TMS/TMM61, TMS/TMM88
Inclination sensors with CANopen interface
Described product

1- and 2-dimensional inclination sensors:

TMS88A
TMM88A
TMS88B
TMM88B
TMS61B
TMM61B

Manufacturer

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Original document

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1 About this document

1.1 Function of this document

These operating instructions are intended to give technical personnel working for the machine manufacturer or machine operator instructions on the mounting, electrical installation, commissioning, and operation of the TMS/TMM61 and TMS/TMM88 inclination sensors.

These operating instructions do not provide information on operating the machine in which an inclination sensor is integrated. For information about this, refer to the operating instructions of the particular machine.

1.2 Explanation of symbols

Warnings in these operating instructions are labeled with symbols. The warnings are introduced by signal words that indicate the extent of the danger. These warnings must be observed at all times and care must be taken to avoid accidents, personal injury, and material damage.

DANGER
... indicates a situation of imminent danger, which will lead to a fatality or serious injuries if not prevented.

WARNING
... indicates a potentially dangerous situation, which may lead to a fatality or serious injuries if not prevented.

CAUTION
... indicates a potentially dangerous situation, which may lead to minor/slight injuries if not prevented.

NOTICE
... indicates a potentially harmful situation, which may lead to material damage if not prevented.

NOTE
... highlights useful tips and recommendations as well as information for efficient and trouble-free operation.
2 Safety information

2.1 Intended use

The TMS/TMM61 and TMS/TMM88 inclination sensors are measuring devices consisting of an electronic sensor and integrated evaluation electronics. The tasks for which the measuring devices are designed include recording inclinations in solar thermal energy, photovoltaics or heavy-duty vehicle applications.

SICK AG assumes no liability for losses or damage arising from the use of the product, either directly or indirectly. This applies in particular to use of the product that does not conform to its intended purpose and is not described in this documentation.

2.2 Incorrect use

TMS/TMM61 and TMS/TMM88 inclination sensors do not constitute safety components in accordance with the EC Machinery Directive (2006/42/EC). The inclination sensors must not be used in explosion-hazardous areas. Any other use that is not described as intended use is prohibited. Any use of accessories not specifically approved by SICK AG is at your own risk.

**WARNING**

Danger due to improper use!

Any incorrect use can result in dangerous situations.

Therefore, take note of the following information:

- Inclination sensors should be used only according to intended use specifications.
- All information in these operating instructions must be strictly complied with.

2.3 Requirements for the qualification of personnel

The personnel who work on and with the device must be suitably authorized, trained, and sufficiently qualified. Skilled personnel refers to the following:

- A member of staff who has received specialist training, which is backed up by additional knowledge and experience.
- A member of staff who knows the relevant technical terms and regulations.
- A member of staff who can appraise the work assigned to them, recognize potential hazards, and take suitable safety precautions.

<table>
<thead>
<tr>
<th>Task</th>
<th>Qualification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mounting</td>
<td>• Technical training&lt;br&gt;• Knowledge of current workplace safety regulations</td>
</tr>
<tr>
<td>Electrical installation</td>
<td>• Electrotechnical training&lt;br&gt;• Knowledge of the current electrotechnical workplace safety regulations&lt;br&gt;• Knowledge of the operation and control of the sensor in the particular application</td>
</tr>
<tr>
<td>Commissioning, configuration, and operation</td>
<td>• Technical training&lt;br&gt;• Knowledge of the operation and control of the sensor in the particular application</td>
</tr>
</tbody>
</table>

*Table 1: Skilled personnel qualifications*
Overview

Properties
- 1-dimensional inclination sensor with measuring range: 360° (±180°)
- 2-dimensional inclination sensor with measuring range: 90° (X/Y)
- High sampling rate and bandwidth
- High resolution (0.01°)
- High accuracy (up to 0.02°)
- Compensated cross sensitivity
- Configurable vibration suppression
- Convenient CANopen interface
- Meets the requirements of CiA DS-301, device profile CiA DSP-410
- Baud rates from 10 kbit/s up to 1 Mbit/s
- Automatic baud rate detection
- Setting of node ID and baud rate via LSS service
- Functions:
  - Transmit PDO: Can be mapped dynamically (RTR, cyclic, event-driven, synchronized)
  - SYNC consumer (sync. sending of the Transmit PDO following receipt of a SYNC message)
  - EMCY producer fault monitoring using heartbeat or node guarding/lifeguarding
- UV-resistant, impact-resistant plastic housing or compact and rugged aluminum housing
- Suitable for industrial use:
  - Temperature range: -40 °C to +80 °C
  - Enclosure rating: IP65/67

TMS 1-dimensional inclination sensors are used to measure inclinations in the 360° range. TMM 2-dimensional inclination sensors are used to measure inclinations in 2 ±90° ranges (X/Y). To ensure high levels of accuracy, the sensors are calibrated at the factory.

A compact and rugged design makes the sensors an ideal solution for measuring angles in harsh environments. They are compatible for use in all manner of applications in industry and automotive engineering. All parameter settings can be made easily via the CANopen interface or with the PGT-12-Pro hand-held programing tool.

Areas of application
- Agricultural and forestry machinery
- Construction machinery and special-purpose vehicles
- Solar thermal energy and photovoltaics
- Automated guided systems
- Crane and lifting technology
4 Technical data

4.1 Notice

NOTE
In this chapter you will find an extract from the technical data. For more details, see the product information TMM55, TMS/TMM61, TMS/TMM88 (8019181)

4.2 Technical data for TMS88A/TMM88A

<table>
<thead>
<tr>
<th>General parameters</th>
<th>TMS88A</th>
<th>TMM88A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of measuring axes</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Measuring ranges</td>
<td>360°</td>
<td>±90°</td>
</tr>
<tr>
<td>Resolution</td>
<td>0.01°</td>
<td>0.01°</td>
</tr>
<tr>
<td>Accuracy</td>
<td>Range up to ±60° Typical ±0.04° Maximum ±0.01°</td>
<td>Range up to ±60° Typical ±0.02° Maximum ±0.05°</td>
</tr>
<tr>
<td>Cross sensitivity (compensated)</td>
<td>-</td>
<td>Typ. ±0.09° (±0.10%FS) Max. ±0.45° (±0.50%FS)</td>
</tr>
<tr>
<td>Temperature coefficient (zero point)</td>
<td>Typ. ±0.008°/K</td>
<td></td>
</tr>
<tr>
<td>Sampling rate</td>
<td>80 Hz</td>
<td></td>
</tr>
<tr>
<td>Limit frequency</td>
<td>Typ. 20 Hz, 2nd order (no digital filter) / 0.1 ... 25 Hz, 8th order (with digital filter)</td>
<td></td>
</tr>
<tr>
<td>Operating temperature</td>
<td>-40 °C to +80 °C</td>
<td></td>
</tr>
</tbody>
</table>

Properties

| Data rates | 10 k, 20 k, 50 k, 62.5 k, 100 k, 125 k, 250 k, 500 k, 800 kbit/s, 1 Mbit/s |
| Automatic detection | |

Functions

Polling of angle, cyclic and synchronized transmission, digital filter (critically damped (default) or Butterworth low pass, 8th order), configuration via object directory

Electrical parameters

| Supply voltage | 8 ... 48 VDC |
| Current consumption | <33 mA @ 24 V |

Mechanical parameters

| CAN connection | 2 x 5-pin M12 plug connectors (male connector - female connector, looped through) to CiA 303-1 |
| Enclosure rating | IP65/67 |
| Dimensions / Weight | Large plastic housing: 66 mm x 90 mm x 36 mm / approx. 215 g |

CANopen conformity

CiA DS-301, v4.2.0 Application layer and communication profile

Table 2: Technical data for TMS88A/TMM88A
General parameters

<table>
<thead>
<tr>
<th></th>
<th>TMS88A</th>
<th>TMM88A</th>
</tr>
</thead>
<tbody>
<tr>
<td>CiA DS-410</td>
<td>Device profile for inclinometer</td>
<td></td>
</tr>
<tr>
<td>CiA DSP-305</td>
<td>Layer setting service (LSS) and protocols</td>
<td></td>
</tr>
<tr>
<td>CiA DR-303-3</td>
<td>Indicator specification (status LED)</td>
<td></td>
</tr>
<tr>
<td>CiA AN-801</td>
<td>Automatic bit-rate detection</td>
<td></td>
</tr>
</tbody>
</table>

Table 2: Technical data for TMS88A/TMM88A

1) All specified angular accuracies apply after a run-in time of 10 min at 25 °C, limit frequency 0.3 Hz, absolute calibration accuracy (at 25 °C): ±0.05°

Figure 1: TMS88A measuring axis (large plastic housing)

Figure 2: TMS88A measuring axes (large plastic housing)

4.3 Technical data for TMS88B/TMM88B

<table>
<thead>
<tr>
<th></th>
<th>TMS88B</th>
<th>TMM88B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of measuring axes</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Measuring ranges</td>
<td>360°</td>
<td>±90°</td>
</tr>
<tr>
<td>Resolution</td>
<td>0.01°</td>
<td>0.01°</td>
</tr>
<tr>
<td>Accuracy</td>
<td>Range 0...360° Typical ±0.15° Maximum ±0.25°</td>
<td>Range up to ±60° Typical up to ±80° Maximum ±0.10° Typical ±0.20° Maximum ±0.30°</td>
</tr>
<tr>
<td>Cross sensitivity</td>
<td>-</td>
<td>Typ. ±0.10° (±0.11%FS) Max. ±0.20° (±0.22%FS)</td>
</tr>
</tbody>
</table>

Table 3: Technical data for TMS88B/TMM88B
<table>
<thead>
<tr>
<th>General parameters&lt;sup&gt;1)&lt;/sup&gt;</th>
<th>TMS88B</th>
<th>TMM88B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature coefficient (zero point)</td>
<td>Typ. ±0.008°/K</td>
<td></td>
</tr>
<tr>
<td>Sampling rate</td>
<td>80 Hz</td>
<td></td>
</tr>
<tr>
<td>Limit frequency</td>
<td>Typ. 20 Hz, 2nd order (no digital filter) / 0.1 ... 25 Hz, 8th order (with digital filter)</td>
<td></td>
</tr>
<tr>
<td>Operating temperature</td>
<td>-40 °C to +80 °C</td>
<td></td>
</tr>
</tbody>
</table>

**Properties**

| Data rates | 10 k, 20 k, 50 k, 62.5 k, 100 k, 125 k, 250 k, 500 k, 800 kbit/s, 1 Mbit/s, Automatic detection |
| Functions | Polling of angle, cyclic and synchronized transmission, digital filter (critically damped (default) or Butterworth low pass, 8th order), configuration via object directory |

**Electrical parameters**

| Supply voltage | 8 ... 48 VDC |
| Current consumption | <16 mA @ 24 V |

**Mechanical parameters**

| CAN connection | 1 x 5-pin M12 sensor plug connector (male connector) |
| Enclosure rating | IP65/67 |
| Dimensions / Weight | Aluminum housing: 58 mm x 90 mm x 31 mm / approx. 200 g |

**CANopen conformity**

| CiA DS-301, v4.2.0 | Application layer and communication profile |
| CiA DS-410 | Device profile for inclinometer |
| CiA DSP-305 | Layer setting service (LSS) and protocols |
| CiA DR-303-3 | Indicator specification (status LED) |
| CiA AN-801 | Automatic bit-rate detection |

Table 3: Technical data for TMS88B/TMM88B

<sup>1)</sup> All specified angular accuracies apply after a run-in time of 10 min at 25 °C, limit frequency 0.3 Hz, absolute calibration accuracy (at 25 °C): ±0.05°
4.4 Technical data for TMS61B/TMM61B

<table>
<thead>
<tr>
<th>General parameters(^1)</th>
<th>TMS61B</th>
<th>TMM61B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of measuring axes</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Measuring ranges</td>
<td>360°</td>
<td>±90°</td>
</tr>
<tr>
<td>Resolution</td>
<td>0.01°</td>
<td>0.01°</td>
</tr>
<tr>
<td>Accuracy</td>
<td>Range</td>
<td>Typical</td>
</tr>
<tr>
<td></td>
<td>0...360°</td>
<td>±0.15°</td>
</tr>
<tr>
<td></td>
<td>up to ±60°</td>
<td>±0.10°</td>
</tr>
<tr>
<td></td>
<td>up to ±80°</td>
<td>±0.20°</td>
</tr>
<tr>
<td>Cross sensitivity (compensated)</td>
<td>-</td>
<td>Typ. ±0.09° (±0.10%FS)</td>
</tr>
</tbody>
</table>

Table 4: Technical data for TMS61B/TMM61B
### General parameters

<table>
<thead>
<tr>
<th></th>
<th>TMS61B</th>
<th>TMM61B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature coefficient (zero point)</td>
<td>Typ. ±0.01°/K</td>
<td></td>
</tr>
<tr>
<td>Sampling rate</td>
<td>80 Hz</td>
<td></td>
</tr>
<tr>
<td>Limit frequency</td>
<td>Typ. 20 Hz, 2nd order (no digital filter) / 0.1...25 Hz, 8th order (with digital filter)</td>
<td></td>
</tr>
<tr>
<td>Operating temperature</td>
<td>-40 °C to +80 °C</td>
<td></td>
</tr>
</tbody>
</table>

### Properties

- **Data rates**: 10 k, 20 k, 50 k, 62.5 k, 100 k, 125 k, 250 k, 500 k, 800 kbit/s, 1 Mbit/s
- **Automatic detection**
- **Functions**: Polling of angle, cyclic and synchronized transmission, digital filter (critically damped (default) or Butterworth low pass, 8th order), configuration via object directory

### Electrical parameters

- **Supply voltage**: 8 ... 45 VDC
- **Current consumption**: <16 mA @ 24 V

### Mechanical parameters

- **CAN connection**: Cable, 5-wire, 0.2 m, with 5-pin M12 male connector
- **Enclosure rating**: IP65/67
- **Dimensions / Weight**: Small plastic housing: 68 mm x 36.3 mm x 20.7 mm / approx. 80 g (with cable)
- **CANopen conformity**
  - CiA DS-301, v4.2.0: Application layer and communication profile
  - CiA DS-410: Device profile for inclinometer
  - CiA DSP-305: Layer setting service (LSS) and protocols
  - CiA DR-303-3: Indicator specification (status LED)
  - CiA AN-801: Automatic bit-rate detection

Table 4: Technical data for TMS61B/TMM61B

1) All specified angular accuracies apply after a run-in time of 10 min at 25 °C, limit frequency 0.3 Hz, absolute calibration accuracy (at 25 °C): ±0.05°

**Figure 5: TMS61B measuring axis (small plastic housing)**
Figure 6: TMS61B measuring axis (small plastic housing)
5 Transport and storage

5.1 Transport

For your own safety, please read and observe the following notes:

NOTE
Damage to the device due to improper transport.

- The device must be packaged for transport with protection against shock and damp.
- Recommendation: Use the original packaging as it provides the best protection.
- Transport should be performed by trained specialist staff only.
- The utmost care and attention is required at all times during unloading and transportation on company premises.
- Note the symbols on the packaging.
- Do not remove packaging until immediately before you start mounting.

5.2 Transport inspection

Immediately upon receipt in Goods-in, check the delivery for completeness and for any damage that may have occurred in transit. In the case of transit damage that is visible externally, proceed as follows:

- Do not accept the delivery or only do so conditionally.
- Note the scope of damage on the transport documents or on the transport company's delivery note.
- File a complaint.

NOTE
Complaints regarding defects should be filed as soon as these are detected. Damage claims are only valid before the applicable complaint deadlines.

5.3 Storage

Store the device under the following conditions:

- Recommendation: Use the original packaging.
- Do not store outdoors.
- Store in a dry area that is protected from dust.
- So that any residual damp can evaporate, do not package in airtight containers.
- Do not expose to any aggressive substances.
- Protect from sunlight.
- Avoid mechanical shocks.
- For storage periods of longer than 3 months, check the general condition of all components and packaging on a regular basis.
### 6 Mounting

#### Layout of the fixing holes

The holes for screw-mounting the sensor are located in the baseplate of the inclination sensor (dimensions in mm).

![Figure 7: Fixing holes, aluminum housing](image)

![Figure 8: Fixing holes, large plastic housing](image)

![Figure 9: Fixing holes, small plastic housing](image)

---

**NOTICE**

There is a risk of damage to the housing if inadequate lifting accessories are used!

- Use suitable washers for plastic housings.
7 Connection

Plug connector pin assignment

TMS/TMM88A and TMS/TMM88B inclination sensors are equipped with a standard 5-pin M12 round male connector (A-coded). TMS/TMM61 inclination sensors are supplied with a 20 cm long cable at the end of which there is a 5-pin M12 round male connector (A-coded). TMS/TMM88A inclination sensors also have a 5-pin M12 female connector (A-coded). The pin assignment corresponds to CiA DR-303-1.

![Diagram of male connector]

<table>
<thead>
<tr>
<th>Pin</th>
<th>Signal</th>
<th>Pin assignment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CAN_SHLD</td>
<td>Screen</td>
</tr>
<tr>
<td>2</td>
<td>CAN_V+</td>
<td>Supply voltage (+24 V)</td>
</tr>
<tr>
<td>3</td>
<td>CAN_GND</td>
<td>GND / 0 V / V-</td>
</tr>
<tr>
<td>4</td>
<td>CAN_H</td>
<td>CAN_H bus cable</td>
</tr>
<tr>
<td>5</td>
<td>CAN_L</td>
<td>CAN_L bus cable</td>
</tr>
</tbody>
</table>

*Table 5: CANopen M12 male connector pin assignment*

![Diagram of female connector]

<table>
<thead>
<tr>
<th>Pin</th>
<th>Signal</th>
<th>Pin assignment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CAN_SHLD</td>
<td>Screen</td>
</tr>
<tr>
<td>2</td>
<td>CAN_V+</td>
<td>Supply voltage (+24 V)</td>
</tr>
<tr>
<td>3</td>
<td>CAN_GND</td>
<td>GND / 0 V / V-</td>
</tr>
<tr>
<td>4</td>
<td>CAN_H</td>
<td>CAN_H bus cable</td>
</tr>
<tr>
<td>5</td>
<td>CAN_L</td>
<td>CAN_L bus cable</td>
</tr>
</tbody>
</table>

*Table 6: CANopen M12 female connector pin assignment*

Bus terminator

**NOTE**
The inclination sensors do not have an internal terminator.
8 Description of operation

8.1 Function overview

The inclination sensors have a standardized CANopen interface according to CiA DS-301 and a device profile according to CiA DS-410. All measured values and parameters can be accessed via the object directory (OD). The individual configuration can be saved in the internal permanent memory (EEPROM). The following CANopen functions are available:

- One transmission data object (Transmit PDO 1), can be mapped dynamically in four different operating modes:
  - Specific request via remote transmit request (RTR) message
  - Cyclic transmission based on interval time
  - Event-controlled transmission on inclination change
  - Synchronous transmission following receipt of a SYNC message
- One service data object (standard SDO)
- Error messages based on emergency object (EMCY) with support:
  - Of the general error register
  - Of the manufacturer specific status register
  - Of the pre-defined error field
- Monitoring mechanisms: heartbeat as well as node guarding / lifeguarding
- Save and restore functions for all parameters (store and load parameter field)
- Status and error display via bi-color LED (according to CiA DR-303-3)

There are more manufacturer-specific / profile-specific properties in addition to the CiA DS-301 functionality:

- Limit frequency (digital filter), freely configurable
- Configuration of the minimum change in angle for Transmit PDO 1 transmission event
- Change in direction of the inclination angle
- Zero-point setting of the inclination angle
- Setting of node ID and baud rate via LSS service according to CiA DSP-305
- Automatic baud rate detection according to CiA AN-801
9 CANopen interface

9.1 Communication profile

The CANopen communication profile (documented in CiA DS-301) regulates how the devices in a CANopen network exchange data.

9.1.1 CANopen in the OSI model

The CANopen protocol is a standardized Layer 7 protocol for the CAN bus. This layer is based on the CAN Application Layer (CAL).

![CANopen in the OSI layers model](image)

NOTE
Layers 3 to 6 are not used in the CANopen definition.

9.1.2 Communication channels

CANopen features various communication channels (SDO, PDO, Emergency Messages). These channels are formed with the help of the communication object identifier (COB ID). The COB IDs are based on the node IDs of the individual devices on the CANopen bus (see "Node IDs and COB IDs", page 19).
Layer setting services (LSS) are used to set the node ID of the inclination sensor (see "Layer setting services (LSS)", page 20).

After this, the inclination sensor can be addressed via the network management services (NMT) (see "Network management: NMT", page 23) and its CANopen state machine can be switched to the necessary status (Pre-Operational, Operational, or Stopped) by the master.

In Pre-Operational status, communication and configuration can be carried out via service data objects (SDO) (see "Service data objects (SDO)", page 27). In Operational status, communication is also possible via process data objects (PDO) and emergency messages (EMGY).

9.1.3 Topology

T-connectors or Y-cables are used to integrate the inclination sensors into the CANopen trunk cable (the T-connectors are available as accessories). The trunk cable must be terminated at the end. This is not necessary for the stub cables that are connected to the sensors.

NOTE
Since TMS/TMM88A inclination sensors have a female connector with looped-through CAN bus, they can also be integrated into the trunk cable without the need for T-connectors or Y-cables.
9.1.4 Introducing an inclination sensor into a CANopen network

An ESD file makes it easy to link the inclination sensors to a CANopen master. This file contains information on the following features of the inclination sensors:

- Information about the device manufacturer
- Name, type and version number of the device
- Type and version number of the protocol to be used for this device
- Inclination sensor default parameters
- Process data default configuration

Figure 13: ESD file integration

9.2 Node IDs and COB IDs

There can be a maximum of 128 devices on a CANopen network: one master and up to 127 slaves. Every device has a unique node ID (node address).

The COB IDs (communication object identifiers) of the communication channels are derived from this ID.

<table>
<thead>
<tr>
<th>Calculation of COB ID [dec] [hex]</th>
<th>ID ranges [dec] [hex]</th>
<th>Function</th>
<th>Direction from the point of view of the sensor</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>Network management</td>
<td>Receive</td>
</tr>
<tr>
<td>128 0080h</td>
<td>128 0080h</td>
<td>SYNC</td>
<td>Receive</td>
</tr>
<tr>
<td>128 + node ID 0080h + node ID</td>
<td>129 ... 255 0081h ... 00FFh</td>
<td>Emergency message</td>
<td>Transmit</td>
</tr>
<tr>
<td>384 + node ID 0180h + node ID</td>
<td>385 ... 511 0181h ... 01FFh</td>
<td>Transmit PDO 1</td>
<td>Transmit</td>
</tr>
<tr>
<td>1408 + node ID 0580h + node ID</td>
<td>1409 ... 1535 0581h ... 05FFh</td>
<td>Transmit SDO</td>
<td>Transmit</td>
</tr>
<tr>
<td>1536 + node ID 0600h + node ID</td>
<td>1537 ... 1663 0601h ... 067Fh</td>
<td>Receive SDO</td>
<td>Receive</td>
</tr>
<tr>
<td>1792 + node ID 0700h + node ID</td>
<td>1793 ... 1919 0701h ... 077Fh</td>
<td>Node guarding, heartbeat, boot up</td>
<td>Transmit</td>
</tr>
</tbody>
</table>

Table 7: Overview of node IDs and COB IDs
Table 7: Overview of node IDs and COB IDs

<table>
<thead>
<tr>
<th>Calculation of COB ID [dec] [hex]</th>
<th>ID ranges [dec] [hex]</th>
<th>Function</th>
<th>Direction from the point of view of the sensor</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020 07E4h</td>
<td>2020 07E4h</td>
<td>Transmit LSS</td>
<td>Transmit</td>
</tr>
<tr>
<td>2021 07E5h</td>
<td>2021 07E5h</td>
<td>Receive LSS</td>
<td>Receive</td>
</tr>
</tbody>
</table>

Example

The sensor receives node ID = 5, then sends emergency messages via ID 133, Transmit PDO 1 via ID 389, and SDOs via ID 1413.

The layer setting services can be used to configure the node ID of the sensor (see "Layer setting services (LSS)", page 20).

9.3 Layer setting services (LSS)

Layer setting services are supported to set the node ID and the baud rate of the inclination sensor.

The LSS slave is accessed via its LSS address (identity object), which is stored in object 1018h.

The LSS address comprises:
- Manufacturer ID
- Product code
- Revision number
- Serial number

The master uses the LSS services to request the individual services that are then executed by the inclination sensor. The LSS telegrams facilitate communication between LSS master and LSS slave.

The following COB IDs are used:
- 07E4h = LSS slave to LSS master
- 07E5h = LSS master to LSS slave

Format of an LSS telegram

NOTE
An LSS telegram is always 8 bytes long. Byte 0 contains the command specifier (CS), followed by 7 bytes for the data. All bytes that are not in use must be set to zero.

<table>
<thead>
<tr>
<th>COB-ID</th>
<th>Byte 0</th>
<th>Byte 1</th>
<th>Byte 2</th>
<th>Byte 3</th>
<th>Byte 4</th>
<th>Byte 5</th>
<th>Byte 6</th>
<th>Byte 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>07E5h</td>
<td>04h</td>
<td>Mode</td>
<td>00h</td>
<td>00h</td>
<td>00h</td>
<td>00h</td>
<td>00h</td>
<td></td>
</tr>
</tbody>
</table>

Table 9: Format of the Switch Mode Global command

Switch Mode Global

The Switch Mode Global command switches the configuration mode on or off. The command remains unconfirmed and the inclination sensor does not respond.
Byte 1 mode:
00h = Switches LSS configuration mode off
01h = Switches to LSS configuration mode

**Configure Node ID**

This command is used to set the node address.

<table>
<thead>
<tr>
<th>COB-ID</th>
<th>Byte 0</th>
<th>Byte 1</th>
<th>Byte 2</th>
<th>Byte 3</th>
<th>Byte 4</th>
<th>Byte 5</th>
<th>Byte 6</th>
<th>Byte 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>07E5h</td>
<td>11h</td>
<td>Node ID</td>
<td>00h</td>
<td>00h</td>
<td>00h</td>
<td>00h</td>
<td>00h</td>
<td>00h</td>
</tr>
</tbody>
</table>

*Table 10: Format of the Configure Node ID command*

Byte 1 node ID:
01h = node address 1
...
7Fh = node address 127

Response:

<table>
<thead>
<tr>
<th>COB-ID</th>
<th>Byte 0</th>
<th>Byte 1</th>
<th>Byte 2</th>
<th>Byte 3</th>
<th>Byte 4</th>
<th>Byte 5</th>
<th>Byte 6</th>
<th>Byte 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>07E4h</td>
<td>11h</td>
<td>Error code</td>
<td>Error extend</td>
<td>00h</td>
<td>00h</td>
<td>00h</td>
<td>00h</td>
<td></td>
</tr>
</tbody>
</table>

*Table 11: Response to the Configure Node ID command*

Byte 1 error code:
00h = Configuration successful
01h = Parameter invalid
FFh = Contains a specific error code

Byte 2 error extend:
The error extension is manufacturer-specific; it is always 00h in the case of the inclination sensor.

**Configure Bit Timing Parameters**

This command is used to set the baud rate based on a baud rate table.

<table>
<thead>
<tr>
<th>COB-ID</th>
<th>Byte 0</th>
<th>Byte 1</th>
<th>Byte 2</th>
<th>Byte 3</th>
<th>Byte 4</th>
<th>Byte 5</th>
<th>Byte 6</th>
<th>Byte 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>07E5h</td>
<td>13h</td>
<td>00h</td>
<td>Table index</td>
<td>00h</td>
<td>00h</td>
<td>00h</td>
<td>00h</td>
<td></td>
</tr>
</tbody>
</table>

*Table 12: Format of the Configure Bit Timing Parameters command*

Byte 1 table index from the baud rate table:

<table>
<thead>
<tr>
<th>Table index</th>
<th>Baud rate</th>
<th>Supported</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1,000 kbit/s</td>
<td>Yes</td>
</tr>
<tr>
<td>1</td>
<td>800 kbit/s</td>
<td>Yes</td>
</tr>
<tr>
<td>2</td>
<td>500 kbit/s</td>
<td>Yes</td>
</tr>
<tr>
<td>3</td>
<td>250 kbit/s</td>
<td>Yes</td>
</tr>
<tr>
<td>4</td>
<td>125 kbit/s</td>
<td>Yes</td>
</tr>
<tr>
<td>5</td>
<td>100 kbit/s</td>
<td>No</td>
</tr>
<tr>
<td>6</td>
<td>50 kbit/s</td>
<td>Yes</td>
</tr>
</tbody>
</table>

*Table 13: Baud rate table*
Table 13: Baud rate table

<table>
<thead>
<tr>
<th>Table index</th>
<th>Baud rate</th>
<th>Supported</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>20 kbit/s</td>
<td>Yes</td>
</tr>
<tr>
<td>8</td>
<td>10 kbit/s</td>
<td>Yes</td>
</tr>
<tr>
<td>9</td>
<td>Automatic detection</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Response:

<table>
<thead>
<tr>
<th>COB-ID</th>
<th>Byte 0</th>
<th>Byte 1</th>
<th>Byte 2</th>
<th>Byte 3</th>
<th>Byte 4</th>
<th>Byte 5</th>
<th>Byte 6</th>
<th>Byte 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>07E4h</td>
<td>13h</td>
<td>Error code</td>
<td>Error extend</td>
<td>00h</td>
<td>00h</td>
<td>00h</td>
<td>00h</td>
<td>00h</td>
</tr>
</tbody>
</table>

Table 14: Response to the Configure Bit Timing Parameters command

Byte 1 error code:
00h = Configuration successful
01h = Parameter invalid
FFh = Contains a specific error code

Byte 2 error extend:
The error extension is manufacturer-specific; it is always 00h in the case of the inclination sensor.

Store Configuration

The command saves the configuration.

NOTE
The configuration is not saved in the non-volatile memory (EEPROM). Object 1010h – Save Parameters must be used in order to do this.

<table>
<thead>
<tr>
<th>COB-ID</th>
<th>Byte 0</th>
<th>Byte 1</th>
<th>Byte 2</th>
<th>Byte 3</th>
<th>Byte 4</th>
<th>Byte 5</th>
<th>Byte 6</th>
<th>Byte 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>07E5h</td>
<td>17h</td>
<td>00h</td>
<td>00h</td>
<td>00h</td>
<td>00h</td>
<td>00h</td>
<td>00h</td>
<td>00h</td>
</tr>
</tbody>
</table>

Table 15: Format of the Store Configuration command

Response:

<table>
<thead>
<tr>
<th>COB-ID</th>
<th>Byte 0</th>
<th>Byte 1</th>
<th>Byte 2</th>
<th>Byte 3</th>
<th>Byte 4</th>
<th>Byte 5</th>
<th>Byte 6</th>
<th>Byte 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>07E4h</td>
<td>17h</td>
<td>Error code</td>
<td>Error extend</td>
<td>00h</td>
<td>00h</td>
<td>00h</td>
<td>00h</td>
<td>00h</td>
</tr>
</tbody>
</table>

Table 16: Response to the Store Configuration command

Byte 1 error code:
00h = Store successful
01h = Store Configuration command is not supported
02h = Error occurred during store operation
FFh = Contains a specific error code

Byte 2 error extend:
The error extension is manufacturer-specific; it is always 00h in the case of the inclination sensor.
Inquire LSS Address Service

This command can be used to read out the node ID of the inclination sensor and, from object 1018h, the manufacturer ID, the product code, the revision number, and the serial number.

<table>
<thead>
<tr>
<th>COB-ID</th>
<th>Byte 0</th>
<th>Byte 1</th>
<th>Byte 2</th>
<th>Byte 3</th>
<th>Byte 4</th>
<th>Byte 5</th>
<th>Byte 6</th>
<th>Byte 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>07E5h</td>
<td>00h</td>
<td>00h</td>
<td>00h</td>
<td>00h</td>
<td>00h</td>
<td>00h</td>
<td>00h</td>
<td></td>
</tr>
</tbody>
</table>

Table 17: Format of the Inquire LSS Address Service command

Byte 0 CMD from the command table:

<table>
<thead>
<tr>
<th>CMD</th>
<th>Parameter</th>
<th>Subindex of object 1018h</th>
</tr>
</thead>
<tbody>
<tr>
<td>5Eh</td>
<td>Node ID</td>
<td></td>
</tr>
<tr>
<td>5Dh</td>
<td>Serial number</td>
<td>.4</td>
</tr>
<tr>
<td>5Ch</td>
<td>Revision number</td>
<td>.3</td>
</tr>
<tr>
<td>5Bh</td>
<td>Product code</td>
<td>.2</td>
</tr>
<tr>
<td>5Ah</td>
<td>Vendor ID</td>
<td>.1</td>
</tr>
</tbody>
</table>

Table 18: Command table

Response:

<table>
<thead>
<tr>
<th>COB-ID</th>
<th>Byte 0</th>
<th>Byte 1</th>
<th>Byte 2</th>
<th>Byte 3</th>
<th>Byte 4</th>
<th>Byte 5</th>
<th>Byte 6</th>
<th>Byte 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>07E4h</td>
<td>00h</td>
<td></td>
<td>Data-X (LSB)</td>
<td>Data-X</td>
<td>Data-X (MSB)</td>
<td>00h</td>
<td>00h</td>
<td>00h</td>
</tr>
</tbody>
</table>

Table 19: Response to the Inquire LSS Address Service command

NOTE

The data is 4 bytes long in little-endian byte sequence. If fewer than 4 bytes of data are read out, the remaining bytes are set to 0.

Identify Non-Configured Slave Device

The command is used to identify non-configured devices.

<table>
<thead>
<tr>
<th>COB-ID</th>
<th>Byte 0</th>
<th>Byte 1</th>
<th>Byte 2</th>
<th>Byte 3</th>
<th>Byte 4</th>
<th>Byte 5</th>
<th>Byte 6</th>
<th>Byte 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>07E5h</td>
<td>00h</td>
<td>00h</td>
<td>00h</td>
<td>00h</td>
<td>00h</td>
<td>00h</td>
<td>00h</td>
<td></td>
</tr>
</tbody>
</table>

Table 20: Format of the Identify Non-Configured Slave Device command

Response:

<table>
<thead>
<tr>
<th>COB-ID</th>
<th>Byte 0</th>
<th>Byte 1</th>
<th>Byte 2</th>
<th>Byte 3</th>
<th>Byte 4</th>
<th>Byte 5</th>
<th>Byte 6</th>
<th>Byte 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>07E4h</td>
<td>00h</td>
<td>00h</td>
<td>00h</td>
<td>00h</td>
<td>00h</td>
<td>00h</td>
<td>00h</td>
<td></td>
</tr>
</tbody>
</table>

Table 21: Response to the Identify Non-Configured Slave Device command

9.4 Network management: NMT

Network management (NMT) initializes the nodes in a CANopen network. It also adds the nodes to the network, as well as stopping and monitoring them.

There is only one NMT master (network management master) in a CANopen network. All other devices, including the inclination sensor, are NMT slaves. The NMT master monitors all devices and can change their status.

A PLC or a PC usually serves as the NMT master.
9.4.1 CANopen state machine

Like every CANopen slave, the inclination sensor features what is known as a CANopen state machine. The following statuses can be identified:

<table>
<thead>
<tr>
<th>Status</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initializing</td>
<td>Initialization commences. Both the device application and device communication are initialized. After this, the node automatically switches to Pre-Operational status.</td>
</tr>
<tr>
<td>Pre-Operational</td>
<td>The inclination sensor is ready for configuration; acyclic communication can take place via SDO. However, the inclination sensor is not yet able to commence PDO communication and is not sending out any emergency messages.</td>
</tr>
<tr>
<td>Operational</td>
<td>In this status, the inclination sensor is fully ready for operation and can transmit messages autonomously (PDOs, emergency messages).</td>
</tr>
<tr>
<td>Stopped</td>
<td>In this status, the inclination sensor is not actively communicating (although communication is still being actively monitored via node guarding).</td>
</tr>
</tbody>
</table>

Table 22: Status of the CANopen state machine

9.4.2 Network management services

NMT services are used to switch between the individual statuses of the CANopen state machine. The NMT telegrams for device monitoring use the COB ID 0 and thus have the highest priority.

<table>
<thead>
<tr>
<th>COB-ID</th>
<th>Byte 0, CCD</th>
<th>Byte 1</th>
<th>Byte 2</th>
<th>Byte 3</th>
<th>Byte 4</th>
<th>Byte 5</th>
<th>Byte 6</th>
<th>Byte 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>00h</td>
<td>CCD</td>
<td>Node ID</td>
<td>00h</td>
<td>00h</td>
<td>00h</td>
<td>00h</td>
<td>00h</td>
<td>00h</td>
</tr>
</tbody>
</table>

Table 23: Format of the NMT telegram

<table>
<thead>
<tr>
<th>Byte 0, CCD</th>
<th>Parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>01h</td>
<td>Start Remote Node</td>
</tr>
<tr>
<td></td>
<td>Sets the inclination sensor to Operational status.</td>
</tr>
<tr>
<td>02h</td>
<td>Stop Remote Node</td>
</tr>
<tr>
<td></td>
<td>Sets the inclination sensor to Stopped status and stops it communicating</td>
</tr>
<tr>
<td></td>
<td>(although communication is still being actively monitored via node guard-</td>
</tr>
<tr>
<td></td>
<td>ing).</td>
</tr>
<tr>
<td>80h</td>
<td>Enter Pre-Operational</td>
</tr>
<tr>
<td></td>
<td>Sets the inclination sensor to Pre-Operational status. All communication</td>
</tr>
<tr>
<td></td>
<td>channels except the PDOs can be used.</td>
</tr>
<tr>
<td>81h</td>
<td>Reset Node</td>
</tr>
<tr>
<td></td>
<td>Resets the values of the profile parameters to the default values. After</td>
</tr>
<tr>
<td></td>
<td>this, the inclination sensor switches to Reset Communication status.</td>
</tr>
<tr>
<td>82h</td>
<td>Reset Communication</td>
</tr>
<tr>
<td></td>
<td>Sets the inclination sensor to Reset Communication status. After this, the</td>
</tr>
<tr>
<td></td>
<td>inclination sensor switches to Initialization status.</td>
</tr>
</tbody>
</table>

Table 24: Meaning of byte 0
Transitions between the individual operating statuses

Figure 14: Process diagram of status changes

<table>
<thead>
<tr>
<th>Transition</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>After switching on, the inclination sensor switches to Initialization status.</td>
</tr>
<tr>
<td>2</td>
<td>After Initialization, the inclination sensor automatically switches to Pre-Operational status.</td>
</tr>
<tr>
<td>3 and 8</td>
<td>The Start Remote Node command switches the inclination sensor to Operational status.</td>
</tr>
<tr>
<td>4 and 7</td>
<td>The Enter Pre-Operational State command resets the inclination sensor to Pre-Operational status.</td>
</tr>
<tr>
<td>5 and 6</td>
<td>The Stop Remote Node command switches the inclination sensor to Stopped status.</td>
</tr>
<tr>
<td>9, 10, and 11</td>
<td>The Reset Node command switches the inclination sensor to Initialization status.</td>
</tr>
<tr>
<td>12, 13, and 14</td>
<td>The Reset Communication command switches the inclination sensor to Initialization status.</td>
</tr>
</tbody>
</table>

Table 25: Transitions between operating statuses

9.4.3 Boot-up message

To signal that the device is ready for operation following switching on, a “boot-up message” is sent out. This message uses the ID of the NMT error control protocol and is permanently linked to the set device address (700h + node ID).

9.4.4 Node guarding and heartbeat

The inclination sensor can be monitored permanently with the node guarding protocol or the heartbeat protocol.
NOTE
It is not possible to use the node guarding protocol and the heartbeat protocol in parallel with a single node. If the heartbeat time parameter of object 1017h is not equal to 0, the heartbeat protocol is used.

Node guarding
The node guarding telegram is sent to poll the status of the inclination sensor at regular intervals. The sensor responds within the response time configured in objects 100Ch (guard time) and 100Dh (life-time factor).

This time is referred to as the node life time. It is calculated as follows:

“Node life time” = “guard time” x “life-time factor”

If the inclination sensor does not send a response within this time, the connection is considered to have been lost.

<table>
<thead>
<tr>
<th>COB-ID</th>
<th>Byte 0</th>
<th>Byte 1</th>
<th>Byte 2</th>
<th>Byte 3</th>
<th>Byte 4</th>
<th>Byte 5</th>
<th>Byte 6</th>
<th>Byte 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>700h + node ID</td>
<td>Status</td>
<td>00h</td>
<td>00h</td>
<td>00h</td>
<td>00h</td>
<td>00h</td>
<td>00h</td>
<td>00h</td>
</tr>
</tbody>
</table>

Table 26: Format of the node guarding telegram

<table>
<thead>
<tr>
<th>Byte 0, status</th>
<th>Parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bit 7</td>
<td>Toggle bit</td>
</tr>
<tr>
<td></td>
<td>The bit changes its value every time it is polled.</td>
</tr>
<tr>
<td>Bits 6 ... 0</td>
<td>Operating status of the inclination sensor:</td>
</tr>
<tr>
<td></td>
<td>127 = Pre-Operational</td>
</tr>
<tr>
<td></td>
<td>5 = Operational</td>
</tr>
<tr>
<td></td>
<td>4 = Stopped</td>
</tr>
<tr>
<td></td>
<td>0 = Boot Up</td>
</tr>
</tbody>
</table>

Table 27: Meaning of byte 0

Example for an inclination sensor in Operational operating status:
85h, 05h, 85h = no error
85h, 05h, 05h = error

NOTE
If node guarding is active, the inclination sensor expects to receive a corresponding status query from an NMT master within a certain time frame. If it does not, the slave switches to Pre-Operational status.

Heartbeat
If the heartbeat telegram is used, the inclination sensor sends its status autonomously at cyclic intervals. This can be monitored by every other node in the network.

The heartbeat time is configured with object 1017h.

<table>
<thead>
<tr>
<th>COB-ID</th>
<th>Byte 0</th>
<th>Byte 1</th>
<th>Byte 2</th>
<th>Byte 3</th>
<th>Byte 4</th>
<th>Byte 5</th>
<th>Byte 6</th>
<th>Byte 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>700h + node ID</td>
<td>Status</td>
<td>00h</td>
<td>00h</td>
<td>00h</td>
<td>00h</td>
<td>00h</td>
<td>00h</td>
<td>00h</td>
</tr>
</tbody>
</table>

Table 28: Format of the heartbeat telegram
### Byte 0, status

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bit 7</td>
<td><strong>Toggle bit</strong></td>
</tr>
<tr>
<td></td>
<td>The bit changes its value every time it is polled.</td>
</tr>
<tr>
<td>Bits 6 ... 0</td>
<td>Operating status of the inclination sensor:</td>
</tr>
<tr>
<td></td>
<td>127 = Pre-Operational</td>
</tr>
<tr>
<td></td>
<td>5 = Operational</td>
</tr>
<tr>
<td></td>
<td>4 = Stopped</td>
</tr>
<tr>
<td></td>
<td>0 = Boot Up</td>
</tr>
</tbody>
</table>

*Table 29: Meaning of byte 0*

- **NOTE**
  - Heartbeat has a significant influence on the bus load of the CANopen network but only generates half the bus load of node guarding.

### 9.5 Service data objects (SDO)

Service data objects (SDO) form the communication channel through which device parameters are transmitted. They are used for status queries.

SDOs can be used to transmit data of any length. The data might have to be split into several CAN messages. An SDO is always transmitted with confirmation, i.e. the receipt of every message is acknowledged by the receiver.

**Transmit SDO and Receive SDO**

The inclination sensor has a Transmit SDO channel and a Receive SDO channel, to which two CAN identifiers are assigned.

SDO communication corresponds to the client-server model. The inclination sensor functions as an SDO server.

In its request, the SDO client (e.g., the PLC) specifies the parameter, the access method (read/write), and the value, if applicable. The inclination sensor executes read or write access and responds to the request.

The maximum data length of a CAN telegram of 8 bytes is assigned by an SDO as follows:

<table>
<thead>
<tr>
<th>COB-ID</th>
<th>CCD</th>
<th>Index</th>
<th>Subindex</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>600h + node ID</td>
<td>Byte 0</td>
<td>Byte 1</td>
<td>Byte 2</td>
<td>Byte 3</td>
</tr>
</tbody>
</table>

*Table 30: Format of the SDO telegram*

The command code (CCD) identifies whether read or write access is required. In the event of an error, the data range will contain a 4-byte error code which provides information about the cause of the error.
In the example, the inclination sensor (ID = 5) receives the read request (CCD = 40h) for object 1000h from the PLC via ID 0605h (Receive SDO 0600h + inclination sensor ID).

The inclination sensor responds by sending ID 0585h (Transmit SDO 0580h + inclination sensor ID) with feedback (CCD = 43h).

Figure 15: Example request/response telegram

9.6 Process data objects (PDO)

Process data objects (PDO) are used for rapid and efficient data exchange of real-time data (e.g., I/O data, setpoint values or actual values).

PDOs are transmitted without confirmation.

The inclination sensor supports one Transmit PDO.
9.6.1 PDO mapping

The format of the PDO telegram between master and inclination sensor must be agreed through what is known as PDO mapping. The process data can be arranged at will in the PDO message. The address (i.e. index and subindex) and the size (number of bits) from the entry in the object directory are entered in the mapping object for this purpose.

Example:

Object 1A00h is factory-set to contain the following objects, depending on sensor type:
- 6010.00h - inclination value, axial (TMS) or longitudinal (TMM)
- 6020.00h - inclination value, lateral (TMM only)

The content of the objects is transmitted in the Transmit PDO telegram.

<table>
<thead>
<tr>
<th>COB-ID</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>0180h + node ID</td>
<td>Byte 0</td>
</tr>
<tr>
<td>Inclination value, axial</td>
<td>Not used</td>
</tr>
</tbody>
</table>

Table 32: Example Transmit PDO telegram (TMS)

<table>
<thead>
<tr>
<th>COB-ID</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>0180h + node ID</td>
<td>Byte 0</td>
</tr>
<tr>
<td>Inclination value longitudinal</td>
<td>Inclination value lateral</td>
</tr>
</tbody>
</table>

Table 33: Example Transmit PDO telegram (TMM)

9.6.2 PDO data transmission

The PDOs can be transmitted cyclically or acyclically. This is determined by the Transmit PDO and the transmission type defined in its subindex 02.
Synchronized data transmission

In synchronized data transmission, the process data is transmitted with the SYNC messages. The cycle is formed from a multiple of the SYNC messages. The factor can be between 1 and 240.

Cyclic data transmission

In cyclic data transmission, the inclination sensor sends the PDO at defined intervals. The associated period duration is configured in object 1800.05h.

Acyclic data transmission

For acyclic data transmission, the inclination sensor is triggered by one of the following criteria:

- Application-specific / device-specific triggering
  The sending of the PDO is triggered by an event. This event is defined in object 3001h.
- On request (RTR telegram)
  In this case, another bus node (usually the master) requests the process data.

**NOTE**

For the inclination sensor to output the PDO cyclically or acyclically, the transmission type must be changed in the Transmit PDO in object 1800.02h (see "Transmit PDO 1 – Transmission type (1800h)", page 34).

9.7 Object directory

The object directory contains all data objects which can be accessed from outside and which have an impact on communication, application and state machines. It is divided into three parts:

- Communication-specific part (index: 0x1000 – 0x1FFF)
- Manufacturer-specific part (index: 0x2000 – 0x5FFF)
- Profile-specific part (index: 0x6000 – 0x9FFF)

The parameters it contains can be read and written with the standard SDO based on index and subindex.

The following sections describe all parameters in the object directory of an inclination sensor including index, subindex, data type, access right and default value (factory setting). The Storage column indicates whether a parameter can be saved in the internal permanent memory (write save signature to OD index 1010h/01h).

### 9.7.1 Communication parameters (to CiA DS-301)

<table>
<thead>
<tr>
<th>Index</th>
<th>Subindex</th>
<th>Parameter</th>
<th>Data type</th>
<th>Access</th>
<th>Default value</th>
<th>Storage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000h</td>
<td>0</td>
<td>Device type (device profile 410)</td>
<td>UNS32</td>
<td>ro</td>
<td>1019Ah/2019Ah</td>
<td></td>
</tr>
<tr>
<td>1001h</td>
<td>0</td>
<td>Error register</td>
<td>UNS8</td>
<td>ro</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>1002h</td>
<td>0</td>
<td>Manufacturer status register</td>
<td>UNS32</td>
<td>ro</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>1003h</td>
<td>0</td>
<td>Predefined error field</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number of error entries</td>
<td>UNS32</td>
<td>rw</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1..5</td>
<td>Error code (oldest error assigned to highest index)</td>
<td>UNS32</td>
<td>ro</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>1005h</td>
<td>0</td>
<td>COB ID sync message</td>
<td>UNS32</td>
<td>rw</td>
<td>80h</td>
<td></td>
</tr>
</tbody>
</table>

*Table 34: Communication parameters in the object directory*
<table>
<thead>
<tr>
<th>Index</th>
<th>Subindex</th>
<th>Parameter</th>
<th>Data type</th>
<th>Access</th>
<th>Default value</th>
<th>Storage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1008h</td>
<td>0</td>
<td>Device name</td>
<td>VSTR</td>
<td>const</td>
<td>dep. on type</td>
<td></td>
</tr>
<tr>
<td>100Ah</td>
<td>0</td>
<td>Software version (&quot;Vxx.yy&quot;)</td>
<td>VSTR</td>
<td>const</td>
<td>dep. on type</td>
<td></td>
</tr>
<tr>
<td>100Ch</td>
<td>0</td>
<td>Guard time (multiple of 1 ms)</td>
<td>UNS16</td>
<td>rw</td>
<td>0</td>
<td>x</td>
</tr>
<tr>
<td>100Dh</td>
<td>0</td>
<td>Life-time factor</td>
<td>UNS8</td>
<td>rw</td>
<td>0</td>
<td>x</td>
</tr>
<tr>
<td>1010h</td>
<td></td>
<td>Save parameters (signature: 's','a','v','e' - 65766173h in subindex 1...4)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1011h</td>
<td></td>
<td>Restore default parameters (signature: 'l','o','a','d' - 64616F6Ch in subindex 1...4)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1014h</td>
<td>0</td>
<td>COB ID emergency message</td>
<td>UNS32</td>
<td>ro</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>1015h</td>
<td>0</td>
<td>Inhibit time between two EMCY messages (multiple of 100 µs)</td>
<td>UNS16</td>
<td>rw</td>
<td>0</td>
<td>x</td>
</tr>
<tr>
<td>1017h</td>
<td>0</td>
<td>Heartbeat rate time (multiple of 1 ms, 0 deactivated)</td>
<td>UNS16</td>
<td>rw</td>
<td>0</td>
<td>x</td>
</tr>
<tr>
<td>1018h</td>
<td></td>
<td>Identity object</td>
<td>UNS8</td>
<td>ro</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>1200h</td>
<td></td>
<td>Server SDO1 parameters</td>
<td>UNS8</td>
<td>ro</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>1800h</td>
<td></td>
<td>Transmit PDO 1 communication parameters</td>
<td>UNS8</td>
<td>ro</td>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>

Table 34: Communication parameters in the object directory
Table 34: Communication parameters in the object directory

9.7.1.1 Error register (1001h)

The error register indicates the general error status of the device. Each bit stands for an error group. If a bit is set (= 1), at least one error in this group is currently active. The content of this register is transmitted in every EMCY message. The following error groups may be encountered:

<table>
<thead>
<tr>
<th>Bit7</th>
<th>Bit6</th>
<th>Bit5</th>
<th>Bit4</th>
<th>Bit3</th>
<th>Bit2</th>
<th>Bit1</th>
<th>Bit0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturer-specific error</td>
<td>Accuracy Warning</td>
<td>Profile-specific error</td>
<td>Communication error</td>
<td>Not used</td>
<td>At least one error active</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 35: Error register (1001h)
If the device is in error status (at least one error active), this is indicated by bit 0 being set. In the event of a communication error (overrun of send/receive buffer, guarding error or CAN controller in passive/busoff mode), bit 4 is set. A profile-specific error (sensor error) is indicated by bit 5. Bit 7 signals a manufacturer-specific error (EEPROM error).

9.7.1.2Manufacturer status register (1002h)

This register indicates the current status of all detectable errors. Each bit represents a specific error. If a bit is set (= 1), this error is currently active. The lower-value 16 bits of this register (bits 15 to 0) are transmitted in the first two bits of the manufacturer-specific part of each EMCY message as well as in the additional information field (bits 31 to 16) of the predefined error field 1003h.

<table>
<thead>
<tr>
<th>Bit31...Bit16</th>
<th>Bit15...Bit8</th>
<th>Bit7...Bit0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not used</td>
<td>Bit field Communication error</td>
<td>Bit field Device error</td>
</tr>
</tbody>
</table>

Table 36: Manufacturer status register (1002h)

9.7.1.3Predefined error field (1003h)

Each inclination sensor keeps a list of the five most recent errors that have occurred. Entry 1003.00h contains the number of error entries in the error field. All other subindices contain all of the error states that have occurred in chronological order. The most recent error is always listed under subindex 01h. The oldest error is located in the highest available subindex (value of 1003.00h). It is removed from the list first when more than five errors occur. When an error occurs, a new error entry is added to 1003h and an EMCY message is also sent by way of notification. An error entry is structured as follows:

<table>
<thead>
<tr>
<th>Additional information field (bits 31 to 16)</th>
<th>Error code (bits 15 to 0)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bits 15 to 0 of the manufacturer-specific register 1002h (at the time the error occurred)</td>
<td>0x0000 Error reset or no more errors pending</td>
</tr>
<tr>
<td>Bit field Communication error</td>
<td>0x5010 Sensor error / sensor error X</td>
</tr>
<tr>
<td>Bit field Device error</td>
<td>0x5020 Sensor error Y</td>
</tr>
<tr>
<td>Bit field Communication error</td>
<td>0x8110 Receive / send buffer overflow</td>
</tr>
<tr>
<td>Bit field Device error</td>
<td>0x8120 CAN warning limit exceeded</td>
</tr>
<tr>
<td></td>
<td>0x8130 Node guard event</td>
</tr>
<tr>
<td></td>
<td>0x8140 Exit busoff status</td>
</tr>
</tbody>
</table>

Table 37: Error entry in predefined error field (1003h)

To delete the entire content of the error list, write a value of 0 to entry 1003.00h.

9.7.1.4Saving (1010h) and restoring (1011h) parameters

Changes that are made to parameters in the object directory are applied immediately. So that the modified parameters remain active even after a reset, they must be saved in the internal permanent memory. Writing the Save signature (65766173h) to entry 1010.01h transmits all current parameters from the object directory to the permanent memory.

To reset the object directory to the factory settings, write the Load signature (64616F6Ch) to entry 1011.01h. This writes the factory parameters to the permanent memory. The changes are applied after a Reset Application (NMT command) or a Hardware Reset (if only a Reset Communication (NMT command) is sent, only the factory settings of the communication parameters are effective initially).
It is possible to save or load only parts of the object directory by writing the signature to subindex: 02h, 03h, or 04h.

9.7.1.5 Transmit PDO 1 – Transmission type (1800h)

Entry 1800.02h is used to define how the sending of the PDO is triggered.

<table>
<thead>
<tr>
<th>Transmission type</th>
<th>Description</th>
</tr>
</thead>
</table>
| 1...240           | Synchronous (cyclic)  
                    Transmission after every 1...240th receipt of the SYNC object  
                    Only synchronized transmission with SYNC possible |
| 253               | Transmission exclusively with RTR |
| 254               | Asynchronous, manufacturer-specific  
                    Cyclic sending and/or sending when angle changes can be activated by means of corresponding configuration. |

Table 38: Transmit PDO 1 – Transmission type (1800.02h)

9.7.2 Manufacturer-specific part

<table>
<thead>
<tr>
<th>Index</th>
<th>Subindex</th>
<th>Parameter</th>
<th>Data type</th>
<th>Access</th>
<th>Default value</th>
<th>Storage</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002h</td>
<td>0</td>
<td>Automatic busoff recovery</td>
<td>BOOL</td>
<td>rw</td>
<td>0</td>
<td>x</td>
</tr>
<tr>
<td>3000h</td>
<td>Digital filter settings</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>Highest subindex supported</td>
<td>UNS16</td>
<td>ro</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Filter type (0=off, 1=Butterworth, 2=critically damped)</td>
<td>UNS16</td>
<td>rw</td>
<td>2</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Digital filter limit frequency (100...25000/8000, in mHz)</td>
<td>UNS16</td>
<td>rw</td>
<td>2000</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>3001h</td>
<td>Transmit PDO 1, send when angle changes, types TMS88/TMS61</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>Highest subindex supported</td>
<td>UNS16</td>
<td>ro</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Activate/deactivate send when angle changes (1/0)</td>
<td>UNS16</td>
<td>rw</td>
<td>0</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Minimum change in angle for axial axis (in °/100)</td>
<td>UNS16</td>
<td>rw</td>
<td>100</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>3001h</td>
<td>Transmit PDO 1, send when angle changes, types TMM88/TMM61</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>Highest subindex supported</td>
<td>UNS16</td>
<td>ro</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Activate/deactivate send when angle changes (1/0)</td>
<td>UNS16</td>
<td>rw</td>
<td>0</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Minimum change in angle for longitudinal (X) axis (in °/100)</td>
<td>UNS16</td>
<td>rw</td>
<td>100</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Minimum change in angle for lateral (Y) axis (in °/100)</td>
<td>UNS16</td>
<td>rw</td>
<td>100</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>5555h</td>
<td>Reserved index (for manufacturer access only)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 39: Manufacturer-specific part of the object directory

9.7.2.1 Automatic busoff recovery (2002h)

This feature regulates the behavior of the inclination sensor whenever it is in busoff status. When activated, the inclination sensor can switch out of this status back to the error-active status with reset error counters. To do this, it must detected 11 consecutive recessive bits on the bus 128 times.
When deactivated, the inclination sensor remains in busoff status.

9.7.2.2 Digitalfiltereinstellungen (3000h)

Der Neigungssensor bietet die Möglichkeit, den kontinuierlich entstehenden Winkelwert gegenüber externen, störenden Schwingungen unempfindlicher zu machen. Mit Hilfe der parametrierbaren Tiefpassfilter achter Ordnung können parasitäre Schwingungen/Vibrationen bis zu 0,1 Hz unterdrückt werden. Im Sensor stehen zwei Digitalfilter zur Verfügung, die entsprechend dem Anwendungsgebiet des Sensor ausgewählt werden können.

<table>
<thead>
<tr>
<th>Filter</th>
<th>einstellbarer Frequenzbereich</th>
<th>Einsatzfälle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Butterworth</td>
<td>0,1 Hz ... 25 Hz</td>
<td>statische Neigungsmessung bei hoher Dämpfung gegenüber Vibrationen</td>
</tr>
<tr>
<td>Kritisch gedämpft</td>
<td>0,1 Hz ... 8 Hz</td>
<td>Neigungsmessung bei Anwendungen, die einer gewissen Dynamik unterliegen / ohne Überschwingen bei Winkeländerungen bei gleichzeitig guter Dämpfung</td>
</tr>
</tbody>
</table>

Table 40: Filterauswahl

Über den Eintrag 3000.01h wird der Digitalfilter ausgewählt. Die Grenzfrequenz wird über das Objekt 3000.02h eingestellt. Dabei sind Werte von 100 (= 0,1 Hz) bis 25000/8000 (= 25 Hz/8 Hz) zulässig.

Figure 17: Impulsantwort der beiden Filter
9.7.2.3 Transmit PDO 1, send when angle changes (3001h)

The event-driven sending of Transmit PDO 1 when the angle changes can be activated (= 1) and deactivated (= 0) via entry 3001.01h.

For activation, the transmission type for Transmit PDO 1 must be set to asynchronous, manufacturer-specific (1800.02h = 254). Subindices 02h and 03h can be used to set the minimum necessary change in angle separately for the longitudinal (X) and the lateral (Y) axis. These two angle values are specified in °/100 (100x angle value) and can be set to user-defined values starting from 1 (= 0.01°).

If sending when the angle changes is activated, in Operational status, the inclination sensor will always send Transmit PDO 1 again whenever the inclination value of the longitudinal and/or the lateral axis has changed by the angle value set under 3001.02h and 03h. The difference in angle between the current inclination value and the last angle value sent with Transmit PDO 1 is constantly calculated and checked.

Every time the status switches to Operational, the inclination sensor signals the current position by sending Transmit PDO 1 once (only if 3001.01h = 1).

**NOTE**

If minor differences in angle are entered under 3001.02h and 03h, we recommend activating the digital filter (index 3000h) in order to minimize the effect of vibrations and thus the frequent sending of Transmit PDO 1.
9.7.3 Profile-specific part (to CiA DS-410)

<table>
<thead>
<tr>
<th>Index</th>
<th>Subindex</th>
<th>Parameter</th>
<th>Data type</th>
<th>Access</th>
<th>Default value</th>
<th>Storage</th>
</tr>
</thead>
<tbody>
<tr>
<td>6000h</td>
<td>0</td>
<td>Resolution (multiple of 0.001°)</td>
<td>UNS16</td>
<td>ro</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>6010h</td>
<td>0</td>
<td>Inclination value, longitudinal (X axis, 100x angle value in °)</td>
<td>INT16</td>
<td>ro</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>6011h</td>
<td>0</td>
<td>Operating parameter, longitudinal (inversion, zero-point setting)</td>
<td>UNS8</td>
<td>rw</td>
<td>0 x</td>
<td></td>
</tr>
<tr>
<td>6012h</td>
<td>0</td>
<td>Default value for longitudinal (X) axis</td>
<td>INT16</td>
<td>rw</td>
<td>0 x</td>
<td></td>
</tr>
<tr>
<td>6013h</td>
<td>0</td>
<td>Offset value for longitudinal (X) axis</td>
<td>INT16</td>
<td>rw</td>
<td>0 x</td>
<td></td>
</tr>
<tr>
<td>6014h</td>
<td>0</td>
<td>Difference offset value for longitudinal (X) axis</td>
<td>INT16</td>
<td>rw</td>
<td>0 x</td>
<td></td>
</tr>
<tr>
<td>6020h</td>
<td>0</td>
<td>Inclination value, lateral (Y axis, 100x angle value in °)</td>
<td>INT16</td>
<td>ro</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>6021h</td>
<td>0</td>
<td>Operating parameter, lateral (inversion, zero-point setting)</td>
<td>UNS8</td>
<td>rw</td>
<td>0 x</td>
<td></td>
</tr>
<tr>
<td>6022h</td>
<td>0</td>
<td>Default value for lateral (Y) axis</td>
<td>INT16</td>
<td>rw</td>
<td>0 x</td>
<td></td>
</tr>
<tr>
<td>6023h</td>
<td>0</td>
<td>Offset value for lateral (Y) axis</td>
<td>INT16</td>
<td>rw</td>
<td>0 x</td>
<td></td>
</tr>
<tr>
<td>6024h</td>
<td>0</td>
<td>Difference offset value for lateral (Y) axis</td>
<td>INT16</td>
<td>rw</td>
<td>0 x</td>
<td></td>
</tr>
</tbody>
</table>

Table 41: Profile-specific part of the object directory

9.7.3.1 Resolution (6000h)

The resolution of all inclination sensors is set to a fixed value of 0.01° (default: 10 * 0.001°). All angle values in the object directory (6010h, 6012h, 6013h, 6014h plus 6020h, 6022h, 6023h, 6024h) must be interpreted as a multiple of 0.01°.

Example:
Angle value = -2370 x 0.01° → -23.70°

9.7.3.2 Longitudinal and lateral angle values (6010h and 6020h)

Up-to-date angle values for the inclination axes can be accessed both via SDO access to the object directory (in any device status) and with a Transmit PDO. When zero-point setting is activated (operating parameters: 6011h and 6021h), the inclination angle is calculated as follows:

Inclination value = inclination value physically measured + difference offset value + offset value

When zero-point setting is deactivated:

Inclination value = physically measured inclination value

Operating parameters (6011h and 6021h) describes how the 100x signed 16-bit inclination value (two's complement) is converted.

Example:
Value range, TMS type: -18,000 ... +17,999 → -180.00° ... +179.99° = 0 ...359.99°
Value range, type TMM: -9,000 ... +9,000 → - 90.00° ... + 90.00°

9.7.3.3 Operating parameters (6011h and 6021h)

The operating parameter settings of an inclination sensor (6011h and 6021h) can be used to convert the mathematical sign of the inclination value and also for zero-point setting. These options are deactivated on delivery, i.e., the direction of the angle value (polarity of the axes) corresponds to the assignment indicated on the device type label.
9.7.3.4 Zero-point setting: Default value, offset value, difference offset value (60x1/2/3h)

A zero-point setting for the inclination angle can be made using the values for default value, offset value, and difference offset value. This setting is only active if bit 1 is set in the operating parameters (6011h/6021h).

<table>
<thead>
<tr>
<th>Value</th>
<th>Object</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Default value</td>
<td>6012h/</td>
<td>Default value for zero-point setting</td>
</tr>
<tr>
<td></td>
<td>6022h</td>
<td>Value range depending on setting in object 6000h</td>
</tr>
<tr>
<td>Offset value</td>
<td>6013h/</td>
<td>Calculated offset value when writing to object 6012h or 6022h</td>
</tr>
<tr>
<td></td>
<td>6023h</td>
<td>Calculated offset value = default value with tacc – inclination value physically measured with tacc – difference offset value.</td>
</tr>
<tr>
<td>Difference offset value</td>
<td>6014h/</td>
<td>Additional offset, independent of object 6012h and 6013h / 6022h and 6023h</td>
</tr>
<tr>
<td></td>
<td>6024h</td>
<td>The value entered here is added directly to the current inclination value.</td>
</tr>
</tbody>
</table>

Table 43: Zero-point setting

9.8 Error messages: Emergency

Emergency messages are used to transmit important internal device errors and CAN communication errors to other nodes on the bus. In the event of one of these errors, the OD entries 1001h (error register), 1002h (manufacturer status register), and 1003h (predefined error field) are updated.

Once an error has been resolved, an emergency message is sent with the error code 0x0000. Any errors that are still pending are signaled in byte 2 (error register) and bytes 3 and 4 of the manufacturer-specific error field. As soon as a device is error-free, it sends an emergency message containing zeros only. The current device status (Pre-Operational, Operational, or Stopped) is not affected by the error statuses, except in the case of guarding errors.

Emergency messages are sent with high priority on the bus. They are always 8 bytes long:

<table>
<thead>
<tr>
<th>Emergency object</th>
</tr>
</thead>
<tbody>
<tr>
<td>Byte0</td>
</tr>
<tr>
<td>Emergency error code</td>
</tr>
<tr>
<td>Bit field Communication error</td>
</tr>
<tr>
<td>0x00</td>
</tr>
</tbody>
</table>

Table 44: Emergency object
<table>
<thead>
<tr>
<th>Emergency error codes</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x0000</td>
</tr>
<tr>
<td>0x5010</td>
</tr>
<tr>
<td>0x5020</td>
</tr>
<tr>
<td>0x8110</td>
</tr>
<tr>
<td>0x8120</td>
</tr>
<tr>
<td>0x8130</td>
</tr>
<tr>
<td>0x8140</td>
</tr>
</tbody>
</table>

Table 45: Emergency error code

<table>
<thead>
<tr>
<th>Bit field</th>
</tr>
</thead>
<tbody>
<tr>
<td>Device error</td>
</tr>
<tr>
<td>0x01</td>
</tr>
<tr>
<td>0x01</td>
</tr>
<tr>
<td>0x02</td>
</tr>
<tr>
<td>0x80</td>
</tr>
</tbody>
</table>

Communication error
| 0x01  | CAN warning limit exceeded (too many error frames) |
| 0x02  | CAN busoff status reached. An emergency message is sent after automatically exiting busoff status. |
| 0x04  | Receive queue overrun, receive buffer overrun, CAN messages lost |
| 0x08  | Send queue overrun, send buffer overrun, CAN messages lost |
| 0x80  | Guarding error; the failure of the guarding master has been detected (node guard event) |

Table 46: Emergency: Manufacturer-specific error field

### 9.9 Automatic baud rate detection (to CiA AN-801)

Automatic baud rate detection automatically sets the baud rate of the inclination sensor to the current baud rate on the network. For this purpose, following switching on of the power supply, the inclination sensor is in what is known as listen-only mode. In this mode, it monitors the messages that are being sent and received on the CAN bus but does not acknowledge them. This operational status is indicated by the RUN LED flickering (see also chapter Status LED (to CiA DR-303-3)).

In this status, it is testing all available baud rates. When a valid CAN telegram is received, the correct baud rate is identified and set. After this, the inclination sensor starts up, logs in with a boot-up message, and switches to Pre-Operational mode.

**NOTE**

In order for baud rate detection to function correctly, telegrams from other bus nodes must be available.

### 9.10 Status LED (to CiA DR-303-3)

The built-in status LED shows the current device status (RUN LED, green) as well as any CAN communication errors that might have occurred (ERROR LED, red). The statuses listed in the following table can be identified based on the color and flashing frequency of the associated LEDs.
### Status LED

<table>
<thead>
<tr>
<th>RUN LED</th>
<th>LED status</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Off</td>
<td>The device is in Reset status or the power supply is absent.</td>
</tr>
<tr>
<td></td>
<td>Flickering</td>
<td>Automatic baud rate detection in progress (active).</td>
</tr>
<tr>
<td></td>
<td>Flashing</td>
<td>The device is in Pre-Operational status.</td>
</tr>
<tr>
<td></td>
<td>Simple flash</td>
<td>The device is in Stopped status.</td>
</tr>
<tr>
<td></td>
<td>On</td>
<td>The device is in Operational status.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ERROR LED</th>
<th>LED status</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Off</td>
<td>The device is operating without errors.</td>
</tr>
<tr>
<td></td>
<td>Simple flash</td>
<td>CAN controller error counter has reached or exceeded its warning limit.</td>
</tr>
<tr>
<td></td>
<td>Double flash</td>
<td>The device has detected the failure of the guarding master (node guard event).</td>
</tr>
<tr>
<td></td>
<td>On</td>
<td>The device is in “busoff” status.</td>
</tr>
</tbody>
</table>

Table 47: Status and error information indicated by the status LED

Key: ○ LED off, ⚡ LED on, ⏯ LED flickering (50 ms on/off), ○/⚡ duration: 200 ms
Australia
Phone +61 3 9457 0600
1800 334 802 – tollfree
E-Mail sales@sick.com.au

Austria
Phone +43 (0)22 36 62 28 80
E-Mail office@sick.at

Belgium/Luxembourg
Phone +32 (0)2 466 55 66
E-Mail info@sick.be

Brazil
Phone +55 11 3215-4900
E-Mail marketing@sick.com.br

Canada
Phone +1 905 771 14 44
E-Mail information@sick.com

Czech Republic
Phone +420 2 57 91 18 50
E-Mail sick@sick.cz

Chile
Phone +56 2 2274 7430
E-Mail info@schadler.com

China
Phone +86 4000 121 000
E-Mail info.china@sick.net.cn

Denmark
Phone +45 45 82 64 00
E-Mail sick@sick.dk

Finland
Phone +358-9-2515 800
E-Mail sick@sick.fi

France
Phone +33 1 64 62 35 00
E-Mail info@sick.fr

Germany
Phone +49 211 5301-301
E-Mail info@sick.de

Great Britain
Phone +44 (0)1727 831121
E-Mail info@sick.co.uk

Hong Kong
Phone +852 2153 6300
E-Mail ghk@sick.com.hk

Hungary
Phone +36 1 371 2680
E-Mail office@sick.hu

India
Phone +91–22–4033 8333
E-Mail info@sick-india.com

Israel
Phone +972-4-6881000
E-Mail info@sick-sensors.com

Italy
Phone +39 02 27 43 41
E-Mail info@sick.it

Japan
Phone +81 (0)3 5309 2112
E-Mail support@sick.jp

Malaysia
Phone +603 808070425
E-Mail enquiry.my@sick.com

Netherlands
Phone +31 (0)30 229 25 44
E-Mail info@sick.nl

New Zealand
Phone +64 9 415 0459
0800 222 278 – tollfree
E-Mail sales@sick.co.nz

Norway
Phone +47 67 81 50 00
E-Mail sick@sick.no

Poland
Phone +48 22 837 40 50
E-Mail info@sick.pl

Romania
Phone +40 356 171 120
E-Mail office@sick.ro

Russia
Phone +7-495-775-05-30
E-Mail info@sick.ru

Singapore
Phone +65 6744 3732
E-Mail sales.sg@sick.com

Slovakia
Phone +421 482 901201
E-Mail mail@sick-sk.sk

Slovenia
Phone +386 (0)1-47 69 990
E-Mail office@sick.si

South Africa
Phone +27 11 472 3733
E-Mail info@sickautomation.co.za

South Korea
Phone +82 2 786 6321
E-Mail info@sickkorea.net

Spain
Phone +34 93 480 31 00
E-Mail info@sick.es

Sweden
Phone +46 10 110 10 00
E-Mail info@sick.se

Switzerland
Phone +41 41 619 29 39
E-Mail contact@sick.ch

Taiwan
Phone +886 2 2375-6288
E-Mail sales@sick.com.tw

Thailand
Phone +66 2645 0009
E-Mail tawiwat@sicksgp.com.sg

Turkey
Phone +90 (216) 528 50 00
E-Mail info@sick.com.tr

United Arab Emirates
Phone +971 (0) 4 88 65 878
E-Mail info@sick.ae

USA/Mexico
Phone +1(952) 941-6780
1 (800) 325-7425 – tollfree
E-Mail info@sick.com

Vietnam
Phone +84 8 62920204
E-Mail Ngo.Duy.Linh@sicksgp.com.sg

More representatives and agencies
at www.sick.com