Baumer

Passion for Sensors

Manual

Dynamic inclination sensors GIM700DR with CANopen® interface

Firmware version 1.14.2 and higher

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Created by:
Baumer IVO GmbH & Co. KG

1 Introduction

1.1 Scope of delivery

Please check the delivery upon completeness prior to commissioning.
Depending on sensor configuration and part number, delivery is including:

- Sensor
- Mounting instruction

Further information is available as download via www.baumer.com

- Manual (sensor interface description)
- EDS file (electronic data sheet)

1.2 Product assignment

Product / Device name	**Product code**	**Measuring direction**	**Variant**	**EDS file**
GIM700DR	60h	1-dimensional (1D, vertical installation)	1D-VP	GIM700DR_1-dim_PDO_SPEC_V1_00.eds
GIM700DR	61h	2-dimensional (2D, horizontal installation)	2D-HP	GIM700DR_2-dim_PDO_SPEC_V1_00.eds
GIM700DR	61h	2-dimensional (2D, vertical installation)	2D-VP	GIM700DR_2-dim_PDO_SPEC_V1_00.eds

2 Safety and operating instructions

Intended use

- The inclination sensor is a precision measuring device to determine angular positions and to supply the downstream device with measured values in the form of electronic output signals. The inclination sensor must not be used for any other purpose.
- Make sure the appropriate safety measures are present to prevent damage to persons, the system or operating facilities in case of sensor error or failure.

Personnel qualification

- The inclination sensor must only be installed by a qualified electronics and precision mechanics.
- Observe the user manual of the machine manufacturer.

Maintenance

- The inclination sensor is maintenance-free and must not be opened or modified in its electronics or mechanical design. Opening the sensor can lead to personal injury.

Disposal

- The inclination sensor contains electronic components. At its disposal, local environmental guidelines must be followed.

Installation

- Avoid mechanical impacts or shocks on the housing.

Electrical commissioning

- Do not perform any electrical modifications at the inclination sensor.
- Do not carry out any wiring work when the inclination sensor is live.
- Do not dock or undock the electrical connection while the inclination sensor is live.
- Ensure that the entire equipment is installed in line with EMC requirements. Ambient conditions and wiring affect the electromagnetic compatibility of the inclination sensor. Install sensor and supply cables separately or far away from lines with high interference emissions (frequency converters, contactors, etc.).
- Provide separate power supply for the inclination sensor where working with consumers that have high interference emissions.
- Completely shield the inclination sensor housing and connecting cables.
- Connect the sensor to protective earth (PE) using shielded cables. The braided shield must be connected to the cable gland or connector. Ideally, aim at a bilateral connection to protective earth (PE), the housing via the mechanical assembly and the cable shield via the downstream devices. In case of earth loop problems, earth on one side only as a minimum requirement.

Supplementary information

- This manual is intended as a supplement to already existing documentation (i.e. catalogue, product information and mounting instruction).

3 CAN-bus and CANopen communication

CAN bus (CAN: Controller Area Network) was developed by Bosch and Intel for high-speed, economic data transmission in automotive applications. Today, CAN bus is commercialized for use in industrial automation. CAN bus is a fieldbus system (standards administered by CAN in Automation, CiA) for communication between appliances, actors and sensors of different brands.

3.1 CAN-bus characteristics

• Data rate of 1 Mbit/s with network expansion up to 40 m
• Network connected on both sides
• The bus medium is a twisted-pair cable
• Real time capability: Defined maximum waiting time for high-priority messages.
• Theoretically 127 users at one bus (depending on the driver).
• Ensures data consistency across the network. Damaged messages are notified as faulty for all network nodes.
• Message-oriented communication
The message is identified by a message identifier. All network nodes use the identifier to test whether the message is of relevance for them.
• Broadcasting, multicasting
All network nodes receive each message simultaneously. Synchronization is therefore possible.
• Multi-Consumer capability
Each user in the field bus is able to independently transmit and receive data without being dependent upon the priority of the Consumer. Each user is able to start its message when the bus is not occupied. When messages are sent simultaneously, the user with the highest priority prevails.
• Prioritization of messages
The identifier defines the priority of the message. This ensures that important messages are transmitted quickly via the bus.
• Residual error probability
Safety procedures in the network reduce the probability of an undiscovered faulty data transmission to below 10^{-11}. In practical terms, it is possible to ensure a 100% reliable transmission.
• Function monitoring
Localization of faulty / failed stations: The CAN protocol encompasses a network node monitoring function. The function of network nodes which are faulty is restricted, or they are completely uncoupled from the network.
• Data transmission with short error recovery time
By using several error detection mechanisms, falsified messages are detected to a high degree of probability. If an error is detected, the message transmission is automatically repeated.

In the CAN Bus, several network users are connected by means of a bus cable. Each network user is able to transmit and receive messages. The data between network users is serially transmitted.

Examples of network users for CAN bus devices are:
• Automation devices such as PLCs
• PCs
• Input and output modules
• Drive control systems
• Analysis devices, such as a CAN monitor
• Control and input devices as Human Machine Interfaces (HMI)
• Sensors and actuators

3.2 CANopen

Under the technical management of the Steinbeis Transfer Centre for Automation, the CANopen profile was developed on the basis of the Layer 7 specification CAL (CAN Application Layer). In comparison with CAL, CANopen only contains the functions suitable for this application. CANopen thus represents only a partial function of CAL optimized for the application in hand, so permitting a simplified system structure and the use of simplified devices. CANopen is optimized for fast data exchange in real time systems.
The organization CAN in Automation (CiA) is responsible for the applicable standards of the relevant profiles.
CANopen permits:

- Simplified access to all device and communication parameters
- Synchronization of several devices
- Automatic configuration of the network
- Cyclical and event-controlled process data communication

CANopen comprises four communication objects (COB) with different characteristics:

- Process data objects for real time data (PDO)
- Service data objects for parameter and program transmission (SDO)
- Network management (NMT, Heartbeat)
- Pre-defined objects (for synchronization, emergency message)

All device and communication parameters are subdivided into an object directory. An object directory encompasses the name of the object, data type, number of sub-indexes, structure of the parameters and the address. According to CiA, this object directory is subdivided into three different parts. Communication profile, device profile and a manufacturer-specific profile (see object directory).

3.3 CANopen communication

3.3.1 Communication profile

Communication between the network users and the Consumer (PC / Control) takes place by means of object directories and objects. The objects are addressed via a 16-bit index. The CANopen communication profile DS 301 standardizes the various communication objects. They are accordingly divided into several groups:

- Process data objects PDO for real time transmission of process data
- Service data objects SDO for read/write access to the object directory
- Objects for synchronization and error display of CAN users:
  - SYNC object (synchronization object) for synchronization of network user
  - EMCY object (emergency object) for error display of a device or its peripherals
- Network management NMT for initialization and network control
- Layer Setting Services LSS for configuration by means of serial numbers, revision numbers etc. in the middle of an existing network

3.3.2 CANopen message structure

The first part of a message is the COB-ID (identifier).
Structure of the 11-bit COB-ID:

Function code				Node-ID						
4-bit function code				7-bit Node-ID						

The function code provides information on the type of message and priority
The lower the COB-ID, the higher the priority of the message

Broadcast messages:

Function code	COB-ID
NMT	0h
SYNC	80h

Peer-to-peer messages:

Function code	COB-ID
Emergency	80h + Node-ID
PDO1 (tx)[1)]	180h + Node-ID
PDO2 (tx)[1)]	280h + Node-ID
SDO (tx)[1)]	580h + Node-ID
SDO (rx)[1)]	600h + Node-ID
Heartbeat	700h + Node-ID
LSS (tx) [1)]	7E4h
LSS (rx) [1)]	7E5h

1): (tx) and (rx) from the viewpoint of the sensor

The Node-ID can be freely selected by means of the CANopen bus between 1 and 127.
The sensors are supplied with the Node-ID 1 and baud rate 50 kbits/s.
This can be changed with the service data object 2101h or object 2100h or using LSS.

A CAN telegram is made up of the COB-ID and up to 8 bytes of data:

COB-ID	DLC	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
xxx	x	xx	xx	xx	xx	xx	xx	xx	xx

The precise telegram is outlined in more detail at a later point.

3.3.3 CANopen service data communication (SDO)

The service data objects correspond to the standards of the CiA. It is possible to access an object via index and sub-index. The data can be requested or where applicable written into the object.

General information on the SDO

Structure of an **SDO telegram**:

COB-ID	DLC	Command	Object LSB	Object MSB	Sub-index	Data 0	Data 1	Data 2	Data 3

An SDO-**COB-ID** is composed as follows:
Consumer -> Sensor : 600h + Node-ID
Sensor -> Consumer : 580h + Node-ID

DLC (data length code) describes the length of the telegram. This is composed as follows:
1 byte command + 2 bytes object + 1 byte sub-index + no. of data bytes (0…4).

The **command byte** defines whether data is read or set, and how many data bytes are involved.

SDO command	Description	Data length	
22h	Download request	Max. 4 Byte	Transmits parameter to sensor
23h	Download request	4 byte	
2Bh	Download request	2 byte	
2Fh	Download request	1 byte	
60h	Download response	-	Confirms receipt to Consumer
40h	Upload request	-	Requests parameter from sensor
42h	Upload response	Max. 4 byte	Parameter to Consumer with max. 4 byte
43h	Upload response	4 byte	
4Bh	Upload response	2 byte	
4Fh	Upload response	1 byte	
80h	Abort message	-	Sensor transmits Error Code to Consumer

An **abort message** indicates an error in the CAN communication. The SDO command byte is 80h. The object and sub-index are those of the requested object. The error code is contained in bytes 5…8.

Identifier	DLC	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
580h + Node-ID	8	80h	Object LSB	Object MSB	Sub-index	ErrByte 0	ErrByte 1	ErrByte 2	ErrByte 3

Byte 7...4 results in the SDO abort message (byte 7 = MSB).
The following messages are supported:

05040001h : Command byte is not supported
06010000h : Incorrect access to an object
06010001h : Read access to write only

06010002h : Write access to read only
06020000h : Object is not supported
06090011h : Sub-index is not supported
06090030h : Value outside the limit
06090031h : Value too great
08000000h : General error
08000020h : Incorrect save signature
08000021h : Data cannot be stored

SDO examples

Request of the resolution value by the Consumer from the Producer
A frequent request will be a request for the resolution. → Object 6000h

COB-ID	DLC	Command	Object LSB	Object MSB	Sub-index	Data 0	Data 1	Data 2	Data 3
600h+Node-ID	8	40h	00h	60h	0	x	x	x	x

Response by the Producer **to the request** for a value
The resolution is 2 bytes long, the precise values can be found under object 6000h.

COB-ID	DLC	Command	Object LSB	Object MSB	Sub-index	Data 0	Data 1	Data 2	Data 3
580h+Node-ID	8	4Bh	00h	60h	0	a	b	c	d

Writing of a value by the Consumer into the Producer
Inclination setting can be performed with preset for longitudinal slope. → Object 6012h

COB-ID	DLC	Command	Object LSB	Object MSB	Sub-index	Data 0	Data 1	Data 2	Data 3
600h+Node-ID	8	2Bh	12h	60h	0	a	b	c	d

Producer's **response** to the **writing of a value**

COB-ID	DLC	Command	Object LSB	Object MSB	Sub-index	Data 0	Data 1	Data 2	Data 3
580h+Node-ID	8	60h	12h	60h	0	0	0	0	0

3.3.4 Process data communication

Process data objects are used for real time data exchange for process data, for example inclination or operating status. PDOs can be transmitted synchronously or cyclically (asynchronously).

Synchronous communication

In order to transmit the process data synchronously, a value between 1 and F0h (=240) must be written into the object 180xh sub-index 2. If the value is 3, the PDO is transmitted on every third sync telegram (if the value 1 is entered, transmission takes place on every sync telegram).

In synchronous operation, the PDO is requested by the Consumer via the Sync telegram.

Identifier	Byte 1
COB-ID = 80h	0

Cyclical (asynchronous) communication

If you wish the PDOs to be transmitted cyclically, the value FEh must be written into the object 180xh sub-index 2. In addition, the cycle time in milliseconds must be entered in the same object sub-index 5. The entered time is rounded off to 1 msec. If the value is stored for 0 msec, the PDOs are not transmitted. The function is switched off.

PDO transmission modes / PDO mapping

In the following table, the different transmission modes for PDOs are summarized:

180xh		Summarized description
Sub2	Sub5	
FEh/FFh	10 msec	Cyclical transmission every 10 msec
FEh/FFh	0 msec	Transmit PDO switched off
3	xxx	Transmit with every third sync telegram

Structure of PDO-mapping is based on dynamic PDO mapping. Default PDO configuration is shown below:

Variant	ID	DLC	Byte 0+1	Byte 2+3	Byte 4+5	Byte 6+7
1D vertical installation (1D-VP)	180h+Node-ID	4	Object 6511h / Device temperature LSB MSB	Object 6010h / Z-axis LSB MSB	-	-

Variant	ID	DLC	Byte 0+1	Byte 2+3	Byte 4+5	Byte 6+7
2D horizontal installation (2D-HP)	180h+Node-ID	6	Object 6511h / Device temperature LSB MSB	Object 6010h / X-axis LSB MSB	Object 6020h Y-axis LSB MSB	-
2D vertical installation (2D-VP)	180h+Node-ID	6	Object 6511h / Device temperature LSB MSB	Object 6010h / Z-axis LSB MSB	Object 6020h Y-axis LSB MSB	-

3.3.5 Error diagnostics / emergency service

The GIM700DR sensor offers diagnostic functions as described in the following. If device operation causes a warning (e.g. angle limit) or an error (e.g. MEMS saturation), an emergency message is transmitted once, which contains **Error Code**, **Error Register**, **Error Module ID** and **Error ID**. The EMCY message is structured as follows:

COB-ID	DLC	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
80h+Node-ID	8	Error Code LSB MSB		Error Register	Error Module ID MSB LSB		Error ID MSB LSB		reserved

Byte 0+1: Error code

Error Code (hex)	Description
0000	Error reset or no error
1000	Generic error
3200	Supply voltage error
6000	Internal software or sensor error

Byte 2 Error register

Represents the content of object 1001h Error Register

Bit	Description
0	Generic error
2	Supply voltage error

Byte 3+4: Error module ID / Byte 5+6: Error ID

Error Module ID	Error ID	Description
17h	1012h	Angle limit warning. Please check, if angle measurement value in sensor application is near or above specified limit
15h	100Dh 100Fh 1010h	Sensor fusion error. Please check, if acceleration and/or gyroscope rotation rate in sensor application is near or above specified limit
18h	1001h 1004h	Overvoltage voltage error. Please check, if supply voltage in sensor application is near or above specified limit
18h	1005h 1008h	Under voltage error. Please check, if supply voltage in sensor application is near or below specified limit
1Dh	100Eh 1011h	MEMS saturation error. Please check, if acceleration and/or gyroscope rotation rate in sensor application is near or above specified limit

The warning and/or error with a specific Error ID should be considered as active, until the sensor is sending Error Code 0000h for the corresponding Error ID.

Example for EMCY messages

COB-ID [hex]	Error Code LSB [hex]	Error Code MSB [hex]	Error Register [hex]	Error Module ID MSB [hex]	Error Module ID LSB [hex]	Error ID MSB [hex]	Error ID LSB [hex]	Re-served [hex]	Description
80 +Node-ID	00	10	01	00	17	10	12	00	Angle limit warning / generic error set
80 +Node-ID	00	00	00	00	17	00	00	00	Angle limit warning / generic error reset
80 +Node-ID	00	10	01	00	1D	10	11	00	MEMS saturation er-ror set
80 +Node-ID	00	00	00	00	1D	00	00	00	MEMS saturation er-ror reset

3.3.6 Network management services

Network management can be divided into two groups.
Using the NMT services for **device monitoring**, bus users can be initialized, started and stopped.
In addition, NMT services exist for **connection monitoring**.

Description of the NMT command

The commands are transmitted as unconfirmed objects and are structured as follows:

Identifier	Byte 0	Byte 1
COB-ID = 0	Command byte	Node-ID

The **COB-ID** for NMT commands is always zero. The Node-ID is transmitted in byte 1 of the NMT command.

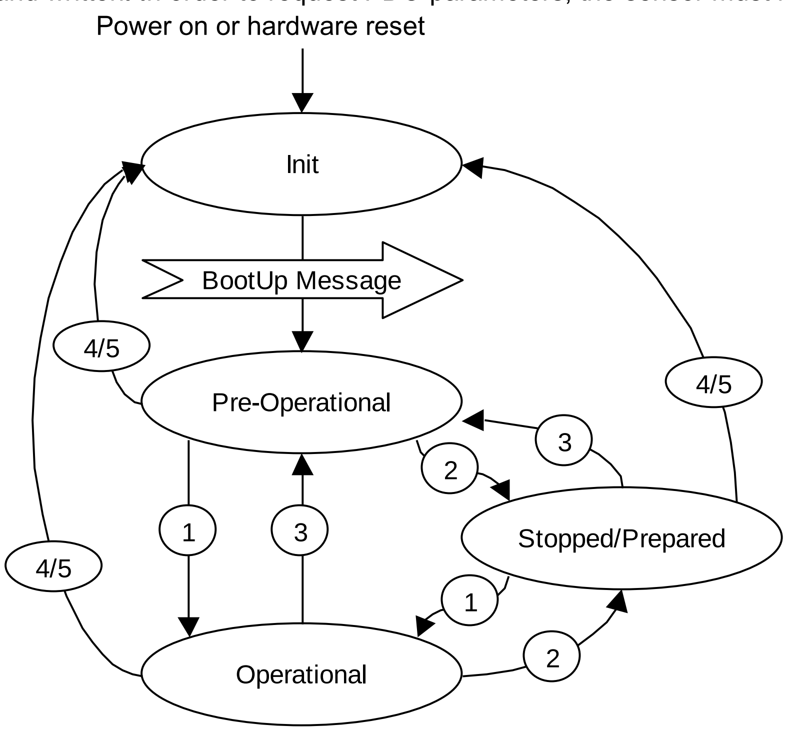
Command byte

Command byte	Description	In state event drawing
01h	Start remote node	1
02h	Stop remote node	2
80h	Enter pre-operational state	3
81h, 82h	Reset remote node	4, 5

The **node number** corresponds to the Node-ID of the required users. With node number = 0, all users are addressed.

NMT state event

Following initialization, the sensor is in the pre-operational state. In this status, SDO parameters can be read and written. In order to request PDO parameters, the sensor must first be moved to the operational state.



The various NMT states

Init

Following initialization, the sensor logs on to the CAN bus with a Boot Up message. The sensor then goes automatically to the pre-operational state.

The COB-ID of the Boot Up message is made up of 700h and the Node-ID.

COB-ID	Byte 0
700h + Node-ID	00

Pre-operational state

In the pre-operational state, SDOs can be read and written.

Operational state

In the operational state, the sensor transmits the requested PDOs. In addition, SDOs can be read and written.

Stopped or prepared state

In the stopped state, only NMT communication is possible. No SDO parameters can be read or set. LSS is only possible in the stopped state.

Status change

Start remote node (1)

With the start command, the sensor is switched to the operational state.

COB-ID	Command byte	Node-ID
0	1h	0…127

Stop remote node (2)

With the stop command, the sensor is switched to the stopped state.

COB-ID	Command byte	Node-ID
0	2h	0…127

Enter pre-operational state (3)

Change to the pre-operational state.

COB-ID	Command byte	Node-ID
0	80h	0…127

Reset remote node (4) or reset communication (5)

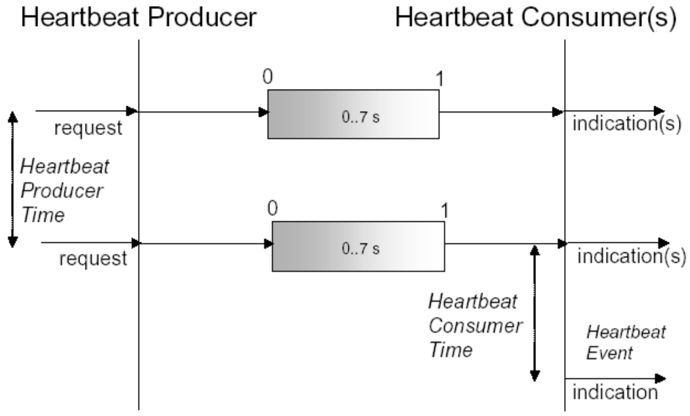
With the reset command, the sensor is re-initialized.
Reset remote node (4):

COB-ID	Command byte	Node-ID
0	81h	0…127

Reset communication (5):

COB-ID	Command byte	Node-ID
0	82h	0…127

3.3.6.1 Heartbeat protocol



A Heartbeat Producer transmits the Heartbeat message cyclically with the frequency defined in Heartbeat producer time object. One or more Heartbeat Consumer may receive the indication. The relationship between producer and consumer is configurable via Object Dictionary entries. The Heartbeat Consumer guards the reception of the Heartbeat within the Heartbeat consumer time. If the Heartbeat is not received within this time a Heartbeat Event will be generated.

Example for a heartbeat protocol

COB-ID	Data/Remote	Byte 0
701h	d	7Fh (127d)

The heartbeat messages consist of the COB-ID and one byte. In this byte, the NMT status is supplied.

0:	Boot Up-Event
4:	Stopped
5:	Operational
127:	Pre-operational

In other words, the sensor is in the pre-operational state (7Fh = 127).

3.3.6.2 Layer Setting Services

In 2000, CiA drafted a new protocol intended to ensure standardized occurrence. The procedure is described under *Layer Setting Services and Protocol, CiA Draft Standard Proposal 305* (LSS).

The sensor is supplied as standard with node-ID 1 and baud rate 50 kbits/s. Several sensors can be connected to the bus system with the same node-ID. To allow individual sensors to be addressed, LSS is used. Each sensor is fitted with its own unique serial number and is addressed using this number. In other words, an optional number of sensors with the same node-ID can be connected to one bus system, and then initialized via LSS. Both the Node-ID and also the baud rate can be reset. LSS can only be executed in the **Stopped state**.

Message structure

COB-ID:

Consumer → Producer : 2021 = 7E5h
Consumer ← Producer : 2020 = 7E4h
After the COB-ID, an LSS command specifier is transmitted.
This is followed by up to seven attached data bytes.

COB-ID	cs	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7

Switch state global

7E5h →	04h	State	reserved

State : 0 → Operational state
: 1 → Configuration state

Switch state selective

The following procedure can be used to address a certain sensor in the bus system.

7E5h →	40h	Vendor ID	reserved
7E5h →	41h	Product code	reserved
7E5h →	42h	Revision number	reserved
7E5h →	43h	Serial number	reserved
7E4h ←	44h	State	reserved

Vendor ID : ECh
Product code : Internal product code for the respective sensor
Revision number : Current revision number of the sensor
Serial number : Unique, consecutive serial number
State : The sensor's response is the new state (0=operating state; 1=configuration state)

Setting node-ID

7E5h →	11h	Node-ID	reserved

7E4h ←	11h	ErrCode	Spec error	reserved

Node-ID : The sensor's new Node-ID
Error code : 0=OK; 1=Node-ID outside range; 2...254=reserved; 255→Specific error
Specific error : If Error code=255 → application-specific error code.

Setting bit timing

7E5h →	13h	Ta-bleSel	TableInd	reserved

7E4h ←	13h	ErrCode	SpecError	reserved

TableSel : Selects the bit timing table 0 : Standard CiA bit timing table
TableInd : Bit timing entry in selected table (see table below).
Error code : 0=OK; 1=Bit timing outside range; 2...254=reserved; 255→Specific error
Specific error : If Error code=255 → Application-specific error code.

Value	Setting via LSS (Standard CiA bit timing table)	Setting baud rate via object 2100h
0	1000 kbits/s	10 kbits/s (not supported)
1	800 kbits/s	20 kbits/s
2	500 kbits/s	50 kbits/s
3	250 kbits/s	100 kbits/s
4	125 kbits/s	125 kbits/s
5	100 kbits/s	250 kbits/s
6	50 kbits/s	500 kbits/s
7	20 kbits/s	800 kbits/s
8	10 kbits/s (not supported)	1000 kbits/s
9	Automatic bit rate detection (not supported)	Automatic bit rate detection (not supported)

Note:

- For setting bit timing via LSS, use values according to standard CiA bit timing table.
- New baud rate has to be saved to non-volatile memory by using object 1010h.
- New baud rate will take effect after restart of the device. Baud rate 10 kbits/s is not supported.

Saving configuration protocol

This protocol saves the configuration parameters in the EEPROM.

7E5h →	17h	reserved

7E4h ←	17h	ErrCode	SpecError	reserved

Error code : 0=OK; 1=Saving not supported; 2=Access error; 3…254=reserved; 255→Specific error
Specific error : If error code=255 → Application-specific error code.

Activate bit timing parameters

The new bit timing parameters are activated with the command specifier 15h.

7E5h →	15h	Switch delay	reserved

Switch Delay : Reset delay in the producer in msec.
After the delay, the sensor logs on with the new baud rate.

Request vendor ID

Requesting the vendor ID of a selected sensor

7E5h →	5Ah	reserved

7E4h ←	5Ah	32-bit vendor ID	reserved

Vendor ID : = ECh

Request product code

Request product code of a selected sensor

7E5h →	5Bh	reserved

7E4h ←	5Bh	Product code	reserved

Product code : Manufacturer-dependent product code

Request revision number

Request revision number of a selected sensor

7E5h →	5Ch	reserved

7E4h ←	5Ch	32-bit revision number	reserved

Revision number : Current revision

Request serial number

Request serial number of a selected sensor

7E5h →	5Dh	reserved

7E4h ←	5Dh	32-bit serial number	reserved

Serial number : Unique consecutive serial number of the sensor

4 Object dictionary

According to CiA (CAN in Automation) the objects are subdivided into three groups:

- **Standard communication objects**:
  1000h – 1FFFh
- **Manufacturer-specific objects**:
  2000h - 5FFFh
- **Device-specific objects**:
  6000h - FFFFh

The table below is giving a summary of all SDO objects supported by the inclination sensor.

Object Object number in Hex
Name Name of parameter
Format Data type
Access ro = read-only, wo = write only, rw = read/write
Default Default value, upon first init or after restore to default value
Save yes → saved in non-volatile memory / can be restored to default values

4.1 Communication parameters (CiA DS-301, CiA DS-302 Part 2)

Object Sub-index	Name	Format	Access	Default	Save
1000h	Device type	U32	ro	102019Ah	
1001h	Error register	U8	ro	0h	
1002h	Manufacturer status register	U32	ro	0h	
1003h	Pre-defined error field				
00h	Number of errors	U8	rw	0h	yes
01h	Newest error entry	U32	ro		
...	…	...	…	…	
10h	Oldest error entry	U32	ro		
1005h	COB-ID SYNC message	U32	rw	80h	yes
1008h	Device name	VSTR	ro	GIM700DR	
1009h	Hardware version	VSTR	ro	1.00 or higher	
100Ah	Software version	VSTR	ro	1.00 or higher	
1010h	Save parameters				
00h	Highest sub-index supported	U8	ro	4h	
01h	Save all parameters	U32	rw		
02h	Save communication parameters	U32	rw		
03h	Save application parameters	U32	rw		
04h	Save manufacturer parameters	U32	rw		
1011h	Restore default parameters				
00h	Highest sub-index supported	U8	ro	4h	
01h	Restore all default parameters	U32	rw		
02h	Restore default communication parameters	U32	rw		
03h	Restore default application parameters	U32	rw		

Object Sub-index	Name	Format	Access	Default	Save
04h	Restore default manufacturer parameters	U32	rw	For device profile specific parameters (CiA DS-410) marked with Save yes	
1014h	Emergency COB-ID	U32	rw	80h + Node-ID	yes
1016h	Consumer heartbeat time				yes
00h	Highest sub-index supported	U8	ro	1h	
01h	Consumer heartbeat time	U32	rw	0h	yes
1017h	Producer heartbeat time	U16	rw	0h	yes
1018h	Identity object				
00h	Highest sub-index supported	U8	ro	4h	
01h	Vendor-ID	U32	ro	ECh	
02h	Product code	U32	ro	1D: 60h 2D: 61h	
03h	Revision number	U32	ro	04040001h or higher	yes
04h	Serial number	U32	ro	Factory-defined	yes
1800h	TX PDO1 communication			Transmit PDO1 communication parameters	
00h	Highest sub-index supported	U8	ro	5h	
01h	COB-ID	U32	rw	$NODEID+40000180h	yes
02h	PDO transmission type	U8	rw	FFh	yes
05h	Event time	U16	rw	C8h	yes
1801h	TX PDO2 communication			Transmit PDO2 communication parameters	
00h	Highest sub-index supported	U8	ro	5h	
01h	COB-ID	U32	rw	$NODEID+40000280h	yes
02h	PDO transmission type	U8	rw	FFh	yes
05h	EventTimer	U16	rw	0h	yes
1802h	TX PDO3 communication			Transmit PDO3 communication parameters	
00h	Highest sub-index supported	U8	ro	5h	
01h	COB-ID	U32	rw	$NODEID+40000380h	yes
02h	PDO transmission type	U8	rw	FFh	yes
05h	Event time	U16	rw	0h	yes
1803h	TX PDO4 communication			Transmit PDO4 communication parameters	
00h	Highest sub-index supported	U8	ro	5h	
01h	COB-ID	U32	rw	$NODEID+40000480h	yes
02h	PDO transmission type	U8	rw	FFh	yes
05h	Event time	U16	rw	0h	yes
1A00h	TX PDO1 mapping			Transmit PDO1 mapping parameters	
00h	Highest sub-index supported	U8	rw	1D: 2h (1-dim slope sensor) 2D: 3h (2-dim slope sensor, horizontal & vertical installation)	yes
01h	Mapping entry 1	U32	rw	1D: 65110010h (device temperature) 2D: 65110010h (device temperature)	yes
02h	Mapping entry 2	U32	rw	1D-VP: 60100010h (Slope long 16-bit, Z-axis, plumb angle, 0…360°) 2D-HP: 60100010h (Slope long 16-bit, X-axis, horizontal installation, plumb angle, ±90°) 2D-VP: 60100010h (Slope long 16-bit, Z-axis, vertical installation, plumb angle, ±90°)	yes

Object Sub-index	Name	Format	Access	Default	Save
03h	Mapping entry 3	U32	rw	1D-VP: 0h 2D-HP: 60200010h (Slope lateral 16-bit, Y-axis, horizontal installation, plumb angle, ±90°) 2D-VP: 60200010h (Slope lateral 16-bit, Y-axis, vertical installation, plumb angle, ±90°)	yes
04h	Mapping entry 4	U32	rw	0	yes
1A01h	TX PDO2 mapping			Transmit PDO2 mapping parameters	
00h	Highest sub-index supported	U8	rw	1D: 0h 2D: 0h	yes
01h	Mapping entry 1	U32	rw	1D: 0h 2D: 0h	yes
02h	Mapping entry 2	U32	rw	1D: 0h 2D: 0h	yes
03h	Mapping entry 3	U32	rw	1D: 0h 2D: 0h	yes
04h	Mapping entry 4	U32	rw	1D: 0h 2D: 0h	yes
1A02h	TX PDO3 mapping			Transmit PDO3 mapping parameters	
00h	Highest sub-index supported	U8	rw	1D: 0h 2D: 0h	yes
01h	Mapping entry 1	U32	rw	1D: 0h 2D: 0h	yes
02h	Mapping entry 2	U32	rw	1D: 0h 2D: 0h	yes
03h	Mapping entry 3	U32	rw	1D: 0h 2D: 0h	yes
04h	Mapping entry 4	U32	rw	1D: 0h 2D: 0h	yes
1A03h	TX PDO4 mapping			Transmit PDO4 mapping parameters	
00h	Highest sub-index supported	U8	rw	1D: 0h 2D: 0h	yes
01h	Mapping entry 1	U32	rw	1D: 0h 2D: 0h	yes
02h	Mapping entry 2	U32	rw	1D: 0h 2D: 0h	yes
03h	Mapping entry 3	U32	rw	1D: 0h 2D: 0h	yes
04h	Mapping entry 4	U32	rw	1D: 0h 2D: 0h	yes
1F80h	NMT startup	U32	rw	0h	yes

4.1.1 Save parameters (1010h)

In order to save parameters, object 1010h has to be accessed. In order to avoid changing parameters by mistake, saving shall be only executed when a specific signature is written to the appropriate sub-index. The signature that shall be written is "save":

Signature	MSB			LSB
ISO8859 character	e	v	a	s
hex	65h	76h	61h	73h

The data saving process is acknowledged promptly but it takes about 2 seconds and interrupts the data processing and communication output. Make sure to restore parameters only, when device data are not in use.

4.1.2 Restore default parameters / factory settings (1011h)

In order to avoid the restoring of default parameters / factory settings by mistake, restoring shall be only executed when a specific signature is written to the appropriate sub-index. The signature that shall be written is "load":

Signature	MSB			LSB
ISO 8859 character	d	a	o	l
hex	64h	61h	6Fh	6Ch

The sensor supports different possibilities to restore default parameters / factory settings (see object 1011h description):

- To restore all parameters to factory settings, the signature "load" shall be written to object 1011h sub-index 01h.
- To restore communication parameters, the signature "load" shall be written to object 1011h sub-index 02h.
- To restore application parameters, the signature "load" shall be written to object 1011h sub-index 03h.
- To restore manufacturer specific parameters, the signature "load" shall be written to object 1011h sub-index 04h.

The data restore process is acknowledged promptly but it takes about 2 seconds and interrupts the data processing. Make sure to restore parameters only, when device data are not in use.

The restore is active after a power cycle or a after a CANopen reset.

4.1.3 NMT startup (1F80h)

This object (specified in DS-302 Part 2) determines if the device will go to operational state after reset. For this option, 08h has to be written to the device. To turn off the auto operational state, 00h has to be written to the device.

4.2 Manufacturer specific parameters

Object Sub-index	Name	Format	Access	Default	Save	Mapp-able	Visi-bility
2100h	Baud rate	U8	rw	2h	yes	no	all
2101h	Node-ID	U8	rw	1h	yes	no	all
2107h	Filter settings: Acceleration raw data	-	-	-	-	-	-
00h	Highest sub-index supported	U8	ro	3h	no	no	all
01h	Filter type	U8	rw	1h	yes	no	all
02h	Filter order	U8	rw	2h	yes	no	all
03h	Cut-off frequency (low-pass filter)	U16	rw	BB8h	yes	no	all
2108h	Filter settings: Rotation rate raw data	-	-	-	-	-	-
00h	Highest sub-index supported	U8	ro	4h	no	no	all
01h	Filter type	U8	rw	1h	yes	no	all
02h	Filter order	U8	rw	2h	yes	no	all
03h	Cut-off frequency 1 (upper cut-off)	U16	rw	BB8h	yes	no	all
04h	Cut-off frequency 2 (lower cut-off)	U16	rw	64h	yes	no	all
2109h	Filter settings: Process data	-	-	-	-	-	-
00h	Highest sub-index supported	U8	ro	3h	no	no	all
01h	Filter type	U8	rw	1h	yes	no	all
02h	Filter order	U8	rw	2h	yes	no	all
03h	Cut-off frequency (upper cut-off)	U16	rw	BB8h	yes	no	all

4.2.1 Baud rate (2100h)

The baud rate can be changed and read through this object. The following parameters are possible:

Baud rate (2100h) / NOTE: Object 2100h table deviates from CiA standard bit timing table for LSS	
Value	**Description**
0	10 kbits/s (not supported)
1	20 kbits/s
2	50 kbits/s
3	100 kbits/s
4	125 kbits/s
5	250 kbits/s
6	500 kbits/s
7	800 kbits/s
8	1000 kbits/s
9	Automatic baud rate detection (not supported)

Note:

- New baud rate must be saved to non-volatile memory by using object 1010h.
- New baud rate will take effect after restart of the device.
- Baud rate 10 kbits/s and automatic baud rate detection are not supported.
- Setting baud rate / bit timing is also possible via LSS. Baud rate object 2100h table deviates from CiA standard bit timing table for LSS.

4.2.2 Node-ID (2101h)

The Node-ID can be changed and read through this object. The following parameters are possible:

Node-ID (2101h)	
Value	**Description**
1…127	Node-ID

Note:

- New node-ID must be saved to non-volatile memory by using object 1010h.
- New node-ID will take effect after restart of device.
- Setting node-ID is also possible via LSS.

4.2.3 Signal filter settings (2107h / 2108h / 2109h)

The GIM700DR provides signal processing filters assigned to different stages in the signal processing path. These filters can be parametrized in their key parameters.

Filters can be applied to the raw calibrated data of the acceleration sensors (all three axes) and the gyroscopes (all three axes), as well as to the process data (slope longitudinal / slope lateral). The filter parametrization is individual for the three groups of signal sources (acceleration sensor, gyroscope sensor and process data). Main parameters like filter type, filter order and cut off frequency can be configured (in given limits).

Filter coefficients depend on each of the configurable parameters. These filter coefficients are calculated on power-up based on the filter parameters, changes to the filter parameters need to be saved and the device needs to undergo a node reset / power cycle before new settings become effective.

4.2.3.1 Filter settings: Acceleration raw data (2107h)

Acceleration sensor: Filter type (2107h-1)	
Value	**Description**
0	Moving average filter (8 data points)
1	Low-pass filter (Butterworth type)

Acceleration sensor: Filter order (2107h-2)	
Value	**Description**
1…6	Order of the filter Only effective if 2107h-1h = 1 (low-pass filter)

Acceleration sensor: Filter cut-off frequency (2107h-3)	
Value	**Description**
100…3000	Cut-off frequency of low pass filter with resolution 0.01 Hz (e.g. 30 Hz -> BB8h) only effective if 2107h-1h = 1 (low-pass filter)

4.2.3.2 Filter settings: Rotation rate raw data (2108h)

Gyroscope sensor: Filter type (2108h-1)	
Value	**Description**
0	Moving average filter (8-tap)
1	Low-pass filter (Butterworth type)
2	Band-pass filter (Butterworth type)

Gyroscope sensor: Filter order (2108h-2)	
Value	**Description**
1…8	Order of the filter. Only effective, if 2108h-1h = 1 (low-pass filter) or 2 (band-pass filter). In case of 2108h-1h = 2 (band-pass filter) only even numbers are valid.

Gyroscope sensor: Filter cut-off frequency 1 (2108h-3)	
Value	**Description**
100…3000	Cut-off frequency 1 (upper cut-off) with resolution 0.01 Hz (30 Hz → BB8h). If 2108h-1h = 0 → no effect. If 2108h-1h = 1 (low-pass filter) → low-pass cut-off. If 2108h-1h = 2 (band-pass filter) → low-pass cut-off.

Gyroscope Sensor: Filer cut-off frequency 2 (2108h-4)	
Value	**Description**
100…3000	Cut-off frequency 2 (lower cut-off) with resolution 0.01 Hz (1 Hz → 64h). If 2108h-1h = 0 → no effect. If 2108h-1h = 1 → no effect. If 2108h-1h = 2 (band-pass filter) → high-pass cut-off.

Note: For correct band-pass filter operation, cut-off frequency 1 must be set higher than cut-off frequency 2. A plausibility check is not implemented.

4.2.3.3 Filter settings: Process data (2109h)

This filter affects the following process data (sensor fusion data): Slope longitudinal / lateral, Euler angles, Quaternion.

Process data: Filter type (2109h-1h)	
Value	**Description**
0	No filter
1	Low-pass filter (Butterworth type)

Process data: Filter order (2109h-2h)	
Value	**Description**
1…8	Order of the filter Only effective, if 2109h-1h = 1 (low-pass filter)

Process data: Cut-off frequency (2109h-3h)	
Value	**Description**
100...3000	Cut-off frequency with resolution 0.01 Hz (30 Hz → BB8h) Only effective, if 2109h-1h = 1 (low-pass filter)

4.3 Device profile specific parameters (CiA DS-410)

Object Sub-index	Name	Format	Access	Default	Save	Mappable	Visible
6000h	Resolution	U16	rw	64h	yes	no	1D 2D
6010h	Slope long 16-bit (1D vertical installation, 1D-VP: Z-axis, 2D horizontal installation, 2D-HP: X-axis, 2D vertical installation, 2D-VP: Z-axis)	I16	ro	-	no	yes	1D 2D
6011h	Slope long 16-bit operating parameter	U8	rw	2h or 3h[1]	yes	no	1D 2D
6012h	Slope long 16-bit preset value	I16	rw	0h	yes	no	1D 2D
6013h	Slope long 16-bit offset	I16	rw	0h	yes	no	1D 2D
6014h	Slope long 16-bit differential offset	I16	rw	0h	yes	no	1D 2D
6020h	Slope lateral 16-bit (Y-axis, for 2-dimensional versions only, 2D-HP and 2D-VP)	I16	ro	-	no	yes	2D
6021h	Slope lateral 16-bit operating parameter	U8	rw	2h or 3h[1]	yes	no	2D
6022h	Slope lateral 16-bit preset value	I16	rw	0h	yes	no	2D
6023h	Slope lateral 16-bit offset	I16	rw	0h	yes	no	2D
6024h	Slope lateral 16-bit differential offset	I16	rw	0h	yes	no	2D
6110h	Slope long 32-bit (1D vertical installation, 1D-VP: Z-axis, 2D horizontal installation, 2D-HP: X-axis, 2D vertical installation, 2D-VP: Z-axis)	I32	ro	-	no	yes	1D 2D
6111h	Slope long 32-bit operating parameter	U8	rw	2h or 3h[1]	yes	no	1D 2D
6112h	Slope long 32-bit preset value	I32	rw	0h	yes	no	1D 2D
6113h	Slope long 32-bit offset	I32	rw	0h	yes	no	1D 2D
6114h	Slope long 32-bit differential offset	I32	rw	0h	yes	no	1D 2D
6120h	Slope lateral 32-bit (Y-axis, for 2-dimensional versions only, 2D-HP and 2D-VP))	I32	ro	-	no	yes	2D
6121h	Slope lateral 32-bit operating parameter	U8	rw	2h or 3h[1]	yes	no	2D
6122h	Slope lateral 32-bit preset value	I32	rw	0h	yes	no	2D
6123h	Slope lateral 32-bit offset	I32	rw	0h	yes	no	2D
6124h	Slope lateral 32-bit differential offset	I32	rw	0h	yes	no	2D
6511h	Device temperature (in degree Celsius)	I16	ro	-	no	yes	All

[1] Depending on product variant

4.3.1 Resolution (6000h)

Object 6000h defines the resolution for the sensor output objects Slope long 16-bit (6010h) and Slope lateral 16-bit (6020h) based on a resolution of 0.001°. This object also defines the resolution for the sensor output objects Slope long 32-bit (6110h) and Slope lateral 32-bit (6120h). Factory default setting is 0.1° (64h). The following table describes all possible resolutions:

Measurement resolution (6000h)	
Value	**Description**
01h (1d)	0.001 degree
Ah (10d)	0.01 degree
64h (100d)	0.1 degree (factory default setting)
3E8h (1000d)	1 degree

4.3.2 Slope long (6010h / 6110h) / slope lateral (6020h / 6120h)

Objects 6010h (16-bit) and 6110h (32-bit) contain the slope long values / sensor output for longitudinal axis.
Objects 6020h (16-bit) and 6120h (32-bit) contain the slope lateral values / sensor output for the lateral axis.

All values are given in angular degrees with resolution specified in object 6000h.

Note: Slope values are defined as plumb / vertical angles, which describe the inclination of the sensor coordinate system with respect to the direction of gravity.
The slope value for rotation around X-axis corresponds to the angle between gravity vector and XZ-plane.
The slope value for rotation around Y-axis corresponds to the angle between gravity vector and YZ-plane.

4.3.3 Slope long preset value (6012h / 6112h) / slope lateral preset value (6022h / 6122h)

Objects 6012h (16-bit) and 6112h (32-bit) contain the preset values of the longitudinal slope.
Objects 6022h (16-bit) and 6122h (32-bit) contain the preset values of the lateral slope.

Accessing these preset objects by SDO directly sets the actual longitudinal / lateral slope value to the desired target slope value. All values must be given in angular degrees with the resolution given in object 6000h.

Recommendation: Use preset objects for adjusting sensor coordinate system / to application coordinate system, for referencing angles in both systems to same value (e.g. to 0°).

Setting preset leads to an internal calculation of sensor offset values.
The calculated application offset of the longitudinal slope value is given in Slope long offset (object 6013h / 6113h). The Slope long offset is calculated with respect to Differential slope long object 6014h / 6114h.

The calculated application offset of the lateral slope value is given in Slope lateral offset (object 6023h / 6123h). The Slope lateral offset is calculated with respect to Differential slope lateral object 6024h / 6124h.

4.3.4 Slope long offset (6013h / 6113h) / slope lateral offset (6023h / 6123h)

Objects 6013h (16-bit) and 6113h (32-bit) contain the application offset of the longitudinal slope.
Objects 6023h (16-bit) and 6123h (32-bit) contain the application offset of the lateral slope.

All value must be given in angular degrees with the resolution given in object 6000h.

Slope offset is automatically calculated by the sensor according to:

Slope offset = A – B – C

where

A is slope preset value at tacc;
B is slope physical measured value at tacc;
C is differential slope offset and tacc = time when accessing preset value object (6012h / 6022h / 6112h / 6122h).

Recommendation: Use preset objects for adjusting sensor coordinate system. Use offset objects only as indicator for difference between sensor coordinate system and direction of gravity in read only mode.

4.3.5 Slope long differential offset (6014h / 6114h) / slope lateral differential offset (6024h / 6124h)

Objects 6014h (16-bit) and 6114h (32-bit) provide the shifting of the Slope long values (6010h, 6110h) independent of the Slope long preset (objects 6012h, 6112h) and the Slope long offset (6013h, 6113h).

Objects 6024h (16-bit) and 6124h (32-bit) provide the shifting of the Slope lateral values (6020h, 6120h) independent of the Slope lateral preset (objects 6112h, 6122h) and the Slope long offset (6023h, 6123h).

All value must be given in angular degrees with the resolution given in object 6000h.

Recommendation: If necessary, use differential offset objects for fine adjusting of sensor coordinate system.

4.3.6 Slope operating parameters scaling / inversion (6011h / 6021h / 6111h / 6121h)

The slope operating parameters scaling and inversion define the interpretation of the slope values, i.e. the sensor output (Slope long 6010h / 6110h, Slope lateral 6020h / 6120h).

If scaling is disabled, the sensor output slope values are equal to the physically measured angles.

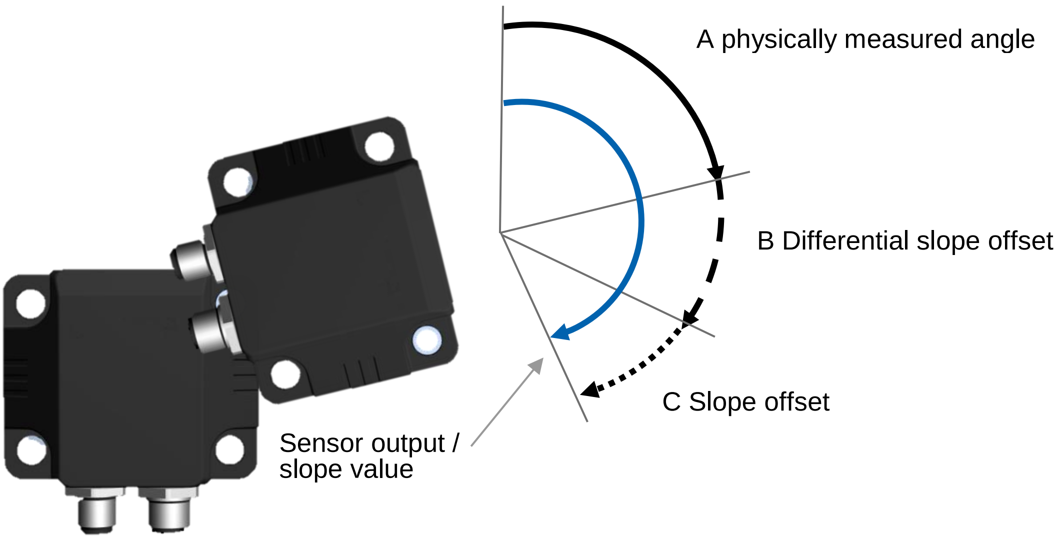
If scaling is enabled, the sensor output / slope values are calculated according to:

Sensor output / slope value = A + B + C

where

A is physically measured angle (current inclination / tilt angle / measurement value);
B is differential slope offset (always added to the current angle);
C is slope offset (calculated by sensor when writing preset).

Illustration of scaling function for 1-dimensional case:



Note:
- Slope operating parameters are applied to the corresponding slope only. For example, Slope long 16-bit operating parameter (6011h) is applied to Slope long 16-bit (6010h).
- Corresponding objects for 16-bit and 32-bit values are linked internally. Changing Slope long 16-bit operating parameter (6011h) leads to change of Slope long 32-bit operating parameter (6111h).

If inversion is enabled, the sensor output / slope values are inverted, which corresponds to an inversion of the direction of rotation.

Examples:
- In general case, a slope value of 30° with disabled inversion results in a slope value of -30° with enabled inversion.
- In case of a 1-dimensional sensor with measuring range 0…360, a slope value of 30° with disabled inversion results in a slope value of 330° with enabled inversion.

Bit mask:

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
	Reserved						s	i
Default	-						1	0

s = Scaling (0 = Disable scaling; 1 = Enable scaling)
i = Inversion (0 = Disable inversion; 1 = Enable inversion)

Factory default setting is “Enable scaling” and “Disable inversion” (object value 2h).

4.3.7 Device temperature (6511h)

The device temperature can be read by accessing object 6511h. The value is given in multiples of 1 °C. It is also part of the standard PDO.

5 Sensor configurations

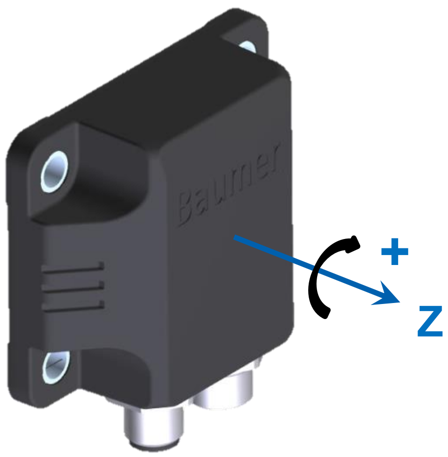
The sensor coordinate system is defined according to ISO 8855.

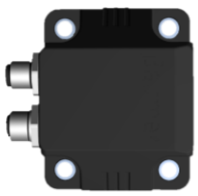
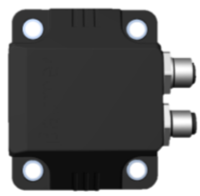
Note: To ensure backward compatibility to previous 1D and 2D versions of GIM500R and GIM140R, for some versions, positive direction of rotation deviates from ISO8855.

5.1.1 1-dimensional sensor / vertical installation / plumb angle 0…360° (1D-VP)

Install sensor in vertical position with horizontal Z-axis (see illustration). For optimum measuring accuracy, limit misalignment (maximum misalignment ±3°).

- Sensor measures rotation around Z-axis with measuring range 0…360°.
- Sensor output / slope value increases during clockwise rotation.
- Sensor output is zero / 0°, when the connectors are pointing downwards.
- Zero degree position may be configured by Slope long preset value objects (6012h, 6112h).



			
Z-axis angle = 0°	Z-axis angle = 90°	Z-axis angle = 180°	Z-axis angle = 270°

5.1.2 2-dimensional sensor / horizontal installation / plumb angle ±90° (2D-HP)

Install sensor with horizontal X-axis and Y-axis (see illustration).

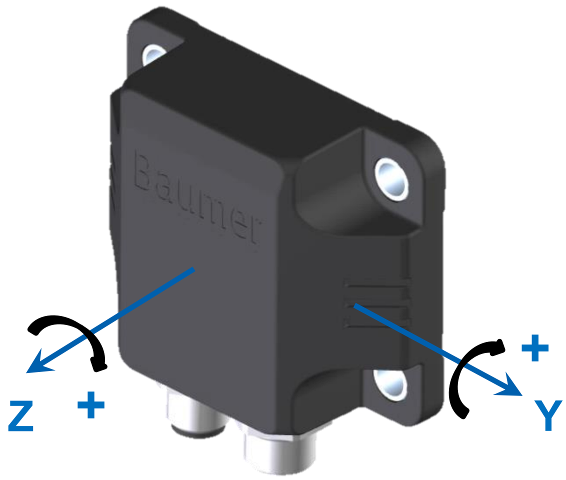
- Sensor measures rotation around X-axis and Y-axis with measuring range ±90°.
- Sensor outputs / slope values increase during clockwise rotation.
- Sensor outputs are zero / 0°, when sensor base plate has horizontal alignment (factory default settings).
- Zero degree positions may be configured by Slope long preset value objects (6012h, 6112h) and Slope lateral preset value objects (6022h, 6122h).

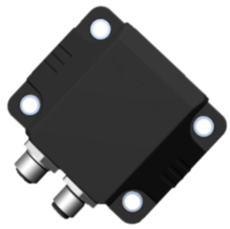
		
X-axis angle = 0° Y-axis angle = 0°	X-axis angle = +30° Y-axis angle = 0°	X-axis angle = +90° Y-axis angle = 0°
		
X-axis angle = 0° Y-axis angle = 0°	X-axis angle = 0° Y-axis angle = -30°	X-axis angle = 0° Y-axis angle = -90°

5.1.3 2-dimensional sensor / vertical installation / plumb angle ±90° (2D-VP)

Install sensor in vertical position with horizontal Z-axis and Y-axis (see illustration).

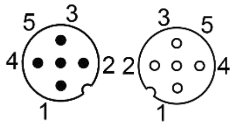
- Sensor measures rotation around Z-axis and Y-axis with measuring range ±90°.
- Sensor outputs / slope values increase during clockwise rotation.
- Sensor outputs are zero / 0°, when Z-axis and Y-axis have horizontal alignment (factory default settings).
- Zero degree positions may be configured by Slope long preset value objects (6012h, 6112h) and Slope lateral preset value objects (6022h, 6122h).



		
Z-axis angle = 0° Y-axis angle = 0°	Z-axis angle = +30° Y-axis angle = 0°	Z-axis angle = +45° Y-axis angle = 0°
		
Z-axis angle = 0° Y-axis angle = 0°	Z-axis angle = 0° Y-axis angle = -30°	Z-axis angle = 0° Y-axis angle = -45°

6 Terminal assignment

6.1 2 x M12 flange connector, 5-pin

Pin	Assignment	Description	M12 (plug / socket)
1	CAN_GND	Ground connection relating to CAN	
2	+Vs	Voltage supply	
3	GND	Ground connection relating to +Vs	
4	CAN_H	CAN Bus signal (dominant High)	
5	CAN_L	CAN Bus signal (dominant Low)	

Terminals with the same designation are connected to each other internally and identical in their functions. Maximum load on the internal clamps Vs-Vs and GND-GND is 0.6 Amps each.