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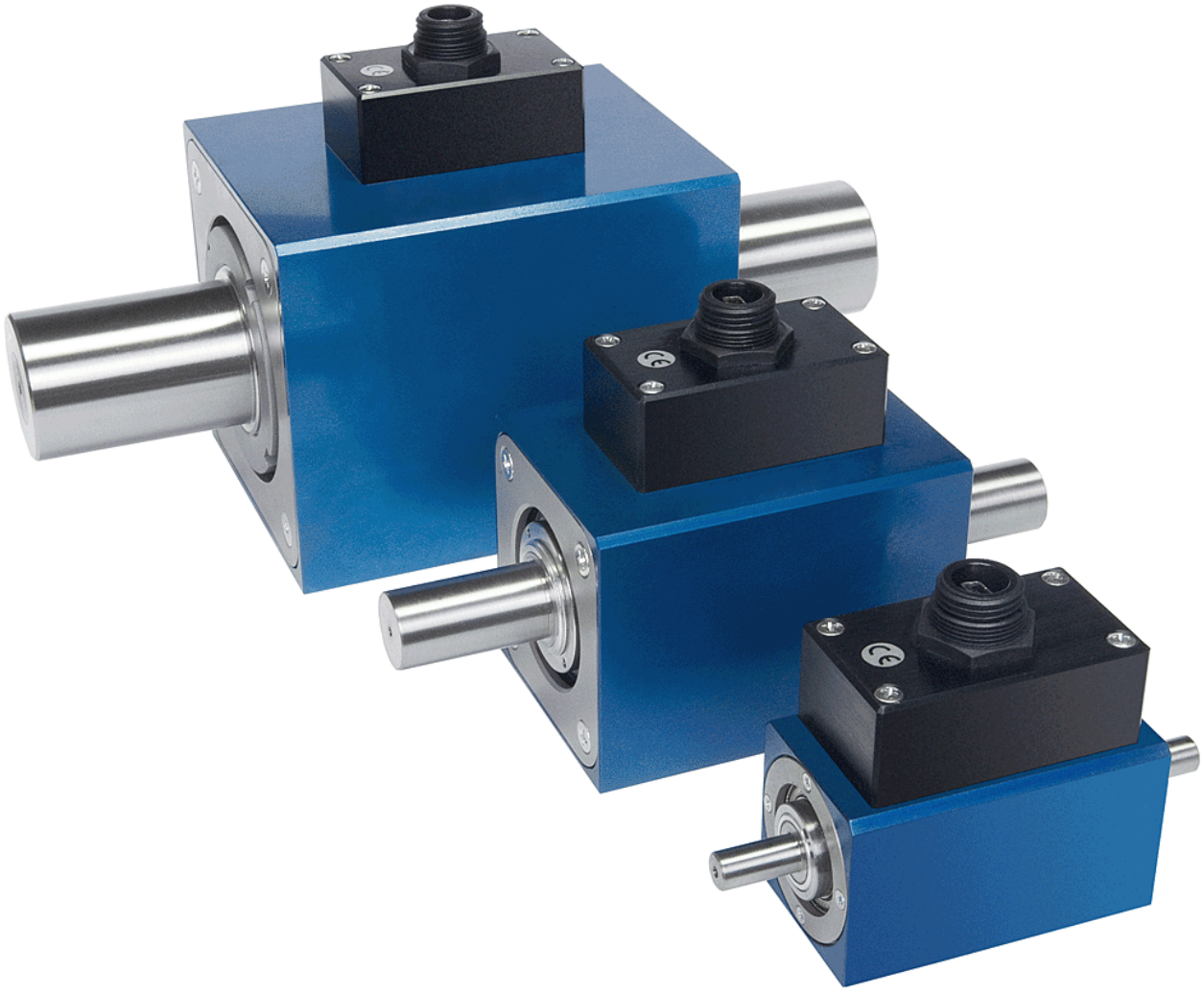
Operation Manual for “Plug and Play“ USB Torque Sensor

Type DR-3000



1 Contents

2 Imprint

Manufacturer, Place	Lorenz Messtechnik GmbH, D-73553 Alfdorf
Valid for...	Torque Sensor Type DR-3000
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Modification	Technical changes reserved.

3 References in this Text

4.6 Warning Notes; Page 5

Attention must be paid to the accident prevention regulations of the trade associations. Coverings and casings are necessary before operating the sensor. This is also valid for commissioning, maintenance and trouble shooting.
Duties of the coverings and casings are:

- ⇒ Protection from detaching parts
- ⇒ Protection from contusion and shear
- ⇒ Prevention from reaching rotating parts
- ⇒ Prevention from being tangled up and/or getting caught by parts

Coverings may

- ⇒ Not grind, Not rotate

Coverings are also necessary outside of operating and motion travel areas of persons. These demands can be modified if other sufficient safety devices are available. During operation, the safety precautions must be operative. By vibrations, damages can occur at the device.

7 Mechanical Assembly; Page 8

During the assembly, the sensor must be protected from falling down.

7.1.3 Alignment of the Measurement Arrangement; Page 8

For further references see the coupling manual of the coupling manufacturer and/or the data sheet.

7.2 General; Page 8

Before the assembly, shafts must be cleaned with dissolver (e.g. acetone), no foreign particles may adhere to them. The hub must fit according to the connection.

Caution: During the assembly inadmissibly large forces may not act on the sensor or the couplings. Especially at small torques (<20 N·m) we strongly recommend to connect the sensor electrically during the assembly and watch the signal. The measuring signal may not exceed the nominal torque.

7.2.1 Torque Sensors of 0.5 N·m to 10 N·m; Page 8

Sensors with nominal torques up to 10 N·m are very sensitive to overload, therefore these sensors must to be handled with major caution.

7.3 Free-floating Assembly; Page 9

Caution: Inadmissibly large forces may not act on the sensor or the couplings during the assembly.

Double-jointed couplings for both sides cannot be used in this installation case.

Risk of breakage!
In this installation case the rotational speed must be limited <10000 rpm! **Risk of breakage by resonance appearances.**

7.4 Foot Version Assembly; Page 9

Caution: Inadmissibly large forces may not act on the sensor or the couplings during the assembly.

9.1 Engaging; Page 10

Warming-up period of the torque sensor is approx. 5 min. This time period can deviate significantly (ambient temperature).

9.4.2 Natural Resonances Page 11

Operation of the equipment in natural resonance can lead to permanent damages.

4 Read First

4.1 Safety and Caution Symbols

Caution:
Injury Risk for Persons
Damage of the Device is possible.

Note:
Important points to be considered.

4.2 Intended Use

Torque sensors are intended for the measurement of torques. This measurand is further suitable for control tasks. The valid safety regulations should be absolutely respected. The torque sensors are not safety components in the sense of the intended use. The sensors need to be transported and stored appropriately. The assembly, commissioning and disassembling must take place professionally.

4.3 Dangers

The torque sensor is fail-safe and corresponds to the state of technology.

4.3.1 Neglecting of Safety Notes

At inappropriate use, remaining dangers can emerge (e.g. by untrained personnel). The operation manual must be read and understood by each person entrusted with the assembly, maintenance, repair, operation and disassembly of the torque sensor.

4.3.2 Remaining Dangers

The plant designer, the supplier, as well as the operator must plan, realize and take responsibility for safety-related interests for the sensor. Remaining dangers must be minimized. Remaining dangers of the torque measurement technique must be pointed out.
Human mistakes must be considered. The construction of the plant must be suitable for the avoidance of dangers. A danger-analysis for the plant must be carried out.

4.4 Reconstructions and Modifications

Each modification of the sensors without our written approval excludes liability on our part.

4.5 Personnel

The installation, assembly, commissioning, operation and the disassembly must be carried out by qualified personnel only. The personnel must have the knowledge and make use of the legal regulations and safety instructions.

4.6 Warning Notes

Attention must be paid to the accident prevention regulations of the trade associations. Coverings and casings are necessary before operating the sensor. This is also valid for commissioning, maintenance and trouble shooting.
Duties of the coverings and casings are:

- ⇒ Protection from detaching parts,
- ⇒ Protection from contusion and shear,
- ⇒ Prevention from reaching rotating parts,
- ⇒ Prevention from being tangled up and/or getting caught by parts.

Coverings may

- ⇒ Not grind, Not rotate

Coverings are also necessary outside of operating and motion travel areas of persons.These demands can be modified if other sufficient safety devices are available. During operation, the safety precautions must be operative. Vibrations can cause damages on the device.

5 Term Definitions

5.1 Terms

Measuring Side:

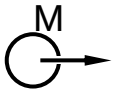
Mechanical connection of the torque sensor in which the torque to be measured is applied. Usually this side has the smallest moment of inertia.

Drive Side:
Mechanical connection of the torque sensor on the opposite side of the measuring side, usually with the largest moment of inertia. At static torque sensors the housing is fastened on this side.

Low Torque Resistance Side:
The shaft of the arrangement (drive, load) which can be turned considerably smaller with torque than the nominal torque of the torque sensor $M << M_{nenn}$.

5.2 Definition of the Pictograms on the Torque Sensor

The measuring side of the torque sensor is designated as follows:

Measuring side: 

or M

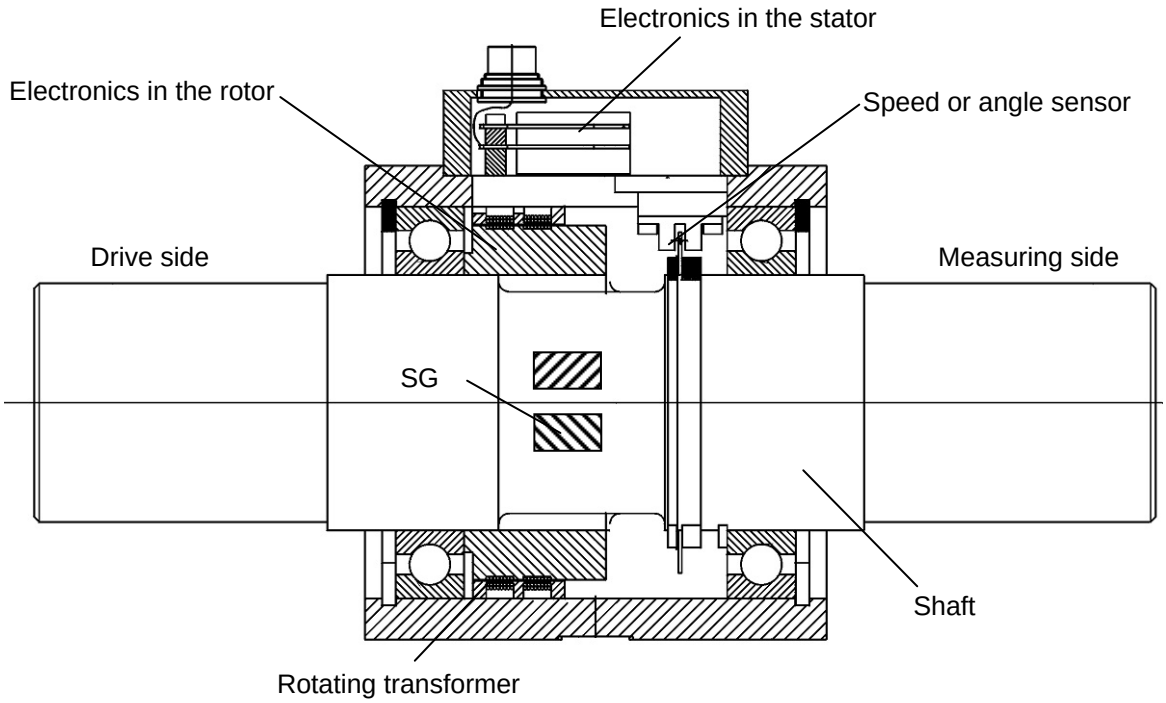
More information can be found on the data sheet.

6 Product Description

The sensor measures static and dynamic torques. The mounting position of the torque sensor is horizontally.
Caution: it is to be differentiated between measuring side and drive side, see data sheet of the sensor: http://www.lorenz-sensors.com

6.1 Mechanical Setup

On the shaft which is located on the housing is an area, reduced at the diameter, on which the SG-bridge is applied. The rotating part of rotating transformer and the rotating electronics are fixed on the shaft as well.
A rotating transformer consists of two coils, concentrical to each other. The two coils are separated by an air gap. By this, one coil can be fixed on the rotor and the other coil can be fixed in the stator. The transmission of energy, resp. measuring signals occurs according the same principle as a transformer. The stationary part of the rotating transformer and electronics are located in the housing. For the electrical connection of the sensor a connector is located in the housing.

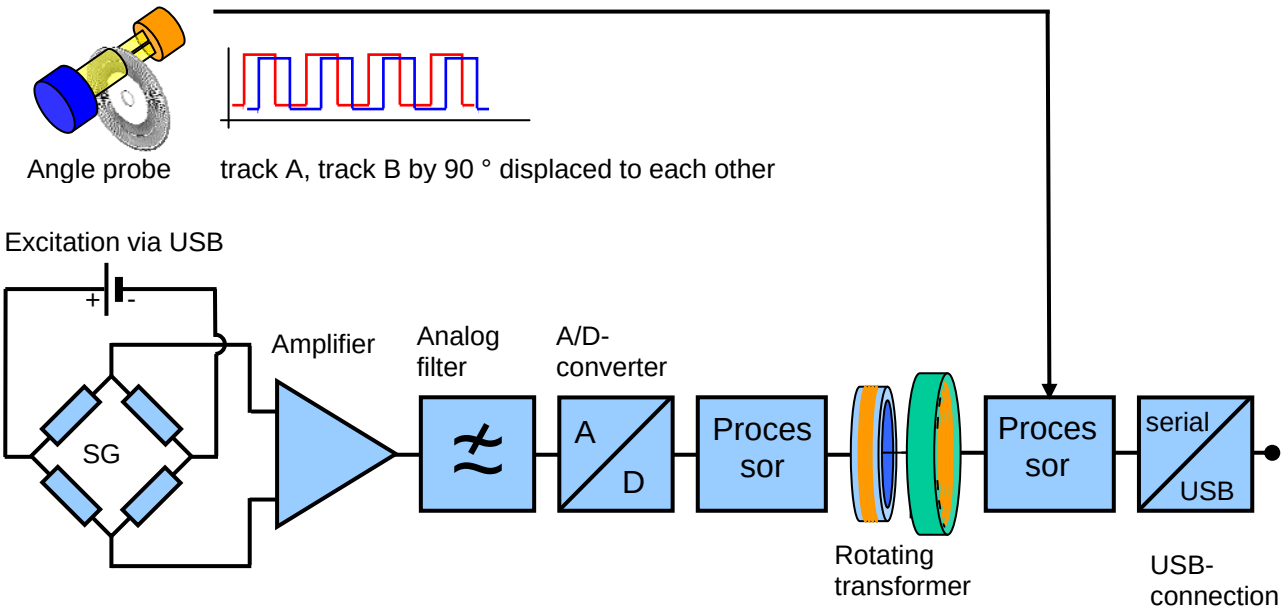


6.2 Electrical Setup

As mentioned in chapter 3.1, the measured value acquisition occurs on the rotating shaft through SG. This measuring signal is immediately filtered, amplified and digitalized. The digital signal then goes to a processor which prepares it in form of a serial word for the transmission to the stator. The transmission from rotor to stator occurs through a rotating transformer. The great advantage of this rotating transformer is its bidirectional use. Signals can be transferred from the rotating shaft to the stator as well as in contrariwise direction. This is being used for the transmission of commands to the rotor and the control.

The data signal gets conditioned in the stator, then it is converted to a serial signal in a processor. This serial signal is then translated into a USB-protocol by a converter. Then, the data are transferred to a PC through an USB-connection. By the use of processors in a sensor, data such as serial number, calibration value, measuring range etc. can be stored in the torque sensor. This information can be read-out for the automatic configuration of the measurement software which leads to high reliability of operation. Additional power supply is not necessary because the excitation of the sensor occurs via 5 V DC voltage of the USB-interface.
If the 100 % calibration control is activated at the mechanical unloaded sensor, the SG measuring bridge will be out of tune. At the output, a signal corresponding to nominal torque is being issued as a response.

By this, the function of the complete measurement chain can be checked, without having to load the sensor with a reference variable.



Block diagram for sensor with integrated electronics.

6.3 Angle of Rotation- and Speed Measurement

The angle, resp. speed acquisition occurs in two different methods. At angle of rotation, only the flanks of the TTL-signal of the angle sensor are processed, so that a pulse-shaped signal is available for each flank. By this, two angle tracks with each 360 °/rev. 4 x 360 pulses, thus 1440 pulses are obtained, which is equivalent to a dissolution of ¼ °. The information of rotating direction is obtained from the phase shift of the two angle tracks.
The sensor does not issue the usual TTL-signals. It directly issues the conditioned angle signal in ¼-degree-steps. By this, the correct angle of rotation for torque is always obtained.
At speed measurement a periodic durability measurement is carried out and from this, the speed is determined. Also here, a TTL-signal as a value is not available, but directly the speed in unit rpm.
At speed and angle of rotation measurement the result is issued as a 16 bit-value by the sensor.

6.4 Sensor Communication

The communication with the sensor occurs by a protocol (document no. 090110) which was developed by Lorenz Messtechnik GmbH. It contains a number of commands which configure the sensor and it assures the unobstructed measured value transmission. The protocol controls different transmission modes.
In **Lorenz mode**, all important commands for control and configuration of the sensor are available. The communication is secured by checksums and has the highest data security at transmission. This mode can be used for the transmission of the configuration data and for the measured data rates of 1/min up to 10/s (1 per minute up to 10 per second). For the transmission of measured values under WINDOWS, the protocol contains the **Speed Optimized Streaming Mode.** Here, the sensor continuously sends the measured values in the adjusted measuring rate to a PC. The measuring rate can be changed in the range between 20/s and 2500/s by the user (periodic multiple of 200 µs).
The protocol is described in detail in document no. 90110. It can be downloaded free of charge from http://www.lorenz-sensors.com/ .

7 Mechanical Assembly

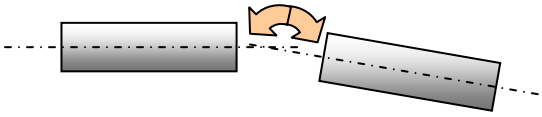
For the assembly of a torque sensor in a shaft line, in each case we recommend to use couplings which can be misaligned.

During the assembly, the sensor must be protected from falling down.

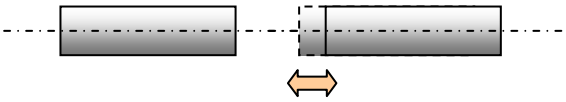
7.1 Couplings

We recommend multi-disc couplings for our torque sensors. Couplings must be able to balance an axial, radial or angular offset of the shafts and not allow large forces to act on the sensor. The assembly instructions of the respective coupling manufacturer must be considered.

7.1.1 Misalignment Possibilities of Single-Jointed Couplings

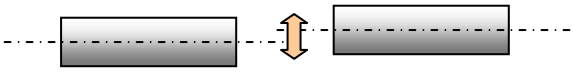


Angular misalignments



Axial misalignments

Note: Radial misalignments are only possible in the combination of
single-jointed coupling - torque sensor (as adapter) - single-jointed coupling.
Thus, with both single-jointed couplings the torque sensor forms a double-jointed coupling.



Radial misalignments

7.1.2 Double-Jointed Couplings

Double-jointed couplings are used for the balance of inevitable angular, axial and radial misalignments.

7.1.3 Alignment of the Measurement Arrangement

Precisely alignment of the couplings reduces the reaction forces and increases the durability of the couplings. Disturbance variables are minimized as well.
Due to the multitude of applications, an alignment of the coupling with a straight edge in two levels, vertical to each other, is sufficient.
However, in drives with high speed an alignment of the coupling (shaft ends) with a dial gauge or a laser is recommended.

For further references see coupling manual.

7.2 General

Before the assembly, shafts must be cleaned with dissolver (e.g. acetone), no foreign particles may adhere to them. The hub must fit corresponding to the connection.

Connections with a Clamping Piece:

The indications of the clamping piece manufacturer must be considered. The clamping piece must be able to transfer the arising torques safely.

Caution: During the assembly inadmissibly large forces may not act on the sensor or the couplings. At small torques (< 20 N·m) connect the sensor electrically during the assembly and observe the signal, the measurement signal may not exceed the nominal torque.

7.2.1 Torque Sensors of 0.5 N·m to 10 N·m

Sensors with nominal torques up to 10 N·m are very sensitive to overload, therefore these sensors need to be handled with major caution.

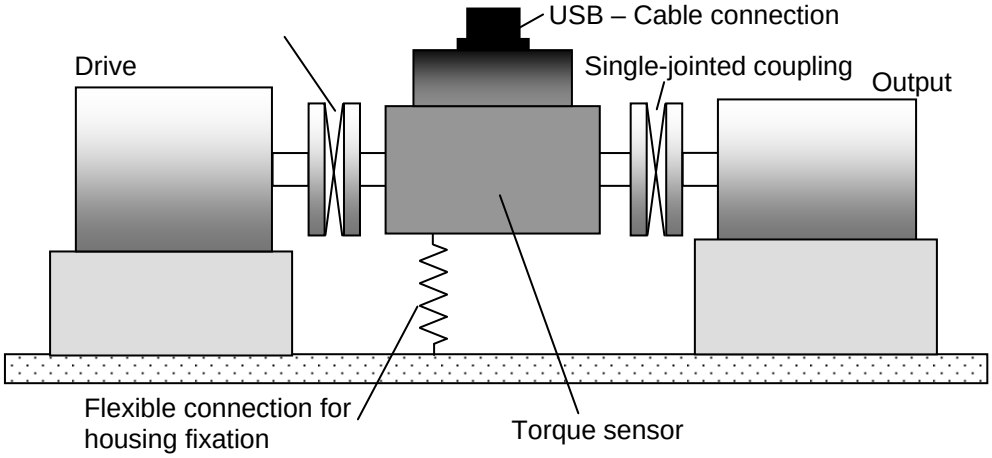
1. We highly recommend to connect the sensor electrically during the assembly and observe the measuring signal. The measurement signal may not exceed the nominal torque during the assembly.
2. Align the arrangement before the parts are firmly assembled.
3. Assemble the sensor at the **low torque resistance side** first, then at the stationary side (this avoids impermissibly large torques from acting on the sensor).
4. Hold the sensor by hand, so impermissibly large torques or disturbance variables can not act on the torque sensor
5. Do not use power of impact (e.g. hammer to loosen tight parts)

7.3 Free-floating Assembly

The sensor is installed between two single-jointed couplings and contributes to he balance of an inevitable axis offset between the two mechanical connections. If no couplings are used, very large transverse forces can affect the sensor. addition, large forces occur on the bearings in drive and output, which limit their life span very strongly. Shift couplings on shafts (use entire clamping length of the coupling) and align shafts. Assure absolutely that the data of the couplings (axis offset, angular offset, tension, compression) are not exceeded.

Caution: During the assembly inadmissibly large forces may not act on the sensor or the couplings. Do not use power of impact!

The housing must be protected from twisting e.g. by a flexible connection. **The cable connection may not be used for this.**
The cable connection must be placed loosely (form of goose neck), so that it can follow the light movements of the stator.



In this case, with both single-jointed couplings, the torque sensor forms a double-jointed coupling.
A single-jointed coupling can only balance axial and angular misalignments.

In this installation case, double-jointed couplings can not be used for both sides!
Risk of Breakage!
In this installation case the rotational speed must be limited.
Risk of breakage by resonance appearances.

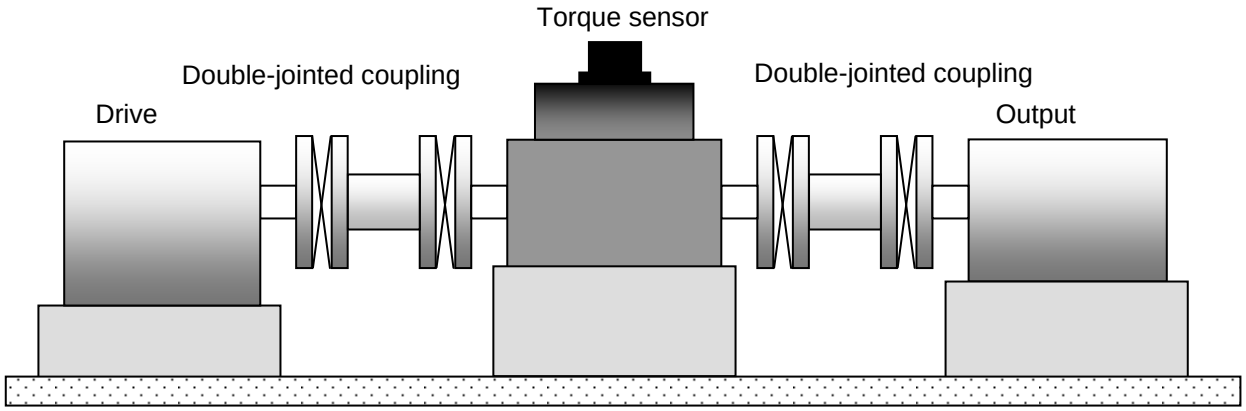
7.4 Foot Version Assembly

The housing of the sensor is designed as a bearing block. A full coupling must be installed at both shaft ends. By this, inevitable misalignments can be balanced, which can occur during the period of operation.

If no couplings are used, very large transverse forces can affect the sensor. In addition, large forces occur on the bearings in drive and output, which limit their life span very strongly.
Furthermore large bending moments occur in the shaft. At small torques (< 20 N·m) connect the sensor electrically during the assembly and observe the signal, the measurement signal may not exceed the limit values

Shafts have to be cleaned with solvent (e.g. acetone) before the assembly
No foreign bodies may adhere to them.
Shift couplings on shaft (use entire clamping length of the coupling) and align shafts.

Absolutely note that the data of the couplings (axis offset, angular offset, tension, compression) are not exceeded.



Caution: During the assembly, inadmissibly large forces may not act on the sensor or the couplings. Do not use power of impact!

8 Electrical Connection

8.1 USB - Cable

Use only shielded cables according USB2.0 specification or higher. We recommend transmission cables from our product range. They have been tested together with the sensors and fulfill the technical requirements for transmission. Further information can also be found on the respective data sheet.

8.2 Shielding Connection

In combination with the sensor and the external electronics, the shield forms a Faraday Cage. By this, electro-magnetic disturbances shall be kept away from the transmission line. All parts of the arrangement must be grounded at one point.

8.3 Running of the Transmission Cables

Do not run USB-transmission cables together with control or heavy-current cables. Always assure that a large distance is kept to engines, transformers and contactors, because their stray fields can lead to interferences of the measuring signals.
If troubles occur through the measuring cable, we recommend to run the cable in a grounded steel conduit.

8.4 Drivers and Software

A PC with installed driver and software DR-3000-VS is necessary for the operation of this sensor. The detailed description (document no. 090302) can be found on our website http://www.lorenz-sensors.com/

8.5 Calibration Control

Only use the 100 % calibration control at unloaded torque sensor condition. The actuation of the calibration control occurs through the provided measuring software via a command which will detune the SG measuring bridge on the rotor accordingly.

9 Measuring

9.1 Engaging

The warming-up period of the torque sensor is approx. 5 min. Afterwards the measurement can be started.

Warming-up period of the torque sensor is approx. 5 min. This time period can deviate significantly (ambient temperature).

9.2 Direction of Torque

Torque means clockwise or clockwise torque if the torque acts clockwise when facing the shaft end. In this case a positive electrical signal is obtained at the output.
Torque sensors by Lorenz Messtechnik GmbH can measure both, clockwise (positive leading sign) and counter-clockwise (negative leading sign) direction.

9.3 Static / Quasi-Static Torques

Static and/or quasi-static torque is a slowly changing torque.
The calibration of the sensors occurs statically on a calibration device.
The applied torque may accept any value up to the nominal torque.

9.4 Dynamic Torques

9.4.1 General

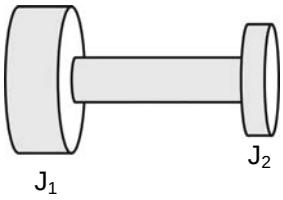
The static calibration procedure of torque sensors is also valid for dynamic applications.
Note: The frequency of torques must be smaller than the natural frequency of the mechanical measurement setup.
The band width of alternating torque must be limited to 70 % of the nominal torque.

9.4.2 Natural Resonances

Estimate of the mechanical natural frequencies:

$$f_0 = \frac{1}{2 \cdot \pi} \cdot \sqrt{c \cdot \left(\frac{1}{J_1} + \frac{1}{J_2} \right)}$$

f_0 = Natural Frequency in Hz
J_1, J_2 = Moment of Inertia in kg·m²
c = Torsional Rigidity in N·m/rad



Further methods for the calculation of natural resonances are corresponding purchasable programs or books (e.g. Holzerverfahren, Dubbel, Taschenbuch für den Maschinenbau, Springer Verlag)

An operation of the device in natural resonance can lead to permanent damages.

9.5 Speed Limits

The maximum speed indicated in the data sheet may not be exceeded in any operating state..
The respective maximum torque indicated in the data sheet must be observed for each component of the arrangement.

9.6 Disturbance Variables

By disturbances, measured value falsifications can occur by

- Vibrations,
- Temperature gradients,
- Temperature changes,
- Arising disturbance variables during operation, e.g. imbalance,
- Electrical disturbances,
- Magnetic disturbances,
- EMC (electromagnetic disturbances),

Therefore avoid these disturbance variables by decoupling of vibrations, covers, etc.

10 Maintenance

10.1 Maintenance Schedule (recommended)

Action	Frequency	Date	Date	Date
Control of cables and connectors	1x p.a.			
Calibration	< 26 months			
Control of fixation (flanges, shafts)	1x p.a.			
Have bearings exchanged by Lorenz Messtechnik GmbH	20000 hrs operating time			

10.2 Trouble Shooting

This chart should help to search for the most frequent errors and their elimination

Problem	Possible Cause	Trouble Shooting
No signal	No sensor excitation	• Outside of permissible range • Cable defect • No mains supply
Sensor does not react to torque	Shaft not clamped	• Clamp correctly
	No power supply	• Outside of permissible range • Cable defect • No mains supply
	Cable defect	• Repair cable
Signal has dropouts	Cable defect	• Repair cable
Zeropoint outside of tolerance	Cable defect	• Repair cable
	Shaft mounted distorted	• Mount correctly
	Distorted shaft string	• Release from distortion
	Strong lateral forces	• Reduce lateral forces
	Shaft overloaded	• Send to manufacturer
Wrong torque indication	Calibration not correct	• Re-calibrate
	Sensor defect	• Repair by manufacturer
	Torque shunt	• Eliminate shunt
Oscillations	Alignment of shaft not correct	• Align correctly
	Unbalance	• Balance the corresponding parts • Change of natural frequency (damping, bearings)

11 Decommission

All sensors must be dismantled professionally. Do not strike sensor housings with tools. Do not apply bending moments on the sensor, e.g. through levers. The torque sensor must be supported to avoid falling down during the dismantling. For decommission, the same rules apply as for assembly.

12 Transportation and Storage

The transportation of the sensors must occur in suitable packing.
For smaller sensors, stable cartons which are well padded are sufficient (e.g., air cushion film, epoxy crisps, paper shavings). The sensor should be tidily packed into film so that no packing material can reach into the sensor (ball bearings).
Larger sensors should be packed in cases.

12.1 Transportation

Only release well packed sensors for transportation. The sensor should not be able to move back and forth in the packing. The sensors must be protected from moisture.
Only use suitable means of transportation.

12.2 Storage

The storage of the sensors must occur in dry, dust-free rooms, only.
Slightly lubricate shafts and flanges with oil before storing (rust).
Please consider the conditions (air humidity, temperature) of the data sheet.

13 Disposal

The torque sensors must be disposed according the valid law.

14 Calibration

At the time of delivery, torque sensors have been adjusted and tested with traceable calibrated measuring equipment at factory side. Optionally, a calibration of the sensors can be carried out.

14.1 Proprietary Calibration

Acquisition of measurement points and issuance of a calibration protocol. Traceable calibrated measuring equipment is being used for the calibration. The sensor data are being checked during this calibration.

14.2 DKD-Calibration

The calibration of the sensor is carried out according to the guidelines of the DKD. The surveillance of the calibrating-laboratory takes place by the DKD. At this calibration, the uncertainty of measurement of the torque measuring instrument is determined. Further information can be obtained from Lorenz Messtechnik GmbH.

14.3 Re-Calibration

The recalibration of the torque sensor should be carried out after 26 months at the latest.
Shorter intervals are appropriate:

- Overload of the sensor
- After repair
- After inappropriate handling
- Demand of high-quality standards
- Special traceability requirements

15 Data Sheet

See www.lorenz-sensors.com

16 Literature

Lorenz Protocol, document no. 090110, Lorenz Messtechnik GmbH
Dubbel, Taschenbuch für den Maschinenbau, Springer Verlag