BEAROMOS® 2020

Sensor (thermoelectric effect/Seebeck effect) for measuring electrical voltage on hydrodynamically lubricated slide bearings

-Operating manual-

- 183008 -

SCHALLER AUTOMATION

Schaller Automation Pte Ltd
114 Lavender Street #09-93 CT Hub 2
Singapore 338729

Phone : +65 6643 5151 24/7
WhatsApp : +65 9788 7550 24/7

info@schallersingapore.com

www.schaller.sg

Dear customer,

this operating manual is intended for all those who work/will work on/with the system described here. They require knowledge of this operating manual to avoid faults in the system and to operate the system without issues. They must therefore have knowledge of this operating manual.

This operating manual applies to the following devices:

- BEAROMOS® 2020

The operating manual is part of the information for users when the system is placed on the market and must be kept so that it is accessible to the operating company and the operator. If the system is relocated, the operating manual and/or the operating manuals (including those of suppliers) must be provided at the new location.

In all phases of life, all the information in the operating manual and/or the operating manuals (including those of the supplier) must be observed. Please read the applicable sections in the operating manual carefully before starting work.
We accept no liability for damage or malfunctions that are the result of failure to comply with this operating manual.
You must specify clearly who is responsible for the machine (the operating company) and who may work on the machine (the operator).

The responsibilities of personnel involved in transport, installation, setup, adjustment, operation, care, maintenance and servicing must be clearly defined.

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Industrielle Automationstechnik GmbH & Co. KG
66440 Blieskastel / Saarland / Germany / Industriering 14 / Postfach 1280
Tel. +49 6842-508-0 / Fax -260 / Email: info@schaller.de /
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Index	Change	Date	Changed by
1.0	Release	07 October 2019	
1.1	Header, document number, EC declaration of conformity	14 September 2021	Flemmer, M.
2.0	Mechanical revision of sensor; sealing system	31 May 2022	Flemmer, M.

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EC Declaration of Conformity.

According to the EC Machinery Directive 2006/42/EC
Annex II A

We hereby declare that the design of the machine described below and the version we have placed on the market fulfils the essential health and safety requirements of EC Directive 2006/42/EC.

Manufacturer:	SCHALLER AUTOMATION Industrielle Automationstechnik GmbH & Co. KG Industriering 14 66440 Blieskastel
Type of device:	Sensor (thermoelectric effect/Seebeck effect)
Type designation:	BEAROMOS® 2020
Intended use:	Measurement of electrical voltage on hydrodynamically lubricated slide bearings

Furthermore, we declare conformity with further Directives applicable to the product, as follows:

- EC Directive 2014/30/EU (EMC Directive)
- EC Directive 2011/65/EU (RoHS Directive)

Applied harmonised standards:

- EN ISO 12100:2010
- IEC 60529: Edition 2.2
- IEC 60068-2-1: Edition 6.0, 2-2: Edition 5.0, 2-6: Edition 7.0, 2-30: Edition 3.0
- IEC/EN 61000-6-2:2015, 6-4:2007+A1:2011
- IEC/EN 61000-4-2:2009, 4-3:2006+A1:2008+A2:2010, 4-4:2012, 4-5:2014, 4-6:2014, 4-11:2005
- EN ISO 12100:2010

Applied national standards and technical specifications:

- DNVGL-CG-0339: Nov2016

The original version of the operating manual for the BEAROMOS® 2020 sensor is provided.

Authorised representative for compiling the technical documents:
Jochen Bock, Industriering 14, 66440 Blieskastel

This EC declaration of conformity shall no longer be valid if:

- the machine is rebuilt, modified or used for purposes other than those for which it is intended without our written consent.
- the instructions in the operating manual are not followed.

Blieskastel, 2021/09/14

Place, date

Stephan Schaller
(Managing Director)

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1 Safety information/safety instructions

To operate the device safely and correctly, the device must be properly transported and stored, correctly installed and put into operation and must be operated as intended.
Only persons who are familiar with installation, commissioning and operation and have the appropriate qualifications for their task may work on the device. You must observe the contents of the operating manual, the information on the device and the relevant safety regulations for the installation and operation of electrical equipment.
The devices are built and tested in accordance with DIN EN 60947 and leave the factory in a technically safe condition. In order to maintain this condition, you must observe the safety instructions that are indicated by “Warning” in the operating manual. Failure to observe the safety instructions may result in death, personal injury or damage to the device itself and to other devices and equipment.
If the information contained in the operating manual is not sufficient in a given case, please contact us directly or your representative.
You must observe the applicable regulations that apply in the country of use when using the device, if the industrial standards and regulations stated in this operating manual and valid in Europe do not apply.

Warning!
The components may heat up during operation.

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2 Technical data

Table 1: Mechanical interfaces

Diameter	140 mm
Total length up to flange connection	125 mm
Weight	4 kg (short adaptation)/4.5 kg (long adaptation)
Attachment	Application-specific adaptation

Table 2: Electrical interfaces

Power supply	9 - 32 V DC
Nominal voltage	24 V DC
Current consumption	Maximum 0.4 A
Rated insulation voltage Ui	48 V
ESD resistance	6000 V (contact discharge)/ 8000 V (air discharge)
Overvoltage category	I
Degree of contamination	3
Test voltage, input/output	548 V 50 Hz
EMC interference immunity	EN 61000-6-3
EMC interference emission	EN 60945
Communication interface	2-wire RS485, electrically isolated
Recommended communication cable	M12 socket 4-pole, A-coded, shielded Cable e.g.: Phoenix Contact SAC-4P-M12FS SH/.../... – 1697483 Connector 77 3530 0000 50704-0500

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Table 3: Environmental conditions

Operating temperature	-20 to +70 °C
Storage temperature range	-25 to +55 °C
Relative humidity	up to 95%
Protection rating	IP 56
Vibrations	5 -13.2 Hz: 1.6 mm peak 13.2 - 100 Hz: 40 m/s² peak (The given values describe the test conditions; there is no experience of operating outside this frequency range)

2.1 Intended use

The BEAROMOS® 2020 sensor may only be used to measure thermoelectric voltages on slide bearings.

When using the sensor, you must make sure that it is aligned with the shaft when it is installed.

The safety instructions must be observed.

2.2 Foreseeable misuse

The sensor must not be installed/removed without the centring pin provided.

Unauthorised persons must not install or maintain the sensor.

It must not be used in potentially explosive atmospheres.

➔ Applications not described in this manual are not allowed!

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2.3 Risk and safety declarations

For welding work on the motor, the sensor must be disconnected from the power supply.

Components of the sensor can become hot. Make sure they have cooled sufficiently before carrying out maintenance and repair work. Wear heat-insulating gloves if necessary.

WARNING! Risk of being drawn into the device during installation

You may only install the device with the motor switched off. The device may only be commissioned once all components have been completely installed.

There is a risk of crushing when installing the sensor

The sensor may only be installed by qualified persons. Wear protective gloves if necessary.

The sensor must be aligned correctly, otherwise the sensor shaft may be damaged, which may then damage the motor as a result. The supplied centring pin must be used for this purpose.

The sensor must be installed by a qualified person. It must be aligned centrally.

WARNING! Risk of being drawn in by rotating parts (shaft).
If disassembled while being operated, parts may be ejected outwards.

The cover may only be removed with the motor switched off.

There may be a risk of slipping, tripping and falling in the working environment.

Depending on the working environment, additional measures may have to be taken to minimise or eliminate the risk of slipping, tripping or falling.

Hazard from external noise - the sensor does not emit any significant noise.

If necessary, wear appropriate PPE if there is noise in the environment (hearing protection).

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3 Product description

The engines/gears/etc. for which the BEAROMOS® is intended have slide bearings in which oil is pressed between the bearing shell and the bearing point by a pump. As a result, the bearing point of the rotating shaft is lifted off the bearing shell, so that there is no longer any contact between the bearing journal and the bearing shell. The bearing then operates outside the mixed friction range. If the lubricating film is interrupted by an operating state or defect, the temperature increases due to friction between the bearing shell and the rotating shaft. Given the large mass of the rotating shaft, the bearing shell sees a greater temperature increase, resulting in an electrical voltage between the bearing shell and the rotating shaft due to the Seebeck effect. This voltage is detected by our BEAROMOS® device.

The BEAROMOS® signal is used to display the status of the monitored bearing(s). It is possible to infer from the signal level and the associated speed whether the friction is hydrodynamic or mixed. If the bearing is operating in the hydrodynamic friction range, there is no indication of wear, deformation or damage from the friction itself. (However, wear, deformation or damage may occur or arise without the lubricating film having first been affected or interrupted) If the bearing is exposed to mixed friction for a longer period of time, this can cause damage to both the bearing and the rotating shaft, which - in the case of the rotating shaft - means substantial downtimes/repair times and therefore considerable cost. As a basic principle, a distinction must be made between three mechanisms of damage:

1. Wear
2. Wear and deformation
3. Thermally-induced damage

The Chart view can be used for further analysis and to identify the relevant mechanism of damage. However, not every mixed friction state is always an error criterion, just as not every error is reflected in or indicated by a mixed friction state. During run-up phases, changes of load, etc., mixed friction very commonly occurs in the bearings, but this is a normal operating condition. The final analysis of the BEAROMOS® signal is the responsibility of the operating company on site. If there are several bearing points, the BEAROMOS® sensor records a cumulative signal across all thermoelectric voltages of the bearing points. It is not possible to link a signal directly to a single bearing. The sensor and the BEAROMOS® signal are therefore only a tool for detecting wear, deformation and damage.

The sensor is contacted at the free shaft end with a customer-specific adaptation. By contacting the shaft end on the outside of the machine housing, it is not necessary to interfere with the inside of the machine.

The sensor indicates irregularities such as friction, wear or deformation in the area of the bearings, which in many cases makes it possible to take measures to avoid major damage. Monitoring with this sensor unfortunately does not offer complete certainty that irregularities will be detected in all cases in time and/or that damage will be avoided.

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4 Installation and removal

4.1 Work and preparations to be completed by the customer

Make sure that the sensor housing has a good earth connection, otherwise the sensor will not function properly. If necessary, you must install an additional earth connection (machine - sensor). The shaft adaptation must also have good electrical conductivity.

As the principle on which the sensor operates relies on measuring the electrical voltage between the bearing and shaft, these must be electrically isolated from each other during operation.

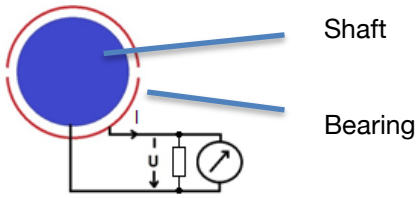

Figure 1: Measuring principle of the sensor

4.2 Installing the sensor

No adjustments have to be made to the sensors. The correct COM port of the RS485 adapter that is used for sensor communication must be set up in the PC software (see 6.1.3 Parameter settings).

- The user must follow safety rules and regulations.
- The sensor is installed with a crankshaft adapter.
- The device is rated to IP56 (for the outer housing).
- M12 plug connector must be tightened “hand-tight” to torque of approx. 0.50 Nm

Do not exceed the maximum permissible temperature during installation. Make sure there is sufficient distance from other devices and sources of heat. If cooling is made more difficult, e.g. because devices with increased surface temperature are next to each other or because the cooling air flow is obstructed, the allowed ambient temperature is lower.

The sensor circuit cables must be laid as separate control cables. Wires from the engine supply cable or other main power cables must not be used. Shielded control cables must be used.

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4.3 Installing the sensor

The BEAROMOS® 2020 sensor is installed on the stand of the object to be monitored with a supporting tube. Make sure that the connection is electrically conductive. You must also make sure that the flange surface is flat, so that the sensor can be aligned.
If liquid is likely to enter the sensor from the object to be monitored (e.g. oil spraying in the direction of the sensor shaft), a suitable seal must be installed (available from Schaller Automation on request), as ingress of liquid will cause the sensor to fail.

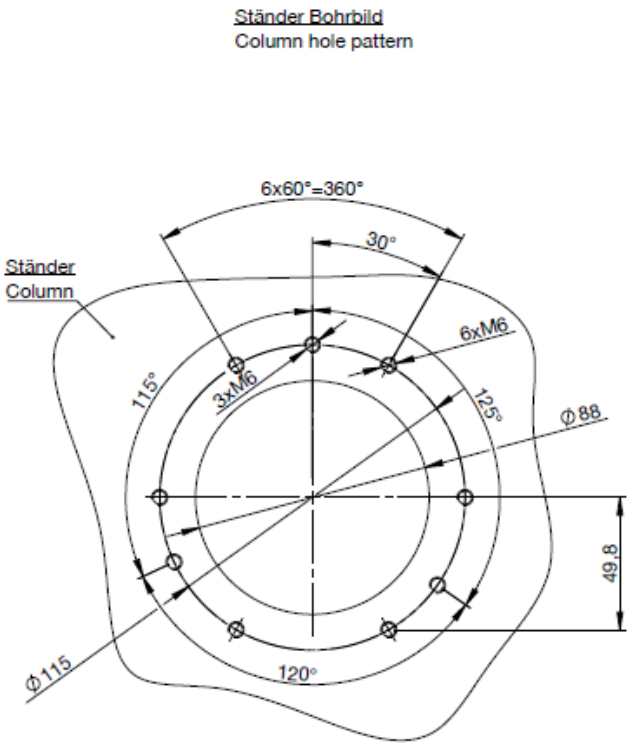

Figure 2: Stand hole pattern

The shaft of the slide bearing is connected using a specific shaft adapter (available on request from Schaller Automation), which is connected to the sensor. Once again, make sure that the connection is electrically conductive. Two types of sensors are used:

- For crankshaft distances up to 300 mm: short adaptation (rigid) according to section 0
- For crankshaft distances from 300 mm to 620 mm: long adaptation with bellows to compensate for crankshaft movement according to section 4.3.3. The bellows is in the adaptation and is not shown here.

For installation of the applicable sensor and its adaptation, follow the enclosed installation instructions.

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4.3.1 Shaft seal system for the BEAROMOS®

If liquid (e.g. oil) is expected for the application and no other precautions have been taken, the Schaller "Shaft seal system for the BEAROMOS®" can be used. It is installed between the sensor and the engine wall.
Pay attention to correct alignment of the sealing plate (see labels on the plate: Adaptorside/Bottom).

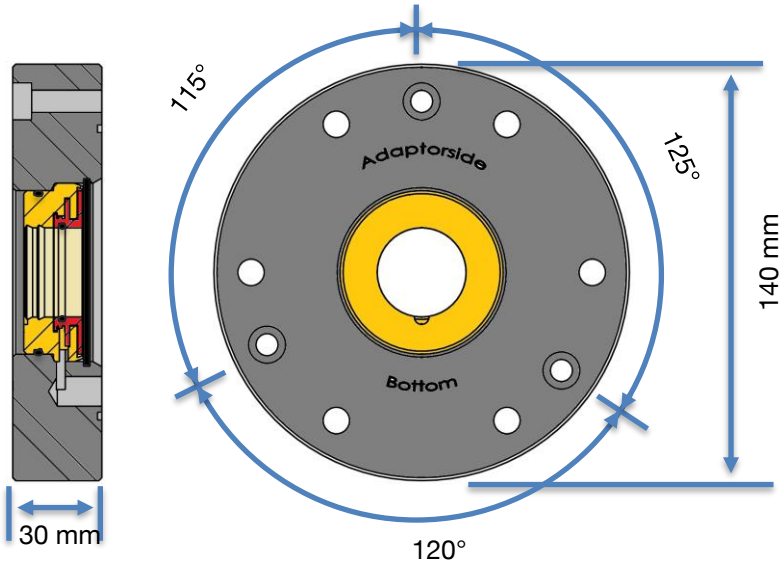

Figure 3: Shaft seal system for the BEAROMOS®

4.3.2 Short adaptation for crankshaft distances up to 300 mm (example)

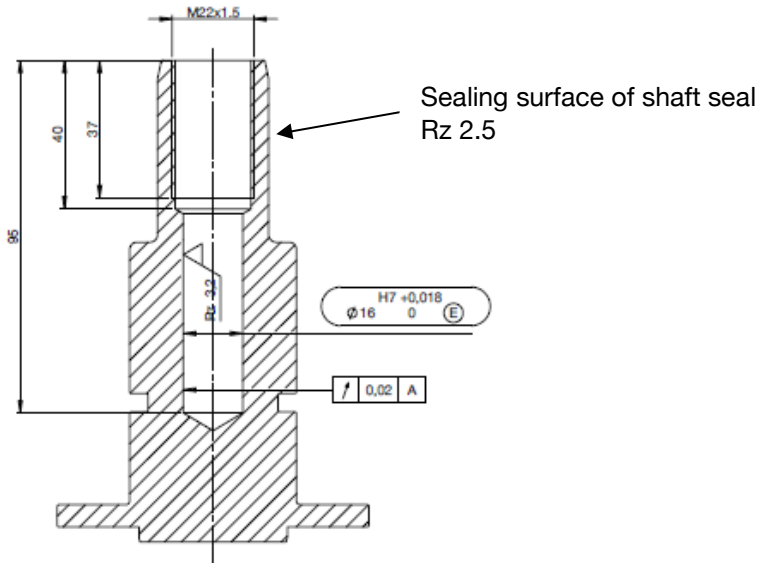

Figure 4: Sensor connection – short crankshaft adapter (example)

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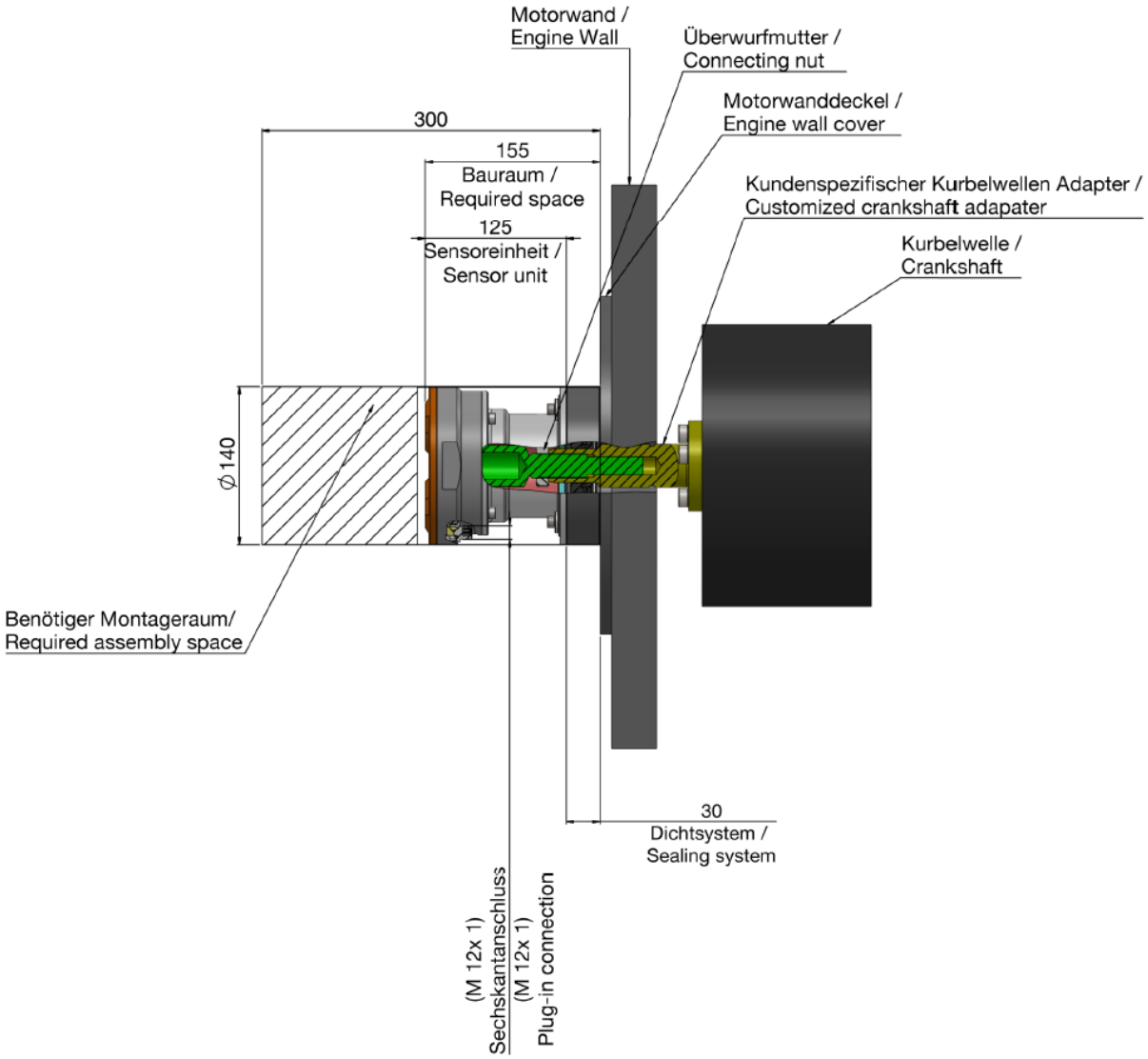

Figure 5: Sensor cross-section - short (with shaft seal)

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4.3.3 Long adaptation for crankshaft distances from 300 mm to 620 mm

A customised coupling shaft for adaptations from 300 mm to 620 mm length is available on request.

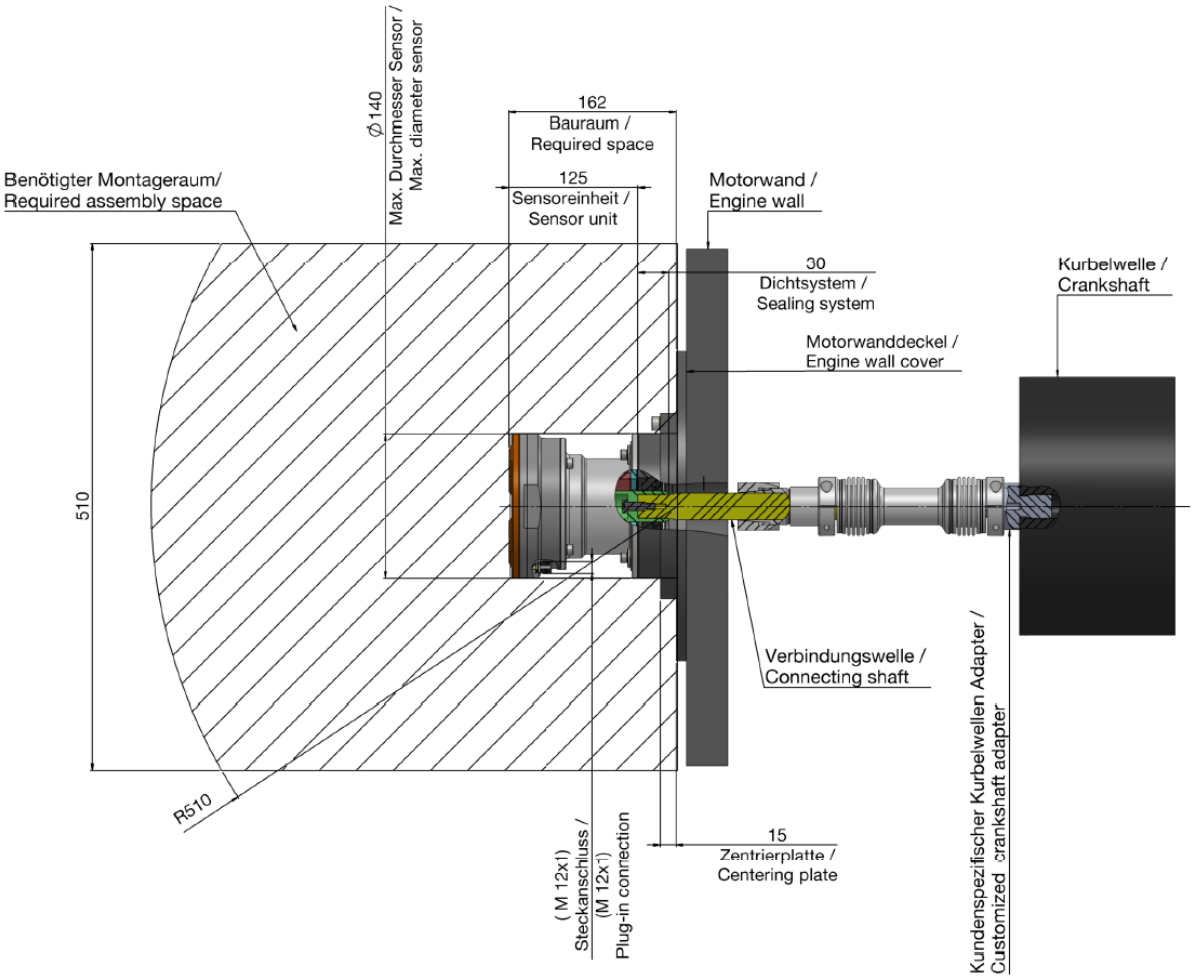

Figure 6: Sensor cross-section – long (with shaft seal)

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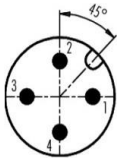
4.4 Electrical adaptation of the sensor



1	brown	*+Ub*
2	white	*GND*
3	blue	*RS485 A*
4	black	*RS485 B*

Shield on housing

Connection plug on the rear
(M12 plug connector must be tightened “hand-tight” to torque of approx. 0.50 Nm)

Figure 7: Electrical connection

4.5 Software installation

Insert the DVD into the DVD-ROM drive of your computer and run the “Setup.exe” file, which is located in the root directory of the DVD. Follow the instructions of the installation routine. When choosing the installation path, make sure that the subsequent user also has write permissions for the folder you choose. A shortcut to the BEAROMOS® Recorder is automatically created on the Windows desktop. The program is started by double-clicking the BEAROMOS® icon.
For the Recorder to work properly, the driver of your bus adapter has to be installed first! Please follow the instructions of the adapter manufacturer (not included).
To make sure that data is saved properly, the “Documents” folders of the user account that is used must not be located on a network drive. If it is, you will get the “<No path>” error message under “Data path”.

4.5.1 System requirements

- Intel Atom 1.6 GHz
- min. 1 GB RAM
- Microsoft Windows 7 SP1/Windows 10
- approx. 3 GB free HDD space
- RS485 interface (virtual COM port)
- Language for software/installation routine: English

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If you want to run several sensors simultaneously on one PC, you can duplicate the program folder manually. This allows you to run multiple instances of the BEAROMOS® Recorder with the specific bus parameterised for the corresponding sensor. Note that the number of sensors that can be operated on one PC depends on the system capacity of the PC that you use.

5 Commissioning

Attention!
Before you switch on the device, make sure that the supply voltage of the device and the mains voltage match

If the sensor is correctly connected, the “BUS connection” indicator on the software window should come on green after the supply voltage is switched on and the correctly configured software is started.

During commissioning and after modification of the system, the RS485 BUS resistance must be measured with a suitable measuring instrument. If the resistance is < 50 Ω, the BUS circuit must be checked for any shortcircuit.

Attention! Check the sensor only with measuring voltages < 2.5 V

6 Operation and application

The sensor itself is a built-in device with LED status indicator. The LED is used to check that the sensor is working:

- Flashing green: Sensor is rotating
- Flashing yellow: Slip rings are worn – service necessary

- Attention! If the shaft is stationary and therefore resting on the bearing, the LED may be continuous yellow. It may also be the case that the LED does not come on during operation, because the rotating magnet for speed detection is not in the region of the Hall sensors. These are not error states.

PC software is used to monitor and evaluate the sensor signal.

Using the BEAROMOS® sensor signal, the BEAROMOS® Recorder software visualises the status of the monitored bearing(s) for the Seebeck effect (described in section 3) and the evaluation algorithm by the software. This visualisation and the speed recorded by the BEAROMOS® sensor are used to make a statement about the state of bearing operation: hydrodynamic friction or mixed friction. This state is visualised by a barchart (Figure 8: Main view) and by the average value over time (Figure 9: Chart view). The event horizon of the Chart view (x-axis) can be scaled step by step, and is max. 60 min. The transition from mixed friction to hydrodynamic friction is determined by a sliding threshold value and a sensitivity that can be configured. The last transition from hydrodynamic friction to mixed friction is recorded with date, time, duration and revolution speed.
An LED indicates that the PC software is communicating correctly with the BEAROMOS® sensor. The Sensor Fault LED indicates any failure of the BEAROMOS® sensor sliding contacts. If the indicator is flashing, at least one of the sliding contacts is worn out and is no longer in contact with the slip ring. There is a button to print the current screen for both the Main screen and the Chart screen. The content of the Chart screen can also be exported to a CSV file using separate buttons.
A freely editable (editable under the Parameter view) field is provided so that the software can be associated with the test object. All data in this field is kept when the software is restarted.

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At runtime, the Parameter view allows you to edit the freely editable field, to select the COM port of the RS485 adapter that is used, to set the save path for the log file and data and to configure the sensitivity. The current software version is also displayed on this tile.
The window is 800 x 600 pixels. The software provides support for using the BEAROMOS® sensor.

6.1 Operation

6.1.1 Main view

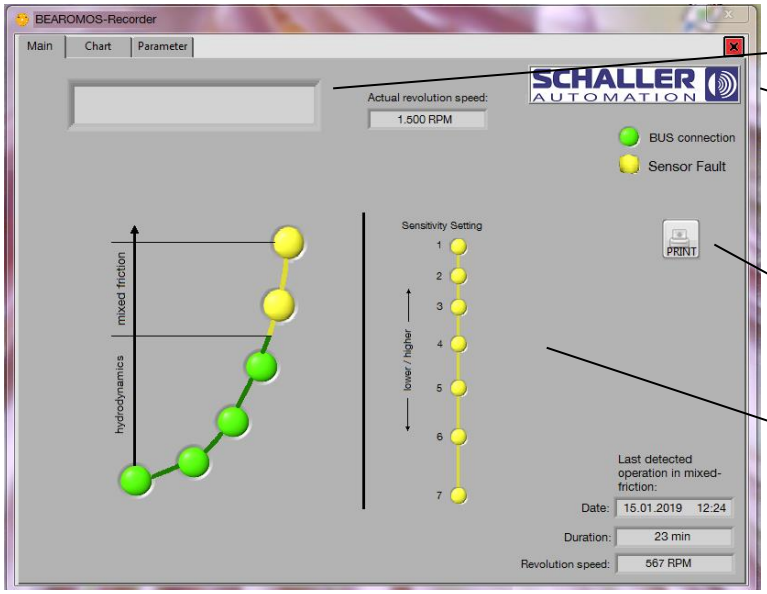

Figure 8: Main view

Freely editable field (the same data is displayed on all tiles; the content is retained across restart)

Schaller logo as a link button to the Schaller homepage

Indicator for correct BUS communication

Detects state of carbon brush wear

Send printout of current view to printer

Display the current status as barchart

Record the last time that the threshold values were exceeded with date, time, duration and revolution speed when exceeded

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6.1.2 Chart view

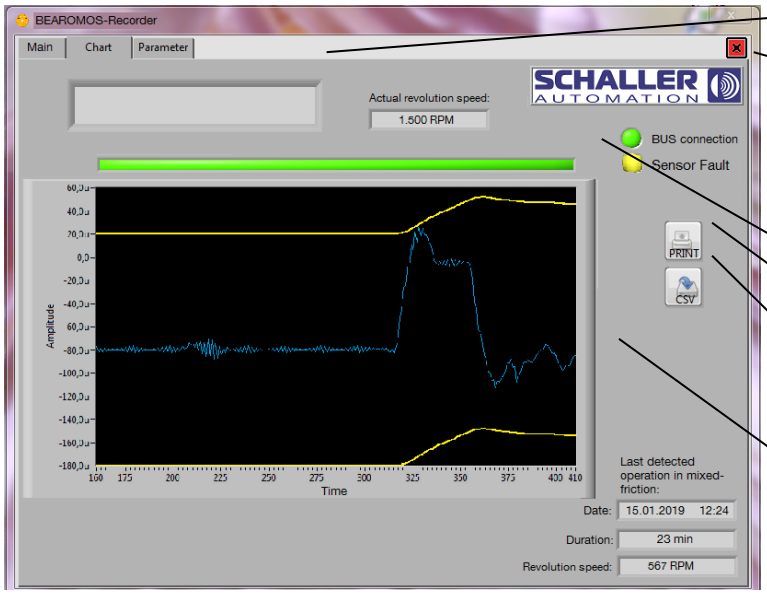

Figure 9: Chart view

Freely editable field (the same data is displayed on all tiles; the content is retained across restart)

Schaller logo as a link button to the Schaller homepage

Indicator for correct BUS communication

Detects state of carbon brush wear

Indicator for thresholds having been exceeded

Send printout of current view to printer

Export the current data content from the chart to a CSV file

Display the average value over time and the sliding limits

Record the last time that the threshold values were exceeded with date, time, duration and revolution speed when exceeded

6.1.3 Parameter settings

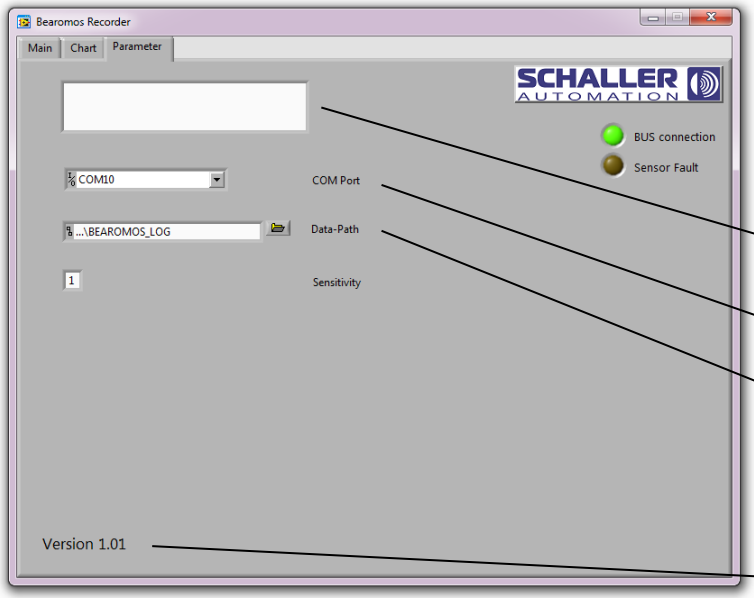

Figure 10: Parameter settings

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Indicator for correct BUS communication

Detects state of carbon brush wear

Freely editable field (the same data is displayed on all tiles; the content is retained across restart)

COM port used for RS485 adapter

Save location for ring buffer/log file

Version number

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6.1.4 Log file and data storage

6.1.4.1 Log file

To record and track changes in the state of the slide bearing, the threshold value with date, time and duration that the threshold is exceeded is recorded in a log file when the thresholds are exceeded. This log file is created in CSV format and has the following structure:
YYYY.MM.DD; HH:MM; [Maximum_value_while_exceeded]; [Duration_exceeded_in_sec]; [Rotation_speed_while_exceeded]

6.1.4.2 Data storage

The average signal over time is stored in a ring buffer (FiFo principle) for a period of 60 days. This file also stores the rotation speed for the current average value, in addition to the average value. This data is saved in separate files, each file containing the data for one day. The file name of the individual files has the following structure with a time stamp:
BEAROMOS_AV_*YYYY-MM-DD_HH-MM*.csv

If recording is interrupted, e.g. by closing the Recorder program, a new file is created when recording continues.

6.1.5 RS485 log

- Baud rate: 230,400 kBit/s
- Parity: None
- Data bits: 8
- Stop bits: 1
- Flow control: None
- Interval of the individual messages: 1.024ms

The BEAROMOS® sensor transmits data in binary format as follows:

Log Message format1 (MF1) ADC value

1. Start character	**0xA0**	1 Byte
2. Consecutive number	LL	2 Byte
3. Measured value	MMM	3 Byte
4. Check byte	C	1 Byte
5. End character	**0x55**	1 Byte

The data represent an ADC measured value in 24Bit signed representation. As this format does not exist in this form, it must be converted into I32.
ADC = ADC << 8; // 32Bit is created from the 24Bit (eight zeros added to the right)
// In particular, the I24 sign bit is shifted to the I32 sign bit position!
ADC = ADC >> 8; // Restore original value, expand sign

Log Message format2 (MF2) Time offset of round trip pulse, amplification

1. Start character	**0xA3**	1 Byte
2. Consecutive number	LL	2 Byte
3. Time offset of round trip pulse for ADC value	TT	2 Byte

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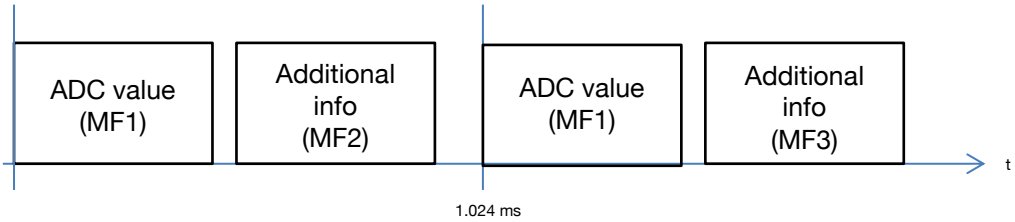
4. Amplification	G	1 Byte
5. Check byte	C	1 Byte
6. End character	**0x55**	1 Byte

Log Message format3 (MF3) Rotation speed

1. Start character	**0xAC**	1 Byte
2. Consecutive number	LL	2 Byte
3. Round trip time	TTT	3 Byte
4. Check byte	C	1 Byte
5. End character	**0x55**	1 Byte

Message format MF1 is sent every 1.024ms. MF2 and MF3 are still sent after MF1 with each round trip pulse that occurs:



Calculating the test byte

To keep the computing time as low as possible, the check byte is created by bytewise XOR linking of the bytes below.

Start character	S1	1 Byte
Consecutive number	LL	2 Byte
24 Bit data (3 Bytes)	MMM	3 Byte

Example: A02A4E56A20C

Start character	A0
Consecutive number	2A 4E
Data	56 A2 0C

Calculation of the check byte

00 ^ A0 = A0
A0 ^ 2A = 8A
8A ^ 4E = C4
C4 ^ 56 = 82
82 ^ A2 = 30
30 ^ 0C = 3C - > Check byte = 3C

Check byte 3C

The following is transferred: **A02A4E56A20C3C55**

During the check on the receiver side, the received bytes are linked **including** the XOR check byte. If the result = 0, it is assumed that the transfer is free of errors.

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6.2 Errors/malfunctions

Sensor does not switch on:

When the shaft is stationary, the LED may not come on green. If BUS communication is nonetheless not established, check the following:

- The supply voltage Ub. The terminal voltage must be 9 to 36 V.
- Whether the sensor (M12 connector) is correctly connected.

Sensor is flashing yellow:

This can occur when the shaft is stationary, even without an error. If the status occurs during operation, check the following:

- Whether the carbon brushes are in place
- Whether the carbon brushes are worn out (no more contact with the slip ring)

No BUS connection possible:

Check the following:

- Whether the sensor (M12 connector) is correctly connected.
- Whether the resistance in the BUS circuit has a value of 50 Ω < R < 1500Ω. The terminal voltage must be < 2 V when the sensor is connected.
- The polarity of the BUS circuit (A and B wires reversed?)
- The terminating resistors of the BUS system

If it is malfunctioning, replace the device. When you return the device for repair, please include a description of the malfunction that has occurred. Repairing the device on site is not appropriate and is therefore not intended.

7 Maintenance and repair

7.1 Maintenance

The sensor is largely wear-free.
The carbon parts of the slip ring collector wear out during use. There is no fixed maintenance interval scheduled. However, we recommend checking the brushes for wear at intervals of approx. 6 months.

You will wee when replacement is necessary, as the sensor LED flashes yellow or you see a message in the Recorder software.

Repairs to the device may only be carried out by the manufacturer. If wear occurs on the slip ring collector, the electronic housing of the sensor (black housing part of the sensor) in which the carbon brush arms are located must be completely replaced.

If the sensor is opened or removed from the object to be monitored for maintenance or repair, the O-ring seals of the sensor must be replaced.

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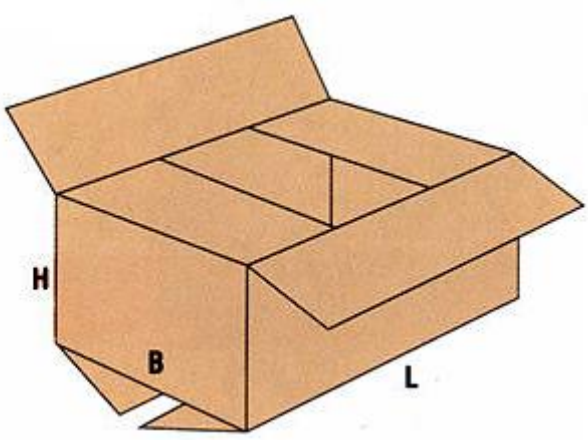
7.2 Repair

Replace sensor housing (black housing part of the sensor, part number: 153125):

1. Remove the sensor cable
2. Loosen cover Allen screws and remove sensor cover
3. Lift off the brush by pulling the black lever of the brush forward and switching it in the direction of the sensor housing.
4. Remove the Allen screws from the sensor housing (x4).
5. Carefully lift the sensor housing off the supporting tube (make sure that the carbon brushes are not damaged).

6. Insert new O-ring seal into supporting tube
7. Carefully place the new sensor housing on the supporting tube (make sure that the carbon brushes are not damaged).
8. Screw the sensor housing to the supporting tube with the 4 Allen screws.
9. Put the brush in place on the shaft by pulling the black lever of the brush forward and turning it in the direction of the shaft.
10. Insert new O-ring seal into sensor housing
11. Attach the cover with the Allen screws in the cover
12. Connect sensor cable to new sensor housing

8 Packaging



H	180 mm
W	220 mm
L	280 mm
Weight	

Table 4: Packaging dimensions

Figure 11: Packaging geometry

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9 Disposal

Please return defective devices or devices that no longer required to us for proper disposal.

10 Part numbers

Material	Description
153150	BEAROMOS® 2020 Sensor – distance to crankshaft of up to 300 mm
153170	BEAROMOS® 2020 sensor – distance to crankshaft from 300 mm to 620 mm
272832	Shaft seal system for the BEAROMOS®

Table 5: Part numbers

11 Spare parts catalogue

Material	Description	Content
290047	Spare parts for the BEAROMOS® 2020	Sensor housing including x2 supporting tube seals & cover seals
290048	Maintenance kit for O-rings	x2 supporting tube seals & cover seals

Table 6: Spare parts

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www.schaller-automation.com

CONTACT

SCHALLER Automation
Industrielle Automationstechnik GmbH & Co. KG
Industriering 14
66440 Blieskastel, Germany
Phone: +49 6842 508 0
Fax: +49 6842 508 260
Email: info@schaller.de
Website: www.schaller-automation.com

Schaller Automation LP
811 Shotgun Road
Sunrise, FL 33326
United States of America
Phone: +1 954 794 1950
Mobile: +1 561 289 1495
Fax: +1 954 794 1951
Person in charge: Mrs. Jurate Holm
Email: info@schalleramerica.com

Schaller Automation Pte Ltd.
114 Lavender Street
#09-93 CT Hub 2
Singapore 338729
Phone: +65 6643 5151
Mobile: +65 9788 7550
Fax: +65 6643 5150
Person in charge: Mr. Sascha Renye
Email: info@schallersingapore.com
Technical Support: Mr. Boon Huah Tan
Email: boonhuah.tan@schallersingapore.com
Website: www.schaller.sg

Schaller Automation – China
Room 401, Juyang Mansion No. 1200
Pudong Avenue,
Shanghai 200135, P.R.China
Phone: +86 21 5093 7566
Mobile: +86 1390 1890 736
Fax: +86 21 5093 7556
Person in charge: Mr. H.J. Li
Email: info@schallerchina.cn