

IK1R

Option card redundant inclinometer with CANopen Safety-interface

User manual

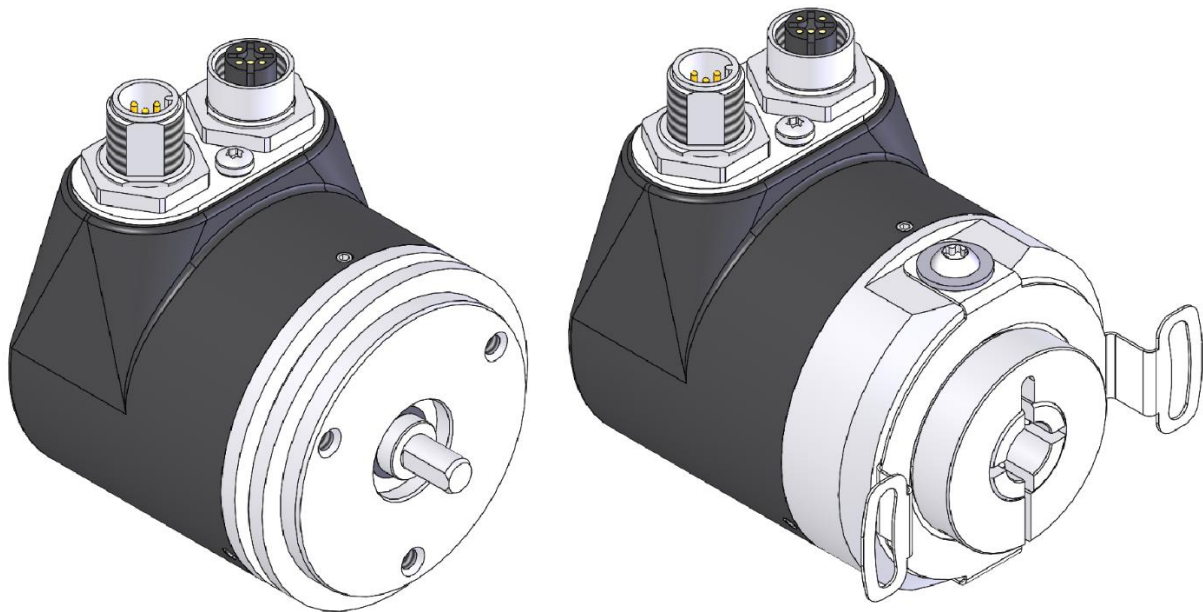


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1 General Information

1.1 Documentation

The following documents are associated with this document:

- The data sheet describes the technical data, the dimensions, the pin assignment, the accessories and the order key.
- The installation instructions describe the mechanical and electrical installation with all safety-relevant conditions and the associated technical specifications.
- The User manual for the sensor commissioning and integration into a fieldbus system.
- EDS file (electronic data sheet); this file enables integration and configuration in a CANopen network by means of commercial CANopen configurators.

You can also download these documents at <http://www.siko-global.com/p/ik1r>.

1.2 Definitions

Decimal values are given as numbers without addition (e. g. 1234), except when indicated in direct connection with binary or hexadecimal values. In this case, the extension "d" is used (e. g. 1234d). Binary values are identified by adding "b" (e. g. 1011b) to the figures whereas hexadecimal values are extended by "h" (e. g. 280h).

2 Intended use

The IK1R is designed for redundant slope detection in one dimension. The inclinometer can be parameterized and read out via the CAN interface using the CANopen protocol and CANopen Safety protocol. The sensor can be used for applications up to Performance Level D (PLd) in the overall system. For this purpose, a higher-level, safe evaluation device is required because the inclinometer sensor with its internal sensor diagnosis is not able to initiate actions itself such as the initiation of a safe state. Increased demands are placed on the electrical and mechanical connection of the inclinometer.

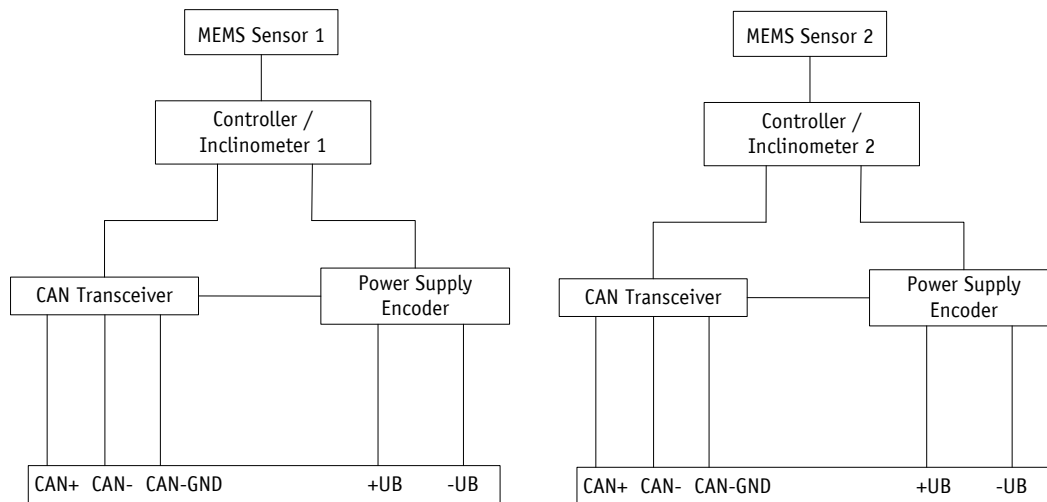


Fig. 1: Block diagram

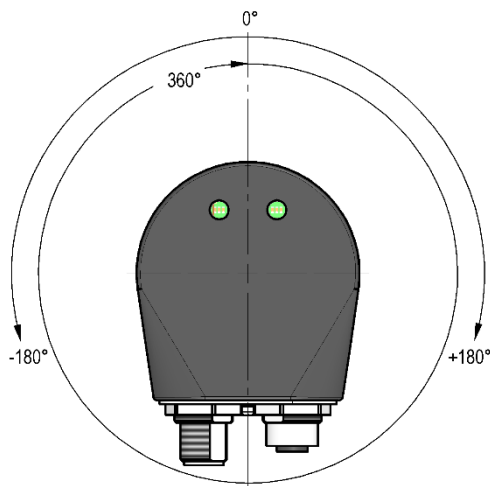


Fig. 2: Measurement axis

2.1 Switching on the supply voltage

The inclinometer initializes after being switched on. The configuration parameters are loaded from the nonvolatile memory into the main memory of the controller during initialization.

Each sensor will work with its default values as long as no changes have been made to it. With parameters changed, the sensor will work with the changed data, which must be stored if they are intended to be used after power off/on.

After completing the initialization procedure, each inclinometer sends a specific NMT command, the boot-up message, which informs the system about their availability. The inclinometer is now in the pre-operational mode. In this state, the sensor can be parameterized via SDO commands in accordance with the requirements of the application. This concerns both the configuration parameters of the sensor system and the way in which it makes its slope values available to the system (asynchronous or synchronous data transmission).

2.2 Device identification

To ensure safe operation, the following parameters should be read and verified with a Safety inclinometer before each parameterization and commissioning.

- [1000h: Device Type](#)
- [1018h: Identity Object](#) Sub-index 01h Vendor ID
- [1018h: Identity Object](#) Sub-index 02h Product Code
- [1018h: Identity Object](#) Sub-index 03h Revision number
- [1018h: Identity Object](#) Sub-index 04h Serial number

3 Functional description

3.1 Measuring range

The inclinometer supports 2 measuring ranges. A measuring range of 0 ... 360° (resolution 0.1°) is set by default. The measuring range can be switched to $\pm 180^\circ$ (resolution 0.1°) via object [6011h: Slope long16 operating parameter](#).

3.2 Calibration

Owing to the absolute system, calibration is required only once when the system is taken into operation and can be performed at any position. This enables alignment of the inclinometer zero point with the system's mechanical zero point. During calibration, the calibration value is used to calculate the slope value.

3.3 Reset to factory settings

To return to the original condition of the device as delivered, there exist the following options:

Access	Coding		Settings are restored
CANopen (see object 1011h: Restore Parameter)	1011h "load"	Sub-index 1	All parameters
		Sub-index 2	Only bus parameters
		Sub-index 3	Only CiA 410 parameters
		Sub-index 4	Only manufacturer-specific parameters

Table 1: Access to factory settings

4 Communication via CAN bus (CANopen and CANopen Safety)

The basis for the inclinometer IK1R is the CANopen communication profile CiA 301 V4.2, the device profile for inclinometer CiA 410 V2.0.0. The CANopen Safety protocol EN50325-5 is additionally implemented for safety-relevant applications. Safety-relevant applications as well as safety-non-relevant applications can be operated on a CAN bus. The IK1R supports device class C1. The details required for a better understanding of the operation are included in this documentation. If more in-depth information is required, we recommend the applicable technical literature on CAN, CANopen and CANopen Safety.

4.1 Telegram structure

The data telegram of a CAN message consists of the following fields:

SOF	Identifier (COB ID)	Control field	Data field (max. 8 Byte)	CRC	ACK / EOF
-----	---------------------	---------------	--------------------------	-----	-----------

SOF:

(Start of Frame) start bit of the telegram.

Identifier (COB ID):

- By means of the identifier, all bus subscribers check whether the message is relevant for each of them.
- The identifier determines the priority of the message. The lower the value of the identifier, the higher is the priority of the message. This enables preferential transmission of important messages via the bus.

The Identifier field contains the identifier as well as bits for the recognition of the length of the identifiers (11 or 29 bits). The device address, channel selection as well as data direction are determined via the identifier as well.

Thus, the 11bits identifier (COB identifier) consists of a 4bit function code and a 7bit node number:

Bit no.	10	9	8	7	6	5	4	3	2	1	0
Type	Functional code						Node number (Node ID)				
Assignment	x	x	x	x	0	0	x	x	x	x	x

The following functional codes have been defined in the "Pre-defined Connection Set" (only the functional codes used in the present device are shown):

Object	Functional code	Resulting COB ID	Object	Page
Network management (NMT)	0000b	0	-	9
SYNC message	0001b	128d (80h)	1005h	11
Emergency message	0001b	128d (80h) + Node ID	1014h	20
TPD01	0011b	384d (180h) + Node ID	1800h	11
SDO (tx)	1011b	1408d (580h) + Node ID	1200h	12
SDO (rx)	1100b	1536d (600h) + Node ID	1200h	12
Heartbeat message	1110b	1792d (700h) + Node ID	-	22
Node Guard message	1110b	1792d (700h) + Node ID	-	21

Object	Functional code	Resulting COB ID	Object	Page
LSS (tx)	-	2020d (7E4h)	-	23
LSS (rx)	-	2021d (7E5h)	-	23

Table 2: Overview of COB identifiers

Changes to COB IDs are only possible in the PRE-OPERATIONAL NMT status. First, the COB ID must be switched invalid via bit 31 = 1b before it can be changed and reactivated.

The COB ID of the Sync object is an exception, where bit 30 must be = 0b to enable the COB ID to be changed. As bit 30 cannot be set to 1b in the inclinometer, the COB ID could be changed at any time.

The node number (Node ID) (see also object [5F0Ah: Node ID and baud rate Bus CAN](#)) is assigned once in every bus system with configuration of the master on IK1R. The node numbers range from 1 to 127. Node ID = 0 is reserved and must not be used.

The adoption of a Node ID or baud rate which was reset occurs only after re-initialization (see chapter [4.2.1](#)).

In the case of the inclinometer IK1R, an inclinometer with node ID 3 (1h) and the redundant inclinometer with node ID 4 (2h) are delivered ex works.

Control field:

Contains bit-by-bit information concerning the number of user data and determines whether a data frame or RTR frame (Remote Transmission Request frame) is concerned.

Data field:

Contains up to 8 bytes of user data. The user data has a different meaning depending on the channel selection.

CRC:

Contains bits for error detection.

ACK/EOF:

The ACK/EOF field contains telegram acknowledgment bits as well as bits for determining the end of telegram.

For a detailed description of the telegram please refer to the applicable technical CAN literature. For simplification, only identifier (COB ID) and data field will be dealt with in the subsequent telegram descriptions.

4.2 Node control

4.2.1 Network management (NMT) services

The master configures, manages and monitors network nodes via the NMT service. The device is always in one of the four communication states "INITIALIZATION", "PRE-OPERATIONAL", "OPERATIONAL" or "STOPPED" (see [Fig. 3](#))

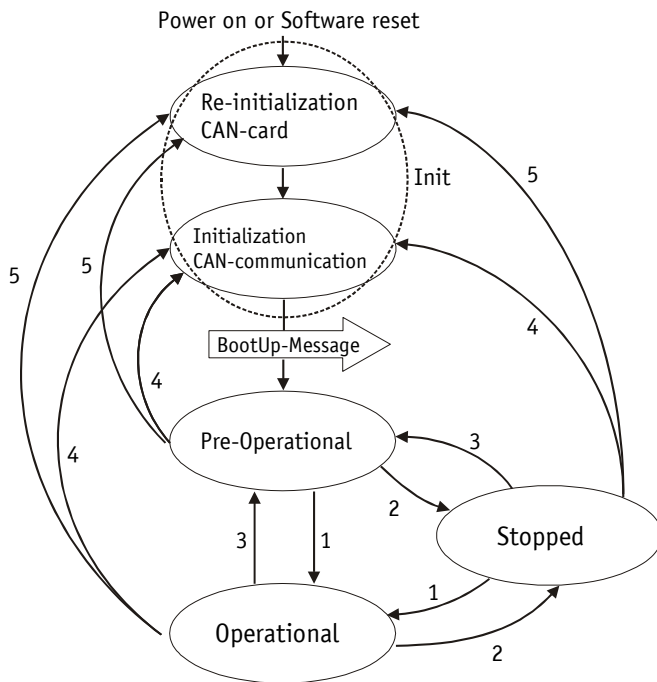


Fig. 3: NMT status diagram

4.2.1.1 NMT communication states

NMT Status INITIALIZATION

The device is not involved in the bus actions in this state. All hardware and software components are initialized. This state is attained after switching on the device or after receipt of the command code 81h ("Reset node") of the own or global addresses. Following receipt of the command code 82h ("Reset Communication"), the inclinometer will enter the initialization stage as well. But only hardware and software associated with CAN communication will be reinitialized. The device signals automatically the completion of initialization by sending a boot-up message. As soon as the boot-up message was sent successfully, the device will enter the "PRE-OPERATIONAL" status.

NMT Status PRE-OPERATIONAL

Parameterization data (SDO) can be exchanged in the pre-operational mode. However, no process data (PDO's) is transferred.

NMT Status OPERATIONAL

The exchange of process data is enabled as well. However, COB ID and Transmit PDO Mapping parameters can no longer be changed in this status.

NMT Status STOPPED

Communication is stopped except for heartbeat and node guarding Only NMT communication is enabled.

4.2.1.2 Toggling between the NMT communication states

For toggling between the communications states, telegrams with the following structures are used:

Change of state		Transition in Fig. 3	COB ID	Com- mand	Node ID
from	to				
PRE-OPERATIONAL / STOPPED	OPERATIONAL	1d	0h	01h	x
OPERATIONAL/ PRE- OPERATIONAL	STOPPED	2d	0h	02h	x
OPERATIONAL / STOPPED	PRE-OPERATIONAL	3d	0h	80h	x
OPERATIONAL / PRE- OPERATIONAL / STOPPED	INITIALIZATION (Reset Node)	5d	0h	81h	x
OPERATIONAL / PRE- OPERATIONAL / STOPPED	INITIALIZATION (Reset Communication)	4d	0h	82h	x

Table 3: Toggling between communication states

If x = 0h is transferred as Node ID, then the message is intended for all bus subscribers.

4.2.2 Boot-Up

The COB ID of the boot-up message is made up of 700h and the Node ID. The "Initialization" NMT status is output as data content.

COB ID	Byte 0
700h + Node ID	00h

Table 4: Boot-Up message

4.2.3 SYNC object

CANopen enables the simultaneous query of all inputs and the simultaneous setting of all outputs. The synchronization message (SYNC), a CAN message with high priority serves this purpose. The identifier of the Sync object can be set via object 1005h (see [1005h: COB ID SYNC message](#)).

4.3 Process data exchange

4.3.1 Transfer of process data objects (PDO)

Process data objects (PDO) serve for fast exchange of process data. A maximum of 8 bytes of user data can be transferred in a PDO. The IK1R supports the Transmit PDO services TPD01 and TPD02 according to CiA 301 and CiA 410.

4.3.1.1 Transmit-PDO (from the IK1R to the master)

PDO transfer from the IK1R to the bus master can be initiated as a result of various events:

- asynchronous, controlled by an internal device timer
- synchronous as a response to a SYNC telegram
- as a response to an RTR message

The TPDO1 contains the slope long16. The transfer behavior of TPDO1 is determined via the objects 1800h and 1A00h and is assigned to asynchronous transmission. Synchronous data transmission is set at delivery. Other TPDOs are not supported.

COB ID	Process data in binary code	
	Byte 0 (LSB)	Byte 1 (MSB)
TPDO1 180h + Node ID	Slope long16	

Table 5: TPDO message

Asynchronous data transmission

If a TPDO1 is to be sent cyclically, 254 (FEh) or 255 (FFh) must be entered in object 1800h, sub-index 02h. The cycle time can be entered in milliseconds in object 1800h, sub-index 05h. The TPDO1 will not be sent if the value 0 ms is written. The function is disabled. The minimum value to be set is 1h (= 1 ms).

Synchronous data transfer

As delivered, the device responds to every SYNC Message received with the output of the TPDO1 message. 1h is entered for synchronous transmission in object 1800h, sub-index 02h. If a value n is entered between 1d and 240d (= F0h), the device will respond to every nth SYNC message.

RTR

Queries can be sent via RTR (see chapter 4.1) to TPDO1.

4.4 Parameter data exchange

4.4.1 Transmission of Service Data Objects (SDO)

Service data objects serve mainly device configuration via the directory of objects. SDOs in the expedited Request/Response and in the normal Request/Response are supported.

The identifier is set to 11 bits and cannot be changed.

Two SDO services are available:

- SDO (rx) (Master → Slave): 600h + Node ID
- SDO (tx) (Slave → Master): 580h + Node ID

Two SDO services are available!

4.4.1.1 Expedited Request/Response

Except for reading the object [100Ah: Manufacturer Software Version](#) all SDOs are exchanged between two subscribers in the expedited Request/Response method. The user data is provided already with the initialization message.

SDO messages are set up as follows:

COB ID	User data in binary code							
	Byte 0 read / write	Byte 1 LSB	Byte 2 MSB	Byte 3	Byte 4 LSB	Byte 5	Byte 6	Byte 7 MSB
SDO rx/tx + Node ID	Command byte	Index		Sub-index	User data (parameter)			

Command byte, byte 0:

The command byte determines the type of access and the number of valid data bytes. The following command bytes are valid for the IK1R:

Command byte	Type	Function
Write Request	23h	SDO (rx), Initiate Download Request, expedited
Write Request	2Bh	SDO (rx), Initiate Download Request, expedited
Write Request	2Fh	SDO (rx), Initiate Download Request, expedited
Write Request	60h	SDO (tx), Initiate Download Response, expedited
Read Request	40h	SDO (rx), Initiate Upload Request
Read Response	43h	SDO (tx), Initiate Upload Response, expedited
Read Response	4Bh	SDO (tx), Initiate Upload Response, expedited
Read Response	4Fh	SDO (tx), Initiate Upload Response, expedited
Error Response	80h	SDO (tx), Abort Domain Transfer

Table 6: Command coding

Index, bytes 1 and 2:

The index (object number) is entered in the user data byte 2 (low byte) and user data byte 3 (high byte) in the Intel data format. Here, the index of the object to be parameterized is entered.

Sub-index, byte 3:

The sub-index indicates the number of the fields for objects realized as an array.

User data (parameters), Byte 4 ... 7:

In the user data, the value of the parameter is entered in left-aligned Intel notation. Byte 4 = Low-Byte ... Byte 7 = High-Byte.

4.4.1.2 Normal Request/Response

If more than 4 bytes of service data are to be transferred, the data is exchanged between two subscribers via the normal Request/Response. This procedure is also initiated by an initialization message, and the actual user data will be transferred in the subsequent segment messages.

For the IK1R this is only the case with reading of the object [100Ah: Manufacturer Software Version](#).

The initialization message has the following structure:

COB ID	User data in binary code							
	Byte 0 read / write	Byte 1 LSB	Byte 2 MSB	Byte 3	Byte 4 LSB	Byte 5	Byte 6	Byte 7 MSB
SDO rx/tx + Node ID	Command byte	Index		Sub-index	User data (number of user data)			

The segment message has the following structure:

COB ID	User data in binary code							
	Byte 0 read / write	Byte 1 LSB	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7 MSB
SDO rx/tx + Node ID	Command byte	User data						

Initialization and segment message: Command byte, byte 0:

The command byte determines the type of access and the number of valid data bytes. The following command bytes are valid for the IK1R:

Command byte	Type	Function
Read Request	40h	SDO (rx), Normal Initiate Upload Request Request parameter from slave (number of bytes to be transferred)
Read Request	60h	SDO (rx), Normal Segment Upload Request Request parameter from slave (user data)
Read Response	41h	SDO (tx), Normal Initiate Upload Response Report parameter to master (number of bytes to be transferred)
Read Response	03h	SDO (tx), Normal Segment Upload Response Report parameter to master (user data)
Error Response	80h	SDO (tx), Abort Domain Transfer Slave reports error code to master

Table 7: Command coding

Initialization message: Index, bytes 1 and 2:

The index (object number) is entered in the user data byte 2 (low byte) and in the user data byte 3 (high byte) in the Intel data format. Here, the index of the object to be parameterized is entered.

Initialization message: Sub-index, byte 3:

The sub-index indicates the number of the fields for objects realized as an array.

Initialization message: User data (parameters), byte 4 ... 7:

In the service data range, the value of the parameter is entered in left-aligned Intel notation. Byte 4 = Low-Byte ... Byte 7 = High-Byte.

Segment message: User data (parameters), Byte 1 ... 7:

In the user data range, the value of the parameter is entered in left-aligned Intel notation. Byte 1 = Low-Byte ... Byte 7 = High-Byte.

4.4.1.3 Error Response in SDO exchange

With invalid access, an error message (Abort) is returned to the master.

The error codes are described in the CANopen profile (CiA 301) or in the inclinometer profile (CiA 410), respectively. The table below shows the error codes used:

Error code	Description
05030000h	Toggle bit in Normal Transfer of Request/Response unequal.
06010000h	Wrong access to an object.
06010001h	Read access to Write-Only.
06010002h	Write access to Read-Only.
06020000h	Object doesn't exist in the object directory.
06090011h	Sub-index does not exist.
06090030h	Wrong value range of selected parameter.
08000020h	Parameters cannot be transferred to application or stored.
08000022h	Parameters cannot be transferred to application or stored due to the current device status.
08000024h	No data available

Table 8: Error codes

4.4.1.4 SDO examples**Example of reading SDO parameters with the expedited Request/Response:**

The calibration value stored in object 1017h of the directory of objects is to be read from the slave with device address 3h.

Calculation of the identifier: 600h + Node ID = 600h + 3h = 603h

Command: 40h
 Index: 1017h
 Sub-index: 00h
 The current value is 1000d = 3E8h.

Request of master from slave with Node ID 3h:

COB ID	User data							
	Command	Index L	Index H	Sub-index	Data 0	Data 1	Data 2	Data 3
603h	40h	17h	10h	00h	x	x	x	x

Response to the request by the slave:

Calculation of the identifier: 580h + Node ID = 583h

COB ID	User data							
	Command	Index L	Index H	Sub-index	Data 0	Data 1	Data 2	Data 3
583h	4Bh (4 bytes valid)	17h	10h	00h	E8h	03h	00h	00h

Example of writing SDO parameters with the expedited Request/Response:

In the slave with device address 3h the cycle timer, which is stored with 2 bytes in object 1017h of the object dictionary, is to be changed.

Calculation of the identifier: 600h + Node ID = 600h + 3h = 603h

Command: 2 bytes are to be written: 2Bh
 Index: 1017h
 Sub-index: 00h
 The new value shall be 100d = 64h.

Writing of a value from master to slave with Node ID 3h:

COB ID	User data							
	Command	Index L	Index H	Sub-index	Data 0	Data 1	Data 2	Data 3
603h	2Bh (2 bytes valid)	17h	10h	00h	64h	00h	00h	00h

Response to the command by the slave:

Calculation of the identifier: 580h + Node ID = 580h + 3h = 583h

COB ID	User data							
	Command	Index L	Index H	Sub-index	Data 0	Data 1	Data 2	Data 3
583h	60h	17h	10h	00h	00h	00h	00h	00h

Example of reading SDO parameters with normal Request/Response:

The manufacturer device name stored in object 100Ah of the directory of objects is to be read from the IK1R with device address 3h.

Calculation of the identifier: $600\text{h} + \text{Node ID} = 600\text{h} + 3\text{h} = 603\text{h}$

Command: 40h

Index: 100Ah

Sub-index: 00h

First request (= initialization) of master from slave with Node ID 3h:

COB ID	User data							
	Command	Index L	Index H	Sub-index	Data 0	Data 1	Data 2	Data 3
603h	40h	0Ah	10h	00h	x	x	x	x

Response to the request by the slave:

Calculation of the identifier: $580\text{h} + \text{Node ID} = 583\text{h}$

COB ID	User data							
	Command	Index L	Index H	Sub-index	Data 0	Data 1	Data 2	Data 3
583h	41h	0Ah	10h	00h	07h	00h	00h	00h

Number of expected user data bytes: 7

Second request of master from slave with Node ID 3h:

COB ID	User data							
	Command	Index L	Index H	Sub-index	Data 0	Data 1	Data 2	Data 3
603h	60h	00h	00h	00h	x	x	x	x

Response to the request by the slave:

COB ID	User data							
	Command	Data 0	Data 1	Data 2	Data 3	Data 4	Data 5	Data 6
583h	01h	30h ("0")	2Eh (".")	39h ("9")	2Eh (".")	30h ("0")	30h ("0")	39h ("9")

4.5 Safety data exchange

4.5.1 Transfer of safety-relevant data objects (SRDO)

Safety-relevant data objects (SRDO) serve the cyclic exchange of safe data in the Operational NMT state. An SRDO consists always of 2 messages with different COB IDs and bit-by-bit inverted data. A maximum of 8 bytes of user data can be transferred in an SRDO. The IK1R supports the Safety Transmit services SRDO1 for the Slope long16 (2 bytes) according to EN50325-5 and CiA 410. The transmit behavior of SRDO is determined via the objects 1301h, 1381h and 6200h. Mapping is static and cannot be changed.

COB ID	Data in binary code	
	Data 0 (LSB)	Data 1 (MSB)
SRD01 COB ID1 000000FFh + 2*Node ID	Slope long16	
SRD01 COB ID2 00000100h + 2*Node ID	Bit-inverted Slope long16	

Table 9: SRD01 message

4.5.2 Transmission of Service Data Objects (SDO) of the Safety Parameters

All safety concerning service data objects for device configuration are addressed in expedited Request/Response.

All changes to safety concerning service data objects are monitored via a checksum CRC-16-CCITT and can only be executed in the Pre-Operational NMT state. The polynomial is $g(x) = x^{16} + x^{12} + x^5 + 1$.

Procedure of changing the configuration data in the objects 1301h and 6200h:

- Change values.
- Enter the new valid checksum (sub-index of the relevant object 13FFh or object 61FFh).
- Switch the relevant configuration to valid via object 13FEh or 63FEh.

4.5.3 Procedure for initial commissioning of the SRD0 message

The following steps are necessary for the exchange of Safety data via the SRD0 message for commissioning:

- Device must be in NMT state "PRE-OPERATIONAL".
- Configuration parameters for SRD01 (see [1301h: SRD01 Communication Parameters](#)) and Safety slope long16 (see [6200h: Safety configuration parameters](#)) must be adapted.
- Calculate checksums (see [13FFh: Safety Configuration Signature \(checksum\)](#) and [63FFh: Safety application configuration signature \(checksum\)](#)).
- Set configurations to valid (see [13FEh: Safety Configuration](#) and [63FEh: Safety application configuration](#)).
- Save configurations as required (see [1010h: Store Parameter](#)).
- Switch to the NMT state "OPERATIONAL" (see [Network management \(NMT\) services](#)).

Then the SRD0 message is transmitted according to the configuration parameters.

4.5.4 Example for calculating a checksum

In the following example the checksum CRC-16-CCITT (polynomial 1021h) for SRD01 should be calculated. The checksum is calculated byte by byte and the low byte by the contents of the two objects 1301h and 1381h.

Object	Sub-index	Name	Extent	Data
1301h	SRD01 Communication parameter			
	01h	Direction of information	1 byte	01h
	02h	Refresh time	2 byte	0019h
	03h	tx: reserved rx: SRVT	1 byte	14h
	04h	COB ID 1	4 byte	00000105h
	05h	COB ID 2	4 byte	00000106h
1381h	SRD01 Mapping parameter			
	00h	Highest sub-index	1 byte	04h
	01h	Sub-index	1 byte	01h
	01h	Safety Slope long16 1 st byte	4 byte	62100108h
	02h	Sub-index	1 byte	02h
	02h	Inverted Safety Slope long16 1 st byte	4 byte	62110108h
	03h	Sub-index	1 byte	03h
	03h	Safety Slope long16 2 nd byte	4 byte	62100208h
	04h	Sub-index	1 byte	04h
	04h	Inverted Safety Slope long16 2 nd byte	4 byte	62110208h

The following data bytes are used to calculate the checksum:

0x01 0x19 0x00 0x14 0x05 0x01 0x00 0x00 0x06 0x01 0x00 0x00 0x04 0x01 0x08 0x01 0x10
0x62 0x02 0x08 0x01 0x11 0x62 0x03 0x08 0x02 0x10 0x62 0x04 0x08 0x02 0x10 0x62

Checksum = 07BFh

4.5.5 Example of change of a configuration

In the following example, the direction of information is to be changed from valid to invalid for SRD01.

Changing the direction of information:

COB ID	User data							
	Command	Index L	Index H	Sub-index	Data 0	Data 1	Data 2	Data 3
600h + Node ID	2Fh	01h	13h	01h	00h	00h	00h	00h

For the checksum, the default value 0000h is entered. This means that the checksum must be specified even if the configuration is not changed.

COB ID	User data							
	Command	Index L	Index H	Sub-index	Data 0	Data 1	Data 2	Data 3
600h + Node ID	2Bh	FFh	13h	01h	63h	8Ah	00h	00h

Enable the configuration for SRD01. During activation, the configuration is monitored by means of the checksum in object 13FFh sub-indexes 01h. Configurations can only be activated with the correct checksums.

COB ID	User data							
	Command	Index L	Index H	Sub-index	Data 0	Data 1	Data 2	Data 3
600h + Node ID	2Fh	FEh	13h	00h	A5h	00h	00h	00h

4.6 Node monitoring

4.6.1 Emergency service (EMCY)

In the case of an error, the status of the bus subscriber is transferred via high-priority emergency messages (emergency telegrams). These messages have a data length of 8 bytes and contain error information.

The emergency message is transferred as soon as a sensor or communication error has occurred or when such errors have been corrected. The cause of the error is deposited in the error buffer (see object [1003h: Pre-defined Error Field](#)). An emergency object is sent only once per error event. Removal of the cause of the error is signaled by sending an emergency message with the error code 0000h (no error). If multiple errors have occurred and one cause of error is removed, the error code 0000h is output as well; the persisting error status is indicated in the error register, however.

Identifier	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
11/ 29 Bit	Emergency Error Code		Error Register (object 1001h)	Manufacturer-specific error field				

Emergency Error Code:

Error Description	Error Code
Cause of the error removed	0000h
Device power supply error V_{in}	3100h
Internal device power supply error V_{cc} , V_{ref}	3200h
Device temperature error	4200h
Device hardware error	5000h
Device software error	6100h
CAN communication error	8100h
CAN buffer overflow error	8110h
CAN passive error	8120h
Heartbeat or life guarding error	8130h
CAN recovered from bus-off error	8140h
PDO error not processed due to invalid length	8210h
PDO length exceeded error	8220h

Error Description	Error Code
Device-specific/sensory error	FF00h

Table 10: Emergency Error Code

Manufacturer-specific error field:

Error Description	Error Code
Lower limit value violation error	0001h
Upper limit value violation error	0002h
Vcc or Vref error	0004h
Temperature error	0008h
MEMS sensor element error	0010h
Controller error	0020h
Memory error	0040h
Operating mode error	0080h
Hardware component error	0100h
MEMS saturation measuring range/measuring range exceedance error	0200h
MEMS self-test error	0400h
MEMS communication error	0800h
MEMS output rate (sample frequency) error	1000h

Table 11: Manufacturer-specific error field

The identifier of the emergency object is set to 80h + Node ID by default; however, it can be changed via object 1014h (see [1014h: COB ID Emergency message](#)). Transmission of an emergency message is enabled in the NMT statuses "OPERATIONAL" or "PRE-OPERATIONAL" only. Transmission of the emergency messages can be disabled by setting the COB ID Valid bit to 1.

4.6.2 Node Guarding

Node guarding is available for failure monitoring of the CANopen network. During node guarding, the master transmits remote frames (RTR, remote transmit request, message request telegrams) on the guarding identifiers of the nodes to be monitored. The latter respond with the guarding message. This message contains the current NMT status of the node as well as a toggle bit whose value must change after each message. The master assumes that a node error has occurred if status or toggle bits do not correspond with those expected by the master or if there is no response.

Via objects 100Ch (Guard Time) and 100Dh (Life Time Factor) the time interval (Life-Time) is set within which the NMT master expects to receive a response. The time interval "Life Time" is calculated from the cycle time "Guard Time", multiplied with the factor "Life Time Factor". If the NMT master does not receive a response to its RTR frame within the "Life Time", it may react with suitable measures. Upon switching on, node guarding will be enabled by sending the first RTR frame of the master to the slave. Node Guarding is deactivated if the value of either object (100Ch or 100Dh) is set to 0h.

The answer of the node to the RTR frame of the master is formed as follows:

Identifier	Byte 0	
700h + Node ID	Bit 7: Toggle Bit	Bit 6 ... 0: NMT state

Toggle Bit:

The toggle bit must alternate between two subsequent responses of the device. After the guarding protocol has been enabled, the toggle bit must have the value 0 with the first response.

NMT state:

4: STOPPED

5: OPERATIONAL

127: PRE-OPERATIONAL

The identifier of the node guarding protocol is permanently set to 700h + Node ID and cannot be changed. A node guard message can be sent in the NMT statuses "OPERATIONAL", "PRE-OPERATIONAL" or "STOPPED".

Note:

Literature recommends heartbeat to be used for node monitoring. Only the master can detect missing communication via the node guarding protocol as opposed to the heartbeat that can be received by all subscribers.

4.6.3 Heartbeat

The master monitors the state of the slave device via Heartbeat protocol. While doing this, the device sends independently its NMT status cyclically. The IK1R is a heartbeat producer, it does not receive nor process heartbeat protocols itself. The cycle time of the heartbeat message is set via object 1017h. The heartbeat protocol is deactivated if the cycle time is 0h.

The heartbeat message consists of the COB ID and an additional byte. In this byte, the current NMT state is deposited.

COB ID	Byte 0
700h + Node ID	NMT state

NMT state:

4: STOPPED

5: OPERATIONAL

127: PRE-OPERATIONAL

The identifier of the heartbeat protocol is permanently set to 700h + Node ID and cannot be changed. Heartbeat messages are sent in the NMT statuses "OPERATIONAL", "PRE-OPERATIONAL" or "STOPPED".

4.7 Layer Setting Service (LSS)

Layer Setting Service (LSS) is a special method described in CiA 305 it serves for retrieving and configuring various parameters (Node ID, baud rate, and Identity Object 1018h).

Every device must have a unique LSS number composed of the entries in Object 1018h.

- Vendor-ID: 0000 0195h
- Product Code: 0201 0002h
- Revision number: FFFF FFFFh
- Serial number: xxxx xxxxh (respective serial number of the inclinometer)

In order to enable the use of full LSS functionality, all devices on the bus must support the LSS method. An LSS master must exist and all nodes must start with the same baud rate. After starting, the device will be in the LSS waiting state. To enable configuration, one or all devices must be switched to the LSS configuration state. If the LSS master expects to receive an answer to its command, only one LSS slave must be switched to the LSS configuration mode.

Two LSS services are available:

- LSS (rx) (LSS Master → Slave): 7E5h
- LSS (tx) (Slave → LSS Master): 7E4h

These LSS identifiers cannot be changed!

A message consists always of 8 bytes. Byte 0 contains the command (Command – Specifier cs), followed by max. 7 data bytes unused data bytes are reserved and must be filled with 00h.

Service	LSS waiting	LSS configuration
Switch state global	yes	yes
Switch state selective	yes	no
Activate bit timing parameters	no	yes, if all devices on the bus support LSS
Configure bit timing parameters	no	yes
Configure Node ID	no	yes
Store configuration	no	yes
Request LSS address	no	yes
Request Node ID	no	yes

Table 12: State behavior of the supported LSS services

4.7.1 State change

4.7.1.1 Switch states of all LSS devices (Switch state global)

COB ID	User data							
	Byte 0 Command	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
7E5h	04h	Mode	00h	00h	00h	00h	00h	00h

Mode:

00h: Switch to LSS waiting state

01h: Switch to LSS configuration state

4.7.1.2 Switch states of individual LSS devices (Switch state selective)

With this command, Individual LSS slave devices can be set to the LSS Configuration state via the unique LSS number.

Master → Slave

COB ID	User data								
	Byte 0 Command	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	
7E5h	40h	Vendor ID				00h	00h	00h	

COB ID	User data								
	Byte 0 Command	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	
7E5h	41h	Product code				00h	00h	00h	

COB ID	User data								
	Byte 0 Command	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	
7E5h	42h	Revision number				00h	00h	00h	

COB ID	User data								
	Byte 0 Command	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	
7E5h	43h	Serial number				00h	00h	00h	

Slave → Master

COB ID	User data							
	Byte 0 Command	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
7E4h	44h	00h	00h	00h	00h	00h	00h	00h

4.7.2 Configuration

4.7.2.1 Setting the Node ID (Configure Node ID)

The LSS master can set the node ID of individual nodes to configuration mode to configure the LSS slave. If the new node ID is intended to still be available after Power off/on, the "Save configuration" command must be output after the change. For immediate activation of the new node ID, the LSS slave must be set to the LSS Waiting mode, followed by an NMT "Reset Communication" 82h. Another possibility would be to execute power off/on after "Save configuration".

Master → Slave

COB ID	User data							
	Byte 0 Command	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
7E5h	11h	NID	00h	00h	00h	00h	00h	00h

NID:

01h ... 7Fh: Node ID

Slave → Master

COB ID	User data							
	Byte 0 Command	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
7E4h	11h	Error code	Spec error	00h	00h	00h	00h	00h

Error Code:

00h: Transmission successful

01h: no valid Node ID

FFh: Implementation error see Spec error

Spec error:

This byte is nonzero only in case of an implementation error and Error Code FFh.

4.7.2.2 Configuration of the baud rate (Configure bit timing parameters)

The baud rate of a single or of multiple LSS slaves can be configured via this command. If the new baud rate is intended to still be available after Power off/on, the "Save configuration" command must be output after the change. To activate the new baud rate the [Activate baud rate \(Activate bit timing parameters\)](#) command must be output and the LSS slave set to the LSS Waiting state. Another possibility of activating the new baud rate would be to execute power off/on after "Save configuration".

Master → Slave

COB ID	User data							
	Byte 0 Command	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
7E5h	13h	Table selector	Table index	00h	00h	00h	00h	00h

Table selector:

00h: CiA 301 bit timing table

80h ... FEh: Manufacturer-specific bit timing table

Table index:

Table index	Baud rate
0	1000 kbit/s
1	800 kbit/s
2	500 kbit/s
3	250 kbit/s
4	125 kbit/s
5	reserved
6	50 kbit/s
7	20 kbit/s
8	not supported
9	not supported

The device supports only Table selector 00h and Table index 0 until 7.

Slave → Master

COB ID	User data							
	Byte 0 Command	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
7E4h	13h	Error code	Spec error	00h	00h	00h	00h	00h

Error Code:

00h: Transmission successful

01h: no valid baud rate

FFh: Implementation error see Spec error

Spec error:

This byte is nonzero only in case of an implementation error and Error Code FFh.

4.7.2.3 Activate baud rate (Activate bit timing parameters)

This command activates the new baud rate set via [Configuration of the baud rate \(Configure bit timing parameters\)](#) without requiring Power off/on.

Master → Slave

COB ID	User data							
	Byte 0 Command	Byte 1 LSB	Byte 2 MSB	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
7E5h	15h	Switch delay		00h	00h	00h	00h	00h

Switch Delay:

The Switch delay parameter defines the length of two delay periods (d1, d2) of the same length and must correspond with a multiple of 1 ms. After expiry of the individual processing time and delay time d1, the new baud rate will be adopted internally. After expiry of the delay time d2, the LSS slave will report with the boot up via the newly set baud rate. This procedure prevents the synchronous presence on the bus of devices with different baud rates. The LSS slave cannot send messages during the two delay periods d1 and d2.

4.7.2.4 Store configuration

This command must only be executed if only one LSS slave is in the configuration mode. The current settings will be stored subsequently.

Master → Slave

COB ID	User data							
	Byte 0 Command	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
7E5h	17h	00h	00h	00h	00h	00h	00h	00h

Slave → Master

COB ID	User data							
	Byte 0 Command	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
7E4h	17h	Error code	Spec error	00h	00h	00h	00h	00h

Error Code:

00h: Transmission successful

01h: Store configuration is not supported

02h: Error occurred during storing

FFh: Implementation error see Spec error

Spec error:

This byte is nonzero only in case of an implementation error and Error Code FFh.

4.7.3 Requesting parameters

The following requests must only be executed if only one LSS slave is in the configuration mode.

4.7.3.1 Request Vendor ID

Master → Slave

COB ID	User data							
	Byte 0 Command	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
7E5h	5Ah	00h	00h	00h	00h	00h	00h	00h

Slave → Master

COB ID	User data							
	Byte 0 Command	Byte 1 LSB	Byte 2	Byte 3	Byte 4 MSB	Byte 5	Byte 6	Byte 7
7E4h	5Ah	Vendor ID (see object 1018.1h)			00h	00h	00h	

4.7.3.2 Request Product Code

Master → Slave

COB ID	User data							
	Byte 0 Command	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
7E5h	5Bh	00h	00h	00h	00h	00h	00h	00h

Slave → Master

COB ID	User data							
	Byte 0 Command	Byte 1 LSB	Byte 2	Byte 3	Byte 4 MSB	Byte 5	Byte 6	Byte 7
7E4h	5Bh	Product code (see object 1018.2h)			00h	00h	00h	

4.7.3.3 Request revision number

Master → Slave

COB ID	User data							
	Byte 0 Command	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
7E5h	5Ch	00h	00h	00h	00h	00h	00h	00h

Slave → Master

COB ID	User data							
	Byte 0 Command	Byte 1 LSB	Byte 2	Byte 3	Byte 4 MSB	Byte 5	Byte 6	Byte 7
7E4h	5Ch	Revision number (object 1018.3h)				00h	00h	00h

4.7.3.4 Request serial number

Master → Slave

COB ID	User data							
	Byte 0 Command	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
7E5h	5Dh	00h	00h	00h	00h	00h	00h	00h

Slave → Master

COB ID	User data							
	Byte 0 Command	Byte 1 LSB	Byte 2	Byte 3	Byte 4 MSB	Byte 5	Byte 6	Byte 7
7E4h	5Dh	Serial number (object 1018.4h)				00h	00h	00h

4.7.3.5 Request Node ID

Master → Slave

COB ID	User data							
	Byte 0 Command	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
7E5h	5Eh	00h	00h	00h	00h	00h	00h	00h

Slave → Master

COB ID	User data							
	Byte 0 Command	Byte 1 LSB	Byte 2	Byte 3	Byte 4 MSB	Byte 5	Byte 6	Byte 7
7E4h	5Eh	Node ID (NID)				00h	00h	00h

4.8 Directory of objects

4.8.1 Overview of objects

The following table offers an overview of the objects of the device.

Name	Description	See page
1000h: Device Type	Device profile and inclinometer type.	31
1001h: Error Register	Current error state of the device.	31
1002h: Manufacturer Status Register	Contains the Transmit Error Counter and the Receive Error Counter.	32
1003h: Pre-defined Error Field	The object stores the 8 error states that have occurred last.	32
1005h: COB ID SYNC message	Setting of the COB ID of the SYNC object.	33
1008h: Manufacturer Device Name	Device name in ASCII notation.	33
1009h: Manufacturer Hardware Version	Indicates the hardware version of the device.	34
100Ah: Manufacturer Software Version	Indicates the software version of the device.	34
100Ch: Guard Time	Parameter for Node Guarding.	34
100Dh: Life Time Factor	Parameter for Node Guarding.	35
1010h: Store Parameter	Object for non-volatile storage of the settings.	35
1011h: Restore Parameter	Object for restoring the factory settings.	37
1014h: COB ID Emergency message	COB ID of the Emergency object.	39
1017h: Producer Heartbeat Time	Setting of the cycle time of the heartbeat timer.	40
1018h: Identity Object	Contains the manufacturer number.	40
1200h: Server SDO Parameter	SDO Parameter	41
1301h: SRD01 Communication Parameters	SRD01 Communication Parameters.	42
1381h: SRD01 Mapping Parameter	SRD01 Transmit Mapping Parameter.	44
13FEh: Safety Configuration	Activate Safety configuration for SRD01.	45
13FFh: Safety Configuration Signature (checksum)	Signature (checksum) for SRD01 configuration.	45
1800h: 1 st Transmit PDO Parameter	Transmit PDO for asynchronous transfer (timer controlled).	42
1A00h: 1 st Transmit PDO Mapping Parameter	Describes the arrangement of the objects, which are mapped in TPD01.	48
2000h: Digital filter cut-off frequency	Defines the set filter time.	49
5F0Ah: Node ID and baud rate Bus CAN	Setting of Node ID and baud rate.	49
6000h: Resolution	Resolution of the Slope long16 value.	50
6010h: Slope long16	Slope long16 value (longitudinal slope).	50
6011h: Slope long16 operating parameter	Operating parameter	51
6012h: Slope long16 Preset value (calibration value)	Calibration value for longitudinal slope (Slope long16 preset value).	51

Name	Description	See page
6013h: Slope long16 Offset	Application offset of the slope (Slope long16 offset).	52
6014h: Differential Slope long16 Offset	Specifies the offset of the Slope long16 value.	52
6200h: Safety configuration parameters	Safety calibration value for longitudinal slope (Safety Slope long16 preset value).	52
6210h: Safety Slope long16 (Safety longitudinal slope value)	Safety Slope long16 (Safety longitudinal slope value).	53
6211h: Safety inverted Slope long16 (Safety inverted longitudinal slope value)	Safety inverted Slope long16 (Safety inverted longitudinal slope value).	54
63FEh: Safety application configuration	Activate Safety Slope long16 configuration.	55
63FFh: Safety application configuration signature (checksum)	Signature (checksum) via the CANopen Safety parameters of the configuration for Safety Slope long16.	55
6511h: Device temperature	Indicates the device temperature.	56

Table 13: Overview of objects

4.8.2 Object Description

4.8.2.1 1000h: Device Type

Object 1000h indicates the device profile number.

Sub-index	00h			
Description	Information about the device profile and encoder type			
Access	ro			
PDO mapping	no			
Data type	UNSIGNED 32			
Default	3001019Ah			
EEPROM	no			
Data content	Device profile -number		Additional information	
	Byte 0	Byte 1	Byte 2	Byte 3
	9Ah	01h	01h	30h

019Ah (= 410d): CANopen Device profile for inclinometer

3001h: Class C1, Default PDO mapping, CANopen Safety (Default SRDO mapping)

4.8.2.2 1001h: Error Register

Object 1001h indicates the error state of the device.

Sub-index	00h	
Description	pending error status	
Access	ro	
PDO mapping	no	
Data type	UNSIGNED 8	
Default	0h	
EEPROM	no	
Data content	Bit	Meaning
	0	set bit indicates the occurrence of any error condition
	1 ... 6	not used

4.8.2.3 1002h: Manufacturer Status Register

Object 1002h outputs the counter readings of the "Receive Error Counter" and "Transmit Error Counter" registers. The contents of these registers provide information on the transmit faults present at the mounting site of the encoder.

Sub-index	00h			
Description	Transmit Error Counter and Receive Error Counter			
Access	ro			
PDO mapping	no			
Data type	UNSIGNED 32			
Default	0h			
EEPROM	no			
Data content	Byte 0	Byte 1	Byte 2	Byte 3
	Receive Error Counter	Transmit Error Counter	01h	00h

4.8.2.4 1003h: Pre-defined Error Field

In object 1003h, the 8 latest error states are archived.

- The entry under sub-index 0 indicates the number of errors saved.
- The latest error status is always stored in sub-index 01h. Previous error messages "slip onwards" in their position by one sub-index.
- The whole error list is deleted by writing the value 0 in sub-index 00h.
- The entries in the error list have the format described in chapter [4.6.1](#).

Sub-index	00h
Description	number of the error messages stored
Access	rw
PDO mapping	no
Data type	UNSIGNED 8
Default	0h
EEPROM	yes

Sub-index	01h ... 08h
Description	error messages that occurred
Access	ro
PDO mapping	no
Data type	UNSIGNED 32
Default	0h
EEPROM	yes

4.8.2.5 1005h: COB ID SYNC message

The COB ID of the SYNC object is set via object 1005h.

Sub-index	00h	
Description	Defines the COB ID of the synchronization object (SYNC)	
Access	rw (writable in the "Pre-Operational" state only see chapter 4.2.1)	
PDO mapping	no	
Data type	UNSIGNED 32	
Default	80h	
EEPROM	yes	
Data content	Bit 31	not defined
	Bit 30	0: The device generates no SYNC message
	Bit 29	0: 11bits identifier (CAN 2.0A) 1: 29bits identifier (CAN 2.0B)
	Bit 28 ... 11	0: if bit 29 = 0 X: Bits 28 ... 11 of the SYNC-COB ID, if Bit 29 = 1
	Bit 10 ... 0	X: Bits 10 ... 0 of the SYNC-COB ID

4.8.2.6 1008h: Manufacturer Device Name

Object 1008h indicates the device name.

Sub-index	00h							
Description	Device name in ASCII notation							
Access	const							
PDO mapping	no							
Data type	Visible_String							
EEPROM	no							
Data content	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
	49h ("I")	4Bh ("K")	31h ("1")	52h ("R")	00h -	00h -	00h -	00h -

4.8.2.7 1009h: Manufacturer Hardware Version

Object 1009h indicates the hardware version.

Sub-index	00h							
Description	Hardware version in ASCII notation							
Access	const							
PDO mapping	no							
Data type	Visible_String							
Default	0h							
EEPROM	no							
Data content	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
	30h ("0")	00h -	00h -	00h -	00h -	00h -	00h -	00h -

4.8.2.8 100Ah: Manufacturer Software Version

Object 100Ah indicates the software version of the device. Because this contains 7 data bytes, the SDO Normal Transfer is required for reading.

Sub-index	00h							
Description	Software version in ASCII notation							
Access	const							
PDO mapping	no							
Data type	Visible_String							
Default	0h							
EEPROM	no							
Data content	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
	-	31h ("1")	2Eh (".")	30h ("0")	2Eh (".")	30h ("0")	37h ("7")	32h ("2")

4.8.2.9 100Ch: Guard Time

Object 100Ch indicates the cycle time set in the master for node guarding (see chapter 4.6.2). The cycle time is indicated in milliseconds Value "0h" means that Node Guarding is deactivated.

Sub-index	00h
Description	Guard Time
Access	rw
PDO mapping	no
Data type	UNSIGNED 16
Default	0h
EEPROM	yes

4.8.2.10 100Dh: Life Time Factor

Object 100Dh indicates the life time factor set in the master for node guarding (see chapter 4.6.2). Value "0h" means that Node Guarding is deactivated.

Sub-index	00h
Description	Life Time Factor
Access	rw
PDO mapping	no
Data type	UNSIGNED 8
Default	0h
EEPROM	yes

4.8.2.11 1010h: Store Parameter

Parameters are transferred into the EEPROM with this object in order to ensure that they are protected from loss of voltage. Different parameter groups are stored depending on the selection of the sub-index to be accessed. The string "Save" must be sent as data content.

Sub-index	00h
Description	indicates the largest supported sub-index
Access	const
PDO mapping	no
Data type	UNSIGNED 8
Default	4h
EEPROM	no

Sub-index	01h			
Description	save all parameters			
Access	rw			
PDO mapping	no			
Data type	UNSIGNED 32			
Default	1h			
EEPROM	no			
Data content	Write:			
	Byte 0	Byte 1	Byte 2	Byte 3
	73h ("s")	61h ("a")	76h ("v")	65h ("e")
	Read:			
	Bit 31 ... 2	0: reserved		
	Bit 1	0: Device does not independently store parameters		
Bit 0	1: Device stores parameters after command			

Sub-index	02h			
Description	save only communication parameters (1000h ... 1FFFh, CiA 301)			
Access	rw			
PDO mapping	no			
Data type	UNSIGNED 32			
Default	1h			
EEPROM	no			
Data content	Write:			
	Byte 0	Byte 1	Byte 2	Byte 3
	73h ("s")	61h ("a")	76h ("v")	65h ("e")
	Read:			
	Bit 31 ... 2	0: reserved		
	Bit 1	0: Device does not independently store parameters		
	Bit 0	1: Device stores parameters after command		

Sub-index	03h			
Description	save only application parameters (6000h ... 9FFFh, CiA 410)			
Access	rw			
PDO mapping	no			
Data type	UNSIGNED 32			
Default	1h			
EEPROM	no			
Data content	Write:			
	Byte 0	Byte 1	Byte 2	Byte 3
	73h ("s")	61h ("a")	76h ("v")	65h ("e")
	Read:			
	Bit 31 ... 2	0: reserved		
	Bit 1	0: Device does not independently store parameters		
	Bit 0	1: Device stores parameters after command		

Sub-index	04h			
Description	save only manufacturer-specific parameters (2000h ... 5FFFh)			
Access	rw			
PDO mapping	no			
Data type	UNSIGNED 32			
Default	1h			
EEPROM	no			
Data content	Write:			
	Byte 0	Byte 1	Byte 2	Byte 3
	73h ("s")	61h ("a")	76h ("v")	65h ("e")
	Read:			
	Bit 31 ... 2	0: reserved		
	Bit 1	0: Device does not independently store parameters		
Bit 0	1: Device stores parameters after command			

4.8.2.12 1011h: Restore Parameter

Object 1011h restores the factory settings of the device depending on the selection. The string "Load" must be sent as data content and the device reset thereafter. If the restored parameters are intended to be permanently available, they must be stored via object [1010h: Store Parameter](#).

Sub-index	00h		
Description	indicates the largest supported sub-index		
Access	const		
PDO mapping	no		
Data type	UNSIGNED 8		
Default	4h		
EEPROM	no		

Sub-index	01h			
Description	reset all parameters to factory settings			
Access	rw			
PDO mapping	no			
Data type	UNSIGNED 32			
Default	1h			
EEPROM	no			
Data content	Write:			
	Byte 0	Byte 1	Byte 2	Byte 3
	6Ch ("l")	6Fh ("o")	61h ("a")	64h ("d")
	Read:			
	Bit 31 ... 1	0: reserved		
	Bit 0	1: Device permits loading of default parameters.		

Sub-index	02h			
Description	set only communication parameters to factory settings (1000h ... 1FFFh, CiA 301) (1000h ... 1FFFh, CiA 301)			
Access	rw			
PDO mapping	no			
Data type	UNSIGNED 32			
Default	1h			
EEPROM	no			
Data content	Write:			
	Byte 0	Byte 1	Byte 2	Byte 3
	6Ch ("l")	6Fh ("o")	61h ("a")	64h ("d")
	Read:			
	Bit 31 ... 1	0: reserved		
	Bit 0	1: Device permits loading of default parameters.		

Sub-index	03h			
Description	set only application parameters to factory settings (6000h ... 9FFFh, CiA 410)			
Access	rw			
PDO mapping	no			
Data type	UNSIGNED 32			
Default	1h			
EEPROM	no			
Data content	Write:			
	Byte 0	Byte 1	Byte 2	Byte 3
	6Ch ("l")	6Fh ("o")	61h ("a")	64h ("d")
	Read:			
	Bit 31 ... 1	0: reserved		
	Bit 0	1: Device permits loading of default parameters.		

Sub-index	04h			
Description	set only manufacturer-specific parameters to factory settings (2000h ... 5FFFh)			
Access	rw			
PDO mapping	no			
Data type	UNSIGNED 32			
Default	1h			
EEPROM	no			
Data content	Write:			
	Byte 0	Byte 1	Byte 2	Byte 3
	6Ch ("l")	6Fh ("o")	61h ("a")	64h ("d")
	Read:			
	Bit 31 ... 1	0: reserved		
Bit 0	1: Device permits loading of default parameters.			

4.8.2.13 1014h: COB ID Emergency message

The COB ID of the Emergency object is set via object 1014h (see chapter 4.6.1)

Sub-index	00h	
Description	Defines the COB ID of the Emergency object (EMCY)	
Access	rw (writable in the "Pre-Operational" state only see chapter 4.2.1)	
PDO mapping	no	
Data type	UNSIGNED 32	
Default	80h + Node ID	
EEPROM	yes	
Data content	Bit 31	0: EMCY object exists / is valid 1: EMCY object does not exists / is invalid
	Bit 30	always 0b
	Bit 29	0: 11bits identifier (CAN 2.0A) 1: 29bits identifier (CAN 2.0B)
	Bit 28 ... 11	0: if bit 29 = 0b X: Bits 28 ... 11 of the EMCY-COB ID, if Bit 29 = 1b
	Bit 10 ... 0	X: Bits 10 ... 0 of the EMCY-COB ID

4.8.2.14 1017h: Producer Heartbeat Time

The cycle time "Heartbeat Time" for the heartbeat protocol is set via object 1017h. The cycle time is indicated in milliseconds.

Sub-index	00h
Description	defines the cycle time of the heartbeat monitoring service
Access	rw
PDO mapping	no
Data type	UNSIGNED 16
Default	0h
EEPROM	yes
Data content	0d, 10d ... 65535d (0h, Ah ... FFFFh); the numerical value corresponds to a multiple of 1 ms. Value 0h disables the service.

4.8.2.15 1018h: Identity Object

The manufacturer identification number (Vendor ID) is indicated by object 1018h.

Sub-index	00h
Description	indicates the largest supported sub-index
Access	const
PDO mapping	no
Data type	UNSIGNED 8
Default	4h
EEPROM	no

Sub-index	01h
Description	the manufacturer identification number (vendor ID) for the company SIKO GmbH allocated by the CiA
Access	ro
PDO mapping	no
Data type	UNSIGNED 32
Default	00000195h
EEPROM	no

Sub-index	02h
Description	Product Code
Access	ro
PDO mapping	no
Data type	UNSIGNED 32
Default	02010002h
EEPROM	no

Sub-index	03h
Description	Revision number (function is not supported, only compatibility entry for various configurators)
Access	ro
PDO mapping	no
Data type	UNSIGNED 32
Default	FFFFFFFFh
EEPROM	no

Sub-index	04h
Description	Serial number
Access	ro
PDO mapping	no
Data type	UNSIGNED 32
Default	1h
EEPROM	yes

4.8.2.16 1200h: Server SDO Parameter

The COB IDs for the server SDOs are indicated via object 1200h. The COB IDs cannot be changed.

Sub-index	00h
Description	indicates the largest supported sub-index
Access	const
PDO mapping	no
Data type	UNSIGNED 8
Default	2h
EEPROM	no

Sub-index	01h
Description	COB ID Client -> Server (rx)
Access	ro
PDO mapping	no
Data type	UNSIGNED 32
Default	00000600h + Node ID
EEPROM	no

Sub-index	02h
Description	COB ID Server -> Client (tx)
Access	ro
PDO mapping	no
Data type	UNSIGNED 32
Default	00000580h + Node ID
EEPROM	no

4.8.2.17 1301h: SRD01 Communication Parameters

The communication behavior of SRD01 can be determined via object 1301h.

Sub-index	00h
Description	indicates the largest supported sub-index
Access	ro
PDO mapping	no
Data type	UNSIGNED 8
Default	6h
EEPROM	no

Sub-index	01h
Description	Direction of information
Access	ro, if NMT state is operational rw, if NMT state is pre-operational
PDO mapping	no
Data type	UNSIGNED 8
Default	1h
EEPROM	yes
Data content	0: SRD01 is not valid 1: SRD01 is TX and valid

Sub-index	02h
Description	refresh time
Access	ro, if NMT state is operational rw, if NMT state is pre-operational
PDO mapping	no
Data type	UNSIGNED 16
Default	25d (0019h)
EEPROM	yes
Data content	10d ... 65535d (000Ah ... FFFFh)

Sub-index	03h
Description	tx: reserved rx: SRVT
Access	ro, if NMT state is operational rw, if NMT state is pre-operational
PDO mapping	no
Data type	UNSIGNED 8
Default	20d (14h)
EEPROM	yes
Data content	0d ... 65535d (0000h ... FFFFh)

Sub-index	04h
Description	transmission type
Access	ro
PDO mapping	no
Data type	UNSIGNED 8
Default	254d (FEh)
EEPROM	no

Sub-index	05h
Description	COB ID1
Access	ro, if NMT state is operational rw, if NMT state is pre-operational
PDO mapping	no
Data type	UNSIGNED 32
Default	00000FFh + 2*Node ID
EEPROM	yes
Data content	257d (101h) ... 383d (17Fh) (odd numerical values only)

Sub-index	06h
Description	COB ID2
Access	ro, if NMT state is operational rw, if NMT state is pre-operational
PDO mapping	no
Data type	UNSIGNED 32
Default	00000100h + 2*Node ID
EEPROM	yes
Data content	258d (102h) ... 384d (180h) (even numerical values only)

4.8.2.18 1381h: SRD01 Mapping Parameter

Object 1381h determines the objects that are mapped in the first Transmit SRDO (SRD01).

Sub-index	00h
Description	indicates the largest supported sub-index
Access	ro
PDO mapping	no
Data type	UNSIGNED 8
Default	4h
EEPROM	no

Sub-index	01h
Description	1 st object of the SRD01 message with the COB ID1 (data byte 0)
Access	ro
PDO mapping	no
Data type	UNSIGNED 32
Default	62100108h (Safety Slope long16 object 6210h, sub-index 01h, 8bit)
EEPROM	no

Sub-index	02h
Description	1 st object of the SRD01 message with the COB ID2 (data byte 0)
Access	ro
PDO mapping	no
Data type	UNSIGNED 32
Default	62110108h (inverted Safety Slope long16 object 6211h, sub-index 01h, 8bit)
EEPROM	no

Sub-index	03h
Description	2 nd object of the SRD01 message with the COB ID1 (data byte 1)
Access	ro
PDO mapping	no
Data type	UNSIGNED 32
Default	62100208h (Safety Slope long16 object 6210h, sub-index 02h, 8bit)
EEPROM	no

Sub-index	04h
Description	2 nd object of the SRD01 message with the COB ID2 (data byte 1)
Access	ro
PDO mapping	no
Data type	UNSIGNED 32
Default	62110208h (inverted Safety Slope long16 object 6211h, sub-index 02h, 8bit)
EEPROM	no

4.8.2.19 13FEh: Safety Configuration

The SRDO configuration can be switched to valid by means of object 13FEh.

Sub-index	00h
Description	This parameter will be switched to invalid automatically after changing a parameter in object 1301h and must be switched valid again via this object. Switching to valid is only enabled if the correct signatures are entered in object 13FFh.
Access	rw
PDO mapping	no
Data type	UNSIGNED 8
Default	0h
EEPROM	yes
Data content	A5h: SRD01 configuration valid 00h ... A4h and A6h ... FFh: SRD01 configuration invalid

4.8.2.20 13FFh: Safety Configuration Signature (checksum)

This object 13FFh contains the signatures (checksums) via the CANopen Safety parameters of the SRD01 configuration. Only a checksum which is valid at that time can be transmitted. The checksum is checked anew before switching the configuration to valid. Any change to the configuration will be valid only after passing.

Sub-index	00h
Description	indicates the largest supported sub-index
Access	ro
PDO mapping	no
Data type	UNSIGNED 8
Default	1h
EEPROM	no

Sub-index	01h				
Description	SRD01 signature (checksum)				
Access	rw				
PDO mapping	no				
Data type	UNSIGNED 16				
Default	0000h				
EEPROM	yes				
Data content	The checksum CRC-16-CCITT is calculated via the content of the two objects 1301h and 1381h.				
	Object	Sub-index	Name	Extent	Value
	1301h	SRD01 communication parameter			
		01h	Direction of information	1 byte	Object1301h sub-index01h
		02h	Refresh time	2 byte	Object1301h sub-index02h
		03h	tx: reserved rx: SRVT	1 byte	Object1301h sub-index03h
		05h	COB ID 1	4 byte	Object1301h sub-index05h
		06h	COB ID 2	4 byte	Object1301h sub-index06h
	1381h	SRD01 mapping parameter			
		00h	Highest sub-index	1 byte	04h
		01h	Sub-index	1 byte	01h
		01h	Safety Slope long16 1 st byte	4 byte	62100108h
		02h	Sub-index	1 byte	02h
		02h	Inverted Safety Slope long16 1 st byte	4 byte	62110108h
		03h	Sub-index	1 byte	03h
		03h	Safety Slope long16 2 nd byte	4 byte	62100208h
		04h	Sub-index	1 byte	04h
	04h	Inverted Safety Slope long16 2 nd byte	4 byte	62110208h	

4.8.2.21 1800h: 1st Transmit PDO Parameter

The communication parameters for TPD01 are set via object 1800h.

Sub-index	00h
Description	indicates the largest supported sub-index
Access	const
PDO mapping	no
Data type	UNSIGNED 8
Default	2h
EEPROM	no

Sub-index	01h
Description	COB ID of PDO1
Access	rw (writable in the "Pre-Operational" state only see chapter 4.2.1)
PDO mapping	no
Data type	UNSIGNED 32
Default	180h + Node ID
EEPROM	yes

Sub-index	02h	
Description	Transmission Type	
Access	rw	
PDO mapping	no	
Data type	UNSIGNED 8	
Default	01h	
EEPROM	yes	
Data content	1h (1d) ... F0h (240d)	PDO is sent after received 1d ... 240d SYNC messages.
	FCh (252d) FDh (253d)	Device responds only to RTR request if RTR Bit 30 is enabled in the COB ID.
	FEh (254d) FFh (255d)	PDO has asynchronous characteristics (PDO is sent depending on the "Event Timer").

Sub-index	03h (is not used, access attempt generates error message)
-----------	---

Sub-index	04h (is not used, access attempt generates error message)
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Sub-index	05h
Description	Event timer for TPDO1
Access	rw
PDO mapping	no
Data type	UNSIGNED 16
Default	0h
EEPROM	yes
Data content	The service is disabled by writing the value 0h. If the value is changed with the timer running, the change will be applied only with the next timer operation.

4.8.2.22 1A00h: 1st Transmit PDO Mapping Parameter

Object 1A00h determines the objects that are mapped on the first Transmit PDO (TPDO1).

Sub-index	00h
Description	indicates the largest supported sub-index
Access	const
PDO mapping	no
Data type	UNSIGNED 8
Default	1h
EEPROM	no

Sub-index	01h
Description	1 st Object of the PDO1 message (Data byte 0 and 1)
Access	ro
PDO mapping	no
Data type	UNSIGNED 32
Default	60100010h (Slope long16 object 6010h, sub-index 00h, 16bit)
EEPROM	yes

4.8.2.23 2000h: Digital filter cut-off frequency

The filter time can be set in object 2000h.

Sub-index	00h
Description	Defines the set filter time.
Access	rw
PDO mapping	no
Data type	UNSIGNED 16
Default	14h (20d)
EEPROM	yes
Data content	1d = 0.1 Hz. Default value: 20 Hz. Possible values: 1d ... 20d (1d ... 14h) in steps of one (= 0.1 ... 1.0 Hz in 0.1 Hz steps); 10d ... 200d (14h ... C8h) in steps of ten (= 1.0 ... 20.0 Hz in 1 Hz steps)

4.8.2.24 5F0Ah: Node ID and baud rate Bus CAN

Node ID and baud rate of the bus can be set via Object 5F0Ah.

Sub-index	00h
Description	indicates the largest supported sub-index
Access	const
PDO mapping	no
Data type	UNSIGNED 8
Default	2h
EEPROM	no

Sub-index	01h
Description	Node ID
Access	rw
PDO mapping	no
Data type	UNSIGNED 8
Default	3h (redundant inclinometer 4h)
EEPROM	yes
Data content	01h ... 7Fh

Sub-index	02h
Description	Baud rate of the CAN bus
Access	rw
PDO mapping	no
Data type	UNSIGNED 8
Default	5h (500 kbit/s)
EEPROM	yes
Data content	1h: 20 kbit/s 2h: 50 kbit/s 3h: 125 kbit/s 4h: 250 kbit/s 5h: 500 kbit/s (Default) 6h: 800 kbit/s 7h: 1000 kbit/s

4.8.2.25 6000h: Resolution

The resolution of the Slope long16 value can be set in object 6000h.

Sub-index	00h	
Description	Resolution	
Access	rw	
PDO mapping	no	
Data type	UNSIGNED 16	
Default	64h	
EEPROM	yes	
Data content	1d (1h)	Resolution 0.001°
	10d (Ah)	Resolution 0.01° (Default for measuring range ±180°)
	100d (64h)	Resolution 0.1° (Default for measuring range 360°)
	1000d (3E8h)	Resolution 1.0°

Scaling of dependent objects with the formula $\text{Object} * [\text{Object } 6000\text{h}] / 1000$.

4.8.2.26 6010h: Slope long16

Object 6010h indicates the current Slope long16 value (longitudinal slope).

Sub-index	00h
Description	Slope long16 value (longitudinal slope).
Access	ro
PDO mapping	no
Data type	INTEGER 16
Default	0h
EEPROM	yes

4.8.2.27 6011h: Slope long16 operating parameter

Operating parameters can be set via object 6011h. If scaling of object 6010h is active, the following formula applies:

$$\text{Slope long16} = \text{slope physical measured} + \text{differential slope long16 preset} + \text{slope long16 offset}$$

If scaling is not active, the Slope long16 value corresponds to the physically measured slope.

Sub-index	00h	
Description	Operating parameter	
Access	rw	
PDO mapping	no	
Data type	UNSIGNED 8	
Default	0h	
EEPROM	yes	
Data content	Bit 6 ... 7	not used
	Bit 5	0 = Measuring range 0 ... 360° (Resolution 0.1°) 1 = Measuring range ±180° (Resolution 0.1°) If the measuring range is changed, the new resolution is set provided that the default value was not changed beforehand.
	Bit 2 ... 4	not used
	Bit 1	0 = Scaling of object 6010h inactive 1 = Scaling of object 6010h active
	Bit 0	0 = Inverting of object 6010h inactive 1 = Inverting of object 6010h active

4.8.2.28 6012h: Slope long16 Preset value (calibration value)

The preset value for the longitudinal slope (Slope long16 preset value) can be set by object 6012h. The Slope long16 value is immediately set to the transferred value. The slope long16 preset value must be specified in ° with the preset resolution of object 6000h. The calculated application offset of the longitudinal slope value (Slope long16 offset) is specified in object 6013h and is dependent on object 6014h.

Sub-index	00h
Description	Calibration value for longitudinal slope.
Access	rw
PDO mapping	no
Data type	INTEGER 16
Default	0h
EEPROM	yes
Data content	0h ... FFFFh

4.8.2.29 6013h: Slope long16 Offset

The application offset of the longitudinal axis is specified in object 6013h. The value must be specified in ° with the resolution set for object 6000h.

Slope long16 offset = slope long16 –slope physical measured – differential slope long16 preset

Sub-index	00h
Description	Application offset of the slope (Slope long16 offset).
Access	rw
PDO mapping	no
Data type	INTEGER 16
Default	0h
EEPROM	yes
Data content	0h ... FFFFh

4.8.2.30 6014h: Differential Slope long16 Offset

Object 6014h indicates the offset of the Slope long16 value (object 6010h) as a function of the Slope long16 preset value (object 6012h) and the Slope long16 offset (object 6013h). The value must be specified in ° with the resolution set for object 6000h.

Sub-index	00h
Description	Specifies the offset of the Slope long16 value.
Access	rw
PDO mapping	no
Data type	INTEGER 16
Default	0h
EEPROM	yes
Data content	0h ... FFFFh

4.8.2.31 6200h: Safety configuration parameters

The Safety preset value for the Safety longitudinal slope (Safety Slope long16 preset value) can be set in object 6012h. The Safety Slope long16 preset value must be specified in ° with the preset resolution of object 6000h.

Sub-index	00h
Description	indicates the largest supported sub-index
Access	const
PDO mapping	no
Data type	UNSIGNED 8
Default	1h
EEPROM	no

Sub-index	01h
Description	Safety calibration value for longitudinal slope (Safety Slope long16 preset value).
Access	ro when NMT state is operational rw when NMT state is pre-operational
PDO mapping	no
Data type	INTEGER 16
Default	0h
EEPROM	yes
Data content	0h ... FFFFh

4.8.2.32 6210h: Safety Slope long16 (Safety longitudinal slope value)

The Safety Slope long16 (Safety longitudinal slope value) can be read byte by byte via object 6210h.

Sub-index	00h
Description	indicates the largest supported sub-index
Access	const
PDO mapping	no
Data type	UNSIGNED 8
Default	2h
EEPROM	no

Sub-index	01h
Description	Safety slope long16 1 st byte
Access	ro
PDO mapping	no
Data type	INTEGER 8
Default	0h
EEPROM	no

Sub-index	02h
Description	Safety slope long16 2 nd byte
Access	ro
PDO mapping	no
Data type	INTEGER 8
Default	0h
EEPROM	no

4.8.2.33 6211h: Safety inverted Slope long16 (Safety inverted longitudinal slope value)

The Safety inverted Slope long16 (Safety inverted longitudinal slope value) can be read byte by byte via object 6211h.

Sub-index	00h
Description	indicates the largest supported sub-index
Access	const
PDO mapping	no
Data type	UNSIGNED 8
Default	2h
EEPROM	no

Sub-index	01h
Description	Safety inverted slope long16 1 st Byte
Access	ro
PDO mapping	no
Data type	INTEGER 8
Default	0h
EEPROM	no

Sub-index	02h
Description	Safety inverted slope long16 2 nd Byte
Access	ro
PDO mapping	no
Data type	INTEGER 8
Default	0h
EEPROM	no

4.8.2.34 63FEh: Safety application configuration

The Safety Slope long16 can be switched to valid via object 61FEh.

Sub-index	00h
Description	This parameter is automatically invalidated after a parameter in object 6200h has been changed and must be set to valid again via this object. Switching to valid is only possible if the correct signatures are entered in object 13FFh.
Access	rw
PDO mapping	no
Data type	UNSIGNED 8
Default	0h
EEPROM	yes
Data content	A5h: Configuration for Safety Slope long16 valid 00h ... A4h and A6h ... FFh: Configuration for Safety Slope long16 not valid

4.8.2.35 63FFh: Safety application configuration signature (checksum)

This object 63FFh contains the signatures (checksums) via the CANopen Safety parameters of the configuration for Safety Slope long16. Only a checksum valid at the time can be transferred. Before the configuration is set to valid, the checksum is checked again. Only then does a change in the configuration become valid.

Sub-index	00h
Description	indicates the largest supported sub-index
Access	ro
PDO mapping	no
Data type	UNSIGNED 8
Default	1h
EEPROM	no

Sub-index	01h				
Description	Signature safety slope long16 (checksum)				
Access	rw				
PDO mapping	no				
Data type	UNSIGNED 16				
Default	0000h				
EEPROM	yes				
Data content	The checksum CRC-16-CCITT is calculated via the content of object 6200h.				
	Object	Sub-index	Name	Extent	Value
	6200h	00h	Highest sub-index	1 byte	01h
		01h	Sub-index	1 byte	01h
	01h	Safety Slope long16 Preset value (Safety calibration value)	2 byte	Object 6200h sub-index 01h	

4.8.2.36 6511h: Device temperature

The current device temperature can be read in object 6511h.

Sub-index	00h				
Description	Device temperature in 1° increments.				
Access	ro				
PDO mapping	no				
Data type	INTEGER 16				
Default	0h				
EEPROM	no				



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