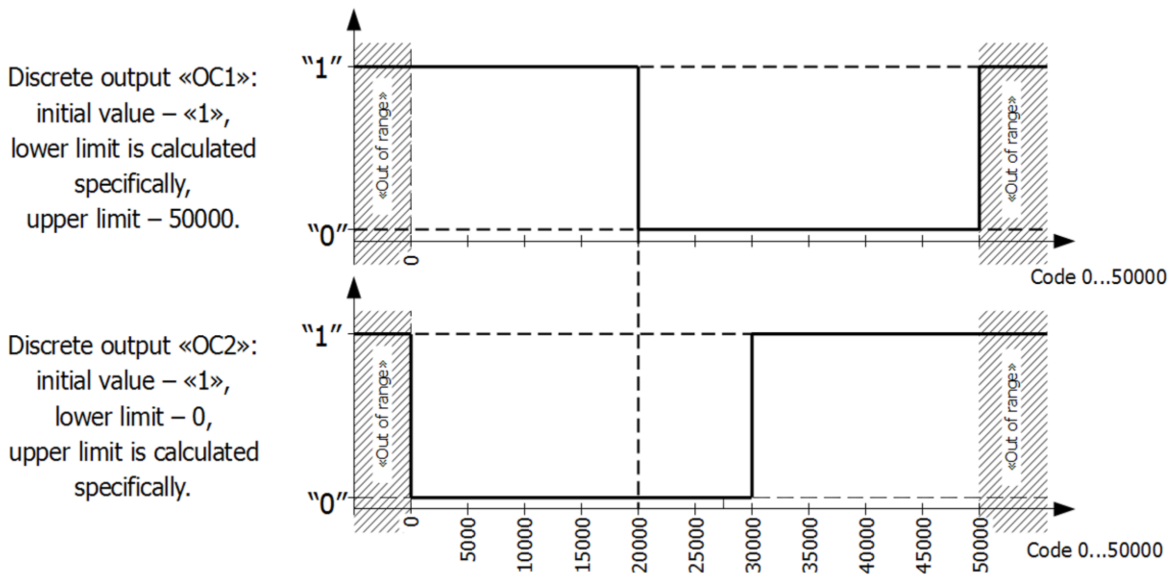


Figure 8.9 – The diagram of operation of discrete outputs for drive control

It is necessary to use both discrete outputs, and it is desirable to save the sensor settings after power off, so, it is advisable to set the parameter «Latching» to «09» (see the table 9.2).

To remember the level of tracking move the welding head to the desired height and press the button. This way the sensor will recalculate the lower limit of the 1st discrete output and the upper limit of the 2nd discrete output.

Thus, it is enough to set the sensor parameters once on the computer, and then use only the button to set the tracking level.

Analog output can also be used to design such automated control systems.

9. DESCRIPTION OF THE PROTOCOL OF THE SERIAL INTERFACE EXCHANGE

9.1. Overview

Depending on the sensor modification, the RS-232 or RS-485 interface is used. On the software side, the exchange on both interfaces is exactly the same. Differences exist only on the physical level.

When exchanging data over the serial interface, the "request-response" principle is applied, i.e. after sending a command to the sensor, it, in turn, must issue a response. All data over the serial interface is transmitted in ASCII format. The sensor has its own network address (from 1 to 255), which is used when accessing this sensor. The broadcast commands sent to address 0 are used to access all sensors in the network. There is no response to broadcast requests.

At the customer's request, the Modbus RTU Protocol can be used for the connection with the sensor (for more information, see the «LS5 Sensor. Data exchange protocol based on Modbus RTU v.1.1b»).

9.2. List of commands for using the serial interface

Each request command starts with the «**#**» character (code **0x23**) and two characters corresponding to the sensor's network address, and ends with the **<cr>** character (code **0x0D**). The response packet starts with the character «**!**» (code **0x21**) and ends with the character **<cr>** (code **0x0D**). Exceptions are the identification (the response packet uses the «**%**» symbol instead of the «**!**» symbol), the output to the stream (packets with results are issued endlessly in response to the start of the stream), and the cases of the broadcast requests (the sensor does not respond to the broadcast requests).

The data stream is used to eliminate the need to send a request to read each measured value. This significantly increases the speed of the exchange over the serial interface and almost allows you to read 1000 results per second at a baud rate of 230400 baud.

The default mode for sensors is "UDP data auto-stream". It means that when the power is turned on, the sensor automatically outputs the measurement results. You can disable this mode by sending the command **#[AA]W7000<cr>**, where **[AA]** is the network address of the sensor (see the table 9.1).

To stop the stream, use the **#[AA]SB<cr>** command. It also suits if you need to get a response confirmation. In addition, the sensor stops output to the stream if it gets at least one correct byte.

The table 9.1 shows the entire list of commands used for working with LS5 sensors.

Table 9.1 – List of commands

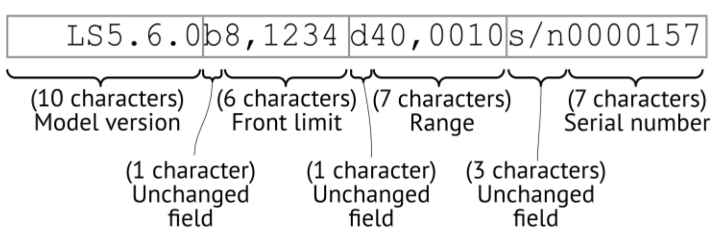
Command name	Request format	Response format
Identification	`#[AA]ID<cr>`	`%[AA][35 bytes]<cr>`
Read the parameter	`#[AA]Raa<cr>` `aa` – parameter's address (HEX)	`![AA]Raadd<cr>`
Write the parameter	`#[AA]Waadd<cr>`[1] `aa` – parameter's address (HEX) `dd` – parameter value (HEX)	`![AA]Waadd<cr>`[2]
Save parameters to non-volatile memory (Store current parameters to FLASH)	`#[AA]FL<cr>`[1]	`![AA]FL<cr>`[2]
Turn on the sensor	`#[AA]ON<cr>`[1]	`![AA]ON<cr>`[2]
Turn off the sensor	`#[AA]OF<cr>`[1]	`![AA]OF<cr>`[2]
Latch the result	`#[AA]FX<cr>`[1]	`![AA]FX<cr>`[2]
Start the result stream	`#[AA]ST<cr>`	Stream of result in format: `![5 bytes of result]<cr>`
Stop the stream	`#[AA]SB<cr>`[1]	`![AA]SB<cr>`[2]
Read the latched result	`#[AA]FR<cr>`	`![AA]FR[5 bytes of result]<cr>`
Read the last result	`#[AA]LR<cr>`	`![AA]LR[5 bytes of result]<cr>`
Restoring default parameters	`#[AA]DF<cr>`[1]	`![AA]DF<cr>`[2]

Notes:

[1] A broadcast request is supported (send a command to address 0).

[2] No response in the case of a broadcast request

It is worth to mention the identification of the sensor. As indicated in the table 9.1, a field of 35 ASCII characters is returned in response to the identification request. This field has its own strictly fixed fields of 10, 7, 8, and 10 characters. Take a look at a specific example:



Here you can find out the device version (LS5.6.0), the lower boundary (8.1234 mm), the range (40.001 mm), and the serial number (157).

As you can see, integers and fractions in the identification field are written in a line. To get a specific numeric value, use the standard functions (when writing computer software) to convert string variables to a floating-point variable (note that the decimal separator is a comma).

The range value is used directly when converting the code 0...50000 to a value in millimeters. A control device that communicates with one or more sensors can automatically correlate the sensor serial number and its range, which makes it easier to replace sensors with different ranges.

9.3. The sensor parameters setting

Each parameter has its own address in the sensor memory. The parameter is read by a command **#[AA]Raa<cr>**, record – by a command **#[AA]Waadd<cr>**. Parameters are recorded in the sensor's RAM. It means that the next time the sensor is turned on, the parameters will return to their old values. To save the parameters in non-volatile memory for the subsequent automatic installation, enter the command **#[AA]FL<cr>** each time after the recording.

The table 9.2 shows all information about the value of parameters and their addressing.

Table 9.2 – The sensor parameters setting

Name of parameter	Accepted values	Default values (HEX)	Parameter's address (HEX)
Network address	01-FF	01	01
Sensor on/off when power is supplied	00 – off 01 – on	01	02
Analog output is enabled/disabled	00 – disabled 01 – enabled	01	03
Byte format at work with serial protocols	00 – no parity, 1 stop bit; 01 – parity control, 1 stop bit; 02 – imparity control, 1 stop bit; 03 – no parity, 2 stop bits; 04 – parity control, 2 stop bits; 05 – imparity control, 2 stop bits.	00	04
Baud rate	01 – 9600 baud; 02 – 19200 baud; 03 – 38400 baud; 04 – 57600 baud; 05 – 115200 baud; 06 – 230400 baud[2]; 07 – 460800 baud[2]; 08 – 921600 baud[2].	05	05
Measurement period (discrete – 0.1 ms, minimum value – 0.1 ms), *t*: *t* = (parameter value)×0,1 [ms]. Example: for *t* = 1 ms parameter is 000A; for *t* = 5,2 ms parameter is 0034. low byte high byte	For the parameter itself: 0001-FFFF 00-FF 00-FF	(corresponds 10 ms) 64 00	 06 07
Coefficient of the data stream thinning, n=T/t, where *t* is the sensor measurement period,	01 – FF[1]	01	08

Name of parameter	Accepted values	Default values (HEX)	Parameter's address (HEX)
T – the period when the sensor issues the results.			
Acceptable time of signal absense (discreteness – 1 ms), τ [ms]: τ = (parameter value)·1 [ms]. Example: for τ= 0 ms parameter is 0000; for τ= 10 ms parameter is 000A. low byte high byte	For the parameter itself: 0000-FFFF 00-FF 00-FF	(corresponds 10 ms) 0A 00	 09 0A
Data pre-filtering type	00 – averaging over n values; 01 – median filtering	00	0B
Number of averaging points, *k*	01-FF (from 1 to 255)	01	0C
Number of points of the median filter, *m* (must be odd: *m* = 2*h* + 1, where *h* = 0, 1, …, 24)	01, 03, 05, …, 31	05	0D
Type of preliminary result	00 – in its pure form; 01 – the derivative of the signal (the difference between the current and previous results)	00	0E
Lower limit of the analog output: low byte high byte	 00-FF 00-C3	 00 00	 11 12
Upper limit of the analog output: low byte high byte	 00-FF 00-C3	 50 C3	 13 14
Discrete outputs setting	XX, Where the first digit is responsible for the first output, the second – for the second. 0 – the discrete output is disabled; 1 – the discrete output is enabled (initial value is 0); 2 – the discrete output is enabled (initial value-1); Example: 12 the first output is enabled with the initial value "0", the second output is enabled with the initial value "1".	12	15
First swing of the first discrete output: low byte high byte	 00-FF 00-C3	 00 00	 16 17

Name of parameter	Accepted values	Default values (HEX)	Parameter's address (HEX)
Second swing of the first discrete output: low byte high byte	 00-FF 00-C3	 50 C3	 18 19
First swing of the second discrete output: low byte high byte	 00-FF 00-C3	 00 00	 1A 1B
Second swing of the second discrete output: low byte high byte	 00-FF 00-C3	 50 C3	 1C 1D
Triggering	00 – by timer 01 – by an external synchronization input	00	1E
Latching	00 – disabled; 01 – enabled, only with a record in the latch; 02 – enabled, except for recording in the latch, the limits of the analog output are recalculated (taking into account the parameter «Fixed range of the analog output»); 03 – the same for the value 02, only the values of the analog output limits are still recorded to the ROM; 04 – enabled, except for recording in the latch, the limits of the 1st discrete output are recalculated (taking into account the parameter «Fixed range of the discrete outputs»); 05 – the same for the value 04, only the values of the limits of the 1st discrete output are still recorded in the ROM; 06 – enabled, except for recording in the latch, the limits of the 2nd discrete output are recalculated (taking into account the parameter «Fixed range of the discrete outputs»); 07 – the same for the value 06, only the values of the limits of the 2nd discrete output are still recorded in the ROM; 08 – enabled, in addition to recording to the latch, the lower limit of the 1st and upper limit of the 2nd discrete outputs are recalculated (taking into account the parameter «Fixed range of the discrete outputs»); 09 – the same for the value 08, only the values of the limits of the corresponding discrete outputs are still recorded in the ROM.	01	1F

Name of parameter	Accepted values	Default values (HEX)	Parameter's address (HEX)
Maximum exposure time[3], μs:	For the parameter itself: 0001-FFFF	(9400 μs)	
low byte	00-FF	B8	20
high byte	00-FF	24	21
Priority of measurement of frequency/sensitivity[3]	00 – priority of the measurement frequency 01 – sensitivity priority	01	22
Fixed range of the analog output[4]:	For the parameter itself: 0001-FFFF		
low byte	00-FF	10	23
high byte	00-FF	27	24
Fixed range of the discrete outputs[4]:	For the parameter itself: 0001-FFFF		
low byte	00-FF	10	25
high byte	00-FF	27	26
Sensor IP address[5]		(192.168.0.3)	
0 byte	0-FF	C0	50
1st byte	0-FF	A8	51
2nd byte	0-FF	00	52
3rd byte	0-FF	03	53
Gateway IP address[5]		(192.168.0.1)	
0 byte	0-FF	C0	54
1st byte	0-FF	A8	55
2nd byte	0-FF	00	56
3rd byte	0-FF	01	57
Subnetwork mask[5]		(255.255.255.255)	
0 byte	0-FF	FF	58
1st byte	0-FF	FF	59
2nd byte	0-FF	FF	5A
3rd byte	0-FF	FF	5B
Destination IP address[5]		(255.255.255.255)	
0 byte	0-FF	FF	5C
1st byte	0-FF	FF	5D
2nd byte	0-FF	FF	5E
3rd byte	0-FF	FF	5F
The MAC address of the sensor[5]			
0 byte	0-FF	1E	60
1st byte	0-FF	30	61
2nd byte	0-FF	6C	62
3rd byte	0-FF	A2	63
4th byte	0-FF	XX	64
5th byte	0-FF	YY	65
		(where **XX** – is the high byte, **YY** – is	

Name of parameter	Accepted values	Default values (HEX)	Parameter's address (HEX)
		the low byte of the sensor's serial number)	
Destination MAC address[5] 0 byte 1st byte 2nd byte 3rd byte 4th byte 5th byte	 0-FF 0-FF 0-FF 0-FF 0-FF 0-FF	 FF FF FF FF FF FF	 66 67 68 69 6A 6B
Destination port number[5] high byte low byte	For the parameter itself: 0001-FFFF 00-FF 01-FF	(603) 02 5B	 6C 6D
Source port number[5] high byte low byte	For the parameter itself: 0001-FFFF 00-FF 01-FF	(5000) 13 88	 6E 6F
UDP data auto-stream[5]	00 – off 01 – on	01	70

Notes:

[1] For n=01, the data output period is $T=t$; for n=FF, the period is $t=255 \cdot t$.

[2] Available in LS5 versions.6.0 and higher (you can find out the version when you identify the sensor).

[3] Available in versions LS5.7.0 and higher.

[4] Available in versions LS5.9.0 and higher.

[5] Available in LS5.12.x versions and only in the Ethernet sensors.

9.4. Examples of the sensor communication sessions over the serial interface

Command description	Type of transmission	View in ASCII	View in HEX
Turn on the sensor with address 01	request	#01ON<cr>	0x23 0x30 0x31 0x4F 0x4E 0x0D
	response	!01ON<cr>	0x21 0x30 0x31 0x4F 0x4E 0x0D
Set the median filtering for the sensor with address 02	request	#02W0B01<cr>	0x23 0x30 0x32 0x57 0x30 0x42 0x30 0x31 0x0D
	response	!02W0B01<cr>	0x21 0x30 0x32 0x57 0x30 0x42 0x30 0x31 0x0D

9.5. An example of the use of analog and discrete outputs

The figure 9.1 shows the time diagrams of the sensor when using the analog and discrete outputs. The table 9.3 for this case shows the sensor parameters and the instructions for setting them.

Table 9.3 – Sensor parameters with address 1 and instructions for setting them (for the example shown in the figure 9.1)

Parameter	Configuration commands (view in ASCII)
1st discrete output is enabled, the initial value is 0. 2nd discrete output is enabled, the initial value – 1.	**#01W1512<cr>**
The first swing of the 1st discrete output equals **20000** (**0x4E20**)	**#01W1620<cr>** **#01W174E<cr>**
The second swing of the 1st discrete output equals **40000** (**0x9C40**)	**#01W1840<cr>** **#01W199C<cr>**
The first swing of the 2nd discrete output equals **10000** (**0x2710**)	**#01W1A10<cr>** **#01W1B27<cr>**
The second swing of the 2nd discrete output equals **30000** (**0x7530**)	**#01W1C30<cr>** **#01W1D75<cr>**
Analog output is enabled	**#01W0301<cr>**
The lower limit of the analog output is **0** (**0x0000**)	**#01W1100<cr>** **#01W1200<cr>**
The upper limit of the analog output is **50000** (**0xC350**)	**#01W1350<cr>** **#01W14C3<cr>**

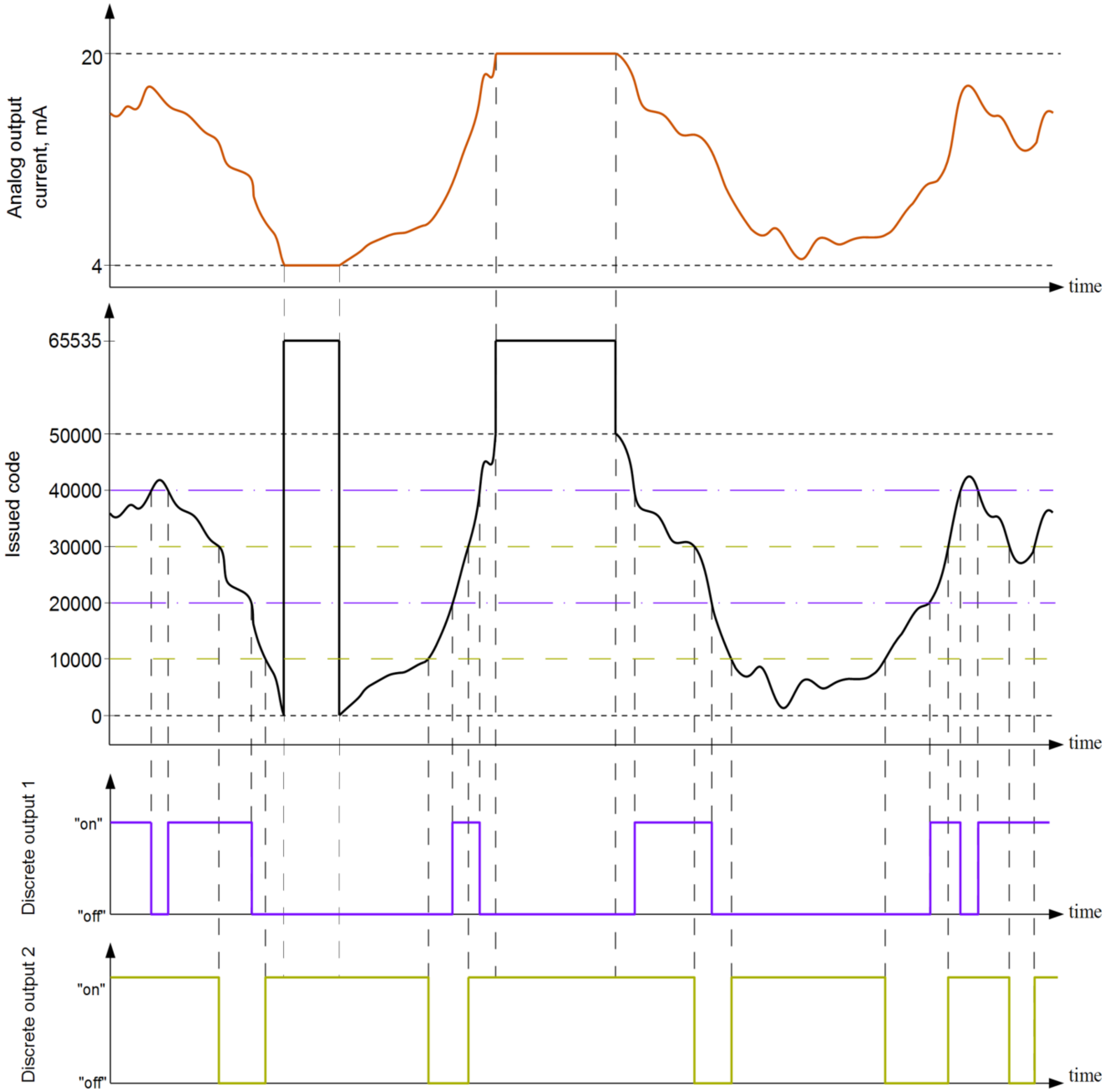


Figure 9.1 – Time diagrams of the sensor operation in the "in-stream" output mode, with discrete outputs enabled and analog current output enabled

10. DESCRIPTION OF THE ETHERNET INTERFACE

The Ethernet interface is only used for the one-way transmission of the measurement stream. The search of the sensors and the parameters setting are via the serial interface. At the customer's request, the Modbus RTU Protocol can be used for the connection with the sensor (for more information, see the «LS5 sensor. Data exchange protocol based on Modbus RTU v.1.1b»).

To transmit data using the Ethernet interface, the internal sensor transfer buffer is first filled with the measurement results according to the set synchronization type and the data output period. The size of the internal buffer is 168 measurements. After the buffer flow, a UDP packet with data is generated and issued. The following network settings are recorded in the sensor by default:

Name of parameter	Default value
Sensor IP address	192.168.0.3
Destination IP address	255.255.255.255
Gateway IP address	192.168.0.1
Subnetwork mask	255.255.255.255
The MAC address of the sensor	**1E:30:6C:A2:XX:YY** (where **XX** – is the high byte, **YY** – is the low byte of the sensor's serial number)
Destination MAC address	**FF:FF:FF:FF:FF:FF**
Destination port number	603
Source port number (sensor)	5000

10.1. The format of the data packet

The sensor transmits a 512-byte UDP packet in the following format:

Byte number	Designation
 0 1	Measurement 1 low byte high byte
2	State word for the measurement 1
 3 4	Measurement 2 low byte high byte
5	State word for the measurement 2
...	...
 501 502	Measurement 168 low byte high byte
503	State word for the measurement 168

Byte number	Designation
 504 505	The serial number of the sensor low byte high byte
 506 507	The lower boundary of the sensor low byte high byte
 508 509	The measurement range of the sensor low byte high byte
510	Cyclic packet number counter
511	The checksum of the package

The measurement result is passed as a two-byte number in the code from 0 to 4000h. To get the measurement result in millimeters, use the formula (10.1):

$$distance = range \cdot \frac{code}{4000h} \tag{10.1}$$

The state word has a dimension of 1 byte. The state of bit 0 is "0" if the measurement has not yet been performed. Otherwise, the "1" is passed.

The state of bit 1 is always "1".

The state of bit 2 is "0" if the result is "OUT OF RANGE", the "1" – otherwise.

The state of bit 3 is "0" if the result corresponds to the distance in pure form, "1" – the result corresponds to the distance derivative.

The remaining bits of the status word are reserved and are always "0" when read.

The cyclic packet number counter is incremented when each packet is transmitted and is used to control the packet loss when data is received.

The packet checksum is calculated as excluding OR all bytes from the UDP packet data field, excluding the byte of the packet number loop counter.

11. MANUFACTURER'S WARRANTY

The manufacturer guarantees that the sensors comply with the technical conditions and that they will work without failure for 24 months from the date of purchase at following the terms of operation, transportation, storage and installation.

The time spent by the sensors in the warehouse for 6 months is not included in the warranty period if the storage conditions are met.

In the event of a malfunction of the sensor in compliance with the required conditions of operation, transportation and storage, the manufacturer is obliged to eliminate the malfunction free of charge. In this case, the warranty period is extended for the time elapsed from the date of filing the complaint until the sensor is put into operation.

The manufacturer reserves the right to make changes to the design that do not impair the technical characteristics of the product.

The manufacturer prematurely removes its warranty obligations in case of non-compliance with the conditions of operation, transportation, and storage.

12. MAINTENANCE AND REPAIR

12.1. Overview

The maintenance of the sensor during operation consists of technical inspection of the sensor, and calibration of its metrological characteristics.

The technical inspection of the sensor is performed by the service personnel at least once a month and includes the following operations:

- cleaning of the sensor case from dust and dirt;
- wiping the protective glasses with a soft cloth soaked in rectified alcohol as they dirty;
- checking the quality of sensor fixation;
- checking of the reliability of the connection of external networks.

When cleaning the sensor’s protective glasses do not use abrasive cleaning agents that can cause scratches.

Defects found during the inspection should be immediately eliminated.

During the maintenance, one should follow the safety measures described in this 2 technical description.

12.2. Calibration of sensors

The sensor should be calibrated once a year, in the case of repairs – immediately after the repair.

The calibration of the sensor should be carried out according to MP 06-233-2009 "GSI. Laser triangulation sensors LS5. Calibration procedure".

The information about verification should be input in the table 10.1, section 10 of the operating manual of the LD.5.001 RE sensor.

12.3. Sensor repair

The sensor repair is carried out by the manufacturer OOO "NPP "Prisma":

http://www.prizmasensors.ru

e-mail: prizma_sensors@inbox.ru

tel: +7(343)268-45-72