

**RIFTEK**  
Sensors & Instruments



## OPTICAL SPEED AND LENGTH SENSORS

### ISD-3 Series

#### User's manual

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## 1. Overview

The main purpose of the Sensor is high precision measurement of speed and traveling distance of the vehicle relative to ground (automotive and railroad application) and speed and length of objects moved relative to the sensor (industrial application).

**Measuring principle** – raster spatial filtration of an object image, technology is patent pending.

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### Main features of the ISD-3 family:

- High precision of measurement: 0,03 – 0,1% RMS in industrial, 0,1 – 0,2% RMS of velocity and <0,1% of distance (>100m) in automotive application.
- Reliable measurements on virtually all types of surfaces.
- Broad range of nominal working distances – from 10 cm to 150 cm and it can vary up to 2,5 times during measurements.
- Big lens aperture – geometric aperture ratio up to 1:4. As a sequence, 10 Wt of halogen lamp or even IR diode of 2 Wt electrical power is enough for object illumination in most cases
- Low weight and power consumption of controller module (1,5 Wt) due to last generation of ARM microcontrollers used.

## 2. Safety precautions

- Use supply voltage and interfaces indicated in the sensor specifications.
- In connection/disconnection of cables, the sensor power must be switched off.

## 3. Electromagnetic compatibility

The sensors have been developed for use in industry and meet the requirements of the following standards:

- EN 55022:2006 Information Technology Equipment. Radio disturbance characteristics. Limits and methods of measurement.
- EN 61000-6-2:2005 Electromagnetic compatibility (EMC). Generic standards. Immunity for industrial environments.
- EN 61326-1:2006 Electrical Equipment for Measurement, Control, and Laboratory Use. EMC Requirements. General requirements.

## 4. General Information

Currently ISD-3 family included 2 models with different versions with working range from 10 cm up to 100 cm and more. Custom-ordered configurations are possible with parameters different from those shown below.

Coming soon are 2-Dimensional sensors to measure, for instance, longitudinal speed of rotating tubes in tube-rolling mill, or transversal displacement of moving objects.

Although a special version of sensor for road application in automotive testing industry will be available soon.

## 5. Main Technical Data (vehicle application)

| Parameters                                                             | Value                                                                                                                                                                                                                                                                                                                                                   | Comments                                                                                                       |
|------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------|
| Parameter                                                              | Value                                                                                                                                                                                                                                                                                                                                                   | Notes                                                                                                          |
| Speed range                                                            | 0,2 – 250 Km/h                                                                                                                                                                                                                                                                                                                                          | At TTLout 400 Hz per m/s. Others on request                                                                    |
| Speed accuracy*                                                        | $\leq \pm 0,15$ % RMS                                                                                                                                                                                                                                                                                                                                   | Determined on test bench (treadmill) at 18,38 km/h                                                             |
| Absolute distance accuracy*                                            | $\leq \pm 0,1$ % RMS                                                                                                                                                                                                                                                                                                                                    | After calibration at $S > 100$ m.                                                                              |
| Measuring frequency                                                    | 34,5 Hz or 47,5 Hz                                                                                                                                                                                                                                                                                                                                      | User adjustable, (max 80 Hz see capt. 10.3. below for details)                                                 |
| Nominal distance to the road and tolerance (range of working distance) | $35 \pm 15$ cm or $50 \pm 20$ cm **                                                                                                                                                                                                                                                                                                                     | Others on request                                                                                              |
| System power supply (tolerance)                                        | 12V nominal (11 – 14,5V) ***                                                                                                                                                                                                                                                                                                                            |                                                                                                                |
| System power consumption                                               | Sensor head: 20 Wt<br>Processor unit: 1,5 Wt                                                                                                                                                                                                                                                                                                            |                                                                                                                |
| Sensor head operation temperature range                                | -20...+50°C                                                                                                                                                                                                                                                                                                                                             |                                                                                                                |
| Weight of the sensor + mounting bracket                                | 280g + 120g                                                                                                                                                                                                                                                                                                                                             | Without cable                                                                                                  |
| Weight of the processor unit                                           | 350g                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                |
| Sensor dimensions                                                      | $\varnothing 55 \times 205$ mm + illuminator                                                                                                                                                                                                                                                                                                            | See fig.2.                                                                                                     |
| Processor unit dimensions                                              | 120 x 100 x 35 mm                                                                                                                                                                                                                                                                                                                                       | Without connectors                                                                                             |
| Sensor cable length                                                    | 5 m                                                                                                                                                                                                                                                                                                                                                     | Up to 10 m on request                                                                                          |
| System power cable length                                              | 2 m                                                                                                                                                                                                                                                                                                                                                     | Up to 10 m on request                                                                                          |
| Environmental sensor head protection                                   | IP67                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                |
| Magnetic fixing tool                                                   | 4 magnets x 16 Kg strength                                                                                                                                                                                                                                                                                                                              | Option, see fig.2.                                                                                             |
| <b>Controller unit outputs:</b>                                        |                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                |
| Analog out                                                             | Speed, 40 mV/(m/s) 3V max.                                                                                                                                                                                                                                                                                                                              |                                                                                                                |
| Frequency out                                                          | Length, 400 pulses/m (=speed 400 Hz/(m/s), meander 0 – 3 V, TTL compatible, up to 200 KHz.                                                                                                                                                                                                                                                              | Typical values, user adjustable (see software description below).<br><br>DAC and frequency resolution – 12 bit |
| Digital out                                                            | Ethernet (UDP protocol):<br>No of meas, Speed, Length,                                                                                                                                                                                                                                                                                                  | Others on request                                                                                              |
| Physical data latency at measurement freq, ms                          |                                                                                                                                                                                                                                                                                                                                                         | Stable, $= \frac{1}{2}$ of measuring time, without averaging.                                                  |
|                                                                        | 34,5 Hz<br>47,5 Hz                                                                                                                                                                                                                                                                                                                                      | 15<br>11                                                                                                       |
| Base Software                                                          | <ul style="list-style-type: none"> <li>- Program to read data via Ethernet, visualization and saving data;</li> <li>- Program for sensor diagnostics</li> <li>- Read data example (LabView 8.2.1 and higher);</li> <li>- Dynamic library (DLL) to read data via Ethernet</li> <li>- Sensor parameters configuration via any Internet browser</li> </ul> | See below for details.<br><br>Custom software by request are possible.                                         |

\* After calibration on the object to eliminate mounting axes errors.

\*\* For typical road surface. On even and non-contrast surface actual upper limit may be less.

\*\*\* Restricted by illuminating lamp only, for it powered directly from power supply. Processor unit and sensor electronics has an individual +5V linear regulator with up to 35 V tolerances.

Due to our continuous efforts to improve sensors, Riftec reserves the right to change specification without prior notice.

## 6. Example of item designation when ordering

ISD – 3 – 30cm – ET+232+CAN – AN(U) – PL – 5m

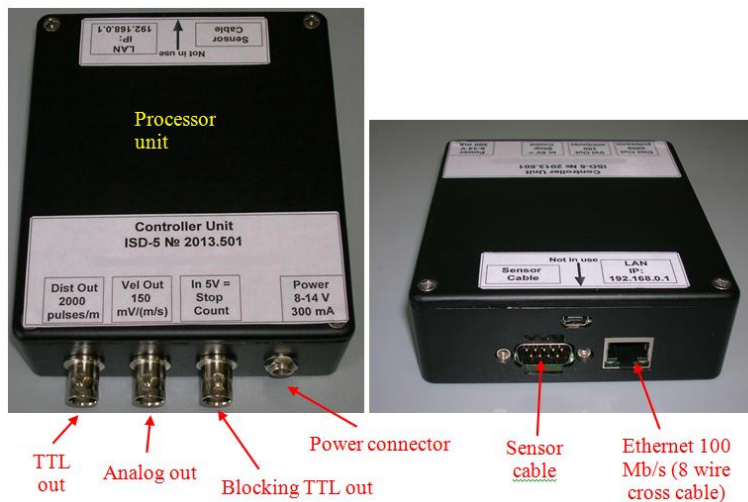
| Symbol     | Description                                                                                                                                                        |
|------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 35cm       | Nominal distance to the object                                                                                                                                     |
| ET+232+CAN | Digital interfaces:<br>ET - Ethernet – base, other - options:<br>232 or 485– RS232 (485),<br>CAN – to avoid any discrepancies the data format of client DAQ needed |
| AN(U)      | Analog out, voltage (U) – base - or current (I)                                                                                                                    |
| PL         | Pulse out – base                                                                                                                                                   |
| 5m         | Cable length from sensor to controller unit                                                                                                                        |

## 7. System Parts and Connections

System parts and connections are shown on fig.1 below.







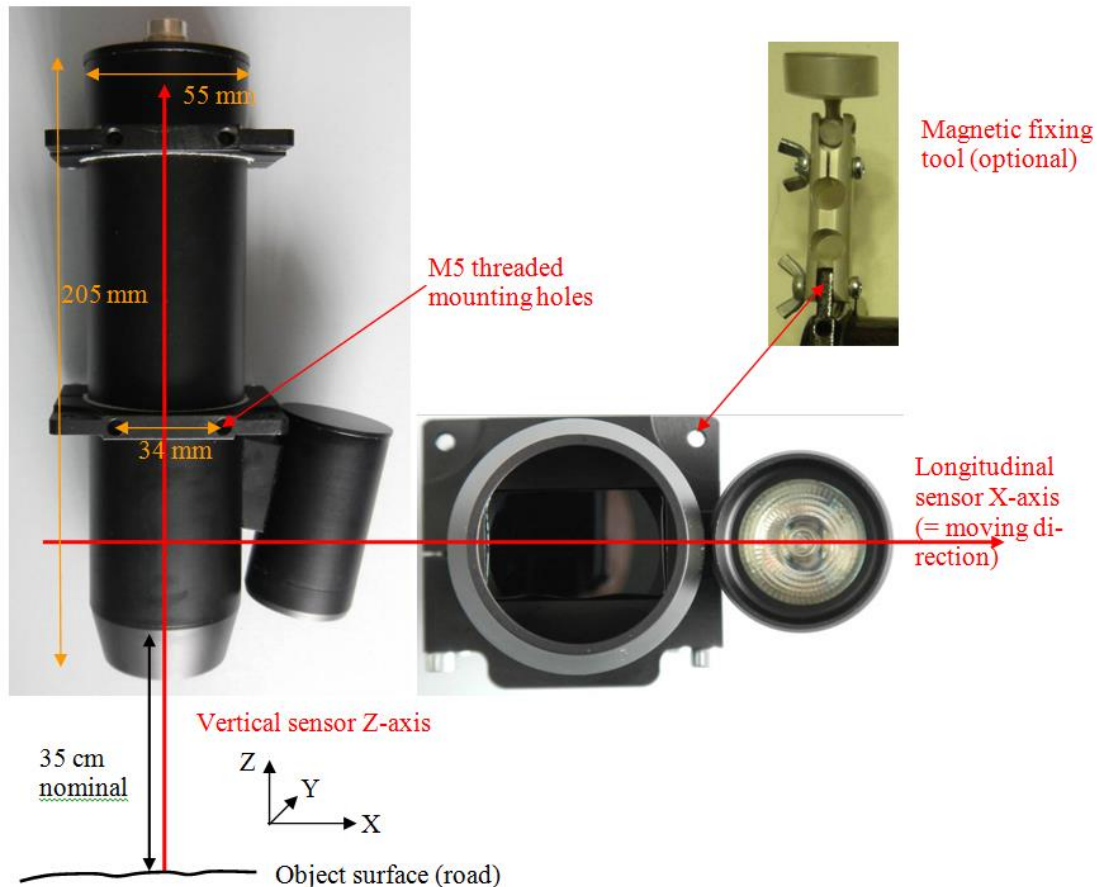
**Fig. 1. Sensor parts and connectors.**

At +5V on "Stop Count" on no pulses on TTL out. It is used when there are long stops moving to avoid false reading in length.

## 8. Dimensions and mounting

### 8.1. Overall demands for sensor mounting

Sensor outline dimension, mounting tools and optical axe location are presented on fig 2.



**Fig. 2. Sensor position relative to the road. Moving along X-axis.**

Nominal distance to the object could be measured from front plane of the sensor, as indicated. Mounting holes positions in brackets – for Mini version.

Sensor X-axis must be perpendicular and Y-axis – parallel to object moving direction. In ZY plane (perpendicular to drawing plane) sensor Z-axis can be tilted from vertical position (for instance, to avoid the light direct reflection to sensor receiver area from glossy surface). Note: inaccuracy (non-perpendicular/parallel with angle  $\alpha$ ) in sensor X and Y axis relative to object moving direction will lead to decreasing the measurements as  $\sin(\alpha)$ . For instance, at  $\alpha=4^\circ$  measured speed will less then actual in 0,24%. That is why, the pre-calibration needed to reject the align errors to achieve the maximum accuracy.

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## 9. Connection

### 9.1. Sensor cable: 5 pin Amphenol C091 type to DB9.

| Signal                 | Sensor head: C091 pin | Controller: DB9 pin |
|------------------------|-----------------------|---------------------|
| Power GND <sup>1</sup> | 1                     | 5, 9                |
| Power (+12V)           | 2                     | 1, 6                |
| Data GND <sup>1</sup>  | 3                     | 4                   |
| Data +                 | 4                     | 3                   |
| Data -                 | 5                     | 2                   |

1 – Grounds joined in controller unit. Signal ground connected to the controller unit housing.

### 9.2. Other cables.

| Destination       | Type         | Comments                                                                           |
|-------------------|--------------|------------------------------------------------------------------------------------|
| Ethernet          | RJ-45        | To connect controller unit with other PC via Ethernet 100 Mb (8 wires cross cable) |
| Pulse output      | BNC          | 0 – 3V, 8 mA max <sup>2</sup>                                                      |
| Analog output     | BNC          | 0,015 – 2,8 V, Rout = 15 KOhm <sup>3</sup>                                         |
| Stop pulse output | BNC          | Input, 5V stops pulses (output stay in «1»)                                        |
| Power             | PY04-4Z plug | 4-pins 1,2 – «+» power, 3,4 – GND.                                                 |

2 – Direct digital output. Max. Freq is 200 KHz.

3 – Direct not buffered DAC output. Load resistance must be > 1,5 MOhm.

### 9.3. Controller reset to factory settings

In any troubles, controller can be reset to factory settings. Unplug the sensor cable from controller (DB9), connect pins 7 and 8, power ON the controller for 2 - 3 s. Factory settings are restored. Power OFF the controller, connect the sensor cable. At the next power ON, the settings are applies.

## 10. Working with system and its software

### 10.1. Working with external (custom) DAQ

- Fix sensor properly relative to the object.
- Connect sensor and controller unit by cable, switch the power ON. Warming time (without thermostabilization) is 1 -2 min.
- Connect pulse output with the counter input. At 2000 pulcas/m 1 count = 0,5 mm.
- At first mounting, to reject a geometric errors, sensor calibration needed. Move the object from stand still to stand stil on the known distance (>2 m or more) for 3 – 5 times. If needed correct the calibration multiplier in DAQ or controller software (see below).

Pulse output can be used for speed measurement too. Frequency 2000 Hz corresponds 1 m/s. But to measure frequency correctly measurement frequency could be at least no less then sensor update frequency.

To measure the speed analog output is more convenient. Calibration multiplier that was found by length measurement could be applied here too. Warning: DAC output is not buffered to keep the metrological characteristic, so load resistance must be high, at least >1,5 MOm. Additinaly, there is a DC offset – ab. 15 mV that could be taken into account.

### 10.2. Working with sensor software

The sensor can be connected to the PC via network. Sensor IP address is 192.168.0.1 by default. To establish the direct cable (use cross cable configuration) connection, PC must have static address 192.168.0.XXX with 255.255.255.0 mask.

### 10.3. Configuration parameters

Open any Internet browser (Internet Explorer, Opera ...), enter controller IP as an address. Page with sensor configuration parameters appears:



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http://www.google.com/ не...
192.168.0.1/pwrite.cgi?IP\_A...

192.168.0.1/pwrite.cgi?IP\_ADDR=192.168.0.1&DATA\_PORT=3000&CMD\_

**TCP/IP config**  
IP\_ADDR   
DATA\_PORT   
CMD\_PORT

**Algorithm parameters**  
SNR\_LIM1   
SNR\_LIM2   
USE\_ACC ☐  
SN\_DIV   
MED\_FLT\_PTS   
AVG\_FLT\_PTS   
VEL\_MLT\_KMH   
VEL\_RSP   
ACC\_COEFF   
LF\_SUPPR ☒ 300 ☐ 500

**Controller mode config**  
OS\_FACTOR   
OP\_MODE ☒ OP\_MODE\_PROCESS  
☐ OP\_MODE\_SEND\_SIG  
☐ OP\_MODE\_SEND\_FFT  
☒ OP\_MODE\_SEND\_SPD  
PROC\_SHIFT

**Output signal config**  
VEL\_MIN   
VEL\_MAX   
OUT\_FRQ\_MIN   
OUT\_FRQ\_MAX   
  
**Noise reduction**  
NOISE\_HARM   
NOISE\_WIDTH

Настройки записаны. Требуется перезагрузить контроллер!

Parameters are writes. Please, restart controller.

Read

Write

Restart

**Fig. 4. Page with sensor configuration parameters.**

What is opened is a content of flash memory of the controller. It is factory (not recommended to change) and user's parameters. It is recommended to save factory configuration, at least as a picture (ALT+PrtSc).

Parameters details:

**“TCP/IP Config”:**

- IP\_ADDR – Contriller's address. Non recommended to change without necessity. If changed – do not forget to enter new address in browther after controller restart.

- DATA\_PORT – Port on PC where data sended. The same must be used as a parameter to read data by DLL (see below).
- CMD\_PORT – Controller port where writes the parameters. Do not change!

#### “Algorithm parameters”:

- SNR\_LIM1 и SNR\_LIM2 – Signal to Noise Ratio Limit – to distinguish between standstill and moving object. If real less – speed regarded as = 0. Typical values at stand still are 4 – 6. At moving object S/N 1 (and S/N 2 at velocities > 20% of Vmax) > 100 typically. See real S/N at stand still in the software (see below) and set it 1,5 – 2,5 times more to guarantee V=0 at stand still. But in some cases (rainy weather, vibrating grass...) – some velocity measurement at standstill can occur. In some range it can be overcome by S/N increasing. Current S/N can be observed in the program supplied (see below). At very high noises at standstill (heavy rain) – use function “Stop Count” (when frequency output used) and unblock it just before the start moving.

- USE\_ACC – at heavy measurement conditions (misreading possible) you can use this function to restrict measured velocity changing to physically reasonable value, which is calculated based on internal 3D accelerometer in controller unit. *If you use this, arrange the controller housing horizontally in the car.*

- S/N\_DIV – for future use, do not change!

- MED\_FLT\_PTS – Median filter order (points of measurements taking into account. Min. value = 0 (no filter).

- AVG\_FLT\_PTS – Order of data averaging filter. Min. value = 1 (no filter)

- VEL\_MLT\_KMH – Velocity calibration multiplier. Act to length calculation too.

- VEL\_RSP – Define the maximum velocity changing at abrupt real velocity changing. The more the value, the faster sensor can react. For automotive application value 10 corresponded ab. 1 g acceleration at 34 Hz measurement.

- AC\_COEFF – Calibration multiplier for internal accelerometer (when USE\_ACC selected). Do not change!

- LF\_SUPPR – for factory use only, do not change!

#### «Controller mode config »:

- OS\_FACTOR – Act on ADC sampling time, Do not change!

- OP\_MODE – Set the controller mode. Selected modes activates ones:

OP\_MODE\_PROCESS – process the data and send the result to frequency and analog output. OP\_MODE\_SEND\_SIG, OP\_MODE\_SEND\_FFT, OP\_MODE\_SEND\_SPD – Send the data via Ethernet. **Only one or no one must be selected** (No one – data not sent to Net, just to Freq and An – max measuring freq possible (up to 100 Hz)).

Use OP\_MODE\_SEND\_SPD to work with a visualization program supplied (see below).  
Use OP\_MODE\_SEND\_FFT to work with a diagnostic program supplied (see below)

- PROC\_SHIFT – Allow to change measurement frequency (sliding average mode) with step of 512 points. But maximum result frequency must not exceed 80 Hz with sending data via Net and 100 Hz without Net.

«**Output signal config**»:

- VEL\_MIN и VEL\_MAX – Limits max and min velocities measured in Km/h in terms of analog and frequency outputs (at VEL\_MIN analog output is 0,015 V, at VEL\_MAX analog output is 3 V). Example: to set 40 mV/m/s :  $3V/0,04V/m/s = 75 m/s = 270 Km/h = VEL\_MAX$

- OUT\_ERQ\_MIN и OUT\_FRQ\_MAX – Define min and max frequency output at VEL\_MIN and VEL\_MAX. To set 400 pulces/m (=400Hz/m/s) :  $400Hz/m/s * 75m/s = 30000 Hz = OUT\_FRQ\_MAX$ .

«**Noise reduction**»:

- NOISE\_HARM и NOISE\_WIDTH – Allows programmatically suppress narrow-band electromagnetic noise. See 10.4. below for details.

After changing and writing parameters, controller must be restarted. Press button “Re-start” (it takes 1 sec only), then you have to reload the page, because during reset the connection with controller was lost.

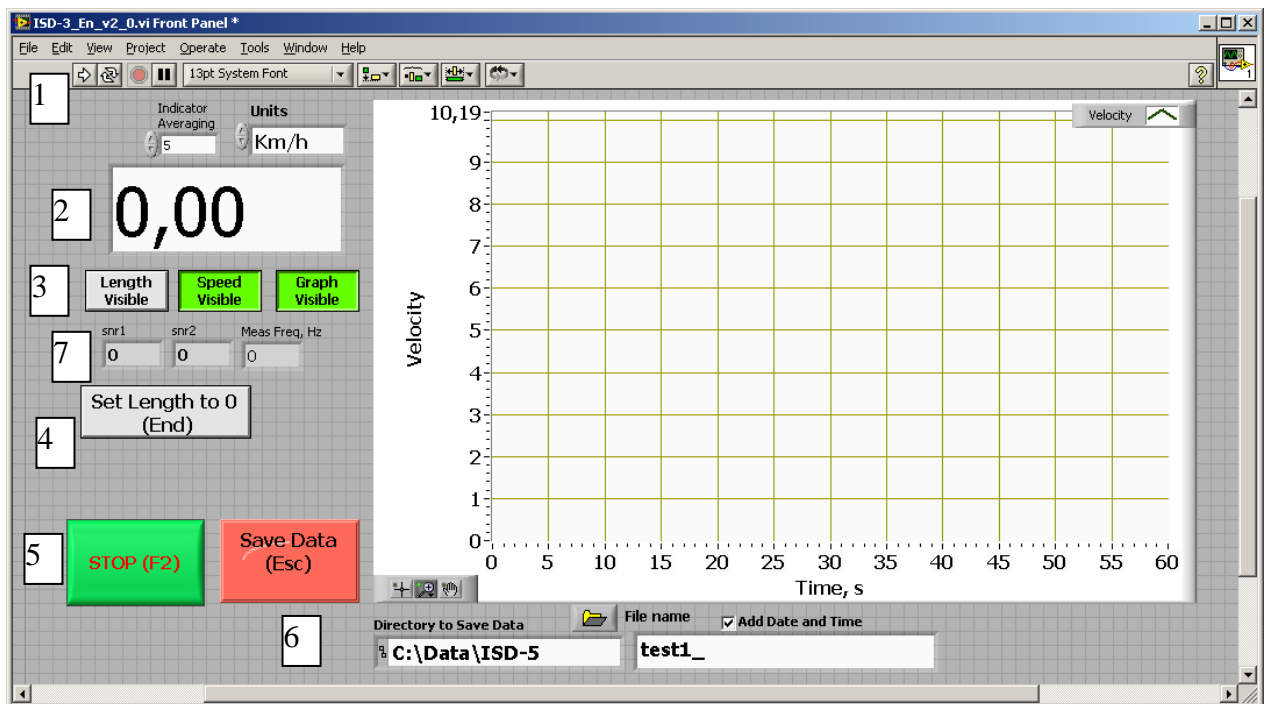
## 10.4. Controller reset to factory settings

In case of controller firmware damage (loosing power during writing new data, writing wrong parametes etc.) it can work incorrect or loose Ethernet connections. In this case initial factory settings can be restored as following:

- Switch OFF Controller Power.
- Unplug the sensor cable from controller and insert DB9 with pins 7 and 8 connected or just connect pins 7 and 8 by wire.
- Switch ON Controller Power for 3 – 5 s. Factory settings is restored.
- Remowe DB9 or wire, plug the sensor cable.
- Do not forget to write user parameters if they were differ from factory ones.



## 10.5. Working with sensor software

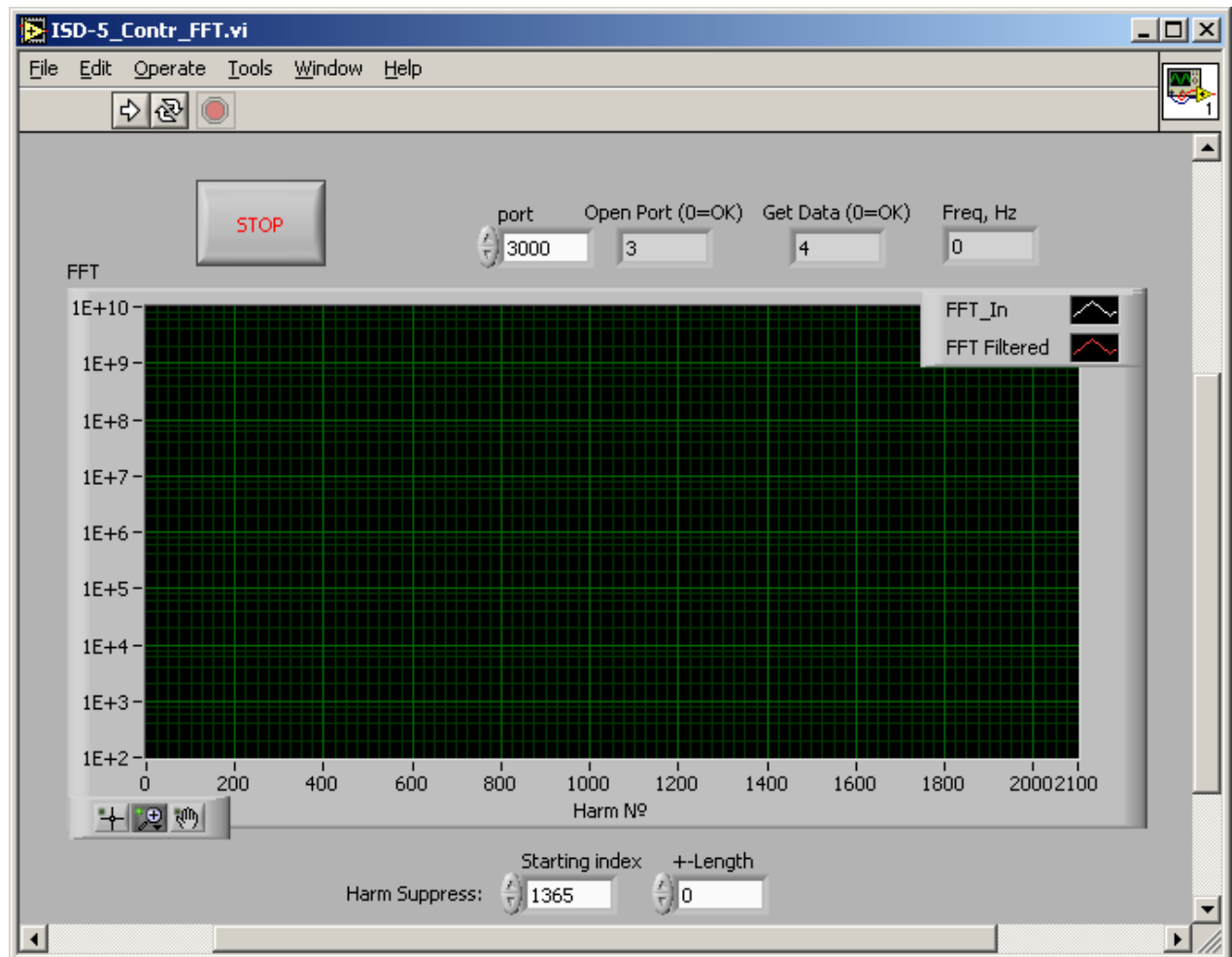
For viewing and saving the sensor data a special program supplied (LabView based). To run LV execution files an environment like Run Time Engine must be installed first. Just run setup in ISD\_Installer directory. After installation, any LV .exe files can be run on this PC.



**Fig.5. ISD-3\_En\_v2\_0.exe – Program to work with sensor data sented from controller to PC via Ethernet connection.**

Here:

- 1 – Run program button  . When it runs the indicator  (abort button) becomes red.
- 2 – Current speed indicator in selectable units and averaging (acts to indicator and Speed Chart only, not to saving data).
- 3 – Visibility ON/OFF of indicators. All ON load PC significantly, especially at high measurement frequency
- 4 – Length indicator with button to set it to 0. Act on saving length data too. Note: controller send cumulative length from its power ON, so use the button “set Length to 0” before start measurement (brake test for instance).
- 5 – Program Stop button. Use it to stop program to correct closing the PC ports and data file (see 6 below).
- 6 – Save Data button. When it pressed, the data writes to file – its directory and name are editable. Note, that the directory must exist (created in advance), file with the name will be created automatically. After test is over, use Stop program button to correct closing the file. Data saves as text file (ASCII) in 3 columns: No of measurement; Speed [Km/h]; Length [m] starting from 0 if Set to 0 was pressed before test starts.
- 7 – Current S/N and measuring frequency indicators. Normally, at standstill S/N is ab. 4 – 7. If it much more – there are some extra noises or mowing objects in the sensor view area (see 10.3 above). Try to increase S/N in “Algorithm Parameters” or use diagnostic program (see fig.6. below).



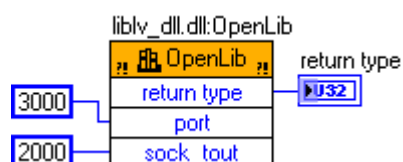
**Fig.6. ISD-5\_Contr\_FFT.exe – Sensor diagnostic program.**

This program mostly designated for industrial sensor application. To work with it, select `OP_MODE_SEND_FFT` in “Controller mode config”. Here the FFT spectrum of sensor signal presented. You can see the presence of signal from moving object, adjust the sensor position to get a maximum signal (measuring of cable length, for instance). Additionally, the possible electromagnetic or optical noises (in hard industrial environment) can be seen. If it present, try to change the sensor position, grounding etc. If it unremovable, it is possible to suppress it with “Noise reduction” function.

## 10.6. Dynamic Link Library description

User can read the sensor data in third party software environment like C++, LabView and others. For this, `liblv_dll.dll` module can be used. Data format is in `lv_dll.h` file. To read the data via Ethernet only 3 function needed. Below are examples for LabView environment.

### OpenLib :



Opens and configure PC ports to work with net UDP protocol.

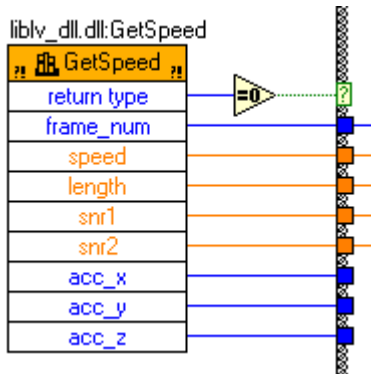
Input parameters:

- **port** - No of port to receive the data – must be the same as in controller DA-TA\_PORT (see. 10.3).

- **sock\_tout** – Timeout for data waiting in ms.

Output: **return type**, 0 = OK, or see lv\_dll.h for list of errors.

**GetSpeed :**



Reads the data continuously.

- **return type**, 0 = OK;
- **frame\_num** – No of measurement;
- **speed** – current speed [Km/h];
- **length** – length [m] from controller power ON;
- **snr1, snr2** – Current S/N;
- **acc\_x, acc\_y, acc\_z** – Current accelerations [ $m/c^2$ ]

**CloseLib :**



Close the port and releases the PC resources. It must be executed before program stops.

## 11. System maintenance

The sensor head and processor unit has no service points. Maintenance limited to keeping clean the sensor windows. Note: Do not use solvents for cleaning!

The only part that may be replaced by user is an illuminating lamp. To change it, unscrew the back cover of the lamp housing, disconnect the G4 connector, then unscrew the front lamp splash guard. Use only the same type of lamp: Halogen 12 V, 35 mm, G4, narrow beam (10° or 8°), 10 or 20 Wt. Adjust the light beam position, it must cross sensor Z-axis at nominal distance. Seal the back cover and the gap between the splash guard and lamp with silicone sealant ( $t > 200^\circ C$ ) to meet the IP67 protection. Note: it is



recommended to replace the lamp with our original one, for it has metal coating to increase the lamp efficiency.

## 12. Warranty

Warranty period is 18 months after selling.

## 13. Troubleshooting

### 13.1. Some constant speed measured at standstill

There is strong electromagnetic noise on the controller ADC input. As a rule, it induced on cable signal wires from power wires, especially if pulse DC-DC converter used or some pulse power consumers (like DAQ system) feed from the same source. Use separate power source if possible. Use diagnostic program to see the noise and to suppress it.

### 13.2. No speed measurement at object mowing

- Cable or electronic damage or wrong parameters in the sensor setup. Use the diagnostic program to see the signals.
- No Ethernet connection (programs does not running). Reset the controller to factory settings (see 9.3. above).

**Sensor repairing must be carried out by manufacturer only.**

## 14. Distributors

|                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                          |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
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