Operating manual

Torque Transducers

T34FN

A0128-20 en

HBM

Contents

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Safety instructions

Appropriate use

The T34FN Torque Transducer may be used for torque-measurement and directly related control and regulation tasks, only. Any other use is not appropriate.

To ensure safe operation, the transducer may only be used according to the specifications given in this manual. When using the transducer, the legal and safety regulations for the respective application must also be observed. The same applies if accessories are used.

The transducer is no safety element in the sense of appropriate use. Prerequisites for correct and safe transducer operation are appropriate transportation, storage, installation and mounting, and careful operation.

General dangers in the case of non-observance of the safety instructions

The transducer complies with the state of the art and is operationally reliable. If the transducer is used and operated inappropriately by untrained personnel, residual dangers might develop.

Any person charged with transducer installation, operation, maintenance or repair must in any case have read and understood the operating manual and the notes on safety, in particular.

Residual dangers

The transducer's scope of performance and supply covers a part of the torque measuring-technology, only. The plant designer/constructor/operator must in addition design, realize and take responsibility for the torque measuring-system's safety such that potential residual dangers are minimized. The respective regulations must in any case be observed. Residual dangers regarding the torque measuring-system must be specified explicitly.

In this manual, the below symbols are used to refer to residual dangers:

Symbol: **DANGER**

Meaning: **Maximum danger level**

Warns of an **imminently** dangerous situation in which failure to comply with safety requirements **will result in** death or serious physical injury.

Symbol: **WARNING**

Meaning: **Potentially dangerous situation**

Warns of a **potentially** dangerous situation in which failure to comply with safety requirements **can result in** death or serious physical injury.

Symbol: **CAUTION**

Meaning: **Potentially dangerous situation**

Warns of a **potentially** dangerous situation in which failure to comply with safety requirements **could result in** damage to property or some form of physical injury.

Symbol: **NOTE**

Means that important information about the product or its handling is being given.

Symbol: CE

Meaning: **CE mark**

The CE mark enables the manufacturer to guarantee that the product complies with the requirements of the relevant EC guidelines (see Declaration of Conformity at the end of this document).

Reconstruction and modifications

HBM's express consent is required for modifications regarding the transducer's construction and safety. HBM does not take responsibility for damage resulting from unauthorized modifications.

Qualified personnel

The transducer may be used by qualified personnel, only; the technical data and the special safety regulations must in any case be observed. When using the transducer, the legal and safety regulations for the respective application must also be observed. The same applies if accessories are used.

Qualified personnel means: personnel familiar with the installation, mounting, start-up and operation of the product, and trained according to their job.

Prevention of accidents

According to the prevailing regulation to prevent accidents a cover has to be fitted after the mounting of the torque transducers T34FN as follows:

- the cover must be stationary
- the cover shall avoid any danger of squeezing and provide protection against parts that might come loose
- the cover shall be installed at a minimum distance from moving pats or shall be of a nature that a hand cannot be put through
- the cover shall be fitted even if moving parts are installed outside the usual access area of persons.

Above regulations could only be disregarded if there is already sufficient protection of machine parts owing to the design of the machine or due to other precautions.

1 General remarks, application areas

Torque transducers measure mechanical torques and shaft rotational speeds. The product of these two parameters represents developed shaft power. Torque transducers are thus used in of power performance and operating efficiency studies on rotating and oscillatory machinery and systems.

The full-floating construction of HBM torque transducers eliminates preventative maintenance and periodic lubrication. Signal interferences due to frictional losses and thermal effects are also eliminated by this choice of design.

Static and dynamic torques can be measured on stationary or rotating shafts.

Potential application areas for torque transducers include:

- test-rigs for small motors, household appliances and office equipment
- test-rigs in quality assurance
- measurements an hydraulic pumps, hydraulic motors and machine tools
- bearing friction and viscosity measurements
- monitoring measurements with thread cutting
- measurements on high-speed drives such as e.g. compressed-air engines

2 Design and operation

2.1 Design

The torque transducer consists of two distinct basic components: a rotor (T34R40/...) and a stator (T34ST).

A measuring element is formed by the rotor core onto which strain gauges are mounted. The measuring element is enclosed in the transmitter sleeve with the windings of the inductive transmission system and a segmented ring for the speed measurement. The rotor electronics is situated on the inside of the transmitter sleeve.

Apart from the windings of the inductive transmission system two field plates are also mounted in the stator. Rotation of the rotor's segmented ring induces voltage pulse trains in these field plates that are used to derive the signals for rotational speed and direction of rotation.

The stator also incorporates a terminal box equipped with a 7-pole plug for the torque signal and a 5-pole plug for the speed signal. The pre-amplifiers for the torque and speed signals are build into the terminal box. Four holes, threaded M4, are located in the base of the stator for installation on the customer's mounting point.

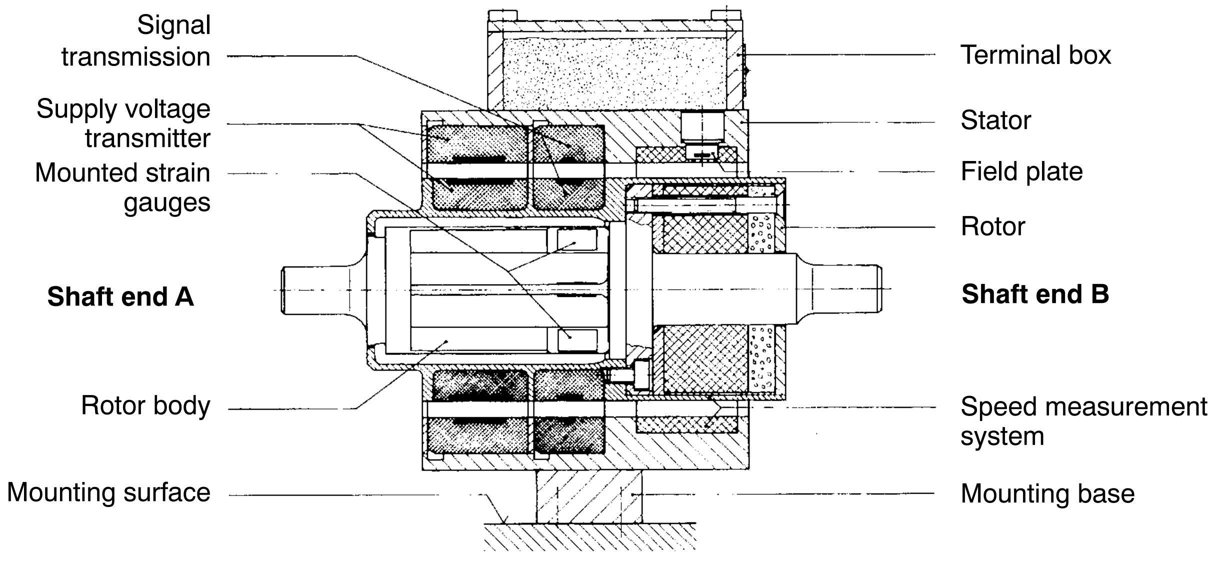

Fig. 2.1: Mechanical design, schematic drawing

2.1.1 The torque measurement system

For determining the applied torque strain gauges are mounted on the rotor of the torque transducers along the principal direction of strain. They are wired as a Wheatstone bridge so that only torques cause unbalance in the bridge. Transverse and longitudinal forces have no effect on the measurement signal within the permissible limits. Supplementary compensation elements effectively eliminate thermal effects over a wide range of temperatures.

The supply voltage (54 V_{pp} ; 15 kHz) provided by the amplifier to which the transducer is connected, is transmitted inductively to the rotor. The frequence-voltage converter built into the rotor converts the supply voltage into a stabilized bridge excitation voltage (U). The applied torque elastically deforms the rotor body and therefore also the strain gauges. The ohmic resistance of the strain gauges then changes by an amount that is proportional to the strain, causing an unbalance in the Wheatstone bridge circuit.

The bridge output voltage (U_A) is fed to a voltage-frequency converter. This produces pulses whose repetition frequency is proportional to the measured quantity. These pulses are inductively transmitted to the stator, where they are converted in the preamplifier into a pulse train in the range 5 kHz...15 kHz and with 12 V (peak-peak) amplitude.

In the unloaded condition, the frequency of this pulse train will be 10 kHz. At nominal torque, signals at a frequency of either 15 kHz or 5 kHz will appear on the ”Md” plug, depending upon the direction of the applied torque.

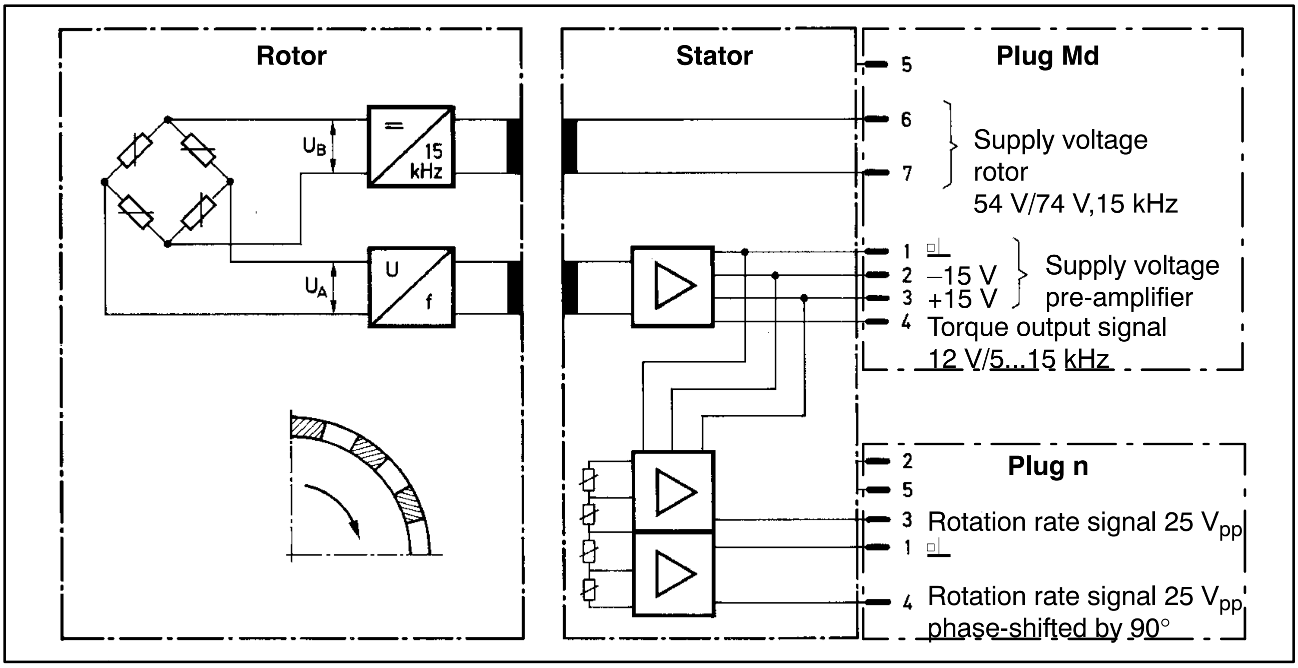

Fig. 2.2: Electrical block schematic

2.1.2 The rotation rate measurement system

A segmented ring having 15 segments is mounted on the rotor for generating rotation rate signals. Rotation of the rotor induces voltage pulses in the two field plates of the stator having repetition frequency proportional to the rotor rotation rate. 15 pulses are generated for each full rotation of the rotor. The two field plates are arranged diametrically opposite one another, but slightly displaced by amounts such that the two pulse trains generated differ in relative phase by 90°. This phase shift serves as an indicator of the direction of torque transducer rotation.

A pre-amplifier converts these two pulse trains into square-wave voltage signals of 25 V (peak-to-peak) amplitude. These square-wave voltages, whose frequency is proportional to rotation rate, are brought out for further processing at plug ”n”.

3 Installation

3.1 General hints and suggestions

- The two stub shafts of torque transducers should be connected to the free ends of shafts or to the couplings of measurement hardware.
- Accurately align the stub shafts. Misalignments and shaft offset errors can be lead to mechanical overloading of torque transducers. HBM recommends that couplings should be used on both shaft ends to eliminate these sources of errors.
- Customer-supplied mountings for the stator must be such that all stated mechanical tolerances are maintained. Axial and radial offsets of drive hardware with respect to rotors must remain within stated tolerated limits (see ”Technical Data”).

3.2 Installation notes

HBM torque transducers may be incorporated into drive trains without use of flexible coupling elements. Quick-connecting types of couplings, such as friction-lock or ”dog” couplers can be used, if desired. A mandatory requirement is that any erroneous loads do not exceed the stated limits (see ”Technical Data”). Excessive loading can arise from, e.g., angular mismatches and off-center misalignments, or can arise from the shaft design.

Since installations are difficult to carry out without employing flexible couplings, HBM recommends that all of its torque transducers be installed using flexible couplings.

3.3 Coupling selection

Suitable types of flexible couplings include, e.g., disc-type couplings. The following criterion are to be observed in selecting couplings for use:

- Couplings should be dimensioned to suit expected torque loads and rotation rates
- Coupling radial stiffness must be sufficient to accommodate rotor weights
- When estimating the loads that may arise, the following must be taken into account as well as the applied torque:
  - Startup, braking, and gear-change torques
  - Transits through critical rotation rates
  - Effective mass moments of inertia
  - Range of dynamic moments

  Nominal torque spikes can be substantially greater in peak amplitude than mean values computed from nominal powers and rotation rates!

  Conservative dimensioning of torque transducers and their coupling hardware provides protection against mechanical overloading.
- Couplings should be selected such that any additional forces and torques they might generate remain within the stated tolerance limits and will not affect the torque transducers.
- Couplings used should be self-centering. Angular mismatches and parallel and axial offsets must be compensated.
- The disc-type couplings supplied by HBM have been tested in running tests with the torque transducer and are suitable for the total speed range (0...40.000 rpm).

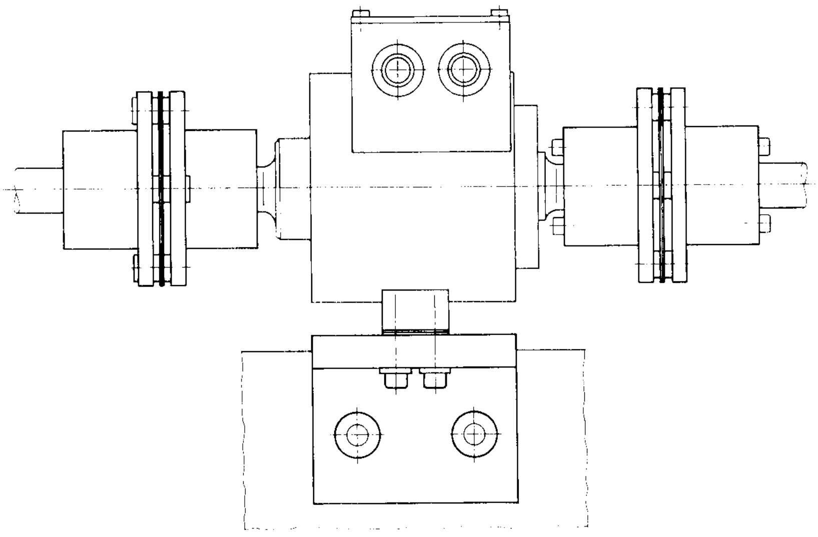

Fig.3.1: Installation example using disc-type coupling

3.4 Precautions

The torque transducers are protected to IP 54 according to EN 60 529. Torque transducers shall be protected against coarse dirt particles, oil solvents and humidity.

3.5 Installed orientation

The torque transducers may be used in any orientation. If flexible couplings are used, follow the manufacturer's recommendations on operating orientations.

Mass moments of inertia

Due to the transducers construction and depending on the measuring range, about 90 % of the total mass moment of inertia J_V is effective at shaft end B. This must be taken into account when mounting the transducer with strong acceleration or braking actions, to prevent the torque transducer from suffering damage by dynamic torques exceeding the permissible limits. Furthermore, do in no case drive or brake shaft end B via the measuring teeth - i.e. not via shaft end A - because of the additional high torques resulting from the mass moments of inertia.

If in doubt, use the below equation

$$M_{zus} = J_{V,ges} \cdot \frac{\pi}{30} \cdot \frac{\Delta n}{\Delta t} \qquad \text{with } J_{V,ges} \text{ in kg} \cdot \text{m}^2,\ n \text{ in min}^{-1},\ t \text{ in s}$$

for an assessment of the additional torque resulting from the mass moments of inertia for a constant acceleration. In this case J_V is the total of all mass moments of inertia effective at the transducer side that is not driven/braked.

Rotation rate

There is an arrow on the stator. When torque transducers rotate in the direction indicated by the arrow, interfaced HBM signal amplifiers will output positive voltages (0...+10 V).

Torque

When the applied torque acts in the direction of the arrow, the output signal frequency will lie within the range 10 kHz...15 kHz. Interfaced HBM signal amplifiers will output positive output voltages (0...+10 V).

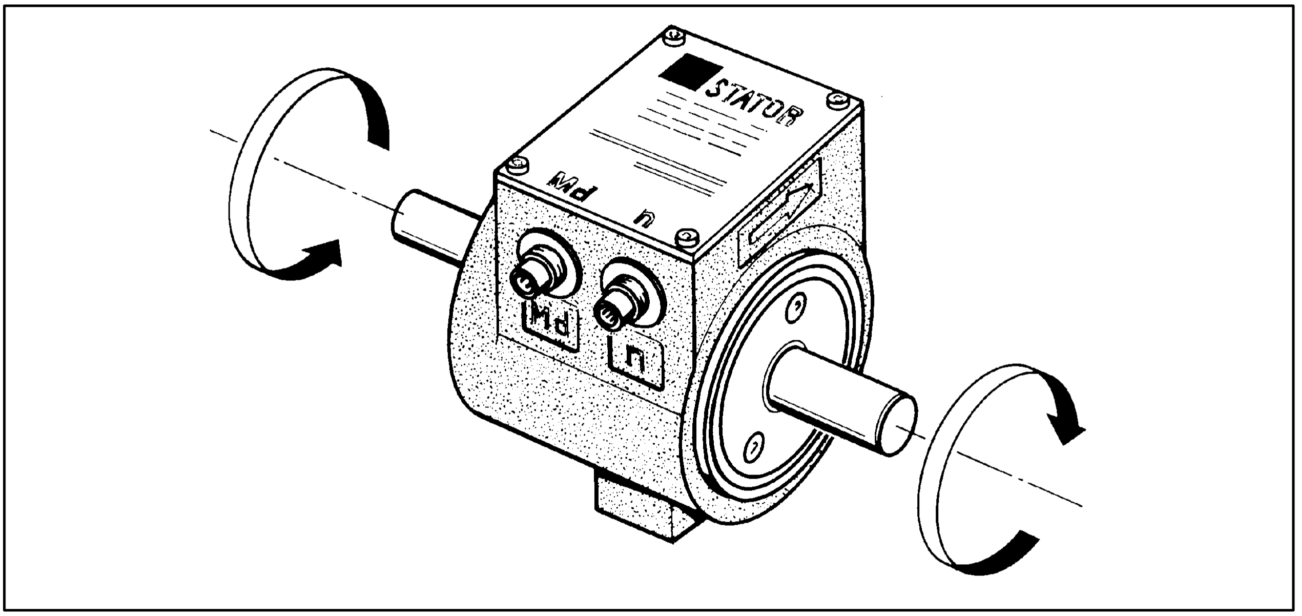

Fig.3.2: Direction of rotation, sense of applied torque

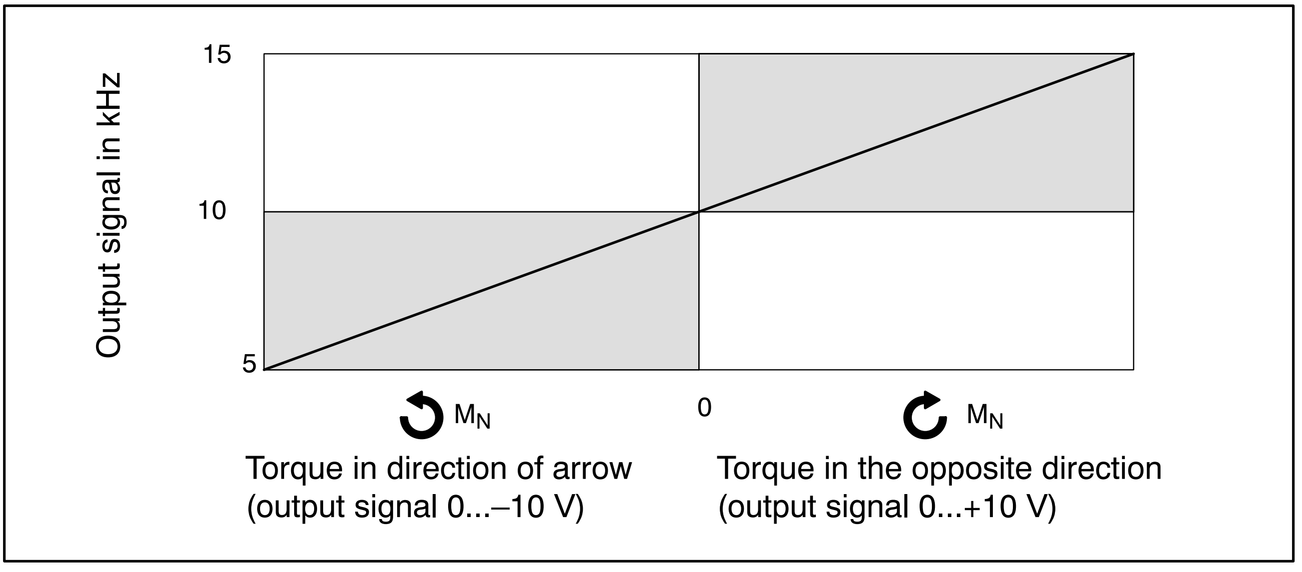

Fig.3.3: Direction of torque

3.6 Assembly

Stators and rotors are supplied as separate items. Two alignment fixtures are provided on the stator as an aid in assembly, and for use in centering the rotor within the stator.

Note: Be certain to remove these fixtures before operating torque transducers!

The following points should be noted on installation:

- Remove the protective sleeve from the rotor. **Always handle rotors with extreme care. Shocks or falls can damage rotor windings.**
- Arrange the two components such that the rotor identification plate and the arrow on the stator are situated on the same side. Insert the rotor into the stator until the rotor is firmly held by the alignment fixture.

  Note: the rotor identification plate should remain visible so that calibration signal data can be read when needed.
- Connect the stub shaft of the torque transducer to the shaft or coupling of the object to be measured. The mating surface of the stator mounting base must seat cleanly on the mounting surface, with no free play or strain distortions. Compensate for height using suitable shims or spacers (cf. Fig. 3.1).
- Insert the base fixing screws, do not fully tighten them yet in order to avoid clamping the alignment fixtures. Mart the position of the stator base or set appropriate limit stops.
- Remove the alignment fixtures from the torque transducer and **store them in a safe place for later use**.
- Tighten the mounting base screws. The stator mounting base and associated mounting hardware should remain in the marked position while tightening the screws. The rotor must rotate freely.
- Check that radial and axial alignment tolerances are maintained (cf. ”Technical Data”). Please carry out measurements with feeler gauges carefully; the transmitter windings must not be damaged.
- Check the rotor for smooth operation with a test run, starting at a slow speed.

3.7 Installing protectors

WARNING

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- **the cover must be stationary**
- **the cover shall avoid any danger of squeezing and provide protection against parts that might come loose**
- **the cover shall be installed at a minimum distance from moving pats or shall be of a nature that a hand cannot be put through**
- **the cover shall be fitted even if moving parts are installed outside the usual access area of persons.**

Above regulations could only be disregarded if there is already sufficient protection of machine parts owing to the design of the machine or due to other precautions.

3.8 Operating precautions

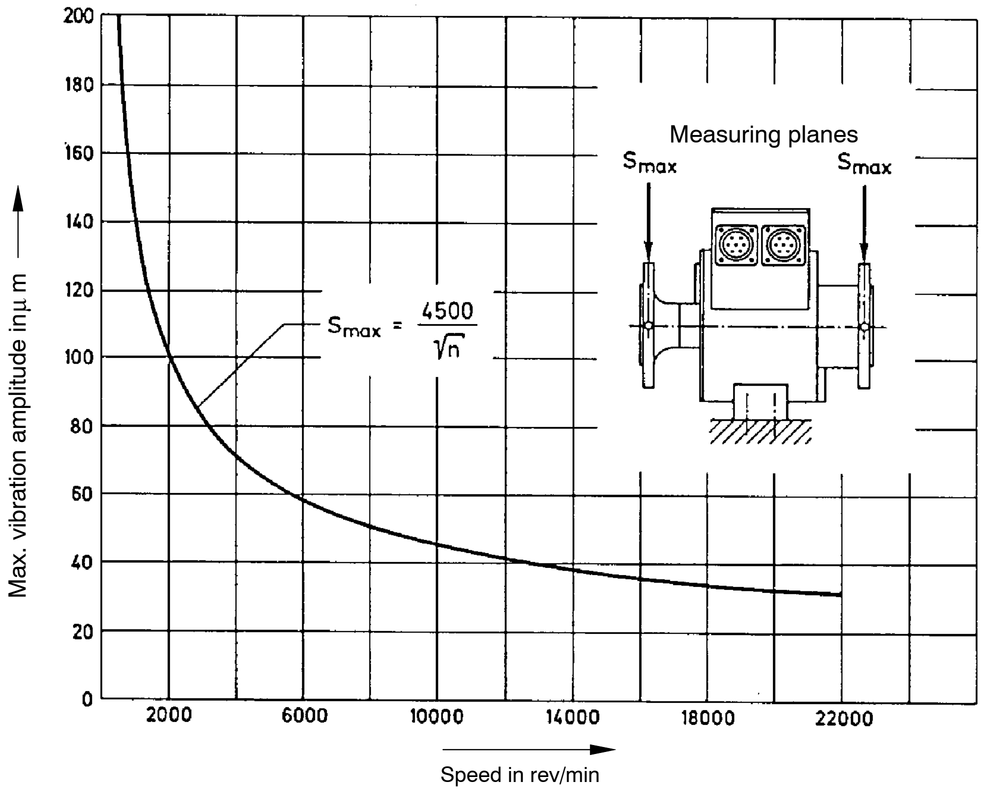
During the operation of a transmission shaft oscillations occur which original from the effects of numerous variables. These include the speed, resonance characteristics, mass distribution of the rotating machine parts and the quality of the bearings.

The torque transducers are carefully balanced to suit their intended operation speed. However, the torque transducer is only one component in the transmission chain. Its quiet running performance depends on the characteristics of the complete test rig.

In order to avoid heavier loads on the transducer and vibrations in the machine system, the operating speed should not be in the vicinity of rough running (critical speed). It is important to quickly pass trough the region of critical speed.

The nominal speed of the torque transducer, for which continuous operation applies and which represents the loadability limit, is given on the nameplate of the rotor.

In the diagram shown, the maximum permitted vibration amplitude s is plotted against the speed.



The maximum values must not be exceeded during normal operation. They refer only to the T34FN torque transducer and not to any connected machinery. s_{max} is defined accordingly to DIN 45670 and VDI 2059.

Diagram 1: Vibration amplitude versus the speed

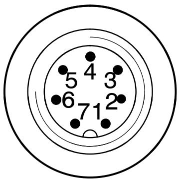
Using a T34FN torque transducer in conjunction with SBG curved-tooth couplings allows the advantages of the T34FN to be utilized for low speeds in combination with cheap couplings. In this combination the continuous speeds are lower than with the GLB curved-tooth couplings normally used.

4 Electrical connections

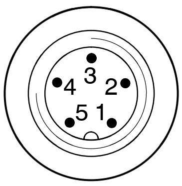
4.1 Connector pin assignments

Two flanged connectors on the stator housing are provided for interfacing to external measuring amplifiers.
The 7-pole connector for the torque channel is labelled with ”Md” and the 5-pole connector for the speed channel with”n”.

Torque

Plug Md 	1	Operating voltage (⏚ 0 V)	<gn>
	2	Pre-amplifier supply voltage (–15 V)	<ye>
	3	Pre-amplifier supply voltage (+15 V)	<pk>
	4	Torque output signal (12 V_{pp}; 5...15 kHz)	<wh>
	5	Not used	
	6	Rotor supply voltage (54 V/74 V_{pp}; 15 kHz)	<bn>
	7	Rotor supply voltage (0 V)	<gy>
		Screen	<bu>

Rotation

Plug n 	1	Operating voltage (⏚ 0 V)	<wh>
	2	Not used	
	3	Rotation rate signal (25 V_{pp}; 15 pulses./rev.)	<bl>
	4	Rotation rate signal (15 pulses./rev. phase-shifted by 90°)	<bu>
	5	Not used	
		Screen	<ye>

The lead screen is laid flat on the connector case. This means that the complete measurement system is enclosed in a Faraday cage, reducing any electromagnetic interference.

With interference caused by potential differences (equalization currents) the system zero–voltage and the housing ground should be isolated from one another and a potential equalization conductor located between the housings of the transducer and the amplifier (flexible stranded wire, 10 mm^2 conductor cross-section).

4.2 Interconnecting cables

Cable (3 m long) for connecting the measuring electronics is included in the supplied items. This cable must not be extended.

The following cable lengths can be obtained from HBM :

Cable extension	**Length (m)**	**Type of cable ends**
Kab 0304A-10	10	7 pole MS socket – 7 pole MS plug (Greenline)
Kab 8/00-6GY/3x2Cx0,14C-PVC	from 10	Cut to length

4.3 Instruments that can be connected

The basic requirements for the trouble-free operation of the torque transducers are:

- Adequate power supply for the non-contact telemetry
- Supply for the preamplifier built into the transducer.

HBM has various amplifiers available for numerous applications and these can supply the transducers and process the torque and torque-proportional signals. The connection details can be found in the operating manual for the relevant electronic measurement system.

5 Calibration

The torque transducers deliver electrical calibration signal that can be called from the amplifier. The supply voltage is increased from 54 V to 74...80 V by pressing the calibration key on the amplifier. This increase in supply voltage cause an additional resistance to be switched in parallel to a bridge resistance in the strain gauge full bridge in the torque transducer. The torque transducer responds with the output of a calibration signal of approximately 50 % of the nominal torque. The precise value is given on the nameplate.

The amplifier has to be adjusted to the precise calibration signal of the connected torque transducer in order to achieve calibration of the measurement chain.

6 Load capability

The torque transducers are suitable for the measurement of static and dynamic torques. When dynamic torque is measured one should note the following :

- The static calibration of the torque transducer is also valid for dynamic torque measurements.

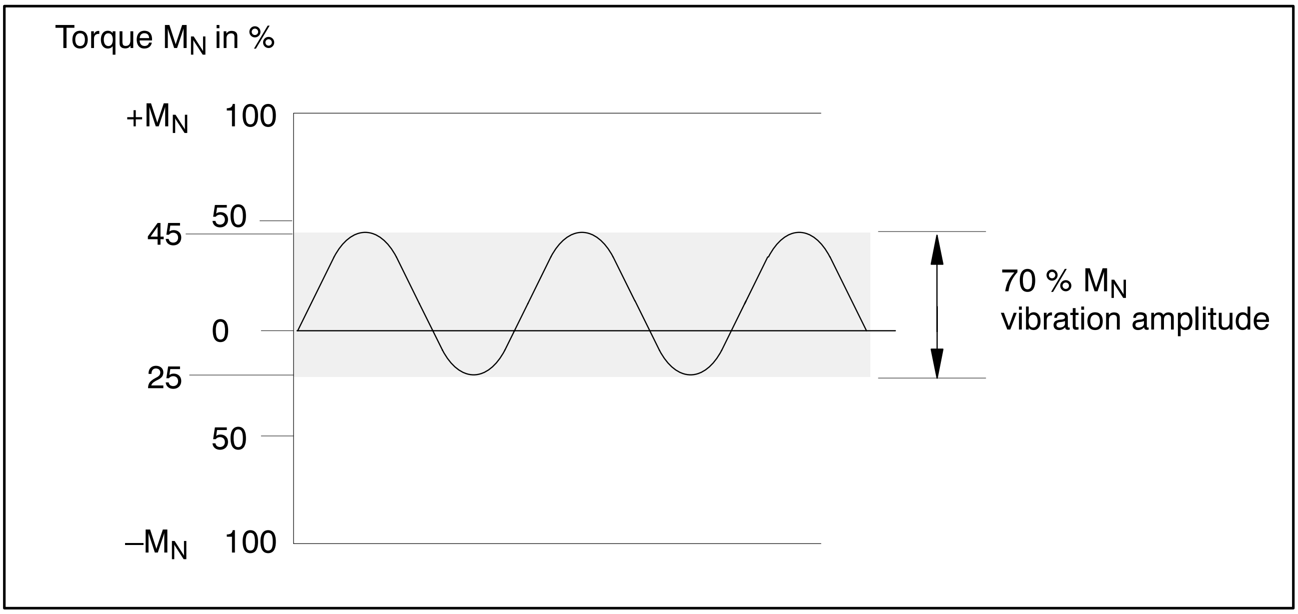
  Note: The frequency of dynamic torque must not exceed the natural frequency of the mechanical measuring installation.

- The natural frequency f_0 of the mechanical measuring installation depends on the moments of inertia J_1 and J_2 of the coupled rotating masses and depends on the torsional stiffness c_T of the arrangement can be calculated with the following equation:

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

f_0 = Natural frequency in Hz
J_1, J_2 = Moment of inertia in $kg{\cdot}m^2$
c_T = Torsional stiffness in N·m/rad

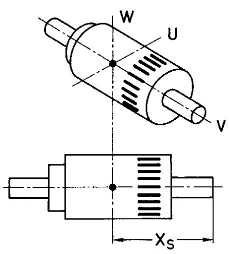
- The amplitudes (peak-to-peak) must never exceed 70% of the nominal torque for the specific type, even with oscillating torque. In all cases the amplitudes must lie within the load range limits of $-M_N$ and $+M_N$.



- The electronic equipment used must not be overdriven by signal peaks. The bandwidth must also be sufficiently wide so that the higher frequency parts are not attenuated.

7 Technical data

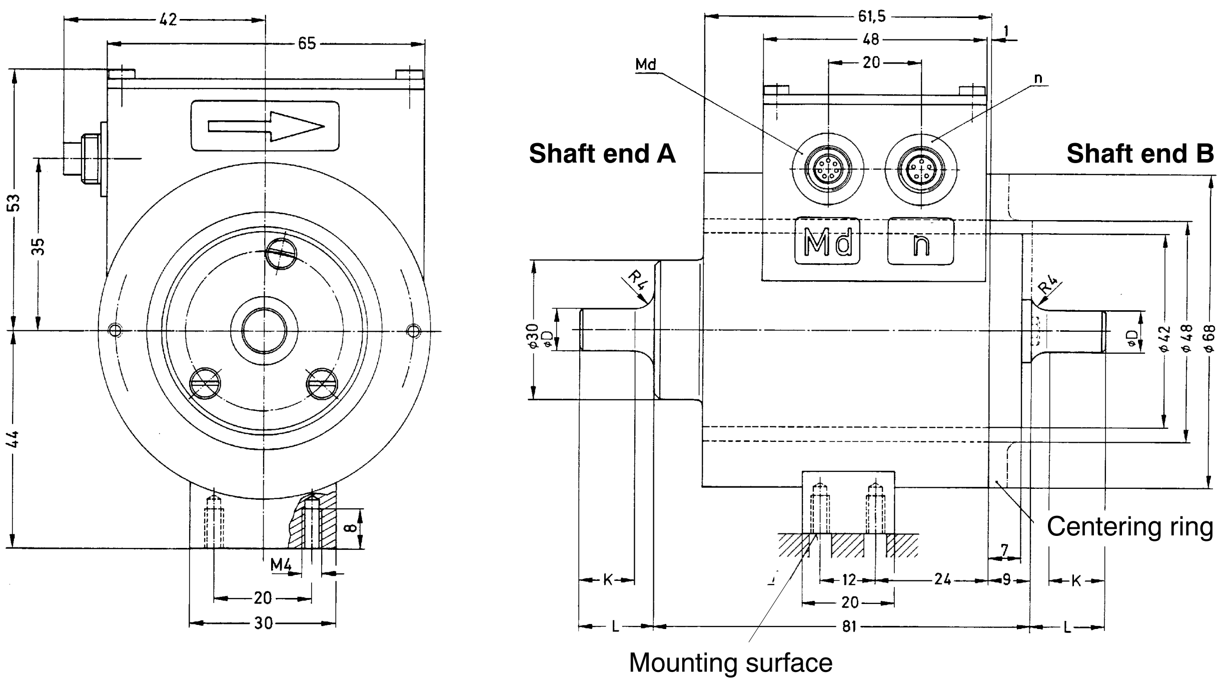
Type		T34 FN				
Torque measuring system						
Nominal torque M_N	N·m	1	2	5	10	20
Nominal sensitivity (nominal signal rage between torque=zero and nominal torque)	kHz	±5				
Sensitivity tolerance (deviation of actual signal range at M_N from nominal signal range)	%	<±0.1				
Output signal at torque =zero	kHz	10				
Nominal output signal						
with positive nominal torque	kHz	15 (12 V peak-to-peak)				
with negative nominal torque	kHz	5 (12 V peak-to-peak)				
Load resistance	kΩ	≥2				
Temperature effect per 10 K in the nominal temperature range on						
output signal, related to the actual value of the signal range	%	<±0.1				
zero signal, related to nominal sensitivity	%	<±0.1				
Supply voltage						
Square wave voltage	V	54 ±5 % / 800 mA ±5%				
Starting calibration signal	V	80 ±5 % / 1000 mA ±5%				
Frequency	kHz	approx. 15				
Supply voltage for the preamplifier	V	-15/0/+15				
Preamplifier, maximum current consumption	mA	-20/0/+20				
Linearity deviation, including hysteresis, related to nominal sensitivity	%	<±0.2				
Relative standard deviation of reproducibility according to DIN 1319, related to change of output signal	%	<±0.03				
Speed measuring system						
Output signal for speed, pulse voltage (peak-to-peak)	V	25 2x15 pulses per revolution, displaced by 2π				
Load resistance	kΩ	≥5				
Minimum speed, for sufficient pulse quality	rpm	2				
General information on the torque transducer						
Protection class EN 60 529		IP 54				
Weight, Rotor	g	345	350	360	375	400
Stator	g	850				
Nominal temperature range	°C[°F]	+10...+60 [+50...+140]				
Service temperature range	°C[°F]	-10...+60 [+14...+140]				
Storage temperature range	°C[°F]	-50...+70 [–58...+158]				

Supplementary reliability data						
Mechanical shock, degree of precision to IEC 68-2-6-1982 Number Duration Acceleration	 n ms ms/s^2	 1000 3 500				
Vibrational stress test, degree of precision to IEC 68-2-6-1982 Frequency range Duration Acceleration	 Hz h ms/s^2	 5...65 1.5 50				
Mechanical data						
Nominal torque M_N	Nm	1	2	5	10	20
Torsional stiffness c_T	Nm/rad	48	95	239	477	955
Torsion angle at M_N approx.	degrees	1.2				
Mass moment of inertia of the rotor J_V (about axis of rotation) J_U=J_W **Centre of gravity of the rotor** x_s 	 kg mm^2 kg mm^2 mm	 78 255 53.6	 78 290 59.8	 79 310 60.3	 80 350 63.8	 82 377 64.3
Permissible residual unbalance per unit weight of inertial body per plane	 g·mm/kg	 0.125				
Quality grade to VDI 2060		G1				
Nominal speed	rpm	40000				
Maximum permissible static eccentricity of the rotor (radially, centering with fixing elements) with torque measurement with speed measurement **Permissible axial displacement** between shaft and housing	 mm mm mm	 ± 2.5 ± 1.5 ± 3				
Load limits Torque limit, related to M_N Destruction torque, related to M_N Axial limit force[1] Lateral limit force[1] Bending limit force[1]	 N·m N·m kN N N·m	 1,5 >3 0.51 8.5 1.9	 3 >6 0.72 12 2.8	 7.5 >15 1.14 19 4.4	 15 >30 1.62 27 6.3	 30 >60 2.28 38 8.9
Vibration amplitude to DIN 50 100 (peak-to-peak)	N·m	0.7	1.4	3.5	7	14

1 Each type of irregular stress can only be permitted with its given limit value (bending moment, side load or axial load, exceeding the nominal speed) if none of the others can occur. Otherwise the limit values must be reduced. If for instance 30 % of the bending moment and also 30 % of the side load are present, only 40 % of the axial load are permitted, provided that the operational torque is below the nominal value. The measurement can be affected up to 1 % by permissible bending moments, axial loads and side loads.

8 Dimensions (in mm; 1 mm=0.03937 inches)

T34FN/1N·m...20N·m



Type	∅D_{J6}	$L_{-0.1}$	k
T 34 FN 40/1N·m	9	16	12
T 34 FN 40/2N·m	10	22	18
T 34 FN 40/5N·m	11	22	18
T 34 FN 40/10N·m	12	25	21
T 34 FN 40/20N·m	13	25	21

Md = Torque signal output plug

n = Plug for speed and indication of direction of rotation

Modifications reserved.
All details describe our products in general form only.They are not to be understood as express warranty and do not constitute any liability whatsoever.

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