TURCK

Industrial Automation

USER MANUAL INCLINOMETERS WITH CANOPEN®-INTERFACE

B2N10H-Q42-CNX2-2H1150
B2N45H-Q42-CNX2-2H1150
B2N60H-Q42-CNX2-2H1150

Sense it! Connect it! Bus it! Solve it!

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Edition 18/01

0 About this manual

0.1 Documentation concept

The first chapter of this manual contains an overview of the TURCK Inclinometers.

The second chapter contains all technical data.

The third and fourth chapters contain information for mounting and the electrical connection.

The fifth chapter contains information for the CANopen interface.

The glossary contains explanations for various CANopen-specific terms.

0.1.1 Explanations for the used symbols

Danger

This symbol is positioned next to warnings which point to a source of danger. This may refer to injury to persons and to damage to systems (hard- and software).
For the user this symbol means: Please proceed with special care.

Attention

This symbol is positioned next to warnings which point to a potential source of danger. This may refer to possible injury to persons and to damage to systems (hard- and software) and installations.

Note

This symbol is positioned next to general instructions which point to important information prior to proceeding step by step.

The respective instructions may lighten the work and, for example, may help prevent extra work caused by the wrong course of action.

0.2 General information

Attention

It is strongly recommended you read this section because safety in connection with handling electrical devices may not be left to chance.

This manual contains the required information for the start-up of the TURCK Inclinometers. It was written specifically for qualified staff with the required technical know-how.

0.2.1 Intended use

Danger

The devices described in this manual may only be used for the intended applications also found in this manual and in the respective technical description, and only in connection with certified OEM devices and OEM components.

The flawless and safe operation of the devices is based on the appropriate transport, storage, assembly, and mounting, as well as careful operation and maintenance.

0.2.2 Information for project planning/ installation of product

Danger

The valid safety and accident prevention rules for the respective application must be adhered to.

1 Overview

1.1 Characteristics

The biaxial inclinometers are suitable for measuring inclinations within the ranges ±10°, ±45° and ±60°. The zero point and measurement range end values are factory calibrated at 25 °C to guarantee high accuracy.

The compact and robust design transforms the sensor into a suitable angle measurement device in a harsh environment and for diverse industrial and automotive engineering applications. The standardized CANopen interface allows user-friendly configuration and start-up. All parameters are stored in a non-volatile memory buffer.

TURCK offers the following sensors:

Table1: Sensor types

Type	Inclination range
B2N10H-Q42-CNX2-2H1150	±10°
B2N10H-Q42-CNX2-2H1150	±45°
B2N60H-Q42-CNX2-2H1150	±60°

Special characteristics:

- Biaxial inclinometers with measurement ranges: ±10° / ±45° / ±60° (depending on design)
- High resolution and accuracy
- User-friendly CANopen interface:
  – meets CiA DS-301, device profile CiA DSP-410
  – Baud rate of 10 kBit/s to 1 MBit/s
- High sample rate and bandwidth
- Parameterizable vibration suppression
- Functions:
  – one TPDO (RTR, cyclic, event-driven, synchronized)
  – SYNC Consumer (synchronized sending of TPDO after receipt of SYNC telegram)
  – EMCY Producer (limit value exceedance, device internal temperature check)
  – failure check with the help of Heartbeat or Nodeguarding / Lifeguarding
  – freely configurable limit frequency (digital filter)
- Robust plastic housing
- Suitable for industrial applications:
  – temperature range: -40 °C to +80 °C
  – housing protection class: IP68/69K

1.2 Applications

The inclinometers are based on MEMS technology (micro-electrical-mechanical systems) and offer diverse application solutions:

- Machines and vending machines
- Vehicles and airplanes
- Harvesters, agricultural machines and construction vehicles
- Transportation devices

2 Technical data

2.1 General, interface, electrical and mechanical parameters

Table 1: General parameters

General parameters	
Measurement axes	2 (X/Y)
Measurement ranges	±10° / ±45° / ± 60°
Resolution	0,05° / 0,1° / 0,1°
Calibration accuracy (at 25 °C)	±0. 1° (zero point and end values)
Non-linearity	max. ±0.2° / ±0.3° /±0.4°
Temperature coefficient (zero point)	Type ±0.008°/K
Limit frequency	Type 20 Hz, 2nd order (no digital filter) / 0.3...25 Hz, 8th order (with digital filter)
Sample rate	100 Hz
Operating temperature	-40...+80 °C

Table 2: Interface characteristics

Interface characteristics	
Interface	CANopen, per CiA DS 301, profile per CiA DSP-410
Bit rate	10 kbps, 20 kbps, 50 kbps, 250 kbps, 500 kbps, 800 kbps, 1 Mbps
Functions	TPDO (RTR, cyclic, event-driven, synchronized), parameterization per SDO and object register, digital filter (Butterworth Lowpass, 8th order), SYNC Consumer, EMCY Producer, output and control of internal device temperature (±2.0 K accuracy), failure control with the help of Heartbeat or Nodeguarding / Lifeguarding

Table 3: Electrical parameters

Electrical parameters	
Power supply voltage	10...30 VDC (The inclinometer must be supplied with the help of a car battery or a safety-low voltage (SELV) with limited power.)
Current consumption	40...105 mA

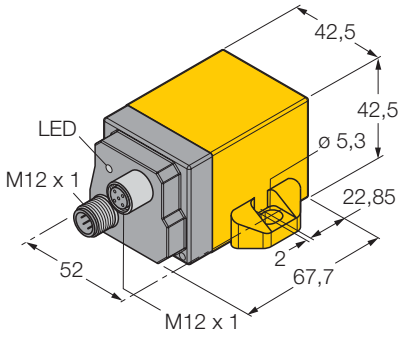
Table 4: Mechanical parameters

Mechanical parameters	
Connection CAN	Sensor connector assembly M12, 5-pole
Housing protection class	IP68/69K
Shock resistance	max. 30 g (11 ms)
Weight	approx. 160 g

3 Mounting

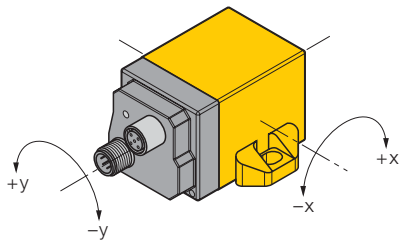
3.1 Dimensional drawing

Figure 1: Dimensional drawing



3.1.1 Definition of the axes (factory default)

Figure 2: Axes-Definition



4 Electrical connection

4.1 Pin assignment of connector assembly

The inclinometers are equipped with a 5-pole round connector M12 (A-coded).
The pin assignment meets CiA DR-303-1 (Diagram 1 and Table 1).

Figure 1: M12 connector assembly

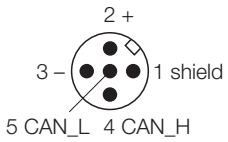


Table 1: Pin assignment

Pin	Signal	Assignment
1	CAN_SHLD	Shield
2	CAN_V+	Supply voltage (+24 VDC)*
3	CAN_GND	GND
4	CAN_H	CAN_H-bus line
5	CAN_L	CAN_L-bus line

*) UL marking requires an approved power supply with energy limitation (UL 61010-1) or with Class 2 according to National Electric Code (USA) / Canadian Electric Code.

4.2 Bus termination resistance

The inclinometers are not equipped with an internal termination resistance.
If needed, it is to be realized externally with the help of a T piece at the end of the bus (120 Ω).

5 CANopen interface

5.1 Review of functions

The inclinometers are equipped with a standardized CANopen interface per CiA DS-301 and a device profile per CiA DSP-410. All measured values and parameters are accessible via the object register (OR). The individual configuration can be stored in the internal, non-volatile memory buffer (EEPROM).

The following CANopen functions are available:

- one Send Data object (TPDO1) with four possible operating modes:
  – individual request per Remote Transmit Request telegram (RTR)
  – cyclic Send per interval time
  – event-driven Send when angle has changed
  – synchronized Send after receipt of SYNC telegram
- one Service Data object (Standard SDO)
- error messages per emergency object (EMCY) with the help of:
  – the general error register
  – the manufacturer specific status register (Manufacturer Status)
  – the error list (Predefined Error Field)
- monitoring mechanism Heartbeat, as well as Nodeguarding/ Lifeguarding
- storage and reload function of all parameters (Store and Load Parameter Field)
- status and error display per two-color LED (per CiA DR-303-3)

Next to the CiA DS-301 functionality, additional manufacturer or rather profile specific characteristics exist:

- setting of Node ID, as well as Baud rate per OR
- freely configurable limit frequency (digital filter)
- configuration of minimal change of angle for TPDO1 send event
- optional monitoring of internal device temperature
- direction switch of inclinometers

5.2 Send PDO (TPDO1)

Each inclinometer has exactly one Send Process Data Object (TPDO). It contains the current inclination values (longitudinal and lateral), as well as the internal device temperature.

PDO mapping of measurement values is fixed as displayed in Table 1.

Table 1: PDO mapping of TPDO1

Data portion of CAN telegram of the TPDO1							
Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
Inclination value longitudinal (X-axis), OR: 6010 h		Inclination value lateral (Y-axis), OR: 6020 h		Internal temperature, OR: 5000 h	Not used		

5.3 PDO communication types

5.3.1 Individual request per Remote Transmit Request telegram (RTR)

A request can be sent to TPDO1 anytime by sending a Remote Transmit Request telegram. This is possible in all operating modes of the inclinometer.

5.3.2 Cyclic operating mode

Cyclic sending of TPDO1 is activated if the entry 1800h/05h (interval time in milliseconds) contains a value greater than 0. For this purpose the entry 1800h/02h (transmission type) must contain the value 254 (asynchronous, manufacturer specific). In the "Operational" mode, the inclinometer cyclically sends the TPDO1 with the set cycle duration time.

5.3.3 Event-driven Send when the angle has changed

The bus load caused by PDOs can be decreased by only sending the TPDO1 when the angle has changed accordingly. This function can be configured under the index 3001h in the manufacturer specific portion of the object register. For this purpose the entry 1800h/02h (transmission type) must contain the value 254 (asynchronous, manufacturer specific).

5.3.4 Synchronized Send after receipt of a SYNC telegram

For the synchronized transmission, the SYNC object is made available by CANopen; here, the TPDO1 is sent after each "nth" receipt of a SYNC telegram. For this purpose the entry 1800h/02h (transmission type) must contain the value n=1...240.

5.4 Object register

The object register of the inclinometers is divided into three parts (communication parameters, manufacturer specific portion, profile specific portion). The existing parameters can be read and written via the Standard SDO and index/subindex. Parameter changes become immediately valid with the exception of the Node ID (2000h) and the Baud rate (2001h).

The following paragraphs provide a description of all parameters in the object register of an inclinometer including index, subindex, data type, access rights and standard value (manufacturer default setting). The column Store identifies whether a parameter can be stored in the internal, non-volatile memory buffer (write "save" signature in OR index 1010h/01h).

5.4.1 Communication parameters (per CiA DS-301)

Table 2: Communication parameter in the object register

Index	Sub-index	Parameter	Data type	Access	Standard value	Store
1000h	0	Device type (device profile 410, two axes)	UNS32	const	2019Ah	
1001h	0	Error register	UNS8	ro	0	
1002h	0	Manufacturer status register	UNS32	ro	0	
1003h	Predefined error field					
	0	Number of error entries	UNS32	rw	0	
	1...5	Error code (oldest error in highest index)	UNS32	ro	0	
1005h	0	COB ID SYNC message	UNS32	rw	80h	
100Ah	0	Software version ("xyy")	VSTR	const	typical	
100Ch	0	Guard Time (a multiple of 1 ms)	UNS16	rw	0	x
100Dh	0	Lifetime factor	UNS8	rw	0	x
1010h	Store parameters					
	0	Highest supported subindex	UNS32	ro	1	
	1	Store all parameters (signature: "save" - 65766173h)	UNS32	rw	0	
1011h	Reload manufacturer default setting		UNS32			
	0	Highest supported subindex	UNS32	ro	1	
	1	Reload all manufacturer default settings (signature: "load" - 64616F6Ch)	UNS32	rw	0	
1014h	0	COB ID emergency message	UNS32	ro	80h+NID	

Table 2: Communication parameter in the object register

Index	Sub-index	Parameter	Data type	Access	Standard value	Store
1015h	0	Off-time between two EMCY messages (a multiple of 100 µs)	UNS16	rw	0	x
1017h	0	Heartbeat interval time (a multiple of 1 ms, 0 deactivated)	UNS16	rw	0	x
1018h	Identity object					
	0	Highest supported subindex	UNS8	ro	4	
	1	Vendor ID	UNS32	ro	159h	
	2	Product code	UNS32	ro	typical	
	3	Revision No.	UNS32	ro	typical	
	4	Serial No.	UNS32	ro	typical	
1200h	Server SDO1 parameter					
	0	Highest supported subindex	UNS8	ro	2	
	1	COB ID Client > Server	UNS32	ro	600h+NID	
	2	COB ID Server > Client	UNS32	ro	580h+NID	
1800h	Transmit PDO1 communication parameters					
	0	Highest supported subindex	UNS8	ro	5	
	1	COB ID	UNS32	ro	180h+NID	
	2	Transmission type (synchronous/ asynchronous manufacturer specific)	UNS8	rw	FEh	x
	3	Off-time between two TPDO messages (a multiple of 100 µs)	UNS16	rw	0	
	4	Compatibility entry	UNS8	rw	0	x
	5	Interval time for cyclic Send (a multiple of 1 ms, 0 deactivated)	UNS16	rw	0	x
1A00h	Transmit PDO1 mapping parameter (fixed mapping)					x
	0	Highest supported subindex	UNS8	ro	3	x

Table 2: Communication parameter in the object register

Index	Sub-index	Parameter	Data type	Access	Standard value	Store
	1	Inclination value longitudinal (X-axis, hundredfold angle value in °)	UNS32	ro	60100010 h	
	2	Inclination value lateral (Y-axis, hundredfold angle value in °)	UNS32	ro	60200010 h	
	3	Internal temperature (in °C)	UNS32	ro	50000008 h	

Error register (1001h)

The error register displays the general error status of the device. Each bit represents an error group. If a Bit is set (=1), at least one error of this group remains active at this time.
The content of this register is transmitted in each EMCY message.

The following error groups may occur:

Table 3: Error register (1001h)

Error register (1001h)					
Bit 7...Bit 6	Bit 5	Bit 4	Bit 3	Bit 2...Bit 1	Bit 0
Not used	Profile specific error	Not used	Temperature error	Not used	At least one error active

If the device remains in the error status (at least one error active), it is displayed by set Bit 0.

During active monitoring of the internal device temperature (5001h/01h = 1), Bit 3 is set when set limit values (5001h/02h...03h) have been underreached or rather overreached.
A profile specific error (sensor error) is displayed by Bit 5.

Manufacturer status register (1002h)

This register displays the current status of all detectable errors. Each bit represents a specific error. If a Bit is set (=1), thus this error is currently active. The low-order 16 bit of this register (Bit 15... Bit 0) are sent in each EMCY message in the first two byte of the manufacturer specific portion and also entered into the additional information field (bit 31... bit 16) of the predefined error field 1003h.

The following errors may occur:

Table 4: Manufacturer status register (1002h)

Manufacturer status register (1002h)							
Bit 31 ... Bit 9	Bit 8	Bit 7 ... Bit 6	Bit 5	Bit 4	Bit 3 ... Bit 2	Bit 1	Bit 0
Not used	EEPROMError	Not used	Temperature overreach	Temperature underreach	Not used	Lateral sensor error	Longitudinal sensor error

If an inclinometer has overreached a specifc angle threshold
(e.g. < 45 ° or > 45 ° at ±45 °-sensor), this error status is displayed in the respective error Bit (Bit 0 = longitudinal axis, Bit 1 = lateral axis). The issued inclination value of this/these axis/axes is/are automatically limited to the value range end value (min. or max.) and therefore should be considered erroneous at a larger inclination.

During active monitoring of the internal device temperature (5001h/01h = 1), bit 4 (underreach) and Bit 5 (overreach) display underreach and overreach conditions of the preset limit values (5001h/02h...03h). When monitoring is deactivated, both bits are 0.

The EEPROMError Bit (Bit 8) displays a significant hardware error. This bit is set when erroneous data is read from the EEPROM during storing or rather reloading device parameters (1010h/01h and 1011h/01h) or after power-on of an inclinometer.

Predefined error field (1003h)

Each inclinometer compiles an error list concerning the five errors that have occurred last. The entry 1003h/00h contains the number of error entries in the error field. All other subindices contain all occurred error states in chronological sequence; the error that has occurred last may always be found under subindex 01h. The oldest error may be found in the highest subindex (value of 1003h/00h) available and is removed first from the list when more than five errors have occurred. If an error occurs, a new error entry is added to 1003h and an EMCY message is sent as well.

An erorr entry is structured as follows:

Table 5: Error entry in the predefined error field (1003h)

Error entry in the predefined error field (1003h)	
Additional information field (bit 31...bit 16)	Error code (bit 15...bit 0)
bit 15...bit 0 of the manufacturer status register 1002h (at the time the error has occurred)	4200h (temperature error), 5000h (hardware error), FF00h (device specific error)

The error list may be completely deleted by writing 0 into the entry 1003h/00h.

Store parameters (1010h) and reload (1011h)

If parameters are changed in the OR, the changes become immediately valid with the exception of Node ID (200h) and Baud rate (2001h). The changed parameters must be stored in the internal EEPROM so that they remain active after a reset. By writing the signature "save" (65766173h) into the entry 1010h/01h all active parameters of the OR are sent to the non-volatile memory buffer.

The OR may be reset to the manufacturer default via the entry 1011h/01h and by writing the signature "load" (64616F6CH) into this entry. Thus the default parameters are written into the non-volatile memory buffer with the exception of the Node ID (2000h) and the Baud rate (2001h). After a "reset application" (NMT command) or rather a hardware reset, the changes become valid; if only a "reset communication" (NMT command) is sent, only the default settings of the communication parameters become valid.

Note

After the "save" and "load" command, a reset should not occur for a minimum time period of approx. one second; this ensures that the parameters are correctly stored in the EEPROM. Storing device parameters in the internal EEPROM may take a relative long time. This is why the "save" and "load" commands are immediately answered, but storing is executed retroactively and "in addition to."

Transmit PDO1 – transmission type (1800h)

With the help of the entry 1800h/02h it can be determined how sending the PDOs is to be initiated.

Table 6: Transmit PDO1 – transmission type (1800h/02h)

Transmit PDO1 – transmission type (1800h/02h)	
Transmission type	Description
1...240	Synchronous (cyclic) Only "synchronized transmission" via SYNC possible
254	Asynchronous, manufacturer specific "Cyclic operating mode" and/or "send when angle has changed" can be activated via respective configuration.

5.4.2 Manufacturer specific portion

Table 7: Manufacturer specific portion of the object register

Index	Sub-index	Parameter	Data type	Access	Standard value	Store
2000h	0	Node ID (1...127)	UNS8	rw	(10)[A)]	x
2001h	0	Baud rate (in kBit/s)	UNS16	rw	(500)[A)]	x
3000h	0	Limit frequency digital filter (0 = deactivated or 300...25000, in mHz)	UNS16	rw	3000	x
3001h	TPDO1 Send when angle has changed					
	0	Highest supported subindex	UNS16	ro	3	x
	1	Send when angle has changed activate/deactivate (1/0)	UNS16	rw	0	x
	2	Minimal change of angle for longitudinal (X) axis (5/10...1000, in °/100)	UNS16	rw	100	x
	3	Minimal change of angle for lateral (Y) axis (5/10...1000, in °/100)	UNS16	rw	100	
5000h	0	Current internal device temperature (in °C, >> TPDO1)	INT8	ro	....	
5001h	Monitoring of internal device temperature		INT8			

Table 7: Manufacturer specific portion of the object register

Index	Sub-index	Parameter	Data type	Access	Standard value	Store
	0	Highest supported subindex	INT8	ro	3	
	1	Temperature monitoring activated/deactivated (1/0)	INT8	rw	0	x
	2	Low temperature limit (in °C, -55...+120)	INT8	rw	-35	x
	3	High temperature limit (in °C, -55...+120)	INT8	rw	75	x
5555h	Reserved index (except for manufacturer access)					

A) *Node ID (2000h) and Baud rate (2001h) are not taken into consideration when default parameters ("load" command) are reset because otherwise the inclinometer would fail to respond. Node ID (2000h) and Baud rate (2001h) must be manually reset to default values if needed.*

Node ID (2000h) and Baud rate (2001h)

After a change has occurred, the Node ID and the Baud rate only become valid after a reset ("reset application", "reset communication" and "hardware reset"). This is why the two parameters must be transferred to the EEPROM with the "save" command (1010h/01h) after a change has occurred. After a reset, all COB IDs are recalculated and reset according to the predefined connection set.

The Baud rate is set in kbps. Table 8 displays all permissible values.

Table 8: Setting of Baud rates (2001h)

Supported Baud rates in kBit/s							
10	20	50	125	250	500	800	1000

Limit frequency digital filter (3000h)

The inclinometer offers the possibility to render continually forming angle values insensitive against external, interfering vibration. With the help of a parameterizable low-pass filter parasitic vibrations may be suppressed. The limit frequency may be set individually between 0.3 and 25 Hz. The digital filter inside the sensor is a Butterworth Low-pass 8th Order. Values of 300 (= 0.3 Hz) to 25000 (= 25 Hz) are thereby permissable. The digital filter is deactivated by the value 0.

TPDO1 – Send when angle has changed (3001h)

Via the entry 3001h/01h the event-driven Send of the TPDO1 can be activated (= 1) or rather deactivated (= 0) when the angle has changed. For activation to occur, the transmission type of the TPDO1 must be set to "asynchronous, manufacturer specific" (1800h/02h = 254).

Subindices 02h and 03h are used to separately set the minimally needed angle change for longitudinal (X) and lateral (Y) axis. These two angle values are provided in °/100 (hundredfold

angle value) and may be freely set from 5 (= 0.05 °, at ±10 °-sensor) or rather 10 (= 0.1 °, at ±45 °- and ±60 °-sensor) to 1000 (= 10 °).

If Send is activated when the angle changes, the inclinometer, while in "Operational" status, will always reissue the TPDO1 when the inclination value of the longitudinal and/or lateral axis has changed per the angle value preset under 3001h/02h and 03h. Here, the angle variations are always determined and checked between the actual inclination value and the angle value sent last via the TPDO1.
Every time the status changes into "Operational", the inclinometer alerts to the current position by a singular send of TPDO1 (only when 3001h/01h = 1).

Note

If small angle variations are to be entered under 3001h/02h and 03h, activation of the digital filter (index 3000h) is recommended in order to avoid vibration interference and therefore the frequent issuance of the TPDO1.

Internal device temperature (5000h)

The internal device temperature is redetermined every 500 ms and activated in the OR. It can be read via SDO access to the object register (in every device mode) or per TPDO. The signed 8-Bit value (two's complement) displays the temperature in °C.

Monitoring of internal device temperature (5001h)

The internal temperature sensor can be used to monitor the internal device temperature. This type of monitoring can be activated (= 1) or rather deactivated via the entry 5001h/01. Both temperature limit values are individually settable. During activated monitoring and when an error occurs - temperature underreach of the low limit value (5001h/02h) or rather temperature overreach of the high limit value (5001h/03h) - an EMCY message with respective error code is generated and the error is entered into the error register (1001h), the manufacturer status register (1002h), as well as the error field (1003h). Please refer to paragraphs „Error register (1001h)” Seite 5-8, „Manufacturer status register (1002h)” Seite 5-8 and „Predefined error field (1003h)” Seite 5-9.)

5.4.3 Profile specific portion (per CiA DSP-410)

Table 9: Profile specific portion of the object register

Index	Sub-index	Parameter	Data type	Access	Standard value	Store
6000h	0	Resolution (a multiple of 0.001°)	UNS16	ro	Typical	
6010h	0	Inclination value longitudinal (X-axis, hundredfold angle value in °, >> TPDO1)	INT16	ro	...	
6011h	0	Inversion, longitudinal, activate/deactivate (1/0)	UNS8	rw	0	x
6020h	0	Inclination value lateral (Y-axis, hundredfold angle value in °, >> TPDO1)	INT16	ro	...	
6021h	0	Inversion, lateral, activate/ deactivate (1/0)	UNS8	rw	0	x

Inclination values, longitudinal and lateral (6010h and 6020h)

The current angle values of the inclination axes are accessible via SDO access to the object register (in every device mode), as well as via TPDO. The recalculation of the hundredfold, signed 16-bit inclination value (two's complement) is as follows:

Example: Value of 6010h = -2370 / 100 → -23.70 °

Stop inversion (6011h and 6021h)

Reassignment of the mathematical prefix of the inclination value is made possible by the operating parameter settings of an inclinometer (6011h and 6021h). This option is deactivated per manufacturer default, this means the direction of the angle value (polarity of the axes) corresponds to the mapping displayed on the type plate of the device.

5.5 Emergency messages

Each inclinometer supports EMCY messages which are sent in case of sensor, temperature, hardware or guarding errors. If one of these errors occurs, the OR entries 1001h (Error Register), 1002h (Manufacturer Status Register) and 1003h (Predefined Error Field) are activated (please refer to paragraphs „Error register (1001h)” Seite 5-8, „Manufacturer status register (1002h)” Seite 5-8 and „Predefined error field (1003h)” Seite 5-9).

After an error has been corrected, the device sends an EMCY message with the "error reset" code (0h) and the current status of the error register, as well as the manufacturer status register. The current device status ("pre-operational, operational or stopped") is not impacted by the error states except by the guarding error.

5.6 Failure monitoring

Failure monitoring functions Heartbeat, as well as Nodeguarding / Lifeguarding are available because the nodes in a CANopen network with event-driven transmission do not respond on a regular basis. Only one of two monitoring methods can be used.

5.6.1 Nodeguarding / Lifeguarding

Nodeguarding describes the monitoring of one or more nodes by the NMT master. For this purpose, the NMT master periodically sends a RTR telegram to the slave to be monitored which will respond with a status or a toggle bit. If the status or toggle bit do not correspond to the one the guarding master expects to receive or if no response is sent, the master assumes an error by the slave.

With the help of this mechanism the node to be monitored is able to also recognize when the guarding master fails. Here, two parameters are used. The interval time the guarding master uses to send a request to the inclinometer to be monitored is the "guard time" (100CH). A second parameter, the "Life Time Factor" (100Dh) defines a multiplicator after which the connection is regarded as being interrupted. This time interval is described as lifetime of the node ("Node Lifetime").

"Node Lifetime" = "Guard Time" × "Lifetime Factor"

In case the inclinometer does not receive a guarding request from the master during this parameterized time interval, it assumes that the master has failed, sends an emergency telegram and resets to the "pre-operational" status. In case one of both parameters is "0" (default setting), monitoring of the master will occur (no lifeguarding).

5.6.2 Heartbeat

Heartbeat is a failure monitoring mechanism which functions without RTR telegrams.

For this purpose the inclinometer cyclically sends a Heartbeat message which contains the status of the device. The master is able to monitor these telegrams. Heartbeat is activated as soon as a value greater than "0" is entered into the register Heartbeat Interval Time (1017h).

Note

Heartbeat significantly impacts the busload of the CANopen network, but only creates half the load compared to Nodeguarding / Lifeguarding.

5.7 COB IDs

The CAN identifiers of the communication objects are set according to the predefined connection set at each reset (communication, application and hardware reset) depending on the preset Node ID (2000h).

Table 10 displays the basis for calculation and the standard values (Node ID = 10).

Table 10: Calculation of COB IDs per predefined connection set

Communication object	Calculation of COB ID	Standard value (Node ID = 10)
NMT	0h	0h
SYNC	80h	80h
EMCY	80h + Node ID	8Ah
TPDO1	180h + Node ID	18Ah
Standard SDO (Client > Server)	600h + Node ID	60Ah
Standard SDO (Server > Client)	580h + Node ID	58Ah
Heartbeat	700h + Node ID	70Ah

5.8 Status LED (per CiA DR-303-3)

The built-in two-color LED displays the current device status (Run LED, green), as well as CAN communication errors (Error LED, red) that might have occurred.

The different states are displayed in Table 11.

Table 11: Status and error display

Status LED		
Run LED, green	**LED status**	**Description**
	Off	The device is in the "reset" status or there is no power supply.
	Blinking	The device is in the "pre-operational“ status.
	Simple, short illumination	The device is in the "stopped" status.
	On	The device is in the "operational" status.
Error LED, red	**LED status**	**Description**
	Off	The device operates error-free.
	Simple, short illumination	Error counter CAN controllers has reached the alarm threshold or overreached it.
	Dual, short illumination	The device recognized failure of the guarding master (Node Guard Event).
	On	The device is in the "bus off" status.

5.9 EDS files

An electronic data sheet (EDS file) is available for each inclinometer (download free of charge from the internet under http://www.turck.com...).

It contains a complete description of the object register and can be easily added to a CANopen project planning software.

6 Glossary

B

Baud rate

Data transmission rate (1 Baud = 1 Bit/s)

C

CAN

Controller Area Network

CANopen

Standardized application layer for CAN devices

CIA

CAN in Automation (membership corporation)

CIA DS

CiA Draft Standard (specification published by CiA)

CIA DS-301

Specification of CANopen application layer and the communication parameters in the OD

CIA DP

CiA Device Profile (device profile published by CiA)

CIA DR

CiA Draft Standard (specification published by CiA)

CIA DR-303-3

Recommended implementation for the display of CANopen device states and errors per LED

CIA DSP

CiA Draft Standard (specification published by CiA)

CIA DSP-410

Specification draft of the device profile 410 for inclination sensors

Client

CANopen participant with utilization access to a server

COB

CANopen Communication Object

COB ID

CAN identifier of a COB

E

EDS - electronic data sheet

Electronic data sheets which must be written according to a standardized text format. Configuration tools are suitable for reading EDS files, for communicating with the respective device and for parameterizing it if needed.

EEPROM - Electrically Erasable Programmable Read-Only Memory

A non-volatile, electronic memory chip is called EEPROM. An EEPROM consists of a field effect transistor matrix with isolated floating gate in which each transistor represents a Bit.

EMCY

Emergency objects are triggered by a significant internal device error. An emergency message can only be sent once for each error. As long as the device remains free of additional errors, no additional emergency objects are sent. Error messages can be received by multiple emergency consumers. The response of the consumers depends on the application. CANopen defines Emergency Error Codes that are sent in the emergency object. The emergency object consists of a single CAN message with eight Byte data supported by standard emergency frames (EMCY) per CiA DS-301.

F

Fieldbus

Data network on sensor- /actuator level. The devices on the field level are connected to a control unit by a fieldbus. A fieldbus is recognized for high transmission integrity and real-time behavior.

FRAM - Ferroelectric Random Access Memory

A non-volatile, electronic storage type based on crystals with ferroelectrical characteristics is called FRAM.

G

Guard COB ID

Identification number for Nodeguarding. This COB ID is fixed and can not be changed.

Guard Time

The request-interval time (display in milliseconds) to be expected from the network slave during Nodeguarding.

H

Heartbeat

The Heartbeat protocol is used to monitor the operating ability of other CANopen bus participants. With the help of the Heartbeat signals, the CANopen node signals to all CANopen network participants that it is ready for operation even when no data transfer has occurred for an extended period of time. The failure of a CANopen node can be registered by all participants! The Heartbeat Producer Time determines the Heartbeat cycle time.

Hexadecimal (...h)

Number system with the basis 16. The count starts at 0 and ends at 9, and continues with the letters A, B, C, D, E and F.

I

IEC 61131

IEC 61131 is an international standard which addresses the basic principles for controllers programmable from memory.

Inhibit Time

Minimum off-period for sending. With the help of Inhibit Time, an off-period between two signals is defined so that the bus is not continuously occupied by high priority messages. Is only supported for TPDOs

Initialization

During initialization (verb: to initialize) the storage slot (for example variables, code, buffer,...) needed for execution is reserved and filled with start values.

INTEGER8

Data type INTEGER8 (8 Bit, two's complement, -128...127)

INTEGER16

Data type INTEGER8 (16 Bit, two's complement, -32768..0.32767)

IP - International Protection

The protection class (IP) defines the suitability of electrical equipment (for example devices, installation material) for diverse environments and in addition, it determines the suitability for protecting persons against potential danger during operation of the electrical equipment.

L

Lateral

Assignment of axes (Y-axis)

Lifetime Factor

This factor, multiplied by the Guard Time, determines the time that must pass after an error has occurred in the Nodeguarding protocol and before the error is signaled by the network slave per EMCY. This is how a communication difficulty that has temporarily occurred, for example high bus load, can be attended to without guarding error.

Longitudinal

Assignment of axes (X-axis)

Logistics

Logistics describes integral planning, control, execution, allocation, optimization and monitoring of processes for moving goods, data, energy and persons, as well as the needed transportation vehicles and equipment.

M

Master

The Master controls the access conditions during a Master-Slave operation on the fieldbus level.

Mode

Operating mode (mode)

MSB

Most Significant Bit. Bit with the highest place value.

N

NID

Node ID

Nodeguarding

Monitoring of the network nodes with the help of a network manager is called nodeguarding. In addition the CANopen network participants are used to check whether their network manager is still operating regularly and whether the network is still operating safely. Nodeguarding is inactive in the default setting. Different parameters must be set via the object register to activate a participant's nodeguarding protocol.

Node ID

Node number of a CANopen device (1...127)

NMT

Network Management Object (object to set and check CANopen device modes)

O

Operational

CANopen device mode (SDO, PDO, EMCY, NMT possible)

OD

Object register (virtual register with device parameters, addressing per index and subindex).

P

Parameterization

Setting of parameters of single bus participants or better their modules in the configuration software of the DP Master.

Preoperational

CANopen device mode (SDO, PDO, EMCY, NMT possible)

Predefined Connection Set

Formula defined in the CiA DS-301 and to be used to calculate the COB IDs of the communication objects in reference to the Node ID.

Process Data Objects (PDOs)

Process data objects (PDO) are sent in a single CAN message. Here, all eight Byte of the data field can be used to send utilization objects. Each PDO must have a clear CAN identifier and must only be sent by one device. However, it can be received by multiple devices (Producer/ Consumer communication). PDO transmissions can be triggered by an internal event (event-driven), also by an internal timer (timer-driven) or by a request from another device.

R

Repeater

In regards to digital communication technology, the repeater is a signal generator which receives a signal in the Bit transfer layer, then reprocesses and resends it. Noise as well as jitter of the run time and the pulse form are removed from the received signal with this type of processing.

RTR Remote Transmission Request

A set RTR Bit (Remote Transmission Request) identifies a remote frame (recessive). A participant may send a data transfer request to another participant with the help of a remote frame.

S

Server

CANopen participant which offers a service for one/multiple client(s)

SDO - Service Data Objects

A service data object (SDO) reads data from the object register or writes data to the object register. The SDO transport protocol is suitable to send objects of different sizes. The first Byte of the first segment contains the needed flow control information. Among others it contains a toggle Bit to solve the problem of CAN messages that were received twice. The next three Byte of the first segment contain the index and subindex of the entry into the object register to be read or written. The last four Byte of the first segment are available for user data. The second and the following segments (which utilize the same CAN identifier) contain the control Byte and up to seven Byte user data. The receiver acknowledges each segment or a segment block so that a peer-to-peer communication (Client/Server) takes place.

Stopped

CANopen device mode (SDO, PDO, EMCY, NMT possible)

T

Transmission Type

The transmission type determines under which circumstances a PDO will be sent or received.

U

UNS8

Data type UNSIGNED8 (8 Bit, unsigned, 0...255)

UNS16

Data type UNSIGNED8 (16 Bit, unsigned, 0..0.65535)

UNS32

Data type UNSIGNED8 (32 Bit, unsigned, 0..0.4294967296)

V

VSTR

Data type VISIBLE STRING (ASCII character string inclusive end identification 0h).

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