ATESTEO

Excellence in drivetrain testing

DF Plus Series Manual

DF Plus Series Manual
Version 2.8

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1 Introduction

Thank you for choosing an ATESTEO quality product. Please read the system description carefully so you make the most of the versatile features of your product.

This operating manual is a component of the DF plus-series and should always be carefully kept with the DF plus-series until it is disposed of.

It is impossible to eliminate every danger to persons or material that the DF plus-series might present. For this reason, every person working at the DF plus-series or is involved in its transport, setting up, control, maintenance or repair must be properly instructed and be informed of the possible dangers.

For this purpose, the operating instructions and, especially, the safety instructions must be carefully read, understood and observed.

Company ATESTEO reserves the right to carry out changes at its products, which serve the technical further development the company ATESTEO. These changes are not documented expressly in every individual case.

This operator's manual and the information contained in it were compiled with the advisable care.

Company ATESTEO GmbH & Co.KG takes on no liability for misprints or other faults or damages resulting from it the company ATESTEO GmbH & Co.KG, however.

The brands mentioned in this operator's manual and product names are trademarks or registered trademarks of the respective titleholders.

Please do not miss to contact us if there is anything in the operating instructions that you cannot clearly understand. We are grateful for any kind of suggestion or criticism that you may wish to make. Please let us know or write to us. This will help us to make the operating instruction still more user-friendly in taking account of your wishes and requirements.

1.1 Change log

V2.8 – 31.05.2024

• Format fixed for better readability

V2.7 – 02.05.2024

• Format review

• Update of drawing “TCU5 dimensions”

• Output switch added to X770

• General filter description added

V2.6 – 06.03.2023:

• Rotation angle added

• Updates for RSS-Gen

V2.5 – 30.01.2023:

• Calibration certificate for DAkkS added.

• Calibration certificate of factory calibration added.

• Remark about sensitivities added to factory and DAkkS calibration.

• Information about FCC updated.

V2.4 – 22.09.2022:

• Mounting distances of speed detection updated.

• Information regarding ping protocol added.

• Description of some functions added in separate chapter.

• Description of zero adjustment added.

• Inline concept description removed.
• Document structure updated.
• Lifting & transport remarks for rotors added.
• IP reset description updated.
• Technical data added.
• Safety remarks enhanced (Fuse in building electricity, operation only inside, avoid oscillations).
• Pin assignment of central cable updated (X775/X776 instead of X773).
• CAN command correctly named.
• FCC ID added.
• ISEC IC added.
• Description of network setup simplified.
• Dimensions of stator updated.
• Tightening torques for DF1 titanium added.

V2.3 22.11.2021:

• First version with change log
• Contact details of service team updated
• Pin assignment: TTL3.3/5.0 corrected

1.2 Software versions

The software versions mentioned in Table 1 were the latest ones when this manual has been released (date of release see 1.1). The software is updated more frequently than the manuals. The latest versions incl. their change logs can be requested from the ATESTEO service.

Software	Version
TCU5plus firmware	V2.4.0
TCU5plus website	V2.11.0
TCU5plus boot loader	V4.2.0
Rotor firmware	V2.10.0

Table 1 Software versions

1.3 Manufacturer

ATESTEO GmbH & Co.KG
(Hereinafter referred to as manufacturer)

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1.4 Manufacturer´s Declaration

The manufacturer declaration can be requested at ATESTEO.

1.5 FCC certification

The components of DF series mentioned in Table 2 comply with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Product changes are only allowed with acceptance of ATESTEO. The FCC ID or a unique component ID is labelled on the components (see 3.6 and 3.7).

1.6 RSS-Gen — General Requirements for Compliance of Radio Apparatus (canada.ca)

This device contains licence-exempt transmitter(s)/receiver(s) that comply with Innovation, Science and Economic Development Canada's licence-exempt RSS(s). Operation is subject to the following two conditions:

1. This device may not cause interference.
2. This device must accept any interference, including interference that may cause undesired operation of the device.

This equipment should be installed and operated with minimum distance 50 cm between the radiator and users' bodies.

L'émetteur/récepteur exempt de licence contenu dans le présent appareil est conforme aux CNR d'Innovation, Sciences et Développement économique Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes :

1. L'appareil ne doit pas produire de brouillage;
2. L'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement

Cet équipement doit être installé et utilisé avec une distance minimale de 50 cm entre le radiateur et le corps des utilisateurs.

The ISED IC or a unique component ID is labelled on the components (see 3.6 and 3.7).

Component	Torque range [Nm]	HVIN	IDs
DF1 plus	50, 100, 200, 500	DF1 plus	**FCC ID:** 2A6NX-DFS1TOS4 **ISED IC:** 28805-DFS1TOS4
DF2 plus	500, 1,000	DF2 plus	
DF3 plus	1,000, 2,000, 3,000	DF3 plus	
DF4 plus	4,000, 5,000	DF4 plus	

Table 2 DF variants of FCC/RSS210 certification

1.7 Disposal and environment

Electrical and electronic products are subject to special conditions for disposal. Proper disposal of old equipment prevents health hazards and environmental damage.

Packaging
The original packaging of ATESTEO equipment can be recycled, as it is made of recyclable material. However, you should keep the packaging for at least the warranty period. In the event of a complaint, the torque flange, as well as the accessories, must be returned in the original packaging.

Due to ecological aspects, the return of the empty packaging should be waived.

Legally prescribed labelling for disposal

Electrical and electronic devices bearing the symbol are subject to European Directive 2002/96 / EC on waste electrical and electronic equipment. The symbol indicates that waste equipment that is no longer usable must be disposed of separately from regular household waste in accordance with European environmental protection and recycling regulations.

However, the disposal regulations vary from country to country, which is why we ask you, if necessary, your supplier how to dispose your waste.

1.8 Scope of supply

The package contains the following terms:

1. Torquemeter (Rotor)
2. DF plus Stator
3. TCU 5 plus (Torque Control Unit)
4. Central cable
5. 12-pin connector
6. 16-pin connector
7. Operating manual
8. Test report
9. Optional speed detection system

1.9 General functionality

The DF plus series is suitable for the highly dynamic measurement of torques at high load and highest resolution. The following figure shows the measuring system, which consists of a torque measuring flange (rotor), a stator and an evaluation unit.

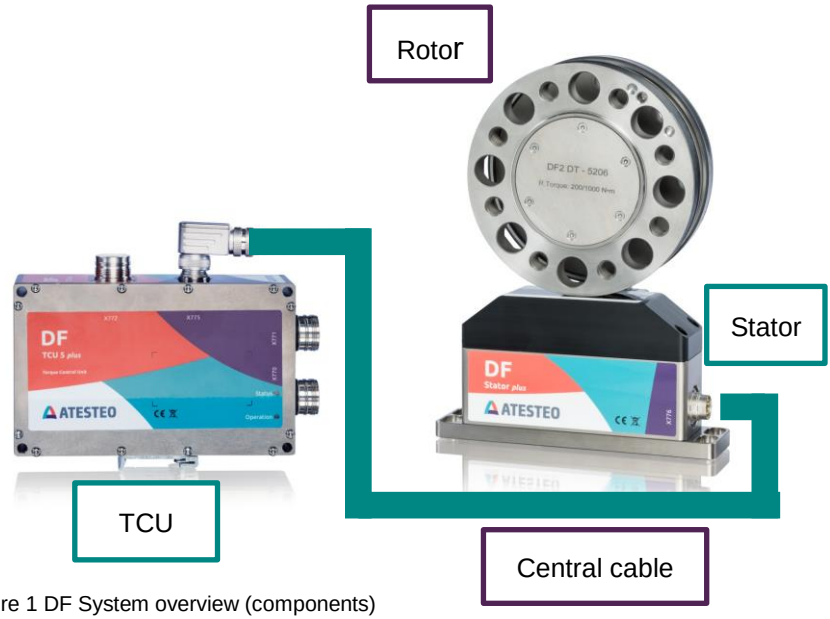


Figure 1 DF System overview (components)

The torque measuring flange and the stator communicate via bidirectional telemetry, while the rotor is simultaneously powered inductively via the stator. The torque is detected via a strain gauge full bridge in the measuring body of the torque measuring flange.

The electrical difference voltage of the full bridge is amplified in the torque measuring flange and digital data words are converted. For error-free signal transmission, the data words are supplemented by a

checksum and transmitted modulated to the stator. The stator demodulates the data words and transmits them via an RS422 interface to the evaluation unit. In the evaluation unit, the signals can additionally be filtered with an adjustable low-pass filter.
The evaluation unit also offers the connection options for the system peripherals. These include a CAN interface, two frequency outputs (Md1, Md2), three galvanically isolated analog outputs (Md1, Md2, Speed), three digital alarm outputs and five digital inputs. The measuring system can be comfortable configured via the Web interface. This also offers the possibility to easily and quickly check measured values and system functions.

A wide range of flange types allows easy connection to your application. The maximum load and the maximum measuring range can be individually adapted to your needs if wanted. Our DT version uses a second measuring channel with a separately calibrated measuring range. The measured values of both measuring channels are transmitted at the same time.

The torque measuring flange additionally monitors the temperature of the measuring body, which is used to eliminate temperature influences and can be called up as an additional CAN message from the evaluation unit.
The exchange of torque measuring flange is enormously simplified and accelerated by the DF plus-series. On the one hand, the stator does not enclose the torque measuring flange, as a result of which it can be easily removed and replaced by another without much effort and on the other hand an electronic data sheet is sent from the measuring flange, which enables automatic configuration of the evaluation unit. The new measuring flange is immediately ready for use.

Optionally, the measuring system can be equipped with a speed measurement. For the capture, a magnet ring on the rotor and a sensor head on the stator are in use. The magnetic ring has two pole tracks, which are offset by 90 ° to each other. So the speed can be determined as well as the direction of rotation. The two tracks can be tapped as RS422 signals at the system outputs. In addition, the speed is measured in the evaluation unit and made available as a digital value via CAN and as a voltage value via the third analog output.

Note

Please note that the torquemeter is a high-precision measuring instrument. Mechanical effects e.g. hammer impacts lead to deformation of the measuring body, which changes its torsional behavior and thus worsens the measuring accuracy! Before mounting, make sure that the fits of your adapters comply with the specified installation tolerances and that they are free from contamination. Only in this way, precise measurements and optimum concentricity can be guaranteed.

Note

The magnet ring (for the optional speed detection) can be damaged by strong magnetic field, as e.g. occur with a permanent magnet.

2 Safety Instructions

2.1 General safety instructions

The manual must be read carefully before start-up, maintenance work or any other work on the torque measuring system. Prerequisite for the safe and proper handling of the equipment knows all safety instructions and safety regulations of the attachment.

Every safeguard needs to be correctly mounted and fully functional before any start-up.
Shafts or adapters mounted to the torquemeter must be properly designed, so that critical bending moment is avoided.

Exclusively qualified laborers are allowed to do maintenance work on any electrical components (see chapter Qualified personnel).
If the torquemeter is sold on, these safety instructions must be included.

2.2 Explanation of symbols and notice

Warnings
Warnings are indicated by symbols in these safety instructions. The hints are going through
Signal words are introduced, which express the extent of the hazard. It is imperative that you follow the instructions and act with care to avoid accidents, personal injury and material damage.

Information
Draws attention to important information about correct handling.

Caution
Warns of a potentially dangerous situation in which failure to comply with safety requirements can result in slight or moderate physical injury.

2.3 Appropriate use

The torquemeter is highly accurate and resistant to rotational speed. The signals from the flange serve to control the test bench and to analyses the components.
The torque flange is used just for torque measurement tasks within the load limits in the specification (see Technical specs). Any other use is not permitted.

The torquemeter is not allowed for use as a safety component.

Note
It´s only permitted when rotor is installed as described in the mounting instruction.

2.4 Modifications/conversions

Any modifications/ conversions of the design or safety engineering of the torquemeter without the explicit agreement from ATESTEO will lead to the loss of warranty or liability. Any damages or injuries of personnel therefrom are in responsibility of the operator.

2.5 Operator's responsibility

Standards

The ATESTEO torquemeter was designed and constructed taking account of a risk analysis and careful selection of harmonized standards and other technical specifications with which it complies. It represents the state of the art and guarantees a maximum degree of safety.

Qualified personnel

Qualified personnel are persons who by reason of their training, experience, instruction and their knowledge of the relevant standards, regulations, accident prevention rules and working conditions have been authorized by the person responsible for the safety of the machine/product to perform the appropriate activities required, and thereby are able to recognize and prevent potentially dangerous situations (For the definition of skilled workers see VDE 0 105 or IEC 364, which also regulate the prohibition of the employment of unqualified persons).
Knowledge of first aid and the local rescue organization must also be available.

Transportation, assembly, installation, commissioning, maintenance and repair will be performed by qualified personnel or controlled by responsible skilled hands.

Safety relevant disconnecting device

The torquemeter cannot implement any safety relevant cut-offs. It is in the operator´s responsibility to integrate the torquemeter into superior safety system.

The electronical conditioning the measurement signal should be designed so that measurement signal failure does not subsequently cause damage.

Residual risks

The power and scope of delivery of the torquemeter covers only a subset of the torque measurement technology. Safety aspects of torque measurement technology must be planned, implemented and taken into account by the system planner, supplier or operator in such a way that residual risks are minimized. Each existing regulations must be observed. Attention should be drawn to residual risks associated with torque measuring technology

In the case of a shaft/flange break, you must ensure that there is no risk of injury. This should be done with a shaft protection cover in a closed test room with corresponding security doors. During operation, no person should stay in the test room.

Usage recommendations for personal protective equipment

Working in a workshop generally requires the wearing of safety shoes.

Use suitable gloves when handling corrosive or irritating solutions and adhesives.

2.6 Transport and storage

Check the delivery immediately for completeness and shipping damage.

Use working gloves and shoes during transport/ assembly/ maintenance.

Storage

- Do not store outdoors
- Store dry and dust-free
- do not expose to aggressive media
- protect from sunlight
- avoid mechanical shocks
- Storage temperature according data sheet

If stored for more than 3 months, regularly check the general condition of all parts and packaging.

2.7 Safety notes for assembly

Tightening torque
When tightening the screws, the specified tightening torques (see mounting instruction) must be observed.

Electric wire
All cables must be professionally laid according to the actual standards.

Rotating parts
Rotating parts must be earthed- risk of static electricity.

2.8 Safety notes for operation

As accident prevention, a covering has to be fitted once the torquemeter have been mounted. This is the fact if the torquemeter is already fully protected by the design of the machine or by existing safety precautions. Please pay attention to following requirements for the covering as accident prevention:

- The covering must not be free to rotate
- Covering must be positioned at a suitable distance or be so arranged that there is no access to any moving parts within.
- Covering should prevent squeezing or shearing and provide sufficient protection against parts that might come loose.
- Covering must still be attached even if the moving parts of the torque flange are installed outside people´s movement and working range.
- The torquemeter system may only be used indoors in closed testing rooms.

Note
Improper use and handling as well as constructional changes will invalidate the EC declaration of conformity.

2.9 Load limits

Observe technical data sheets when using the torquemeter. Pay particular attention to never exceed the respective maximum loads. For example:

- Load limits
- Torque oscillation width,
- Temperature limits,
- Longitudinal limit force, lateral limit force or limit bending moment,
- Limits of electrical load-carrying capacity,
- Limit rotation speed.

3 System description

3.1 Technical data

Description	Value
Power supply	24V DC max. 2A
Dynamic – Frequency output	≤ 6 kHz
Dynamic – Analogue voltage output	≤ 6 kHz
Dynamic – CAN bus	≤ 2,000 Samples/s
Modulation range – Voltage	-12 … 12 V
Modulation range – Frequency	0 … 420 kHz
CAN interface	CAN2B Max. 1 MBaud
Configuration interface	Ethernet (via integrated website)
Nominal temperature range (rotor / stator)	0 … 80 °C
Operation temperature range (rotor / stator)	-20 … 85 °C
Storage temperature range (rotor / stator)	-30 … 85 °C
Nominal temperature range (TCU5)	0 … 70 °C
Operation temperature range (TCU5)	-20 … 70 °C
Storage temperature range (TCU5)	-30 … 85 °C
Protection class	IP54
Frequency outputs	RS422 Torque Magnetic speed detection (optional)

Table 3 Technical data

3.2 System overview (electrical)

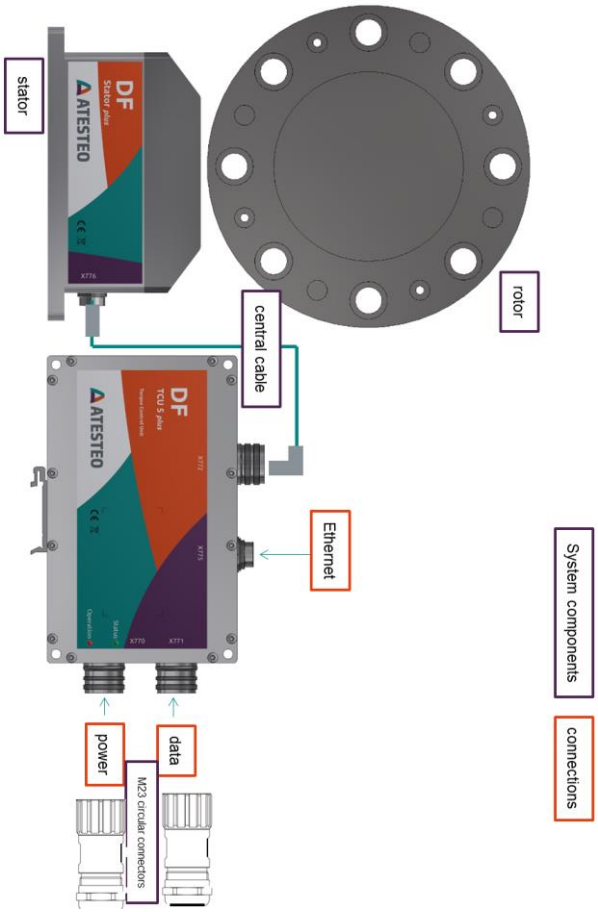


Figure 2 DF system overview (electrical)

3.3 System overview (central cable)

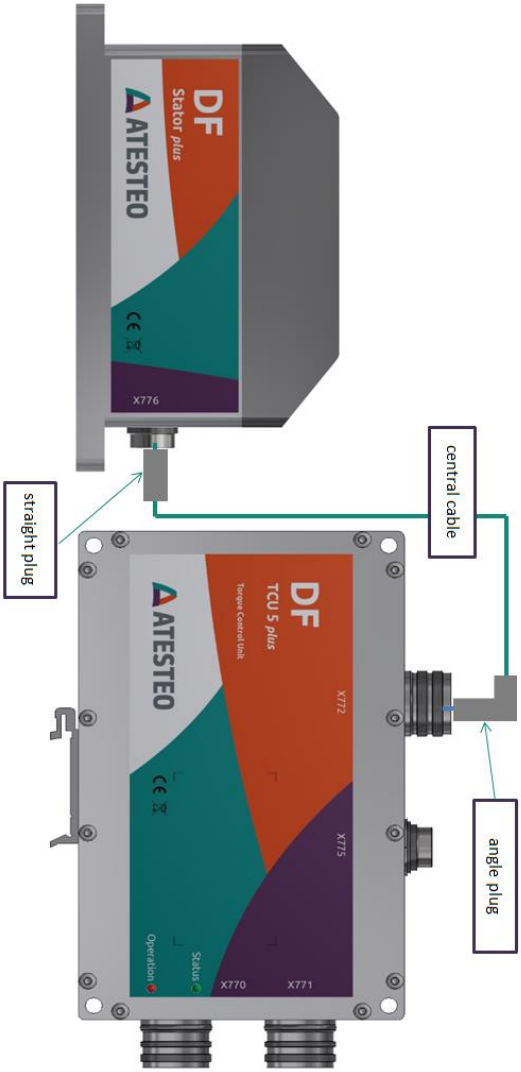


Figure 3 Central cable

3.4 System overview (functional areas)

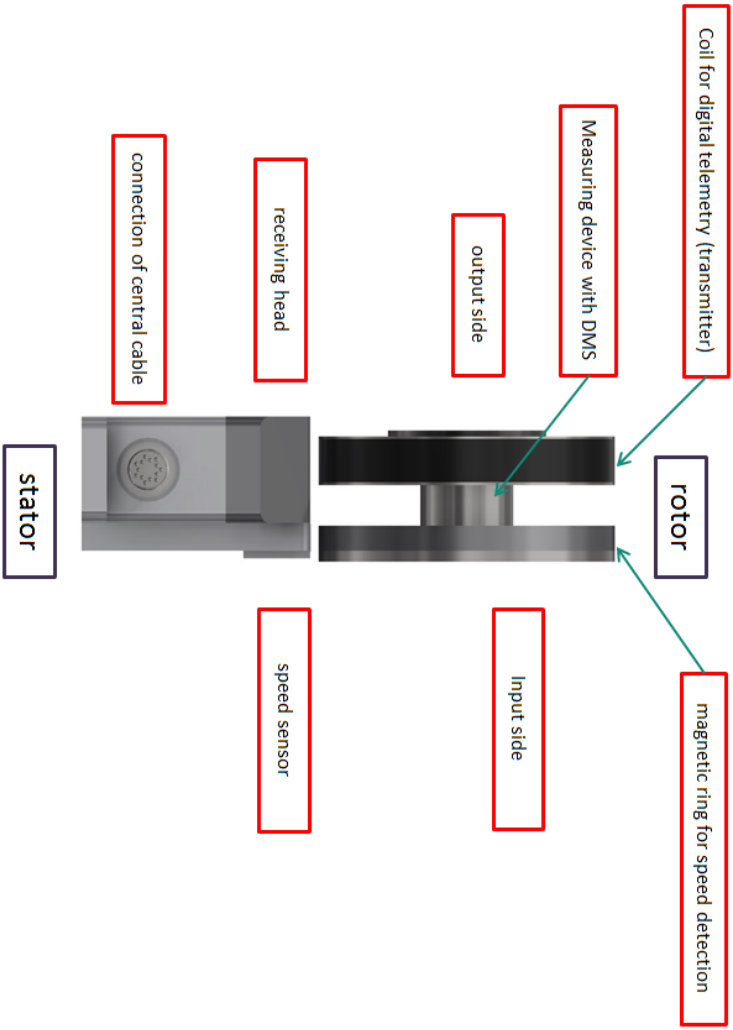


Figure 4 DF system overview (functional)

3.5 System overview (mechanical)

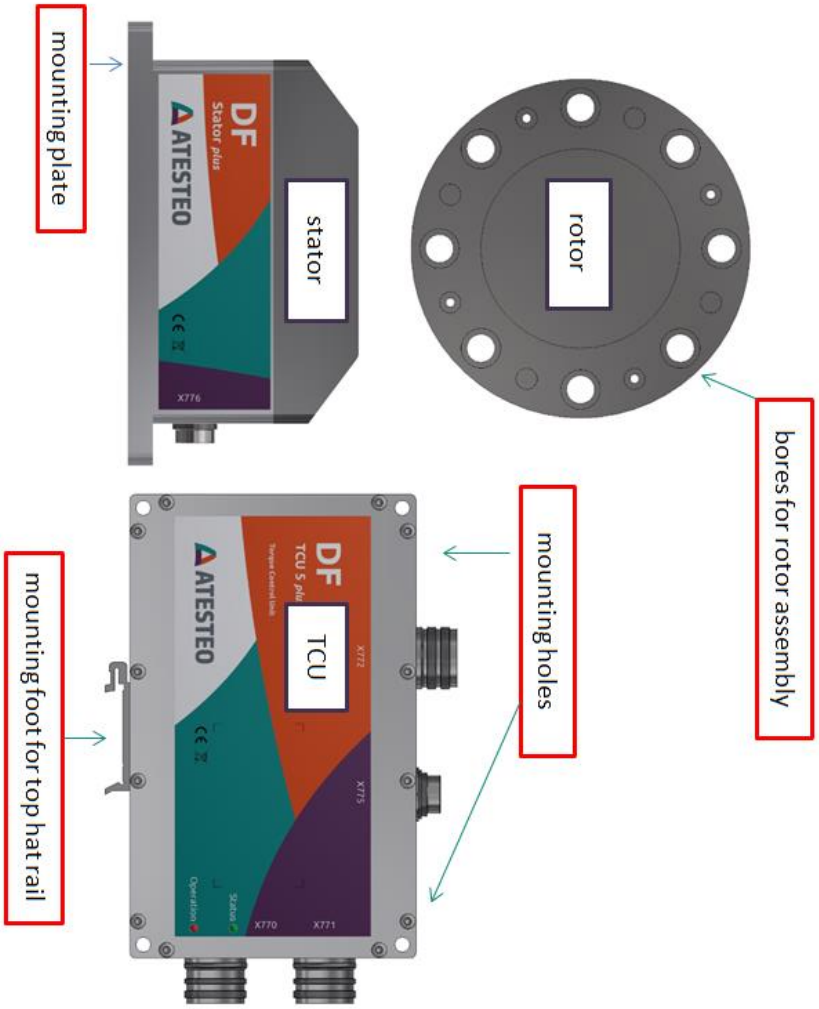


Figure 5 DF System overview (mechanical)

3.6 System overview (location nameplates)

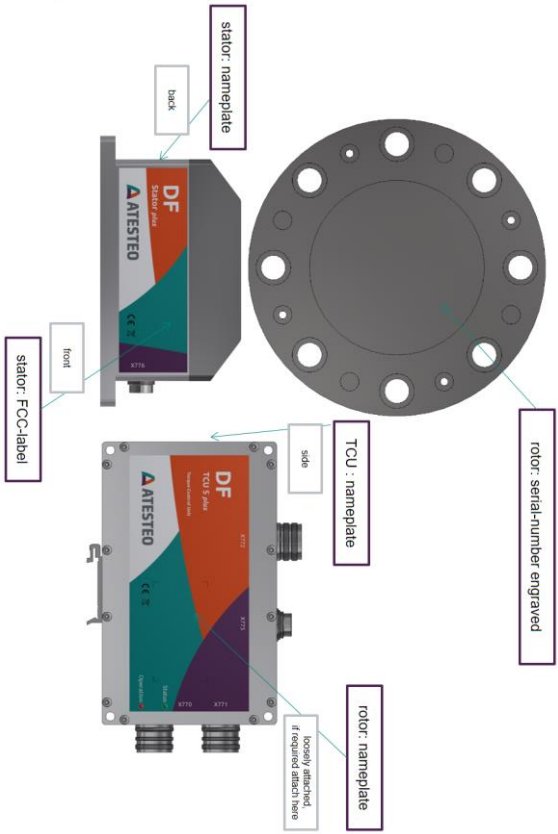
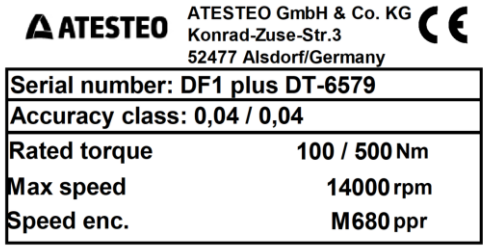


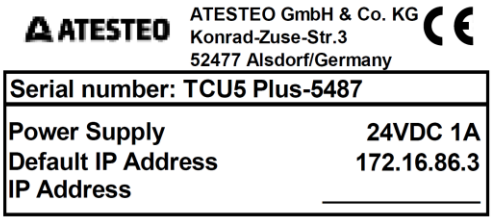
Figure 6 Position of nameplates

3.7 Content of nameplates

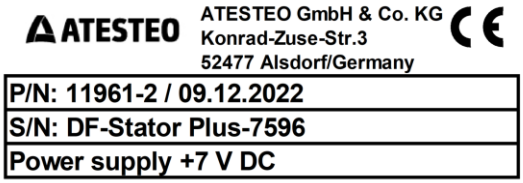
Rotor



TCU



Stator



Stator FCC/ISED label (Example of DF1 plus)

Model: DF1 plus
FCC ID: 2A6NX-DFS1TOS4
ISED IC: 28805-DFS1TOS4
HVIN: DF1 plus
This device complies with part 15 of the FCC Rules.
Operation is subject to the following two conditions:
(1) This device may not cause harmful interference, and
(2) this device must accept any interference received,
including interference that may cause undesired operation.

Figure 7 Position of FCC/ISED label at Stator

3.8 Special design features

- By eliminating the stator ring and the wide positioning distance between the rotor and the stator head, the overall installation of the measuring system as well as the replacement of individual components is very convenient.

- The evaluation unit (TCU5), which is needed to start-up the measuring system, provides all interfaces for a comfortable set up and up-to-date further processing of the measurement data.
- The free design of the torque measuring device also offers an extension as a dual-range measuring flange up to a torque ratio of up to 1:5, without any appreciable impairment of the mechanical properties.

3.9 Calibration documents

The measuring system DF plus is delivered with a test report. It shows the sensitivity in digits / Nm. The optional calibration protocol shows the calibration values in several stages.
On request, a calibration in accordance with DIN 51309 or VDI/VDE 2646 can be carried out in our in-house calibration laboratory, which is accredited by DAkkS according to DIN ISO 17025:2018.

Test report

The following figure shows the example of a standard test report:

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Excellence in drivetrain testing

Torque transducer test report

Serial number: DF2S DT - 5375

Range1

Rated Torque:	150	Nm
Calibrated Torque:	150	Nm
Sensitivity cw:	2623,5100	Digits/Nm
Sensitivity ccw:	2623,8430	Digits/Nm
Test signal:		Nm
Accuracy (Nonlinearity and hysteresis):	0,04% of rated torque	
Temperature effect on zero:	0,04% of rated torque / 10°C	

Range2

Rated Torque:	600	Nm
Calibrated Torque:		Nm
Sensitivity cw:	667,3792	Digits/Nm
Sensitivity ccw:	667,4242	Digits/Nm
Test signal:		Nm
Accuracy (Nonlinearity and hysteresis):	0,04% of rated torque	
Temperature effect on zero:	0,04% of rated torque / 10°C	

Compensated Temperatur Range (Rotor/Stator): 10°C/10°C to 70°C/70°C
Gravitational Constant Alsdorf: 9,81106 m/s²
Ambient Temperature: 21,2 °C

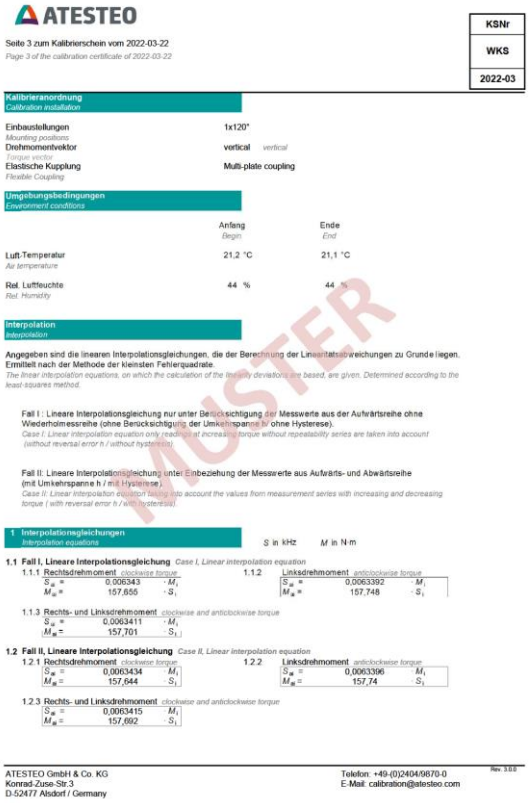
Remarks:
Maximum Speed: 20000 rpm
Speed Disc: ppr
Warming Up Time: 30 minutes

Date: Signed:

Figure 8 Test report example

Factory calibration certificate

The following figure shows a detailed calibration protocol, which is recommended as an option. Sensitivities are given in section “Case II, linear interpolation equation”, 1.2.1 and 1.2.2 (January 2023).



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Seite 3 zum Kalibrierschein vom 2022-03-22
Page 3 of the calibration certificate of 2022-03-22

KSNr
WKS
2022-03

Kalibrieranordnung *Calibration installation*

Einbaustellungen *Mounting positions*	1x120°	
Drehmomentvektor *Torque vector*	vertical	*vertical*
Elastische Kupplung *Flexible Coupling*	Multi-plate coupling	

Umgebungsbedingungen *Environment conditions*

	Anfang *Begin*	Ende *End*
Luft-Temperatur *Air temperature*	21,2 °C	21,1 °C
Rel. Luftfeuchte *Rel. Humidity*	44 %	44 %

Interpolation *Interpolation*

Angegeben sind die linearen Interpolationsgleichungen, die der Berechnung der Linearitätsabweichungen zu Grunde liegen. Ermittelt nach der Methode der kleinsten Fehlerquadrate.
The linear interpolation equations, on which the calculation of the linearity deviations are based, are given. Determined according to the least-squares method.

Fall I : Lineare Interpolationsgleichung nur unter Berücksichtigung der Messwerte aus der Aufwärtsreihe ohne Wiederholmessreihe (ohne Berücksichtigung der Umkehrspanne h/ ohne Hysterese).
Case I: Linear interpolation equation only reading at increasing torque without repeatability series are taken into account (without reversal error h / without hysteresis).

Fall II: Lineare Interpolationsgleichung unter Einbeziehung der Messwerte aus Aufwärts- und Abwärtsreihe (mit Umkehrspanne h / mit Hysterese).
Case II: Linear interpolation equation taking into account the values from measurement series with increasing and decreasing torque (with reversal error h / with hysteresis).

1 Interpolationsgleichungen *Interpolation equations*

S in kHz *M* in N·m

1.1 Fall I, Lineare Interpolationsgleichung *Case I, Linear interpolation equation*

1.1.1 Rechtsdrehmoment *clockwise torque*

S_M = 0,006343 · M_i

M_M = 157,655 · S_i

1.1.2 Linksdrehmoment *anticlockwise torque*

S_M = 0,0063392 · M_i

M_M = 157,748 · S_i

1.1.3 Rechts- und Linksdrehmoment *clockwise and anticlockwise torque*

S_M = 0,0063411 · M_i

M_M = 157,701 · S_i

1.2 Fall II, Lineare Interpolationsgleichung *Case II, Linear interpolation equation*

1.2.1 Rechtsdrehmoment *clockwise torque*

S_M = 0,0063434 · M_i

M_M = 157,644 · S_i

1.2.2 Linksdrehmoment *anticlockwise torque*

S_M = 0,0063396 · M_i

M_M = 157,74 · S_i

1.2.3 Rechts- und Linksdrehmoment *clockwise and anticlockwise torque*

S_M = 0,0063415 · M_i

M_M = 157,692 · S_i

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Rev. 3.0.0

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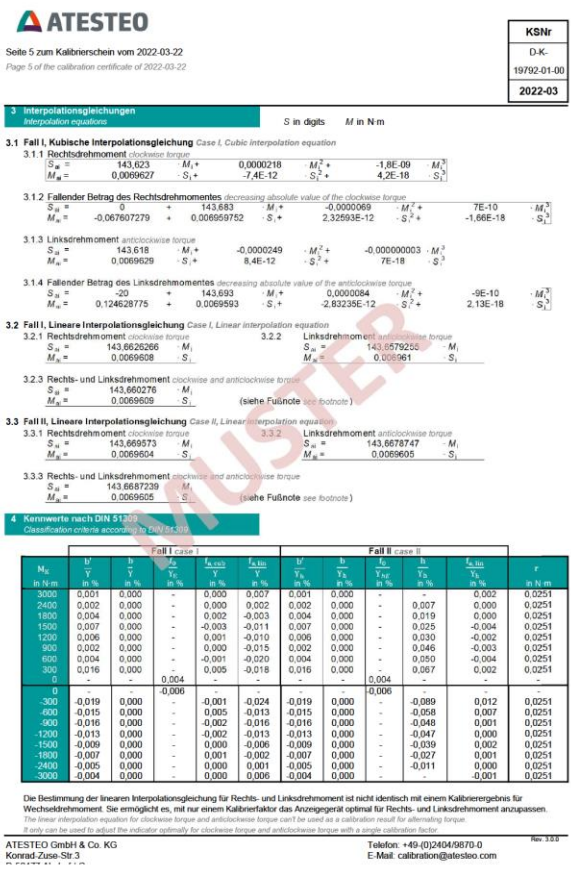
Figure 9 Calibration certificate example (factory calibration)

Calibration certificate according DAkkS

The DAkkS calibration certificate shows the sensitivities in “Case II, Linear interpolation equation”, section 3.3.1 and 3.3.2 (January 2023). For measurement systems supporting only one sensitivity, the value from 3.3.3 can be used (clockwise and anticlockwise torque).



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Seite 5 zum Kalibrierschein vom 2022-03-22
Page 5 of the calibration certificate of 2022-03-22

KSNr
D-K-19792-01-00
2022-03

3 Interpolationsgleichungen *Interpolation equations*

S in digits *M* in N·m

3.1 Fall I, Kubische Interpolationsgleichung *Case I, Cubic interpolation equation*

3.1.1 Rechtsdrehmoment *clockwise torque*

S_M = 143,623 · M_i + 0,0000218 · M_i^2 + -1,8E-09 · M_i^3

M_M = 0,0069627 · S_i + -7,4E-12 · S_i^2 + 4,2E-18 · S_i^3

3.1.2 Fallender Betrag des Rechtsdrehmomentes *decreasing absolute value of the clockwise torque*

S_M = 0 + 143,683 · M_i + -0,0000069 · M_i^2 + 7E-10 · M_i^3

M_M = -0,067607279 + 0,006959752 · S_i + 2,32593E-12 · S_i^2 + -1,66E-18 · S_i^3

3.1.3 Linksdrehmoment *anticlockwise torque*

S_M = 143,618 · M_i + -0,0000249 · M_i^2 + -0,000000003 · M_i^3

M_M = 0,0069629 · S_i + 8,4E-12 · S_i^2 + 7E-18 · S_i^3

3.1.4 Fallender Betrag des Linksdrehmomentes *decreasing absolute value of the anticlockwise torque*

S_M = -20 + 143,693 · M_i + 0,0000084 · M_i^2 + -9E-10 · M_i^3

M_M = 0,124628775 + 0,0069593 · S_i + -2,83235E-12 · S_i^2 + 2,13E-18 · S_i^3

3.2 Fall I, Lineare Interpolationsgleichung *Case I, Linear interpolation equation*

3.2.1 Rechtsdrehmoment *clockwise torque*

S_M = 143,6626266 · M_i

M_M = 0,0069608 · S_i

3.2.2 Linksdrehmoment *anticlockwise torque*

S_M = 143,6579255 · M_i

M_M = 0,0069961 · S_i

3.2.3 Rechts- und Linksdrehmoment *clockwise and anticlockwise torque*

S_M = 143,660276 · M_i

M_M = 0,0069609 · S_i (siehe Fußnote *see footnote*)

3.3 Fall II, Lineare Interpolationsgleichung *Case II, Linear interpolation equation*

3.3.1 Rechtsdrehmoment *clockwise torque*

S_M = 143,669573 · M_i

M_M = 0,0069604 · S_i

3.3.2 Linksdrehmoment *anticlockwise torque*

S_M = 143,6678747 · M_i

M_M = 0,0069605 · S_i

3.3.3 Rechts- und Linksdrehmoment *clockwise and anticlockwise torque*

S_M = 143,6687239 · M_i

M_M = 0,0069605 · S_i (siehe Fußnote *see footnote*)

4 Kennwerte nach DIN 51309 *Classification criteria according to DIN 51309*

	Fall I *case I*					Fall II *case II*					
M_E in N·m	$\frac{b'}{Y}$ in %	$\frac{b}{Y}$ in %	$\frac{f_0}{Y_C}$ in %	$\frac{f_{k\,sup}}{Y}$ in %	$\frac{f_{k\,inf}}{Y}$ in %	$\frac{b'}{Y_S}$ in %	$\frac{b}{Y_S}$ in %	$\frac{f_0}{Y_{hy}}$ in %	$\frac{h}{Y_S}$ in %	$\frac{f_{k\,inf}}{Y_S}$ in %	r in N·m
3000	0,001	0,000	-	0,000	0,007	0,001	0,000	-	-	0,002	0,0251
2400	0,002	0,000	-	0,000	0,002	0,002	0,000	-	0,007	0,000	0,0251
1800	0,004	0,000	-	0,002	-0,003	0,004	0,000	-	0,019	0,000	0,0251
1500	0,007	0,000	-	-0,003	-0,011	0,007	0,000	-	0,025	-0,004	0,0251
1200	0,006	0,000	-	0,001	-0,010	0,006	0,000	-	0,030	-0,002	0,0251
900	0,002	0,000	-	0,000	-0,015	0,002	0,000	-	0,046	-0,003	0,0251
600	0,004	0,000	-	-0,001	-0,020	0,004	0,000	-	0,050	-0,004	0,0251
300	0,016	0,000	-	0,005	-0,018	0,016	0,000	-	0,067	0,002	0,0251
0	-	-	0,004	-	-	-	-	0,004	-	-	-
0	-	-	-0,006	-	-	-	-	0,006	-	-	-
-300	-0,019	0,000	-	-0,001	-0,024	-0,019	0,000	-	-0,089	0,012	0,0251
-600	-0,015	0,000	-	0,005	-0,013	-0,015	0,000	-	-0,058	0,007	0,0251
-900	-0,016	0,000	-	-0,002	-0,016	-0,016	0,000	-	-0,048	0,001	0,0251
-1200	-0,013	0,000	-	-0,002	-0,013	-0,013	0,000	-	-0,047	0,000	0,0251
-1500	-0,009	0,000	-	0,000	-0,006	-0,009	0,000	-	-0,039	0,002	0,0251
-1800	-0,007	0,000	-	0,001	-0,002	-0,007	0,000	-	-0,027	0,001	0,0251
-2400	-0,005	0,000	-	0,000	0,001	-0,005	0,000	-	-0,011	0,000	0,0251
-3000	-0,004	0,000	-	0,000	0,006	-0,004	0,000	-	-	-0,001	0,0251

Die Bestimmung der linearen Interpolationsgleichung für Rechts- und Linksdrehmoment ist nicht identisch mit einem Kalibrierergebnis für Wechseldrehmoment. Sie ermöglicht es, mit nur einem Kalibrierfaktor das Anzeigegerät optimal für Rechts- und Linksdrehmoment anzupassen.
The linear interpolation equation for clockwise torque and anticlockwise torque can't be used as a calibration result for alternating torque. It only can be used to adjust the indicator optimally for clockwise torque and anticlockwise torque with a single calibration factor.

Rev. 3.0.0

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Figure 10 Calibration certificate according to DAkkS (extract)

3.10 Telemetry and measurement ranges

Most DF torquemeter can optionally be purchased with a second (lower) torque range. This variant is called “DT”. The standard variant has a single torque range.

3.10.1 Single range telemetry (standard variant)

The single range torquemeter have one amplifier on the rotor. The measurement values are transferred by telemetry to the stator.

Available output signals:

- Frequency output proportional to torque
- Tow frequency outputs proportional to the rotation speed (optional)
- Analogue voltage output proportional to torque
- Analogue voltage output proportional to rotation speed (optional)
- CAN interface (2B) with a torque signal and an optional rotational speed signal

3.10.2 Double range telemetry (DT)

The double range telemetry or dual range telemetry has two amplifiers on the rotor. Parallel transfer of the two signals is generally possible. In most cases, the parallel transfer of two signals is counterproductive and thus deactivated by default. The parallel transfer can be activated on demand with the support of ATESTEO service.

Available output signals:

- Two frequency outputs proportional to torque

- Frequency output proportional to the rotation speed (optional)
- Two analogue voltage outputs proportional to torque
- Analogue voltage output proportional to rotation speed (optional)
- CAN interface (2B) with two torque signals and an optional rotational speed signal

3.10.3 Switch of measurement range

The second torque range was developed to realize measurement jobs with lower applied torques at higher accuracies. It is not to be used to measure the lower torques in a test cycle, which also contains high torque segments. The selection of the torque range has to been done before starting a test cycle and should not be changed in it.

What has to be considers before switching the torque range:
If a sensor during a test is mostly loaded in one direction, it can indicate a drift after the test is finished. This drift cannot to be traced back to a temperature compensation problem but to the natural hysteresis of the sensor and strain gauges.
The change of the zero value depends on the torque applied or on the test duration. In any case, the value of the zero-drift variation will not be larger than the linearity and hysteresis specified in the technical data for the sensor.

Prior to switching the range, the sensor should be unloaded by a certain procedure. If technical possible, a zero point adjustment should be done (see 3.11.1).

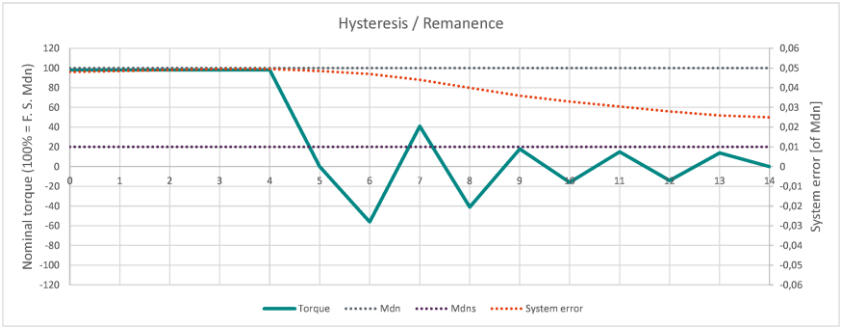


Figure 11 Unload procedure with low torque in positive & negative direction

The turquoise line shows the torque. 100% represents the maximum torque of the large torque range (see grey dotted line). After a long period with big torque, the hysteresis error (red line) might come close to the nominal hysteresis error of the sensor accuracy. Alternating (positive / negative) low torques will unload the measurement body. The hysteresis error will be reduced and the accuracy will be optimized for low torque measurements (purple dotted line).

3.10.4 Selection of measurement range

The user can chose the torque range by several measures:

- Via web interface (see 6.5),
- via digital input (see 7.2) or
- via CAN bus command (6.11.2.2)

The TCU5 will always determine the channel selection (torque range selection) at start-up via the digital input.

The applied channel selection can be checked with several functions:

- via web interface (see 6.5),
- via digital output (see 7.2) or

- via CAN bus state word (see “Active Channel” in 6.11.3)

3.11 Functions

3.11.1 Zero adjustment

Performing a zero (point) adjustment will take the current measured torque value as new zero torque value. Please read the important information in 8.1 before performing the zero adjustment. If the zero point has more than 5% (related to nominal torque) difference from the previous value, an error message will be shown.

Performing a zero point adjustment for the rotation angle will set its value to 0°.

3.11.2 Test signals

The test signals generate an offset jump independent from the current measurement value. The test signal value is given on the test report and it will apply to all signal output types.

Note:

Test signals must be disabled before measuring

3.11.2.1 Controller (TCU5)

The test signal will be applied in the TCU5 and set to all outputs.

3.11.2.2 Torque sensor

The test signal will be generated by an offset jump on the first amplifier in the rotor. From there it will follow the complete measurement chain to the output signals of TCU5.

3.11.3 Reset IP address

If the IP address was changed from standard and not written on the free area on the type label, the following two solutions will help you in case the IP address is lost:

- The tool “TCU Discover” can be used to search TCU5 in a local network. The tool can be downloaded from the ATESTEO website.
- Reset of IP address via digital input (see 7.1).

3.11.4 Filter

The torque inputs can be optionally filtered. As the filtering is carried out at the input, it is independent of the selection of the measuring range (see 3.10.4). All signal outputs are affected by the filter settings (see 6.10).

CAN signals are also averaged via a block filter. The time window of the block filter is determined by the transmission rate of a message. The longer the intervals between two messages, the larger the averaging time window (see 6.11).

3.12 LED coding

3.12.1 TCU5 (evaluation unit)

The TCU has a red and green LED on the top to display the system status. The coding is described in the following table:

Red LED	Green LED	State / Meaning
Off	Off	System switched off.
Off	On	Test signal of rotor or TCU is active.
On	Off	Critical system error. System will reboot.
On	On	System is starting.
Blinking every 2 seconds	Blinking every 2 seconds	TCU is receiving the digital data sheet from the rotor.
Blinking every second	Every state	Disturbance in data transfer or insufficient power supply of the rotor.
Every state	Blinking every second	Normal operating.

Table 4 TCU LEDs

3.12.2 DF stator

The DF stator has a green LED on the side to display the transmission status. The coding is described in the following table:

Green LED	State / Meaning
Off or sometimes off	The signal amplitude received by the torque sensor is too low. Please activate the power of torque sensor on the website or readjust the stator.
Permanent on	The signal amplitude received by the torque sensor is sufficient for data transmission.

Table 5 DF plus stator LED

4 Mechanical & electrical installation

4.1 Transport

The torquemeter of ATESTEO are high precise measurement sensors. Transport must be done with care. Try to use the original packaging whenever possible. When sending torquemeter for calibration to ATESTEO, proper safety case in most sizes are available at ATESTEO.

4.2 Lifting the rotor

The DF rotors typically have weights below 10 kg. Those can be lifted without crane. If own or national regulations require a support (crane) for lifting, please contact ATESTEO service to get information about the proper mechanical lifting interface for each rotor.

4.3 Mechanical dimensions

4.3.1 Mounting distances

The stator must be aligned to the rotor. Distances mention in Table 6 must be observed. Afterwards, an optional speed detection system can be aligned according to the mounting distances table.

Type		DF1 plus	DF2 plus	DF3 plus	DF4 plus	DF5 plus
Mounting distances (without optional speed detection system)						
Nominal axial displacement (rotor - stator)	mm			7		
Tolerance to nominal axial displacement (rotor - stator)	mm			≤±1		
Nominal radial displacement (rotor - stator)	mm			3		
Tolerance to nominal radial displacement (rotor - stator)	mm			+1/-2		
Distance stator to dyno	mm	14.00	17.00	18.00	19.00	29.00
Speed measuring system Magneto resistive (2 tracks approx. 90 degree phase shifted)						
Nominal clearance (sensor - pole ring)	mm			0.7		
Working airgap (sensor - pole ring)	mm			0.1...1.0		
Nominal axial displacement (rotor - stator)	mm			7		
Tolerance to nominal axial displacement (rotor - stator)	mm			±0.5		

Table 6 Mounting distances

4.3.2 Dimensions DF standard rotor

Please check the dimensions of the rotor from the drawings. They can be requested from ATESTEO or can be found in the product data sheets.

4.3.3 Dimensions DF stator

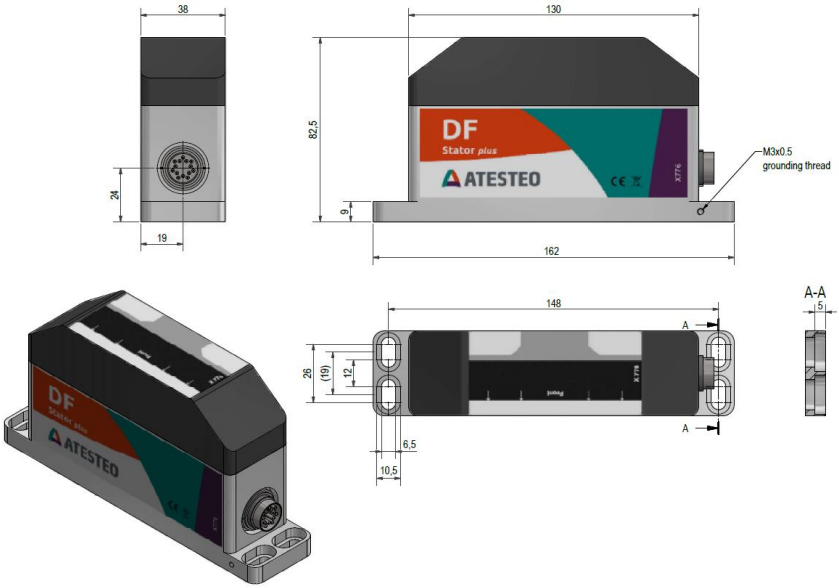


Figure 12 Dimensions of the stator

4.3.4 Dimensions TCU5

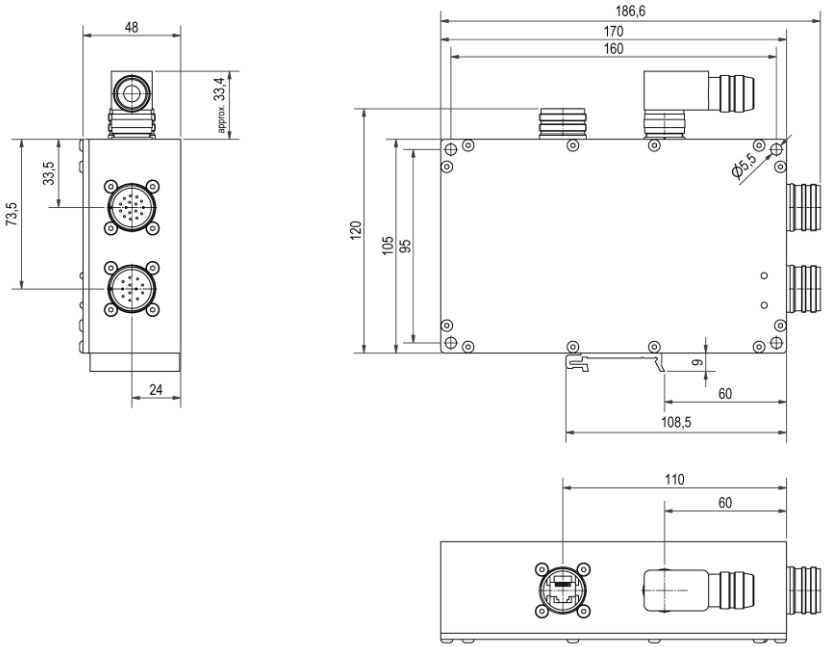


Figure 13 Dimensions of TCU5

4.4 Mounting the rotor

You need a torque wrench for mounting the rotor.

Mounting torquemeter with input side to drive train.

Type	Amount of screws	Tightening torque
DF1 50 / 100 Nm (Titanium)	6x M8 10.9	36 Nm

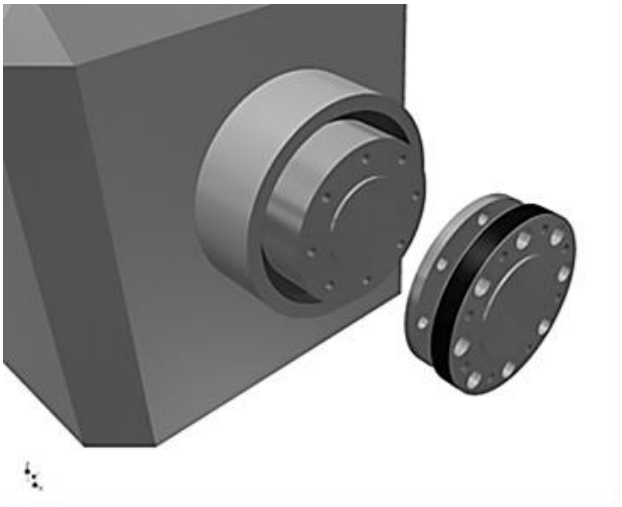
DF1 200 / 500 Nm (Steel)	6x M8 12.9	43 Nm
DF2	8x M10 12.9	84 Nm
DF3	8x M12 12.9	145 Nm
DF4	8x M14 12.9	235 Nm
DF5	8x M16 12.9	360 Nm

Table 7 Tightening torques

You can see the screwing depth in the following table:

Measuring rotor	Thread size	screw depth of the flange (mm)	
		min.	max.
DF1	M8x1.25	8	14
DF2	M10x1.5	10	14
DF3	M12x1.75	12	14
DF4	M14x2	14	17
DF5	M16x2	16	17

Table 8 Screw dimensions



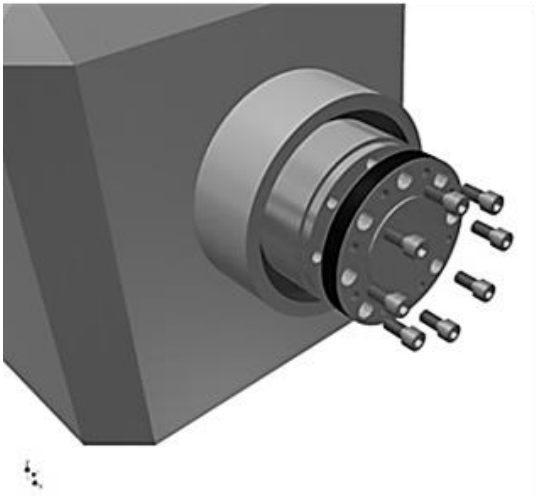


Figure 14 Rotor mounting

4.5 Mounting the stator

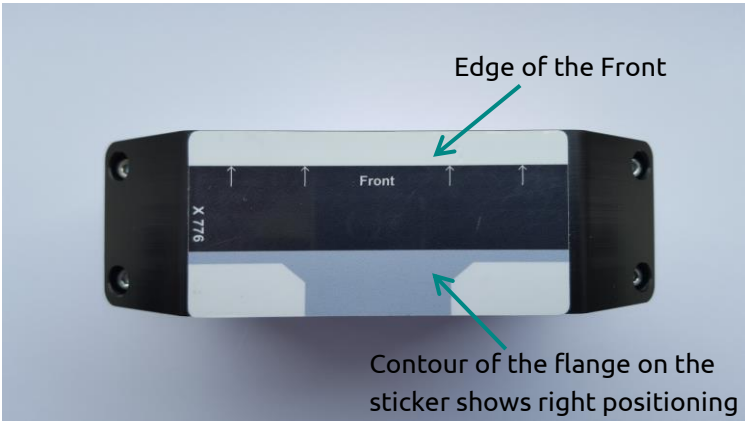


Figure 15 Top-view of the stator

The **DF stator** must be positioned under the measuring flange that the output flange of the rotor covers the black area of the stator (sticker).

Note:

Radial air-gap between receiver and torque-meter: **3mm +1mm /-2mm.** Axial displacement of black area: **±1mm**

You need M6-screws for the mounting.

When mounting the stator, use all four slots.

First, the stator must be grounded. For details, see the section 4.8. The grounding screw should be used.

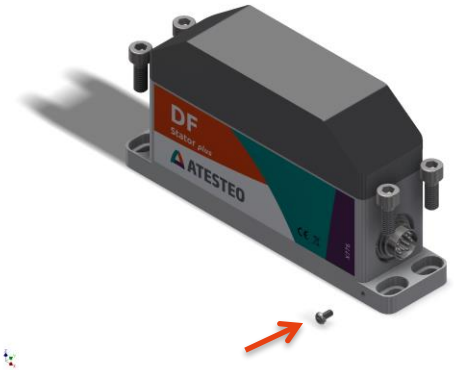


Figure 16 Side view of the stator

You can find information on the dimensioning of the stator mounting to the rotor in chapter 4.3.1.

The following images show the right placement (of the rotor and the stator).

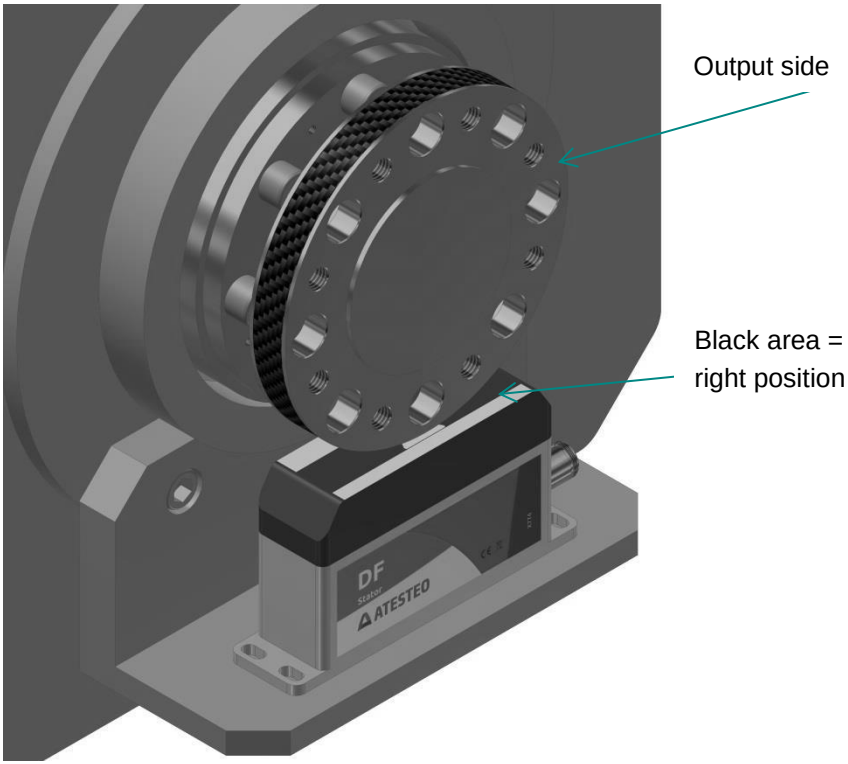


Figure 17 Alignment stator and rotor 1

Right position: output side on the edge of the marking

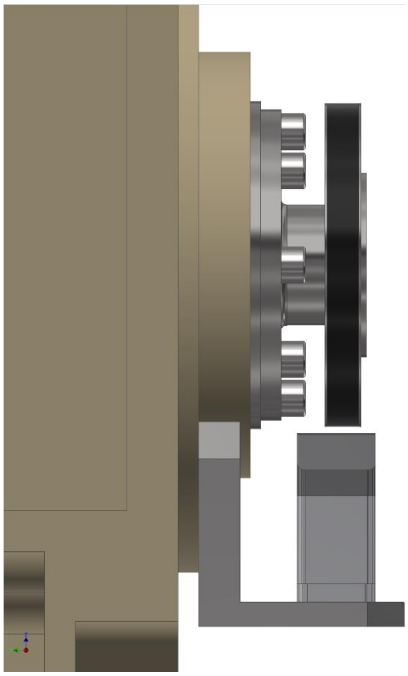


Figure 18 Alignment stator and rotor 2

4.6 Speed-measuring system (optional)

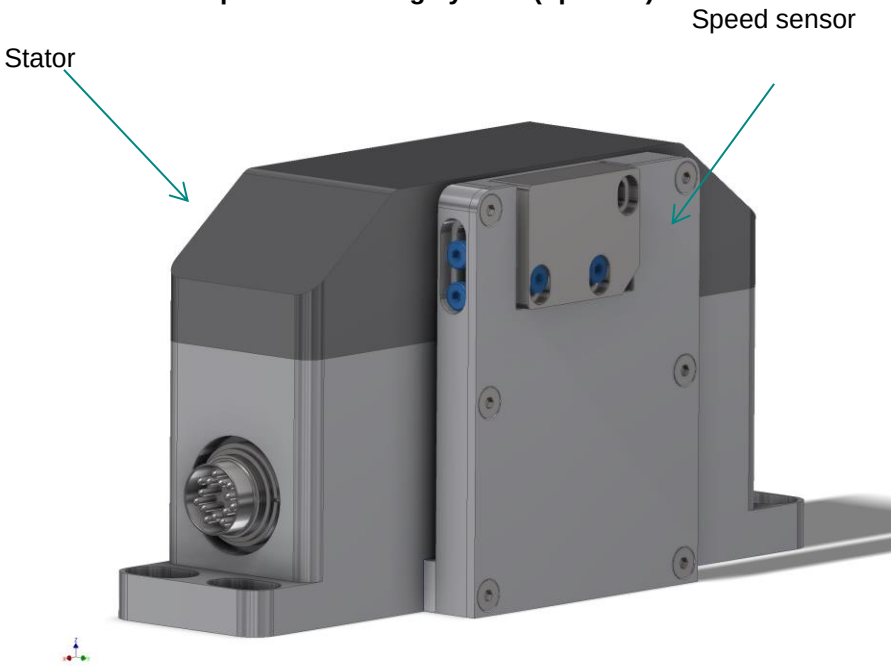
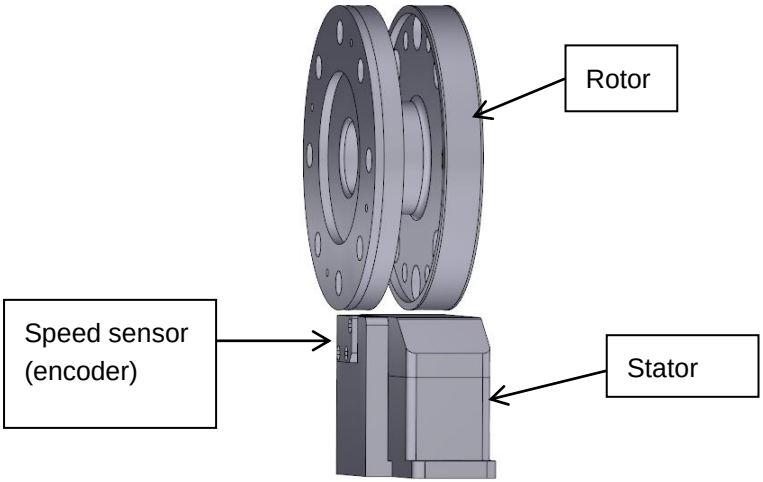


Figure 19 Optional speed detection system at stator

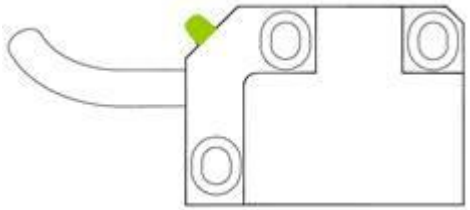
Delivery state
The speed measuring system is factory-set to nominal distance.
If an adjustment of the distance is necessary, please note:
Max. radial distance to the magnetic ring is 1 mm.

Speed sensor alignment
Release the two screws at the speed encoder and move the speed encoder into the correct position. Once the sensor is adjusted in range, fix the two screws again.

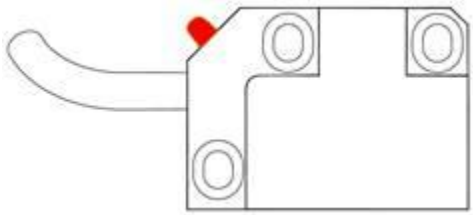
Remark:
Stators of DF series are slightly different. A distance plate between stator backside and speed encoder varies in each stator (DF1, DF2, DF3, …).



The speed-measuring system is equipped with an LED:
LED green: the signal strength is ok / Set-up



LED red: the signal strength is too low / Adjustment necessary



4.7 Assembly evaluation unit (TCU5)

The evaluation unit is not protected against splash or condensation water. That is why the evaluation unit should be assembled in a dry place with a maximum relative humidity of 80 %. The ambient temperature must be between -20 and +70 °C.

4.7.1 Type of installation

The evaluation unit can be mounted in two ways. It can be mounted on an electrically conductive 35 mm DIN rail (cap rail) or on an electrically conductive metal plate.

cap rail mounting

For mounting on a DIN rail, a metal clip is located on one side of the evaluation unit. The following figure shows the position of the metal clip:

Figure 20 Mounting of TCU5 (with clip)

The TCU can be easily hooked with the clip from top to bottom on the DIN rail. Please connect the DIN rail to the central ground point of the test bench via a grounding strap.

Metal plate installation

For mounting on a metal plate, there are four drill holes on the front of the evaluation unit. The following figure shows the position of the holes:

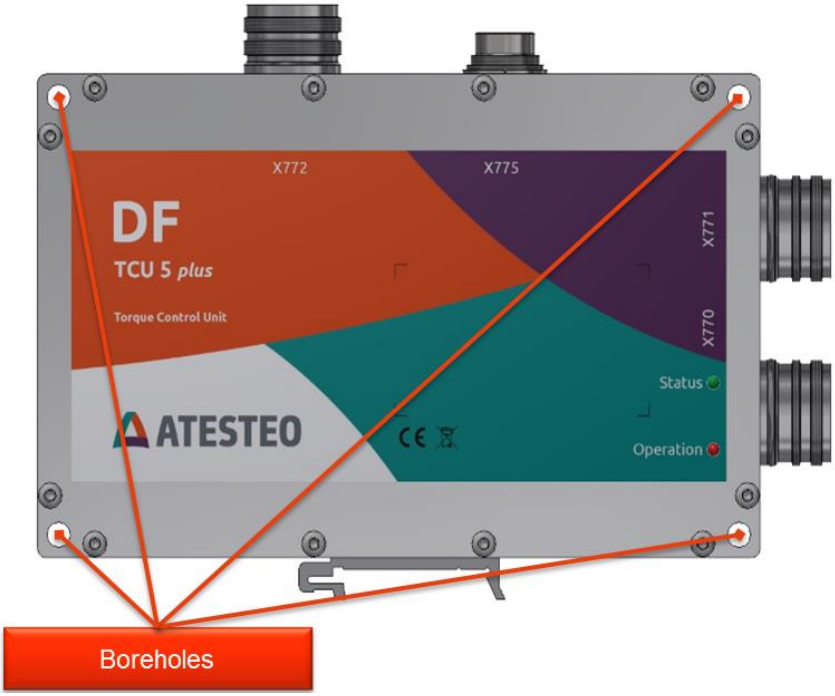


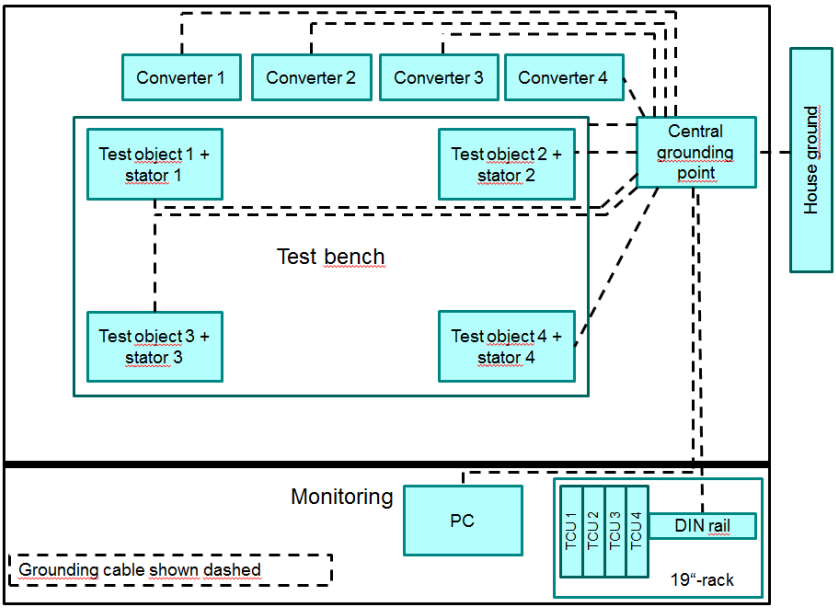
Figure 21 Mounting of TCU5 (with screws)

Attach the evaluation unit to the metal plate with four M5 cylinder head bolts. The drill holes for the screws each have a depth of 48 mm. Please connect the metal plate via a grounding strap to the central ground point of the test bench. The connection of the grounding strap should be placed as close as possible to the evaluation unit. For coated metal plates, the earth strap must be fastened to the evaluation unit via a ring cable lug on one of the four screws mentioned.

4.8 Grounding at the test bench

Today's demands of test stand claims require a powerful and high-frequency clocking hardware. Electronic components are sensitive towards electromagnetic emission. That's why the avoiding of electromagnetic emissions is really important when it comes to test facility planning. The DF plus series hardware is designed to derive electromagnetic interference. These protection circuits only work if the stator and the evaluation unit are each connected via their own cables directly to a central mass point with the test bench ground. It is the same for the remaining hardware in the test bench. If all the components are directly connected to a mass point without detours it enables a low –impedance dissipation of broadband electromagnetic interference and at the same time it avoids unwanted ground loops by different line potentials.

The following illustration outlines the example of a point-to-point grounding concept:



In addition to a sophisticated earthing concept, it makes sense to separate all power cables by the use of separate cable ducts from the sensitive signal lines of the test bench. A spatial separation of the power cables is the best option, but if it is not possible the cables should at least not be laid parallel to each other. The central cable between the stator and the TCU transmits sensitive signals. That's why it shouldn't be laid with the power cables. To add the cable shield protects the cable against external interference. A diligent planning of the grounding concept and the guideways can avoid costly error search and error correction on the fully assembled test bench!

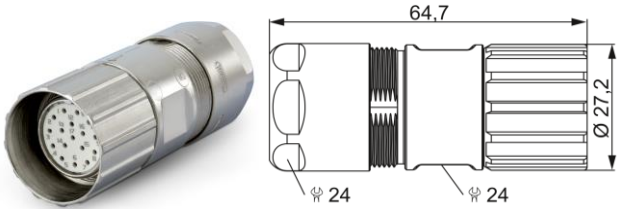
4.9 The wiring of the evaluation unit

The evaluation unit has four device plugs. The respective connector designation is written on the housing cover of the evaluation unit. Device connectors X770 and X771 connect the evaluation unit to the test bench peripherals. Device plug X772 connects the Ethernet interface to the evaluation unit. The central cable connects the device plug X775 of the evaluation unit with the stator. The central cable is not allowed to be longer than 50m. Only use the following cable connectors:

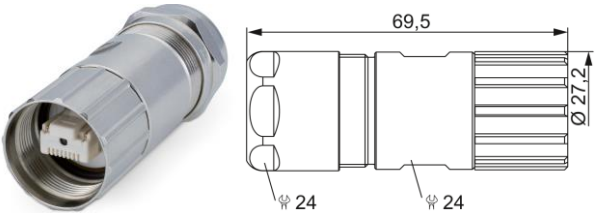
Device plugs	Cable connector (manufactures – manufacturer part number)
X770 (12-polig)	Hummel – 7106500000 + Hummel - 7001912104
X771 (16-polig)	Hummel – 7106500000 + Hummel - 7001916103
X772 (Rj45)	Hummel – 7R10400000*[1] + Hummel – A7RJ-821M51*[1] Or protective cap: Hummel – 7010900102
X775	Binder – 99 5629 75 12

*[1]) not included in the scope of supply

Cable connector for connection X770 and X771



Cable connector for connection X772



If you do not use the housing plug X772, please use the protective cap (included in the delivery) to protect it from electromagnetic field and dirt particles. You can find the pin assignment of the individual plugs in the appendix.

4.10 Power and data cable

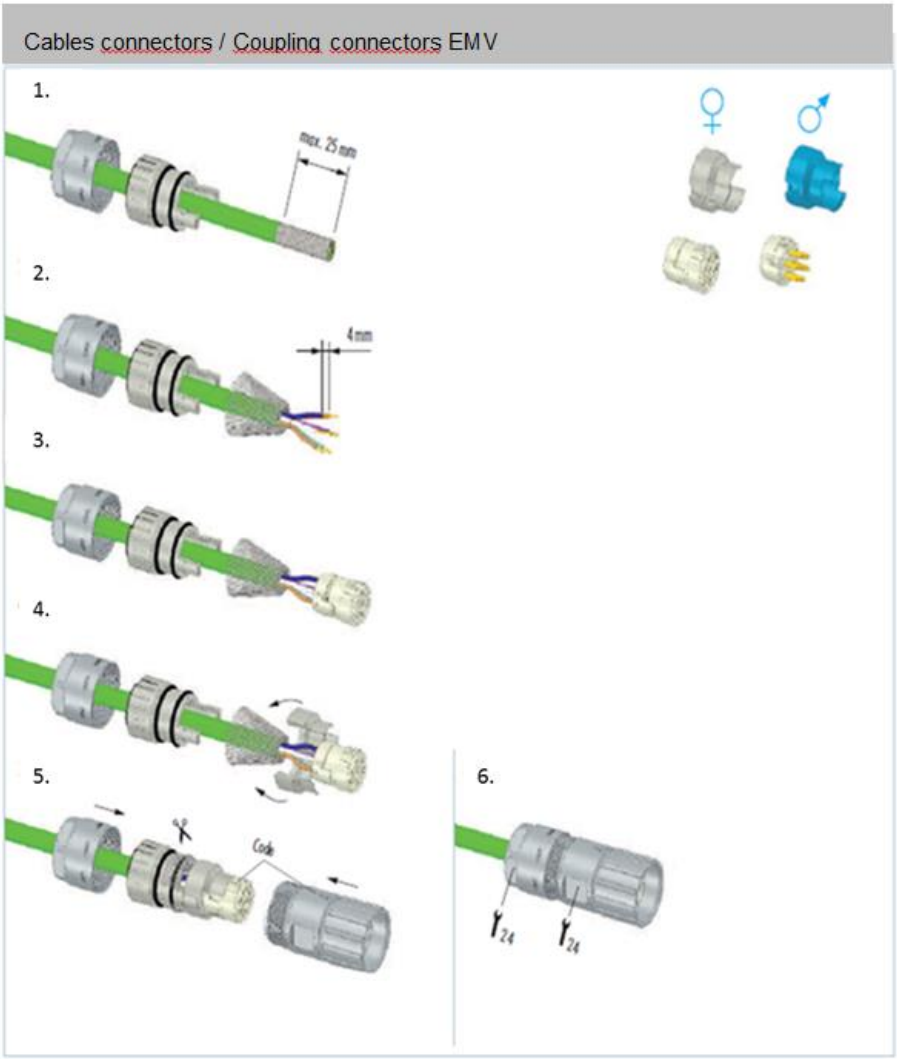
In order to comply with the EMC standards EN61000-6-4 / VDE 0839 parts 6 to 4, the following procedure for connecting and lying the power/data cable is recommended:
Please use a shielded cable with 4x 2x 0.14mm² (twisted pair) + 4x 0.5mm² for connection to X770 and a shielded cable with 8x 2x 0.25mm² wire (twisted pair) for connection to X771. The shielding of the cables must be placed on both ends. The shield must also be placed on the measuring flange side and in the measuring cabinet.

Pin assignment see 7.

Information
We recommend installing a fuse in the control cabinet with an on-and off-switch.

Information
Prefabricated cables are optionally available ex works.

Assembling the power and data cable



5 Start-up

5.1 The first switch on

Before you switch on for the first time, make sure that all system components have been connected and aligned in accordance with the installation instructions in this manual. Check all cable connections for correct and safe mounting. The DF plus series has three LEDs, which indicate the respective operating status. Two LEDs are located on the evaluation unit and one LED on the side of the DF plus stator.

You will find an overview of all flashing codes with the associated system states in the chapter 3.12.

The following chapter describes the setup of the web interface needed to configure the measuring system.

5.2 Installation of a Web browser

Use a common web browser for your system such as Firefox, Chrome, Edge or Safari.

Note
Please use the latest version of the browser

5.3 Network connection

You need a CAT5-Patchcable and an RJ35-connection to connect the TCU5 to an evaluation computer.

Three options to connect to network:

1. Connect directly

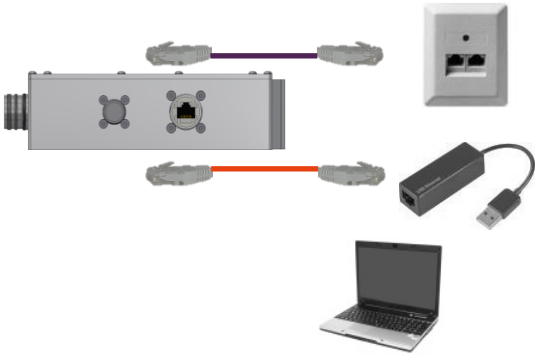
Connect with a patch cable directly from the Ethernet socket of the computer.

2. Connect with network-to-USB adapter:

The adapter needs to be installed on the computer. Now connect the TCU5 with a patch cable to the adapter.

3. Connect in domain network:

Connect the TCU5 using the patch cable with a free network socket.



The TCU5 does not support the ping protocol. Even with correct IP settings, the TCU5 will not reply on ping requests.

5.4 Network settings

Network settings need to be changed, if the system (torquemeter, computer) is not connected to each other with a domain.

Ask your IT department to set up the following IP settings on your computer:

- ID address: 172.16.86.2
- Subnet mask: 255.255.255.0

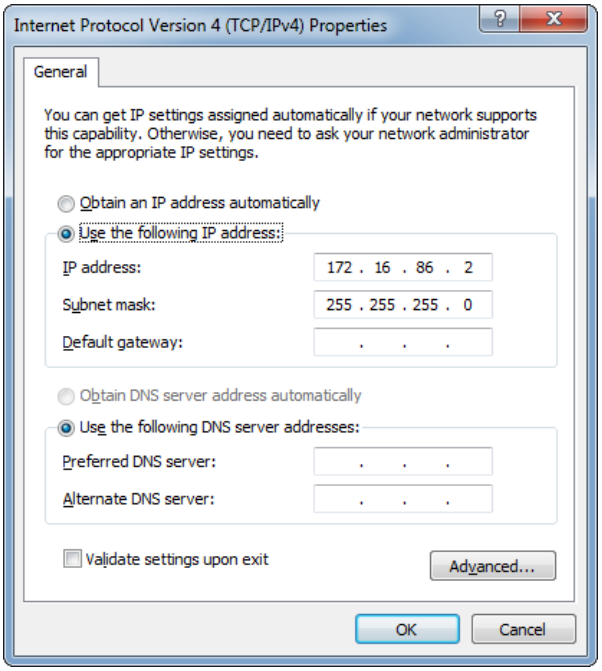


Figure 22 IP configuration (Windows)

5.5 Proxy configuration

Add a new exception for the proxy system for the following address space: 172.16.86.*

5.6 Web interface

The web address of the TCU 5 plus is needed to open the web interface. There are three different ways to open it.

The web address contains of "tcuv-" and [SERIAL NUMBER].

Or you can use the following IP address to open the web interface:

http://172.16.86.3

In case the IP address is unknown and not default, the IP address can be reset (see 3.11.3).

6 Using the web interface

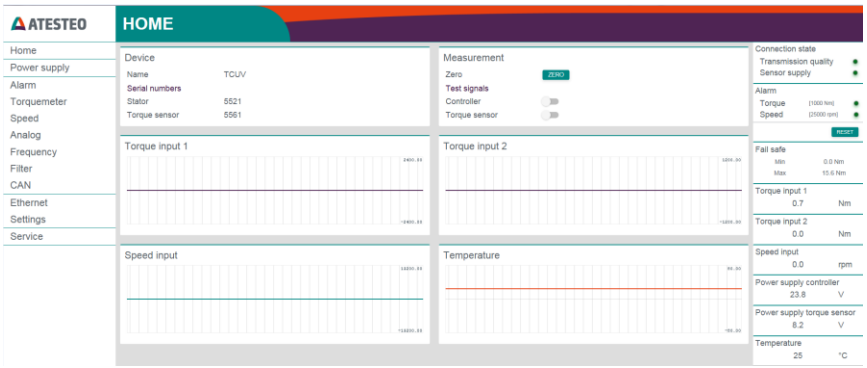
LOGIN

The password must be entered to log in. If the password is not changed, the password is: **admin**.

Important
The password can be changed in the item settings menu. Protect you measuring system from unauthorized access!

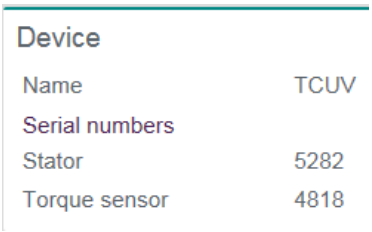
The web interface is only available in English language.

6.1 Home Menu



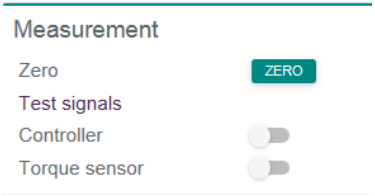
The Web-Interface is divided into different parts:

Device information:



This overview of currently connected devices includes information about the name of the TCU 5 plus and the serial number of the stator and the torque sensor. The device name is editable in the Settings menu.

Measurement features:



The measuring signal is set to zero (see 3.11.1) by pushing the “ZERO” button. Zero adjustment can be done for the signals “torque” and “rotation angle”.

The test signals (see 3.11.2) are enabled or disabled by the slider buttons.

6.1.1 Graph overview

Different signals are displayed in the main part of the home page. These signals graphically represent Torque input 1, Torque input 2[1], Acceleration input[1], the Speed input[1] and the Temperature of the torque sensor. Graphs are automatically scaled according to their nominal value.

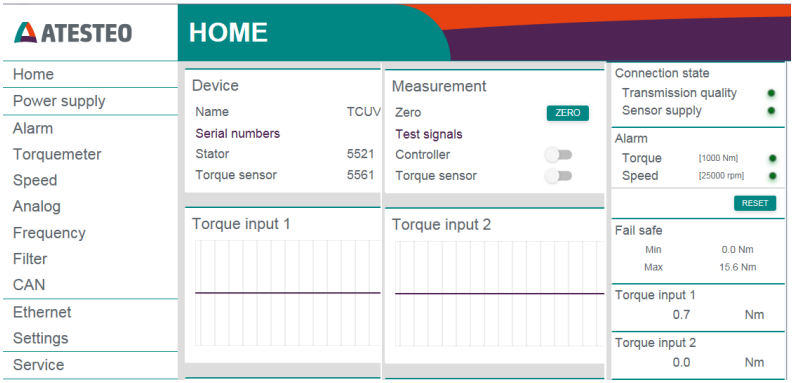
Note

Signals are not displayed in real-time. This may lead to de layed representations.

6.1.2 Navigation menu

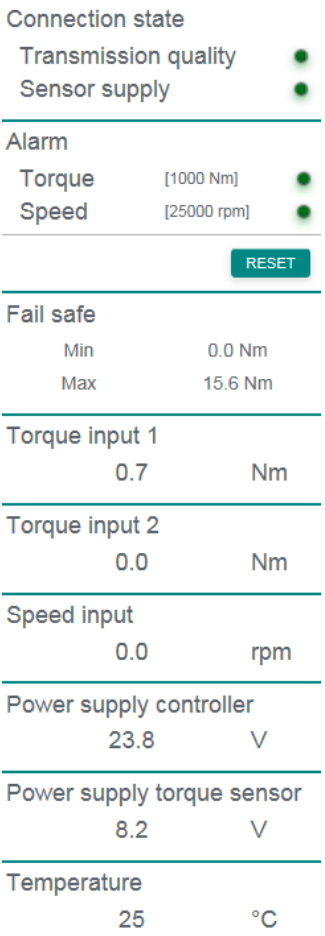
If the navigation bar is closed, click on the company logo to open it again.

[1] Depending on the configuration of the current system



6.2 System overview

The signal bar is shown on the right-hand side of the website.



A Transmitting (green) | No Transmitting (gray)
B Optimal (green) **|** Okay (yellow) **|** Bad (red)
C Value below threshold (green) | Value above threshold (red)

Note

Signals are not displayed in real-time. This may lead to delayed representations.

Important

Check the supply voltage and the orientation between torque sensor and stator-antenna to guarantee an optimal transmission quality.

Connection state

The “Connection state” tab contains information about the transmission status of the system. The LED “’Transmission quality” is an indicator of transmission quality of measured data from torquemeter to torque control unit. The “Sensor supply” LED indicates the status of the torque sensor supply voltage.

Alarm states

Alarm values are displayed in the “Alarm” section. Red indicates that threshold is exceeded. Alarms can be reset by pressing RESET-button. Alarm limits can be set in the “Alarm” settings menu.

Measured data

Below the alarm states the measured data of the different system inputs: Torque input 1, Torque input 2[2], Acceleration input[2], Speed input[2], Power supply torque sensor, Power supply controller, Torque sensor Temperature and Fail safe[2] are displayed numerical.

Fail safe

The overload channel is used to better analyze misconduct at the test bench. While the standard measurement channels can capture torque values up to 110% of the nominal moment, the overload channel allows measurements of up to 300% of the nominal moment with an accuracy of 0.1%.

[2] Depending on the configuration of the current system

Measurements of the overload channel are recorded at a speed of 2 kHz. The sensor determines the absolute maximum or minimum of the measured values in 800ms and then sends them to the TCU.

In addition to the web display, the overload values can also be issued via CAN.

6.3 Power supply

In the menu “Power supply”, the supply voltage of the torque sensor will be adjusted. The power-switch activates and deactivates the power supply. If the power supply is activated, a search is started automatically, which sets the optimum operating point. This also applies to system startup. Because the inductively transmitted power depends on the gap between torque sensor and stator-antenna the supply voltage has to be readjusted after change of position. The optimal supply voltage of the torque sensor is 8.0 V ±0.5 V. There are 2 methods for adjusting:

1. Manuel mode: By pressing the SEARCH button, the optimal supply voltage is automatically set.
2. Automatic search: The search always starts when the system relies on the working range of 8V±>1.5V! If the search starts, the system is no longer ready to measure. System status must always be checked.

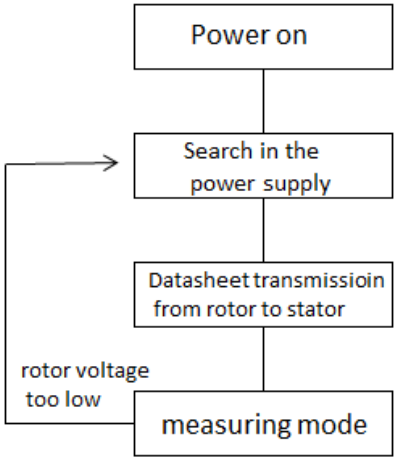
In the following section, the influence of the torque sensor voltage to the signal quality is shown:

Sensor voltage	LED “Sensor supply”	Description
8.0 V ± 0.5 V	Green	Optimal supply voltage
8.0 V ± 1.0 V	Yellow	Supply voltage is OK. Interruption caused by fluctuation of supply voltage possible.
8.0 V ± > 1.0 V	Red	Poor supply voltage. Possibly interrupted transmission, possibly invalid measurement values

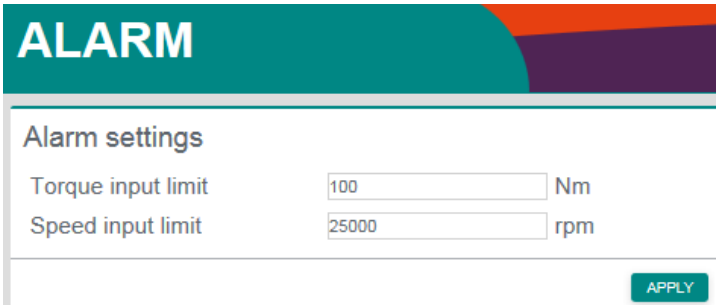
Table 9 Power supply of rotor

Important

The optimal torque sensor supply voltage should be at 8 V. Power supply will be deactivated and set back to zero, if a critically value is adjusted, in order to prevent damage of inductive power supply components. Measurement values can be invalid if the voltage drops



6.4 Alarm settings



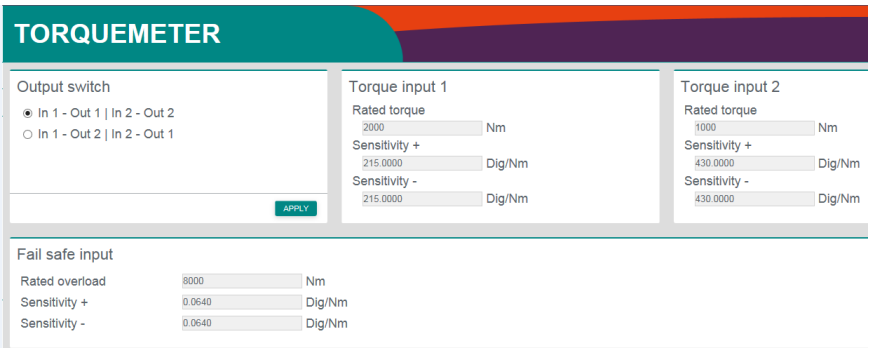
Alarm thresholds for speed[3] and torque can be set.

Torque input limit
If the measuring signal exceeds the set limit value, the alarm is triggered. In dual-range systems, only the large measuring range is

[3] Depending on the configuration of the current system

considered. Both alarms are transferred via the status word (CAN bus) and via the X771 plug.

6.5 Torquemeter



Important

Improper values can falsify measurements or in worst case damage the measurement device. Proper values can be found in the test report.

The “Torquemeter” display is locked for input, as the rotor automatically adopts the values. Manual changes of the settings can be changed in the setting menu (see 6.13).

6.5.1 Output switch

Output / View	Effect of switched output
Website view (Chart / Single value)	None

Frequency output[1]	Swapped
Analogue output (voltage)[1(*)]	Swapped
CAN output[1]	None

Table 10 Output switch

Analogue output channels without ‘”output switch”:

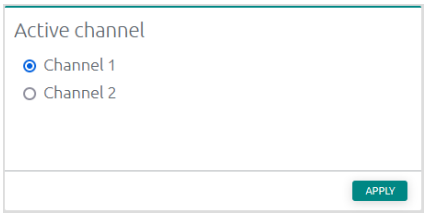
Ana1_out	Torque1
Ana2_out	Torque2
Ana3_out	Speed
Ana4_out	Rotation angle

Analogue output channels with ‘”output switch”:

Ana1_out	Torque2
Ana2_out	Torque1
Ana3_out	Speed
Ana4_out	Rotation angle

6.5.2 Selection of measurement range

For dual-channel torque transducers (DT) with only a single channel active (default setting) the active channel can be chosen. In addition, the current selection can be seen here.



This feature affects the following output signals:

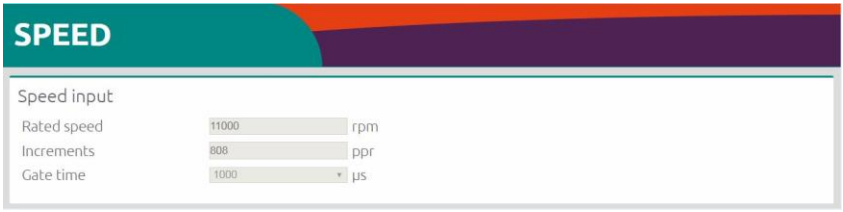
The function of each inactive output is explained in 3.10.2.

6.6 Speed

The page „Speed“ shows the parameter of the optional speed detection system. The rated speed and the number of increments are read from the electronic data sheet of the rotor. If the automatic apply function is deactivated, the values can be defined manually. Please read chapter 6.13.

Important
Incorrect values will lead to wrong measurement values. Correct values are given on the test report.

The gate time is defined independently from the connected rotor. It will affect the averaging of the speed signal.



6.7 Rotation angle

DF systems that have a speed detection system can also measure rotation angles. Two calculation methods are available to generate the rotation angle value:

Method	Description
0 – 360°	Rotation angle value will be generated in range from 0° to <360°. 360° is equivalent to 0° (unipolar mode).
±n * 360°	Rotation angle value will be calculated with sign and factor. “n” (0.5; 1…5). Factor “n” defines the number of rotations before value overload. The following rule applies: -n * 360° < x <= n *360° Overload rule: The largest possible value will be followed by the smallest possible value and vice versa.

Table 11 Rotation angle calculation methods

The resolution of the rotation angle depends on the number of impulses of the magnetic speed detection system.

Model	Impulse number	Rotation angle resolution [°]
DF1 plus	680	0.132
DF2 plus	808	0.111
DF3 plus	1,000	0.090
DF4 plus	1,176	0.077
DF5 plus	1,448	0.062

Table 12 Resolution of the rotation angle signal

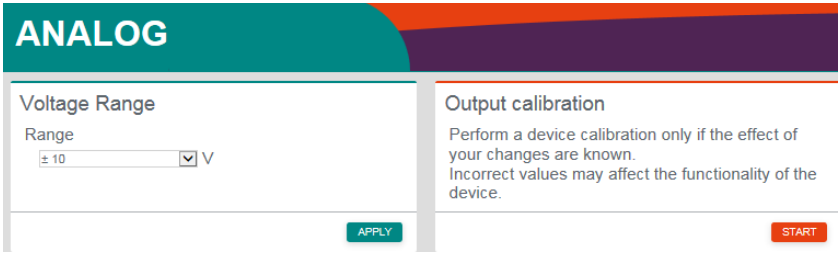
A zero point adjustment of the rotation angle can be triggered in the main menu of the web interface or via CAN bus command.

Restarting the TCU5 also performs a zero point adjustment. Changing the calculation method will come into effect after the first movement of the rotor.

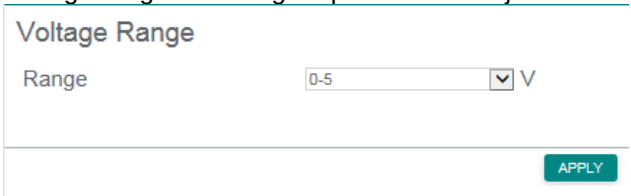
The rotation angle is reset to zero if the connection between stator and rotor is lost. The same happens if the distance between magnet ring and speed sensor is too large. In both cases, the root cause must be solved to get a stable rotation angle value (see 4.6).

The rotation angle output is a CAN signal or an analogue voltage.

6.8 Analog settings



Voltage range of analog outputs can be adjusted.



Default output configuration (Output switch off):

Input	Output
Torque1	Ana1_out
Torque2	Ana2_out
Speed	Ana3_out

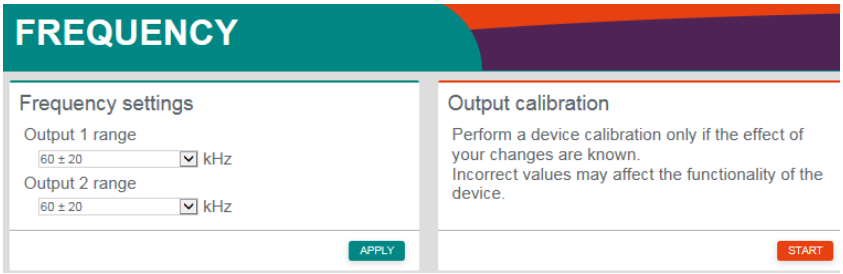
Switched output configuration (Output switch on)

Input	Output
Torque1	Ana2_out
Torque2	Ana1_out
Speed	Ana3_out

Output calibration

Important
The outputs may only be calibrated by trained personnel.
Incorrect values falsify measurements.
The outputs are calibrated at the factory and there is no need to recalibrate them.

6.9 Frequency settings



Various output ranges can be set in the "Frequency" menu. For a dual-channel torque transducer, both ranges can be set separately.

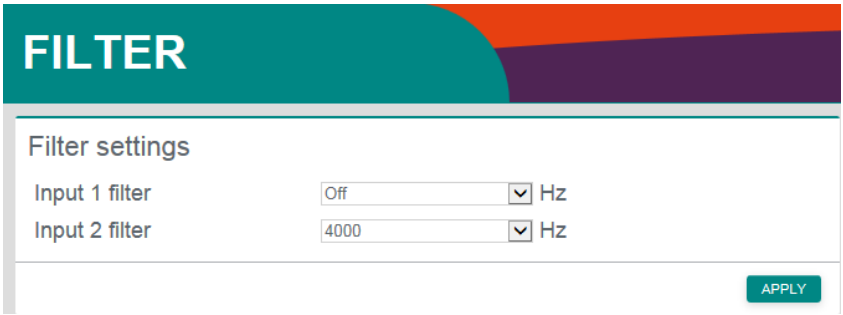
Available frequencies: **10±5; 60±20; 60±30; 240±120 kHz**

Output calibration

Important
The outputs may only be calibrated by trained personnel.
Incorrect values falsify measurements.
The outputs are calibrated at the factory and there is no need to recalibrate them.

6.10 Filter settings

The filter-settings influence the analogue voltage output, frequency output and CAN bus output.



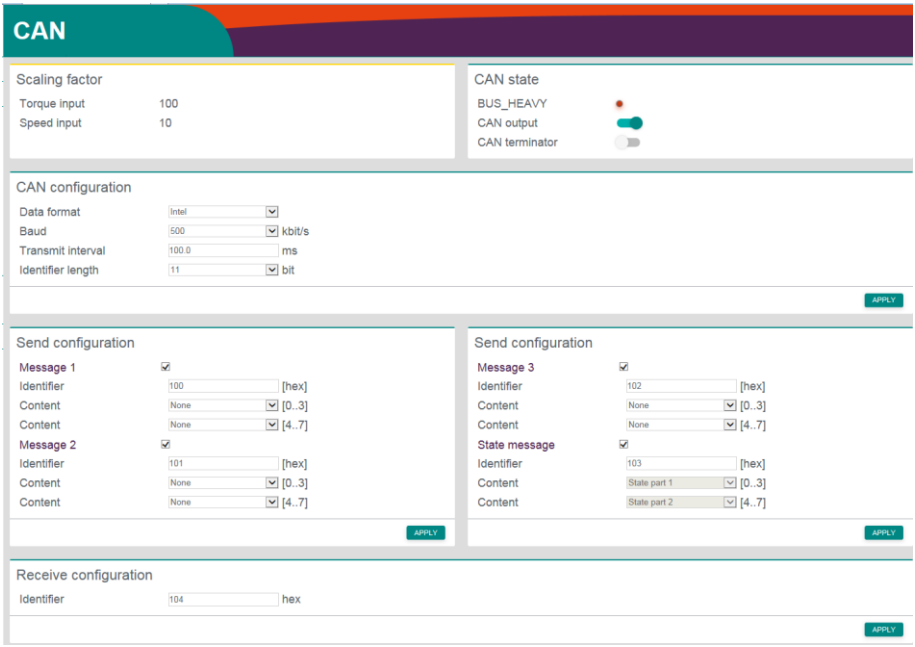
The TCU provides a digital IIR filter 1st order. It is related to the torque input channels. For each input channel, the filter can be activated and the cut-off frequency can be set in the corresponding dropdown-box. The following cut-off frequencies between 1 Hz and 4000 Hz are supported:

1 Hz, 10 Hz, 50 Hz, 100 Hz, 150 Hz, 250 Hz, 500 Hz, 1000 Hz, 2000 Hz and 4000 Hz.

The

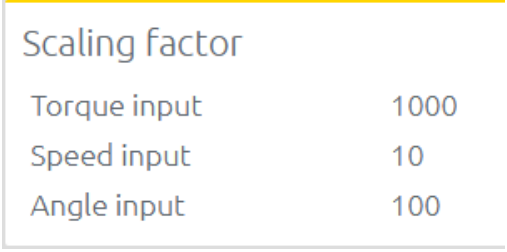
-button is clicked to save the settings.

6.11 CAN settings



The CAN interface can be configured in the CAN menu.

Scaling factors



The torque value and other values are transmitted in integer format. To generate sufficient decimal places in the TCU, the measured value is multiplied by a scaling factor. In order to obtain the true measured value in the measurement data acquisition, the received value must be divided by this scaling factor. The exact scaling factor of system depending signals is shown in the web interface.

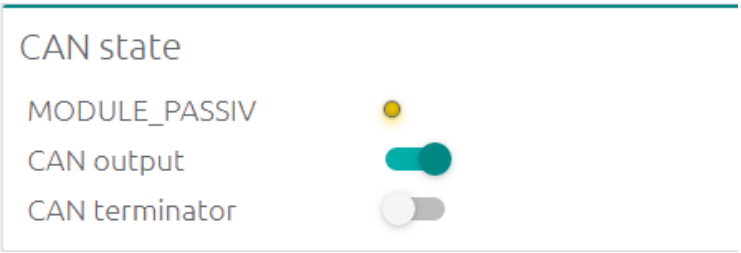
The signal “sensor supply” has always the factor 100.
The signal “temperature” has always the factor 1.

6.11.1 CAN state

CAN transmission is enabled and disabled by toggling the -button.

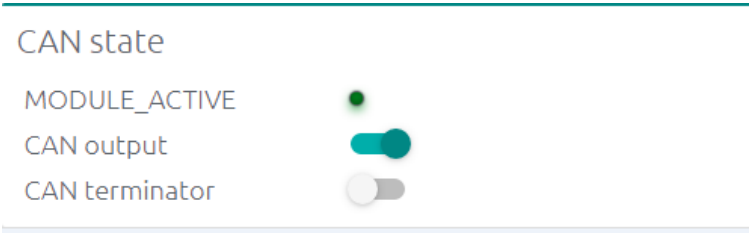
The “CAN State” tab also contains information about the current state of the CAN bus. The different states are explained in the following sections.

MODULE_ACTIVE: The CAN bus is working without any significant problems. The *receive error counter (RX)* and the *transmit error counter (TX)* are < 128.

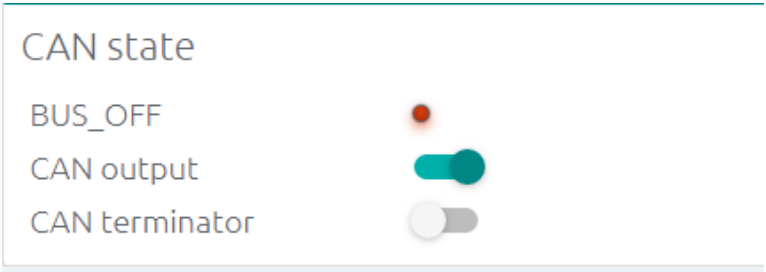


MODULE_PASSIV: The CAN bus works, however, a transmission or reception error occurred. TX or RX is > 127. In case that no more errors

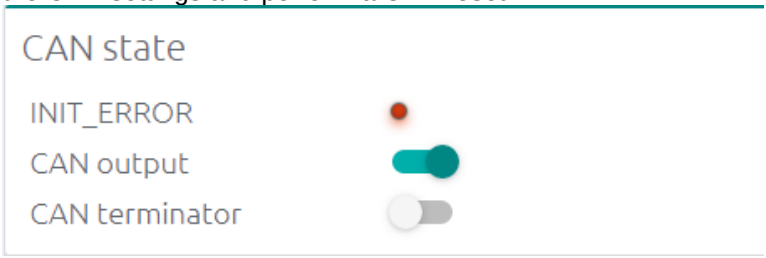
occurred, the counters are decremented and the status changes to MODULE_ACTIVE. Otherwise, the bus should be checked.



BUS_OFF: The CAN module has been disconnected due to many transmission errors (TX > 255).Check the CAN settings and perform a CAN reset.



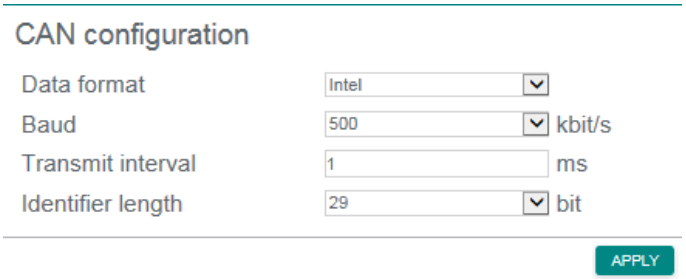
INIT_ERROR: The CAN module cannot connect to the CAN bus. Check the CAN settings and perform a CAN reset.



NOTE: CAN State can be reset by switching the output off and on again.

CAN Terminator
Connectable 120 Ω CAN connection resistor.

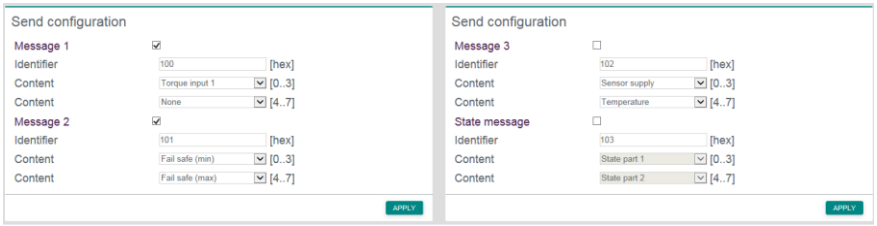
6.11.2 CAN configuration



The general CAN transmission can be configured. Selected values need to fit the values of the current receiver system.

- Data format (Intel, Motorola)
- Baud rate (250kbit, 500kbit, 1Mbit)
- Transmit interval (between 0.5 and 1000 ms)
- Identifier-Length (11 Bit, 29 Bit)
- Message IDs

6.11.2.1 Send configuration



CAN messages are formatted (dependent on configurations) in the following way:

Intel	Data byte 0-3				Data byte 4-7			
Identifier	**D0**	**D1**	**D2**	**D3**	**D4**	**D5**	**D6**	**D 7**
Selectable	Torque 1 x Factor_torque				Torque 2 x Factor_torque			
Selectable	Speed x Factor_speed				0x00			

Motorola								
Identifier	**D3**	**D2**	**D1**	**D0**	**D7**	**D6**	**D5**	**D 4**
Selectable	Torque 1 x Factor_torque				Torque 2 x Factor_torque			
Selectable	Speed x Factor_speed				0x00			

Up to four CAN messages can be configured depending on the CAN configuration. If the busload exceeds 90% due to the configuration, the 3rd CAN message is blocked. This ensures that the CAN messages can continue to be transmitted reliably.

$$CAN - Message\ length_{11\ Bit\ id} = 130\ Bit$$

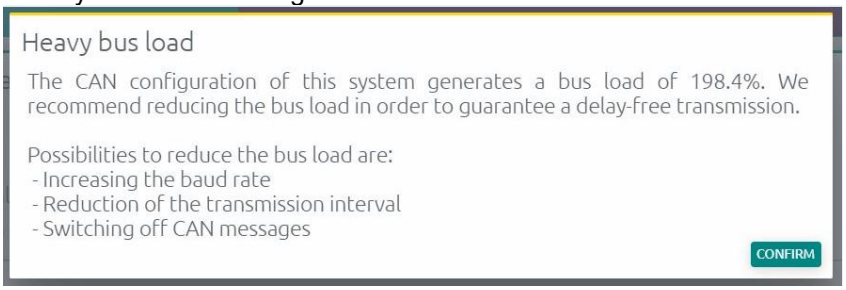
$$CAN - Message\ length_{29\ Bit\ id} = 148\ Bit$$

$$\frac{(CAN - sampling\ rate\ *\ message\ length)}{1000} = Bus\ load\ in\ kBit/s$$

$$\frac{(Bus\ load\ in\ \frac{kBit}{s} *\ Number\ of\ messages)}{Baud\ rate} * 100 = Bus\ load\ in\ \%$$

CAN Messages can be enabled and disabled. Messages one, two and three can be manually chosen and adjusted. The fourth message cannot be configured. It is reserved for the system state and the transmit interval is fixed at 1000ms.

“Heavy bus load” warning:



6.11.2.2 Receive configuration/command

The receiving identifier for CAN command message can be chosen. The following CAN commands can be received:

Command	Command code

	Hex	Dec
Zero adjustment “Torque”	0x4B1	1201
Test signal TCU5 (on)	0x4B2	1202
Test signal TCU5 (off)	0x4B3	1203
Channel selection MD1/MD2	0x4B5	1205
Channel selection MD2/MD1	0x4B6	1206
State reset	0x4BB	1211
Request state	0x4BC	1212
Zero adjustment “Angle”	0x4BD	1213
Power supply (off)	0x514	1300
Power supply (on)	0x515	1301
Alarm reset	0x578	1400
Request Ethernet settings	0xD05	3333

Table 13 CAN command list

The command must be included in the first 4 bytes [data bytes 0-3]. While receiving, distinction is made between Motorola and Intel. A response message is sent if a message is successfully received. The response massage is formatted in the following way:

Response message		
Identifier	**Data byte [0-3]**	**Data byte [4-7]**

receive identifier +1	last command	State part 1

6.11.3 Status word

The status word of DF PLUS-Series uses all 8 Byte of one CAN-Message and is separated in two parts. These are available separately in the selection menu for the CAN messages. The assignment within the CAN status message is fix. The following table shows the assignment:

State Part 2	State Part 1
Byte 7 - 4	Byte 3 - 0

Each State Part is 32 bits long. The following table describes the functions of the individual bits:

State Part 2			
Bit	Name	Description	Category
31	Rotor connected	Voltage search completed and nominal voltage reached	Connectivity
30	CAN active	CAN output activated	
29	-	Reserved	
28	-	Reserved	
27	-	Reserved	
26	-	Reserved	
25	-	Reserved	
24	-	Reserved	
23	-	Reserved	

State Part 2			
Bit	Name	Description	Category
22	-	Reserved	
21	Power supply	Rotor power supply activated	System supply
20	Voltage search	System is in voltage search	
19	-	Reserved	
18	-	Reserved	
17	-	Reserved	
16	-	Reserved	
15	-	Reserved	
14	-	Reserved	
13	-	Reserved	
12	-	Reserved	
11	Test signal rotor	Test signal rotor was triggered (half measuring range)	Test/Service
10	Test signal controller	Test signal controller was triggered (full measuring range)	
9	Configuration mode	Controller is in configuration mode (Service)	
8	Calibration mode	Controller is in calibration mode (service, fixed CAN messages, no calculation)	
7	Watchdog	Counter 0-255 (Increments in transmission speed)	
6			
5			

State Part 2			
Bit	Name	Description	Category
4			
3			
2			
1			
0			

Table 14 CAN status word part 2

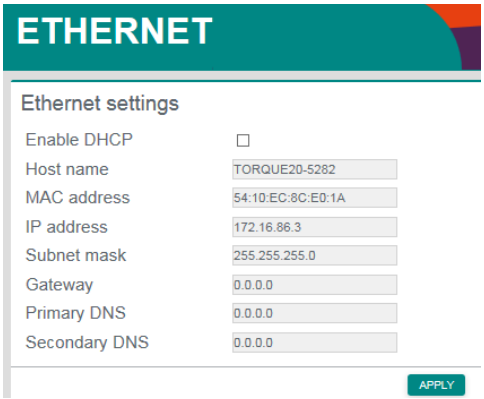
State Part 1			
Bit	Name	Description	Category
31	Alarm RX	System not ready for operation	Alarm/Error
30	Alarm MD	Torque exceeded	
29	Alarm N	Speed exceeded	
28	Alarm ACC	Acceleration exceeded	
27	-	Reserved	
26	-	Reserved	
25	Alarm Overcurrent	Royer current >= 1.4A || Royer current >= 1.2A (~ 5 minutes)	
24	Positioning error	Overcurrent during voltage search	
23	Version error	Incompatible equipment combination	

State Part 1			
Bit	Name	Description	Category
22	OS error	Fatal system error	
21	Current warning W1	Royer current >= 1.2A (~ 1 minute)	Warning
20	Current warning W2	Royer current >= 1.2A (~ 4 minute)	
19	Signal quality warning	Transmission rate < 24000 SPS	
18	-	Reserved	
17	-	Reserved	
16	-	Reserved	
15	-	Reserved	
14	-	Reserved	
13	-	Reserved	
12	-	Reserved	
11	System ready	System ready for operation	Measurement
10	Output switched	Signal input 1 is linked to measurement output 2	
9	Zeroed outputs	The measuring system has been zeroed by the user	
8	Rotor rotating	Internal rotor speed > 0	
7	-	Reserved	
6	-	Reserved	
5	-	Reserved	
4	-	Reserved	

State Part 1			
Bit	Name	Description	Category
3	-	Reserved	
2	-	Reserved	
1	-	Reserved	
0	-	Reserved	

Table 15 CAN status word part 1

6.12 Ethernet settings



Relevant adjustments for embedded measurement system in the intranet can be configured.

Important

Improper settings can break the device. In some cases, the device cannot be reconfigured! In that case, the torque control unit must be reprogrammed in factory.

Administration must be consulted before configuring to get the proper settings.
If the network settings of the TCU have been forgotten, the settings can be queried via the following CAN command:

Command	Command code	
	Hex	**Dec**
Request Ethernet settings	0xD05	3333

Table 16 CAN command to request Ethernet settings

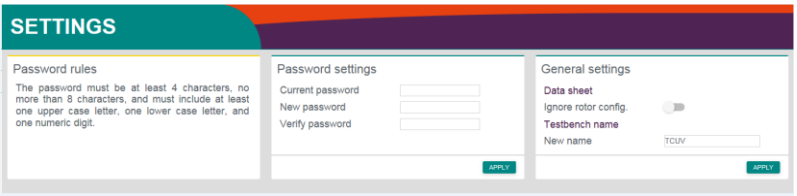
The response of the TCU has the structure IP address, subnet mask:

Type	**IP Address**				**Subnet Mask**			
Byte i	**Byte 0**	**Byte 1**	**Byte 2**	**Byte 3**	**Byte 4**	**Byte 5**	**Byte 6**	**Byte 7**
Content (HEX)	AC	10	56	2	FF	FF	FF	0
Result (DEC)	172	16	86	3	255	255	255	0

Table 17 CAN Response code of TCU

6.13 General settings

Username and password for first access:
Username: **customer**
Password: **admin**



A password and a device name for the measurement system can be adjusted.

Following password characteristics must be fulfilled:

- Total length between 4 and 8 signs
- At least one upper-case letter
- At least one lower-case letter
- At least one digit

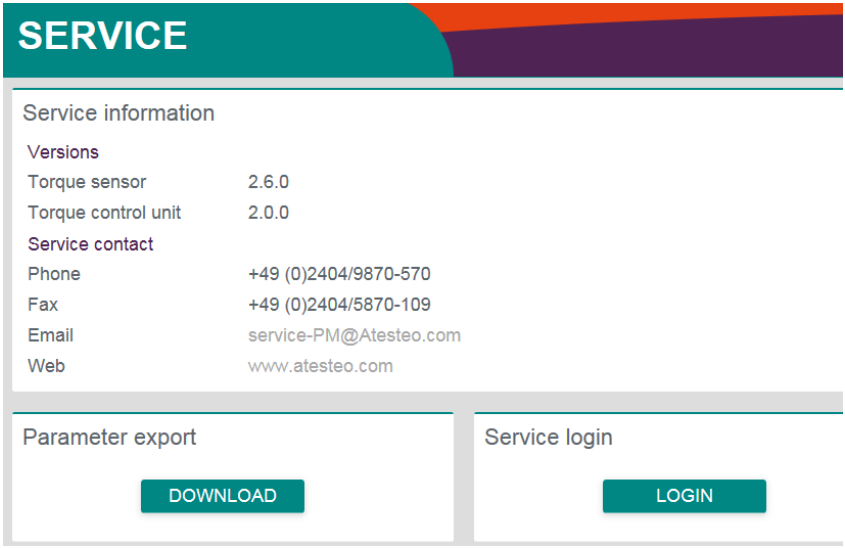
Important

Write down your password and keep it in a safe place. Please contact the service if you cannot remember your password anymore.

Ignore rotor configuration:
Deactivates the automatic data sheet transfer and allows manual entry of parameters.

Test bench name allows defining a customized name for the TCU5.

6.14 Service information



The installed firmware version of the device and manufacturer's contact details can be found on the Service page.
For service purposes, it is also possible to export a list of system parameters.

7 Pin allocations

7.1 X770 Power supply / Frequency output

12-pin connector, type M23					
Pin	**Signal**	**Description**		**Cable color**	**Cross-Section in mm**
		State “Output switch” In1 = Out1 In2 = Out2 (s. 6.5.1)	State “Output switch” In1 = Out2 In2 = Out1 (s. 6.5.1)		
1	F2_out-*1	Frequency output ch. 2 – RS422	Frequency output ch. 1 – RS422	White	0.25
2	F2_out+*1			Brown	0.25
3	N2_out+*1	Speed pulses output track 2 – RS422		Gray	0.25
4	N2_out-*1			Pink	0.25
5	N1_out+*1	Speed pulses output track 1 – RS422		Blue	0.25
6	N1_out-*1			Red	0.25
7	F1_out-	Frequency output ch. 1 – RS422	Frequency output ch. 2 – RS422	Yellow	0.25
8	F1_out+			Green	0.25
9	IP-reset_in	Reset IP-Configuration –3.3 – 30 V (via supply voltage)		White	0.5

10	Power+	Power supply 24 - 30 V / 1 A	Green	0.5
11	Power-		Yellow	0.5
12	Digital GND	Ground connection of digital signals	Brown	0.5

Table 18 X770

*1 Optional – depending on the configuration of the system

Frequency outputs

The frequency output F1 and F2 represents torque output 1 and 2. The second channel is only used if a DF system with dual telemetry was purchased (DFx DT).

The frequency span is declared by the web interface. The maxima represent positive and negative rated torque of the respective channel. When the output switch is activated, the two frequency outputs are switched. The frequency outputs must be connected to RS422 receivers. Connecting an output to ground will damage the TCU. It is irrelevant whether it is a positive or a negative output signal. RSS422 signals have a signal level of around 3.7 V. It is not recommended to misuse the signal as TTL signal without a required converter.

Using a DT torquemeter with single channel is explained in 3.10.2.

Speed-pulses output

The speed-pulses-outputs N1 and N2 represent every single pulse of speed track 1 and 2. The amount of pulses per rounds is dependent on the number of increments parameter of the speed ring. The increments numbers of both tracks are identical and phase shifted by 90°. The speed-pulses output must be connected to RS422 receivers. Connecting an output to ground will damage the TCU. It is irrelevant whether it is a positive or a negative output signal.

IP-reset_in

The IP reset signal resets the IP configuration of the Ethernet interface to the factory setting (see product label). For security reasons, the following procedure must be used for recovery:

1. •Turn on the IP reset signal
   •X770 Pin 9 3.3 V <= U <= 30 V
2. •Turn on the TCU.
3. •Wait until the red LED flashes and the green LED is off.
4. •Wait until the red and green LEDs light up constantly.
5. •Turn off the IP reset signal. The TCU automatically restarts, with the reset IP configuration.

Power supply

Connect the positive and negative power pins with an external power supply. The power supply must have a supply voltage between 24 and 30 Volt and must be able to supply 1 A constant current.

7.2 X771 Analogue / CAN / Alarm / Input

16-pin connector, type M23				
Pin	**Signal**	**Description**	**Cable color (cable optional)**	**Cross-Section in mm**
1	Test_in	Activates controller test signal	White	0.25
2	Zero_in	Zero balance input – 3.3 – 30 V (via supply voltage)	Brown	0.25
3	Digital GND	Ground connection of digital signals	Green	0.25
4	Digital GND		Yellow	0.25
5	CAN_H	CAN HIGH connection	Grey	0.25
6	CAN_L	CAN LOW connection	Pink	0.25
7	An4_out *1	Galvanic isolated analog voltage output	Blue	0.25
8	An2_out *1	Galvanic isolated analog voltage output	Red	0.25
9	An3_out *1	Galvanic isolated analog voltage output	Black	0.25

16-pin connector, type M23				
10	An1_out *[1]	Galvanic isolated analog voltage output	Purple	0.25
11	Alarm-MD_out	Alarm torque limit – open-collector	Grey/Pink	0.25
12	Analog GND	Ground connection of analog signals	Red/Blue	0.25
13	Alarm-N_out	Alarm speed limit – open-collector	White/Green	0.25
14	Output-switch_out / Err-state_out	State of output-switch – open-collector / State of system-errors – open-collector. Depending on software version	Brown/Green	0.25
15	Alarm-reset_in	Reset all alarms – 3.3 – 30 V (via supply voltage)	White/Yellow	0.25
16	Channel_select	See below	Yellow/Brown	0.25

Table 19 X771

*[1] Optional – depending on the configuration of the system

Test_in
The test_in signal activates the controller test signal as soon as the circuit is closed for at least one second until the signal is switched off again. The test signal produces a positive full-scale at all outputs for measured values. A voltage level 3.3 – 30 V (via supply voltage) between test_in pin and digital GND is applied for the control. The signal is active high. Function description see 3.11.2.

Zero_in
The zero_in signal activates the zeroing as soon as the circuit is closed for at least one second. The zeroing is executed only once after trigging. The zeroing sets the instantaneous values of the torque inputs as a new zero points. A voltage level 3.3 – 30 V (via supply voltage) between zero_in pin and digital GND is applied for the control. The signal is active high. Function description see 3.11.1.

CAN
The CAN interface allow the customer to receive the measured data in digital form and simultaneously send control signals to the TCU. The CAN_High and CAN_Low pins have to be connected with a 120 Ohm terminated CAN-Bus.

Analog_out
The analog outputs 1 and 2 represents torque output 1 and 2. The analog output 3 represents speed output. The analog output 4 represents the rotation angle (for systems with magnetic speed detection). The voltage span and channel configuration is declared by the web interface (see 6.5 & 6.7). The maxima represent positive and negative rated values of the respective channel. The rotation angle in unipolar calculation mode will only use positive voltages.

The analog outputs 1-4 are single ended galvanic isolated voltage outputs with separately analog GND.

Using a DT torquemeter with single channel is explained in 3.10.2.

Alarm-MD_out
The alarm-MD output indicates that the torque threshold is exceeded. The threshold value is set in the Web Interface. The alarm remains

active until the Alarm_Reset signal is triggered. The alarm output consists of an open collector circuit. In the active state, it connects the Alarm-MD_out pin with digital GND directly.

Alarm-N_out
The alarm-N output indicates that the speed threshold is exceeded. The threshold value is set in the Web Interface. The alarm remains active until the Alarm_Reset signal is triggered. The alarm output consists of an open collector circuit. In the active state, it connects the Alarm-N_out pin with digital GND directly.

Output-switch_out / Err-state_out / Channel_state_out
The function of this pin depends on the TCU firmware version. All are open-collectors.

Output_switch_out:
The output-switch output indicates the state of the output-switch. On active state the output-switch is active.

Err_state_out:
The error state output indicates whether the system is disturbed. On active state the system works without faults and full transmission.

Channel_state_out:
Active channel

Firmware less than V1.6.10:
Output-switch_out

Firmware equal to V1.6.10 or less than V2.2.0:
Err-state_out

Firmware equal or greater than V2.2.0:
Function of the pin can be defined in the web interface under “Settings”.

With DT torquemeter and a single active channel:
Err_state_out or Channel_state_out

With DT torquemeter and two active channels:
Err_state_out or _Output_switch_out

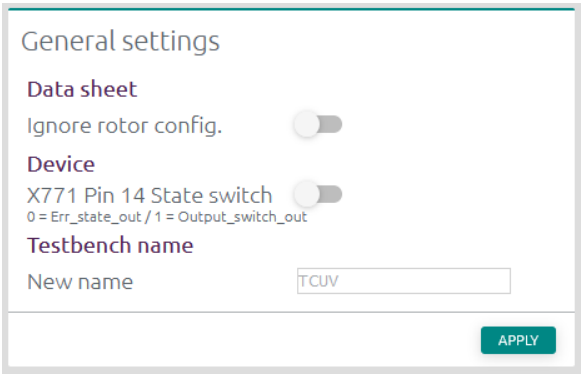


Figure 23 Function selection for X771.Pin14 (DT with 2 active channels)

The signal output consists of an open collector circuit. In the active state, it connects the output pin with digital GND directly.

Alarm-reset_in
The alarm-reset signal resets all alarm-signals as soon as the circuit is closed for at least one second. The reset is executed only once after trigging. A voltage level 3.3 – 30 V (via supply voltage) between alarm-reset_in pin and digital GND must be applied for the control. The signal is active high.

Channel_select
The “Channel_select” signal defines the selection of the active channel for DT torquemeter.

Not connected (0 V): 2. Channel
Connected (3.3 – 30 V): 1. Channel

TCU5 will check the state of “Channel_state” during start up and it will arrange the channel selection accordingly.

7.3 X772 Ethernet

Can be connect with a standard Kat 5e cable for diagnostics or setup. For permanent installation inside the test bench use the special connector.
Hummel - 7R10400000

7.4 X775 / X776 Central cable

15-pin connector, Type M16 **Not for** outdoor usage				
Pin	**Signal**	**Description**	**Cable color**	**Cross-Section in mm² / Type**
A	Power-	Supply voltage	Black	0.25 / straight
B	7V-Power+	Supply voltage	Purple	0.25 / straight
C	Data-in+	Digital rotor data – RS422	Yellow	0.14 / twisted
D	N0+	Speed-pulses – zero position	Grey	0.14 / twisted
E	N0-	Speed-pulses – zero position	Pink	0.14 / twisted
F	7V-Power-	Supply voltage	Grey/Pink	0.25 / straight
G	Power+	Supply voltage	Red/Blue	0.25 / straight
H	N1-	Speed-pulses – track 1	Red	0.14 / twisted
J	N2+	Speed-pulses – track 2	White	0.14 / twisted

K	N2-	Speed-pulses – track 2	Brown	0.14 / twisted
L	Data-in-	Digital rotor data – RS422	Green	0.14 / twisted
M	N1+	Speed-pulses – track 1	Blue	0.14 / twisted

Table 20 X775/X776

The following applies to double telemetry systems:

Channel 1 corresponds to the measuring channel with the **lower rated torque**.
Channel 2 corresponds to the measuring channel with the **higher rated torque**.

8 Appendix

8.1 Recommendations for zero adjustment

Each measuring element, containing flexible spring elements, that is measured by its elastic deformation, will always generate a zero drift even if no load is applied.
Related to strain gauge based torque measuring systems, zero-drifts in a load-free condition can be caused by the following circumstances:

8.1.1 Thermal influences

Despite of a complex temperature compensation a zero-drift related to high temperature fluctuations can always be observed. Due to various temperature influences interacting permanently with the torquemeter, another reason for exiguous zero-drifts is given.
The temperature stability defined in the technical specifications (e.g. 0.05%/10K) is determined by the allowed temperature drift of ±0.05% of the rated torque per 10 Kelvin difference. The temperature difference it related to the difference from the current flange temperature and the flange temperature of the last zero adjustment.

8.1.2 Influences of hysteresis

If a sensor during a test is mostly loaded in one direction, it can indicate a drift after the test is finished. This drift cannot to be traced back to a temperature compensation problem but to the natural hysteresis of the sensor and strain gauges.
The change of the zero value depends on the torque applied or on the test duration. In any case, the value of the zero-drift variation will not

be larger than the linearity and hysteresis specified in the technical data for the sensor.

8.1.3 Aging

If a strain gauge based sensor is dynamically loaded for a long period of time a zero-drift can occur. This value depends on the cycle count and the strain amplitude. This zero-drift will affect the sensitivity of the sensor.
Even though this is a natural effect for strain gauge sensors, ATESTEO torque sensors drift is very low due to a low sensitivity at nominal torque.

8.1.4 Influence of lateral forces

Considering that each torque sensor is part of a powertrain, every component linked to the sensor generates a lateral force. This load will be influenced by the size and installation of the components. This lateral force will be added to the measuring signal. If the installation is performed as specified in the technical specifications, this influence will be extremely small.

8.1.5 General

All the above mentioned items that influence the zero-drift are still in the range of calibration tolerance, as long as the sensor is properly maintained and handled and no transportation damages occurred to the sensor or strain gauges.
Due to the fact that all the above mentioned zero-drifts can happen in different situations at the same time it is very difficult to suggest a general zero-reset procedure.

After considering all the information acquired through our experience and customers feedback we can suggest and comment different scenarios for a proper zero-reset of the torque sensor.

- A zero-reset is only allowed if the torque (real load) is zero.
- If a great zero shift (>10 Hz) is observed during the mounting of the torquemeter please check the adapter flange due to the mechanical properties. A lower zero-shift can be reset.
- The test bench engineer has to decide, whether the accuracy request of the actual test requires a reset of the zero point. Generally it is possible to improve the accuracy by resetting the zero torque after the warming-up period of the test stand and before starting the measurement.
- If the zero shift is greater than 2% of the rated torque, the torquemeter must be checked. These tests (recalibration and other tests) have to be done by ATESTEO to find out the reason for the malfunction.
- A zero shift of 0.05% of the rated torque per month has no influence to the accuracy of the system.

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Your notes

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