MTS SENSORS

Temposonics®

Magnetostrictive Linear Position Sensors

Sensor with Ex approval

TH CANbus ATEX / IECEx / CEC / NEC / KCs / EAC Ex certified / Japanese approval

Operation Manual

Table of contents

1. Introduction

1.1 Purpose and use of this manual

Before starting the operation of Temposonics® position sensors, read this documentation thoroughly and follow the safety information. Keep the manual for future reference!

The content of this technical documentation and of its appendix is intended to provide information on mounting, installation and commissioning by qualified automation personnel [1] or instructed service technicians who are familiar with the project planning and dealing with Temposonics® sensors.

1.2 Used symbols and warnings

Warnings are intended for your personal safety and for avoidance of damage to the described product or connected devices. In this documentation, safety information and warnings to avoid dangers that might affect the life and health of operating or service personnel or cause material damage are highlighted by the pictogram defined below.

Symbol	Meaning
NOTICE	This symbol is used to point to situations that may lead to material damage, but not to personal injury.

2. Safety instructions

2.1 Intended use

This product must be used only for the applications defined under item 1 to item 4 and only in conjunction with the third-party devices and components recommended or approved by MTS Sensors. As a prerequisite of proper and safe operation, the product requires correct transport, storage, mounting and commissioning and must be operated with utmost care.

1. The sensor systems of all Temposonics® series are intended exclusively for measurement tasks encountered in industrial, commercial and laboratory applications. The sensors are considered as system accessories and must be connected to suitable evaluation electronics, e.g. a PLC, IPC, indicator or other electronic control unit.
2. The sensor's surface temperature class is T4.
3. The EU-Type Examination Certificates and Certificates of Compliance have to be taken into account including any special condition defined therein.
4. The position sensor may be used in zones (ATEX, IECEx) and Classes, Zones and Divisions (CEC, NEC) according to chapter 8. Any use of this product outside of these approved areas will void the warranty and all manufacturer's product responsibilities and liabilities. For non-hazardous areas MTS Sensors recommends to use the version N (not approved).

Zone concept			
Ex-Atmosphere	**Zone**	**Category**	**Explosion group**
Gas-Ex	In the baffle between Zone 0		Up to IIC (at the rod)
Gas-Ex	Zone 1	2G	IIA, IIB, IIC
Gas-Ex	Zone 2	3G	IIA, IIB, IIC
Dust-Ex	Zone 21	2D	IIIA, IIIB, IIIC
Dust-Ex	Zone 22	3D	IIIA, IIIB, IIIC
Gas-Ex	In the baffle between Zone 0 and		Up to IIC (at the rod)
	Zone 1 or Zone 2		Up to IIC (at the connection chamber)
Gas-Ex	In the baffle between Zone 0 and		Up to IIC (at the rod)
Dust-Ex	Zone 21 or Zone 22		Up to IIIC (at the connection chamber)

Class and Division concept			
Ex-Atmosphere	**Class**	**Division**	**Group**
Gas-Ex	Class I	Div. 1	A*, B, C, D
Gas-Ex	Class I	Div. 2	A, B, C, D
Dust-Ex	Class II/III	Div. 1	E, F, G
Dust-Ex	Class II/III	Div. 2	E, F, G

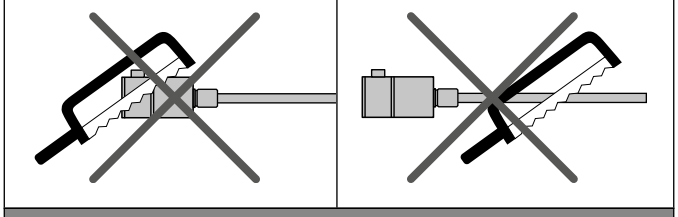
*Cl. I Div. 1 Gr. A not valid for Canada

1/ The term "qualified technical personnel" characterizes persons who:
- are familiar with the safety concepts of automation technology applicable to the particular project
- are competent in the field of electromagnetic compatibility (EMC)
- have received adequate training for commissioning and service operations
- are familiar with the operation of the device and know the information required for correct operation provided in the product documentation

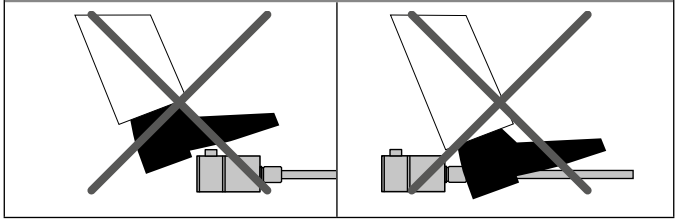
2.2 Forseeable misuse

Forseeable misuse	Consequence
Lead compensating currents through the enclosure	The sensor will be damaged
Use sensor without external fuse in Zone 0	In case of failure, the sensor might overheat
Use a fuse with more than 125 mA	In case of failure, the sensor might overheat
Wrong sensor connection	The sensor will not work properly or will be destroyed
Operate the sensor out of the operating temperature range	No signal output – The sensor can be damaged
Power supply is out of the defined range	Signal output is wrong / no signal output / the sensor will be damaged
Position measurement is influenced by an external magnetic field	Signal output is wrong
Cables are damaged	Short circuit – the sensor can be destroyed / sensor does not respond
Spacers are missing / are installed in a wrong order	Error in position measurement
Wrong connection of ground / shield	Signal output is disturbed – The electronics can be damaged
Use of a magnet that is not certified by MTS Sensors	Error in position measurement

Do not alter the sensor afterwards.
➔ The sensor might be damaged.



Do not step on the sensor.
➔ The sensor might be damaged.



2.3 Installation, commissioning and operation

The position sensors must be used only in technically safe condition. To maintain this condition and to ensure safe operation, installation, connection, cable installation and service, work may be performed only by qualified technical personnel, according to IEC 60079-14, TRBS 1203, Canadian Electrical Code (CEC) and National Electrical Code (NEC) and local regulations.
If danger of injury to persons or of damage to operating equipment is caused by sensor failure or malfunction, additional safety measures such as plausibility checks, limit switches, EMERGENCY STOP systems, protective devices etc. are required. In the event of trouble, shut down the sensor and protect it against accidental operation.

Safety instructions for commissioning
To maintain the sensor's operability, it is mandatory to follow the instructions given below.

1. Follow the specifications given in the technical data.
2. Ensure that equipment and associated components used in a hazardous environment are selected and installed in compliance with regulations governing the geographical location and facility. Only install equipment that complies with the types of protection relevant to the applicable Classes, Zones, Divisions and Groups.
3. In explosive atmospheres use only such auxiliary components that meet all requirements of the local and national standards.
4. The potential equalisation of the system has to be established according to the regulations of erection applicable in the respective country of use (VDE 0100 part 540; IEC 364-5-54).
5. Sensors from MTS Sensors are approved only for the intended use in industrial environments (see chapter "2.1 Intended use" on page 3). Contact the manufacturer for advice if aggressive substances are present in the sensor environment.
6. Measures for lightning protection have to be taken by the user.
7. The user is responsible for the mechanical protection of the sensor.
8. The sensor may be used only for fixed installations with permanently wired cables. The user shall ensure that cables and cable glands correspond to the risk assessment of the hazardous application as well as to thermic, chemical and mechanical environmental conditions. The user is also responsible for the required strain relief. When selecting the sealing, the maximum thermal load of the cables must be taken into account.
9. The user is responsible for meeting all safety conditions as outlined by:
   - Installation instructions
   - Local prevailing standards and regulations
10. Any parts of the equipment which got stuck (e.g. by frost or corrosion) may not be removed by force if potentially explosive atmosphere is present.
11. The surface temperatures of equipment parts must be kept clearly below the ignition temperature of the foreseeable air/ dust mixtures in order to prevent the ignition of suspended dust.

How to ensure safe commissioning

1. Protect the sensor against mechanical damage during installation and operation.
2. Do not use damaged products and secure them against unintentional commissioning. Mark damaged products as being defective.
3. Prevent electrostatic charges.
4. Do not use the sensor in cathodic systems for corrosion protection. Do not allow parasitic currents on the sensor housing.
5. Switch off the supply voltage prior to disconnecting or connecting the connectors.
6. Connect the sensor very carefully and pay attention to the polarity of connections, power supply as well as to the shape and duration of control pulses.
7. Cable entry temperature and branching point temperature may reach 104 °C (219 °F) and 116 °C (241 °F) respectively. Select suitable cable and entry device.
8. For field wiring, use cables suitable for the service temperature range of –40 °C (–40 °F) to +116 °C (241 °F).
9. Do not open when energized. Open the sensor only as shown in Fig. 6 on page 13.
10. A seal shall be installed within 18" of the enclosure (for NEC / CEC only).
11. Use only approved power supplies of Category II according to IEC 61010-1.
12. Ensure that the specified permissible limit values of the sensor for operating voltage, environmental conditions, etc. are met.
13. Make sure that:
    - the sensor and associated components were installed according to the instructions
    - the sensor enclosure is clean
    - all screws (only those of quality 6.8, A2-50 or A4-50 are allowed) are tightened according to specified fastening torque in Fig. 6
    - the cable glands certified according to the required hazardous area classification and IP protection are tightened according to the manufacture's specifications
    - surfaces limiting the joint shall not be machined or painted subsequently (flameproof enclosure)
    - surfaces limiting the joint have not been provided with a seal (flameproof enclosure)
    - the magnet does not grind on the rod. This could cause damage to the magnet and the sensor rod. If there is contact between the moving magnet (including the magnet holder) and the sensor rod, make sure that the maximum speed of the moving magnet is less or equal 1 m/s.
14. Ground the sensor via one of the two ground lugs. Both the sensor and the moving magnet including magnet holder must be connected to protective ground (PE) to avoid electrostatic discharge (ESD).
15. Before applying power, ensure that nobody's safety is jeopardized by starting machines.
16. Check the function of the sensor regularly and provide documentation of the checks
    (see chapter "6.2 Maintenance" on page 45).

2.4 Safety instructions for use in explosion-hazardous areas

The sensor has been designed for operation inside explosion-hazarded areas. It has been tested and left the factory in a condition in which it is safe to operate. Relevant regulations and standards have been observed. According to the marking (ATEX, IECEx, CEC, NEC, KCs, EAC Ex, Japanese approval) the sensor is approved only for operation in defined hazardous areas (see chapter "2.1 Intended use" on page 3).

When do you need an external fuse?

Zone / Div.	T-Series sensor
Zone 0 (rod only)	External fuse required
Zone 1 / 21	No additional fuse
Zone 2 / 22	No additional fuse
Div. 1	External fuse recommended

How to install a T-Series sensor in Zone 0 according to the guidelines (ATEX, IECEx, CEC, NEC, KCs, EAC Ex, Japanese approval)

1. Install an external fuse in compliance with IEC 127 outside the Ex-atmosphere. Connect it upstream to the equipment.
   Current: 125 mA
2. Install the sensor housing in Zone 1, Zone 2, Zone 21 or Zone 22. Only the rod section (for version D, G, and E) can extend into Zone 0.
3. Follow the safety regulations detailed in IEC/EN 60079-26, ANSI/ISA 60079-26 (12.00.03), ANSI/ISA/IEC/EN 60079-10-1 and JNIOSH-TR-46-2 to ensure isolation between Zone 0 and Zone 1.
4. When installing the TH sensor in the boundary wall for Zone 0, the corresponding requirements in ANSI/ISA/IEC/EN 60079-26 and ANSI/ISA/IEC/EN 60079-10-1 have to be noticed. Thereby the screw-in thread is to be sealed air tightly (IP67) according to ANSI/ISA/IEC/EN 60079-26 and ANSI/ISA/IEC/EN 60079-10-1.

2.5 Warranty

MTS Sensors grants a warranty period for the Temposonics® position sensors and supplied accessories relating to material defects and faults that occur despite correct use in accordance with the intended application [2]. The MTS Sensors obligation is limited to repair or replacement of any defective part of the unit. No warranty can be provided for defects that are due to improper use or above average stress of the product, as well as for wear parts. Under no circumstances will MTS Sensors accept liability in the event of offense against the warranty rules, no matter if these have been assured or expected, even in case of fault or negligence of the company. MTS Sensors explicitly excludes any further warranties. Neither the company's representatives, agents, dealers nor employees are authorized to increase or change the scope of warranty.

2.6 Return

For diagnostic purposes, the sensor can be returned to MTS Sensors. Any shipment cost is the responsibility of the sender [2]. For a corresponding form, see chapter "10. Appendix" on page 51.

2/ See also applicable MTS Sensors terms of sales and delivery on: www.mtssensors.com

3. Identification

3.1 Order code of Temposonics® TH

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
T	H										1		N	N	C									
a		b	c					d			e	f	g	h	i							j		

Optional

a	Sensor model
T H	Rod

b	Design
Enclosure Type 3: **TH rod sensor with housing material stainless steel 1.4305 (AISI 303) and rod material stainless steel 1.4306 (AISI 304L)**	
M	Threaded flange with flat-face (M18×1.5-6g)
N	Threaded flange with raised-face (M18×1.5-6g)
S	Threaded flange with flat-face (¾"-16 UNF-3A)
T	Threaded flange with raised-face (¾"-16 UNF-3A)
Enclosure Type 3X: **TH rod sensor with housing material stainless steel 1.4404 (AISI 316L) and rod material stainless steel 1.4404 (AISI 316L)**	
F	Threaded flange with flat-face (¾"-16 UNF-3A)
G	Threaded flange with raised-face (¾"-16 UNF-3A)
W	Threaded flange with flat-face (M18×1.5-6g)

c	Stroke length	
X X X X M	0025…7620 mm	
Standard stroke length (mm)		**Ordering steps**
25 … 500 mm		5 mm
500 … 750 mm		10 mm
750…1000 mm		25 mm
1000…2500 mm		50 mm
2500…5000 mm		100 mm
5000…7620 mm		250 mm
X X X . X U	001.0…300.0 in.	
Standard stroke length (in.)		**Ordering steps**
1 … 20 in.		0.2 in.
20 … 30 in.		0.4 in.
30 … 40 in.		1.0 in.
40…100 in.		2.0 in.
100…200 in.		4.0 in.
200…300 in.		10.0 in.
Non standard stroke lengths are available; must be encoded in 5 mm / 0.1 in. increments		

d	Connection type
C 0 1	Side connection with thread ½"-14 NPT (All versions)
C 1 0	Top connection with thread ½"-14 NPT (All versions)
M 0 1	Side connection with thread M16×1.5-6H (Version E & N)
M 1 0	Top connection with thread M16×1.5-6H (Version E & N)
N 0 1	Side connection with thread M20×1.5-6H (All versions)
N 1 0	Top connection with thread M20×1.5-6H (All versions)
N F 1	Side connection with thread M20×1.5-6H (Version E & N)

e	Operating voltage
1	+24 VDC (–15 / +20 %)

f	Version (see chapter 8 for further information)
D	Ex db and Ex tb (A/F 55)
E	Ex db eb and Ex tb (A/F 55)
G	Ex db and Ex tb (A/F 60) US & CA approval: Explosionproof (XP) **(Note: Group A is not available for Canada)**
N	Not approved

g	Functional safety type
N	Not approved

h	Additional option type
N	None

i See next page

i	Output
C (17) (18) (19) (20) (21) (22) = CANbus	
Protocol [3] (box no. 17, 18, 19)	
3 **0** **4**	CANopen
Baud rate (box no. 20)	
1	1000 kBit/s
2	500 kBit/s
3	250 kBit/s
4	125 kBit/s
Resolution (box no. 21)	
1	5 µm
2	2 µm
Performance (box no. 22)	
1	Standard

Optional:

j	Magnet number for multi-position measurement [4]
Z **0** **2**	2 magnets
Z **0** **3**	3 magnets
Z **0** **4**	4 magnets

NOTICE

Use magnets of the same type (e.g. 2 ring magnets with part no. 201 542-2) for multi-position measurement.

3/ Please contact MTS Sensors if you are interested in further CAN protocols

4/ Note: Specify magnet numbers for your sensing application and order separately

3.2 Nameplate

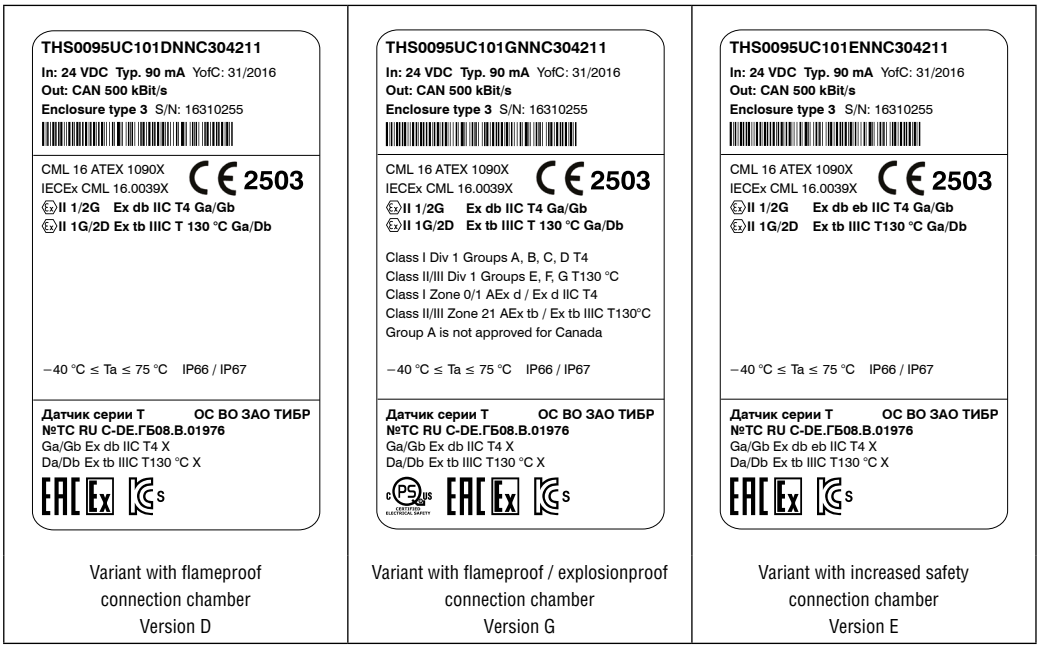


Fig. 1: Example of a nameplate of a TH sensor

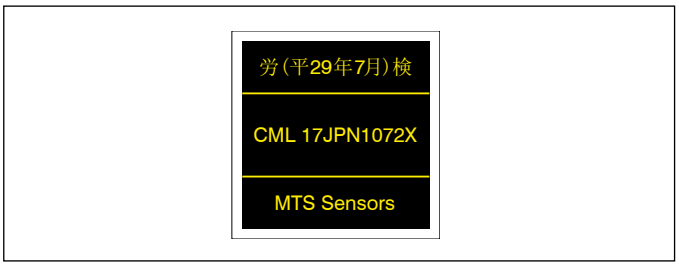


Fig. 2: Label for japanese approval

3.3 Approvals

See chapter “8. Technical data Temposonics® TH” on page 46 f..

NOTICE

For a detailed overview of the certifications, see www.mtssensors.com

3.4 Scope of delivery

TH (rod sensor):

- Sensor

4. Product description and commissioning

4.1 Functionality and system design

Product designation
- Position sensor Temposonics® T-Series

Sensor model
- Temposonics® TH (rod sensor)

Stroke length
- 25…7620 mm (1…300 in.)

Output signal
- CANbus

Application
Temposonics® position sensors are used for measurement and conversion of the length (position) variable in the fields of automated systems and mechanical engineering.
The T-Series sensors are designed for installation in a raised or flat-face flanged hydraulic cylinder, for use as an open-air position sensor or as a liquid level sensor with the addition of a float.

Principle of operation and system construction
The absolute, linear position sensors provided by MTS Sensors rely on the company's proprietary Temposonics® magnetostrictive technology, which can determine position with a high level of precision and robustness. Each Temposonics® position sensor consists of a ferromagnetic waveguide, a position magnet, a strain pulse converter and supporting electronics. The magnet, connected to the object in motion in the application, generates a magnetic field at its location on the waveguide. A short current pulse is applied to the waveguide. This creates a momentary radial magnetic field and torsional strain on the waveguide. The momentary interaction of the magnetic fields releases a torsional strain pulse that propagates the length of the waveguide. When the ultrasonic wave reaches the end of the waveguide it is converted into an electrical signal. Since the speed of the ultrasonic wave in the waveguide is precisely known, the time required to receive the return signal can be converted into a linear position measurement with both high accuracy and repeatability.

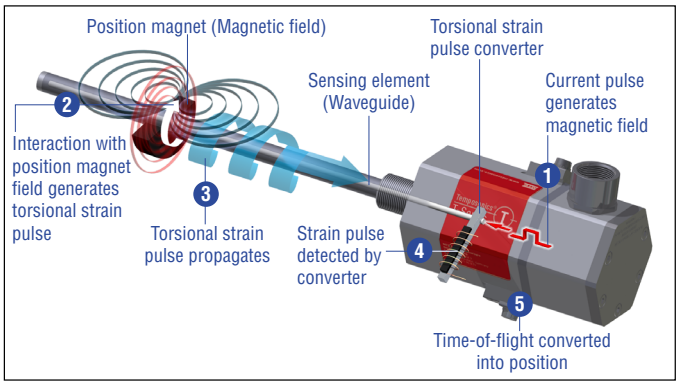


Fig. 3: Time-of-flight based magnetostrictive position sensing principle

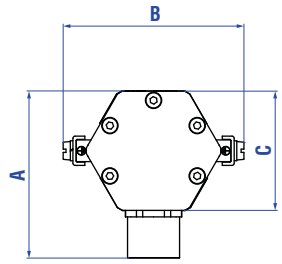
T-Series models
The T-Series is available in four variations, three of which are hazardous classifications:
- Flameproof housing with flameproof connection chamber (version D)
- Flameproof (explosionproof) housing with flameproof (explosion-proof) connection chamber (version G)
- Flameproof housing with increased safety connection chamber (version E)
- Non-hazardous (version N)

The sensor assembly is offered in 1.4305 (AISI 303) stainless steel and in 1.4404 (AISI 316L). Associated with hazardous rating the sensor meets IP66 / IP67. For non-hazardous environments the sensor meets IP66, IP67, IP68, IP69K and NEMA 4X.

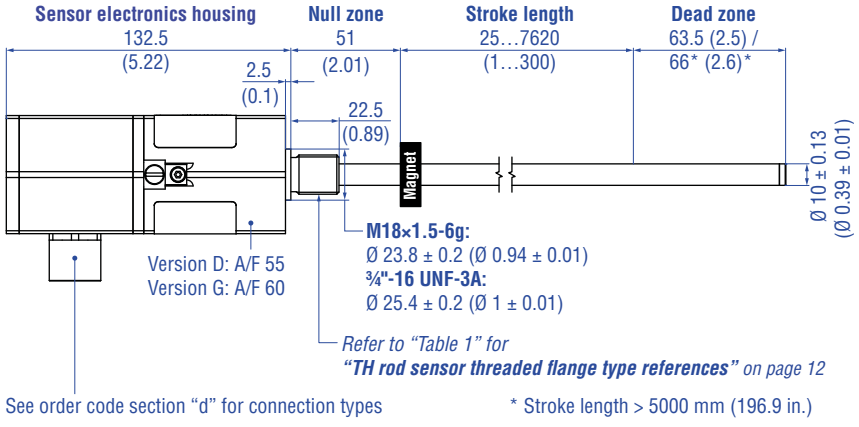
4.2 Styles and installation of Temposonics® TH

Threaded flange with raised-face

Version D & G



	Version D	Version G
A	77 (3.03)	82 (3.23)
B	83.8 (3.29)	89.2 (3.51)
C	55 (2.17)	60 (2.36)

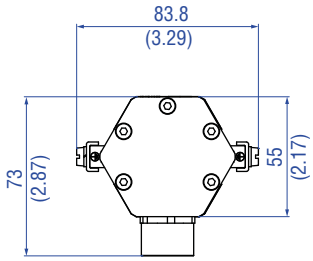


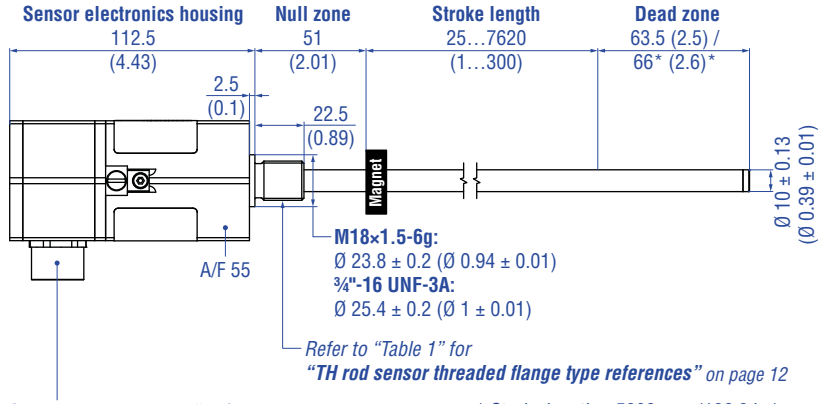
Refer to "Table 1" for ***"TH rod sensor threaded flange type references"*** *on page 12*

See order code section "d" for connection types

* Stroke length > 5000 mm (196.9 in.)

Version E & N





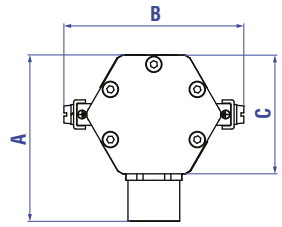
Refer to "Table 1" for ***"TH rod sensor threaded flange type references"*** *on page 12*

See order code section "d" for connection types

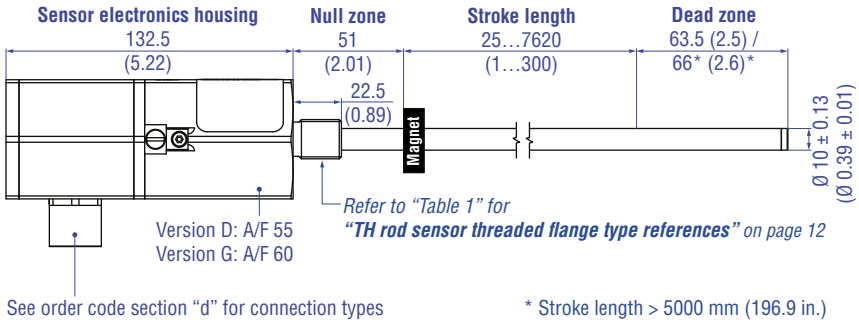
* Stroke length > 5000 mm (196.9 in.)

Threaded flange with flat-face

Version D & G



	Version D	Version G
A	77 (3.03)	82 (3.23)
B	83.8 (3.29)	89.2 (3.51)
C	55 (2.17)	60 (2.36)

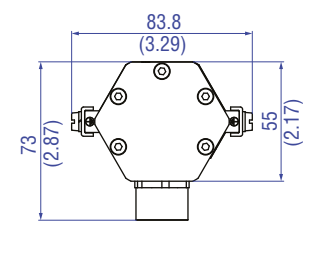


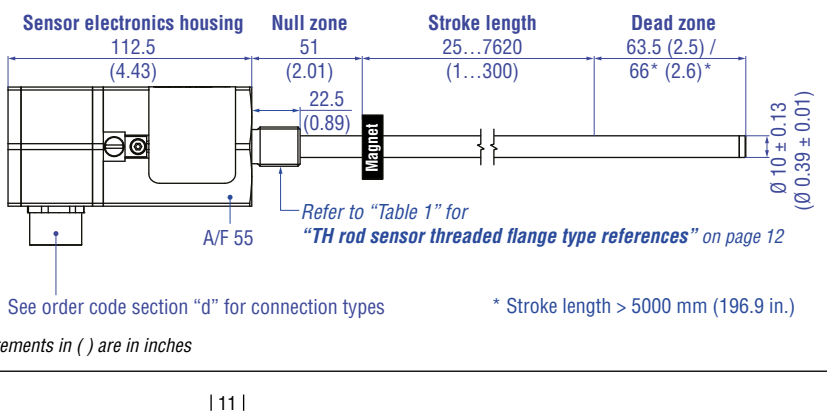
Refer to "Table 1" for ***"TH rod sensor threaded flange type references"*** *on page 12*

See order code section "d" for connection types

* Stroke length > 5000 mm (196.9 in.)

Version E & N





Refer to "Table 1" for ***"TH rod sensor threaded flange type references"*** *on page 12*

See order code section "d" for connection types

* Stroke length > 5000 mm (196.9 in.)

Controlling design dimensions are in millimeters and measurements in ( ) are in inches

Fig. 4: Temposonics® TH with ring magnet

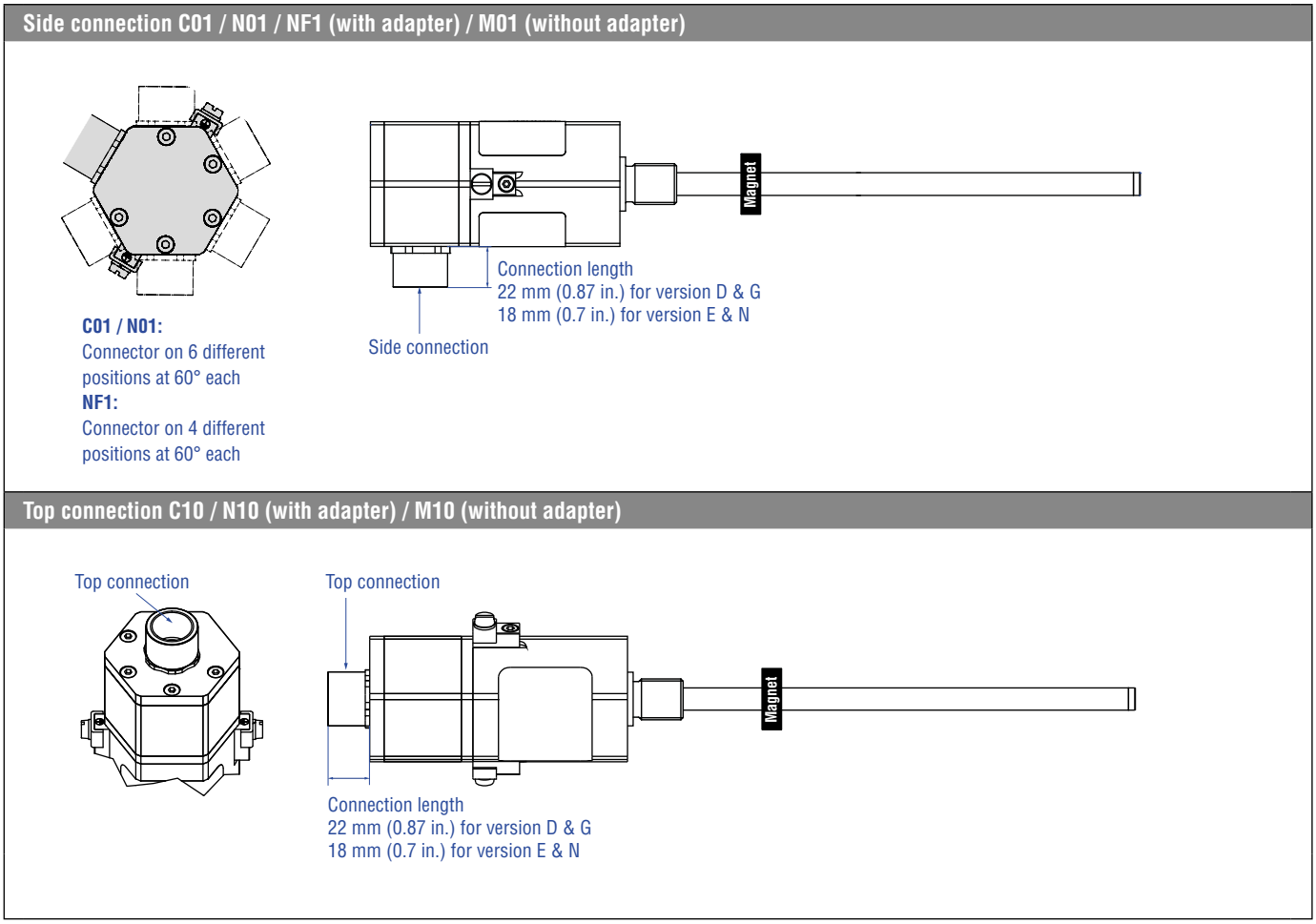
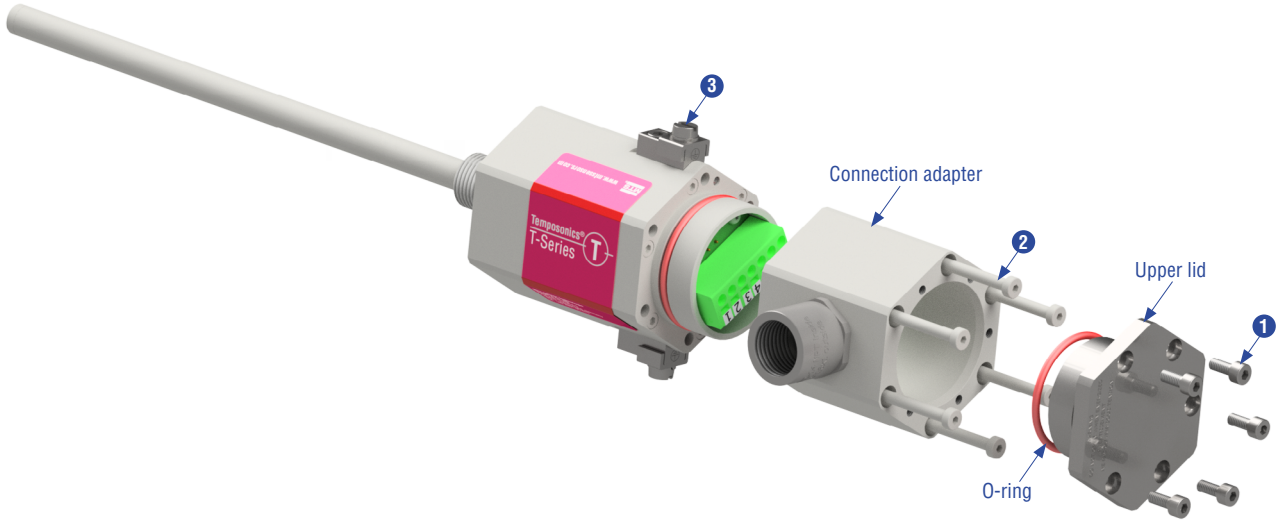


Fig. 5: Temposonics® TH connection options

Threaded flange type	Description	Threaded flange
F	Threaded flange with flat-face Stainless steel 1.4404 (AISI 316L)	¾"-16 UNF-3A
G	Threaded flange with raised-face Stainless steel 1.4404 (AISI 316L)	¾"-16 UNF-3A
M	Threaded flange with flat-face Stainless steel 1.4305 (AISI 303)	M18×1.5-6g
N	Threaded flange with raised-face Stainless steel 1.4305 (AISI 303)	M18×1.5-6g
S	Threaded flange with flat-face Stainless steel 1.4305 (AISI 303)	¾"-16 UNF-3A
T	Threaded flange with raised-face Stainless steel 1.4305 (AISI 303)	¾"-16 UNF-3A
W	Threaded flange with flat-face Stainless steel 1.4404 (AISI 316L)	M18×1.5-6g

Table 1: TH rod sensor threaded flange type references

Version D & G



Version E & N

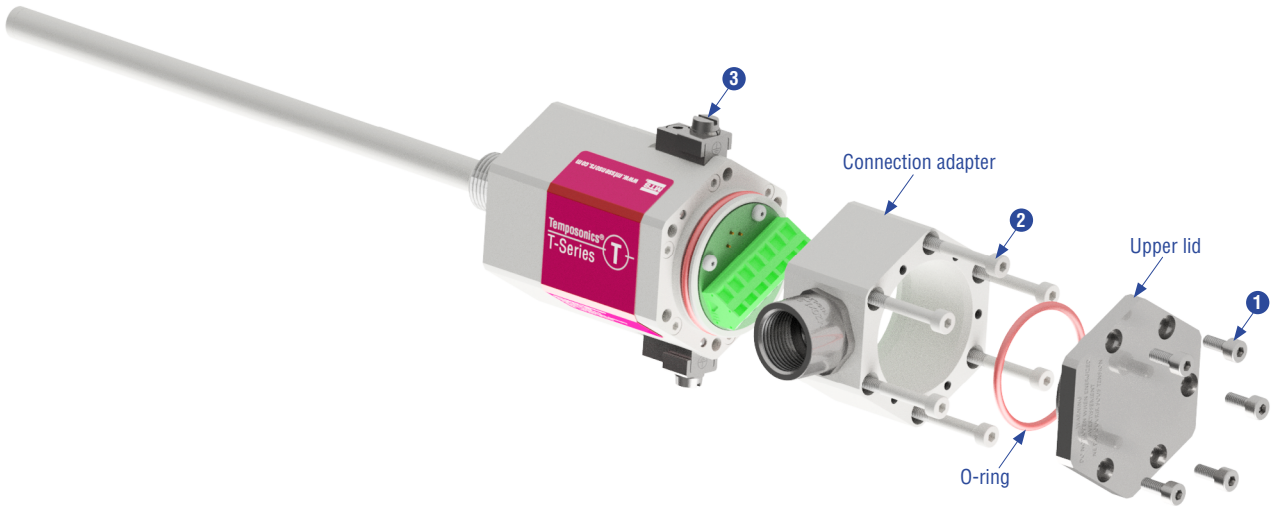


Fig. 6: Temposonics® TH exploded view drawing

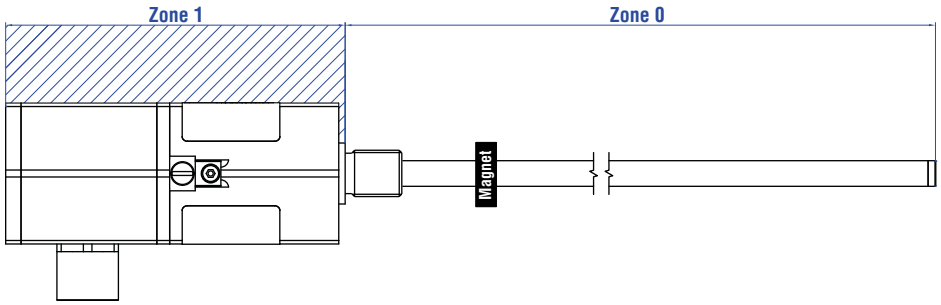
Part	Fastening torque
1 Screw M4×10	1.2 Nm
2 Screw M4×40	1.2 Nm
3 Earthing connection: M5×8 for mounting	2.5 Nm

NOTICE

Connect cable to sensor
See page 21 ff. for more details.

Change orientation of cable bushing (C01, M01, N01, NF1)
Loosen the five hexagonal screws M4 (A/F 3) and remove the upper lid (Fig. 6). Then loosen the six hexagonal screws M4 (A/F 3) of the connection adapter (Fig. 6). Change the orientation of the connector on six different positions at 60° each. Note the example on page 21 ff..

Version D & G (example: Threaded flange with raised-face)
Flameproof (explosionproof) housing with flameproof (explosionproof) connection chamber
Version D: ATEX / IECEx / KCs / EAC Ex / Japanese Approval
Version G: ATEX / IECEx / CEC / NEC / KCs / EAC Ex / Japanese Approval



Version E (example: Threaded flange with raised-face)
Flameproof housing with increased safety connection chamber
ATEX / IECEx / KCs / EAC Ex / Japanese Approval

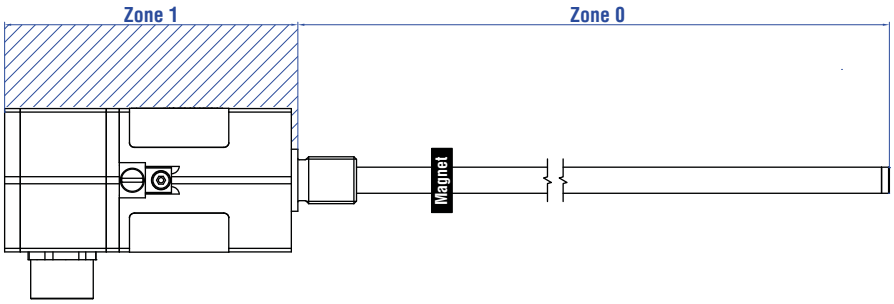


Fig. 7: Temposonics® TH Zone classification

NOTICE

Seal sensor according to ingress protection IP67 between Zone 0 and Zone 1.

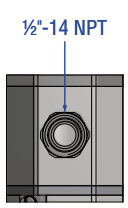
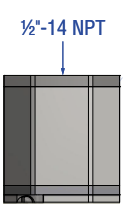
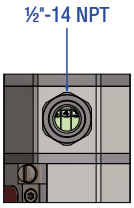
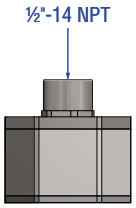
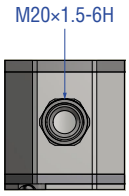
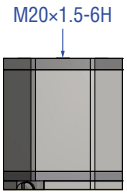
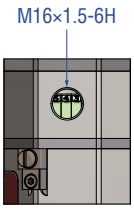
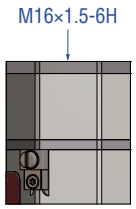
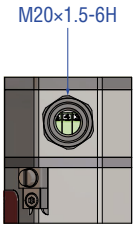
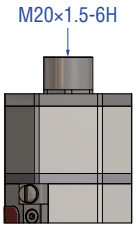
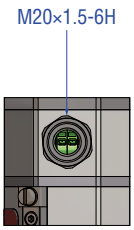
Connection options for version D & G		Connection options for version E & N	
C01	**C10**	**C01**	**C10**
 Side connection with thread ½"-14 NPT	 Top connection with thread ½"-14 NPT	 Side connection with thread ½"-14 NPT	 Top connection with thread ½"-14 NPT
N01	**N10**	**M01**	**M10**
 Side connection with thread M20×1.5-6H	 Top connection with thread M20×1.5-6H	 Side connection with thread M16×1.5-6H	 Top connection with thread M16×1.5-6H
		N01	**N10**
		 Side connection with thread M20×1.5-6H	 Top connection with thread M20×1.5-6H
		NF1	
		 Side connection with thread M20×1.5-6H	

Fig. 8: Connection options

Installation of TH with threaded flange

Fix the sensor rod via threaded flange M18×1.5-6g or ¾"-16 UNF-3A.

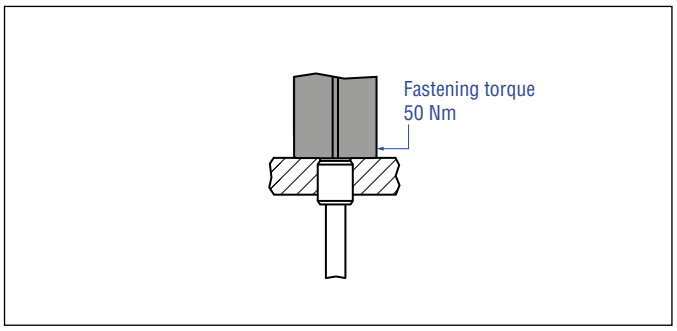


Fig. 9: Mounting example of threaded flange

In the case of threaded flange M18×1.5-6g provide a screw hole based on ISO 6149-1 (Fig. 13). See ISO 6149-1 for further information.

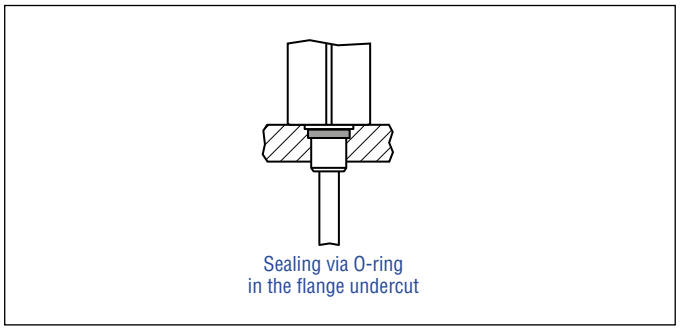


Fig. 11: Possibility of sealing for threaded flange with raised-face

Installation of a rod-style sensor in a fluid cylinder

The rod-style version has been developed for direct stroke measurement in a fluid cylinder. Mount the sensor via threaded flange or a hex nut.

- Mounted on the face of the piston, the position magnet travels over the rod without touching it and indicates the exact position through the rod wall – independent of the hydraulic fluid.
- The pressure resistant sensor rod is installed into a bore in the piston rod.

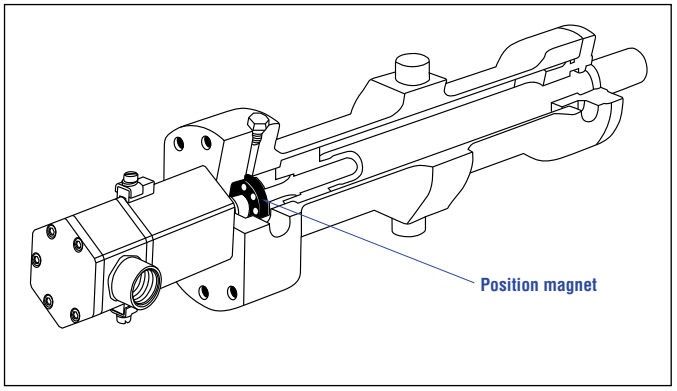


Fig. 10: Sensor in cylinder

Hydraulics sealing for threaded flange with raised-face

Seal the flange contact surface by using an O-ring in the undercut (Fig. 11):
For threaded flange (¾"-16 UNF-3A) »G« / »T«:
O-ring 16.4 × 2.2 mm (0.65 × 0.09 in.) (part no. 560 315)
For threaded flange (M18×1.5-6g) »N«:
O-ring 15.3 × 2.2 mm (0.60 × 0.09 in.) (part no. 401 133)

Hydraulics sealing for threaded flange with flat-face

There are two ways to seal the flange contact surface (Fig. 12):

1. A sealing by using an O-ring (e.g. 22.4 × 2.65 mm (0.88 × 0.1 in.), 25.07 × 2.62 mm (0.99 × 0.1 in.)) in a cylinder end cap groove.
2. A sealing by using an O-ring in the undercut.
   For threaded flange (¾"-16 UNF-3A) »F« / »S«:
   O-ring 16.4 × 2.2 mm (0.65 × 0.09 in.) (part no. 560 315)
   For threaded flange (M18×1.5-6g) »M« / »W«:
   O-ring 15.3 × 2.2 mm (0.60 × 0.09 in.) (part no. 401 133)

In the case of threaded flange M18×1.5-6g provide a screw hole based on ISO 6149-1 (Fig. 13). See ISO 6149-1 for further information.

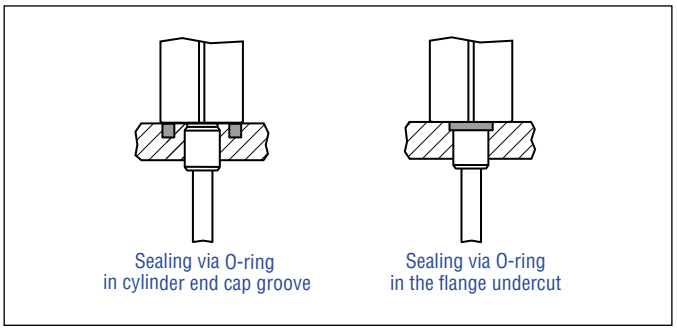
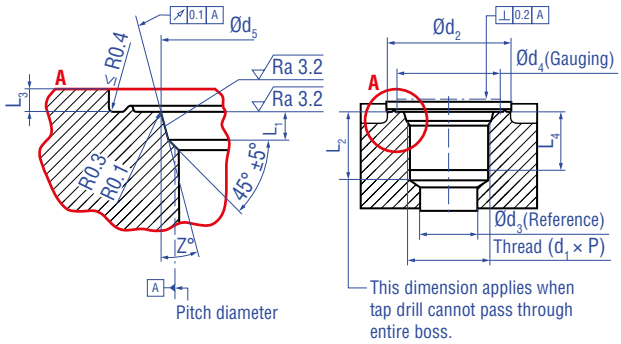


Fig. 12: Possibilities of sealing for threaded flange with flat-face

- Note the fastening torque of 50 Nm.
- Seat the flange contact surface completely on the cylinder mounting surface.
- The cylinder manufacturer determines the pressure-resistant gasket (copper gasket, O-ring, etc.).
- The position magnet should not grind on the sensor rod.
- The piston rod drilling
  (TH-F / -G / -M / -N / -S / -T / -W: ≥ Ø 13 mm (≥ Ø 0.51 in.))
  depends on the pressure and piston speed.
- Adhere to the information relating to operating pressure.
- Protect the sensor rod against wear.

Notice for metric threaded flanges

Thread (d_1×P)	d_2	d_3	d_4	d_5 +0.1 0	L_1 +0.4 0	L_2	L_3	L_4	Z° ±1°
TH-M / -N / -W									
M18×1.5-6g	65	13	24.5	19.8	2.4	28.5	2	26	15°



Controlling design dimensions are in millimeters

Fig. 13: Notice for metric threaded flange M18×1.5-6g based on DIN ISO 6149-1

4.3 Magnet installation

Typical use of magnets

Magnet	Benefits
Ring magnets	• Rotationally symmetrical magnetic field
U-magnets	• Height tolerances can be compensated, because the magnet can be lifted off
Floats	• For liquid level measurement

Fig. 14: Typical use of magnets

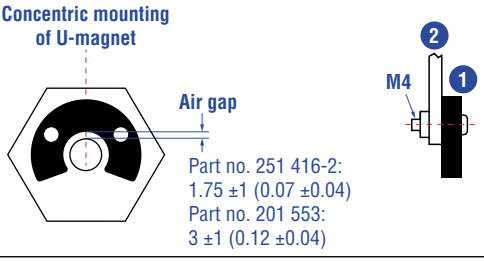
Mounting ring magnets & U-magnets

Install the magnet using non-magnetic material for mounting device, screws, spacers etc.. The magnet must not grind on the sensor rod. Alignment errors are compensated via the air gap.

- Permissible surface pressure: Max. 40 N/mm²
- Fastening torque for M4 screws: 1 Nm; use washers, if necessary
- Minimum distance between position magnet and any magnetic material has to be 15 mm (0.6 in.) (Fig. 16).
- If no other option exists and magnetic material is used, observe the specified dimensions (Fig. 16).

NOTICE

Mount ring magnets and U-magnets concentrically.
The maximum permissible air gap must not be exceeded (Fig. 15).
Take care to mount the primary sensor axis in parallel to the magnet path in order to avoid damage to the carriage, magnet and sensor rod.



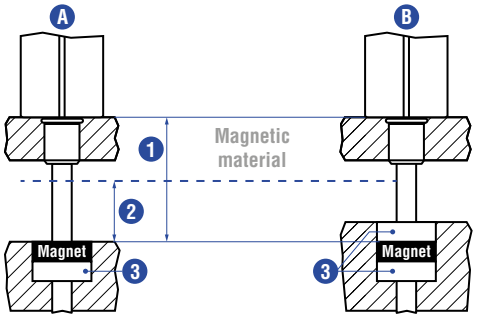
1 U-magnet
2 Non-magnetic mounting plate

Fig. 15: Mounting of U-magnet (part no. 251 416-2 or part no. 201 553)

Magnet mounting with magnetic material

When using magnetic material the dimensions of Fig. 16 must be observed.

A. If the position magnet aligns with the drilled piston rod
B. If the position magnet is set further into the drilled piston rod, install another non-magnetic spacer (e.g. part no. 400 633) above the magnet.



1 Null zone (see Fig. 18)
2 Distance between position magnet and any magnetic material (≥ 15 mm (≥ 0.6 in.))
3 Non-magnetic spacer (≥ 5 mm (≥ 0.2 in.)) – Recommendation: 8 mm (0.31 in.)

Fig. 16: Installation with magnetic material

Controlling design dimensions are in millimeters and measurements in ( ) are in inches

Sensors with stroke lengths ≥ 1 meter (3.3 ft.)

Support horizontally installed sensors with a stroke length from 1 meter (3.3 ft.) mechanically at the rod end. Without the use of a support, rod and position magnet may be damaged. A false measurement result is also possible. Longer rods require evenly distributed mechanical support over the entire length (e.g. part no. 561 481). Use an U-magnet (Fig. 17) for measurement.

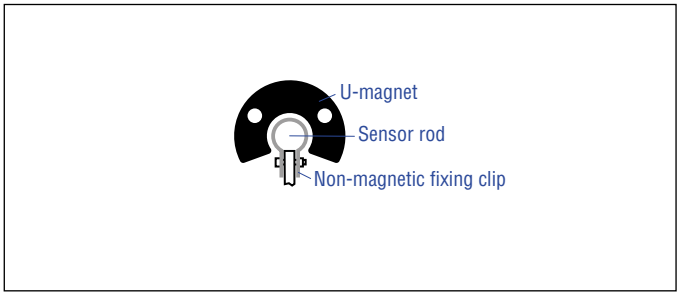


Fig. 17: Example of sensor support (part no. 561 481)

Start and end positions of the position magnets

Consider the start and end positions of the position magnets during the installation. To ensure that the entire stroke length is electrically usable, the position magnet must be mechanically mounted as follows.

TH with ring magnet / U-magnet

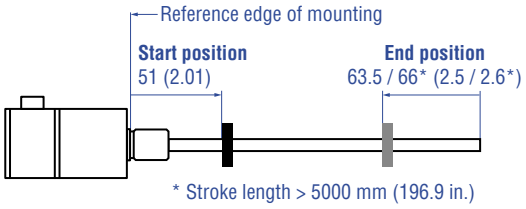


Fig. 18: Start and end positions of magnets

NOTICE

On all sensors, the areas left and right of the active stroke length are provided for null and dead zone. These zones should not be used for measurement, however the active stroke length can be exceeded.

Multi-position measurement

The minimum distance between the magnets is 75 mm (3 in.).

TH with ring magnet / U-magnet

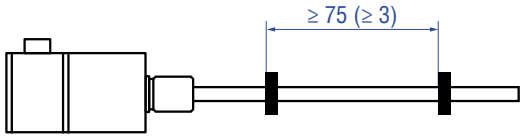


Fig. 19: Minimum distance for multi-position measurement

NOTICE

For multi-position measurement, use magnets of the same type e.g. 2 × U-magnet (part no. 251 416-2).
The minimum allowed distance between the magnets (i.e. front face of one to the front face of the next one) is 75 mm (3 in.). Contact MTS Sensors if you need a magnet distance < 75 mm (3 in.).

Mounting floats

A stop collar is ordered separately with a float. The stop collar consists of material, which is below the specific gravity of the fluid. It is designed to keep the float out of the dead zone. The placement of the stop collar is dependent on the float and placement of the magnet within the float. If your application requires measuring to the bottom of your vessel, ask MTS Sensors about our low lift-off float option.

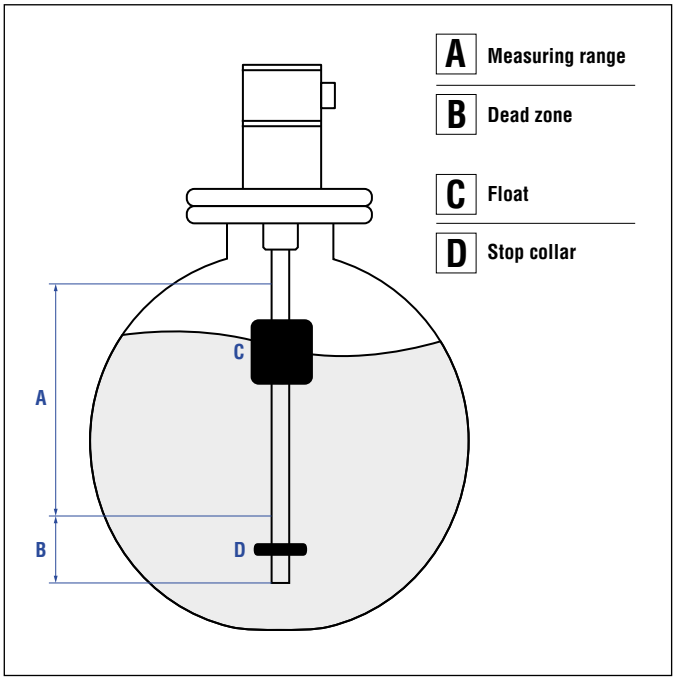


Fig. 20: Liquid level measurement

Controlling design dimensions are in millimeters and measurements in ( ) are in inches

4.4 Electrical connection

Placement of installation and cabling have decisive influence on the sensor's electromagnetic compatibility (EMC). Hence correct installation of this active electronic system and the EMC of the entire system must be ensured by using shielded cables and grounding. Overvoltages or faulty connections can damage the sensor electronics – despite protection – against wrong polarity.

NOTICE

1. Do not mount the sensors in the area of strong magnetic or electric noise fields.
2. Never connect / disconnect the sensor when voltage is applied.

Instruction for connection

- Remove the cover plate as shown in Fig. 6 on page 13 to connect the cables to the sensor.
- If you use a cable / cable gland use low-resistance twisted pair and shielded cables. Connect the shield to ground externally via the controller equipment.
- Keep control and signal leads separate from power cables and sufficiently far away from motor cables, frequency inverters, valve cables, relays, etc..
- Install a conductor of 4 mm² cross section to one of the two external ground lugs.
- Keep all non-shielded leads as short as possible.
- Keep the ground connections as short as possible with a large cross section. Avoid ground loops.
- Use only stabilized power supplies in compliance with the specified electrical ratings.

NOTICE

The contactable cross section is 0.2…2.5 mm² and 0.2…1.5 mm².
Only 1 wire per clamping point is allowed!

Grounding of rod sensors

Connect the sensor electronics housing to machine ground. Ground sensor type TH via one of the two ground lugs as shown in Fig. 21. Refer also to the information given in chapter "2.3 Installation, commissioning and operation" on page 4.

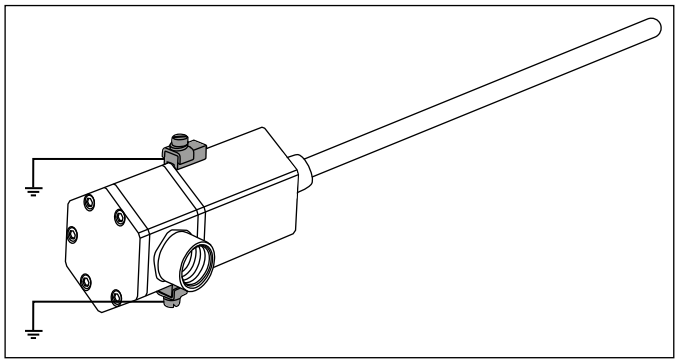


Fig. 21: Grounding via ground lug

Connector wiring

Connect the sensor directly to the control system, indicator or other evaluating systems as follows:

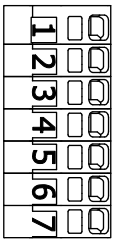
Version E & N suitable for connection types: C01, C10, M01, M10, N01, N10		
Signal + power supply		
Terminal	**Pin**	**Function**
	1	CAN_L
	2	CAN_H
	3	Not connected
	4	Not connected
	5	+24 VDC (–15 / +20 %)
	6	DC Ground (0 V)
	7	Cable shield

Fig. 22: TH (version E & N) wiring diagram (1.5 mm² conductor)

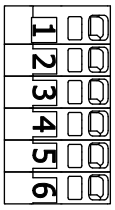
Version E & N suitable for connection type: NF1		
Signal + power supply		
Terminal	**Pin**	**Function**
	1	CAN_L
	2	CAN_H
	3	Not connected
	4	+24 VDC (–15 / +20 %)
	5	DC Ground (0 V)
	6	Cable shield

Fig. 23: TH (version E & N) wiring diagram (2.5 mm² conductor)

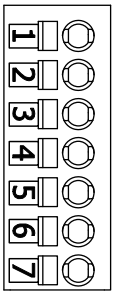
Version D & G suitable for connection types: C01, C10, N01, N10		
Signal + power supply		
Terminal	**Pin**	**Function**
	1	CAN_L
	2	CAN_H
	3	Not connected
	4	Not connected
	5	+24 VDC (–15 / +20 %)
	6	DC Ground (0 V)
	7	Cable shield

Fig. 24: TH (version D & G) wiring diagram (2.5 mm² conductor)

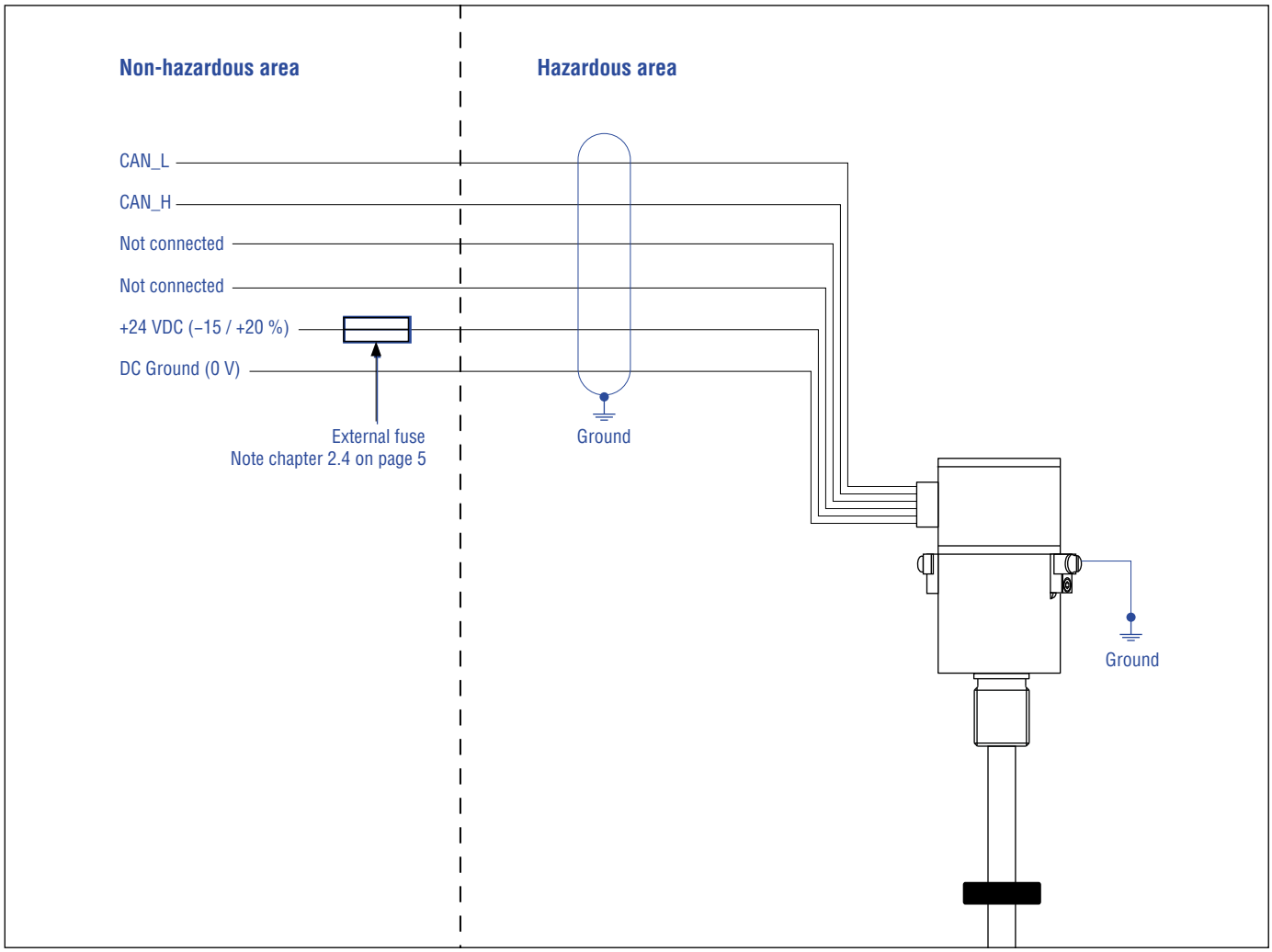


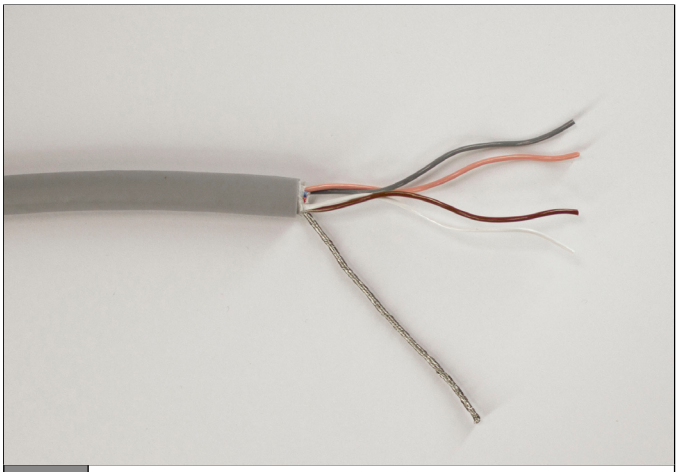
Fig. 25: Installation wiring diagram for side connection and top connection (example: Side connection)

Cable connection (only for versions E and N)

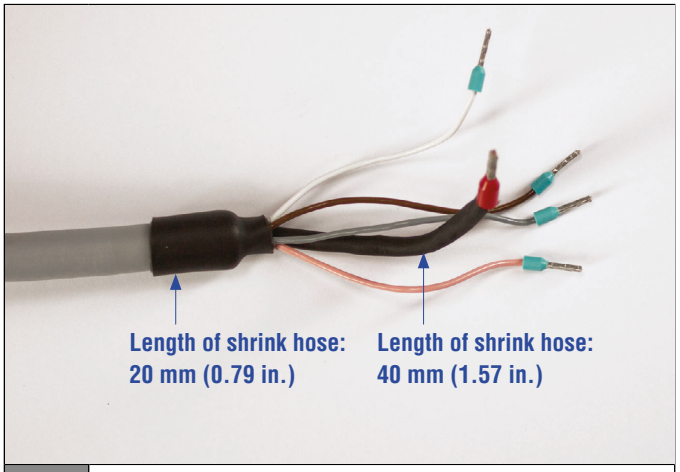
Recommended tools

			
Electric torque screwdriver	**Torque wrench**	**Slotted screwdriver**	**Crimping tool**
3 mm (0.12 in.), fastening torque 1.2 Nm	Torque depending on cable gland	2.0 × 40 mm (0.08 × 1.57 in.)	For ferrules with max. 2.5 mm²

Step 1: Preparing of cable



1 Strip the cable for approx. 60 mm (2.36 in.).



2 Install the shrink hose and the ferrules (max. 1.5 mm² or max. 2.5 mm² depending on connection).

The following two options present how to connect the cable to the T-Series sensor:

Option 1: Cable connection via disassembly of connection adapter (see page 22)
Option 2: Cable connection without disassembly of connection adapter (see page 23)

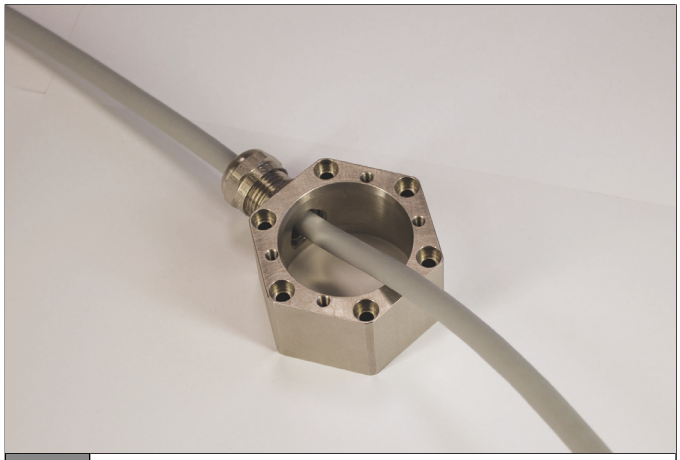
NOTICE

The example “Cable connection” is only valid for versions E and N of the TH sensor. Refer to the corresponding installation requirements and local regulations, if you like to connect a cable to the TH sensor versions D and G.

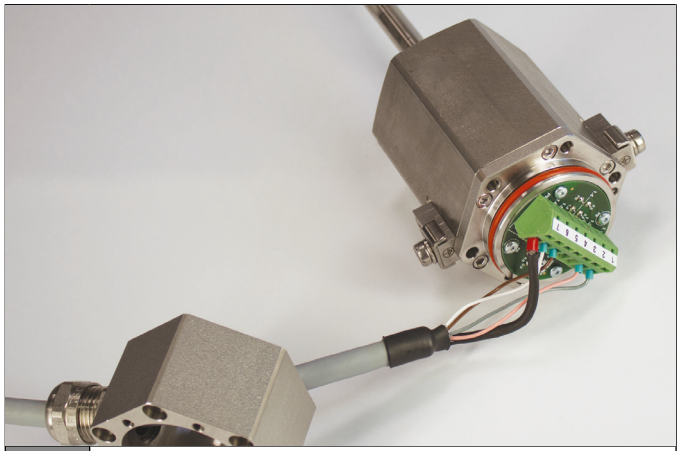
The figures are examples.
Variations are possible, e.g. different cable colors

Step 2: Cable connection (Option 1: Disassembly of connection adapter)

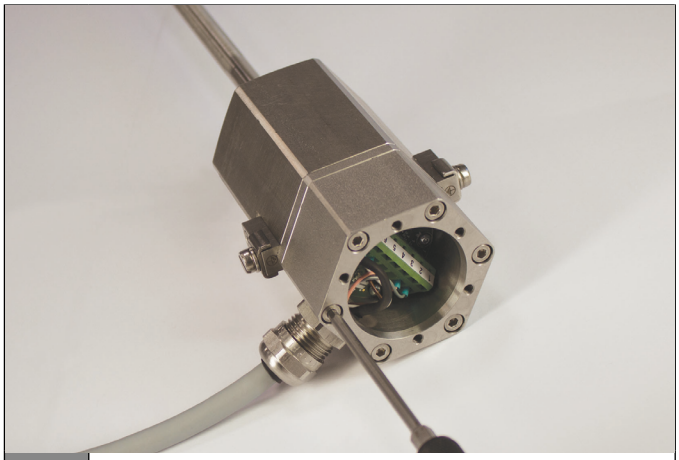
1	Loosen the five M4×10 screws (A/F 3). Remove the upper lid. Loosen the six M4×40 screws (A/F 3) of the connection adapter. Remove the connection adapter. See also Fig. 6.



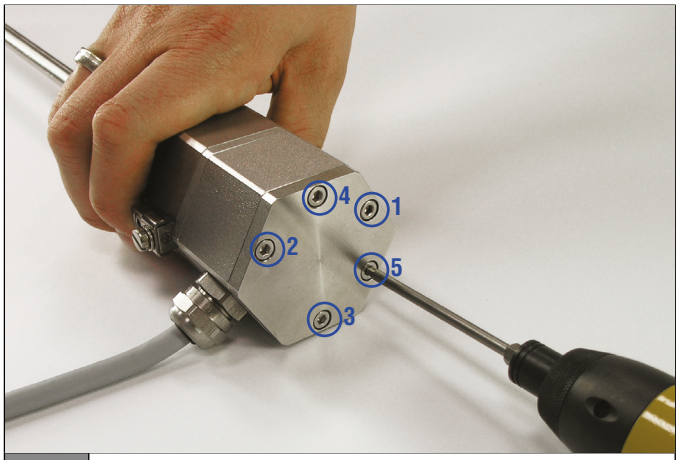
2	Mount the cable gland at the connection adapter. Note the instructions given by the manufacturer of the cable gland!



3	Connect the cable to the sensor. Note the connection wiring on page 19.



4	Inspect surfaces and O-ring for damage. Wipe surfaces clean and apply O-ring lube. Tighten the screws of the connection adapter with a fastening torque of 1.2 Nm.



5	Inspect surfaces and O-ring for damage. Wipe surfaces clean and apply O-ring lube. Check the position of O-ring between upper lid and connection adapter. Tighten the screws of the upper lid crosswise with a fastening torque of 1.2 Nm (see figure for right sequence).

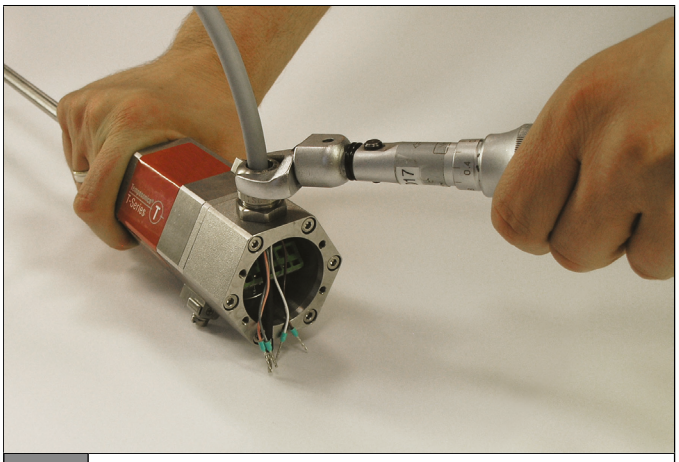
NOTICE

The example “Cable connection” is only valid for versions E and N of the TH sensor. Refer to the corresponding installation requirements and local regulations, if you like to connect a cable to the TH sensor versions D and G.

The figures are examples.
Variations are possible, e.g. different cable colors

Step 2: Cable connection (Option 2: Without disassembly of connection adapter)

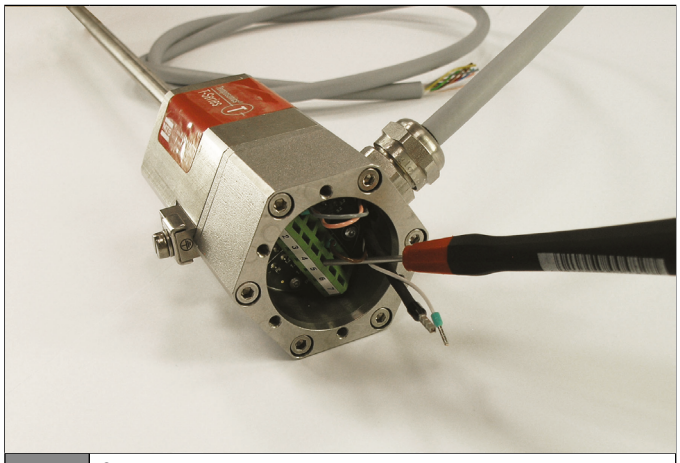
1 Loosen the five M4×10 screws (A/F 3).



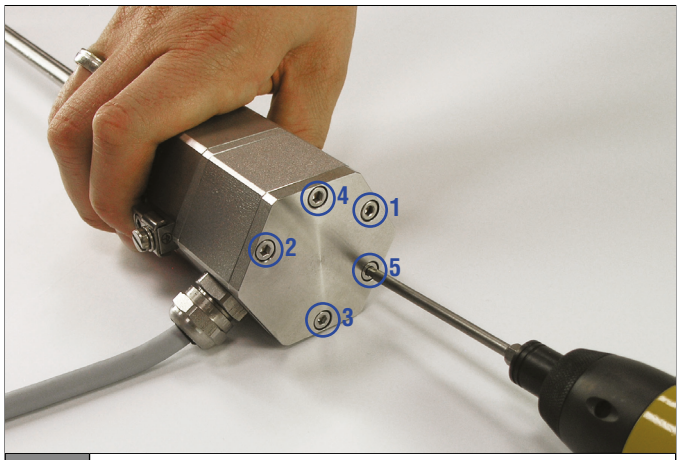
2 Mount the cable and cable gland. Note the instructions given by the manufacturer of the cable gland!

NOTICE

The example “Cable connection” is only valid for versions E and N of the TH sensor. Refer to the corresponding installation requirements and local regulations, if you like to connect a cable to the TH sensor versions D and G.



3 Connect the cable to the sensor.
Note the connection wiring on page 19.

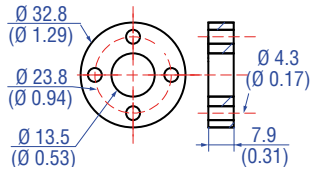


4 Inspect surfaces and O-ring for damage. Wipe surfaces clean and apply O-ring lube. Check the position of O-ring between upper lid and connection adapter.
Tighten the screws of the upper lid crosswise with a fastening torque of 1.2 Nm (see figure for right sequence).

The figures are examples.
Variations are possible, e.g. different cable colors

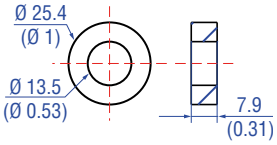
4.5 Frequently ordered accessories – Additional options available in our Accessories Guide 551444

Position magnets



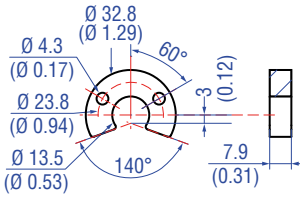
Ring magnet OD33
Part no. 201 542-2

Material: PA ferrite GF20
Weight: Approx. 14 g
Surface pressure: Max. 40 N/mm²
Fastening torque for M4 screws: 1 Nm
Operating temperature:
–40…+105 °C (–40…+221 °F)



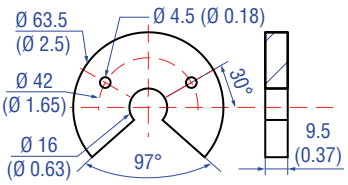
Ring magnet OD25.4
Part no. 400 533

Material: PA ferrite
Weight: Approx. 10 g
Surface pressure: Max. 40 N/mm²
Operating temperature:
–40…+105 °C (–40…+221 °F)



U-magnet OD33
Part no. 251 416-2

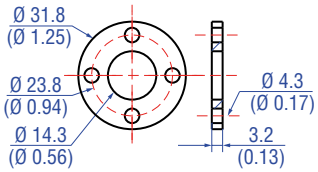
Material: PA ferrite GF20
Weight: Approx. 11 g
Surface pressure: Max. 40 N/mm²
Fastening torque for M4 screws: 1 Nm
Operating temperature:
–40…+105 °C (–40…+221 °F)



U-magnet OD63.5
Part no. 201 553

Material: PA 66-GF30,
magnets compound-filled
Weight: Approx. 26 g
Surface pressure: 20 N/mm²
Fastening torque for M4 screws: 1 Nm
Operating temperature:
–40…+75 °C (–40…+167 °F)

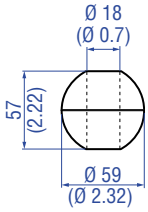
Magnet spacer



Magnet spacer
Part no. 400 633

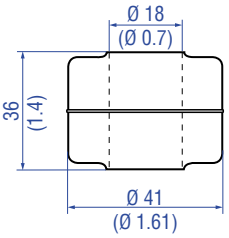
Material: Aluminum
Weight: Approx. 5 g
Surface pressure: Max. 20 N/mm²
Fastening torque for M4 screws: 1 Nm

Floats [5]



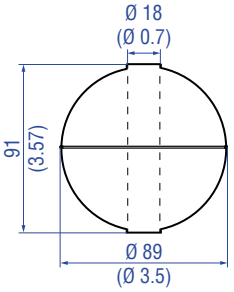
Float
Part no. 251 387-2

Material: Stainless steel (AISI 316L)
Weight offset: Yes
Pressure: 22.4 bar (325 psi)
Magnet offset: No
Specific gravity: Max. 0.48
Operating temperature:
–40…+125 °C (–40…+257 °F)



Float
Part no. 200 938-2

Material: Stainless steel (AISI 316L)
Weight offset: Yes
Pressure: 8.6 bar (125 psi)
Magnet offset: No
Specific gravity: Max. 0.74
Operating temperature:
–40…+125 °C (–40…+257 °F)



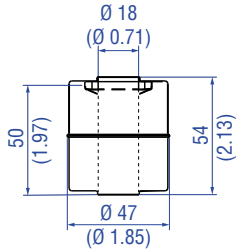
Float
Part no. 251 469-2

Material: Stainless steel (AISI 316L)
Weight offset: Yes
Pressure: 29.3 bar (425 psi)
Magnet offset: No
Specific gravity: Max. 0.45
Operating temperature:
–40…+125 °C (–40…+257 °F)

Controlling design dimensions are in millimeters and measurements in ( ) are in inches

5/ • Be sure that the float specific gravity is at least 0.05 less than that of the measured liquid as a safety margin at ambient temperature
• For interface measurement: A minimum of 0.05 specific gravity differential is required between the upper and lower liquids
• When the magnet is not shown, the magnet is positioned at the center line of float
• An offset weight is installed in the float to bias or tilt the float installed on the sensor tube. So the float remains in contact with the sensor tube at all times and guarantees permanent potential equalization of the float. The offset is required for installations that must conform to hazardous location standards

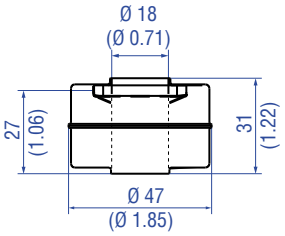
Floats [6]



Float
Part no. 201 605-2

Material: Stainless steel 1.4571
(AISI 316 Ti)
Weight offset: Yes
Pressure: 4 bar (60 psi)
Magnet offset: Yes
Specific gravity: Max. 0.6
Operating temperature:
–40…+125 °C (–40…+257 °F)

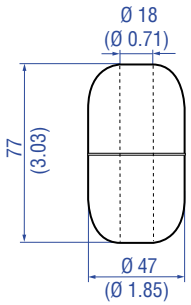
Standard float that can be expedited



Float
Part no. 201 606-2

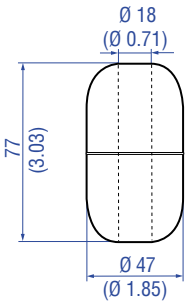
Material: Stainless steel 1.4571
(AISI 316 Ti)
Weight offset: Yes
Pressure: 4 bar (60 psi)
Magnet offset: Yes
Specific gravity: 0.93 ± 0.01
Operating temperature:
–40…+125 °C (–40…+257 °F)

Standard float that can be expedited



Float
Part no. 251 982-2

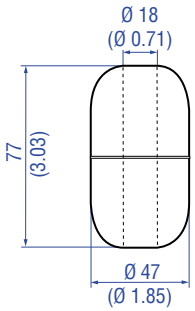
Material: Stainless steel (AISI 316L)
Weight offset: Yes
Pressure: 29.3 bar (425 psi)
Magnet offset: No
Specific gravity: 0.93 ± 0.01
Operating temperature:
–40…+125 °C (–40…+257 °F)



Float
Part no. 251 983-2

Material: Stainless steel (AISI 316L)
Weight offset: Yes
Pressure: 29.3 bar (425 psi)
Magnet offset: No
Specific gravity: 1.06 ± 0.01
Operating temperature:
–40…+125 °C (–40…+257 °F)

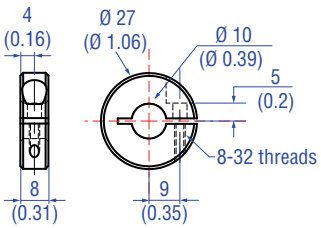
Float [6]



Float
Part no. 251 981-2

Material: Stainless steel (AISI 316L)
Weight offset: Yes
Pressure: 29.3 bar (425 psi)
Magnet offset: No
Specific gravity: Max. 0.67
Operating temperature:
–40…+125 °C (–40…+257 °F)

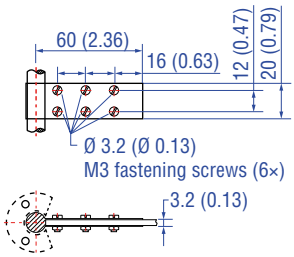
Collar



Stop collar
Part no. 560 777

Provides end of stroke stops for float
Material: Stainless steel 1.4301
(AISI 304)
Weight: Approx. 30 g
Hex key $^{7}/_{64}$" required

Optional installation hardware



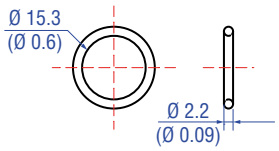
Fixing clip
Part no. 561 481

Application: Used to secure sensor rods (Ø 10 mm (Ø 0.39 in.)) when using an U-magnet or block magnet
Material: Brass, non-magnetic

Controlling design dimensions are in millimeters and measurements in ( ) are in inches

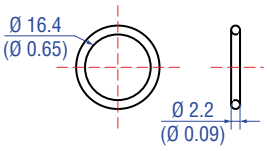
6/ • Be sure that the float specific gravity is at least 0.05 less than that of the measured liquid as a safety margin at ambient temperature
• For interface measurement: A minimum of 0.05 specific gravity differential is required between the upper and lower liquids
• When the magnet is not shown, the magnet is positioned at the center line of float
• An offset weight is installed in the float to bias or tilt the float installed on the sensor tube. So the float remains in contact with the sensor tube at all times and guarantees permanent potential equalization of the float. The offset is required for installations that must conform to hazardous location standards

O-rings



O-ring for threaded flange
M18×1.5-6g
Part no. 401 133

Material: Fluoroelastomer
Durometer: 75 ± 5 Shore A
Operating temperature:
–40…+204 °C (–40…+400 °F)



O-ring for threaded flange
¾"-16 UNF-3A
Part no. 560 315

Material: Fluoroelastomer
Durometer: 75 ± 5 Shore A
Operating temperature:
–40…+204 °C (–40…+400 °F)

Controlling design dimensions are in millimeters and measurements in ( ) are in inches

5. Operation

5.1 Getting started

The sensor is factory-set to its order sizes.

NOTICE

Observe during commissioning

1. Before initial switch-on, check carefully if the sensor has been connected correctly.
2. Position the magnet in the measuring range of the sensor during first commissioning and after replacement of the magnet.
3. Ensure that the sensor control system cannot react in an uncontrolled way when switching on.
4. Ensure that the sensor is ready and in operation mode after switching on.
5. Check the pre-set start and end positions of the measuring range (see Fig. 18) and correct them via the customer's control system, if necessary.

CANopen bus interface
CANbus (Controller Area Network) is designed for high-speed data exchange at machine level. CAN is a vendor independent open fieldbus system, based on standard ISO 11898. CAN specifies the functional and technical parameters with which the intelligent digital automation devices can be networked via a master-slave serial link by using a communication profile. Protocol architecture of functional and applications data is oriented to the ISO reference model (ISO 7498). Bus technology is administrated and developed by the user organisation CiA (CAN in Automation).

5.2 Encoder functionality system description

Temposonics® sensors are linear transducers and are suitable for a CANopen protocol network. That is a CAN based higher layer protocol. The sensor can be used as a CANbus slave in networks with the CANopen data protocol (CiA Standard DS 301 V3.0), the encoder profile DS 406 V3.1 and the LSS Service DS 305 V2.1.1. The sensor is performing Class C2 functionality.

Network Management (NMT) – Slave
The NMT state machine defines the communication behavior of the CANopen device.

Layer Setting Services (LSS) DS 305
Layer Setting Services (LSS) are used in order to configure the sensor in terms of node-ID and / or the baud rate. The sensor can be switched to LSS configuration mode either globally or selectively.

Service Data Object (SDO)
SDO messages are used for reading and writing access to all entries of the object dictionary. SDOs are used for device configuration in the first place.

Identity objects
An identity object includes vendor-ID, product code, revision number and serial number.

Variable Process Data Object (PDO) mapping
The real-time data transfer of position, velocity and limit switch states is performed by PDO messages. Data is transmitted within four TPDO's (transmit PDO) and each with a maximum 8 byte wide data block. Variable PDO mapping can be configured via SDO messages.

Special Function Object (SFO) sync object
The sync object is broadcasted periodically by the synchronisation device to all application devices. Synchronous PDOs will be transmitted to the controller after receiving the sync message.

Emergency message (EMCY)
Emergency messages are triggered by the occurrence of a device internal fatal error situation and are transmitted from the application device concerned to the other devices with highest priority.
This makes them suitable for interrupting type error alerts.

Node guarding
The node guarding is used to monitor the whole network state.
The node guarding is sent cyclically to detect the sensor that the controller works well. On a missing node guarding (i.e. controller stopped) the sensor can automatically stop PDO data transmission to reduce the busload.

Heartbeat function
Instead of the node-guarding the heartbeat-function can be used.
The Producer-Heartbeat-Time defines the time frame in which a new heartbeat message is sent.

Event timer
The event timer defines the asynchronous transmission period for PDOs.

Encoder profile DS 406
The encoder profile DS 406 consists of:
- Up to four work areas with upper and lower limits and corresponding status register
- Up to four cam switches with upper or lower threshold level and status register.

CANbus connection
The CANopen encoders are equipped with a bus trunk line in various lengths and can be terminated in the device. If possible, drop lines should be avoided, as in principle they lead to signal reflections. As a rule the reflections caused by the drop lines are not critical, if they have completely decayed before the point in time when the scanning occurs.

5.3 Encoder installations configuration of node parameters

LSS address
Each sensor (node) in the CAN network is defined unique by the LSS address. This address consists of:
Vendor-ID: 0x40
Product code: 0x43333034 (C304)
Revision no.: 0x00010005
Serial no.: 17143876

CANbus specific parameters like baud rate and node address (node-ID) can be configured and recorded by LSS service routines.

Configure baud rate
The maximum baud rate depends on the cable length of the total CAN network. The sensor is shipped with an order dependent baud rate, as printed on the sensor label. If necessary, the baud rate can be changed via LSS service.

NOTICE

Program the baud rates according to the LSS protocol.
Note the parameters given in Table 2.

Cable length	Baud rate
< 25 m (82 ft.)	1000 kBit/s
< 50 m (164 ft.)	800 kBit/s
< 100 m (328 ft.)	500 kBit/s
< 250 m (820 ft.)	250 kBit/s

Table 2: Baud rate according to cable length (see CiA DS 301)

Configure node-ID
Each node gets a node identifier (node-ID) for identification in a CANopen network. Each node-ID can be assigned only once in a CAN network. Valid node-IDs range is from 1…127, with 127 being the default setting on delivery.

Configure bus termination
The internal bus termination resistor (120 Ω) can be switched on by writing “1” to object 2101 sub-index 0 and off by writing “0”.

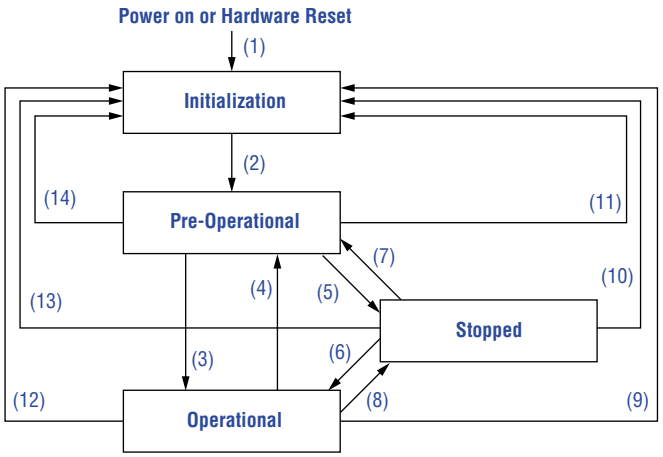
EDS (Electronic Data Sheet) file
The EDS file is the standardized format for the description of devices. It contains information about:
- File properties (name, version, release date,…)
- General device information (manufacturer name and code)
- Device name and type, version, LSS address
- Supported baud rates and boot-up options
- Description of supported objects and attributes

5.4 Configuration of process parameters

The sensor starts up using the parameters stored in its internal EEPROM; the user can change and/or permanently store settings using SDO uploads as desired. Be aware that in case the node-ID is changed using LSS, the identifiers for PDOs etc. will be changed accordingly. The sensors implement the encoder communication profile “Device Profile for Encoder – DS 406 V3.1”. In the following object dictionary the programming of the operating parameters is described.

5.5 CANopen Network Management (NMT)

The following description is part of the CANopen communication profile DS 301.



(1)	After power on or hardware reset the initialization state is entered autonomously
(2)	Initialization finished – enter pre-operational automatically
(3), (6)	Start remote node indication
(4), (7)	Enter pre-operational state indication
(5), (8)	Stop remote node indication
(9), (10), (11)	Reset node indication
(12), (13), (14)	Reset communication indication

Fig. 26: CANopen state machine

COB-ID	Request / Respond	DLC	Data D0	Data D1	Description
0x000	Rx	2	**Command**	**Address**	
			0x01		**Start remote node (3), (6):** Through this service the NMT master sets the state of the selected NMT slave(s) to “operational”.
			0x02		**Stop remote node (5), (8):** Through this service the NMT master sets the state of the selected NMT slave(s) to “stopped”.
			0x80		**Enter pre-operational state (4), (7):** Through this service the NMT master sets the state of the selected NMT slave(s) to “pre-operational”.
			0x81		**Reset node (9), (10), (11):** Through this service the NMT master sets the state of the selected NMT slave(s) from any state to the “reset application” sub-state.
			0x82		**Reset communication (12), (13), (14):** Through this service the NMT master sets the state of the selected NMT slave(s) from any state to the “reset communication” sub-state. After completion of the service, the state of the selected remote nodes will reset communication.
				0x00	Set 0x00 for all devices (global mode)
				Node-ID	Set node-ID (0x01…0x7F) for a specific device

Table 3: Description of NMT commands

Network initialization
When powering the sensor after a Network Management (NMT) reset command (chapter 5.5) or after an internal reset, the sensor automatically enters the NMT initialization state. In this state the sensor loads all parameters from the non-volatile memory into the RAM. The sensor performs several test functions and configuration tasks. In this state there is no communication with the sensor. After finishing the NMT initialization state the sensor automatically enters the NMT pre-operational state.

Network pre-operational state
In the pre-operational state communication via SDOs (chapter 5.7) is possible, while (PDO) communication is not allowed. Configuration of PDOs and device parameters may be performed. Also the emergency objects and error control service like the CANopen sensors “heartbeat message” occur in this state. The node will be switched into the operational state directly by sending a NMT “start remote node” (3) (Fig. 26).

Network operational state
In the operational state all communication objects – including PDO handling – are active. Object dictionary access via SDO is possible.

Network stopped state
By switching a device into the stopped state it is forced to stop the communication, except node guarding and heartbeat, if active.

5.6 Configuration

The complete configuration of the T-Series CANbus sensor is done through the CANbus interface.

5.6.1 Layer Setting Service (LSS)

Every CAN device must have an unique node identifier in the CAN network.
The node-ID and the baud rate can be programmed by using the LSS protocol DS 305 published by the CiA.

To program the node-ID and/or the baud rate the T-Series CAN sensor has to be changed to the LSS configuration state.

COB-ID	Request / Respond	DLC	Data								Description
			D0	D1	D2	D3	D4	D5	D6	D7	
0x7E5	Rx	8	**Entry**	**Index**	0x00	0x00	0x00	0x00	0x00	0x00	
			0x04	0x01							Configuration mode *(without confirmation)*
				0x00							Normal mode *(without confirmation)*
			0x11	0x01…0x7F							Set node-ID (1…127)
			0x13	0x00	0x00						Set baud rate 1000 kbit/s
				0x00	0x01						Set baud rate 800 kbit/s
				0x00	0x02						Set baud rate 500 kbit/s
				0x00	0x03						Set baud rate 250 kbit/s
				0x00	0x04						Set baud rate 125 kbit/s
			0x15	Switch delay							Activate bit timing parameter Switch delay: Timing in ms internal multiplied by 2 when the new bit timing parameters become active.
			0x17								Store configuration in EEPROM
			0x40								Vendor-ID
			0x41								Product code
			0x42								Revision number
			0x43								Serial number
			0x5A								Inquire identity vendor-ID
			0x5B								Inquire identity product code
			0x5C								Inquire identity revision number
			0x5D								Inquire identity serial number
			0x5E								Inquire node-ID
0x7E4	Tx	8	**Entry**	**Status**	0x00	0x00	0x00	0x00	0x00	0x00	
			0x11	0							Protocol successfully completed
			0x11	1							Node-ID out of range
			0x13	0							Protocol successfully completed
			0x13	1							Bit timing not supported
			0x17	0							Protocol successfully completed
			0x17	2							Storage media access error

Table 4: LSS commands and options

Example: How to configure a new node-ID

COB-ID	Request / Respond	DLC	Byte								Description
			0	1	2	3	4	5	6	7	
0x7E5	Rx	8	0x04	0x01							Configuration mode global
0x7E5	Rx	8	0x11	0x7F							Configure new node-ID 0x7F (127)
0x7E4	Tx	8	0x11								Protocol successfully completed
0x7E5	Rx	8	0x17								Store configuration EEPROM
0x7E4	Tx	8	0x17								Protocol successfully completed
0x7E5	Rx	8	0x04								Waiting state / Normal mode
0x000	Rx	2	0x81								NMT reset node-ID

Example: How to read a node-ID

0x7E5	Rx	8	0x04	0x01							Configuration mode global
0x7E5	Rx	8	0x5E								Inquire node-ID
0x7E4	Tx	8	0x5E	0x7F							Node-ID: 0x7F (127)

Example 1: Configuration of node-ID

NOTICE

The new node-ID will get active after a reset of the sensor. Furthermore the following COB-IDs will be automatically updated according to the pre-defined connection set of the #2 DS 301:

- DO(Tx);
- SDO(Rx);
- Emergency;
- Error control;
- PDO1(Tx)

Example: Configurate the baud rate to 500 kbit/s

COB-ID	Request / Respond	DLC	Byte								Description
			0	1	2	3	4	5	6	7	
0x000	Rx	2	0x80	0x7F							Enter pre-operational state (node-ID 127)
0x7E5	Rx	8	0x04	0x01							Configuration mode (global) *(without confirmation)*
0x7E5	Rx	8	0x13	0x00	0x02						Set baud rate 500 kbit/s
0x7E4	Tx	8	0x13								Protocol successfully completed
0x7E5	Rx	8	0x17								Store configuration in EEPROM
0x7E4	Tx	8	0x17								Protocol successfully completed
0x7E5	Rx	8	0x04	0x00							Normal mode *(without confirmation)*

Example 2: Configurate the baud rate to 500 kbit/s

NOTICE

The baud rate will get active after receiving the “activate bit timing parameters” command or after the “store configuration data” command with the next power on / reset.

Emergency messages (EMCY)

Emergency objects are triggered by the incident of a CANopen device internal error situation and are transmitted onto the network.
Emergency objects are suitable for error alerts. An emergency object is transmitted only once per event.
After starting the system (Power-on / reset) the sensor will transmit an emergency object without reasonable data (power-on message).
This just indicates that the device is present in the network. Emergency objects go along with changes of the internal error status register.
An emergency object consists of 8 data bytes and is built like shown (Table 5).

COB-ID	Request / Respond	DLC	Byte								Description
			0	1	2	3	4	5	6	7	
0x080 + Node-ID	Tx	8	**Error code**		**Register**	Manufacturer specific error field					
			0x0000								Error reset or no error
			0x3100								Main voltage (generic)
			0x5000								CANopen device hardware – generic error
			0x6300								Data set (generic)
			0x8100								Communication (generic)
			0x8110								CAN overrun (objects lost)
			0x8120								CAN in error or heartbeat error
			0x8130								Life guarding error or heartbeat error
			0x8140								Recovered from bus off
			0x8150								CAN ID collision
			0x8210								PDO not processed due to length error

Table 5: Error codes

Register

Bit								Hex	Description
7	6	5	4	3	2	1	0		
Manufacturer specific	**Reserved**	**Device profile specific**	**Communication error**	**Temperature**	**Voltage**	**Current**	**Generic error**		
0	0	0	0	0	0	0	0	0x00	No error
0	0	0	1	0	0	0	1	0x11	Communication error
0	0	0	0	0	1	0	1	0x05	Main voltage error
1	0	0	0	0	0	0	1	0x81	Transducer error

Table 6: Error code register

NOTICE

The emergency message error register is equal to the content of register 1001.

Example

COB-ID	Request / Respond	DLC	Byte								Description
			0	1	2	3	4	5	6	7	
0x080 + Node-ID	Tx	8	0x00	0x31	0x05						Main operating voltage error (generic)

Example 3: Emergency message for voltage error

5.6.2 Error control service

Through error control services the NMT detects failures in a CAN based network.
When the error control service is enabled the T-Series CANbus sensor transmits a heartbeat message cyclically.
One or more heartbeat consumers receive the indication. The relationship between producer and consumer is configurable via the object dictionary by SDOs. By default the heartbeat is disabled.
The data byte of the heartbeat message contains the current network management state of the T-Series CAN sensor.
Consider the change of the node-ID takes place after a restart of the device or “immediately”.

COB-ID	Request / Respond	DLC	Byte	Description
			0	
0x700 + Node-ID	Tx	1	**State**	
			0x00	Boot up
			0x04	Stopped
			0x05	Operational
			0x7F	Pre-operational

Table 7: Heartbeat message

5.7 Programming parameter

5.7.1 SDO download

The SDO download service is used to configure the communication, device and manufacturer specific parameters of the T-Series CANbus sensor.

COB-ID	Request / Respond	DLC	Data							
			D0	D1	D2	D3	D4	D5	D6	D7
0x600 + Node-ID	Rx	8	0x2x	Index		Sub-index	Data LSB	Data	Data	Data MSB
0x580 + Node-ID	Tx	8	0x60	Index		Sub-index	0x00	0x00	0x00	0x00

Table 8: SDO download and sensor response

D0	Description
0x22	Write bytes without explicit length specification
0x23	Write 4 bytes
0x2B	Write 2 bytes
0x2F	Write 1 byte

Table 9: Explanation of the command byte “D0”

5.7.2 SDO upload

The SDO upload service is used to read the communication, device and manufacturer specific parameters of the T-Series CANbus sensor.

COB-ID	Request / Respond	DLC	Data							
			D0	D1	D2	D3	D4	D5	D6	D7
0x600 + Node-ID	Rx	8	0x40	Index		Sub-index	0x00	0x00	0x00	0x00
0x580 + Node-ID	Tx	8	0x4x	Index		Sub-index	Data LSB	Data	Data	Data MSB

Table 10: SDO upload and sensor response

D0	Description
0x43	Upload of 4 bytes
0x4B	Upload of 2 bytes
0x4F	Upload of 1 byte

Table 11: Explanation of the response byte “D0”

5.7.3 SDO abort

If SDO download or SDO upload service fails for any reason the T-Series CAN sensor does not respond with the corresponding SDO message, but with a SDO abort protocol.

COB-ID	Request / Respond	DLC	Byte								Description
			0	1	2	3	4	5	6	7	
0x580 + Node-ID	Tx	8	0x80	Index		Sub-index	**Abort code**				
							0x06	0x09	0x00	0x11	Sub-index does not exist
							0x06	0x09	0x00	0x30	Value exceeded
							0x06	0x02	0x00	0x00	Object does not exist in the object dictionary
							0x06	0x01	0x00	0x01	Object is write only
							0x06	0x01	0x00	0x02	Attempt to write a read only object
							0x08	0x00	0x00	0x20	Data transport error
							0x08	0x00	0x00	0x00	General error
							0x08	0x00	0x00	0x22	Wrong state
							0x06	0x01	0x00	0x00	Unsupported access to an object
							0x06	0x07	0x00	0x01	Data type does not match

Table 12: SDO abort codes

5.7.4 SDO TPDO communication parameter: Index 1800 (PDO1) to index 1803 (PDO4)

Example

COB-ID	Request / Respond	DLC	Byte								Description
			0	1	2	3	4	5	6	7	
Sub-index 1 COB-ID of the TPDO											
600 + Node-ID	Rx	8	0x23	0x00	0x18	0x01	0x00000180 + Node-ID	0x01	0x00	0x40	Set transmission types example (11-bit CAN-ID 1FFh, no RTR allowed, valid: yes)
580 + Node-ID	Tx	8	0x60	0x00	0x18	0x01	0x00	0x00	0x00	0x00	
600 + Node-ID	Rx	8	0x40	0x00	0x18	0x01	0x00	0x00	0x00	0x00	Readout transmission types example
580 + Node-ID	Tx	8	0x43	0x00	0x18	0x01	0x00000180 + Node-ID	0x01	0x00	0x40	
Sub-index 2 transmission character											
0x67F	Rx	8	0x2F	0x00	0x18	0x02	0xFE	0x00	0x00	0x00	Set transmission character “FE event-driven (manufacturer-specific)”
0x5FF	Tx	8	0x60	0x00	0x18	0x02	0x00	0x00	0x00	0x00	
0x67F	Rx	8	0x40	0x00	0x18	0x02	0x00	0x00	0x00	0x00	Readout transmission character example “FE”
0x5FF	Tx	8	0x4F	0x00	0x18	0x02	0xFE	0x00	0x00	0x00	
Sub-index 5 contains the event-timer (The value is defined as multiple of 1 msec. A value of “0” disables the event-timer.)											
0x67F	Rx	8	0x2B	0x00	0x18	0x05	0x01	0x00	0x00	0x00	Set event timer example “1 ms”
0x5FF	Tx	8	0x60	0x00	0x18	0x05	0x00	0x00	0x00	0x00	
0x67F	Rx	8	0x40	0x00	0x18	0x05	0x00	0x00	0x00	0x00	Readout event timer example “1 ms”
0x5FF	Tx	8	0x4B	0x00	0x18	0x05	0x01	0x00	0x00	0x00	

Example 4: Configuration of index 1800 (PDO1)

5.7.5 SDO PDO mapping: Index 1A00 to index 1A03

This object contains the mapping for the PDOs the device is able to transmit. Make sure to disable the dedicated PDO by setting the number of mapping entries to zero before changing it. Sub-index 0x00 contains the number of valid object entries within the mapping record.

Example

COB-ID	Request / Respond	DLC	Byte								Description
			0	1	2	3	4	5	6	7	
0x67F	Rx	8	0x40	0x00	0x1A	0x00	0x00	0x00	0x00	0x00	Readout of amount of currently mapping PDOs “3”
0x5FF	Tx	8	0x4F	0x00	0x1A	0x00	0x03	0x00	0x00	0x00	
0x67F	Rx	8	0x2F	0x00	0x1A	0x00	0x00	0x00	0x00	0x00	Set number of application objects “0 disable”
0x5FF	Tx	8	0x60	0x00	0x1A	0x00	0x00	0x00	0x00	0x00	
Sub-index 1: PDO mapping for the 1st application object											
0x67F	Rx	8	0x23	0x00	0x1A	0x01	0x20	0x01	0x20	0x60	Set the mapping PDO1 to Position1 “Object: Index 6020 sub-index 1; length bits: 20h”
0x5FF	Tx	8	0x60	0x00	0x1A	0x01	0x00	0x00	0x00	0x00	
0x67F	Rx	8	0x40	0x00	0x1A	0x01	0x00	0x00	0x00	0x00	Readout of the mapping PDO1 to Position1 “0x60200120”
0x5FF	Tx	8	0x43	0x00	0x1A	0x01	0x20	0x01	0x20	0x60	
Sub-index 2: PDO mapping for the 2nd application object											
0x67F	Rx	8	0x23	0x00	0x1A	0x02	0x10	0x01	0x30	0x60	Set the mapping PDO1 to Velocity1 “Object: Index 6030 sub-index 1; length bits: 10h”
0x5FF	Tx	8	0x60	0x00	0x1A	0x02	0x00	0x00	0x00	0x00	
0x67F	Rx	8	0x40	0x00	0x1A	0x02	0x00	0x00	0x00	0x00	Readout of the mapping PDO1 to Velocity1 “60300110h”
0x5FF	Tx	8	0x43	0x00	0x1A	0x02	0x10	0x01	0x30	0x60	
Sub-index 3: PDO mapping for the 3rd application object											
0x67F	Rx	8	0x23	0x00	0x1A	0x03	0x08	0x01	0x00	0x63	Set the mapping PDO1 to Cam state register “Object 0x6300, sub-index 0x01, length 8 bits”
0x5FF	Tx	8	0x60	0x00	0x1A	0x03	0x00	0x00	0x00	0x00	
0x67F	Rx	8	0x40	0x00	0x1A	0x03	0x00	0x00	0x00	0x00	Readout of the mapping PDO1 to Cam state register “0x63000108”
0x5FF	Tx	8	0x43	0x00	0x1A	0x03	0x08	0x01	0x00	0x63	
Set number of application objects											
0x67F	Rx	8	0x2F	0x00	0x1A	0x00	0x03	0x00	0x00	0x00	Set number of application objects to “3”
0x5FF	Tx	8	0x60	0x00	0x1A	0x00	0x00	0x00	0x00	0x00	

Example 5: How to modify the PDO settings

5.7.6 SDO store parameter index 1010

Using the store parameter command, all current settings are transferred into permanent memory.

COB-ID	Request / Respond	DLC	Byte								Description
			0	1	2	3	4	5	6	7	
0x67F	Rx	8	0x22	0x10	0x10	0x01	0x73	0x61	0x76	0x65	**Note:** This takes at least 20 ms of time!
0x5FF	Tx	8	0x60	0x10	0x10	0x01	0x00	0x00	0x00	0x00	

Table 13: Store parameter and sensor response

5.7.7 Restore default parameters index 1011

Using the restore parameter command, all current settings are restored to default values.

COB-ID	Request / Respond	DLC	Byte								
			0	1	2	3	4	5	6	7	
0x67F	Rx	8	0x22	0x11	0x10	0x01	0x6C	0x6F	0x61	0x64	
0x5FF	Tx	8	0x60	0x11	0x10	0x01	0x00	0x00	0x00	0x00	

Table 14: Restore parameters

5.7.8 Sensor communication default parameter

These parameters are related to the C304 order code configuration type.

Index	Sub-index	Description	Type	Attribute	Default Value	Comment
1005		COB-ID sync	Unsigned 32	rw	0x080	
1008		Device name	String	ro	C304	
1009		Hardware version release	String	ro	1.00	
100A		Software version release	String	ro	1.01	
100B		Node-ID	Unsigned 32	ro	0x7F	
100C		Guard time	Unsigned 16	rw	0	
100D		Life time factor	Unsigned 8	rw	0	
100E		COB-ID Guarding Protocol	Unsigned 32	rw	0x700 + Node-ID	
100F		Number of SDOs supported	Unsigned 32	ro	0x01	
1014		COB-ID EMCY	Unsigned 32	rw	0x080 + Node-ID	
1017		Producer heartbeat	Unsigned 16	rw	0	
1018	0	Identity object	Unsigned 8	ro	4	
	1	Vendor-ID	Unsigned 32	ro	0x00000040	MTS Sensor
	2	Product code	Unsigned 32	ro	0x43333034	C304
	3	Revision number	Unsigned 32	ro	0x00010005	
	4	Serial number	Unsigned 32	ro	17143876	

Table 15: Device properties

5.7.9 PDO mapping

Index	Sub-index	Description	Type	Attribute	Default Value	Description
Process Data Object (PDO1)						
1800	0	Transmit 1st PDO	Unsigned 8	ro	5	Number of largest sub-index
	1	COB-ID used by PDO1	Unsigned 32	rw	0x00000180 + Node-ID	PDO enabled
	2	Transmission type	Unsigned 8	rw	0xFE	254 (async)
	5	Event timer	Unsigned 16	rw	1	msec
1A00	0	1st transmit PDO mapping	Unsigned 8	rw	3	Number of largest sub-index
	1	1st application object	Unsigned 32	rw	0x60200120	Position
	2	2nd application object	Unsigned 32	rw	0x60300110	Velocity
	3	3rd application object	Unsigned 32	rw	0x63000108	Cam state register
Process Data Object (PDO2)						
1801	0	Transmit 2nd PDO	Unsigned 8	ro	5	Number of largest sub-index
	1	COB-ID used by PDO2	Unsigned 32	rw	0x80000280 + Node-ID	PDO disabled
	2	Transmission type	Unsigned 8	rw	0xFE	254 (async)
	5	Event timer	Unsigned 16	rw	1	msec
1A01	0	2nd transmit PDO mapping	Unsigned 8	rw	3	Number of largest sub-index
	1	1st application object	Unsigned 32	rw	0x60200220	Position
	2	2nd application object	Unsigned 32	rw	0x60300210	Velocity
	3	3rd application object	Unsigned 32	rw	0x63000208	Cam state register
Process Data Object (PDO3)						
1802	0	Transmit 3rd PDO	Unsigned 8	ro	5	Number of largest sub-index
	1	COB-ID used by PDO3	Unsigned 32	rw	0x80000380 + Node-ID	PDO disabled
	2	Transmission type	Unsigned 8	rw	0xFE	254 (async)
	5	Event timer	Unsigned 16	rw	1	msec
1A02	0	3rd transmit PDO mapping	Unsigned 8	rw	0	Number of largest sub-index
	1	1st application object	Unsigned 32	rw	0x60200320	Position
	2	2nd application object	Unsigned 32	rw	0x60300310	Velocity
	3	3rd application object	Unsigned 32	rw	0x63000308	Cam state register
Process Data Object (PDO4)						
1803	0	Transmit 4th PDO	Unsigned 8	ro	5	Number of largest sub-index
	1	COB-ID used by PDO4	Unsigned 32	rw	0x80000480 + Node-ID	PDO disabled
	2	Transmission type	Unsigned 8	rw	0xFE	254 (async)
	5	Event timer	Unsigned 16	rw	1	msec
1A03	0	4th transmit PDO mapping	Unsigned 8	rw	0	Number of largest sub-index
	1	1st application object	Unsigned 32	rw	0x60200420	Position
	2	2nd application object	Unsigned 32	rw	0x60300410	Velocity
	3	3rd application object	Unsigned 32	rw	0x63000408	Cam state register

Table 16: PDO configuration

5.7.10 Device properties according to CiA DS 406

Index	Sub-index	Description	Type	Attribute	Default Value	Description
6000		Operating parameter	Unsigned 16	rw	0x0000	Scaling fix
6002		Total measuring range	Unsigned 32	rw	0	Total measuring range in measuring units
6005	0	Linear encoder measuring step settings	Unsigned 8	ro	2	Number of objects
	1	Position measuring step	Unsigned 32	ro	Resolution dependend	Position step in 0.001 µm
	2	Velocity measuring step	Unsigned 32	ro		Velocity step in 0.01 mm/s
6200		Cyclic timer	Unsigned 16	rw	0x01	Cycle time in msec
6500		Operating status	Unsigned 16	ro		
6501		Measuring step	Unsigned 32	ro	Resolution dependend	Measuring step in 0.001 µm
6503		Alarms occured	Unsigned 16	ro	0x0000	Missing magnet
6504		Alarms supported	Unsigned 16	ro	0x0001	
6505		Warning occured	Unsigned 16	ro	0x0000	
6506		Warning supported	Unsigned 16	ro	0x0004	
6507		Profile and software version	Unsigned 32	ro	0x03010401	
650A	0	Module identification	Unsigned 8	ro		
	1	Manufacturer offset value	Integer 32	ro		
	2	Manufacturer min. position value	Integer 32	ro	Min. position	Sensor units
	3	Manufacturer max. position value	Integer 32	ro	Max. position	Sensor units
650B		Serial number	Unsigned 32	ro		

Table 17: Device properties

5.7.11 Manufacturer specific profile area

Index	Sub-index	Description	Type	Attribute	Default Value	Description
2101	0	Enable bus termination	BOOLEAN	rw	false	Enable CANbus termination (120 Ω)
2901	0	Temperature	Unsigned8	ro	5	Number of objects
	1		Integer8	ro	x	Actual temperature
	2		Integer8	ro	x	Max. temperature since startup
	3		Integer8	ro	x	Min. temperature since startup
	4		Integer8	ro	x	Max. temperature over operational life
	5		Integer8	ro	x	Min. temperature over operational life

Table 18: Manufacturer specific profile area

5.7.12 Cam channels

Index	Sub-index	Description	Type	Attribute	Default Value	Description
Cam channel 1						
6010	1	Preset value channel 1	Integer 32	rw	0	Sensor units
6020	1	Position value channel 1	Integer 32	ro		Current position in sensor units
6030	1	Velocity value channel 1	Integer 16	ro		Current velocity in sensor units
6300	1	Cam state channel 1	Unsigned 8	ro		
6301	1	Cam enable channel 1	Unsigned 8	rw	0	
6302	1	Cam polarity channel 1	Unsigned 8	rw	0	
6310	1	Cam1 low limit channel 1	Integer 32	rw	0	
6311	1	Cam2 low limit channel 1	Integer 32	rw	0	
6312	1	Cam3 low limit channel 1	Integer 32	rw	0	
6313	1	Cam4 low limit channel 1	Integer 32	rw	0	
650C	1	Offset value for multi sensor devices	Integer 32	ro	0	
6400	1	Work area state channel 1	Unsigned 8	ro		
6401	1	Work area low limit channel 1	Integer 32	rw	Min. position	Sensor units
6402	1	Work area high limit channel 1	Integer 32	rw	Max. position	Sensor units
Cam channel 2						
6010	2	Preset value channel 2	Integer 32	rw	0	Sensor units
6020	2	Position value channel 2	Integer 32	ro		Current position in sensor units
6030	2	Velocity value channel 2	Integer 16	ro		Current velocity in sensor units
6300	2	Cam state channel 2	Unsigned 8	ro		
6301	2	Cam enable channel 2	Unsigned 8	rw	0	
6302	2	Cam polarity channel 2	Unsigned 8	rw	0	
6310	2	Cam1 low limit channel 2	Integer 32	rw	0	
6311	2	Cam2 low limit channel 2	Integer 32	rw	0	
6312	2	Cam3 low limit channel 2	Integer 32	rw	0	
6313	2	Cam4 low limit channel 2	Integer 32	rw	0	
650C	2	Offset value for multi sensor devices	Integer 32	ro	0	
6400	2	Work area state channel 2	Unsigned 8	ro		
6401	2	Work area low limit channel 2	Integer 32	rw	Min. position	Sensor units
6402	2	Work area high limit channel 2	Integer 32	rw	Max. position	Sensor units

Table 19: Cam / work area configuration

Index	Sub-index	Description	Type	Attribute	Default Value	Description
Cam channel 3						
6010	3	Preset value channel 3	Integer 32	rw	0	Sensor units
6020	3	Position value channel 3	Integer 32	ro		Current position in sensor units
6030	3	Velocity value channel 3	Integer 16	ro		Current velocity in sensor units
6300	3	Cam state channel 3	Unsigned 8	ro		
6301	3	Cam enable channel 3	Unsigned 8	rw	0	
6302	3	Cam polarity channel 3	Unsigned 8	rw	0	
6310	3	Cam1 low limit channel 3	Integer 32	rw	0	
6311	3	Cam2 low limit channel 3	Integer 32	rw	0	
6312	3	Cam3 low limit channel 3	Integer 32	rw	0	
6313	3	Cam4 low limit channel 3	Integer 32	rw	0	
650C	3	Offset value for multi sensor devices	Integer 32	ro	0	
6400	3	Work area state channel 3	Unsigned 8	ro		
6401	3	Work area low limit channel 3	Integer 32	rw	Min. position	Sensor units
6402	3	Work area high limit channel 3	Integer 32	rw	Max. position	Sensor units
Cam channel 4						
6010	4	Preset value channel 4	Integer 32	rw	0	Sensor units
6020	4	Position value channel 4	Integer 32	ro		Current position in sensor units
6030	4	Velocity value channel 4	Integer 16	ro		Current velocity in sensor units
6300	4	Cam state channel 4	Unsigned 8	ro		
6301	4	Cam enable channel 4	Unsigned 8	rw	0	
6302	4	Cam polarity channel 4	Unsigned 8	rw	0	
6310	4	Cam1 low limit channel 4	Integer 32	rw	0	
6311	4	Cam2 low limit channel 4	Integer 32	rw	0	
6312	4	Cam3 low limit channel 4	Integer 32	rw	0	
6313	4	Cam4 low limit channel 4	Integer 32	rw	0	
650C	4	Offset value for multi sensor devices	Integer 32	ro	0	
6400	4	Work area state channel 4	Unsigned 8	ro		
6401	4	Work area low limit channel 4	Integer 32	rw	Min. position	Sensor units
6402	4	Work area high limit channel 4	Integer 32	rw	Max. position	Sensor units

Table 20: Cam / work area configuration

5.8 Process data

Transmission of data
The transmission type object (index 1800 ff sub-index 2) allows the user to switch between the different transmission modes: Synchronous and asynchronous.

5.8.1 Synchronous mode

When the T-Series CANopen sensor is in NMT operational state and the transmission type (index 1800 ff sub-index 2) is between n = 0…240 the synchronous mode is enabled.
The PDO is transmitted by the T-Series CANopen sensor after receiving every nth sync object.
The sync object has the following format:

COB-ID	Rx/Tx	DLC	Data							
			D0	D1	D2	D3	D4	D5	D6	D7
0x080	Rx	0	–	–	–	–	–	–	–	–

Table 21: Sync object

NOTICE

The COB-ID of the sync object message can be programmed individually with index 1005.
So the COB-ID of the sync message may be different, depending on the configuration of the sensor.

5.8.2 Asynchronous mode

When the CANopen sensor is in NMT operational state and the transmission type (index 1800 ff sub-index 2) is 254 or 255 the asynchronous mode is enabled. The PDO is transmitted by the T-Series CANopen sensor after the event timer (index 1800 ff sub-index 5) is expired. The value of the timer is given in ms.

5.8.3 PDO message format

This is the format of the T-Series CAN sensor default PDO message. The current PDO mapping can be seen at index 1A00 ff.

COB-ID	Rx/Tx	DLC	Data							
			D0	D1	D2	D3	D4	D5	D6	D7
0x180 + Node-ID	Tx	6	Pos LSB	Pos	Pos	Pos MSB	Velocity LSB	Velocity MSB	Status	–

Table 22: Default PDO format

NOTICE

For the PDO message the measuring steps for the position (Pos) and velocity values can be read with object linear encoder measuring step settings (index 6005).

5.8.4 PDO transmission time consideration

For the configuration of the network it is helpful to estimate the time of data transmission.
According to the physical cable length the baud rate of the data transmission is limited. Furthermore the event timer interval indicates how often PDOs are generated. The number of PDOs generated by the slave determine the time required for the transmission.

In case of default PDO mapping (hosting 1 PDO with 4 byte position, 2 byte velocity and 1 byte for status data) the CAN message becomes 103…126 bits (depending on stuff bit count).

Data transmission times depends on the baud rate in the network assuming default PDO mapping.

Baud rate	Time
125 kBit/s	824…1004 µs
250 kBit/s	412 … 502 µs
500 kBit/s	206 … 251 µs
1000 kBit/s	103 … 125.5 µs

Table 23: Data transmission times

5.8.5 Cam switch

The sensor enables a cam switch depending on the position of the magnet. When the magnet passes the switch position the cam is activated or inactivated respectively.

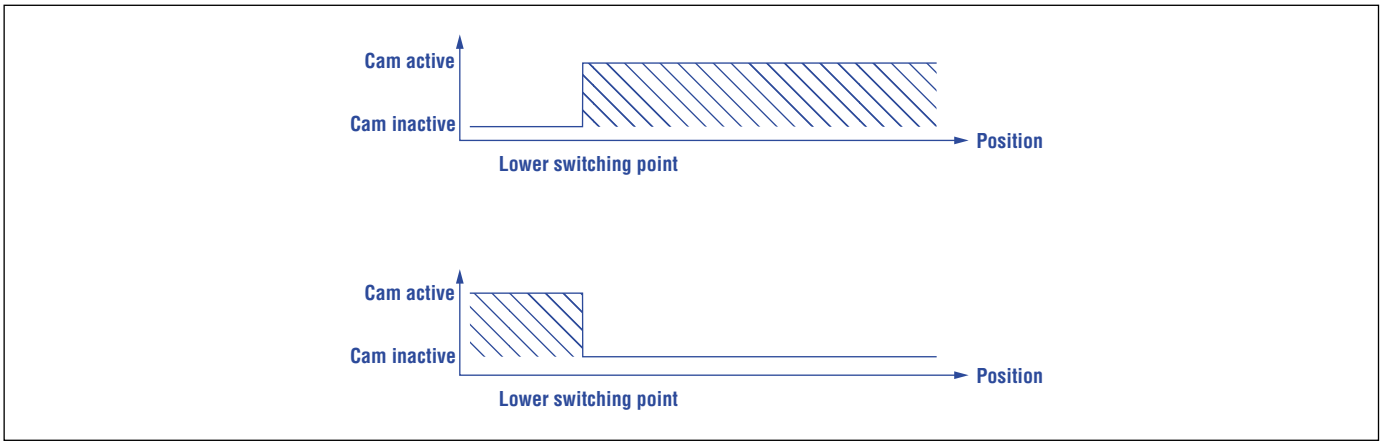


Fig. 27: Cam switch depending on the cam polarity setting

6. Maintenance and troubleshooting

6.1 Error conditions, troubleshooting

See chapter “5.6.1 Layer Setting Service (LSS)” on page 31.

6.2 Maintenance

The required inspections need to be performed by qualified personnel according to IEC 60079-17 / TRBS 1203. These inspections should include at least a visual inspection of the housing, associated electrical equipment entrance points, retention hardware and equipment grounding. Inside the Ex-atmosphere the equipment has to be cleaned regularly. The user determines the intervals for checking according to the environmental conditions present at the place of operation. After maintenance and repair, all protective devices removed for this purpose must be refitted.

Type of inspection	Visual inspection every 3 months	Close inspection every 6 months	Detailed inspection every 12 months
Visual inspection of the sensor for intactness, removal of dust deposits	●		
Check of electrical system for intactness and functionality			●
Check of entire system	User’s responsibility		

Fig. 28: Schedule of inspection

Maintenance: Defines a combination of any actions carried out to retain an item in, or restore it to, conditions in which it is able to meet the requirements of the relevant specification and perform its required functions.
Inspection: Defines an activity with the purpose of checking a product carefully, aiming at a reliable statement of the condition of the product. The inspection is carried out without dismantling, or, if necessary, with partial dismantling, and supplemented by other measures, e.g. measurements.
Visual inspection: Optical inspection of product aims at the recognition of visible defects like missing bolts without using auxiliary equipment and tools.
Close inspection: Defines an inspection which encompasses those aspects covered by a visual inspection and, in addition, identifies those defects, such as loose bolts, which will be apparent only by the use of access equipment, for example steps, where necessary, and tools.
Detailed inspection: Defines an inspection which encompasses those aspects covered by a close inspection and, in addition, identifies those defects, such as loose terminations, which will only be apparent by opening the enclosure, and / or using, where necessary, tools and test equipment.

NOTICE

Perform maintenance work that requires a dismantling of the system only in an Ex-free atmosphere. If this is not possible take protective measures in compliance with local regulations.

6.3 Repair

Repairs of the sensor may only be performed by MTS Sensors or a repair facility explicitly authorized by MTS Sensors. Repairs of the flameproof joints must be made by the manufacturer in compliance with the constructive specifications. Repairs must not be made on the basis of values specified in tables 1 and 2 of IEC/EN 60079-1.

6.4 List of spare parts

No spare parts are available for this sensor.

6.5 Transport and storage

Note the storage temperature of the sensor, which is from –40…+93 °C (–40…+200 °F).

7. Removal from service / dismantling

The product contains electronic components and must be disposed of in accordance with the local regulations.

8. Technical data Temposonics® TH

Output	
Interface	CAN-Fieldbus System according to ISO 11898
Data protocol	Corresponds to encoder profile DS 406 V3.1 (CiA Standard DS 301 V3.0)
Baud rate, kBit/s	1000 800 500 250 125 50 20
Cable length, m	< 25 < 50 < 100 < 250 < 500 < 1000 < 2500
	The sensor will be supplied with ordered baud rate, which is changeable by customer
Measured value	Position / option: Multi-position measurement (2…4 positions)
Measurement parameters	
Resolution	2 µm, 5 µm; velocity step size: See following table

For stroke lengths	having a cycle time of		Velocity step size	
			at 5 µm position resolution	at 2 µm position resolution
Up to 2400 mm	1.0 ms	results in the following velocity step size ⇨	0.5 mm/s	0.2 mm/s
Up to 4800 mm	2.0 ms		0.25 mm/s	0.1 mm/s
Up to 7620 mm	4.0 ms		0.125 mm/s	0.05 mm/s

Cycle time	1.0 ms up to 2400 mm stroke length 2.0 ms up to 4800 mm stroke length 4.0 ms up to 7620 mm stroke length
Linearity deviation [7]	< ±0.01 % F.S. (minimum ±40 µm)
Repeatability	< ±0.001 % F.S. (minimum ±2.5 µm) typical
Hysteresis	< 4 µm typical
Temperature coefficient	< 15 ppm/K typical
Operating conditions	
Operating temperature	–40…+75 °C (–40…+167 °F)
Humidity	90 % relative humidity, no condensation
Ingress protection	Version D, G, and E: IP66 / IP67 (if properly connected by means that support IP66 / IP67 (pipe, gland, etc.)) Version N: IP66, IP67, IP68, IP69K, NEMA 4X, depending on cable gland
Shock test	100 g (single shock), IEC standard 60068-2-27
Vibration test	15 g / 10…2000 Hz, IEC standard 60068-2-6 (excluding resonant frequencies)
EMC test	Electromagnetic emission according to EN 61000-6-3 Electromagnetic immunity according to EN 61000-6-2 The sensor meets the requirements of the EU directives and is marked with CE
Operating pressure	350 bar static (5076 psi static)
Magnet movement velocity [8]	Any
Design / Material	
Sensor electronics housing	Stainless steel 1.4305 (AISI 303); option: Stainless steel 1.4404 (AISI 316L)
Flange	See “Table 1: TH rod sensor threaded flange type references” on page 12
Sensor rod	Stainless steel 1.4306 (AISI 304L); option: Stainless steel 1.4404 (AISI 316L)
Stroke length	25…7620 mm (1…300 in.)

See next page for “Mechanical mounting”

7/ With position magnet # 201 542-2

8/ If there is contact between the moving magnet (including the magnet holder) and the sensor rod, make sure that the maximum speed of the moving magnet is ≤ 1 m/s (Safety requirement due to ESD [Electro Static Discharge])

Mechanical mounting	
Mounting position	Any
Mounting instruction	Please consult the technical drawings on page 11
Electrical connection	
Connection type	T-Series terminal
Operating voltage	+24 VDC (–15 / +20 %)
Ripple	≤ 0.28 V_{PP}
Current consumption	90 mA typical
Dielectric strength	700 VDC (DC ground to machine ground)
Polarity protection	Up to –30 VDC
Overvoltage protection	Up to 36 VDC

Certifications

Certification required	Version E	Version D	Version G	Version N
IECEx / ATEX (IECEx: Global market; ATEX: Europe)	Ex db eb IIC T4 Ga/Gb Ex tb IIIC T130°C Ga/Db Zone 0/1, Zone 21 –40 °C ≤ Ta ≤ 75 °C	Ex db IIC T4 Ga/Gb Ex tb IIIC T130°C Ga/Db Zone 0/1, Zone 21 –40 °C ≤ Ta ≤ 75 °C	Ex db IIC T4 Ga/Gb Ex tb IIIC T130°C Ga/Db Zone 0/1, Zone 21 –40 °C ≤ Ta ≤ 75 °C	No hazardous area approval
NEC (USA)	—	—	**Explosionproof** Class I Div. 1 Groups A, B, C, D T4 Class II/III Div. 1 Groups E, F, G T130°C –40 °C ≤ Ta ≤ 75 °C **Flameproof** Class I Zone 0/1 AEx d IIC T4 Class II/III Zone 21 AEx tb IIIC T130°C –40 °C ≤ Ta ≤ 75 °C	No hazardous area approval
CEC (Canada)	—	—	**Explosionproof** Class I Div. 1 Groups B, C, D T4 Class II/III Div. 1 Groups E, F, G T130°C –40 °C ≤ Ta ≤ 75 °C **Flameproof** Class I Zone 0/1 Ex d IIC T4 Ga/Gb Class II/III Zone 21 Ex tb IIIC T130°C Db –40 °C ≤ Ta ≤ 75 °C	No hazardous area approval
EAC Ex (Russian market)	Ga/Gb Ex db eb IIC T4 X Da/Db Ex tb IIIC T130°C X Zone 0/1, Zone 21 –40 °C ≤ Ta ≤ 75 °C	Ga/Gb Ex db IIC T4 X Da/Db Ex tb IIIC T130°C X Zone 0/1, Zone 21 –40 °C ≤ Ta ≤ 75 °C	Ga/Gb Ex db IIC T4 X Da/Db Ex tb IIIC T130°C X Zone 0/1, Zone 21 –40 °C ≤ Ta ≤ 75 °C	No hazardous area approval
KCs (South Korea)	Ex d e IIC T4 Ex tb IIIC T130°C Zone 0/1; Zone 21 –40 °C ≤ Ta ≤ 75 °C	Ex d IIC T4 Ex tb IIIC T130°C Zone 0/1; Zone 21 –40 °C ≤ Ta ≤ 75 °C	Ex d IIC T4 Ex tb IIIC T130°C Zone 0/1; Zone 21 –40 °C ≤ Ta ≤ 75 °C	No hazardous area approval
Japanese approval	Ex d e IIC T4 Ga/Gb Ex t IIIC T130°C Db Zone 0/1, Zone 21 –40 °C ≤ Ta ≤ 75 °C	Ex d IIC T4 Ga/Gb Ex t IIIC T130°C Db Zone 0/1, Zone 21 –40 °C ≤ Ta ≤ 75 °C	Ex d IIC T4 Ga/Gb Ex t IIIC T130°C Db Zone 0/1, Zone 21 –40 °C ≤ Ta ≤ 75 °C	No hazardous area approval

Fig. 29: Certifications

9. Declaration of conformity

EU-Konformitätserklärung
EU-Konformitätserklärung
Déclaration UE de Conformité

MTS SENSORS
www.mtssensors.com

EC15.020C

MTS Sensor Technologie GmbH & Co. KG

declares as manufacturer in sole responsibility that the position sensor type
erklärt als Hersteller in alleiniger Verantwortung, dass der Positionssensor Typ
déclare en qualité de fabricant sous sa seule responsabilité que les capteurs position de type

Temposonics® **TH-x-xxxxx-xxx-1-D-N-N-Cxxxxxx-xxx**
TH-x-xxxxx-xxx-1-G-N-N-Cxxxxxx-xxx
TH-x-xxxxx-xxx-1-E-N-N-Cxxxxxx-xxx

comply with the regulations of the following European Directives:
den Vorschriften folgender Europäischen Richtlinien entsprechen:
sont conformes aux prescriptions des directives européennes suivantes:

2014/30/EU	Electromagnetic Compatibility Elektromagnetische Verträglichkeit Compatibilité électromagnétique
2014/34/EU	Equipment and protective systems for use in potentially explosive atmospheres Geräte und Schutzsysteme zur Verwendung in explosionsgefährdeten Bereichen Appareils et systèmes de protection à être utilisés en atmosphères explosibles
2011/65/EU	Restriction of the use of hazardous substances in electrical and electronic equipment Beschränkung der Verwendung gefährlicher Stoffe in Elektro- und Elektronikgeräten Limitation de l'utilisation de substances dangereuses dans les équipements électriques et électroniques

Applied harmonized standards / Angewandte harmonisierte Normen / Normes harmonisées appliquées:

EN 60079-0 :2012+A11 :2013, EN 60079-1 :2014, EN 60079-7 :2015+A1 :2018, EN 60079-26 :2015, EN 60079-31 :2014
EN 61000-6-2 :2005, EN 61000-6-3 :2007+A1+AC :2012, EN 50581:2012

EC type examination certificate: EG-Baumusterprüfbescheinigung: Certificat de l`examen CE:	**CML 16 ATEX 1090X Issue 1**
Issued by / ausgestellt durch / exposé par:	**CML B.V.** **Hoogoorddreef 15, 1101BA, Amsterdam, The Netherlanders**
Notified body for quality assurance control: Benannte Stelle für Qualitätsüberwachung: Organisme notifié pour l'assurance qualité:	**CML B.V.** **Hoogoorddreef 15, 1101BA, Amsterdam, The Netherlanders**
Ident number / Kennnummer / No. d`identification:	**2776**
Kennzeichnung / Marking / Marquage:	**Ⓔx II 1/2G Ex db IIC T4 Ga/Gb resp.** **Ⓔx II 1/2G Ex db eb IIC T4 Ga/Gb** **Ⓔx II 1/2D Ex tb IIIC T130°C Ga/Db**

Luedenscheid, 2019-03-17

Dr.-Ing. Eugen Davidoff
Zulassungsmanager / Approvals Manager

EU-Konformitätserklärung
EU-Konformitätserklärung
Déclaration UE de Conformité

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EC16.015E

declares as manufacturer in sole responsibility that the position sensor type
erklärt als Hersteller in alleiniger Verantwortung, dass der Positionssensor Typ
déclare en qualité de fabricant sous sa seule responsabilité que les capteurs position de type

Temposonics®	**TH-x-xxxxx-xxx-1-N-N-N-Cxxxxxx-xxx**	C = output type CANbasic / CANopen
	TH-x-xxxxx-xxx-x-N-N-N-Sxxxxxx-xxx	S = output type SSI

comply with the regulations of the following European Directives:
den Vorschriften folgender Europäischen Richtlinien entsprechen:
sont conformes aux prescriptions des directives européennes suivantes:

2014/30/EU	Electromagnetic Compatibility Elektromagnetische Verträglichkeit Compatibilité électromagnétique
2011/65/EU	Restriction of the use of hazardous substances in electrical and electronic equipment Beschränkung der Verwendung gefährlicher Stoffe in Elektro- und Elektronikgeräten Limitation de l'utilisation de substances dangereuses dans les équipements électriques et électroniques

Applied harmonized standards / Angewandte harmonisierte Normen / Normes harmonisées appliquées:

EN 61000-6-2 :2005, EN 61000-6-3 :2007+A1+AC :2012
EN 50581 :2012

Luedenscheid, 2019-03-17

Dr.-Ing. Eugen Davidoff
Zulassungsmanager / Approvals Manager

Safety Declaration

Dear Customer,
If you return one or several sensors for checking or repair, we need you to sign a safety declaration. The purpose of this declaration is to ensure that the returned items do not contain residues of harmful substances and / or that people handling these items will not be in danger.

MTS Sensors order number: _____ Sensor type(s): _____

Serial number(s): _____ Sensor length(s): _____

The sensor has been in contact with the following materials:

Do not specify chemical formulas.
Please include safety data sheets of the substances, if applicable.

In the event of suspected penetration of substances into the sensor, consult MTS Sensors to determine measures to be taken before shipment.

Short description of malfunction:

Corporate information

Company: _____

Address: _____

_____

Contact partner

Name: _____

Phone: _____

E-mail: _____

We hereby certify that the measuring equipment has been cleaned and neutralized.
Equipment handling is safe. Personnel exposure to health risks during transport and repair is excluded.

Stamp

Signature

Date

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