360° Inclination Sensors with CAN Bus Interface

Figure similarly

User Manual

MR405.1111.1 (D)

MR405.1121.1

Version: 2.2

Date: August 25th 2006

Revision History

Date	Revision	Changes
2004-03-25	0	- First version
2004-04-27	1	- Extension of the CAN protocol
2004-04-30	2	- Various changes
2004-09-01	3	- Correction of mistake in ordering information
2004-10-08	4	- Various changes and correction of mistakes
2005-06-06	5	- Various changes
Version 2		
2005-09-28	0	- Adaptation of technical data to new sensor - documentation of functional enhancement (digital filter)
2006-03-02	1	- Correction of layout
2006-08-25	2	- Correction of ordering information, technical data extended

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1 Overview

1.1 Characteristics

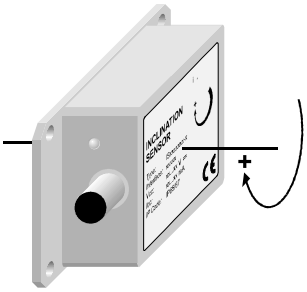
Figure similarly

- **1-dimensional 360° inclination sensor**
- **High resolution and accuracy**
- **Comfortable CAN Bus interface:**
  - Freely selectable IDs
  - Baud rates from 10 kBit/s to 1 MBit/s
- **High sampling rate and bandwidth**
- **Programmable vibration suppression**
- **Functions:**
  - Position request and cyclical output
  - Comfortable setting of parameters
  - Configurable cut-off frequency (digital filter)
- **Four freely configurable, potential-free switching outputs** (type MR405.1121.1 only)
- **Robust, simply mountable aluminium housing**
- **Suitable for industrial use:**
  - Temperature range: -40°C to +80°C
  - Degree of protection: IP65/67

The 1-dimensional inclination sensors MR405 enable the measurement of inclinations or rotation angles related to a horizontal rotation axis over a range of 360°. To guarantee a high accuracy each sensor is calibrated factory-made at 25 °C.

The inclination sensor MR405.1121.1 includes four freely configurable, potential-free switching outputs and can also be used as transducer in control systems without connection to the CAN Bus.

The compact and robust design makes the sensor a suitable angle measurement device in rough surroundings for different applications in industry and vehicle technology. A simple configuration and putting into operation is possible by the standardised CAN Bus interface. All parameters are saved in the internal permanent memory.



1.2 Applications

- **Industry automation**
- **Agricultural and forestry machines**
- **Utility vehicles**
- **Crane and hoisting technology**

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2 Technical Data

General Parameters	
Measurement axes	1
Measurement range	360° (no limit stop)
Resolution	0,01°
Calibration accuracy (at 25° C)	±0,1°
Nonlinearity	max. ±0,2°
Temperature coefficient (zero point)	typ. ±0,008 °/K
Cross sensitivity	Error at ±45° cross slope max. ±1.5°
Cut-Off frequency	typ. 20 Hz, 2nd order (without digital filter) / 0,3 ... 25 Hz, 8th order (with digital filter)
Sampling rate	100 s^{-1}
Operating temperature	-40 °C bis +80 °C
Characteristics	
Interface	CAN 2.0 A and B (11- and 29-Bit-ID) according ISO 11898-2
Data rates	10; 20; 50; 62,5; 100; 125; 250; 500; 800 kBit/s; 1 MBit/s
Functions	Position request, cyclical transmission, setting of parameters, digital filter (butterworth lowpass , 8th order), output of the device's internal temperature (±2.0 K accuracy)
Four switching outputs**	PhotoMOS relais, synchronically switched
Display of function	Two-colour LED (green / red)
Electrical Parameters	
Supply voltage	10 bis 30 V DC
Current consumption (MR405.1121.1)	105 mA to 40 mA / 150 mA to 60 mA
Current carrying capacity of the switching outputs**	0,5 A, max. 30 V DC, short-circuit-proof
Mechanical Parameters	
Connector CAN	Sensor connector 5-pole (M12)
Connector switching outputs**	Sensor connector 8-pole (M12)
Degree of protection	IP65/67
Mechanical shock	max. 3,500 g
Dimensions	58 mm x 90 mm x 31 mm
Mass	ca. 160 g

Table 1: Technical Data

**type MR405.1121.1 only

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3 Mounting

3.1 Position of Drilling Holes

The four drilling holes to mount the sensor (Figure 1) are situated in the basic plate of the inclination sensor. The additional M5 press-in bolt is used as ground-connector.

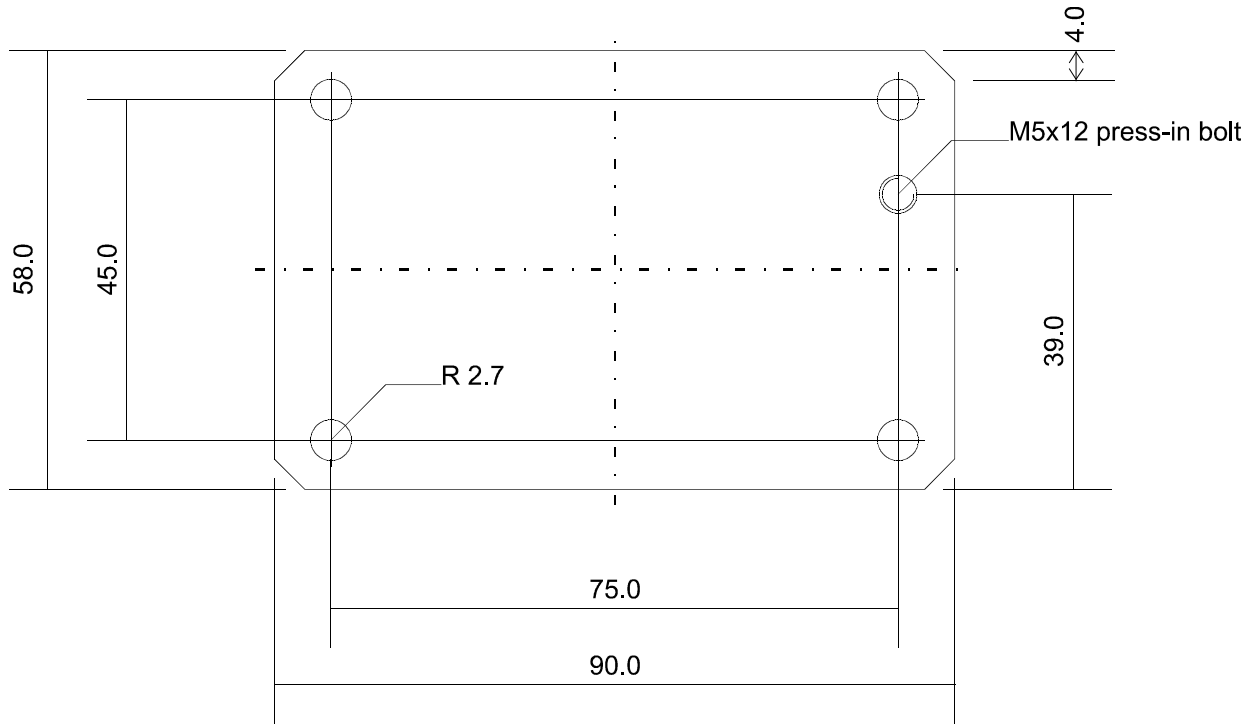

Figure 1: Dimensioned Sketch of the Basic Housing Plate

3.2 Definition of the Axes

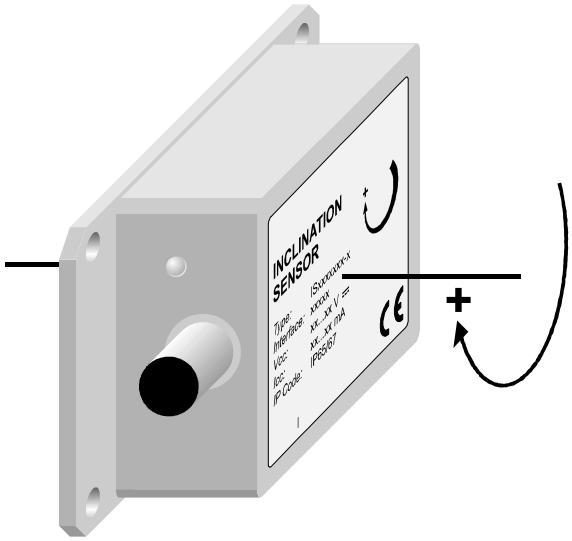

Figure 2: Definition of the Axes

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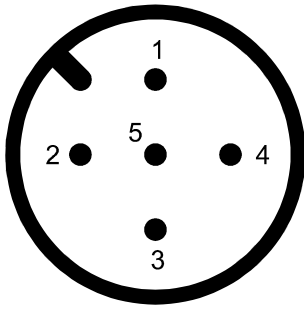
4 Connection

4.1 Connector Pin Out

4.1.1 4.1.1 CAN Bus Connection

The inclination sensors MR405 are equipped with a common 5-pole round plug M12 (A-coded).
The pin allocation fulfils CiA DRP 303-1 (Figure 3).

Pin	Allocation
1	Shield
2	Supply voltage (+24 V)
3	GND (data reference potential)
4	CAN_H
5	CAN_L



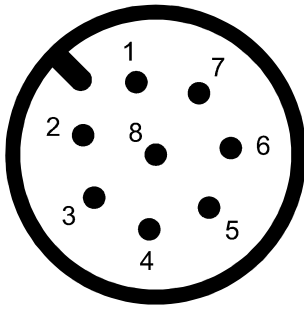
(View from the outside)

Figure 3: Connector Pin Out CAN Bus

4.1.2 4.1.2 Connection of Switching Output (Type MR405.1121.1 only)

The MR405.1121.1 additionally includes an 8-pole round plug M12 to connect the switching outputs. The pin allocation is shown in Figure 4.

Pin	Switching Output	Allocation
1	0	+U
2		-U
3	1	+U
4		-U
5	2	+U
6		-U
7	3	+U
8		-U



(View from the outside)

Figure 4: Connector Pin Out Switching Outputs

4.2 Bus-Termination Resistor

The inclination sensors MR4054 contain no internal termination resistor. It can be realised externally by a T-stick at the end of the bus on request (120 Ω).

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5 Software Description

Each inclination sensor offers the following three operation modes:

- Position request
- (Automatically) cyclical transmission of the position
- Reading/writing of device parameters

For each mode a CAN-ID for receipt of data/commands (except cyclical transmission) and a CAN-ID for transmission of the reply/confirmation are available. These IDs are saved in an internal permanent memory (EEPROM) and can be configured freely. CAN 2.0 A (Standard Frame Format) as well as CAN 2.0 B (Extended Frame Format) are supported.

5.1 Format of the CAN Frames

5.1.1 Data Part in the CAN Frame

The data part of all transmission and receipt frames always contains a function select code (FSC) and additionally up to seven data bytes depending on the FSC. The length of the data part of the CAN frame is defined in the DLC field (Data Length Code). The general format of the data part is structured as follows:

Byte0	Byte1	Byte2	Byte3	Byte4	Byte5	Byte6	Byte7
FSC	D0/Status	D1	D2	D3	D4	D5	D6

Table 2: Format of the CAN Frames

FSC: Function Select Code – Function code (detailed description in the sections about the operation modes). Each frame of the inclination sensor always contains the FSC of the preceding request as confirmation.

D0-D7: Data bytes, depending on the function select code

Status: Status information which is included in each frame output by the inclination sensor (see section 5.1.2).

Frames which are transmitted to the inclination sensor may contain further data bytes beyond the needed ones – those will not be evaluated. Frames sent by the inclination sensor only contain the data bytes defined by the function select code.

5.1.2 Status Byte (STATUS)

Each frame output by the inclination sensor contains the recent status of the device in Byte1 of the CAN frame. The status byte is structured as follows:

Bit7-5	Bit4	Bit3	Bit2	Bit1	Bit0
Reserved	Sensor Error	CmdParam Error	EEPROM Error	Default Param	Cyclic Mode

Table 3: Status Byte

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When “1”, the status bits have the following meaning (default value in brackets):

CyclicMode: The inclination is in the cyclic mode. This means it transmits the recent angle values cyclically (for detailed description please see section 5.4).

DefaultParam: The default device parameters have been restored. This case occurs, if the default parameters have been set or invalid parameters are read from the EEPROM after device reset. This bit is only reset if a device parameter in the EEPROM is changed by a Set Parameter Frame. The inclination sensor is delivered with the default de-vice parameters listed in section 5.10). Therefore this bit is set automatically.

EEPROMError: While reading/writing on the EEPROM an error occurred, for example data loss. The correct function of the inclination sensor is no longer guaranteed. This bit is reset by reading of the status byte (Set Parameter Telegram with FSC = 02h).

CmdParamError: A received frame contained a command or parameter error (invalid FSC, too less data bytes, invalid values). This bit is also set if an error occurred in the execution of a function (for example writing/reading error on EEPROM). It will be reset by reading of the status byte (Set Parameter Frame with FSC = 02h).

SensorError: The sensor is located outside the allowed slant (Cross sensitivity) – the inclination value can be incorrect. This bit is reset automatically if the sensor is located in the tolerable vertical position.

5.2 Boot Up Message

After device reset (hardware or software reset) the inclination sensor outputs a “boot up” message twice. With this the correct boot process is displayed and the Set Parameter ID is notified (CAN-ID on that the inclination sensor can be parameterised). This frame contains the following information:

“Boot up“ message after device reset: Reply Parameter ID (default ID: 301h)

FSC	D0	D1	D2	D3	D4	D5	D6
FFh	Status	SID0	SID1	SID2	SID3	SWV0	SWV1

Table 4: “Boot Up” Message

SID0-3: Set Parameter ID (description in section 5.5)

SWV0-1: Software version
Format: 16 bit unsigned integer value
Example: 67h = 103 (corresponds to v1.03)

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5.3 Position Request Mode

The position request is always available. In this mode the angle value of the inclination sensor can be requested via a **Request Position Update Frame**. The inclination sensor replies to that frame via a **Reply Position Update Frame**. Both frames are structured as follows:

FSC	D0	D1	D2	D3	D4	D5	D6
00h	-	-	-	-	-	-	-

Table 5: Request frame: Request Position Update ID (default ID = 100h)

FSC	Status	D1	D2	D3	D4	D5	D6
00h	Status	Angle0	Angle1	Temp	-	-	-

Table 6: Reply frame: Reply Position Update ID (default ID = 101h)

Angle0/1: Recent angle value
Format: 16 bit unsigned integer value (0 – 35995)
Conversion: Value / 100 = angle value
Example: 34585 / 100 = 345.85°

Temp: Temperature between -55 °C and +120 °C
Format: 8 bit signed value (two's complement)

5.4 Cyclic Mode

The inclination sensor supports the cyclical transmission of the recent position (angle position) after the expiration of a defined time interval. This operation mode can be (de)activated separately and the needed time interval (cycle time) can be parameterised freely

5.4.1 Operation Procedure

The cyclic mode is activated if the status bit STATUS:CyclicMode is set. Corresponding to the operational principle shown in Figure 5 the inclination sensor outputs the recent position value in periodical intervals (cycle time) with a **Cyclic Position Update Frame**. This is structured as follows:

FSC	D0	D1	D2	D3	D4	D5	D6
30h	Status	Angle0	Angle1	Temp	-	-	-

Table 7: Cyclic position frame: Cyclic Position Update ID (default ID = 201h)

Meaning of the data bytes as mentioned in section 5.3.

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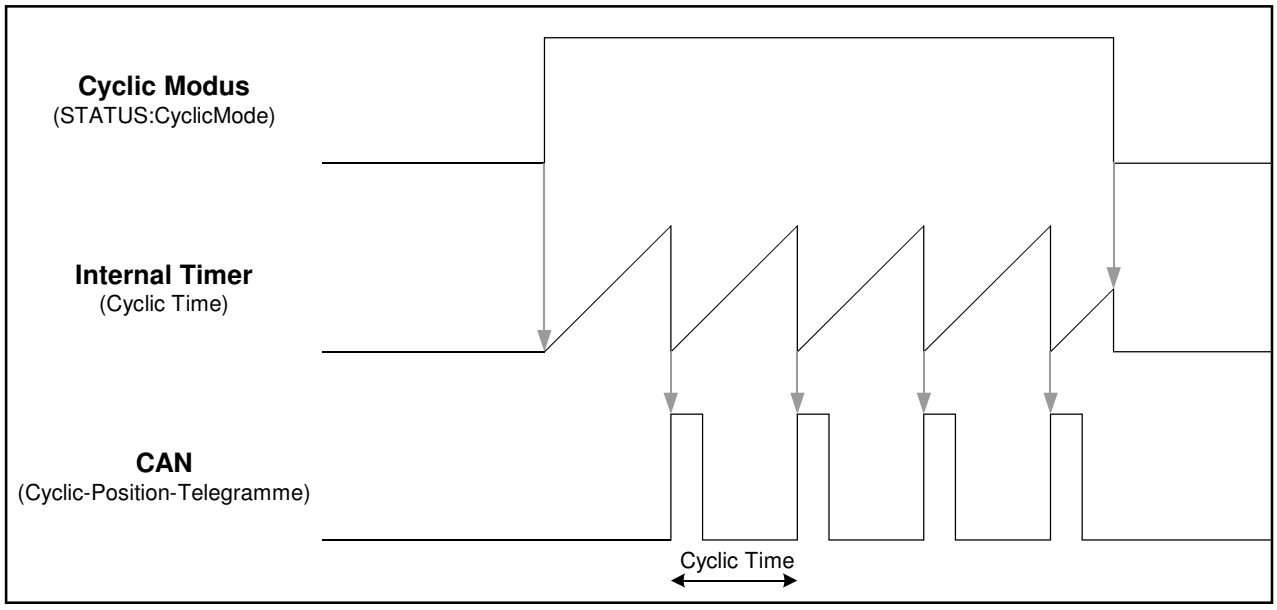

Figure 5: Operational Principle of the Cyclic Mode

5.4.2 Settings

The cyclic mode can be configured by Set Parameter Frames (see section 5.5). It has to be considered that changes in the internal permanent memory (EEPROM) will go into effect after device reset. Changes in the non-permanent memory (RAM) are effected immediately and are lost after reset.

For configuration of the cyclic mode the following two parameters are available:

- Cycle time (CYT): Period interval in milliseconds (1 – 65,535)
- Cycle mode (CYM): (De)activate cyclic mode
- Cyclic position update ID: CAN ID of the Cyclic Position Update Frame

5.5 Set Parameter Mode

The set parameter mode is always active. It enables the reading and setting of the needed device parameters as well as the execution of various commands. The complete parameters like CAN IDs, baud rate, cyclic time etc. can be set and requested via the **Set Parameter Fram**e. The inclination sensor confirms each Frame with a **Reply Parameter Frame** which also contains the needed data according to FSC.

5.5.1 Set Parameter Frame

Each function of the Set Parameter Mode is defined by a special FSC. Table 8 shows all the supported function select codes and the according parameters of a Set Parameter Frame.

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Set/request parameters: Set Parameter ID (default ID = 300h)

FSC	D0	D1	D2	D3	D4	D5	D6	Description	
01h	-	-	-	-	-	-	-	Software reset	
02h	-	-	-	-	-	-	-	Read status	
03h	CYT0	CYT1	-	-	-	-	-	Write cyclic time in RAM	
04h	CYM	-	-	-	-	-	-	Set cyclic mode in RAM	
11h	-	-	-	-	-	-	-	Cyclic time	Read from EEPROM
12h	-	-	-	-	-	-	-	Cyclic mode	
13h	-	-	-	-	-	-	-	Request Position Update ID	
14h	-	-	-	-	-	-	-	Reply Position Update ID	
15h	-	-	-	-	-	-	-	Cyclic Position Update ID	
16h	-	-	-	-	-	-	-	Set Parameter ID	
17h	-	-	-	-	-	-	-	Reply Parameter ID	
18h	-	-	-	-	-	-	-	Baud rate	
19h	-	-	-	-	-	-	-	Cut-off frequency digital filter	
1Ah	-	-	-	-	-	-	-	Zero point offset	
1Bh	SNO	-	-	-	-	-	-	Switching output (A hyst.)*	
1Ch	SNO	-	-	-	-	-	-	Switching output (B hyst.)*	
1Dh	SNO	-	-	-	-	-	-	Switching output active status*	
21h	CYT0	CYT1	-	-	-	-	-	Cyclic time	Write in EEPROM
22h	CYM	-	-	-	-	-	-	Cyclic mode	
23h	ID0	ID1	ID2	ID3	-	-	-	Request Position Update ID	
24h	ID0	ID1	ID2	ID3	-	-	-	Reply Position Update ID	
25h	ID0	ID1	ID2	ID3	-	-	-	Cyclic Position Update ID	
26h	ID0	ID1	ID2	ID3	-	-	-	Set Parameter ID	
27h	ID0	ID1	ID2	ID3	-	-	-	Reply Parameter ID	
28h	BR	-	-	-	-	-	-	Baud rate	
29h	CF0	CF1	-	-	-	-	-	Cut-off frequency digital filter	
2Ah	OF0	OF1	-	-	-	-	-	Zero point offset	
2Bh	SNO	A10	A11	A20	A21	-	-	Switching output (A hyst.)*	
2Ch	SNO	B10	B11	B20	B21	-	-	Switching output (B hyst.)*	
2Dh	SNO	SAC	-	-	-	-	-	Switching output active status*	
40h	'R'	'E'	'S'	'T'	'O'	'R'	'E'	Default device parameters	

Table 8: Supported FSC and Parameters of the Set Parameter Frames

* These function select codes are available for type MR405.1121.1 only.

(a) Configuration of Cyclic Mode

Parameters:

CYT0/1: Cyclic time in ms
Format: 16 bit unsigned integer value (1 – 65,535)

CYM: (De) activate cyclic mode
= 0 → cyclic mode deactivated
= 1 → cyclic mode activated

The section 5.4 contains a detailed description of the usage of the cyclic mode.

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(b) Configuration of the CAN Identifier

Parameters:

ID0-3: CAN Identifier (ID), 11 bit ID (CAN 2.0 A) or 29 bit ID (CAN 2.0 B)
Format: 32 bit value with the following structure:

ID3								ID2								ID1								ID0							
7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
0	-																				11 Bit ID (CAN 2.0 A)										
1	-	29 Bit ID (CAN 2.0 B)																													

Table 9: CAN Identifier

Example: CAN ID = 361h (29 Bit ID, CAN 2.0 B)
ID0 = 61h, ID1 = 03h, ID2 = 00h, ID3 = 80h

If a CAN ID is set newly, it must not be used by another frame type. If this occurs the error bit STATUS:CmdParamError is set in the Reply Param Frame and the CAN ID is refused.

(c) Setting of Baud Rate

Parameters:

BR: Code of a baud rate
Format: 8 bit unsigned integer value (0 - 9)

Code :			
	0: 10 kBit/s	1: 20 kBit/s	2: 50 kBit/s
	3: 62,5 kBit/s	4: 100 kBit/s	5: 125 kBit/s
	6: 250 kBit/s	7: 500 kBit/s	8: 800 kBit/s
	9: 1 MBit/s		

(d) Configuration of Cut-off Frequency

CF0/1: Cut-off frequency in mHz
Format: 16 bit unsigned integer value (300 – 25,000 / 0 = digital filter disabled)

The section 5.6 contains a detailed description.

(e) Setting of Zero Point Offset

Parameters:

OF0/1: Angle offset related to the zero point of the inclination sensor
Format: 16 bit unsigned integer value (0 – 35995 or FFFFh)
Conversion: Value / 100 = angle offset
Validity: 0° – 359.95° □ set offset directly
FFFFh → set current position as zero position

The section 5.7 contains a detailed description.

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(f) Configuration of the Switching Outputs (Type MR405.1121.1 only)

Parameters:

SNO: Number of a switching output
Format: 8 bit unsigned integer value (0 - 3)

A10/1: Angle value for lower hysteresis threshold A1
Format: 16 bit unsigned integer value (0 – 35995)
Conversion: Value / 100 = angle value
Example: 34585 / 100 = 345.85°

A20/1: Angle value for upper hysteresis threshold A2 (format equal to A10/1)

B10/1: Angle value for lower hysteresis threshold B1 (format equal to A10/1)

B20/1: Angle value for upper of hysteresis threshold B2 (format equal to A10/1)

SAC: (De) activate switching output
= 0 → switching output deactivated (switch always open)
= 1 → switching output activated (switch active)

The section 5.8 contains a detailed description.

(g) Restoration of Default Device Parameters

Parameters:
The following ASCII text sequence has to be transmitted in the data bytes D0-D6 as protection against unintentional reset of the device parameters to factory-made settings:

D0	D1	D2	D3	D4	D5	D6
'R'	'E'	'S'	'T'	'O'	'R'	'E'
52h	45h	53h	54h	4Fh	52h	45h

Table 10: Restoration of Default Device Parameters

The section 5.10 contains a detailed description.

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5.5.2 Reply Parameter Frames

Each Reply Parameter Frame contains the identical FSC as confirmation to the correctly received Set Parameter Frame. The error bits of the status byte indicate insufficient or invalid parameters or errors occurred while writing into the EEPROM (see section 5.1.2). The structure of a Reply Parameter Frames in dependence to the FSC is shown in Table 11.

Reply parameter (on Set Parameter Frames): Reply Parameter ID (default ID = 301h)

FSC	Status	D0	D1	D2	D3	D4	D5	D6	Description	
01h	Device reset (2 frames with FSC = FFh)								Software reset	
02h	Status	-	-	-	-	-	-	-	Read status	
03h	Status	-	-	-	-	-	-	-	Write cyclic time in RAM	
04h	Status	-	-	-	-	-	-	-	Set cyclic mode in RAM	
11h	Status	CYT0	CYT1	-	-	-	-	-	Cyclic time	Read from EEPROM
12h	Status	CYM	-	-	-	-	-	-	Cyclic mode	
13h	Status	ID0	ID1	ID2	ID3	-	-	-	Request Position Update ID	
14h	Status	ID0	ID1	ID2	ID3	-	-	-	Reply Position Update ID	
15h	Status	ID0	ID1	ID2	ID3	-	-	-	Cyclic Position Update ID	
16h	Status	ID0	ID1	ID2	ID3	-	-	-	Set Parameter ID	
17h	Status	ID0	ID1	ID2	ID3	-	-	-	Reply Parameter ID	
18h	Status	BR	-	-	-	-	-	-	Baud rate	
19h	Status	CF0	CF1	-	-	-	-	-	Cut-off frequency digital filter	
1Ah	Status	OF0	OF1	-	-	-	-	-	Zero point offset	
1Bh	Status	SNO	A10	A11	A20	A21	-	-	Switching output (A hyst.)*	
1Ch	Status	SNO	B10	B11	B20	B21	-	-	Switching output (B hyst.)*	
1Dh	Status	SNO	SAC	-	-	-	-	-	Switching output active status*	
21h	Status	-	-	-	-	-	-	-	Cyclic time	Write in EEPROM
22h	Status	-	-	-	-	-	-	-	Cyclic mode	
23h	Status	-	-	-	-	-	-	-	Request Position Update ID	
24h	Status	-	-	-	-	-	-	-	Reply Position Update ID	
25h	Status	-	-	-	-	-	-	-	Cyclic Position Update ID	
26h	Status	-	-	-	-	-	-	-	Set Parameter ID	
27h	Status	-	-	-	-	-	-	-	Reply Parameter ID	
28h	Status	-	-	-	-	-	-	-	Baud rate	
29h	Status	-	-	-	-	-	-	-	Cut-off frequency digital filter	
2Ah	Status	-	-	-	-	-	-	-	Zero point offset	
2Bh	Status	-	-	-	-	-	-	-	Switching output (A hyst.)*	
2Ch	Status	-	-	-	-	-	-	-	Switching output (B hyst.)*	
2Dh	Status	-	-	-	-	-	-	-	Switching output active status*	
40h	Status	-	-	-	-	-	-	-	Default device parameters	

Table 11: Function Codes and Parameters of the Reply Parameter Frames

* These function select codes are available for type MR405.1121.1 only.

The section 5.5.1contains a detailed description of the parameters of the several frames.

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5.6 Digital Filter

The inclination sensor offers the possibility to suppress the influence of external disturbing vibrations. The internal lowpass digital filter (Butterworth, 8th order) is programmable down to 0.3 Hz. The cut-off frequency is adjustable between 0.3 and 25 Hz.

The cut-off frequency is programmable by FSC = 19h (Set Parameter Frame). Values for CF are allowed between 300 (= 0.3 Hz) and 25,000 (= 25 Hz). CF = 0 disables the digital filter.

5.7 Setting of the Zero Point

5.7.1 Operational Principle

The Position of the zero point of the inclination sensor can be adjusted to adapt it to the installed zero point position by adding an offset angle to the internal angle value. While doing so the rotation direction does not change.

5.7.2 Settings

The offset angle can be set in the following two ways with the Set Parameter Frame:

- Set angle offset directly (0° - 359.95°, 0 ≤ OF0/1 ≤ 35995)
- Automatically zero point adjustment (OF0/1 = FFFFh)

For direct setting of the angle offset value it has to be observed that this value is not added to the actually output angle value (with possibly set zero point postponement) but to the internal sensor zero point.

For an automatic zero point adjustment the inclination sensor first has to be moved to the needed zero point position and then the corresponding Set Parameter Frame has to be sent with the code (OF0/1 = FFFFh) (see section 5.5). The current position is saved as new zero point.

Before an automatic zero point setting is carried out, it is useful to set a suitable averaging and reset the sensor (software reset or power off to take over the settings) – especially in case of vibrations. In this way the influence of disturbing vibrations on the angle value can be minimised extensively and the zero point setting can be carried out more precisely.

As the offset angle is saved in the internal EEPROM the inclination sensor has to be reset after setting of the new zero point position (software reset or power off). Just after this reset the new zero point will go into effect.

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5.8 Use of the Switching Outputs (Type MR405.1121.1 only)

The four switching outputs of the inclination sensor ME405.1121.1 are configurable individually. Each setting can be saved in the internal permanent memory (EEPROM). By this an autonomous operation of the switching outputs (without CAN Bus interface) is possible.

5.8.1 5.8.1 Operational Principle

Figure 6 shows the operational principle of a switching output. For each switching output four freely configurable angle ranges are available which determine the switching behaviour of the output.

These ranges are bounded by the absolute inclination values A1, A2, B1 and B2, in which A1/A2 limit the hysteresis A and B1/B2 the hysteresis B. If the inclination position is within one of those hystereses the status of the output is not changed. In the dark grey range (A2 → B1) the switch is closed, in the white range (B2 → A1) it is open.

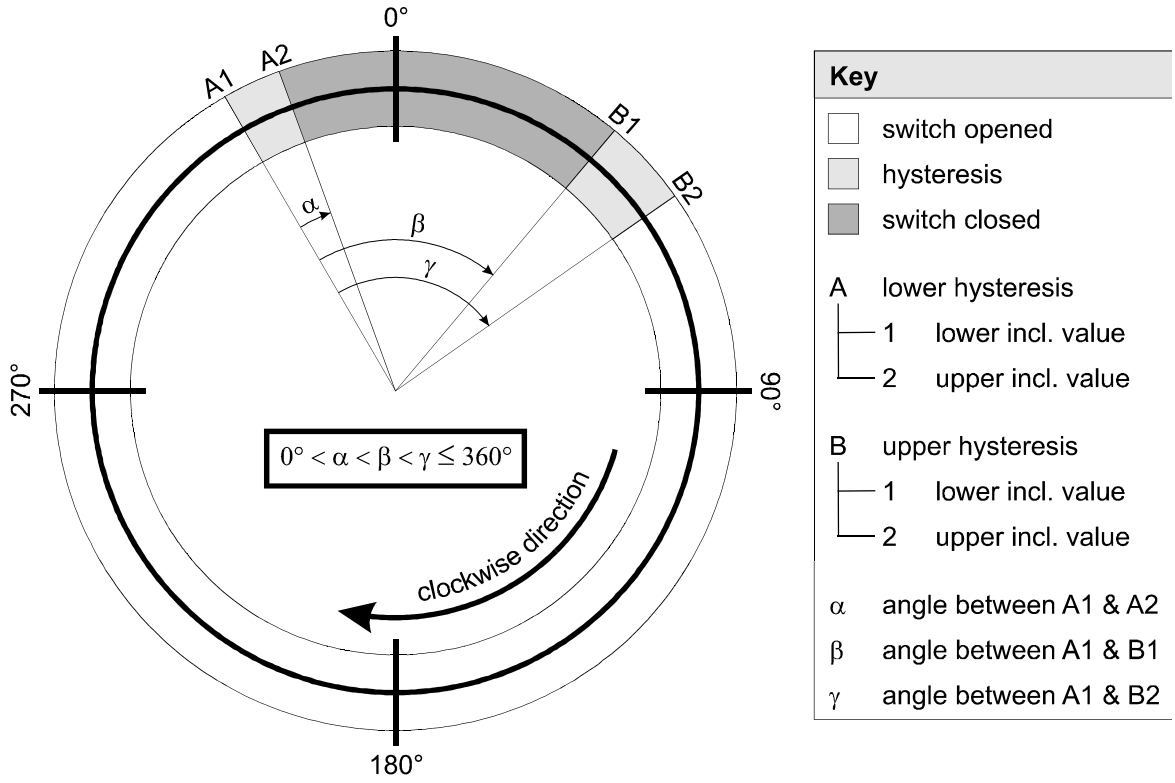

Figure 6: Operational Principle of a Switching Output

A switching output can be (de)activated via the configuration byte active status (SAC). In the deactivated status (SAC = 0) the switch is always open.

5.8.2 Settings

The function of the switching outputs can be configured by the Set Parameter Frames (see section 5.5). All the settings are saved in the internal permanent memory (EEPROM) and will go into effect after reset. The settings which were effective during the change are not influenced.

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The function of one switching output is defined by the following parameters:

- Number of switching output (SNO): Assignment to a switching output (0, 1, 2 or 3)
- Hysteresis A and B with each (values according to zero point):
  - Lower hysteresis threshold (A1 and B1): Angle value for lower hysteresis threshold
  - Upper hysteresis threshold (A2 and B2): Angle value for upper hysteresis threshold
- Active status of a switching output (SAC)

For safety reasons the hysteresis data of a switching output can only be changed if the according active status in the EEPROM is set to „deactivated“ (SAC = 0). Only in this state changes on the angle values A1/2 and B1/2 are possible. Otherwise Set Parameter Frames for the Switching Outputs are ignored and the status bit STATUS:ErrCmdParam is set.

Remarks:

When setting the switching outputs it has to be observed that:

- The values of the angles A1, A2, B1, B2 do not overrun the allowed range of values (0° - 359.95°)
- The difference angles (α , β and γ) fulfil the condition $0° < \alpha < \beta < \gamma < 360°$ (positive angles in clockwise direction) between the range borders (A1, A2, B1 and B2).
- The number of the switching output is valid (SNO ≤ 3)

If one of these conditions is not fulfilled the settings in this Set Parameter Frame are ignored and the error is displayed in the status bit (STATUS:CmdParamError).

To verify the correctness of the new hysteresis data after setting and to activate the switching output the active status has to be set finally (SAC = 1). If this frame is confirmed correctly (STATUS:CmdParamError = 0) the data has been set correctly and the switching output will be active after device reset.

5.9 Status Display of the Two-Coloured LED

The operating status of the inclination sensor is displayed by the two-coloured LED. Here the following in-formation are differed:

- Colour of the LED (red/green) → sensor error (yes/no) (according to status bit STATUS:SensorError)
- LED (flashing/not flashing) → CAN data transfer (sensor is transmitting/sensor is not transmitting data)

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5.10 Default Device Parameters

The inclination sensor is delivered with the default device parameters shown in Table 12. These can be restored by a Set Parameter Frame with FSC = 40h (see section 5.5).

Parameter	**Default Value**		
Cyclic time (CYT)	250 ms		
Cyclic mode (CYM)	0 (deactivated)		
Request Position Update ID	100h (CAN 2.0 A Standard Frame)		
Reply Position Update ID	101h (CAN 2.0 A Standard Frame)		
Cyclic Position Update ID	201h (CAN 2.0 A Standard Frame)		
Set Parameter ID	300h (CAN 2.0 A Standard Frame)		
Reply Parameter ID	301h (CAN 2.0 A Standard Frame)		
Baud rate (BR)	7 (500 kBit/s)		
Cut-off frequency (CF)	3000 (3 Hz)		
Zero point offset (OF0/1)	0		
Switching output 0 (SNO = 0)*	Active status (SAC)	0 (switching output deactivated)	
	Hysteresis A	1 (A10/1)	35750 (357,5°)
		2 (A20/1)	250 (2,5°)
	Hysteresis B	1 (B10/1)	8750 (87,5°)
		2 (B20/1)	9250 (92,5°)
Switching output 1 (SNO = 1)*	Active status (SAC)	0 (switching output deactivated)	
	Hysteresis A	1 (A10/1)	35750 (357,5°)
		2 (A20/1)	250 (2,5°)
	Hysteresis B	1 (B10/1)	8750 (87,5°)
		2 (B20/1)	9250 (92,5°)
Switching output 2 (SNO = 2)*	Active status (SAC)	0 (switching output deactivated)	
	Hysteresis A	1 (A10/1)	35750 (357,5°)
		2 (A20/1)	250 (2,5°)
	Hysteresis B	1 (B10/1)	8750 (87,5°)
		2 (B20/1)	9250 (92,5°)
Switching output 3 (SNO = 3)*	Active status (SAC)	0 (switching output deactivated)	
	Hysteresis A	1 (A10/1)	35750 (357,5°)
		2 (A20/1)	250 (2,5°)
	Hysteresis B	1 (B10/1)	8750 (87,5°)
		2 (B20/1)	9250 (92,5°)

Table 12: Default Settings of the Device Parameters

* These parameters are available for type MR405.1121.1 only.

These default settings will also be set if invalid device parameters are read from the EEPROM after device reset. If the default settings have been restored this is displayed by the status bit STATUS:DefaultParam =1.

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6 Ordering Information

Article Number	Product Type	Description / Difference
MR405.1111.1		1-dimensional, 360°, CAN Bus Interface
MR405.1121.1		2-dimensional, 360°, CAN Bus Interface, with 4 switching outputs

Table 13: Ordering Information

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