

Instruction manual

Version: 1.2

No.: 9010052B01D

N6/N7 Tilt sensor

N6SA, N6SC static

N7DA, N7DC dynamic



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1. User information

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Validity This Instruction manual generally applies to the product N6/N7 listed on the title page and must be appended to the product documents of the downstream machine. Other variants are possible and are also listed in case of deviating specifications. Depending on the customer's wishes or special versions, individual components may be missing or deviate from the standard. Some drawings and figures in this Instruction manual are for illustrative purposes only. Deviations from the original part are therefore possible and desired for reasons of a better representation.

The publisher has tried to make this Instruction manual as accurate and up-to-date as possible. We are constantly working on developing our products further. We reserve the right to make changes to the scope of delivery in terms of shape, equipment and technology. No claims can be derived from the information, figures and descriptions in this documentation.

This Instruction manual is a translation of the original Instruction manual. For more information, we are at your disposal.

1.1 General

This document makes it possible to safely work and handle the product properly N6/N7. Read through this Instruction manual carefully before commissioning and observe the relevant health and safety and accident prevention regulations. Also observe all warnings to avoid hazards for personnel, the environment or the product.

Make this Instruction manual as well as other information about the product (e. g. data sheets) available to the person who installs, maintains or repairs the product. When passing on or selling the product, this Instruction manual must be enclosed with the product because it is part of the product. Therefore, keep this Instruction manual safe for the entire service life of the product and readily accessible in a legible condition.

If you do not understand this Instruction manual or parts of it, please ask us.

1.2 Representation conventions



Information!

Refers to effective and practical use of the product.

Text/image reference

(1) Item number: Refers to an item number in a figure

↓ ↑ ↺ ↻ Direction arrows: Indicate movement directions and screwing directions or specific information on the coordinate system.

Lists

Numbered and non-numbered lists are represented as follows:

1. Numbered list
2. Numbered list
- List, level 1
 - List, level 2
 - List, level 2

Handling instructions

Handling instructions in chronological order for operating the machine are represented as follows:

Action task

1. Action step: Prompts an action.
Interim result: To check an action step.
2. Action step: Prompts an action.
Interim result: To check an action step.
3. Action step: Prompts an action.

✓ Result of action

Individual handling instructions, without a chronological order, are represented as follows:

- Unordered action step

1.3 Abbreviations used

The following abbreviations are used in this document:

| | |
|-------|--|
| ° | Grad |
| °/s | Grad pro Sekunde |
| CAN | Controller Area Network |
| CE | Conformité Européenne (engl.: Conformity for Europe) |
| CiA | CAN in Automation (CAN application interest group) |
| ECU | Electronic Control Unit |
| EMC | Electromagnetic compatibility |
| EMCY | Emergency Message |
| EUC | Equipment under control |
| FIR | Finite impulse response |
| FMEA | Failure Mode and Effect Analysis |
| FMI | Failure Mode Identifier |
| ID | Identifier |
| IMU | Inertial measurement unit |
| IP | International Protection |
| Kbps | Thousand bits per second |
| LED | Light Emitting Diode |
| MAVG | Moving Average Filter |
| MEMS | Microelectromechanical System |
| n.c. | not connected |
| OTE | Output of Test Equipment |
| PDO | Process Data Object |
| PGN | Parameter Group Number |
| REACH | Regulation, Evaluation, Authorisation and Restriction of Chemicals |
| RoHS | Restriction of Hazardous Substances |
| SRS | System Requirements Specification |
| SPN | Suspect Parameter Number |
| TAA | Average ambient temperature |
| UDS | Unified Diagnostic Services |
| UKCA | United Kingdom Conformity Assessed |
| UV | Ultraviolet |

Table 1

1.4 Functional principle

N6/N7 is a compact and robust tilt sensor that can be easily integrated into agricultural machinery, construction machinery and industrial trucks to record tilt information from machine components and make it available via an electrical interface.

For the electrical connection to a higher-level system, the tilt sensor provides a connector on the back as an electrical interface.

1.4.1 Intended use

The tilt sensor is a measuring device for determining tilts in mobile machinery and for supplying the downstream device with measured values in the form of electronic output signals. The tilt sensor must not be used for any other purpose.

Typical applications of mobile machines:

- Mobile machinery
- Forestry and agricultural machinery
- Construction machinery
- Industrial trucks
- Automated guided vehicles (AGV)

The application is only within the limits of the technical data and the latest data sheet. The ambient conditions must be checked by the user before using the tilt sensor.

- Only operate the tilt sensor in a completely closed and undamaged housing.
- Only use the tilt sensor correctly and as intended.
- If used incorrectly, any guarantee and manufacturer liability is forfeited.
- Ensure that the safety regulations of the individual machines are complied with.
- Ensure that the international and national regulations are complied with.

1.4.2 Foreseeable misuse (improper use)

Any improper use of the product and any activities not described in this Instruction manual are unauthorised use outside the legal liability limits of the manufacturer.

In the event of improper use, hazards can arise for persons or property.

The following operating conditions, amongst others, are classified as misuse:

- Use in potentially explosive areas. The product is not a safety component per the EC Machinery Directive (2006/42/EC).
- Use in aeronautical and aerospace applications, nuclear and military applications.
- Fall from heights over 1 metre. The function of the product is no longer guaranteed.
- Non-compliance with the technical data.

Operation contrary to the intended use will void the warranty.

1.5 Warranty and liability

All products are extensively tested for all functions before delivery. Nevertheless, material and/or manufacturing defects may occur.



Information

This product has a warranty of 24 months beginning at the time of transfer of risk. The general terms and conditions of the manufacturer apply to the warranty and liability.

Defects in the form of material or manufacturing defects that occur during this warranty period shall be rectified free of charge either by repair or replacement. The General Terms and Conditions of Delivery of elobau GmbH & Co. KG apply.

If a warranty is provided, the warranty period is not extended.

We reserve the right to charge for costs resulting from unjustified claims, e. g. installation or operating errors.

Liability exclusion

The manufacturer excludes warranty and liability claims for personal injury and property damage if they are caused by one or more of the following causes:

- Non-compliance with this manual.
- Improper use.
- Unauthorised repairs, conversions and modifications that are not described in this Instruction manual. This also includes painting the tilt sensor.
- Deliberate damage or improper handling.
- Use of spare parts or accessories that have not been approved by the manufacturer.

The warranty does not apply in the event of third-party interference or dismantling by a third party without our prior consent. To the extent permitted by law, other claims for compensation are excluded.

1.6 Manufacturer



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2. Safety instructions

2. Safety instructions

2.1 General labelling of hazards and information

The severity of the hazard and its consequences are classified in this Instruction manual with the following signal words and colours.

VORSICHT!



Here is a brief description of the type and source of danger.

If the safety instruction "CAUTION" appears, there is a low risk of danger. The occurrence of the mentioned hazard may result in reversible minor personal injuries.

► Listing of all measures which must be taken to prevent the consequences.

ACHTUNG!



Here is a brief description of the type and source of danger.

If the following safety instruction "ATTENTION" appears, there is a situation which may potentially result in property damage.

► Listing of all measures which must be taken to prevent the consequences.

2.2 Definition of personnel groups

2.2.1 Operator/contractor

The operator of the downstream machine is responsible for training personnel to work in a safety-conscious manner at regular intervals and to ensure the personnel are appropriately qualified for the necessary work.

The operator is obligated to only allow personnel to work on the machine, system, assembly or with the software who:

- Have been trained in the procedures and operation.
- Are familiar with the regulations on health and safety and accident prevention.
- Have read and understood the content of the Instruction manual in order to prevent hazards for personnel or the product.

2.2.2 User / operating and maintenance personnel

This includes all persons who are responsible for the installation, operation, set-up times, maintenance work (including cleaning) and troubleshooting on behalf of the operator/contractor. Personnel tasked with operation and maintenance must be appropriately qualified for this work. The area of responsibility, competence and supervision of personnel must be precisely regulated by the operator. If personnel do not possess the requisite knowledge, the operator must provide training and instruction. If necessary, this can be provided by the manufacturer or supplier on behalf of the operator.

2.3 Conformity

The product N6/N7 conforms to the state of the art plus the applicable safety conditions at the time of bringing into circulation within the scope of its intended use. From a design point of view, foreseeable misuse cannot be avoided without limiting the intended functionality.

The specification of this system is based on the following documents:

- REACH 1907/2006/EU
- RoHS 2011/65/EU
- DIN EN 12895 (EMC standard)
- DIN EN ISO 13766 (EMC standard)
- DIN EN ISO 14982 (EMC standard)
- DIN EN 60068 (Environmental influences)
- ISO 11898 (CAN)
- ISO 20653 (IP protection)

2.4 Changes, modification

Any unauthorised change or modification is expressly forbidden. The activities described in this Instruction manual are excluded from this.

3. Transport and storage

During transport and storage, protect the product against heat, moisture, chemicals and impacts. Transport and storage only permitted in the original packaging. Do not exceed the permissible storage temperature of -40°C to +85°C.

4. Product-specific information**4.1 System description**

The system offers the following functions:

- Provision of tilt information as the main function,
- Visual status display.

The following information received is processed by the system and leads to a corresponding action:

- Setting a tilt offset,
- Downloading logged data from the system memory.

Depending on the output signal variant of the system, the transmitted tilt signal and the transmitted "harmless error signal" can be an analogue output signal or a corresponding CAN message.

4. Product-specific information

4.2 Dimensions

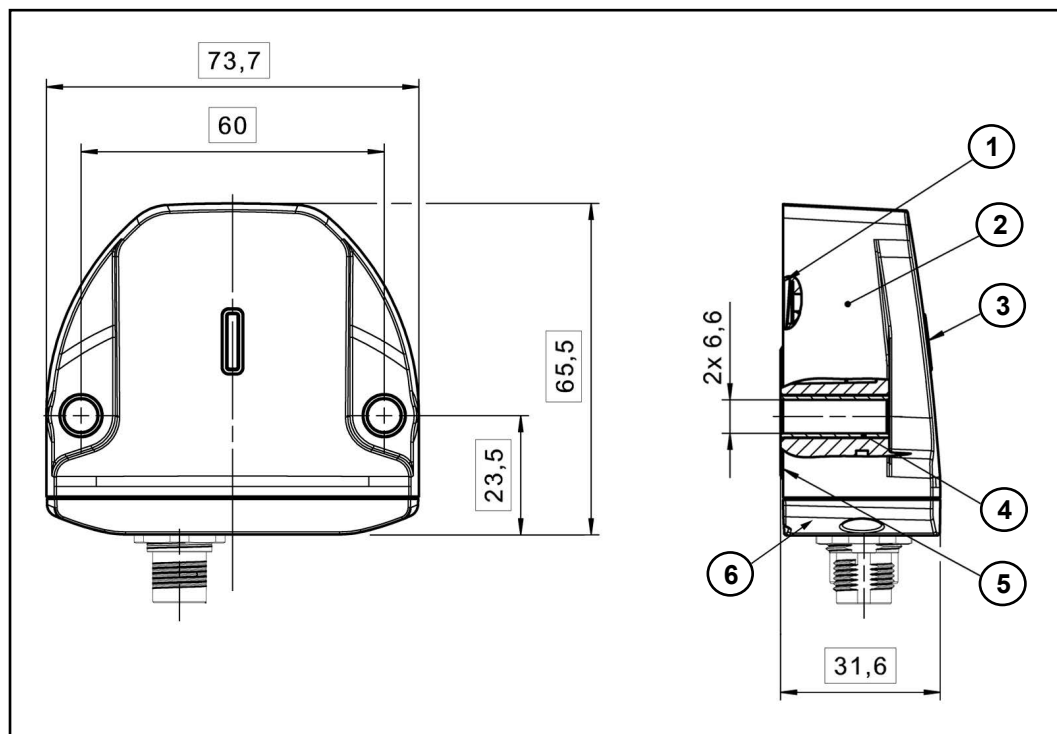


Figure 1

1. Pressure equalisation membrane
2. Housing
3. Status display
4. Receptacle
5. Labelling
6. Lid

Please refer to your data sheet for further details.

4.2.1 Pressure equalisation membrane

There is a pressure equalisation membrane on the underside of the sensor. This enables the sensor to operate at different temperatures and altitudes.

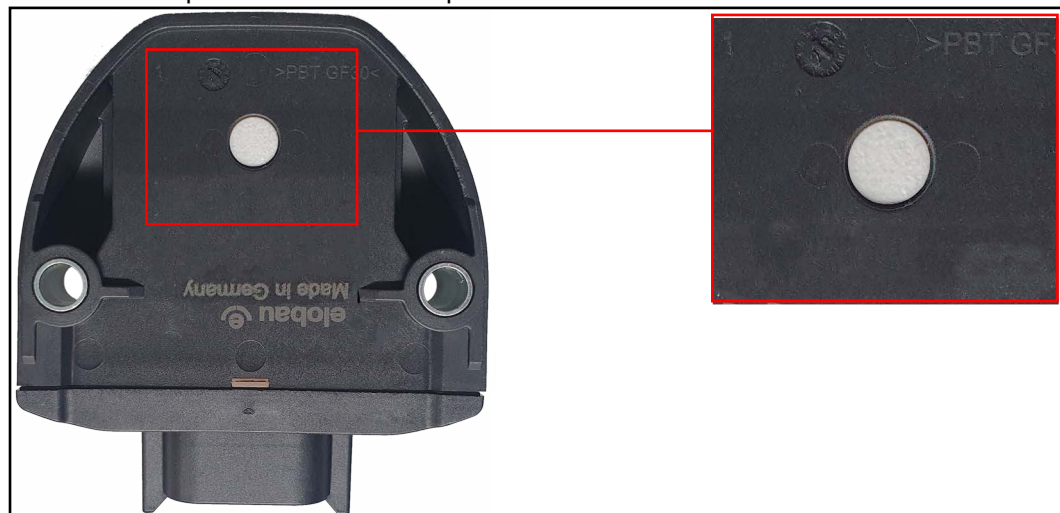


Figure 2

**ACHTUNG!****System error due to mechanical damage!**

If the pressure equalisation membrane is damaged, this can lead to a system failure.

- ▶ Protect the membrane from external influences of any kind.
- ▶ Do not paint over the membrane.
- ▶ Position the tilt sensor accordingly.

4.2.2 Material definition and materials

The materials of the tilt sensor are selected taking various aspects into account to ensure a long service life.

All materials that are applied to the outside of the system, e. g. on the housing, or are visible from the outside, e. g. behind the light guide, are selected with the following aspects in mind:

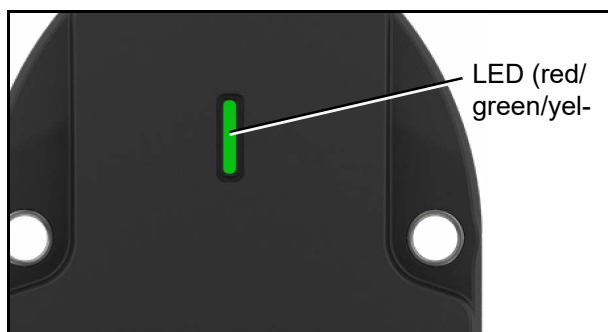
- Resistance to the effects of salt,
- Resistance to the effects of the following chemicals:
 - Petrol, diesel, biodiesel, bioethanol (E85), rapeseed methyl ester (CME), AdBlue (DEF), engine oil, transmission oil,
 - Brake fluid,
 - Lubricating grease,
 - Underbody protection,
 - Antifreeze mixture (incl. ethylene glycol), windscreen antifreeze, windscreen washer fluid, isopropyl alcohol,
 - Degreaser, contact spray (e.g. WD40),
 - Battery acid, NPK fertiliser and urea nitrogen,
- Resistance to UV radiation,
- Compliance with the REACH Regulation [1907/2006/EU],
- Fulfilment the RoHS Regulation [2011/65/EU] and lead-free.
- Scratch-resistant grain and do not release any hazardous substances.

All materials that are using internally, e. g. the control board, are selected with the following aspects in mind:

- Compliance with the REACH Regulation [1907/2006/EU].
- Fulfilment the RoHS Regulation [2011/65/EU] and lead-free.

4. Product-specific information

4.2.3 Integrated LED configuration



An integrated LED enables the functional status of the tilt sensor to be monitored.

Figure 3

| System operation | Mode | Colour |
|-----------------------|-----------------|--------|
| Not operating | Off | - |
| Booting / Activation | Continuously on | Yellow |
| Normal operation | Continuously on | Green |
| Communication stopped | Continuously on | Red |
| Error information | Flashing | Yellow |

Table 2

LED status

| LED | Sensor | Cause | Remedy |
|-----------------|--------|---|------------------------------|
| Red constant | N6/N7 | CAN Bus Off Error | Rectify error in CAN network |
| | | CAN has incorrect baud rate set | Check CAN baud rate |
| | | Sensor defective | Contact elobau |
| Yellow constant | N7 | Filter not initialised | Sensor reset |
| | | Too much vibration when sensor starts | Lower vibrations |
| Yellow flashing | N7 | Maximum rotation speed exceeded | Increase measuring range |
| | | Maximum acceleration exceeded | Increase measuring range |
| | | Sensor temperature too low/high | Check ambient temperature |
| | | Sensor input voltage too low/high | Check voltage |
| off | N6/N7 | Sensor temperature clearly too low/high | Check ambient temperature |
| | | Sensor input voltage clearly too low/high | Check voltage |
| | | Sensor defective | Contact elobau |

Table 3

4.3 Electrical data

| N6SA ⁽¹⁾ | N6SC ⁽¹⁾ | N7DC ⁽¹⁾ | N7DA ⁽¹⁾ | Description |
|---------------------|---------------------|---------------------|---------------------|--|
| x | x | x | x | EMC conformity in accordance with the current off-highway standards (chapter 2.3 "Conformity") |
| x | x | x | x | Ideally suited for use in harsh environmental conditions: <ul style="list-style-type: none"> • Temperature range: -40 - +85 °C • Protection type: IP67K / IP6K9K • Robust housing |
| x | x | x | x | Large supply voltage range 8 VDC - 36 VDC |
| x | x | x | x | Compact design for use in tight installation situations |
| x | x | x | x | Application-specific configuration by means of parametrisation |
| x | x | x | x | Modular connector principle (Deutsch connector, 1x M12 connector, 2x M12 connector - daisy chain) |
| x | x | x | x | 1-axis and 2-axis tilt sensor |
| | | x | | Use as an acceleration or angular rate sensor |
| x | | | x | Analogue output signals 4 mA - 20 mA or 0.5 V - 4.5 V ⁽²⁾ |
| | x | x | | Convenient CANopen or SAE J1939 interface |
| x | x | x | x | Output signals in combination with relay outputs |
| | | x | x | Initial measurement unit (IMU) consisting of accelerometer and gyroscope <ul style="list-style-type: none"> • Dynamic applications • Compensation of external accelerations • Fast response time • Intelligent sensor fusion filter |
| | x | x | | Diagnosis, updating, flashing or troubleshooting via UDS 14229 |
| x | x | x | x | CO ₂ neutral production - Made in Germany |
| x ⁽¹⁾ | x | x | x ⁽¹⁾ | Programmable parameters: <ul style="list-style-type: none"> • Zero point adjustment • Switch-on/switch-off delay • Hysteresis • Switching points • Connection type • Signal path • Measuring range • Cut-off frequency • Coordinate system |
| x | x | x | x | Diagnostic function |

Table 4

(1) Factory configurable

(2) Signal outputs can be scaled by configuration, e. g. 0 V - 10 V or 0 mA - 20 mA signal (see "Detection of the position in relation to the reference plane" page 23).

4. Product-specific information



Information!

Consult elobau in the event of deviations from the permissible technical data. Validation performed by testing.

4.4 Signal flow

Below is a signal flow diagram from the raw data to the output signals.

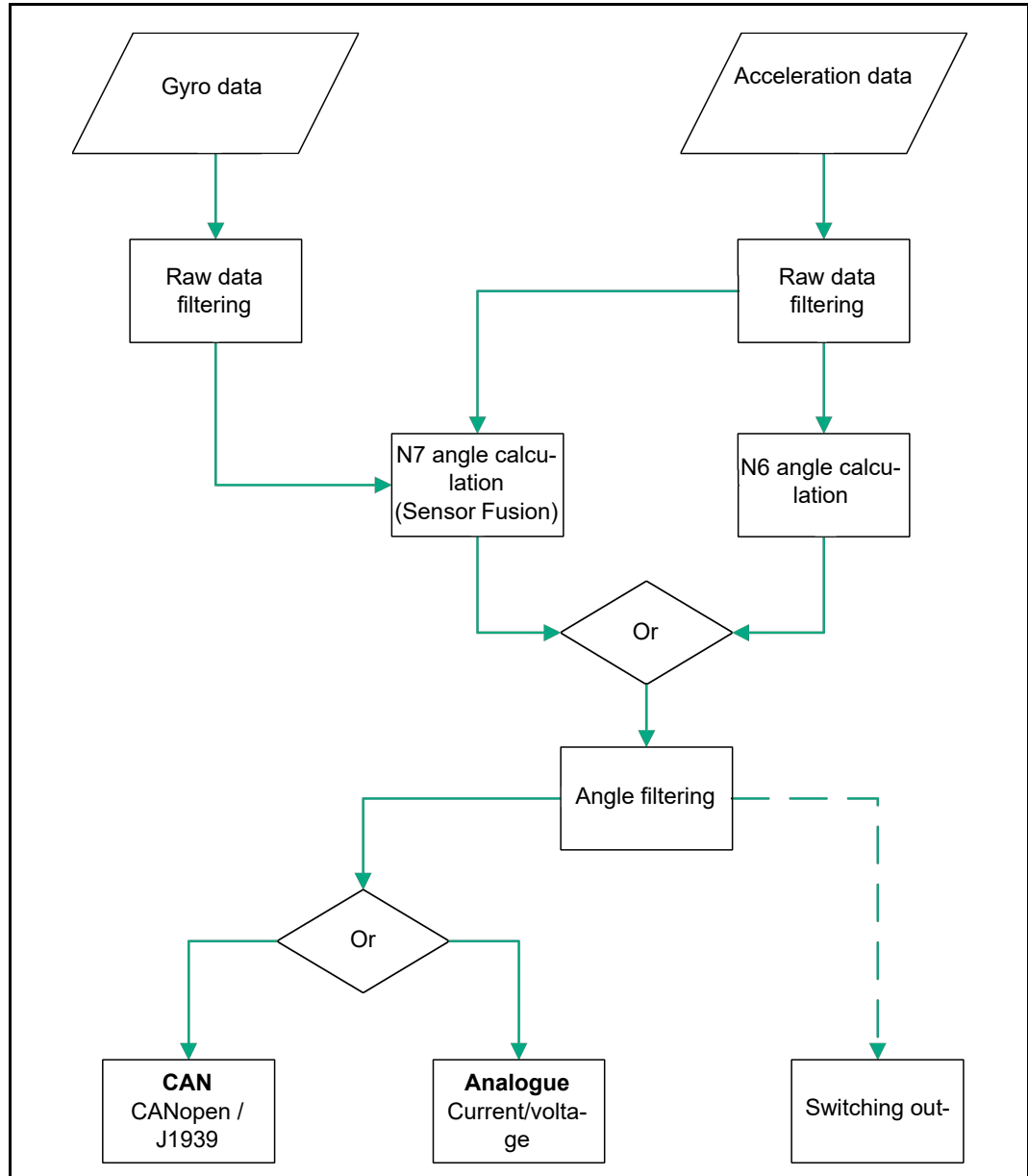


Figure 4

4.5 Output signals

The tilt sensor N6/N7 has three interfaces via which it can provide tilt information. Currents or voltages can be output via the analogue output in proportion to the angle. Alternatively, the calculated angles can also be sent via CAN, whereby the CANopen and J1939 protocols are available.

In addition, the tilt sensor offers two switching outputs for variants with a Deutsch connector, the switching thresholds of which can be set at the factory and at the customer's location (only with CAN) (see "Relay switching outputs" page 19).

4.5.1 Analogue output signals

The standard signal range is shown in the following tables. Other configurations are possible on request.

| Output signal | Error signal |
|---------------|--------------|
| 4 mA - 20 mA | 22 mA |
| 0.5 V - 4.5 V | 5 V |

Further technical details can be found in the relevant data sheet for your configuration.

Table 5

Z-axis output characteristics

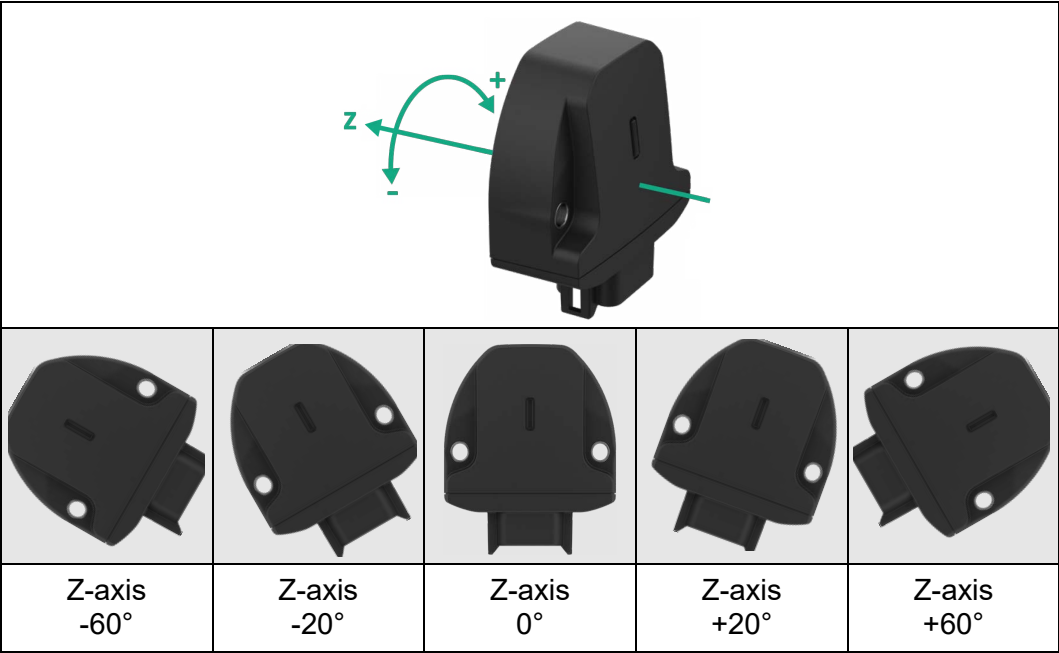


Figure 5

CAN: Z = Roll

Measuring range $\pm 60^\circ$ - vertical mounting (Z-axis)

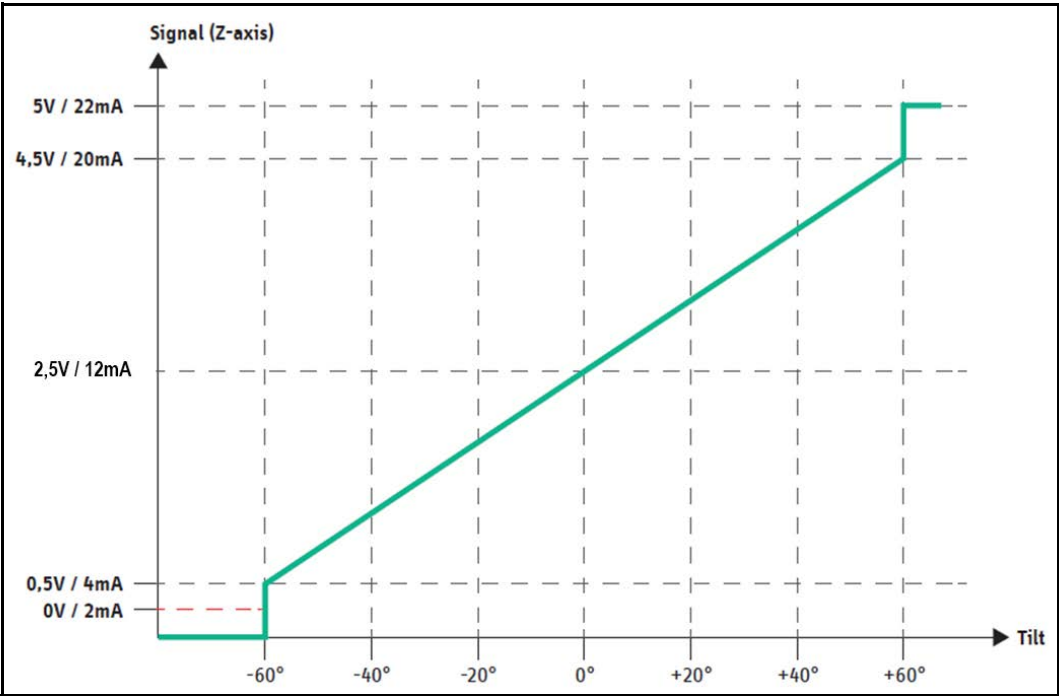


Figure 6

4. Product-specific information

X/Z-axis output characteristics

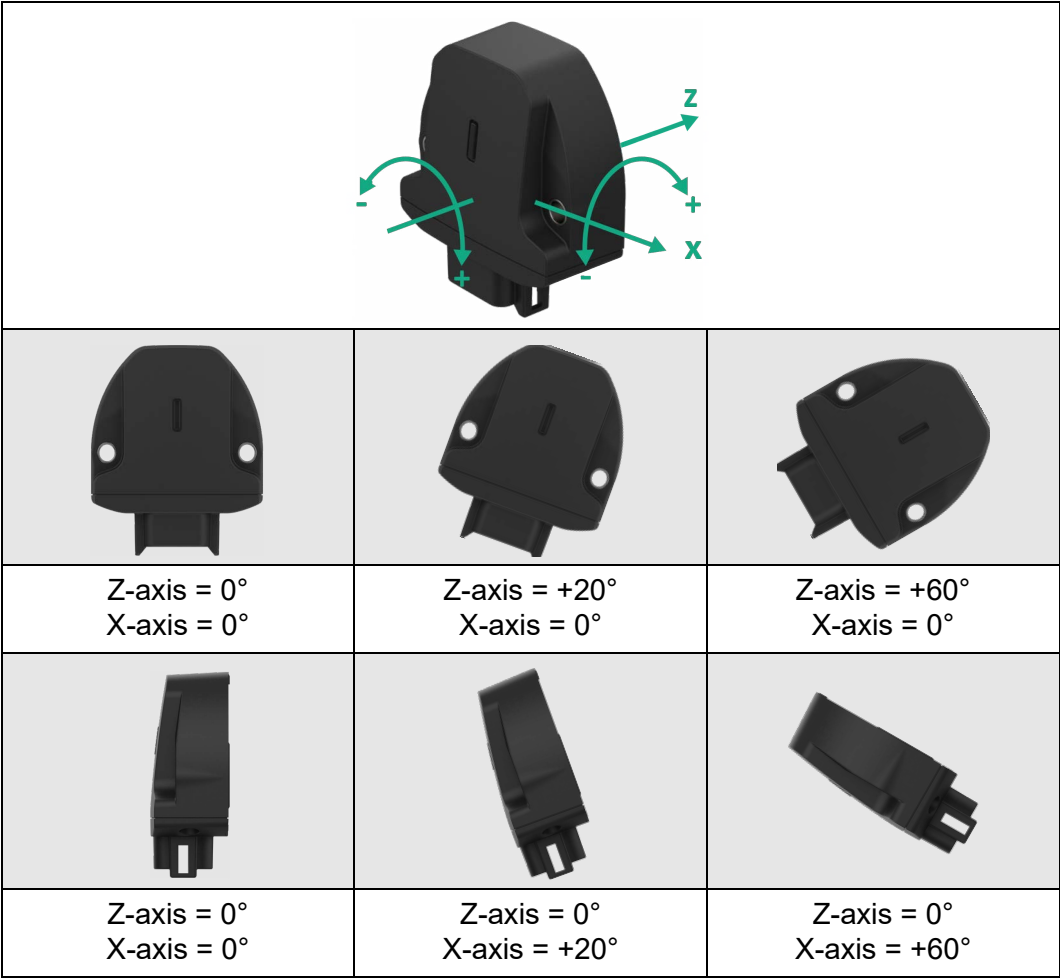


Figure 7
CAN: Z = Roll, X = Pitch

Measuring range ±60° - vertical mounting (X/Z-axis)

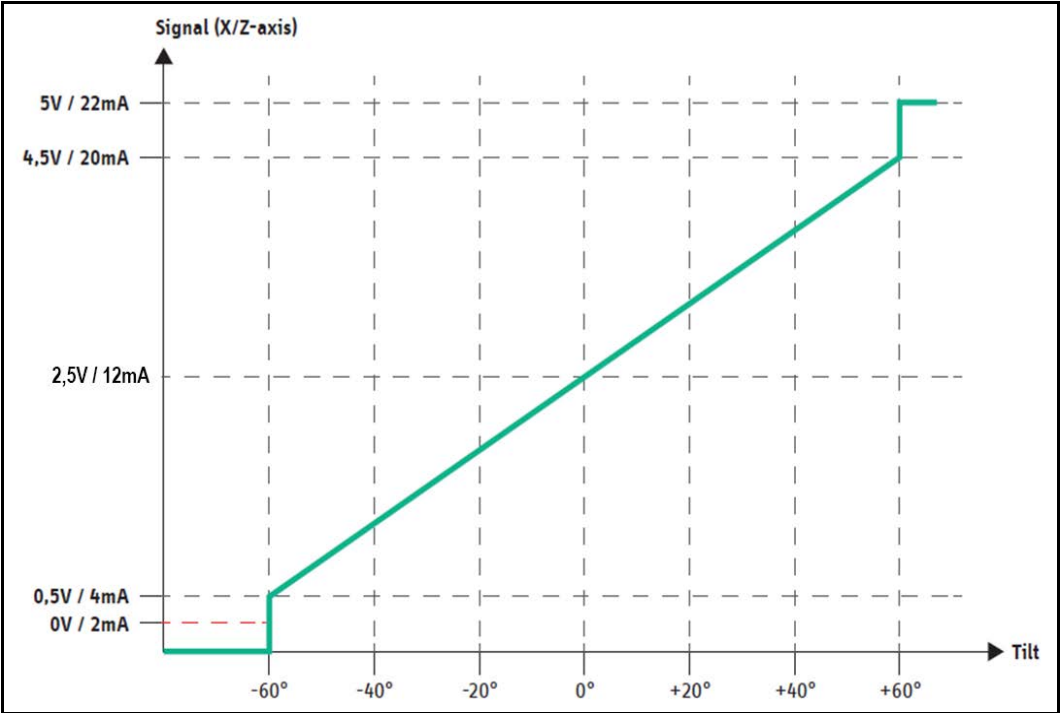


Figure 8

X/Y-axis output characteristics

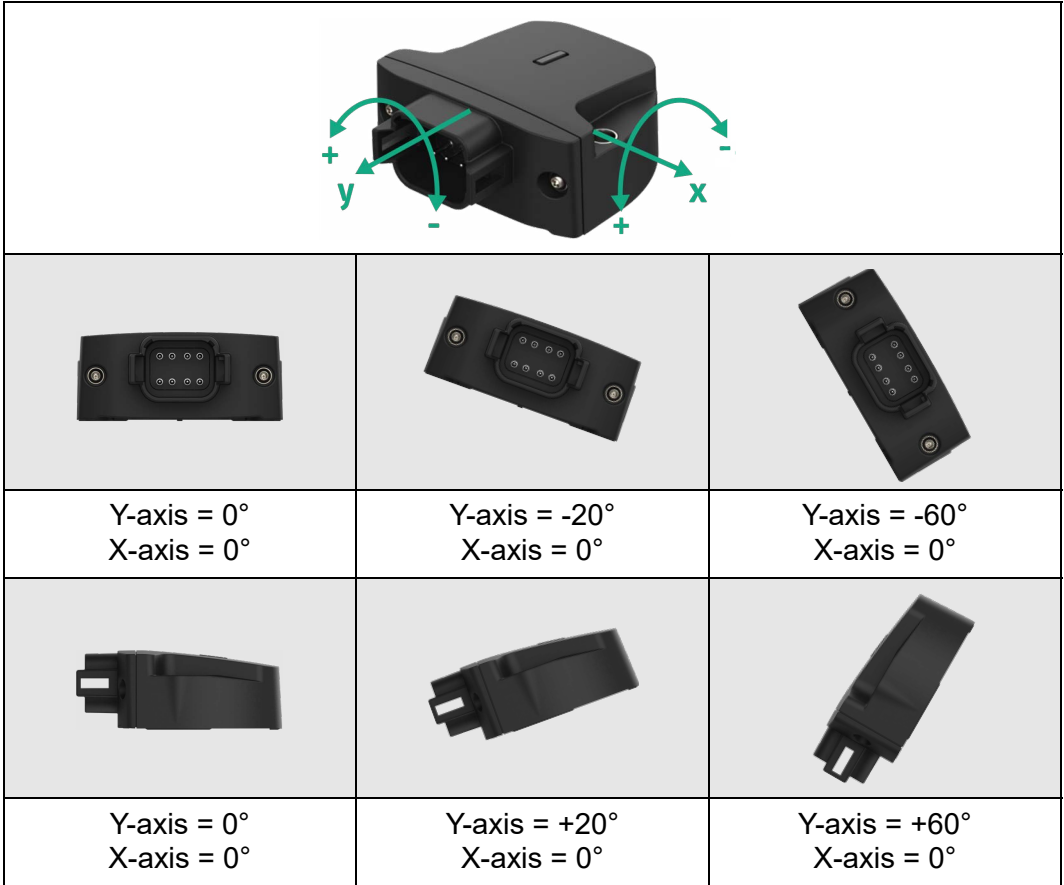


Figure 9

CAN: Y = Roll, X = Pitch

Measuring range $\pm 60^\circ$ - vertical mounting (X/Y-axis)

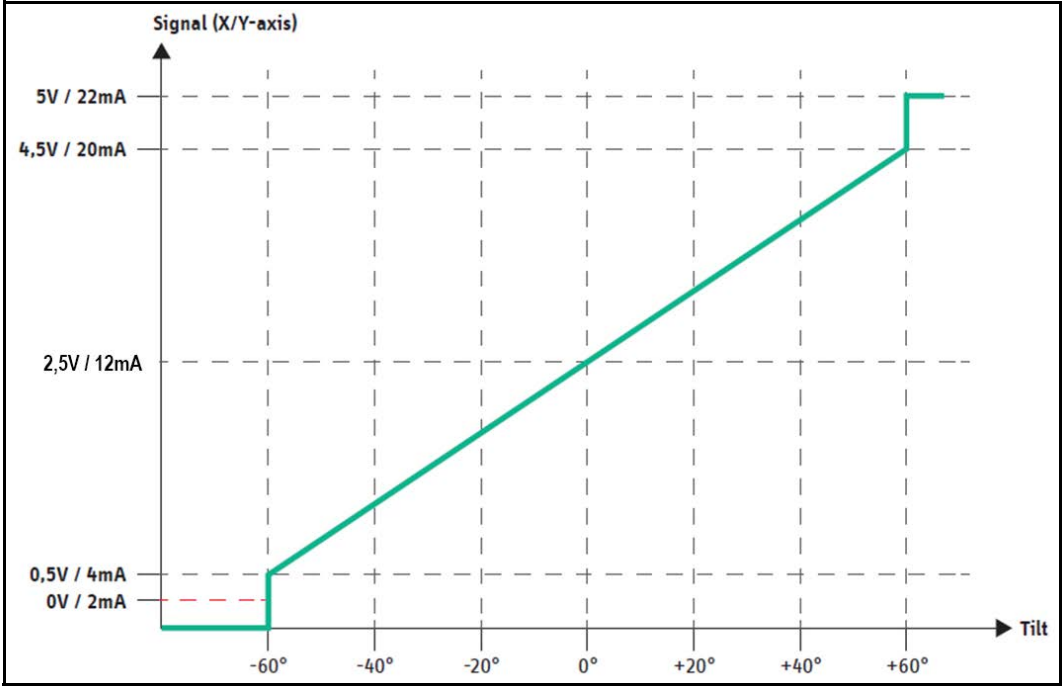


Figure 10

4. Product-specific information

Derating curve The derating curve describes the maximum permissible operating voltage of the tilt sensor depending on its ambient temperature in variants with a current output.

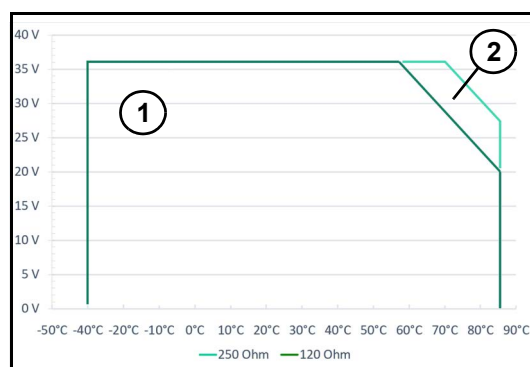


Figure 11

1. Permissible operating range with a load resistance of $R_L = 120 \Omega$.
2. Permissible operating range with a load resistance of $R_L = 250 \Omega$.

Example:

With a selected load resistance of $R_L = 250 \Omega$, the tilt sensor may be operated at an ambient temperature of up to 70°C with an operating voltage of $U_B = 36\text{ V}$. To operate at an ambient temperature of up to 85°C , the operating voltage must be reduced up to $U_B = 27.4\text{ V}$.

Note Only operate the tilt sensor N6/N7 within the permissible operating range. If operated outside the permissible operating range, a function is no longer guaranteed and can destroy the tilt sensor under certain circumstances.

4.5.2 Adaptation of analogue signals

The analogue output signals can be adapted independently of each other for each signal output, taking into account the following rules:

- The mapping always results in linear output behaviour. Non-linear mappings are not supported.
- The mapping allows you to set the tilt range of interest (e. g. $\pm 30^\circ$). Ranges that are not symmetrically tilted to zero are also supported.
- The mapping enables the use of any part of the analogue signal output (e. g. 0.5 V to 4.5 V).
- The mapping enables a negative gradient (e. g. falling with increasing tilt).

The following illustration shows the standard output signal design for a signal output and two customised output signals as examples.

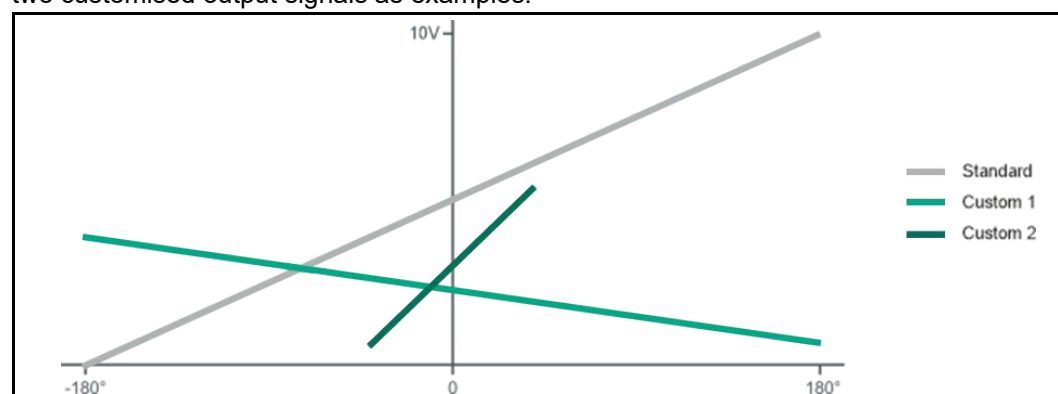


Figure 12

| Examples | Angle range | Output voltage |
|-------------------------|--------------------------|-----------------------------|
| Standard | $-180^\circ - 180^\circ$ | $0\text{ V} - 10\text{ V}$ |
| Custom 1 ⁽¹⁾ | $-180^\circ - 180^\circ$ | $4\text{ V} - 0.5\text{ V}$ |
| Custom 2 ⁽¹⁾ | $-30^\circ - 30^\circ$ | $0.5\text{ V} - 6\text{ V}$ |

Table 6

⁽¹⁾ Configurable on request

4.5.3 CAN output

All information on CAN output can be found at chapter 6. "CANopen | J1939 interface".

4.6 Relay switching outputs

The switching outputs offer a simple option of communicating the exceeding of an angle threshold of a connected evaluation unit. 4 switching thresholds per axis are available which can be assigned to the two relays.

| N6SA | N6SC | N7DC | N7DA | | |
|------|------|------|------|-------------------|--|
| x | x | x | x | Switching output | 2x NC contact (NO contact on request) |
| x | x | x | x | Switching voltage | 36 V DC (max.) |
| x | x | x | x | Switching current | 1 A (max.) |
| x | x | x | x | Switching power | 30 W (max.) |
| x | x | x | x | Hysteresis* | 0.1° - 10° |
| x | x | x | x | Switch-on delay* | Selectable (0 - 2 s in 0.5 s increments) |
| x | x | x | x | Switch-off delay* | Selectable (0 - 2 s in 0.5 s increments) |

Table 7

* The values listed can be configured ex works.

4.6.1 Connection types of the relay outputs

Installation position vertical mounting (Z-axis)

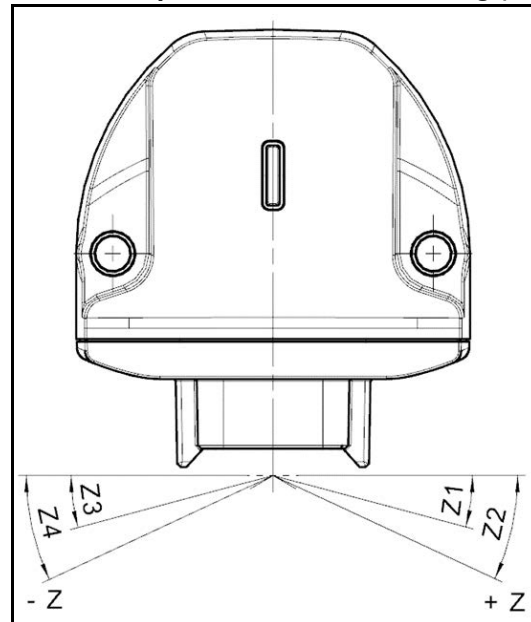


Figure 13

4. Product-specific information

Possible linking types for vertical mounting (Z-axis):

| Linking type | Relay linking |
|--------------|------------------------------------|
| B8 | Relay 1 = Z1/Z3 Relay 2 = Z2/Z4 |
| B9 | Relay 1 = Z1 Relay 2 = Z3 |

Table 8

Installation position vertical mounting (X/Z-axis)

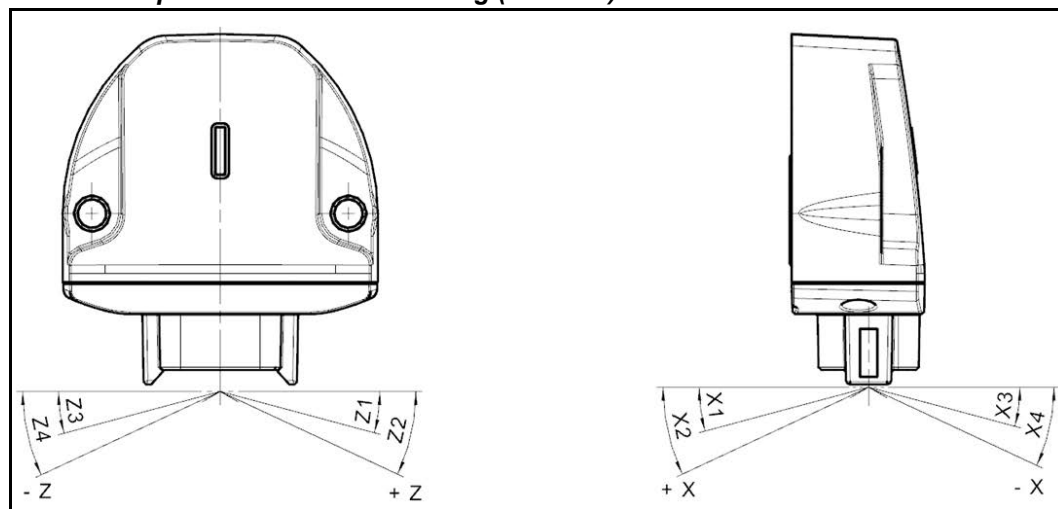


Figure 14

Possible linking types for vertical mounting (X/Z-axis):

| Linking type | Relay linking |
|--------------|--|
| B1 | Relay 1 = X1/X3 Z1/Z3 Relay 2 = - |
| B2 | Relay 1 = X1/X3 Relay 2 = Z1/Z3 |
| B3 | Relay 1 = X1/X3 Z1/Z3 Relay 2 = X2/X4 Z2/Z4 |
| B4 | Relay 1 = X1/X3 Relay 2 = X2/X4 |
| B6 | Relay 1 = X1 Relay 2 = X3 |
| B8 | Relay 1 = Z1/Z3 Relay 2 = Z2/Z4 |
| B9 | Relay 1 = Z1 Relay 2 = Z3 |

Table 9

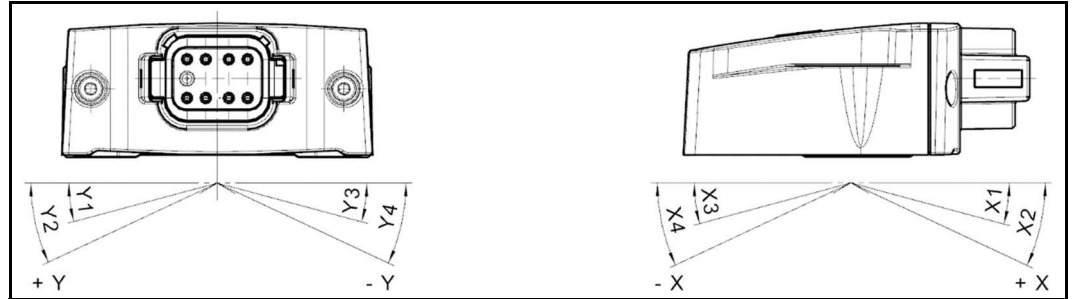
Installation position horizontal mounting (X/Y-axis)

Figure 15

Possible linking types for horizontal mounting (X/Y-axis):

| Linking type | Relay linking |
|--------------|--|
| B1 | Relay 1 = X1/X3 Y1/Y3 Relay 2 = - |
| B2 | Relay 1 = X1/X3 Relay 2 = Y1/Y3 |
| B3 | Relay 1 = X1/X3 Y1/Y3 Relay 2 = X2/X4 Y2/Y4 |
| B4 | Relay 1 = X1/X3 Relay 2 = X2/X4 |
| B6 | Relay 1 = X1 Relay 2 = X3 |
| B8 | Relay 1 = Y1/Y3 Relay 2 = Y2/Y4 |
| B9 | Relay 1 = Y1 Relay 2 = Y3 |

Table 10

4.6.2 Switching behaviour

The switched signalling line is always designed as a "normally closed" contact and supplies the two output signals:

- Activated (open = no signal)
- Unactivated (closed = signal)

On request, the signalling line is also available as a "normally open" contact.

Switch-off behaviour

If the power supply fails, the switched signalling line switches to "Unactivated".

4. Product-specific information

Switching delay

A switching delay of 0 s to 20 s can be configured for the signal output of the switched signal line. This delay can be configured separately for

- “delay on”.
The switchover is performed within the configured time period after the trigger condition occurs.
- “delay off”.
The last signal for the configured time period is held after the next trigger condition has occurred.

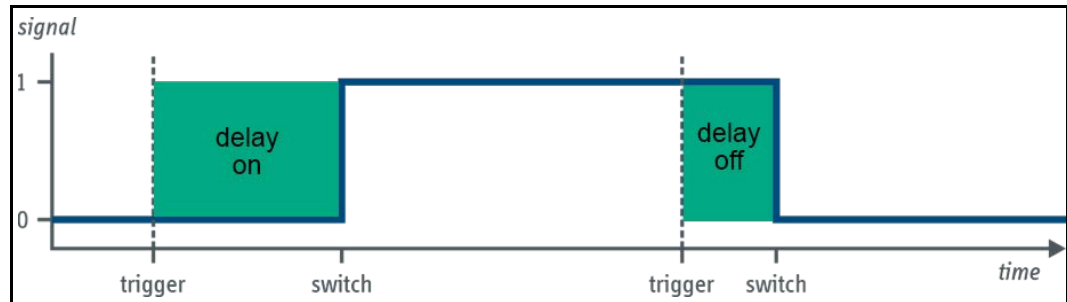


Figure 16

Calculation of the switching signal line trigger

The trigger condition for a switched signal output is calculated using a logical equation. The following rule applies:

$$Trig = (Ax1CondA \wedge or \vee Ax1CondB) \wedge or \vee (Ax2CondC \wedge or \vee Ax2CondB)$$

- The trigger condition is a logical combination of up to four individual slope conditions (CondA to CondD).
- A slope condition can be set or hidden.
- Two of the tilt conditions refer to the first axis of the tilt plane, the other two tilt conditions refer to the second axis of the tilt plane.
- The two trigger conditions that refer to an axis of the tilt plane can be logically ANDed or ORed.
- The tilt conditions of one axis can be ANDed or ORed with the tilt conditions of the other axis.

Example of a trigger condition that uses a single tilt condition:

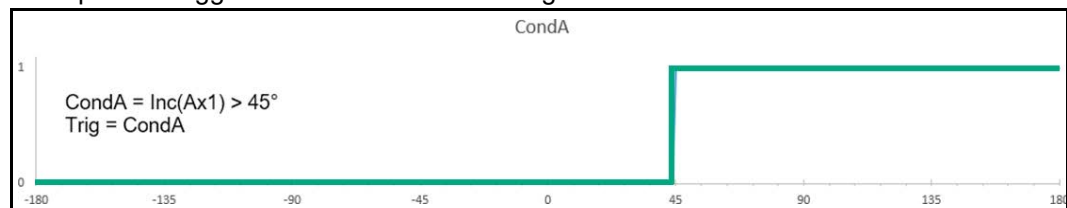


Figure 17

Example of a trigger condition that uses two ORed tilt conditions:

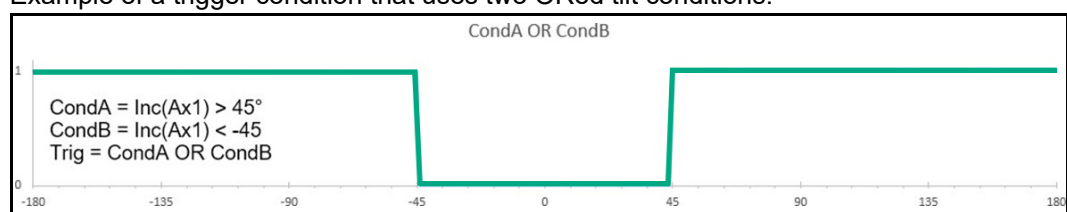


Figure 18

Below is an example of a trigger condition that uses two tilt conditions of each axis, combined with an OR. The result is a switched signal output that is triggered when the N6/N7 device is tilted by more than 45° in either direction.

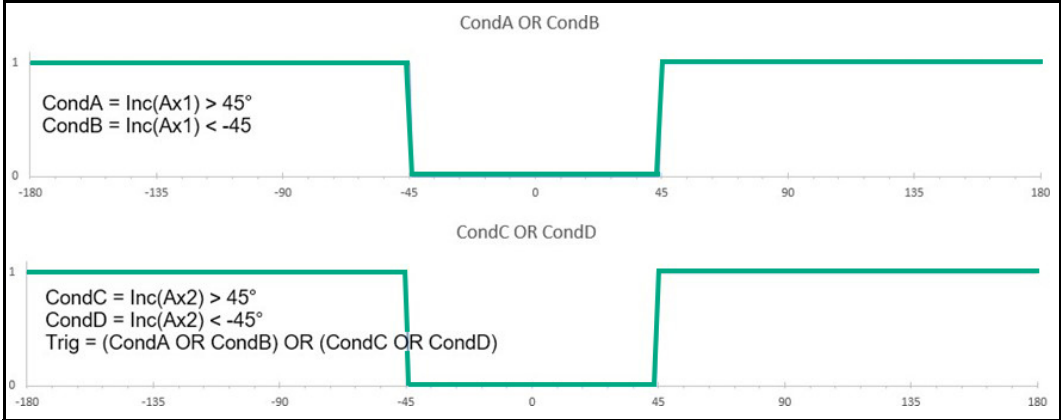


Figure 19

4.7 Behaviour of output signals

The system offers the following angle measurement ranges:

| State | Range | Remark |
|-------------|--|---|
| Single axis | +/- 180° | Endless fluctuation supported |
| Double axes | First tilt axis: +/- 180° Second tilt axis: +/- 90° | Endless changeover of the first axis supports dynamic assignment of first/second axis |

Table 11

4.7.1 Detection of the position in relation to the reference plane

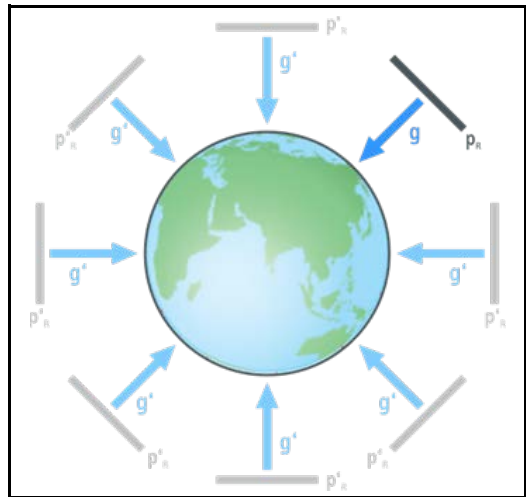


Figure 20

To obtain information about its tilt to the surroundings, the system detects the earth's gravity vector g (Figure 20). The sensor calculates the tilt angle from the standard reference plane orthogonal to the earth's gravity vector and the alignment of the sensor.

4.8 Filter

Tilt sensors are based on an indirect measurement of the tilt due to the earth's gravitational field. Parasitic accelerations, e. g. due to vibrations and lateral acceleration, influence the function of the sensor due to the principle of operation.

4. Product-specific information

The tilt sensor offers the option of making the angle value less sensitive to external, disruptive vibrations. By adjusting the integrated filters, the sensor can be specifically adapted to an application (see “Setting options Filtering for raw data and angle signals” page 34).

A distinction is made between two basic filters:

4.8.1 Low-pass filter (N6)

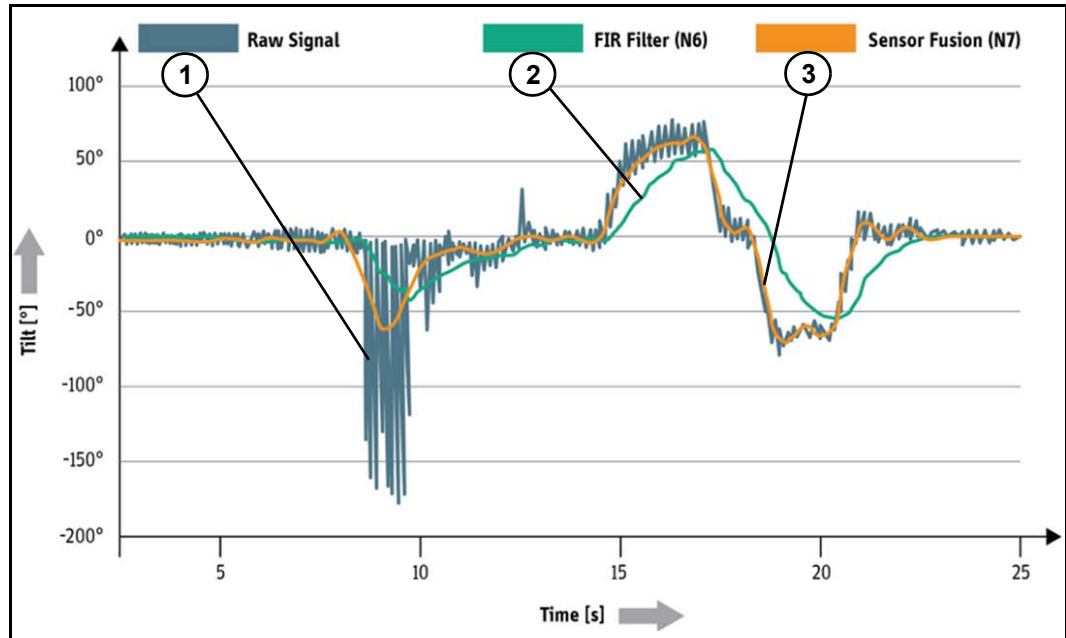


Figure 21

In Figure 21 it can be seen that the sensor fusion filter (orange line) reacts more precisely and faster to the raw signal (grey line) than the FIR filter (green line). This is made possible by a combination of the filters described below.

The N6 tilt sensor offers various options for smoothing the angle signal and making it more robust against vibrations. There are two different types of filter that can be selected at two points in the signal flow (Figure 4): a mid-pass filter or a low-pass filter. The first point is the filtering of the raw data (acceleration data). The filtering of the calculated angles forms the second point. The filters can be set independently of each other at both points.

The averaging filter allows you to set the length of the averaging process. In raw data filtering, the number 400 means averaging over one second. Equivalently, the number 200 is set for angle filtering in order to filter one second.

A FIR filter with a Blackman-Harris window is implemented as a low-pass filter, which is optimally suited for smoothing the angular signal. This filter offers the option to set the filter length and the cut-off frequency. The filter length behaves in the same way as the average value filter.

More information about the filter settings can be found in chapter 6.2 “Setting options Filtering for raw data and angle signals”.

4.8.2 Sensor fusion filter (N7)

Tilt sensors are subject to rapid movements, diffuse accelerations, jerky impacts or various vibrations in any dimension, particularly in mobile machinery applications. Tilt sensors with only low-pass filters do not reliably suppress such interference. (See also Figure 21).

In addition to the earth's gravitational field, the sensor fusion filter also utilises the rotation rate information from a gyroscope as an additional measured variable. By combining both measured variables, parasitic accelerations can be successfully suppressed without the tilt information being subject to a noticeable time delay (Kalman filter).

Typical application scenarios:

- Dynamic applications in mobile machinery
- Measurements with the smallest possible time delay in the output signal
- Measurements when cornering
- Measurements during acceleration/braking processes

5. Installation and putting into service

5.1 Installation



ACHTUNG!

Danger due to incorrect installation!

The tilt sensor may be damaged by excessive impacts and vibrations. The housing must not be subjected to torsional forces or other mechanical loads.

- Ensure that the tilt sensor is only installed by specially trained, authorised personnel.
- Avoid hitting the housing. If possible, protect housing using additional measures (enclosure).

Installing the tilt sensor

1. Remove the tilt sensor from the packaging.
2. Check the tilt sensor for damage.
3. Install the tilt sensor on a level surface (free from mechanical strains or stresses).
Do not exceed the maximum tightening torque of the fastening screws.

✓ **Tilt sensor is attached and can be connected.**

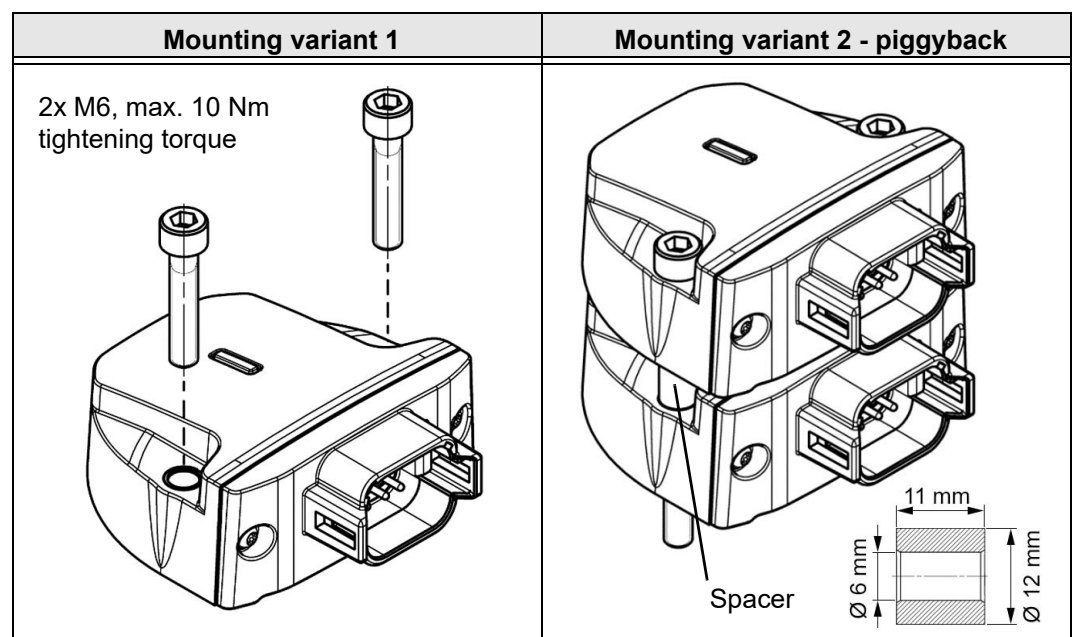


Figure 22

Figure 23

ACHTUNG!



Danger due to incorrect installation!

When mounting two identical tilt sensors as a piggyback variant, damage can occur due to the application of force.

- Only mount tilt sensors as a piggyback if spacers are used between the two tilt sensors!

5.2 Mounting position

The tilt sensors N6/N7 can be placed on the machine flexibly to suit the application. However, the aspects under chapter 7.2 "Performance-Influencing factors", page 52 must be taken into consideration.

The sensors can be ordered for horizontal and vertical installation positions. The difference is where the zero point of the angle measurement is seen. Further information about this can be found in chapter 4.5.1 "Analogue output signals", page 15.

If the tilt sensor cannot be mounted in the desired zero position, this can be remedied via the offset setting (chapter 5.5.2 "Offset setting", page 31), or via the zero point adjustment (chapter 5.5.1 "Zero point adjustment (teach process)", page 30).

5.3 Raw data

The tilt sensor N7* can also output the raw data of the MEMS sensors in addition to the tilt angle and status information. This raw data is the acceleration and rotation rate which is output via its own CAN messages (see chapter 9.1 "Parameter configuration J1939", page 55 and chapter 9.2 "Parameter configuration CANopen" page 60).

The measuring ranges of the acceleration and rotation rate sensors can be adjusted in order to optimally adapt the tilt sensor to the respective application. These can be configured via UDS or CANopen.



Information

Changing the measuring range of the raw data also influences the angle calculation! Therefore, this function is only recommended for experts or if the angle output is not used.

5.3.1 Acceleration | Measurement axes (N7DC*)

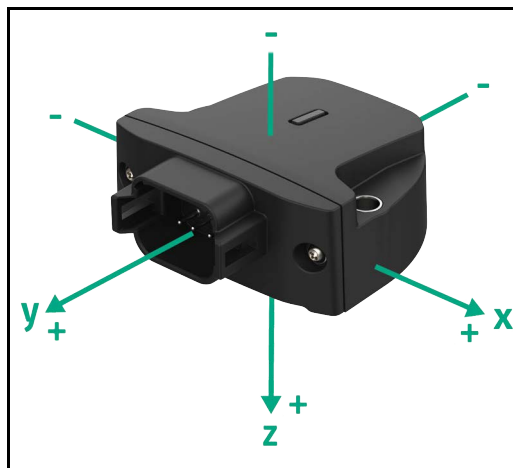


Figure 24

The acceleration values are output with the standard alignment as shown in the following illustration.

Adjustable measuring ranges:

- ± 2 g
- ± 4 g
- ± 8 g (default)
- ± 16 g (max)

5.3.2 Rotation rate | Measurement axes (N7DC*)

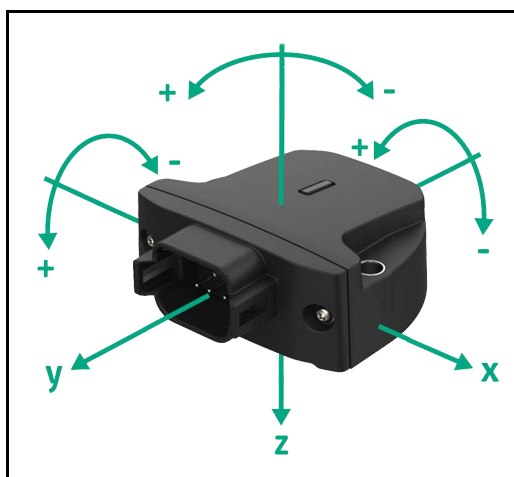


Figure 25

The rotation rate values are output with the standard alignment as shown in the following illustration.

Adjustable measuring ranges:

- $\pm 15.125 \text{ }^\circ/\text{s}$
- $\pm 31.25 \text{ }^\circ/\text{s}$
- $\pm 62.5 \text{ }^\circ/\text{s}$
- $\pm 125 \text{ }^\circ/\text{s}$
- $\pm 250 \text{ }^\circ/\text{s}$ (default)
- $\pm 500 \text{ }^\circ/\text{s}$
- $\pm 1000 \text{ }^\circ/\text{s}$
- $\pm 2000 \text{ }^\circ/\text{s}$

5.4 Electrical connection

For electrical connection to a supersystem, the tilt sensor provides a connector on the rear as an electrical interface.

The following illustration shows the various connector options.

| M12 connector 1x 5-pole | M12 connector 2x 5-pole | Deutsch connector 8-pole. (DT06-8S) |
|-------------------------|-------------------------|--|
| | | |

Figure 26

ACHTUNG!**Danger due to errors during electrical connection!**

Electronic components can be destroyed, thereby resulting in malfunctioning of the machine, and hence, injuries to personnel or property damage.

- Please find and comply with the electrical data in the respective data sheet.
- Signal path of the output signal is depicted on the data sheet or is made available by elobau on request.
- Please pay attention to temperature drift.

Connecting the tilt sensor

1. Check voltage-free condition of all supply lines.
2. Connect the tilt sensor per the pin assignment - see connector pin assignment below.

✓ **Tilt sensor is connected and ready for setup.**

5. Installation and putting into service

5.4.1 Pin-assignment 1x M12 connector (analogue)

In the variant with analogue signal output, the system can be equipped with a M12 connector with 5 pins (Figure 26).

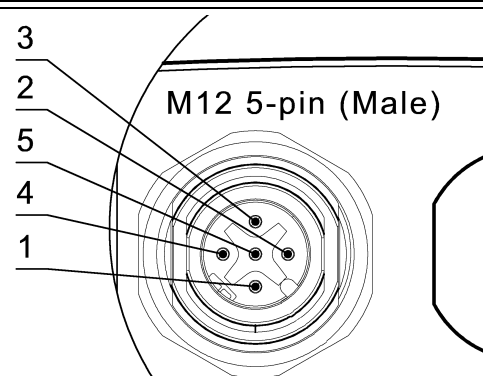
| Pin | Connection | Description |  |
|-----|----------------|-------------------|--|
| 1 | U _B | Operating voltage | |
| 2 | Out1 | Output 1 | |
| 3 | GND | Ground | |
| 4 | Out2 | Output 2 | |
| 5 | n.a. | | |

Table 12

Pin assignment based on the mounting type selected

| | | |
|---------------------|------------------|---------------------------------|
| Vertical mounting | 1-axis / Z-axis | Out1 = Z-axis |
| Vertical mounting | 2-axis / XZ-axis | Out1 = X-axis Out 2 = Z-axis |
| Horizontal mounting | 2-axis / XY-axis | Out1 = X-axis Out2 = Y-axis |

Table 13

5.4.2 PIN assignment 1x M12 connector (CAN)

In the variant with CAN signal output, the system can be equipped with a M12 connector with 5 pins (Figure 26).

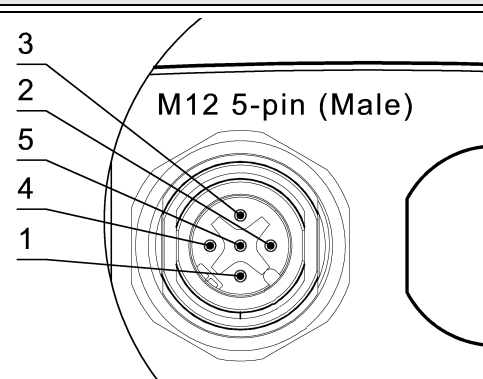
| Pin | Connection | Description |  |
|-----|----------------|-------------------|--|
| 1 | n.c. | not connected | |
| 2 | U _B | Operating voltage | |
| 3 | GND | Ground | |
| 4 | CAN_H | CAN signal line | |
| 5 | CAN_L | CAN signal line | |

Table 14

5.4.3 PIN assignment 2x M12 connector (CAN)

In the variant with CAN signal output, the system can be equipped with two M12 connector, each with 5 pins (Figure 26). This assignment is backwards compatible with existing elobau tilt sensors.

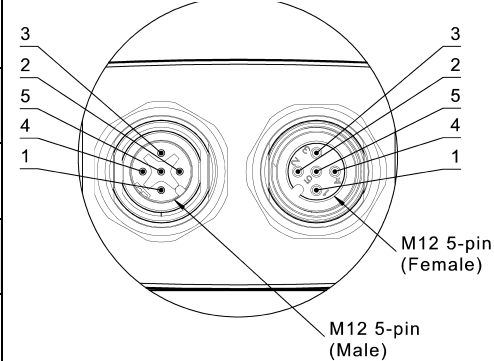
| Pin | Connection | Description | |
|-----|----------------|-------------------|--|
| 1 | n.c. | not connected |  |
| 2 | U _B | Operating voltage | |
| 3 | GND | Ground | |
| 4 | CAN_H | CAN signal line | |
| 5 | CAN_L | CAN signal line | |

Table 15

5.4.4 PIN assignment Deutsch connector (DT06-8S) 8-pole (analogue)

In the variant with analogue signal output, the system can be equipped with a Deutsch connector with 8 pins (Figure 26). This assignment is backwards compatible with existing elobau tilt sensors.

Depending on the variant, not all pins are assigned.

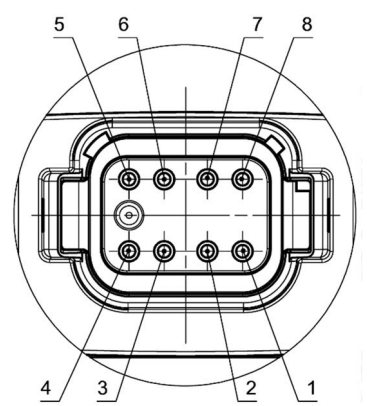
| Pin | Connection | Description | |
|-----|----------------|--------------------|---|
| 1 | U _B | Operating voltage |  |
| 2 | GND | Ground | |
| 3 | Out1 | Output 1 | |
| 4 | Out2 | Output 2 | |
| 5 | Relay1 | Switching output 1 | |
| 6 | Relay1 | Switching output 1 | |
| 7 | Relay2 | Switching output 2 | |
| 8 | Relay2 | Switching output 2 | |

Table 16

Pin assignment based on the mounting type selected

| | | |
|---------------------|------------------|---------------------------------|
| Vertical mounting | 1-axis / Z-axis | Out1 = Z-axis |
| Vertical mounting | 2-axis / XZ-axis | Out1 = X-axis Out 2 = Z-axis |
| Horizontal mounting | 2-axis / XY-axis | Out1 = X-axis Out2 = Y-axis |

Table 17

5.4.5 PIN assignment Deutsch connector (CAN)

In the variant with CAN signal output, the system can be equipped with a Deutsch connector with 8 pins (Figure 26). This assignment is backwards compatible with existing elobau tilt sensors.

5. Installation and putting into service

Depending on the variant, not all pins are assigned.

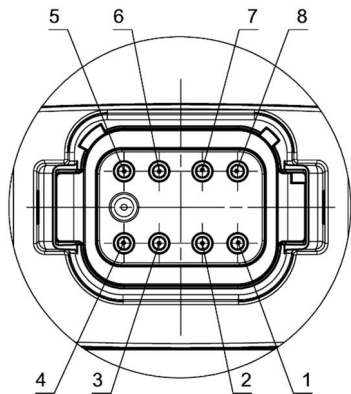
| Pin | Connection | Description |  |
|-----|----------------|--------------------|---|
| 1 | U _B | Operating voltage | |
| 2 | GND | Ground | |
| 3 | CAN_L | CAN signal line | |
| 4 | CAN_H | | |
| 5 | Relay1 | Switching output 1 | |
| 6 | Relay1 | Switching output 1 | |
| 7 | Relay2 | Switching output 2 | |
| 8 | Relay2 | Switching output 2 | |

Table 18

5.5 Offset correction

A correction of the zero point may be required depending on the positioning of the tilt sensor in the machine (offset correction).

There are two basic types of offset correction.

- The zero point adjustment is carried out after installing the sensor to the machine. The current position is set as the zero point.
- The offset setting is set ex works or via CAN and moves the zero point to a defined angle value.

5.5.1 Zero point adjustment (teach process)



Information

To ensure high accuracy of the sensor during operation, a zero point adjustment is always recommended before initial commissioning. Zero point adjustment is only possible if both axes have an angle of less than 60 degrees.

Variant with analogue signal output (Teach by Wire) - N6SA*

Zero point adjustment is only possible immediately after the power supply is applied.

Adjust zero point with analogue signal output

1. Move the tilt sensor to the final position.
2. Connect the tilt sensor to the power supply.
3. Connect signal output 1 or 2 for the duration of at least 3 s up to max. 10 s with ground.
The sensor confirms the setting of the zero point by restarting.

✓ **The current position was successfully taken into account as the zero point.**

Variant with J1939 signal output - N6SC* | N7DC*

Appropriate UDS protocols are required for zero point adjustment via CAN. See the procedure below.

Adjusting the zero point via UDS

1. Extended Diagnostic Session (0x3)
 2. Seed & Key
 3. Start routine S31 0x0103
 4. Hard reset (S11 0x1)
- The angle output returns the value "0".*

✓ **Zero point adjusted via UDS.**

Adjusting the zero point via CANopen

1. Set object 0x6012 to 0 (longitudinal)
2. Set object 0x6022 to 0 (lateral)
3. Saving in object 0x5999
4. Save sub index 0x3 via "save" (0x65766173).

✓ **Adjust the zero point via CANopen.**

5.5.2 Offset setting

On the system side, an offset value of -60° to $+60^\circ$ can be set individually for each axis via the parameterisation and added to the determined tilt information. Depending on the application and alignment of the sensor in the higher-level system, this can be advantageous.

Adjusting the offset via UDS

1. Extended Diagnostic Session (0x3)
2. Seed & Key
3. Write offset angle for roll in DID 0xF204.
4. Write offset angle for pitch in DID 0xF205.
5. Hard reset (S11 0x1)

The angle output is moved in the roll or pitch by the configured values.

Note: The unit of the register is 0.001° , i.e. 45000 must be entered for 45° .

✓ **Adjust the offset via UDS.**

5.5.3 Adjusting the offset via CANopen

Several objects are available to the user in CANopen. The following section explains which objects can be used to calculate an additional offset to the angle signal.

| Longitudinal | Lateral | Description |
|--------------|---------|---------------------------|
| 0x6010 | 0x6020 | Slope_Angle |
| 0x6011 | 0x6021 | Slope_Operating_Parameter |
| 0x6012 | 0x6022 | Slope_Preset_Value |
| 0x6013 | 0x6023 | Slope_Offset |
| 0x6014 | 0x6024 | Slope_Differential_Offset |

Table 19

5. Installation and putting into service

Slope_Operating_Parameter

| Function | Bit | 0 | 1 |
|-----------------------|-------|----------|---------|
| Inversion | 0 | disabled | enabled |
| Scaling | 1 | disabled | enabled |
| reserved | 2...4 | - | - |
| Manufacturer-specific | 5...7 | - | - |

Table 20

If scaling has been activated, the angle is calculated in the objects 0x6010 and 0x6020 according to the following equation:

$$\text{Slope_Angle} = \text{current measured value} + \text{Slope_Differential_Offset} + \text{Slope_Offset}$$

If the “scaling” parameter is deactivated, only the measured angle is output.

Slope_Preset_Value

The set angle is adjusted directly to the set value and the value in Slope_Offset is recalculated taking Slope_Differential_Offset into account.

Slope_Offset

The user can enter an optional offset.

$$\text{Slope_Offset} = \text{Slope_Preset_Value} - \text{current measured value} - \text{Slope_Differential_Offset}$$

Slope_Differential_Offset

The output angle is moved regardless of the “Slope_Preset_Value”.

5.6 Sensor behaviour when measuring range exceeded

The following settings are recommended for the various sensor variants:

| DID | Parameter | Description | Default | Min | Max | Unit | CO_IDX | CO_SUB_IDX |
|--------|------------------------------|---|---------|-----|-----|--|--------|------------|
| 0xF208 | meas_overflow_fault_reaction | How the system reacts on a measurement overflow | 4 | 0 | 5 | 0: No reaction 1: Signal SafeState (No Healing) 2: Signal SafeState (Healing) 3: System SafeState 4: Reinit Algorithm 5: Reset Sensor | 0x2003 | 0x4 |

Table 21

Note N6 In order to readjust the behaviour of the N5 with the N6 when exceeding 1:1, the error response can be changed to “no reaction”. The current angle is also calculated during the excess. This procedure, however, is not recommended.

Note N7 For the N7, only the following settings (1), (3), (4), (5) are recommended. Exceeding the measuring range results in a drift of the angle sensor over several seconds to minutes. The height of the angle deviation is dependent on the height of the excess and duration of the measuring range.

Note relay If an error was detected and also set, the relay is switched into the error state at the same time.

No reaction (0)

The sensor does not react to the excess and continues to output an angle signal.

Signal SafeState (No Healing) (1)

J1939 DM1 message is set if the measuring range is exceeded. The “figure of merit” in the CAN messages SSI, SSI2, ACCS, ARI and ePSSI1 is set to “degraded”. The sensor must be restarted in order to mark the error as inactive.

CANopen An EMCY message is sent.

Signal SafeState (Healing) (2)

J1939 DM1 message is set if the measuring range is exceeded and resets automatically as soon as the measuring range is no longer exceeded. The “figure of merit” in the CAN messages SSI, SSI2, ACCS, ARI and ePSSI1 is set to “degraded” as long as the error is active.

CANopen The EMCY message is set and reset as soon as there is no longer an error.

System-SafeState (3)

The sensor stops the functional CAN communication in the event of a measured value overflow. This means that the sensor can still be reached via diagnostics. A power-on cycle is required in order to restore sensor communication.

Reinit-Algorithm (4)

If the measured value is exceeded, the angle signal output is marked as invalid and the sensor fusion is set again in initialisation mode. The sensor must remain in a situation in which there are only low movement changes or vibrations for up to 2 seconds until the sensor goes back into operating mode.

J1939 The DM1 message is set and reset. The “figure of merit” in the messages SSI, SSI2, ACCS, ARI and ePSSI1 is also set accordingly.

CANopen The EMCY message is set and deactivated when the sensor goes back into operating mode.

Reset sensor (5)

The sensor automatically restarts if the measuring range is exceeded (as with power ON).

5.7 Putting into service**Putting the tilt sensor into operation**

1. Ensure that the electrical specifications are adhered to.

The values must never be exceeded.

2. Do not plug or unplug electrical connection whilst energised.
3. Install the entire machine in an EMC-appropriate manner.

The installation environment and cabling can influence the electromagnetic compatibility of the tilt sensor. So, install the tilt sensor and supply lines separately and at a sufficient distance from lines with a high interference level (frequency converters, contactors, etc.).

4. Connect all assigned outputs.

Non-assigned outputs must not be connected.

5. Connect the operating voltage and check the functioning of the tilt sensor.

✓ **The tilt sensor is ready for operation.**

6. CANopen | J1939 interface

The tilt sensor has standardised interfaces:

- CANopen
- J1939

The description of the respective interfaces is provided in the appendix in chapter 9.1 "Parameter configuration J1939" and chapter 9.2 "Parameter configuration CANopen".

Functional description

The tilt sensor provides tilt information via the CAN bus. In addition, two relays can be actuated independently of various defined switching points per axle, optionally with configurable switching delays and hysteresis.

CAN data

| CAN | ISO 11898, CAN specification 2.0A/2.0B | |
|--------------------|---|---------------------------|
| Protocol | CANopen | J1939 |
| Baud rate | 20 kbit/s - 1000 kbit/s 250 kbit/s (default) | |
| Transmission cycle | 10 ms...2000 ms 10 ms (default) | |
| J1939 Source | | 92 – 237 226 (default) |
| CANopen NodeID | 0 – 127 32 (default) | |

Table 22

6.1 Bus terminating resistor



Information

A terminating resistor must be present on the end of the network. The elobau tilt sensor does not have an internal terminating resistor.

6.2 Setting options Filtering for raw data and angle signals

The filter unit contains an average value filter or a vibration filter (FIR filter), which can be applied to the raw data and to the angle signals.

Raw data and angle filtering

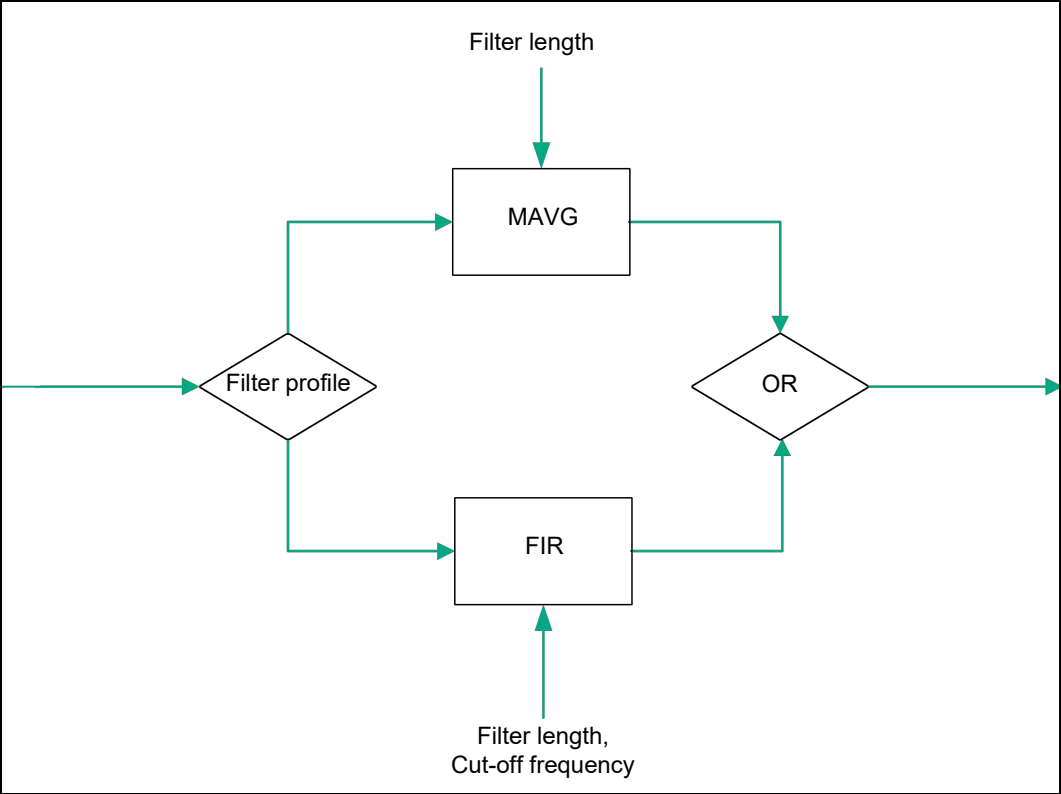


Figure 27

| CANopen | | | | | | | |
|--------------------|----------------|-----------|-------------------------|---------|------|-------|--|
| UDS 0x... | Index 0x... | Sub-index | Description | Default | Min. | Max. | Unit |
| Raw data filtering | | | | | | | |
| F215 | 2001 | 0x3 | Filter profile | 0 | 0 | 1 | 0: Low-pass filter with Blackman-Harris window 1: Moving average filter |
| F214 | 2001 | 0x2 | Filter length | 32 | 12 | 1024 | 2.5 ms |
| F213 | 2001 | 0x1 | Cut-off frequency [mHz] | 0 | 0 | 25000 | 0.001 Hz |
| Angle filtering | | | | | | | |
| F212 | 2000 | 0x7 | Filter profile | 0 | 0 | 1 | 0: Low-pass filter with Blackman-Harris window 1: Moving average filter |
| F211 | 2000 | 0x6 | Filter length | 32 | 6 | 512 | 5 ms |
| F210 | 2000 | 0x5 | Cut-off frequency [mHz] | 0 | 0 | 25000 | 0.001 Hz |

Table 23

Angle data (0xF210 - 0xF212)

The calculated tilt information is then filtered using these objects.

Raw data (0xF213 - 0xF215)

These objects are used to apply the FIR filter to the raw data (acceleration and - if available - rotation rate data). The filtered values are used to calculate the tilt information.

6.2.1 Average value filter

The noise of the MEMS sensor or also interference such as vibrations can be reduced with the aid of the moving average filter MAVG. The objects (0xF211 or 0xF214) determine the filter order. Filter order 32 is defined by default.

Further object addressing can be found in chapter 9.1 "Parameter configuration J1939", page 55 and in chapter 9.2 "Parameter configuration CANopen", page 60.

6.2.2 Vibration filter

A digital low pass filter (FIR filter) is implemented in the N6 and N7 tilt sensors, in which the filter order and the limit frequency can be set.

With the objects 0xF210 or F213 (cut-off frequency), the cut-off frequency can be set between 1 Hz and 25 Hz in steps of 0.001 Hz. If the value 0 is saved, the FIR filter is deactivated (See also table 23 on page 35).

The objects (0xF211 or 0xF214) determine the filter order. Filter order 32 is defined by default.

More information about the filter and its applications can be found in chapter 4.8 "Filter", page 23.

6.2.3 Application examples

| CANopen | | | | | | |
|--------------------------|----------------|-----------|-------------------------|-----------------|------------------|------------------|
| UDS 0x... | Index 0x... | Sub-index | Description | Light vibration | Medium vibration | Strong vibration |
| Low-pass filter raw data | | | | | | |
| F215 | 2001 | 0x3 | Filter profile | 0 | 1 | 1 |
| F214 | 2001 | 0x2 | Filter length | 0 | 50 | 400 |
| F213 | 2001 | 0x1 | Cut-off frequency [mHz] | 0 | 0 | 0 |
| Low-pass filter angle | | | | | | |
| F212 | 2000 | 0x7 | Filter profile | 0 | 0 | 0 |
| F211 | 2000 | 0x6 | Filter length | 32 | 20 | 20 |
| F210 | 2000 | 0x5 | Cut-off frequency [mHz] | 5000 | 1000 | 1000 |

Table 24

The following diagrams represent a noise signal with filter examples listed in Table 24.

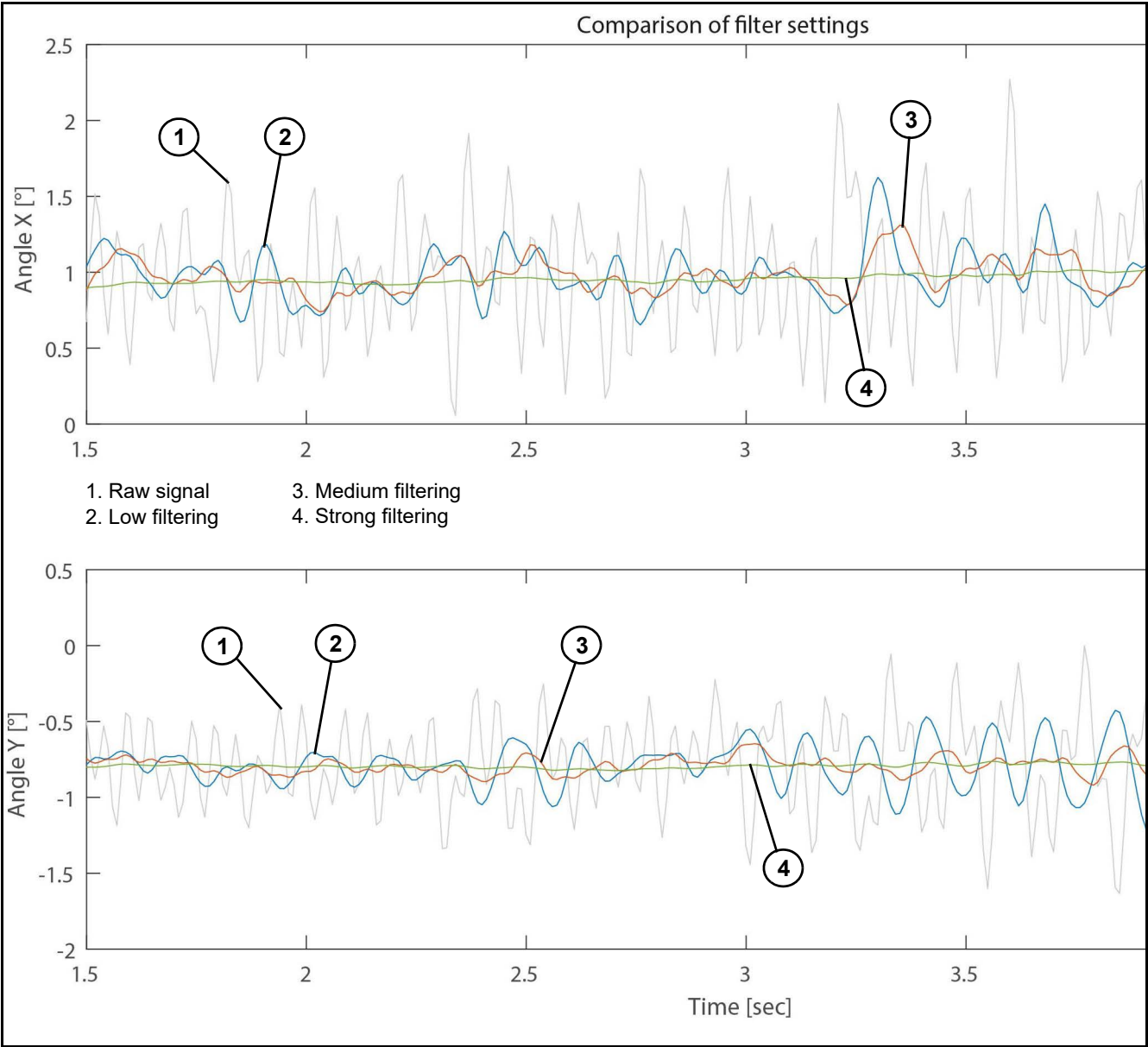


Figure 28: Noise signal with different filter settings

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The following figure shows the step response for different filter settings (see table 23 on page 35)

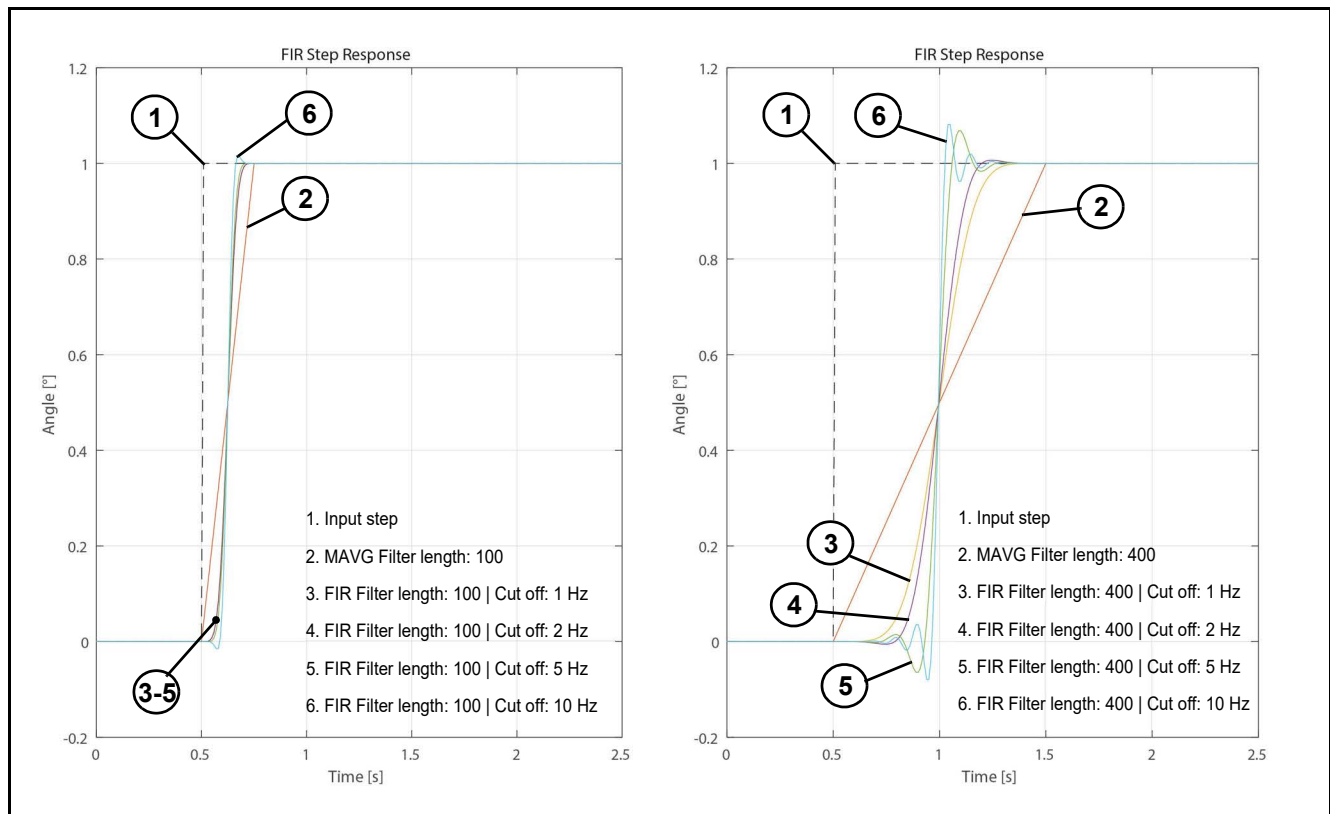


Figure 29: Step response for different filter settings

It can be seen that with increasing filter length (from 100 to 400) the delay time also increases. If both graphics are compared, it can be seen that cut-off frequency has less influences with a short filter length than with a longer one.

Figure 30 shows the frequency response of the FIR filter, as an example with a cut-off frequency of 5 Hz and different filter lengths. It can be seen that the filter slope increases with increasing filter length. However, a higher filter length also results in a greater delay (group delay) of the signal:

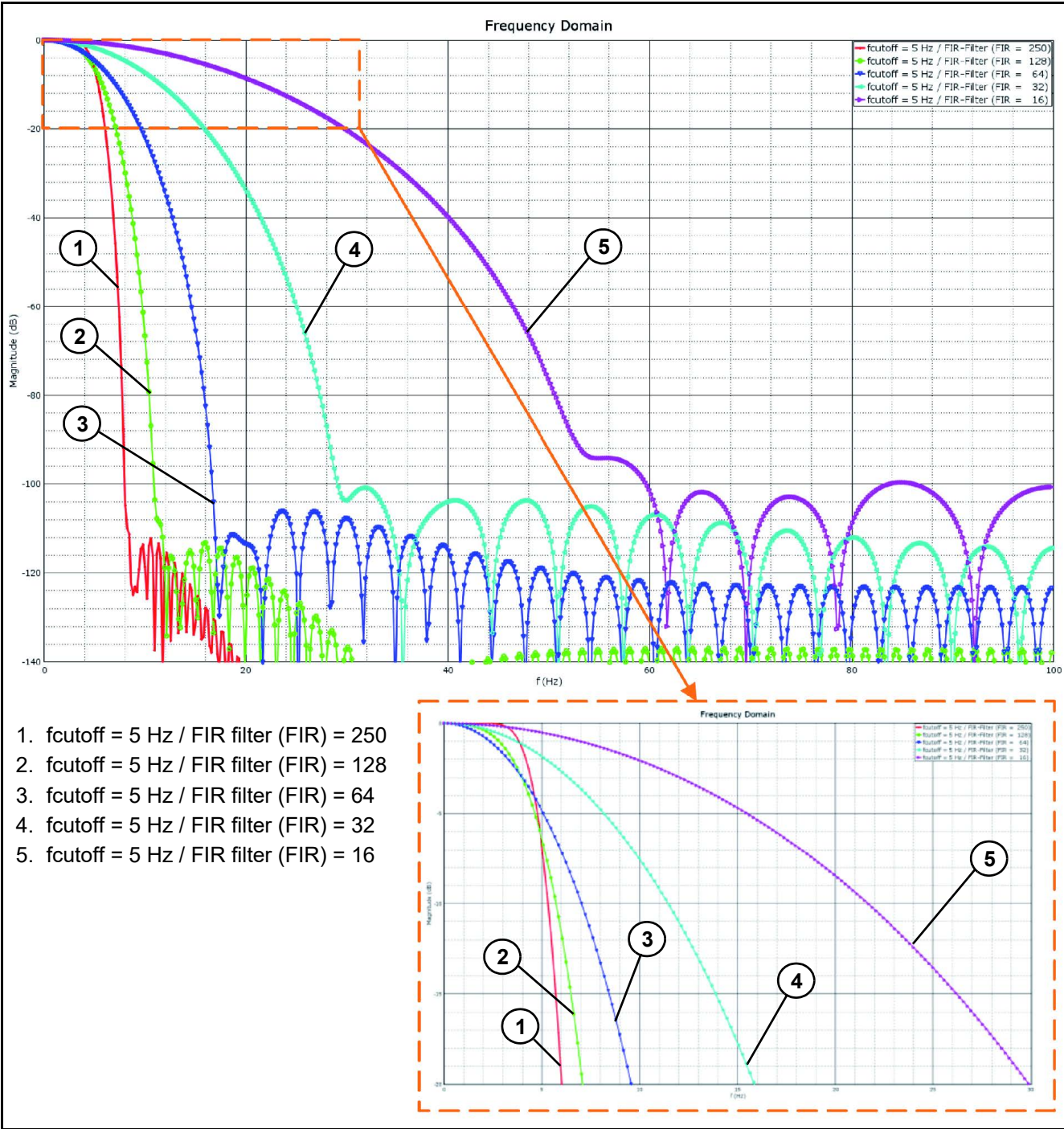


Figure 30: Representation of the FIR filter in the frequency domain

The following filter settings are defined as standard ex works:

| Parameter | Default value | Description |
|---|---------------|-------------|
| Low-pass filter cut-off frequency | 20 Hz | |
| Zero point offset (see chapter 5.5.1 "Zero point adjustment (teach process)") | 0 | Off |

Table 25

6.3 Relay switching points

The tilt sensor N6/N7 is available with up to 2 relay outputs. Up to 4 switching points can be assigned to the two outputs with the aid of different connection types. A switch-on and switch-off delay time can be defined for each of these switching points as well as a hysteresis. These settings can be made in the objects 0xF250 to 0xF282 (see chapter 9.3 "Switching output", page 70).

6.4 Messages

There are different types of CAN messages for communication with the tilt sensor. The messages and signals are described in the following chapters.

6.4.1 CANopen interface



Information

Each node-ID may only be assigned once in the network.

COB-IDs / Node-ID (standard): 32 (20h)

| Communication object | COB-ID |
|-----------------------|-----------------|
| NMT | 0h |
| EMCY | 80h + Node-ID |
| TPDO #0 | 0x180 + Node-ID |
| SDO (Client → Server) | 600h + Node-ID |
| SDO (Server → Client) | 580h + Node-ID |
| Heartbeat | 700h + Node-ID |

Table 26

TPDO #0

The transmit process data object (TPDO #0) asynchronously transmits the current position of the tilt sensor.

If the "Event Timer" is activated (object: 0x1800.5 > 0), the data are sent cyclically with the specified value of the "Event Timer" after transmitting of the status "Operational".

The data of the individual axes are sent as displayed in the following table.

The Z-axis is only used to determine the correct installation position of the tilt sensor. A constant + 1° (standard installation position) or -1° (sensor is rotated by >±90°) is sent.

| Byte | 0 | 1 | 2 | 3 | 4 | 5 |
|---------|--------------------------|---------------------------|--------------------------|---------------------------|--------------------------|---------------------------|
| Content | Angle X (low Byte) | Angle X (high Byte) | Angle Y (low Byte) | Angle Y (high Byte) | Angle Z (low Byte) | Angle Z (high Byte) |

Table 27

The Event Timer is preconfigured with a value of 10 ms. The sequence of the TPDO#0 can be adjusted upon request.

TPDO #1

In TPDO #1, the raw data of the acceleration sensor is transmitted in [g]. The data is sent under the message ID 0x280 + Node ID. The message can be activated in the object directory under the message ID 0x1801.5.

| Byte | 0 | 1 | 2 | 3 | 4 | 5 |
|---------|------------------------------|-------------------------------|------------------------------|-------------------------------|------------------------------|-------------------------------|
| Content | Acceleration Y (low Byte) | Acceleration Y (high Byte) | Acceleration X (low Byte) | Acceleration X (high Byte) | Acceleration Z (low Byte) | Acceleration Z (high Byte) |

Table 28

TPDO #2

In TPDO #2, the raw data of the gyroscope is transmitted in [°/s]. The data is sent under the message ID 0x380 + Node ID. The message can be activated in the object directory under the message ID 0x1802.5.

| Byte | 0 | 1 | 2 | 3 | 4 | 5 |
|---------|-------------------------------|--------------------------------|-------------------------------|--------------------------------|-------------------------------|--------------------------------|
| Content | Rotation Rate Y (low Byte) | Rotation Rate Y (high Byte) | Rotation Rate X (low Byte) | Rotation Rate X (high Byte) | Rotation Rate Z (low Byte) | Rotation Rate Z (high Byte) |

Table 29

**Information**

All messages are only 6 bytes long and not 8 bytes.

Heartbeat message

The “Heartbeat-Time” is pre-set to 300 ms. This time can be changed using object 0x1017.

| COB-ID | Byte | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|-------------------|---------|---|---|---|---|---|---|---|---|
| 0x700+ Node-ID | Content | 0: BOOTUP 4: STOPPED 5: OPERATIONAL 127: PRE-OP. | | | | | | | |

Table 30

Emergency messages

The EMCY message comprises 8 bytes. The message comprises the “Emergency Error Code”, the “Error Register” (object: 0x1001) and the manufacturer-specific Error Code.

| COB-ID | Byte | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|------------------|---------|----------------------|---|-----------------------------------|--|---|----------------------------------|---|---|
| 0x80+ Node-ID | Content | Emergency Error Code | | Error Register (object 0x1001) | Manufacturer specific error code (object 0x4001) | | Manufacturer specific error code | | |

Table 31

The content of “Manufacturer specific error code” (Byte 5,6,7) is an SPN from Table 54 Diagnostic Trouble Codes page 51. Byte 4 specifies how often the error is occurring.

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6.4.2 CANopen Error Codes

| EMCY Error Code | Title | Description |
|-----------------|---------------------------------|--|
| 0x1000 | APP_MANUFACTURER_SPECIFIC_ERROR | DTC Error List is mapped into this error |
| 0x5010 | APP_ACCEL_X_VALUE_OUT_OF_RANGE | Overflow of accelerometer x value |
| 0x5020 | APP_ACCEL_Y_VALUE_OUT_OF_RANGE | Overflow of accelerometer y value |
| 0x5030 | APP_ACCEL_Z_VALUE_OUT_OF_RANGE | Overflow of accelerometer z value |
| 0x5040 | APP_GYRO_X_VALUE_OUT_OF_RANGE | Overflow of gyroscope x value |
| 0x5050 | APP_GYRO_Y_VALUE_OUT_OF_RANGE | Overflow of gyroscope y value |
| 0x5060 | APP_GYRO_Z_VALUE_OUT_OF_RANGE | Overflow of gyroscope z value |
| 0x6100 | APP_INTERNAL_SOFTWARE | internal software error |
| 0x8140 | APP_RECOVERED_FROM_BUS_OFF | µC Power Supply undervoltage |
| 0xFF01 | APP_SENSOR_IS_DEFECT | Defect of sensor component |

Table 32: Table CANopen Error Codes

6.4.3 J1939 Standard Message Overview

| Name | Direction | Remarks |
|------|-----------|--|
| ACL | TX | J1939 Address Claim Message |
| RQST | RX | Request Message. Used to request e.g. the ACL message. |

Table 33: Table J1939 CAN messages

6.4.4 UDS Message overview

| Name | Direction | Remarks |
|----------|-----------|---|
| ISO15765 | TX | This message is used for UDS communication with the tilt sensor. PGN: 0xDA00, Priority: 0x6, e.g. tilt sensor SA 0x70, DA: 0xF9: message ID = 0x18DAF970 |
| ISO15765 | RX | This message is used for UDS communication with the tilt sensor. PGN: 0xDA00, Priority: 0x6, e.g. Tester SA 0xF9, DA: 0x70: message ID = 0x18DA70F9 |

Table 34: Table UDS related CAN messages

6.4.5 J1939 Message overview

| Name | Direction | Remarks | Proprietary |
|--------|-----------|---|-------------|
| SSI | TX | Slope Sensor Information | no |
| SSI2 | | Slope Sensor Information 2 | no |
| ACCS | | Acceleration Status | no |
| ARI | | Angular Rate Information | no |
| ePSSI1 | | elobau Proprietary Slope Sensor Information 1 | yes |
| ePSSI5 | | elobau Proprietary Slope Sensor Information 5 | yes |

Table 35: Table Proprietary CAN messages

6.4.6 Detailed message definition

SSI

Used to transmit information about the calculated tilt sensor information. Provides the tilt and roll angle in a range of -64° and 64.51° . The resolution of the angle is set to 16-bit.

Message parameter

| Parameter | Definition | Remarks |
|------------------------------|-------------------|--|
| Cycle Time [ms] | 10 ms (default) | This parameter is configurable |
| Send Type | Cyclic (default), | The message will be sent periodically with the defined cycle time. |
| Requestable | False | Cyclic messages are not requestable. |
| Data Length (DLC) | 8 | Data length of the message type. |
| Priority | 3 | Priority of the message type. |
| Message type | Proprietary B | User defined PGN in range 0xFF00 – 0xFFFF |
| Parameter Group Number (PGN) | 0xF013 | Slope Sensor Information |

Table 36: Table SSI Parameters

Message layout

| Signal | Description | Unit | Size |
|------------------------------------|---|-------|---------|
| Pitch Angle | - | deg | 16 bits |
| Roll Angle | - | deg | 16 bits |
| Pitch Rate | - | deg/s | 16 bits |
| Figure Of Merit - Pitch Angle | 0 = functional, 1 = degraded, 2 = error, 3 = N/A | - | 2 bits |
| Figure Of Merit - Roll Angle | 0 = functional, 1 = degraded, 2 = error, 3 = N/A | - | 2 bits |
| Figure Of Merit - Pitch Rate | 0 = functional, 1 = degraded, 2 = error, 3 = N/A | - | 2 bits |
| Pitch And Roll Compensated | 0 = Sensor Fusion enabled 1 = Sensor Fusion disabled | - | 2 bits |
| Pitch and Roll Latency Measurement | Latency of the measured tilt angle signal. Just returns the latency introduced by the sampling frequency of 100 Hz. Doesn't account for delay introduced by low pass filters. | ms | 8 bits |

Table 37: Table SSI Message Layout

SSI2

Used to transmit information about the calculated tilt sensor information. Provides the tilt angle in a range of $\pm 90^{\circ}$ and the roll angle in a range of $\pm 180^{\circ}$. The resolution of the angle is set to 24-bit.

Message parameter

| Parameter | Definition | Remarks |
|------------------------------|------------------|--|
| Cycle Time [ms] | 10 ms (default) | This parameter is configurable |
| Send Type | Cyclic (default) | The message will be sent periodically with the defined cycle time. |
| Requestable | False | Cyclic messages are not requestable. |
| Data Length (DLC) | 8 | Data length of the message type. |
| Priority | 3 | Priority of the message type. |
| Message type | Proprietary B | User defined PGN in range 0xFF00 – 0xFFFF |
| Parameter Group Number (PGN) | 0xF029 | Slope Sensor Information 2 |

Table 38: Table SSI2 Parameters

Message layout

| Signal | Description | Unit | Size |
|--|---|------|---------|
| Pitch Angle Extended Range | - | deg | 24 bits |
| Roll Angle Extended Range | - | deg | 24 bits |
| Pitch Angle Extended Range Compensation | 0 = Sensor Fusion enabled 1 = Sensor Fusion disabled | - | 2 bits |
| Figure Of Merit - Pitch Angle Extended Range | 0 = functional, 1 = degraded, 2 = error, 3 = N/A | - | 2 bits |
| Roll Angle Extended Range Compensation | 0 = Sensor Fusion enabled 1 = Sensor Fusion disabled | - | 2 bits |
| Figure Of Merit - Roll Angle Extended Range | 0 = functional, 1 = degraded, 2 = error, 3 = N/A | - | 2 bits |
| Latency Measurement | Latency of the measured tilt angle signal. Just returns the latency introduced by the sampling frequency of 100 Hz. Doesn't account for delay introduced by low pass filters. | ms | 8 bits |

Table 39: Table SSI2 Message Layout

elobau Proprietary Slope Sensor Information 1

The elobau Proprietary Slope Sensor Information message provides:

- Angle of tilt,
- Roll angle in an extended format,
- Status of the relay outputs,
- Sensor status,
- Relay status.

In addition, a message counter and a checksum are added at the end of the message.

Message parameter

| Parameter | Definition | Remarks |
|------------------------------|-----------------|--|
| Cycle Time [ms] | 10 ms (default) | This parameter is configurable |
| Send Type | Cyclic | The message will be sent for each new demand. |
| Requestable | False | Cyclic messages are not requestable. |
| Data Length (DLC) | 8 | Data length of the message type. |
| Default Priority | 6 | Priority of the message type. |
| Message type | Proprietary B | User defined PGN in range 0xFF00 – 0xFFFF |
| Parameter Group Number (PGN) | 0xFF2A | elobau Proprietary Slope Sensor Information 1. |

Table 40: Table elobau Proprietary Slope Sensor Information 1

Message layout

| Signal | Description | Unit | Size |
|----------------------------|---|------|---------|
| Pitch Angle Extended Range | - | deg | 24 bits |
| Roll Angle Extended Range | - | deg | 24 bits |
| Relay 1 - Switch Status | 0 = relay closed, 1 = relay open, 2 = error, 3 = N/A | - | 2 bits |
| Relay 2 - Switch Status | 0 = relay closed, 1 = relay open, 2 = error, 3 = N/A | - | 2 bits |
| Overhead signal | 0 = No vehicle rollover detected 1 = Vehicle rollover detected | - | 2 bits |
| Combined Figure of Merit | 0 = functional, 1 = degraded, 2 = error, 3 = N/A | - | 2 bits |
| Message Counter | Rotating counter between 0...7 | - | 4 bits |
| Message Checksum | Checksum according to SPN 4207 | - | 4 bits |

Table 41: Table elobau Proprietary Slope Sensor Information 1

The ePSSI1 message contains an additional message counter to recognise lost messages and other error states of the control unit. In addition to the message counter, an additional checksum is formed in the data bytes. The checksum contains the message counter, so the checksum changes even though the message signals are unchanged. The message counter ranges from 0 to 7.

ACCS

Used to transmit information about the measured acceleration data. The measured signal is compensated by the factory calibration and sensor fusion (if activated). Only available with N7.

Message parameter

| Parameter | Definition | Remarks |
|------------------------------|-----------------|--|
| Cycle Time [ms] | 10 ms (default) | This parameter is configurable |
| Send Type | Cyclic | The message will be sent for each new demand. |
| Requestable | False | Cyclic messages are not requestable. |
| Data Length (DLC) | 8 | Data length of the message type. |
| Default Priority | 6 | Priority of the message type. |
| Message type | Proprietary B | User defined PGN in range 0xFF00 – 0xFFFF. |
| Parameter Group Number (PGN) | 0xFF2B | elobau Proprietary Slope Sensor Information 2. |

Table 42: Table elobau Proprietary Slope Sensor Information 2

Message layout

| Signal | SPN | Size |
|---------------------|------|---------|
| Acceleration X | 5347 | 16 bits |
| Acceleration Y | 5348 | 16 bits |
| Acceleration Z | 5349 | 16 bits |
| Figure of Merit - X | 5350 | 2 bits |
| Figure of Merit - Y | 5351 | 2 bits |
| Figure of Merit - Z | 5352 | 2 bits |

Table 43: Table elobau Proprietary Slope Sensor Information 2

ARI

Used to transmit information about the measured rotation rate of the gyroscope. The measured signal is compensated by the factory calibration and sensor fusion (if activated). Only available with N7.

Message parameter

| Parameter | Definition | Remarks |
|------------------------------|-----------------|--|
| Cycle Time [ms] | 10 ms (default) | This parameter is configurable |
| Send Type | Cyclic | The message will be sent for each new demand |
| Requestable | False | Cyclic messages are not requestable. |
| Data Length (DLC) | 8 | Data length of the message type. |
| Default Priority | 6 | Priority of the message type. |
| Message type | Proprietary B | User defined PGN in range 0xFF00 – 0xFFFF |
| Parameter Group Number (PGN) | 0xFF2C | elobau Proprietary Slope Sensor Information 3. |

Table 44: Table elobau Proprietary Slope Sensor Information 3

Message layout

| Signal | SPN | Size |
|---------------------|------|---------|
| Rotation Rate X | 4983 | 16 bits |
| Rotation Rate Y | 4984 | 16 bits |
| Rotation Rate Z | 4985 | 16 bits |
| Figure of Merit - X | 4986 | 2 bits |
| Figure of Merit - Y | 4987 | 2 bits |
| Figure of Merit - Z | 4988 | 2 bits |

Table 45: Table elobau Proprietary Slope Sensor Information 3

elobau Proprietary Slope Sensor Information 5

Indicates the orientation in quaternion notation.

Message parameter

| Parameter | Definition | Remarks |
|------------------------------|-----------------|--|
| Cycle Time [ms] | 10 ms (default) | This parameter is configurable |
| Send Type | Cyclic | The message will be sent for each new demand. |
| Requestable | False | Cyclic messages are not requestable. |
| Data Length (DLC) | 8 | Data length of the message type. |
| Default Priority | 6 | Priority of the message type. |
| Message type | Proprietary B | User defined PGN in range 0xFF00 – 0xFFFF |
| Parameter Group Number (PGN) | 0xFF2E | elobau Proprietary Slope Sensor Information 5. |

Table 46: Table elobau Proprietary Slope Sensor Information 5

Message layout

| Signal | SPN | Size |
|-------------------|-----|---------|
| Quaternion scalar | | 16 bits |
| Quaternion i | | 16 bits |
| Quaternion j | | 16 bits |
| Quaternion k | | 16 bits |

Table 47: Table elobau Proprietary Slope Sensor Information 5

6.4.7 Definition of J1939 request PGN**PGN definition**

This message type identified by the PGN makes it possible to request information globally or from a specific destination. Requests that relate to a specific target are referred to as tar-

6. CANopen | J1939 interface

get-specific requests. The information in the table below shows the PGN definition for the "Request PGN" parameter group.

| Name | Description |
|------------------------------|---|
| Parameter Group Name | Request |
| Definition | Used to request a Parameter Group from a network device or devices. |
| Transmission repetition rate | Per user requirements , generally recommended that requests occur no more than 2 or 3 times per second. |
| Data length | 3 bytes (The CAN frame for this PG shall set the DLC to 3.) |
| Extended Data Page | 0 |
| Data page | 0 |
| PDU Format | 234 |
| PDU specific field | Destination Address (global or specific). |
| Default priority | 6 |
| Parameter Group Number | 59904 (0x00EA00) |
| Byte: 1,2,3 | Parameter Group Number being requested. |

Table 48: Table Request PGN definition

Requestable PGNs of the tilt sensor

| PGN | Description |
|--------|-----------------|
| 0xEE00 | Address claimed |
| 0xFEDA | Soft |
| 0xFDC5 | ECU ID |
| 0xFECA | DM1 |
| 0xFECB | DM2 |
| 0xFECC | DM3 |
| 0xFED3 | DM11 |

Table 49: Table Requestable PGNs

Response codes

The tilt sensor responds to a target-specific request with the following acknowledgement control bytes.

| Acknowledgment-Control byte | Description |
|-----------------------------|--|
| 0 | Positive Acknowledgment (ACK), if the request was successful. |
| 1 | Negative Acknowledgment (NACK), if the requested PGN does not exist/ is not implemented. |
| 2 | Access Denied, not used. |
| 3 | Cannot Respond, BAM protocol is busy. |

Table 50: Table Acknowledgement control bytes

Requestable PGN definition**J1939 Soft PGN**

| Byte | Description |
|---------|--|
| 0 | 4 (Number of software identification designators represented in the software identification parameter group) |
| 1...15 | Customer SOFT-ID 0 |
| 16 | Field delimiter (*) |
| 17...31 | Customer SOFT-ID 1 |
| 32 | Field delimiter (*) |
| 33...47 | Software Version Number (example „001.000.000.000“) |
| 48 | Field delimiter (*) |
| 49...63 | Part Number of the Configuration |
| 64 | Field delimiter (*) |

Table 51: Table Soft PGN definition

J1939 ECUID PGN

| Byte | Description |
|---------|-----------------------|
| 0...14 | ECU Serial Number |
| 16 | Field delimiter (*) |
| 17...30 | ECU Manufacturer Name |
| 31 | Field delimiter (*) |
| 32 | Hardware Version |
| 33 | Field delimiter (*) |

Table 52: Table ECU ID PGN definition

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J1939 DM1 / DM2

| Bit | Length | Description | Value |
|-----|--------|----------------------------------|--|
| 0 | 2 | Protection Lamp Status | 00: Lamp off 01: Lamp on |
| 2 | 2 | Amber Warning Lamp | 00: Lamp off 01: Lamp on |
| 4 | 2 | Red Stop Lamp | 00: Lamp off 01: Lamp on |
| 6 | 2 | Malfunction Indicator Lamp | 00: Lamp off 01: Lamp on |
| 8 | 2 | Flash Protection Lamp | 00: Slow Flash (1 Hz, 50% duty cycle) 01: Fast Flash (2 Hz or faster, 50% duty cycle) 10: reserved 11: Unavailable / 00 Not Flash |
| 10 | 2 | Flash Amber Warning Lamp | 00: Slow Flash (1 Hz, 50% duty cycle) 01: Fast Flash (2 Hz or faster, 50% duty cycle) 10: reserved 11: Unavailable / 00 Not Flash |
| 12 | 2 | Flash Red Stop Lamp | 00: Slow Flash (1 Hz, 50% duty cycle) 01: Fast Flash (2 Hz or faster, 50% duty cycle) 10: reserved 11: Unavailable / 00 Not Flash |
| 14 | 2 | Flash Malfunction Indicator Lamp | 00: Slow Flash (1 Hz, 50% duty cycle) 01: Fast Flash (2 Hz or faster, 50% duty cycle) 10: reserved 11: Unavailable / 00 Not Flash |
| 16 | 32 | DTC1 | Error Code - optional |
| 48 | 32 | DTC2 | Error Code - optional |
| 80 | 32 | DTC3 | Error Code - optional |
| 112 | 32 | DTC4 | Error Code - optional |

Table 53 J1939 DM1 / DM2

6.5 Diagnostic Trouble Codes (DTCs)

| Customer ID | Description | SPN | FMI | Resulting system state | special instruction |
|--|---|--------|----------|------------------------|---|
| spn_generic_sw_error | General SW error | 522000 | 12 | system_safe_state | replace firmware/sensor |
| spn_can_busoff_detected | CAN bus off detected | 522001 | 2 | - | temporary condition, check the can bus wiring + configuration |
| spn_cpu_temperature_error_limit | CPU Temperature monitoring | 522131 | 3, 4 | system_stop_state | temporary condition, the operating range was exceeded |
| spn_mems_temperature_error_limit | MEMS Temperature monitoring | 522133 | 3, 4 | system_stop_state | temporary condition, the operating range was exceeded |
| spn_power_supply | Power supply monitoring | 522140 | 3, 4 | system_stop_state | temporary condition, the operating range was exceeded |
| spn_the_device_config_is_corrupt | The device configuration is corrupt | 522301 | 12 | system_safe_state | replace firmware/sensor |
| spn_the_calibration_config_could_not_be_loaded | The calibration config could not be loaded. | 522302 | 13 | system_safe_state | replace firmware/sensor |
| spn_hw_version_not_supported | hw version not supported | 522303 | 12 | system_safe_state | replace firmware/sensor |
| spn_acceleration_on_x_axis | Acceleration on X-Axis over/underflow | 522510 | 2 | signal_safe_state | temporary condition, the operating range were exceeded |
| spn_acceleration_on_y_axis | Acceleration on Y-Axis over/underflow | 522511 | 2 | signal_safe_state | temporary condition, the operating range were exceeded |
| spn_acceleration_on_z_axis | Acceleration on Z-Axis over/underflow | 522512 | 2 | signal_safe_state | temporary condition, the operating range were exceeded |
| spn_input_rotation_rate_x | Rotation rate on X-Axis overflow/underflow | 522513 | 2 | signal_safe_state | temporary condition, the operating range were exceeded |
| spn_input_rotation_rate_y | Rotation rate on Y-Axis overflow/underflow | 522514 | 2 | signal_safe_state | temporary condition, the operating range were exceeded |
| spn_input_rotation_rate_z | Rotation rate on Z-Axis overflow/underflow | 522515 | 2 | signal_safe_state | temporary condition, the operating range were exceeded |
| spn_angle_calculation_is_implausible | Output of sensor fusion is implausible | 522601 | 2 | signal_safe_state | temporary condition, the operating range were exceeded |
| spn_internal_temporary_fault | Detected a temporary fault | 522800 | 2, 4, 12 | - | internal hw fault caused reset in last cycle. Replace on many sporadic errors |
| spn_internal_permanent_fault | Detected a permanent fault | 522801 | 12 | system_safe_state | replace sensor |

Table 54 Diagnostic Trouble Codes

7. Operation

The system is ready for operation within a maximum period of 500 ms. This means that:

- Measured values are available,
- Analogue signal outputs (depending on the variant) are valid,
- Switched signal outputs (depending on the variant) are valid,
- Cyclical CAN communication (depending on the variant) has started with valid data.

7.1 Calibration



Information!

The tilt sensor is subject to stringent quality control. It is extensively tested before despatch and calibrated and adjusted for the desired end application.

7.2 Performance-Influencing factors

The N6/N7 uses acceleration sensors to calculate changes in direction. Some factors can influence operation.

Vibrations

In certain applications with strong vibrations or long cornering, the integrated sensors can cause interference. These disturbances are detected by N6/N7 as angle changes and can have a negative effect on the operation of the tilt sensor, depending on the application.

To ensure regular operation, we recommend a check after installation to identify measures to minimise strong vibrations or shocks.

If there is a fault due to vibrations, the following measures can lead to an improvement:

- ▶ Make sure that the mounting recommendations described in this document are always complied with.
- ▶ Application-specific adaptation of the set filters, e. g. the fusion algorithm.
- ▶ Consider vibration dampers to minimise vibrations (e. g. rubber pads).
- ▶ Increase the dimensions of the mounting surface (e. g. increase the material thickness).
- ▶ Reduce the vibrations emanating from the source.
- ▶ Move the sensor to an area with less vibration.
- ▶ Avoid assembly in areas with large temperature fluctuations.

7.3 Error messages, troubleshooting

| Problem | Cause | Remedy |
|---|---|--|
| No output signal | Missing operating voltage | Check operating voltage |
| | Cable break in supply voltage or signal output | Check lines and cable connections |
| | Connector contact problems | Check that plug-in connections are correctly seated and fastened |
| | Fuse on the vehicle side | Check fuses |
| Output signal not correct / implausible | Sensor loose | Check fastening |
| | Alignment/mounting correct? | Check installation position ⁽¹⁾ |
| | Termination resistor (on vehicle side) for signal output correct? | Check for correct terminating resistor |
| | Offset for signal output (teaching) used correctly? | Repeat zero point adjustment (teach process) ⁽²⁾ |
| | Applications with strong vibrations | See chapter 7.2 "Performance-Influencing factors", page 52. |

Table 55

⁽¹⁾ See chapter 5.2 "Mounting position", page 26.

⁽²⁾ See chapter 5.5.1 "Zero point adjustment (teach process)", page 30.

8. Maintenance and servicing

The tilt sensor is maintenance-free.

**VORSICHT!****Danger due to opening the tilt sensor.**

Opening the N6/N7 results in voiding of warranty and exclusion of liability. Furthermore, machinery malfunctions can lead to personal injury or damage to property.

- ▶ Do not open the tilt sensor.
- ▶ Do not modify the electronics or mechanical components.

Under extreme usage conditions, please check the tilt sensor as part of regular inspections:

- ▶ Carry out a visual inspection and functional test.
- ▶ Check the connection cables for damage.

8.1 Decommissioning

- ▶ De-energise the tilt sensor.
- ✓ **Tilt sensor is out of operation.**

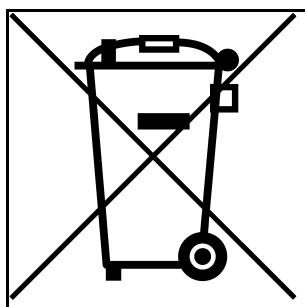
8.2 Dismantling

Remove the tilt sensor

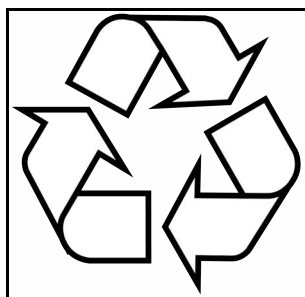
1. Ensure a voltage-free state.
2. Undo the electrical lines on the tilt sensor.
3. Unscrew and remove screws.

✓ ***The tilt sensor is removed.***

8.3 Disposal



The symbol means that a product must be collected separately from other waste when it reaches the end of its service life in accordance with directive 2012/19/EU. For more information, please contact elobau or your dealer on site.



Dispose of packaging and used parts in accordance with the relevant national regulations. Do not dispose of N6/N7 with domestic waste; e. g. dispose of at the collection centre of a waste management utility.

Figure 31

9. Appendix

9.1 Parameter configuration J1939

| | | | | | | | J1939 | |
|--------------|-------------------------------|---|---------|--------|-------|--|----------------|---------------|
| DID 0x... | Parameter | Description | Default | Min | Max | Unit | Index 0x... | Sub- index |
| F202 | inc_plane | Mounting position of the sensor (horizontal, vertical) | 0 | 0 | 3 | Configuration Index | 2000 | 0x1 |
| F203 | inc_offset_yaw | Add an offset to the pitch angle | 0 | -60000 | 60000 | 0,001° | 2000 | 0x4 |
| F204 | inc_offset_roll | Add an offset to the roll angle | 0 | -60000 | 60000 | 0,001° | 2000 | 0x2 |
| F205 | inc_offset_pitch | Add an offset to the pitch angle | 0 | -60000 | 60000 | 0,001° | 2000 | 0x3 |
| F206 | overhead_signal_debounce_time | Overhead signal debounce time. Filtering of the overhead signal in the J1939 Message ePSSI1 and TPDO1 in CANopen. | 0 | 0 | 20000 | ms | | |
| F207 | inc_sensor_fusion_enabled | Filter Selection. On N7 devices, it's possible to disable the sensor fusion. | 1 | 0 | 1 | 0 = 3-DOF Angle Calculation 1 = 6-DOF Sensor Fusion | 2003 | 0x1 |
| F208 | meas_overflow_fault_reaction | How the system reacts on a measurement overflow | 4 | 0 | 5 | 0 = No reaction 1 = Signal SafeState (No Healing) 2 = Signal SafeState (Healing) 3 = System SafeState 4 = Reinit Algorithm 5 = Reset Sensor | 2003 | 0x4 |
| F209 | legacy_filter_mode | Filter mode of the legacy filter | 0 | 0 | 1 | 0 = Sensor mode 360 1 = Sensor mode 90 | 2008 | 0x1 |
| F210 | inc_lp_cutoff_freq | Inclination low pass filter cutoff frequency | 0 | 0 | 25000 | 0,001 Hz | 2000 | 0x5 |
| F211 | inc_lp_filter_len | inclination FIR length | 32 | 6 | 512 | 0,5 ms | 2000 | 0x6 |
| F212 | inc_lp_filter_profile | inclination FIR profile | 0 | 0 | 1 | 0 = low pass filter with blackman harris window 1 = Moving average filter | 2000 | 0x7 |
| F213 | raw_lp_cutoff_freq | Raw low pass filter cutoff frequency | 0 | 0 | 25000 | 0,001 Hz | 2001 | 0x1 |

9. Appendix

| | | | | | | | J1939 | |
|--------------|-----------------------------------|--|---------|---------|--------|--|----------------|---------------|
| DID 0x... | Parameter | Description | Default | Min | Max | Unit | Index 0x... | Sub- index |
| F214 | raw_lp_filter_len | Raw FIR length | 32 | 12 | 1024 | 0,25 ms | 2001 | 0x2 |
| F215 | raw_lp_filter_profile | Raw FIR profile | 0 | 0 | 1 | 0 = low pass filter with blackman harris window 1 = Moving average filter | 2001 | 0x3 |
| F21E | accelerometer_range | Measurement range of accelerometer | 8 | 2 | 16 | g | 2003 | 0x2 |
| F21F | gyroscope_range | Measurement range of gyroscope | 250 | 15 | 2000 | */s | 2003 | 0x3 |
| F250 | swed_output_0_enable | Enable or disable switched signal output | 0 | 0 | 1 | 0 = output disabled 1 = output enabled | 200A | 0x1 |
| F251 | swed_output_0_hyst | Set the angle hysteresis value | 0 | 0 | 45000 | 0,001° | 200A | 0x2 |
| F252 | swed_output_0_delay_switch_on_0 | Signal delay after positive condition | 0 | 0 | 20000 | ms | 200A | 0x3 |
| F253 | swed_output_0_delay_switch_off_0 | Signal delay after negative condition | 0 | 0 | 20000 | ms | 200A | 0x11 |
| F254 | swed_output_0_logic_link | Overall logic operation to compare both axis | 0 | 0 | 2 | 0 = only single axis 1 = AND 2 = OR | 200A | 0x4 |
| F255 | swed_output_0_axis_0_angle | Input signal to use to compare axis | 0 | 0 | 2 | 0 = yaw 1 = pitch 2 = roll | 200A | 0x5 |
| F256 | swed_output_0_axis_0_logic_link | Overall logic operation to compare operators of axis 0 | 0 | 0 | 2 | 0 = only single operator 1 = AND 2 = OR | 200A | 0x6 |
| F257 | swed_output_0_axis_0_cond_0_angle | Threshold angle that triggers compare function | 0 | -180000 | 180000 | 0,001° | 200A | 0x7 |
| F258 | swed_output_0_axis_0_cond_0_cmp | Compare function to use | 0 | 0 | 2 | 0 = none 1 = less than 2 = greater than | 200A | 0x8 |
| F259 | swed_output_0_axis_0_cond_1_angle | Threshold angle that triggers compare function | 0 | -180000 | 180000 | 0,001° | 200A | 0x9 |
| F25A | swed_output_0_axis_0_cond_1_cmp | Compare function to use | 0 | 0 | 2 | 0 = none 1 = less than 2 = greater than | 200A | 0xA |
| F25B | swed_output_0_axis_1_angle | Input signal to use to compare axis | 0 | 0 | 2 | 0 = yaw 1 = pitch 2 = roll | 200A | 0xB |

| | | | | | | | J1939 | |
|--------------|--|--|---------|-------------|--------|---|----------------|---------------|
| DID 0x... | Parameter | Description | Default | Min | Max | Unit | Index 0x... | Sub- index |
| F25C | swed_out- put_0_axis_1_lo- gic_link | Overall logic operation to compare operators of axis 0 | 0 | 0 | 2 | 0 = only single operator 1 = AND 2 = OR | 200A | 0xC |
| F25D | swed_out- put_0_axis_1_con d_0_angle | Threshold angle that trig- gers compare function | 0 | - 180000 | 180000 | 0,001° | 200A | 0xD |
| F25E | swed_out- put_0_axis_1_con d_0_cmp | Compare function to use | 0 | 0 | 2 | 0 = none 1 = less than 2 = greater than | 200A | 0xE |
| F25F | swed_out- put_0_axis_1_con d_1_angle | Threshold angle that trig- gers compare function | 0 | - 180000 | 180000 | 0,001° | 200A | 0xF |
| F260 | swed_out- put_0_axis_1_con d_1_cmp | Compare function to use | 0 | 0 | 2 | 0 = none 1 = less than 2 = greater than | 200A | 0x10 |
| F261 | swed_out- put_0_de- fault_state | Initial State relays | 0 | 0 | 1 | 0 = OFF 1 = ON | 200A | 0x12 |
| F262 | swed_out- put_0_in- vert_switch | Invert the logic of the pins | 0 | 0 | 1 | 0 = false 1 = true | 200A | 0x13 |
| F263 | swed_out- put_0_de- lay_switch_on_1 | Signal delay after positive condition | 0 | 0 | 20000 | ms | 200A | 0x14 |
| F264 | swed_out- put_0_de- lay_switch_off_1 | Signal delay after nega- tive condition | 0 | 0 | 20000 | ms | 200A | 0x15 |
| F270 | swed_out- put_1_enable | Enable or disable swit- ched signal output | 0 | 0 | 1 | 0 = output disa- bled 1 = output ena- bled | 200B | 0x1 |
| F271 | swed_out- put_1_hyst | Set the angle hysteresis value | 0 | 0 | 45000 | 0,001° | 200B | 0x2 |
| F272 | swed_out- put_1_de- lay_switch_on_0 | Signal delay after positive condition | 0 | 0 | 20000 | ms | 200B | 0x3 |
| F273 | swed_out- put_1_de- lay_switch_off_0 | Signal delay after nega- tive condition | 0 | 0 | 20000 | ms | 200B | 0x11 |
| F274 | swed_out- put_1_logic_link | Overall logic operation to compare both axis | 0 | 0 | 2 | 0 = only single axis 1 = AND 2 = OR | 200B | 0x4 |
| F275 | swed_out- put_1_axis_0_ang le | Input signal to use to compare axis | 0 | 0 | 2 | 0 = yaw 1 = pitch 2 = roll | 200B | 0x5 |
| F276 | swed_out- put_1_axis_0_lo- gic_link | Overall logic operation to compare operators of axis 0 | 0 | 0 | 2 | 0 = only single operator 1 = AND 2 = OR | 200B | 0x6 |

9. Appendix

| | | | | | | | J1939 | |
|--------------|-----------------------------------|---|---------|---------|------------------|---|----------------|---------------|
| DID 0x... | Parameter | Description | Default | Min | Max | Unit | Index 0x... | Sub- index |
| F277 | swed_output_1_axis_0_cond_0_angle | Threshold angle that triggers compare function | 0 | -180000 | 180000 | 0,001° | 200B | 0x7 |
| F278 | swed_output_1_axis_0_cond_0_cmp | Compare function to use | 0 | 0 | 2 | 0 = none 1 = less than 2 = greater than | 200B | 0x8 |
| F279 | swed_output_1_axis_0_cond_1_angle | Threshold angle that triggers compare function | 0 | -180000 | 180000 | 0,001° | 200B | 0x9 |
| F27A | swed_output_1_axis_0_cond_1_cmp | Compare function to use | 0 | 0 | 2 | 0 = none 1 = less than 2 = greater than | 200B | 0xA |
| F27B | swed_output_1_axis_1_angle | Input signal to use to compare axis | 0 | 0 | 2 | 0 = yaw 1 = pitch 2 = roll | 200B | 0xB |
| F27C | swed_output_1_axis_1_logic_link | Overall logic operation to compare operators of axis 0 | 0 | 0 | 2 | 0 = only single operator 1 = AND 2 = OR | 200B | 0xC |
| F27D | swed_output_1_axis_1_cond_0_angle | Threshold angle that triggers compare function | 0 | -180000 | 180000 | 0,001° | 200B | 0xD |
| F27E | swed_output_1_axis_1_cond_0_cmp | Compare function to use | 0 | 0 | 2 | 0 = none 1 = less than 2 = greater than | 200B | 0xE |
| F27F | swed_output_1_axis_1_cond_1_angle | Threshold angle that triggers compare function | 0 | -180000 | 180000 | 0,001° | 200B | 0xF |
| F280 | swed_output_1_axis_1_cond_1_cmp | Compare function to use | 0 | 0 | 2 | 0 = none 1 = less than 2 = greater than | 200B | 0x10 |
| F281 | swed_output_1_default_state | Initial state relays | 0 | 0 | 1 | 0 = OFF 1 = ON | 200B | 0x12 |
| F282 | swed_output_1_invert_switch | Invert the switching logic of the relay | 0 | 0 | 1 | 0 = false 1 = true | 200B | 0x13 |
| F283 | swed_output_1_delay_switch_on_1 | Signal delay after positive condition | 0 | 0 | 20000 | ms | 200B | 0x14 |
| F284 | swed_output_1_delay_switch_off_1 | Signal delay after negative condition | 0 | 0 | 20000 | ms | 200B | 0x15 |
| F291 | can_baudrate | Baudrate of the CAN | 1000000 | 20000 | 1000000 | bit/s | 5999 | 0x01 |
| F292 | can_busoff_restore_attempts | Number of attempts to reset a detected bus off state (within on drive cycle) before stay in bus off state | 32 | 0 | 0x7FFF FFFFFF | | 5001 | 0x0 |
| F293 | can_busoff_restore_timeout | Time between to CAN bus reset events | 250 | 0 | 1000 | ms | 3000 | 0x1 |

| | | | | | | | J1939 | |
|--------------|--------------------------------------|---|---------|----------------|-----------------|--|----------------|---------------|
| DID 0x... | Parameter | Description | Default | Min | Max | Unit | Index 0x... | Sub- index |
| F294 | can_busoff_de- crement_time | Time of fault free CAN bus which leads to a decrementing of the error counter | 300000 | 0 | 100000 0 | ms | 3000 | 0x2 |
| F295 | can_s27_ext_key | Please contact elobau, if your application requires your own Seed&Key | 0x0 | 0x8000 0000 | 0x7FF FFFFFF | | | |
| F296 | can_s27_prog_key | Please contact elobau, if your application requires your own Seed&Key | 0x0 | 0x8000 0000 | 0x7FF FFFFFF | | | |
| F2A0 | can_protocol | Used CAN protocol | 0 | 0 | 1 | 0 = J1939 1 = CANopen | 599B | 0x0 |
| F2A1 | can_node_source_address | Node source address | 0xE2 | 0x00 | 0xFE | | | |
| F2A2 | can_com_sig_on_change_send | Com default mode | 0 | 0 | 1 | 0 = cyclic transmission 1 = send on signal change | 3000 | 0x3 |
| F2A3 | can_com_sig_on_change_min_delta_time | Minimum delta time between signal changed | 20 | 0 | 100 | ms | 3000 | 0x4 |
| F2B0 | can_com_msg_ssi_cycle_time | Configure the cycle time of SSI message | 0 | 0 | 10000 | ms | | |
| F2B1 | can_com_msg_ssi2_cycle_time | Configure the cycle time of SSI2 message | 0 | 0 | 10000 | ms | | |
| F2B2 | can_com_msg_ari_cycle_time | Configure the cycle time of ARI message | 0 | 0 | 10000 | ms | | |
| F2B3 | can_com_msg_accs_cycle_time | Configure the cycle time of ACCS message | 0 | 0 | 10000 | ms | | |
| F2B4 | can_com_msg_epssi1_cycle_time | Configure the cycle time of ePSSI1 message | 0 | 0 | 10000 | ms | | |
| F2B8 | can_com_msg_epssi5_cycle_time | Configure the cycle time of ePSSI5 message | 0 | 0 | 10000 | ms | | |
| F2D0 | can_j1939_dm1_enable | Enable cyclic transmission of DM1 | 0 | 0 | 1 | | | |
| F2D1 | can_j1939_dm1_transmit_if_zero | Transmit if zero | 1 | 0 | 1 | | | |
| F2D2 | customer_ecuid_0 | Free customer entry | 0 | 0x8000 0000 | 0x7FF FFFFFF | | 2009 | 0x1 |
| F2D3 | customer_ecuid_1 | Free customer entry | 0 | 0x8000 0000 | 0x7FF FFFFFF | | 2009 | 0x2 |
| F2D4 | customer_softid_0 | Free customer entry | 0 | 0x8000 0000 | 0x7FF FFFFFF | | 2009 | 0x3 |
| F2D5 | customer_softid_1 | Free customer entry | 0 | 0x8000 0000 | 0x7FF FFFFFF | | 2009 | 0x4 |

Table 56

9. Appendix

9.2 Parameter configuration CANopen

| | | | | | | | | CANopen | |
|---|------|-------------|--|------------------|-----|-----|---|----------------|-----------|
| DID 0x... | Typ | Parameter | Description | Default | Min | Max | Unit | Index 0x... | Sub-index |
| | U32 | (read only) | Device Type | 0x0002019A | | | Device profile DS410 (Two axis with resolution max. 16-bit) | 1000 | |
| | U8 | (read only) | Error Register | 0xx00 | | | 0 = generic error 1 = current 2 = voltage 3 = temperature 4 = communication error 5 = device-profile specific error 6 = reserved = 0 7 = manufacturer specific | 1001 | |
| | strg | (read only) | Manufacturer Device Name | NGS | | | „NGS“: Neigungs-sensor (Tilt sensor) | 1008 | |
| | strg | (read only) | Manufacturer Hardware Version | | | | „Maj.MinMin“ | 1009 | |
| | strg | (read only) | Manufacturer Software Version | | | | „Maj.MinMin“ | 100A | |
| Attention: Please use this service with care. Make sure before saving parameters, that only volitional parameters are changed. | | | | | | | | | |
| Store Parameter | | | | | | | | | |
| | U8 | (read only) | Number of Entries | 1 | | | | 1010 | 0x0 |
| | U32 | | Save all Parameters | 1 | | | „save“ (0x65766173) to save all parameters (objects with marking PARA except LSS parameter) | 1010 | 0x1 |
| Restore Default Parameter | | | | | | | | | |
| | U8 | (read only) | Number of Entries | | | | | 1011 | 0x0 |
| | U32 | | Restore all Default Parameters | | | | „load“ (0x64616F6C) to restore all parameters (objects with marking PARA) to factory settings. | 1011 | 0x1 |
| | U32 | (read only) | COB-ID EMCY | 0x80+N ode-ID | 1 | | | 1014 | |
| | U16 | | Producer Heartbeat Time - PARA (Unit 1 ms) | 300 | | | 0 = not used | 1017 | |
| Identity Object | | | | | | | | | |
| | U8 | (read only) | Number of Entries | 4 | | | | 1018 | 0x0 |

| | | | | | | | | CANopen | |
|--------------------------------|-----|------------------------------|--|-----------------|--------|-------|--|----------------|-----------|
| DID 0x... | Typ | Parameter | Description | Default | Min | Max | Unit | Index 0x... | Sub-index |
| | U32 | (read only) | Vendor ID | 0x0000 00B4 | | | elobau Vendor ID: 0x000000B4 | 1018 | 0x1 |
| | U32 | (read only) | Product Code | 0x0000 0301 | | | | 1018 | 0x2 |
| | U32 | (read only) | Revision Number | 0x0000 0000 | | | | 1018 | 0x3 |
| | U32 | (read only) | Serial Number | | | | | 1018 | 0x4 |
| Error behaviour | | | | | | | | | |
| | U8 | (read only) | Number of Entries | 1 | | | | 1029 | 0x0 |
| | U8 | | Communication Error | 0x00 | | | 0 = Pre-Operational (only if current state is operational) 1 = No state change 2 = Stopped 3-127 = Reserved | 1029 | 0x1 |
| SDO #0 Server Parameter | | | | | | | | | |
| | U8 | (read only) | Number of Entries | 2 | 2 | 2 | | 1200 | 0x0 |
| | U32 | (read only) | COB-ID Client->Server (Rx) | 0x600 + Node-ID | | | | 1200 | 0x1 |
| | U32 | (read only) | COB-ID Client->Server (Tx) | 0x580 + Node-ID | | | | 1200 | 0x2 |
| F202 | I32 | inc_plane | Mounting position of the sensor (horizontal, vertical) | 0 | 0 | 3 | Configuration Index | 2000 | 0x1 |
| F203 | I32 | inc_offset_yaw | Add an offset to the pitch angle | 0 | -60000 | 60000 | 0,001° | 2000 | 0x4 |
| F204 | I32 | inc_offset_roll | Add an offset to the roll angle | 0 | -60000 | 60000 | 0,001° | 2000 | 0x2 |
| F205 | I32 | inc_offset_pitch | Add an offset to the pitch angle | 0 | -60000 | 60000 | 0,001° | 2000 | 0x3 |
| F207 | I32 | inc_sensor_fusion_enabled | Filter Selection. On N7 devices, it's possible to disable the sensor fusion. | 1 | 0 | 1 | 0 = 3-DOF Angle Calculation 1 = 6-DOF Sensor Fusion | 2003 | 0x1 |
| F208 | I32 | meas_overflow_fault_reaction | How the system reacts on a measurement overflow | 4 | 0 | 5 | 0 = No reaction 1 = Signal SafeState (No Healing) 2 = Signal SafeState (Healing) 3 = System SafeState 4 = Reinit Algorithm 5 = Reset Sensor | 2003 | 0x4 |

9. Appendix

| | | | | | | | | CANopen | |
|--------------|-----|----------------------------------|--|---------|-----|-------|--|----------------|-----------|
| DID 0x... | Typ | Parameter | Description | Default | Min | Max | Unit | Index 0x... | Sub-index |
| F209 | I32 | legacy_filter_mode | Filter mode of the legacy filter | 0 | 0 | 1 | 0 = Sensor mode 360 1 = Sensor mode 90 | 2008 | 0x1 |
| F210 | I32 | inc_lp_cut_off_freq | Inclination low pass filter cutoff frequency | 0 | 0 | 25000 | 0,001 Hz | 2000 | 0x5 |
| F211 | I32 | inc_lp_filter_len | inclination FIR length | 32 | 6 | 512 | 0,5 ms | 2000 | 0x6 |
| F212 | I32 | inc_lp_filter_profile | inclination FIR profile | 0 | 0 | 1 | 0 = low pass filter with blackman harris window 1 = Moving average filter | 2000 | 0x7 |
| F213 | I32 | raw_lp_cutoff_freq | Raw low pass filter cutoff frequency | 0 | 0 | 25000 | 0,001 Hz | 2001 | 0x1 |
| F214 | I32 | raw_lp_filter_len | Raw FIR length | 32 | 12 | 1024 | 0,25 ms | 2001 | 0x2 |
| F215 | I32 | raw_lp_filter_profile | Raw FIR profile | 0 | 0 | 1 | 0 = low pass filter with blackman harris window 1 = Moving average filter | 2001 | 0x3 |
| F21E | I32 | accelerometer_range | Measurement range of accelerometer | 8 | 2 | 16 | g | 2003 | 0x2 |
| F21F | I32 | gyroscope_range | Measurement range of gyroscope | 250 | 15 | 2000 | */s | 2003 | 0x3 |
| F250 | I32 | swed_output_0_enable | Enable or disable switched signal output | 0 | 0 | 1 | 0 = output disabled 1 = output enabled | 200A | 0x1 |
| F251 | I32 | swed_output_0_hyst | Set the angle hysteresis value | 0 | 0 | 45000 | 0,001° | 200A | 0x2 |
| F252 | I32 | swed_output_0_delay_switch_on_0 | Signal delay after positive condition | 0 | 0 | 20000 | ms | 200A | 0x3 |
| F253 | I32 | swed_output_0_delay_switch_off_0 | Signal delay after negative condition | 0 | 0 | 20000 | ms | 200A | 0x11 |
| F254 | I32 | swed_output_0_logic_link | Overall logic operation to compare both axis | 0 | 0 | 2 | 0 = only single axis 1 = AND 2 = OR | 200A | 0x4 |
| F255 | I32 | swed_output_0_axis_0_angle | Input signal to use to compare axis | 0 | 0 | 2 | 0 = yaw 1 = pitch 2 = roll | 200A | 0x5 |
| F256 | I32 | swed_output_0_axis_0_logic_link | Overall logic operation to compare operators of axis 0 | 0 | 0 | 2 | 0 = only single operator 1 = AND 2 = OR | 200A | 0x6 |

| | | | | | | | | CANopen | |
|--------------|-----|-----------------------------------|--|---------|---------|--------|---|----------------|---------------|
| DID 0x... | Typ | Parameter | Description | Default | Min | Max | Unit | Index 0x... | Sub- index |
| F257 | I32 | swed_output_0_axis_0_cond_0_angle | Threshold angle that triggers compare function | 0 | -180000 | 180000 | 0,001° | 200A | 0x7 |
| F258 | I32 | swed_output_0_axis_0_cond_0_cmp | Compare function to use | 0 | 0 | 2 | 0 = none 1 = less than 2 = greater than | 200A | 0x8 |
| F259 | I32 | swed_output_0_axis_0_cond_1_angle | Threshold angle that triggers compare function | 0 | -180000 | 180000 | 0,001° | 200A | 0x9 |
| F25A | I32 | swed_output_0_axis_0_cond_1_cmp | Compare function to use | 0 | 0 | 2 | 0 = none 1 = less than 2 = greater than | 200A | 0xA |
| F25B | I32 | swed_output_0_axis_1_angle | Input signal to use to compare axis | 0 | 0 | 2 | 0 = yaw 1 = pitch 2 = roll | 200A | 0xB |
| F25C | I32 | swed_output_0_axis_1_logic_link | Overall logic operation to compare operators of axis 0 | 0 | 0 | 2 | 0 = only single operator 1 = AND 2 = OR | 200A | 0xC |
| F25D | I32 | swed_output_0_axis_1_cond_0_angle | Threshold angle that triggers compare function | 0 | -180000 | 180000 | 0,001° | 200A | 0xD |
| F25E | I32 | swed_output_0_axis_1_cond_0_cmp | Compare function to use | 0 | 0 | 2 | 0 = none 1 = less than 2 = greater than | 200A | 0xE |
| F25F | I32 | swed_output_0_axis_1_cond_1_angle | Threshold angle that triggers compare function | 0 | -180000 | 180000 | 0,001° | 200A | 0xF |
| F260 | I32 | swed_output_0_axis_1_cond_1_cmp | Compare function to use | 0 | 0 | 2 | 0 = none 1 = less than 2 = greater than | 200A | 0x10 |
| F261 | I32 | swed_output_0_default_state | Initial State relays | 0 | 0 | 1 | 0 = OFF 1 = ON | 200A | 0x12 |
| F262 | I32 | swed_output_0_invert_switch | Invert the logic of the pins | 0 | 0 | 1 | 0 = false 1 = true | 200A | 0x13 |
| F263 | I32 | swed_output_0_delay_switch_on_1 | Signal delay after positive condition | 0 | 0 | 20000 | ms | 200A | 0x14 |

9. Appendix

| | | | | | | | | CANopen | |
|--------------|-----|-----------------------------------|--|---------|---------|--------|---|----------------|-----------|
| DID 0x... | Typ | Parameter | Description | Default | Min | Max | Unit | Index 0x... | Sub-index |
| F264 | I32 | swed_output_0_delay_switch_off_1 | Signal delay after negative condition | 0 | 0 | 20000 | ms | 200A | 0x15 |
| F270 | I32 | swed_output_1_enable | Enable or disable switched signal output | 0 | 0 | 1 | 0 = output disabled 1 = output enabled | 200B | 0x1 |
| F271 | I32 | swed_output_1_hyst | Set the angle hysteresis value | 0 | 0 | 45000 | 0,001° | 200B | 0x2 |
| F272 | I32 | swed_output_1_delay_switch_on_0 | Signal delay after positive condition | 0 | 0 | 20000 | ms | 200B | 0x3 |
| F273 | I32 | swed_output_1_delay_switch_off_0 | Signal delay after negative condition | 0 | 0 | 20000 | ms | 200B | 0x11 |
| F274 | I32 | swed_output_1_logic_link | Overall logic operation to compare both axis | 0 | 0 | 2 | 0 = only single axis 1 = AND 2 = OR | 200B | 0x4 |
| F275 | I32 | swed_output_1_axis_0_angle | Input signal to use to compare axis | 0 | 0 | 2 | 0 = yaw 1 = pitch 2 = roll | 200B | 0x5 |
| F276 | I32 | swed_output_1_axis_0_logic_link | Overall logic operation to compare operators of axis 0 | 0 | 0 | 2 | 0 = only single operator 1 = AND 2 = OR | 200B | 0x6 |
| F277 | I32 | swed_output_1_axis_0_cond_0_angle | Threshold angle that triggers compare function | 0 | -180000 | 180000 | 0,001° | 200B | 0x7 |
| F278 | I32 | swed_output_1_axis_0_cond_0_cmp | Compare function to use | 0 | 0 | 2 | 0 = none 1 = less than 2 = greater than | 200B | 0x8 |
| F279 | I32 | swed_output_1_axis_0_cond_1_angle | Threshold angle that triggers compare function | 0 | -180000 | 180000 | 0,001° | 200B | 0x9 |
| F27A | I32 | swed_output_1_axis_0_cond_1_cmp | Compare function to use | 0 | 0 | 2 | 0 = none 1 = less than 2 = greater than | 200B | 0xA |
| F27B | I32 | swed_output_1_axis_1_angle | Input signal to use to compare axis | 0 | 0 | 2 | 0 = yaw 1 = pitch 2 = roll | 200B | 0xB |
| F27C | I32 | swed_output_1_axis_1_logic_link | Overall logic operation to compare operators of axis 0 | 0 | 0 | 2 | 0 = only single operator 1 = AND 2 = OR | 200B | 0xC |

| | | | | | | | | CANopen | |
|--------------|-----|-----------------------------------|---|-------------|---------|----------------|--|----------------|-----------|
| DID 0x... | Typ | Parameter | Description | Default | Min | Max | Unit | Index 0x... | Sub-index |
| F27D | I32 | swed_output_1_axis_1_cond_0_angle | Threshold angle that triggers compare function | 0 | -180000 | 180000 | 0,001° | 200B | 0xD |
| F27E | I32 | swed_output_1_axis_1_cond_0_cmp | Compare function to use | 0 | 0 | 2 | 0 = none 1 = less than 2 = greater than | 200B | 0xE |
| F27F | I32 | swed_output_1_axis_1_cond_1_angle | Threshold angle that triggers compare function | 0 | -180000 | 180000 | 0,001° | 200B | 0xF |
| F280 | I32 | swed_output_1_axis_1_cond_1_cmp | Compare function to use | 0 | 0 | 2 | 0 = none 1 = less than 2 = greater than | 200B | 0x10 |
| F281 | I32 | swed_output_1_default_state | Initial state relays | 0 | 0 | 1 | 0 = OFF 1 = ON | 200B | 0x12 |
| F282 | I32 | swed_output_1_invert_switch | Invert the switching logic of the relay | 0 | 0 | 1 | 0 = false 1 = true | 200B | 0x13 |
| F283 | I32 | swed_output_1_delay_switch_on_1 | Signal delay after positive condition | 0 | 0 | 20000 | ms | 200B | 0x14 |
| F284 | I32 | swed_output_1_delay_switch_off_1 | Signal delay after negative condition | 0 | 0 | 20000 | ms | 200B | 0x15 |
| F291 | I32 | can_baud_rate | Baudrate of the CAN | 100000 0 | 20000 | 100000 0 | bit/s | 5999 | 0x01 |
| F292 | I32 | can_bus-off_restore_attempts | Number of attempts to reset a detected bus off state (within on drive cycle) before stay in bus off state | 32 | 0 | 0x7FFF FFFF | | 5001 | 0x0 |
| F293 | I32 | can_bus-off_restore_timeout | Time between to CAN bus reset events | 250 | 0 | 1000 | ms | 3000 | 0x1 |
| F294 | I32 | can_bus-off_decrement_time | Time of fault free CAN bus which leads to a decrementing of the error counter | 300000 | 0 | 100000 0 | ms | 3000 | 0x2 |
| F2A0 | I32 | can_protocol | Used CAN protocol | 0 | 0 | 1 | 0 = J1939 1 = CANopen | 599B | 0x0 |
| F2A2 | I32 | can_comsig_on_change_send | Com default mode | 0 | 0 | 1 | 0 = cyclic transmission 1 = send on signal change | 3000 | 0x3 |

9. Appendix

| | | | | | | | | CANopen | |
|--------------|-----|--------------------------------------|--|------------|------------|-------------|--|----------------|-----------|
| DID 0x... | Typ | Parameter | Description | Default | Min | Max | Unit | Index 0x... | Sub-index |
| F2A3 | I32 | can_com_sig_on_change_min_delta_time | Minimum delta time between signal changed | 20 | 0 | 100 | ms | 3000 | 0x4 |
| F2D2 | I32 | customer_ecu_id_0 | Free customer entry | 0 | 0x80000000 | 0x7FFF FFFF | | 2009 | 0x1 |
| F2D3 | I32 | customer_ecu_id_1 | Free customer entry | 0 | 0x80000000 | 0x7FFF FFFF | | 2009 | 0x2 |
| F2D4 | I32 | customer_softid_0 | Free customer entry | 0 | 0x80000000 | 0x7FFF FFFF | | 2009 | 0x3 |
| F2D5 | I32 | customer_softid_1 | Free customer entry | 0 | 0x80000000 | 0x7FFF FFFF | | 2009 | 0x4 |
| F2E0 | I32 | co_node_id | can open node id | 32 | 1 | 127 | | 5999 | 0x2 |
| F2E1 | I32 | co_sync_cob_id | Defines the COBID der SYNC Message. | 0x80 | 0x80000000 | 0x7FFF FFFF | | 1005 | 0x00 |
| F2E2 | I32 | co_producer_heart_beat_time | Interval for heart beat message | 300 | 0 | 0xFFFF | ms | 1017 | 0x0 |
| F2E3 | I32 | co_tpdo1com_cob_id | COBID used | 0x40000180 | 0x80000000 | 0x7FFF FFFF | | 1800 | 0x1 |
| F2E4 | I32 | co_tpdo1com_transmission_type | Transmission type | 254 | 0 | 254 | 0x00 = after each sync 0xFE = Async with the cycle time of canopen_tpdo1com_eventtimer, zero deactivates the event timer. | 1800 | 0x2 |
| F2E5 | I32 | co_tpdo1com_inhibit_time | It is expressed in multiples of 100 microseconds. A value of zero will disable the inhibit time. This time is the minimum interval for PDO transmissions if transmission type is set to 0xFE or 0xFF. This value limits the transmission rate of the TPDOs even if the event time is set to a smaller time or the mapped objects change faster than the inhibit time | 0 | 0 | 0xFFFF | us | 1800 | 0x3 |

| | | | | | | | | CANopen | |
|--------------|-----|-----------------------------------|---|------------|--------------|-------------|---|----------------|-----------|
| DID 0x... | Typ | Parameter | Description | Default | Min | Max | Unit | Index 0x... | Sub-index |
| F2E6 | I32 | co_tpdo1com_event_timer | The time is the maximum interval for PDO transmission if the transmission type is set to 0xFE | 10 | 0 | 0xFFFF | ms | 1800 | 0x5 |
| F2E7 | I32 | co_tpdo1map_parameter1 | object 0x6010.00 (X-Axis) | 0x60100010 | 0x80000000 | 0x7FFF FFFF | co object address | 1A00 | 0x1 |
| F2E8 | I32 | co_tpdo1map_parameter2 | object 0x6020.00 (Y-Axis) | 0x60200010 | 0x80000000 | 0x7FFF FFFF | co object address | 1A00 | 0x2 |
| F2E9 | I32 | co_tpdo1map_parameter3 | object 0x2030.00 (Z-Axis) | 0x20300010 | 0x80000000 | 0x7FFF FFFF | co object address | 1A00 | 0x3 |
| | I32 | (read only) | Manufacturer Specific Error | 0 | | | 0x0000: No error 0x0002: Parameter checksum error 0x0010: Operating voltage error 0x0020: Internal 5V error 0x0040: Internal 3,3V error 0x0080: Internal Uref error 0x0100: Temperature error 0x0200: Configuration error 0x0400: Internal HW error | 4001 | |
| F2EA | I32 | co_tpdo1_resolution | Resolution | 10 | 1 | 1000 | 1 = 0.001 deg 10 = 0.01 deg 100 = 0.1 deg 1000 = 1.0 deg | 6000 | 0x0 |
| F2EB | I32 | co_slope_long_operation_parameter | Slope long16 operating parameter | 2 | 0 | 255 | 7...5: Manufacturer 4...2: reserved 1: scaling enabled 0: inversion enabled | 6011 | 0 |
| F2EC | I32 | co_slope_long_preset_value | Slope long16 preset value | 0 | 0xFFFF F8000 | 0x7FFF | Set the current position to a fixed value. | 6012 | 0 |
| F2ED | I32 | co_slope_long_offset (read only) | Slope long16 offset | 0 | 0xFFFF F8000 | 0x7FFF | Add offset value to the slope value | 6013 | 0 |
| F2EE | I32 | co_slope_long_diff_offset | Differential slope long16 offset | 0 | 0xFFFF F8000 | 0x7FFF | Additional offset to add | 6014 | 0 |

9. Appendix

| | | | | | | | | CANopen | |
|--------------|-----|-----------------------------------|--|----------------|----------------|----------------|--|----------------|-----------|
| DID 0x... | Typ | Parameter | Description | Default | Min | Max | Unit | Index 0x... | Sub-index |
| F2EF | I32 | co_slope_lat_operati-on_parameter | Slope lateral16 operating parameter | 2 | 0 | 255 | 7...5: Manufacturer 4...2: reserved 1: scaling enabled 0: inversion enabled | 6021 | 0 |
| F2F0 | I32 | co_slope_lat_preset_value | Slope lateral16 preset value | 0 | 0xFFF F8000 | 0x7FFF | Set the current position to a fixed value. | 6022 | 0 |
| F2F1 | I32 | co_slope_lat_offset (read only) | Slope lateral16 offset | 0 | 0xFFF F8000 | 0x7FFF | Add offset value to the slope value | 6023 | 0 |
| F2F2 | I32 | co_slope_lat_diff_offset | Differential slope lateral16 offset | 0 | 0xFFF F8000 | 0x7FFF | Additional offset to add | 6024 | 0 |
| F2F3 | I32 | co_auto_nmt | CANopen auto NMT start | 0 | 0 | 1 | 0: not activated 1: activated (starts the PDO transmission automatically after power on - no CANopen; standard) | 5000 | 0 |
| F2F4 | I32 | co_error_mode | Behaviour of the sensor in „signal safe state“ | 2 | 2 | 4 | 2: Preoperational 3: Operational 4: Stop | 1029 | 0x3 |
| F2F5 | I32 | co_tpdo2com_cob_id | COBID used | 0x4000 0280 | 0x8000 0000 | 0x7FFF FFFF | | 1801 | 0x1 |
| F2F6 | I32 | co_tpdo2com_transmission_type | Transmission type | 254 | 0 | 254 | 0x00 = after each sync 0xFE = Async with the cycle time of canopen_tpdo1com_eventtimer, zero deactivates the event timer. | 1801 | 0x2 |
| F2F7 | I32 | co_tpdo2com_inhibit_time | It is expressed in multiples of 100 microseconds. A value of zero will disable the inhibit time. This time is the minimum interval for PDO transmissions if transmission type is set to 0xFE or 0xFF. This value limits the transmission rate of the TPDOs even if the event time is set to a smaller time or the mapped objects change faster than the inhibit time | 0 | 0 | 0xFFFF | us | 1801 | 0x3 |

| | | | | | | | | CANopen | |
|--------------|-----|-------------------------------|--|----------------|----------------|----------------|--|----------------|-----------|
| DID 0x... | Typ | Parameter | Description | Default | Min | Max | Unit | Index 0x... | Sub-index |
| F2F8 | I32 | co_tpdo2com_eventtimer | The time is the maximum interval for PDO transmission if the transmission type is set to 0xFE | 0 | 0 | 0xFFFF | ms | 1801 | 0x5 |
| F2F9 | I32 | co_tpdo3com_cob_id | COBID used | 0x4000 0380 | 0x8000 0000 | 0x7FFF FFFF | | 1802 | 0x1 |
| F2FA | I32 | co_tpdo3com_transmission_type | Transmission type | 254 | 0 | 254 | 0x00 = after each sync 0xFE = Async with the cycle time of canopen_tpdo1com_eventtimer, zero deactivates the event timer. | 1802 | 0x2 |
| F2FB | I32 | co_tpdo3com_inhibit_time | It is expressed in multiples of 100 microseconds. A value of zero will disable the inhibit time. This time is the minimum interval for PDO transmissions if transmission type is set to 0xFE or 0xFF. This value limits the transmission rate of the TPDOs even if the event time is set to a smaller time or the mapped objects change faster than the inhibit time | 0 | 0 | 0xFFFF | us | 1802 | 0x3 |
| F2FC | I32 | co_tpdo3com_eventtimer | The time is the maximum interval for PDO transmission if the transmission type is set to 0xFE | 10 | 0 | 0xFFFF | ms | 1802 | 0x5 |

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9. Appendix

9.3 Switching output

| UDS 0x... | Switch output | Description | Unit |
|--------------|------------------|--|--|
| F250 | 1 | Enable switching output | 0 = Switched off 1 = Switched on |
| F251 | 1 | Hysteresis | 0,001° |
| F252 | 1 | Switch-on delay measuring axis 1 | ms |
| F263 | 1 | Switch-on delay measuring axis 2 | ms |
| F253 | 1 | Switch-off delay measuring axis 1 | ms |
| F264 | 1 | Switch-off delay measuring axis 2 | ms |
| F254 | 1 | Logical operator of measuring axis 1 with measuring axis 2 | 0 = Only result from measuring axis 1 1 = (Measuring axis 1) AND (Measuring axis 2) 2 = (Measuring axis 1) OR (Measuring axis 2) |
| F255 | 1 | Measuring axis 1: for Switching point 1 and Switching point 2 | 0 = Z 1 = X 2 = Y |
| F256 | 1 | Logical operator of Switching point 1 and Switching point 2 | 0 = Only Switching point 1. Switching point 2 is not evaluated 1 = AND 2 = OR |
| F257 | 1 | Switching point 1 | 0,001° |
| F258 | 1 | Switching point 1: Logical operator | 0 = Disabled 1 = less than 2 = greater than |
| F259 | 1 | Switching point 2 | 0,001° |
| F25A | 1 | Switching point 2: Logical operator | 0 = Disabled 1 = less than 2 = greater than |
| F25B | 1 | Measuring axis 2: for Switching point 3 and Switching point 4 | 0 = Z 1 = X 2 = Y |
| F25C | 1 | Logical operator of switching point 3 and switching point 4 | 0 = Only switching point 3. Switching point 4 is not evaluated 1 = AND 2 = OR |
| F25D | 1 | Switching point 3 | 0,001° |
| F25E | 1 | Switching point 3: Logical operator | 0 = Disabled 1 = less than 2 = greater than |
| F25F | 1 | Switching point 4 | 0,001° |
| F260 | 1 | Switching point 4: Logical operator | 0 = Disabled 1 = less than 2 = greater than |
| F261 | 1 | Initial state of the relay | 0 = Switched off 1 = Switched on |
| F262 | 1 | If the inversion is active (closed-circuit current principle), the relay switches off when the switching points are exceeded and the NC contact of the relay is closed. of the relay is closed. If the inversion is deactivated, the NC contact opens when the switching points are exceeded. | 0 = Disabled 1 = Enables |

| UDS 0x... | Switch output | Description | Unit |
|--------------|------------------|--|--|
| F270 | 2 | Activate switching output | 0 = Switched off 1 = Switched on |
| F271 | 2 | Hysteresis | 0,001° |
| F272 | 2 | Switch-on delay measuring axis 1 | ms |
| F283 | 2 | Switch-on delay measuring axis 2 | ms |
| F273 | 2 | Switch-off delay measuring axis 1 | ms |
| F284 | 2 | Switch-off delay measuring axis 2 | ms |
| F274 | 2 | Logical operator of measuring axis 1 with measuring axis 2 | 0 = Only result from measuring axis 1 1 = (Measuring axis 1) AND (Measuring axis 2) 2 = (Measuring axis 1) OR (Measuring axis 2) |
| F275 | 2 | Measuring axis 1: for switching point 1 and switching point 2 | 0 = Z 1 = X 2 = Y |
| F276 | 2 | Logical operator of setpoint 1 and setpoint 2 | 0 = Only switching point 1. Switching point 2 is not evaluated 1 = AND 2 = OR |
| F277 | 2 | Switching point 1 | 0,001° |
| F278 | 2 | Switching point 1: Logical operator | 0 = Disabled 1 = less than 2 = greater than |
| F279 | 2 | Switching point 2 | 0,001° |
| F27A | 2 | Switching point 2: Logical operator | 0 = Disabled 1 = less than 2 = greater than |
| F27B | 2 | Measuring axis 1: for switching point 3 and switching point 4 | 0 = Z 1 = X 2 = Y |
| F27C | 2 | Logical operator of setpoint 3 and setpoint 4 | 0 = Only switching point 3. Switching point 4 is not evaluated 1 = AND 2 = OR |
| F27D | 2 | Switching point 3 | 0,001° |
| F27E | 2 | Switching point 3: Logical operator | 0 = Disabled 1 = less than 2 = greater than |
| F27F | 2 | Switching point 4 | 0,001° |
| F280 | 2 | Switching point 4: Logical operator | 0 = Disabled 1 = less than 2 = greater than |
| F281 | 2 | Initial state of the relay | 0 = Switched off 1 = Switched on |
| F282 | 2 | If the inversion is active (closed-circuit current principle), the relay switches off when the switching points are exceeded and the NC contact of the relay is closed. If the inversion is deactivated, the NC contact opens when the switching points are exceeded. | 0 = Disabled 1 = Enables |

