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CAN User Manual Inclination Safety Sensor (Type D)V2.3

Original instructions

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1. Introduction

This manual is only valid for CAN Open safety inclination sensor (D-type inclination sensors)

DIS CAN Open safety inclination sensor **(**D-type) family overview:

- Three housing types: 60x50mm plastic or aluminium (QG65), 70x60 stainless steel (QG76)
- Three inclination devices:
  Inclination 1-axis (vertical plane) 1x ±180°
  Inclination 2 axis (horizontal plane) 2x ±30°
  Inclination 2 axis (horizontal plane) 2x ±90°
- Two firmware branches. See release note for more details.
  Codesys comptabile branch
  Non-Codesys compatible branch
- Various CAN settings can be configured according to the CANopen standard
- Various Sensor settings can be configured via CANopen
- CAN Device Profile CIA410 V2.0.0 is supported
- EDS files are available
- CRC calculation tool is available (2 different CRC calculations available, check your firmware version first)

2. Quick Reference Guide

- Hexadecimal figures will have suffix “h” in this manual
- CAN hardware interface: CAN2.0 A and B (complies to ISO11898-1&2)
- CAN communication profile: CAN Open (complies to CiA301 version 4.2.0 & EN50325-4)
- CAN device profile: CiA410 DSP 2.0.0 for inclinometers
- Baud-rate: default 125 kbit/s (can be set to 10, 20, 50, 125, 250, 500, 1000 kbit/s)
- Node-ID: default 01h (possible range 01h – 7Fh, so max. 127 nodes)
- SRDO1 refresh time: default 80ms
- SRDO1 normal: 0FFh + 2*node-ID (101h for node-ID 1).
- SRDO1 inverse: 100h + 2*node-ID (102h for node-ID 1).
- TPDO1 output: 180h + node-ID (181h for node-ID 1). Default ‘off’
- TPDO2 output: 280h + node-ID (281h for node-ID 1). Default ‘off’
- Byte-sequence on CAN-bus: little-endian (least significant byte first)
- Boot-up mode after power on.
- Negative values: two’s complement
- Heartbeat: default off.
- Vendor-ID DIS: 000001BDh (index 1018h sub index 01h)
- Firmware-version available via CAN Object Dictionary (index 1018h sub index 03h)
- Serial number available via CAN Object Dictionary (index 1018h sub index 04h)
- Pre-set/zero adjustment available via CAN Object Dictionary (index 300Fh sub index 01h)
- Sample rate g-sensor-chip: 1600 Hz. Averaging during event-time TPDO1
- Input filter:
  - Fixed 32 taps 45dB suppression (low-pass cut off freq. 20 Hz). (for firmware other than v2.5.4, v2.5.5 / v4.0, v4.1)
  - Bessel filter: low-pass, cut off freq. 10Hz. Controlled by CAN object 3014h. （for firmware v2.5.4 v2.5.5 / v4.0, v4.1 only）
- Output filter: adjustable high- or low-pass filter 1st order. Controlled by CAN object 300Eh.
- Peak Suppression Filter: adjustable by CAN object 4007h and 4008h.
- Document data-types definition:

U8	Unsigned 8-bits number (0 - 255)
U16	Unsigned 16-bit number (0 - 65535)
U32	Unsigned 32-bit number (0 - 4294967295)
S8	Signed 8-bits number (-128 - +127) (also known as ‘Integer 8’)
S16	Signed 16-bits number (-32768 - +32767) (also known as ‘Integer 16’)
S32	Signed 32-bits number (-2147483648 - +2147483647) (also known as ‘Integer 32’)

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3. Safety, Installation, use & maintenance

- By ignoring the safety instructions, the manufacturer cannot be hold responsible for any damage or hazard.
- If any damage is noticed (M12 connector(s) and/or the enclosure) the device must be replaced by a new one in order to avoid hazard.
- Never move the sensor by pulling the cable.
- The device should only be used in situations covered by the datasheet.
- Only a SELV power supply should be used.
- Only the CANopen Safety interface according to EN50325-5 should be used.
- As this device is accelerometer-based the sensor is inherent sensitive for accelerations/vibrations. Application specific testing must be carried out to check whether this sensor will fulfil customer requirements.
- The family of sensors involved will have a variety of types due to different outputs, measuring ranges, enclosures and connection options. Datasheets are available for each specific type. Customer must select and read the datasheet for the product he is using.
- The Safety Related Fault Response Time (SRFRT) of this device is defined as the maximum time the sensor will report a non-safe situation to the outside world, after detecting an internal safety error. Actual value is specified in the datasheet
- Configuration of the device like changing Node-ID, COB-ID's and centering (sensor-offset) can only be done after a new CRC-code is generated separately and written to the device.
- The sensor should be mounted on a stable flat surface with all screws tightened.
- Use only double twisted double shielded CAN cables.
- The proof test interval for this sensor is 20 years. After this interval the sensor should be replaced or checked by comparing the output to a reference sensor or checked / recalibrated by the manufacturer. This is to check for any non-detectable faults and/or degradation. This check / recalibration is not included in the price.
- The calculated MTTFd of the sensor is specified in the datasheet.
- This sensor does not require any maintenance between proof-test intervals.

<u>The user of this safety device shall only use this device when:</u>

- The user is educated to design in / use functional safety sensors.
- The user has taken knowledge of both the datasheet and the user manual.
- the zeroing / centering function is only performed in the right position by an authorized person.
- the redundancy compare parameters (both Redundancy Compare Time and Redundancy Compare Angle) are set by the customer according to the application demands. The actual values used by the customer should fit the application involved. Before using this sensor and with the settings chosen the customer should evaluate risks in order to check whether the chosen settings satisfy his safety requirements. Manufacturer is not responsible for any damage caused by these customer-setting, even when the manufacturer defaults are used.
- the bandwidth settings are according to the application demand
- the device is used inside the specified environmental situation

<u>The user of this safety device shall consider its output as 'defective' in the following situations:</u>

- the device is not responding
- the device is not running in operational state
- the device is not running in the desired mode of operation. To be checked at installation/start-up.
- the device is sending an emergency message
- the device switches to NMT stop state
- the safeguard cycle time (SCT) exceeds the limit
- the safety related validation time (SRVT) exceeds the limit
- the angle output is 200°

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4. Certification

EC Type examination by:
Name: DEKRA testing and Certification GmbH
Adress: Handwerkstraße 15, D-70565, Stuttgart, Germany
Identification Nr.: 0158
EC Type-Examination Certificate no. 4821024.21001
Certificate valid until June 14th 2026
Certified level: SIL CL2 (claim limit 2 according to IEC 62061) & PLd (according to EN ISO 13849)
Architecture: HFT=1 (according to IEC 62061) & CAT3 (according to EN ISO 13849)

5. Inclination sensor explained

An inclinometer measures the angle(s) of the device with respect to earth gravity, using earth gravity vector as external reference. The inclinometer involved is based on an accelerometer. The acceleration values are used to calculate the angle(s). The device takes both the static component (100%) and the dynamic component (partial, depending on frequency and bandwidth-setting) into account. The device will periodically send a CAN message on the CAN-bus containing the angle(s) in degrees.

6. Safety function

The safety function of the inclinometer sensor is to generate angle information based on acceleration values (caused by gravitation) measured by a MEMS acceleration sensor chip. Based on this angle information the safety controller of the application can switch the machine to safe-mode in order to prevent for a dangerous situation.

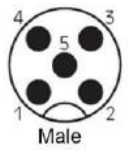
Example: a crane having a maximum tilt angle of the chassis. If the tilt angle of the chassis exceeds a certain critical value, the crane will fall over. To prevent for this an inclinometer can be mounted on the chassis, measuring the X- and Y tilt of the chassis. The safety controller of the application should monitor the X- and Y tilt angles and should switch the crane to safe-mode as soon as a certain tilt angle for X and/or Y exceeds the limits for the application. This will significantly reduce the risk of a dangerous situation to happen.

7. Hardware setup

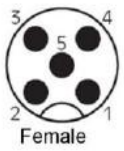
Connection:

Default: 2x 5-pins M12 connector (A-coding), female & male, loop-through.
According to CiA303 V1.8.0

Pin 1:	Shield
Pin 2:	Vcc
Pin 3:	Gnd & CAN_GND
Pin 4:	CAN_H
Pin 5:	CAN_L



Male



Female

Figure 1 Layout CAN bus connector

Optional: 1x 5-pins M12 connector (A-coding) male only
CAN-Cable with 5-pins M12 connector (A-coding) male
CAN-Cable 5-wire

CAN-bus termination 120Ω
Default: no CAN-bus termination inside
Optional: CAN-bus termination inside

Tip: the last CAN-device in the chain should be terminated. For this purpose, you can use the M12 male 5-pin termination resistor' (DIS article number 10217) or the M12 female 5-pin termination resistor' (DIS article number 10194).

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8. Signal processing

The Safety sensor transmits SRDO messages. These messages must be used to check the data and timing. In this SRDO message the angle information is available in normal and in inverse format. Customer should compare these messages in order to check the sensor output is safe. It is also possible to send the data via the TPDO message according to CiA410 but in this case the sensor should be treated as a non-safety sensor. An output filter is available for a stable signal. To compensate for mounting tolerances a pre-set/zero adjustment option is available. When pre-set/zero values are changed a CRC must be calculated off-line (CRC calculate tool available) and written to the sensor. The settings of the SRDO messages are also protected with a CRC code. When these are changed also new CRC code must be determined. When the sensor detects a failure an emergency message is generated and a safe state is activated. In the safe state no communication is possible (No SRDO, TPDO and Heartbeat).

8.1 Sample rate:

The internal g-sensor chip is sampled every 10ms. Each sample of the element consists of 16 samples for each axis. Resulting in sample rate of 1600 Hz. These samples are input for a low-pass Bessel filter. Each 10ms new data is available for the CAN bus.

8.2 Low-pass Bessel filter (for firmware v2.5.4, v2.5.5 / v4.0, v4.1 only)

The sampled MEMS data is processed by a 2nd order low-pass Bessel filter in default. You can set the order of this filter also to 1st order or 3rd order with CAN object dictionary (index 3014h). The cut off frequency is 10Hz fixed.

8.3 Output filter:

The output of the sensor can be extra filtered by a 1st order low-pass filter. Default this output filter is disabled. Via the CAN object dictionary (index 300Eh) this filter can be controlled, by setting the time-constant in ms, with a maximum of the redundancy compare time (set by index 4006h sub-index 02h) .
The time constant is defined as the time in which the output changes to 70% of the step after a step response. The -3dB frequency can be calculated by the formula f = 1 / (2*pi*time-constant). This -3dB frequency is independent of a change in TPDO1 event time and the SRDO refresh time. But when the output filter time-constant is set < min. [TPDO1 event time, the SRDO refresh time], the output filter is disabled. With the factory default, the filter time-constant can be set within 50ms – 2000ms, other value will disable the filter.

8.4 Averaging:

The filtered values are averaged during the TPDO1 cycle time set by the customer. A longer TPDO cycle time results is a smaller bandwidth and therefore a more stable output signal (less noise), but also more phase delay.
e.g. if Event time TPDO1 is 10 ms (fastest time) → a filtered value of 16 samples is available.
e.g. if Event time TPDO1 is 100 ms → an average value of 10*16 samples is available.

8.5 Peak Suppression Filter:

To prevent false emergency stops and incorrect inclination outputs due to acceleration spikes, two Peak Suppression Filters (PSF) are employed.

PSF principle: When activated, the PSF temporarily retains the last valid inclination output for a specified duration to neutralize the effects of acceleration peaks that could distort angle measurements. The sensor continuously monitors the difference between the current and previous readings. If this difference surpasses the threshold angle set by subindex 01h of objects 4007h and 4008h, the inclination output is held for the duration defined by subindex 02h of these objects.

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PSF in the redundancy compare chain (object 4007h) can prevent false safety alarms. For a detailed explanation of the redundancy comparison function in the safety sensor, refer to Chapter 10..
PSF in the inclination output chain (object 4008h) makes the inclination output more stable and realistic.

PSF can be adjusted with 2 parameters:

- Angle (°): This parameter defines the threshold for comparing differences. Only peaks that surpass this threshold will be excluded. If the angle is set to 0°, the PSF (Peak Suppression Filter) will be disabled, allowing all peaks to be considered.
- Time (ms): Once the peak suppression filter is activated, it maintains the previous inclination reading for a duration specified by this parameter, allowing for more stable signal output during transient events.

Default values for Object 4007h: on, 3°, 40ms
Default values for Object 4008h: on, 9°, 50ms

9. Pre-set/zero adjustment:

To eliminate mechanical offsets a pre-set/ zero value can be added. This can be done with the pre-set/zero adjustment method, so introducing a permanent offset on the output of the sensor (centre point = middle of measuring range). The current position will be regarded as the new pre-set/zero position. This can be done limited to 100.000x. (The value is written in EEPROM. The write actions for EEPROM are limited to 100.000x)
Via CAN object 300Fh (see sensor specific part) the centering/zeroing can be done for each axis separately or for both axis at the same time. Status information of the result is available from the same object 300Fh
Since the offset has a direct influence on the output angle, the pre-set/zero value is protected with a CRC code. This CRC code must be set via object 63FFh. When the CRC code is written it must be validated with object 63FE sub id 0 writing data A5h.
The polynomial of the CRC code is:

$$g(x) = x^{16} + x^{12} + x^5 + 1$$

Table 1 Object fields for zero value (pre-set) CRC calculation

Order	Index	Sub index	Value	Size	Data
1	6200h	00h	Highest sub index supported	1 octet	a_7 *to* a_0
2		01h	Sub index number	1 octet	b_7^1 *to* b_0^1
3			Safety slope longitudinal offset (pre-set) value	2 octets	c_{15} *to* c_0
4		02h	Sub index number	1 octet	b_7^2 *to* b_0^2
5			Safety slope lateral offset(pre-set) value	2 octets	d_{15} *to* d_0

For CRC calculation a PC tool is developed and can be found on the DIS web site www.dis-sensors.com
We have implemented two different CRC-calculations. Please check your firmware version number first, and then select the right Firmware version when using the PC-tool.
A CRC code is also mandatory for SRDO1 messages. For more detailed information about generating see EN 50325-5. This CRC code can also be calculated with the same PC tool.

10. Accelerometer element tolerance

The sensor consists of two accelerometer elements. The acceleration values of these elements are converted to angles. These angles are compared, and a safe state is set when the elements differ too much. To prevent false alarms, a tolerance can be configured. The tolerance consists of allowing an angle of deviation during a certain time.
These values are adjustable via object 4006h sub- index 01h and 02h. The default values are 300d and 200d (3° during 2000 ms). The actual values used by the customer should fit the application involved. Before using this sensor and with the settings chosen, the customer should evaluate risks in order to check whether the chosen settings satisfy his safety requirements. Manufacturer is not responsible for any damage caused by these customer-setting, even when the manufacturer defaults are used.
Definitions for the Redundancy error:
'Redundancy Compare time' (user programmable, default 2000ms)
'Redundancy Compare angle' (user programmable, default 3°)

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11. Output invalid

A vertical device measures the angle relative to the gravity. When a device is tilted towards the horizontal plane for more than 45°, the angle can't be accurately measured because the gravitation vectors become shorter. In this case, the output is set to 200°. This value indicates that the output is invalid.

For horizontal devices, the same principle is valid. When the longitudinal axis is greater than 45 degrees, the output for lateral axis is set to 200°. When the lateral axis is greater than 45°, the longitudinal is set to 200°. The output is also invalid when the range limits are reached. Example when angle is 32° for a ±30 device the output is limit to ±30°. For a ±90 device, the angle is limited to ±90°.

12. Writing objects

When writing an object, it can have a major influence on the output. To prevent unauthorized changes, most write action can only be executed when the device is in pre-operational state. According to EN 50325-5

13. Changing SRDO1 settings

When changing an SRDO1 setting the sensor must be in pre-operating state.
The direction 1301h sub id 01h must be disabled by writing 00h to object 1301h sub id 01h.
When the SRDO setting is changed the CRC code must also be changed and activated. Finally, the data must be stored in EEPROM

Example to change SRDO1 refresh time

Load object:	1301h sub id 01h with:	00h	disable SRDO1 communication.
Load object:	1301h sub id 02h with:	0064h	new SRDO1 refresh time.
Load object:	1301h sub id 01h with:	01h	enable transmit SRDO1 communication.
Load object:	13FFh sub id 01h with:	xxxxh	code from CRC calculation tool.
Load object:	13FEh sub id 00h with:	A5h	validate new CRC.
Load object:	1010h sub id 01h with:	"save" or 65766173h	write new SRDO1 refresh time, CRC and validation to EEPROM.

After a power reset and when the device is set to operational, the transmission time is equal to the desired time.

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14. Internal diagnostic tests

To ensure safety the hard- and software of the safety sensor is continuously checked. When a failure is detected, an emergency message is sent. After sending this message, the device goes to a safe state, in which no communication is possible (No SRDO, TPDO and Heartbeat). In this state, a NMT reset will not restart the sensor. Failure should be analyzed by reading the emergency message. If the error can be fixed, giving the sensor a new power cycle will restart the communication. If it is a 'sensor element error (redundancy error), you might consider updating 'redundancy compare time' and/or 'redundancy compare angle. If the error cannot be fixed, please contact your distributor.

The receiving application should detect that no communication is possible and shall set the system to a safe state.

Table 2 Emergency code

CAN ID: 080h+NODE_ID (emergency message)		
Byte number	Type	Description
01h and 00h	U16	Error-code: 0000h: no error FF00h: CAN Open device specific error code
02h	U8	Error-register: 00h: no error 01h: error register object 1001h
04h and 03h	U8	Diagnose error CAN stack: 0000h: No error 0001h: Reset state 0002h: Can driver has to be reset 0004h: Safety cycle is ready 0008h: reserved 0010h: Timeout by watchdog diagnose 0020h: Overvoltage 0040h: Unknown interrupt occurs 0080h: CSC stack has entered safety stop 0100h: Initialization error 0200h: Can error 0400h: CAN NMT state error 0800h: Diagnose error 1000h: Safety cycle error 2000h: SRDO error 4001h: RAM error 8000h: Unknown error -multiple errors can be indicated (bitwise OR-ed) simultaneously. -when an overvoltage occur, the device stays permanent in safe state
05h		Unique Identifier: 3Eh: Voltage error - either overvoltage or undervoltage detected. -Full code list see appendix C
06h	U8	Diagnose error CAN stack: 00h: Start CRC calculation ROM 01h: Check register 02h: Check stack 03h: Check addressing part unit 1 04h: Check addressing part unit 2 05h: Check conditional jumps 06h: Check opcode 07h: Check CRC for SRDO's

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		09h: Check time stamp 0Ah: Wait for end of CRC calculation for CSC main 0Bh: Start CRC calculation ROM for application 0Ch: Wait for end of CRC calculation for application 0Dh: Start CRC calculation ROM for start-up monitor 0Eh: Wait for end of CRC calculation for start-up monitor 0Fh: Check RAM with GALPAT algorithm 10h: Check software interrupt 11h: Check software interrupt was ok 12h: Check undefined instruction interrupt 19h: Check undefined instruction interrupt was ok 7Fh: Idle state
07h	U8	Application error 00h: No application error 01h: Unknown interrupt occurs 02h: Safety RAM error 04h: SRDO error 08h: 3V3 monitor error 10h: Sensor element error (Redundancy Error) 20h: RAM CRC error 40h: EEPROM error 80h: Watchdog error Multiple errors can be indicated (bitwise OR-ed) simultaneously.
Sensor goes to safe state (stop state) when an error is reported. Sensor must be power cycled to restart.		

Example 1:
Receive COB-id 81h with data 00h FFh 01h 80h 00h 00h 0Eh 08h
81 emergency message of node id 01h
00h FFh-> FF00h CAN Open device specific error code
01h-> error register object 1001h
80h 00h ->0080h CSC stack has entered safety stop
00h reserved
0Eh Wait for end of CRC calculation for start-up monitor
08h. 3V3 monitor error

Example 2:
Receive COB-id 81h with data 00h FFh 01h A0h 00h 3Eh 00h 00h
81 emergency messages of node id 01h
00h FFh-> FF00h CAN Open device specific error code
01h-> error register object 1001h
A0h 00h ->00A0h Overvoltage and CSC stack has entered safety stop
3Eh Voltage error
00h Start CRC calculation ROM
00h. No application error

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15. CAN Predefined Connection Object ID's

Table 3 COB-ID's

Standard CAN Connection Object ID's (Most used)		
CAN-ID	Data	Description (client = CAN master, server = sensor)
000h		NMT Network Management
080h		Sync command to sensor
080h + node-ID		Emergency message from sensor
0FFh + 2 * node-ID		SRDO1 normal message
100h + 2 * node-ID		SRDO1 inverse message
180h + node-ID		TPDO1 message from sensor
280h + node-ID		TPDO2 message from sensor
580h + node-ID		SDO Download Request: Feedback from sensor (server to client)
600h + node-ID		SDO Upload Request: Write to sensor (client to server)
700h + node-ID	00h 04h 05h 7Fh	heartbeat from sensor, boot-up mode heartbeat from sensor, stopped mode heartbeat from sensor, operational mode heartbeat from sensor, pre-operational mode

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16. CAN Object Dictionary Entries (Communication Profile section)

Table 4 Communication profile section

Index	Sub-index	Type	Read/Write	Data	Description
1000h	00h	U32	R	3001019Ah 3002019Ah	Device Type = Inclination, C1 (360°) normal TPDO = Inclination, C2 (±90° or ±30°) normal TPDO
1001h	00h	U8	R	00h 81h	Error Register = Normal operation = Device error
1003h	00h	U32	R		Predefined error field
1005h	00h	U32	R+W		COB-ID SYNC
1008h	00h	ASCII	R	DIS sensors QGxx CANopen Safety	Device name
1009h	00h	ASCII	R	12986-01-A0	Hardware version
100Ah	00h	ASCII	R	FW275-4.0.0	Software version
100Ch	00h	U16	R		Guard time
100Dh	00h	U8	R		Life time factor
1010h	Store parameters in EEPROM				
	01h	U32	R+W	“save” in ASCII Or “65766173h”	Save all parameters
	02h	U32	R+W	“save” in ASCII Or “65766173h”	Save communication parameters
	03h	U32	R+W	“save” in ASCII Or “65766173h”	Save application parameters
1011h	Restore parameters from EEPROM. (CRC validation is oblige after restoring the default values.)				
	01h	U32	R+W	“load” in ASCII Or “64616F6Ch”	Restore all parameters
	02h	U32	R+W	“load” in ASCII Or “64616F6Ch”	Restore communication parameters
	03h	U32	R+W	“load” in ASCII Or “64616F6C h”	Restore application parameters
1014h	00h	U32	R+W	$NODEID+0x80	COB-ID EMCY
1017h	00h	U16	R+W	0000h	Producer Heartbeat time (ms) = 0 ms (heartbeat switched off, default)
1018h	01h	U32	R	000001BDh	Vendor ID
	02h	U32	R	04000001h 04000002h 04000003h	Product Code = Inclination 1-axis (vertical plane): 360° = Inclination 2-axis (horizontal plane): 2x ±90° = Inclination 2-axis (horizontal plane): 2x ±30°
	03h	U32	R	00020001h	Firmware version sensor (000x000yh) = v2.1
	04h	U32	R	00000000h up to FFFFFFFFh	Serial number sensor (32 bit, unique)
1300h	00h	U8	R+W	00h 01h	GFC parameter = Invalid = Valid
1301h	SRDO1 communication parameter				
	01h	U8	R+W	00h 01h 02h	SRDO1 direction = Disabled = Tx/SRDO producer (default) = RX/SRDO consumer
	02h	U16	R+W	50h/80d	SRDO1 refresh time/SCT = 80 ms default (min.=SRVT) (Tolerance: -10ms...+30ms)
	03h	U8	R+W	14h/20d	Safety-relevant validation time (SRVT) = 20 ms default
	04h	U8	R+W	FEh/254d	Transmission type = Asynchronous (default)
	05h	U32	R+W	101h	COB-ID1 0xFFh + Node ID *2 (default)

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Index	Sub-index	Type	Read/Write	Data	Description
	06h	U32	R+W	102h	COB-ID2 0x100h + Node ID *2 (default)
1381h	SRDO1 mapping parameter				
	00h	U8	R	8 16	Highest sub-index supported = Codesys compatible version = non-Codesys compatible version
	01h	U32	R	62100108h	SRDO1 mapping object 1 (normal) = Normal longitudinal bit 0-7
	02h	U32	R	62110108h	SRDO1 mapping object 1 (inverse) = Inverse longitudinal bit 0-7
	03h	U32	R	62100208h	SRDO1 mapping object 2 (normal) = Normal longitudinal bit 8-15
	04h	U32	R	62110208h	SRDO1 mapping object 2 (inverse) = Inverse longitudinal bit 8-15
	05h	U32	R	62200108	SRDO1 mapping object 3 (normal) = Normal lateral bit 0-7
	06h	U32	R	62210108	SRDO1 mapping object 3 (inverse) = Inverse lateral bit 0-7
	07h	U32	R	62200208	SRDO1 mapping object 4 (normal) = Normal lateral bit 8-15
	08h	U32	R	62210208	SRDO1 mapping object 4 (inverse) = Inverse lateral bit 8-15
	09h – 10h	U32	R	00000000	non-codesys compatible version
13FEh	00h	U8	R+W	A5h Other value	SRDO configuration validation = SRDO configuration signature valid = SRDO configuration signature not valid
13FFh	01h	U16	R+W		CRC of SRDO1
1800h	TPDO1 Communication Parameter				
	01h	U32	R+W	40000181h C0000181h	COB-ID TPDO1 = Enable = Disable (default)
	02h	U8	R+W	01h FFh	Transmission Type = Enable = Disable (default)
	03h	U16	R+W	0000h	Inhibit Time
	05h	U16	R+W	0032h/50d 0000h	TPDO1 event-time (in ms) = 50 ms (default) (Max. = 5000ms) = 0 ms (disable TPDO1)
1801h	TPDO2 Communication Parameter				
	01h	U32	R+W	40000281h C0000281h	COB-ID TPDO2 = Enable = Disable (default)
	02h	U8	R+W	01h FFh	Transmission Type = Sync = Event-driven (default)
	03h	U16	R+W	0000h	Inhibit Time
	05h	U16	R+W	0032h/50d 0000h	TPDO2 event-time (in ms) = 50 ms (default) (Max. = 5000ms) = 0 ms (disable TPDO2)
1A00	01h	U8	R+W	60100010h	TPDO1 Mapping Parameter Longitudinal slope
	02h	U8	R+W	60200010h	Lateral slope
1A01	01h	U8	R+W	60100010h	TPDO2 Mapping Parameter Longitudinal slope
	02h	U8	R+W	60200010h	Lateral slope

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17. CAN Object Dictionary Entries (Manufacturer Specific Profile section)

Table 5 Manufacturer specific profile section

Index	Sub index	Type	Read/ Write	Data	Description
3000h	01h	U8	R+W	01h up to 7Fh	Node-ID 01h (default) up to 7Fh (when Node-ID >3Fh non-standard COB-ID of SRDO1 must be used) *(changes are being affected after a power cycle only)*
3001h	01h	U8	R+W	06h 05h 04h 03h 02h 01h 00h	Baud rate (kbit/s) = 50 = 100 = 125 (default) = 250 = 500 = 800 = 1000 *(changes are being affected after a power cycle only)*
300Eh	01h	U16	R+W	0000h 0064h/100d	Output filter time in ms (1st order low pass filter) = Disabled (default) = Enabled, 100 ms (f=1.59 Hz) (Max. = 'redundancy compare time')
300Fh	01h	S8	R+W	Write 01h Write 02h Write 03h Read 00h Read FFh Read FEh Read FDh	Pre-set(Zero) adjustment = start zero longitudinal (1-axis) = start zero lateral (2-axis) = start longitudinal and lateral (2-axis) = zero successful = fail zero longitudinal (1-axis) = fail zero lateral (2-axis) = fail zero both axis (2-axis)
3014h	01h	U8	R+W	00h 01h 02h 03h	Low pass Bessel filter f_{-3dB}=10Hz (for firmware v2.5.4,V2.5.5 / V4.0, V4.1 only) = OFF = ON 1st order = ON 2nd order (default) = ON 3rd order
4006h	01h	U16	R+W	012Ch/300d	Redundancy Compare Angle (maximal allowed angle difference between two elements) = 3,00° (default) Max. = 18° (360°)/ 3° (±30h) / 9° (±90h)
	02h	U16	R+W	00C8h/200d	Redundancy Compare Time [x10 ms] (Time within maximal deviation is allowed) = 2000 ms (default) (Max. = 10 s)
4007h	Peak Suppression Redundancy (PSF in Redundancy Compare Chain)				
	01h	U16	R+W	0000h 012Ch/300d	Peak Suppression Redundancy Angle (Maximal angle deviation between two output to enable the filter) = Disabled = 3° (default) (Min. = 3°)
	02h	U16	R+W	0004h/4d 03E8h/1000d	Peak Suppression Redundancy Time [x10 ms]. (Output holding time) = 40 ms (default) = 10s (Max.)
4008h	Peak Suppression Output (PSF in Output Chain)				
	01h	U16	R+W	0000h 0384h/900d 012Ch/300d	Peak Suppression Output Angle (Threshold to enable the filter) = Disabled = 9° (default for all type) = 3° (Min. for all type)
	02h	U16	R+W	0005h 03E8h/1000d	Peak suppression output time [x10 ms]. (Output holding time) = 50 ms (default) = 10 s (Max.)

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18. CAN Object Dictionary Entries (Application Specific Profile section)

Table 6 Application specific profile section

Index	Sub index	Type	Read/ Write	Data	Description
6000h	00h	U8	R	0Ah/10d	Resolution = 0,01°
6010h	00h	S16	R		Longitudinal slope
6011h	00h	U8	R+W	 Bit0 = 0 Bit0 = 1 Bit1 = 0 Bit1 = 1 Other bits	Operating parameter longitudinal slope = Slope normal (default) = Slope inverse = Pre-set disabled = Pre-set enabled (default) = No function
6020h	00h	S16	R		Lateral slope
6021h	00h	U8	R+W	 e.g. Bit0 = 0 e.g. Bit0 = 1 e.g. Bit1 = 0 e.g. Bit1 = 1 e.g. Other bits	Operating parameter lateral slope = Slope normal = Slope inverted = Pre-set disabled = Pre-set enabled = No function
6200h	01h	S16	R+W		Pre-set value longitudinal
	02h	S16	R+W		Pre-set value lateral
6210h	01h	U8	R		Bit 0-7 of normal longitudinal slope
	02h	U8	R		Bit 8-15 of normal longitudinal slope
6211h	01h	U8	R		Bit 0-7 of inverse longitudinal slope
	02h	U8	R		Bit 8-15 of inverse longitudinal slope
6220h	01h	U8	R		Bit 0-7 of normal lateral slope
	02h	U8	R		Bit 8-15 of normal lateral slope
6221h	01h	U8	R		Bit 0-7 of inverse lateral slope
	02h	U8	R		Bit 8-15 of inverse lateral slope
63FEh	00h	U8	R+W	 A5h 00h	Pre-set configuration field = Signature valid = Signature not valid
63FFh	01h	U16	R+W		Pre-set value signature

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19. EDS files

The “Electronic Data Sheet” (EDS file) is a file format that describes the communication behavior and the object dictionary entries of a device. In fact, it’s a template. This allows tools such as CAN configuration tools to handle the device properly. The file format is described in CiA306 V1.3.0

The EDS-file contains all possible settings and functions for the device by describing the CAN object dictionary for the device to be set by CAN commands.

The EDS-file does not contain a customer specific configuration description (the values of the object dictionary, like i.e. the chosen baud rate, TPDO1 event time, Node ID etc.). For this purpose, the customer can generate a so called DCF-file (Device Configuration File) with all customers specific settings out of the EDS-file. The DCF file is in fact the incarnation of the EDS-file.
After loading the DCF-file into the device you have to store the settings into EEPROM by index 1010h sub index 01h to store permanently, see “CAN Object Dictionary Entries”.

The EDS-files available for sensors with embedded firmware version D-type described in this document should have a version D-type also.

The next EDS-files are available at www.dis-sensors.com under ‘downloads’:

- QG_Dtype_1_axis_360v_v*.*
- QG_Dtype_2_axis_30h_v*.*
- QG_Dtype_2_axis_90h_v*.*

20. Document revision control

V1.0 first release
V1.1 Add SRD1 objects programming. Add Writing objects in pre-operating state. Major text additions
V1.2 Add commend after review JK
V1.3 Safety information added (MvA)
V1.4 Layout changed (RMo), safety chapters modified (MvA)
V1.5 Change mapping object 1381h for 1 axis and 2 axis according to profile (RMo)
V1.6 20190725 Various more accurate descriptions, some parameters maximized, see release notes firmware v2.9 & v2.5.3
V1.7 20200831 Insert Peak suppression filter for MEMS elements and for inclination output (MvA)
V1.8 20210823 correct proof test period and pre-set disable/enable(SX).
V1.9 20210917 Re-certification / EC type examination by DEKRA successful. New certificate nr.
V2.0 20220321 Add max. redundancy compare angle. (SX)
V2.1 20230116 Add low-pass Bessel filter and new objects 1008-100Ah for the device information. (SX)
20230515 Input filter and the schematic updated for the new firmware. (SX)
V2.2 20251202 object dictionary updated with the latest information. Correct PSF description and EMCY, add tolerance time to SRDO refresh time. (SX)
V2.3 20260512 Update EMCY code with unique identifier. Update firmware version in quick reference input filter. (SX)

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A. Appendixes1 Schematic overview inclination measurement (for firmware other than v2.5.4, v2.5.5 / V4.0, V4.1)

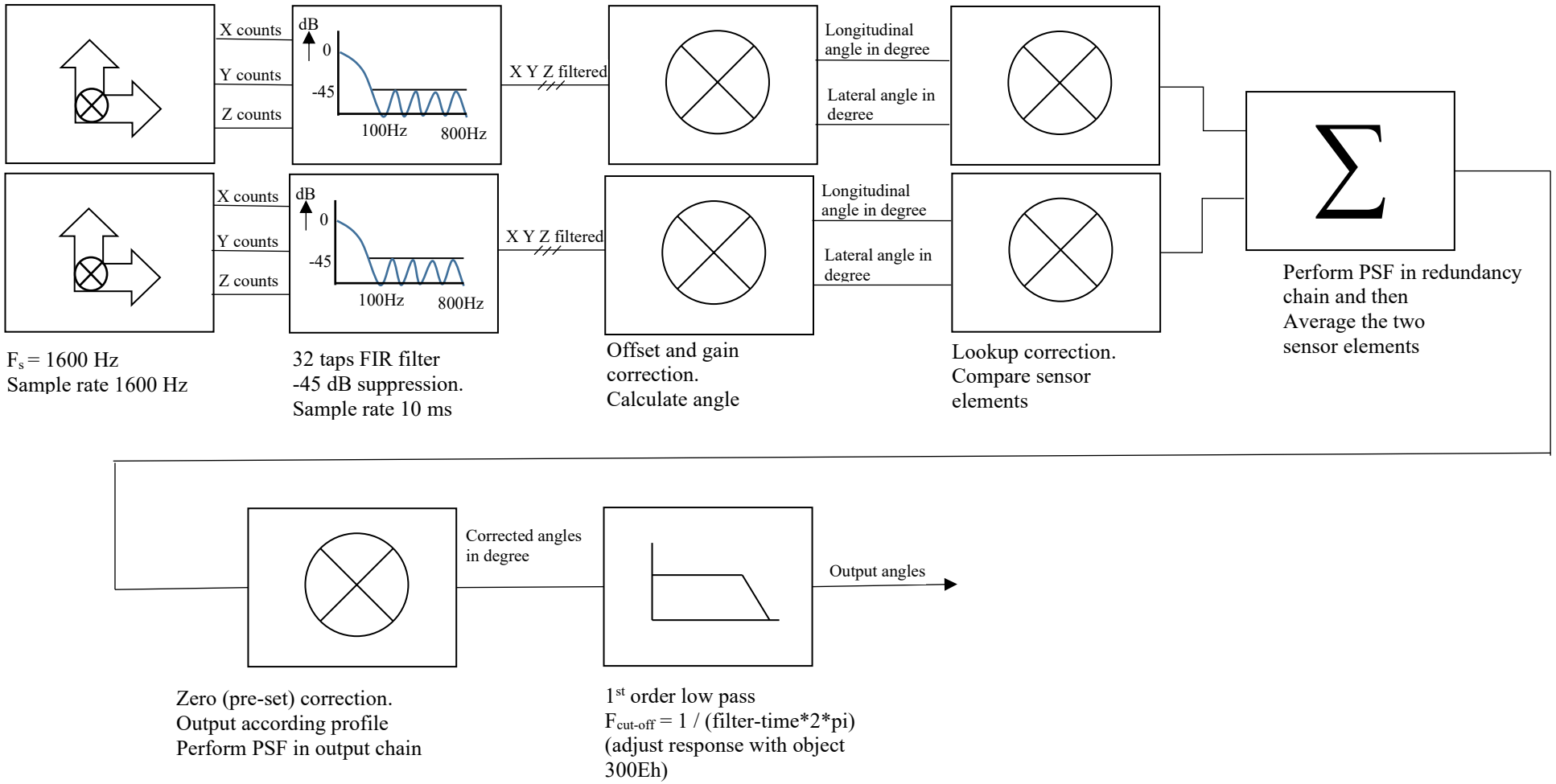


Figure 2 Schematic overview inclination measurement.

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B. Appendixes2 Schematic overview inclination measurement (for firmware v2.5.4, v2.5.5 / V4.0, V4.1 only）

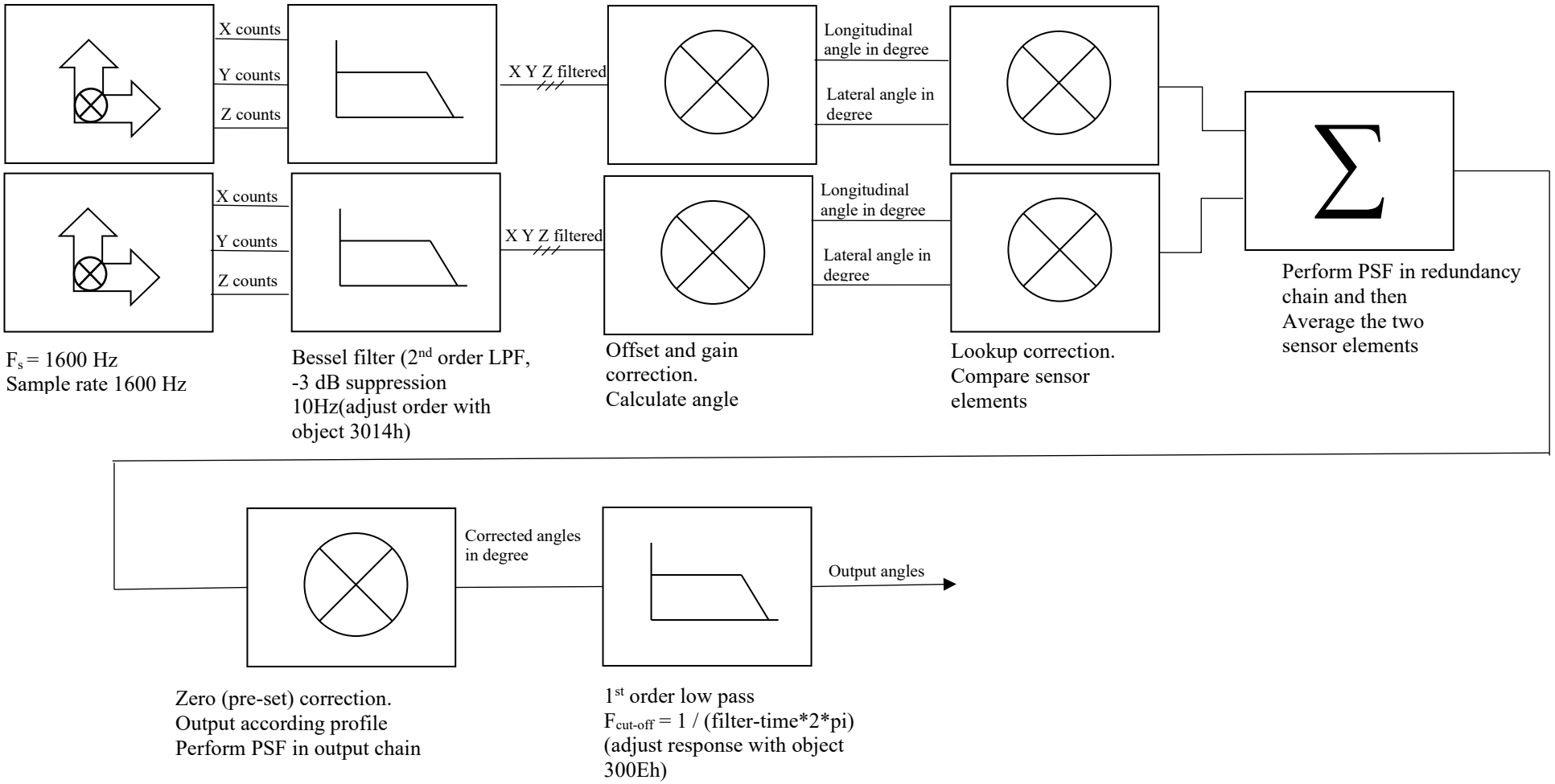


Figure 3 Schematic overview inclination measurement.

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C. Appendixes3 Code list for EMCY message byte 05 Unique Identifier

Unique ID	Description	Unique ID	Description
0x00	Angle calculation between 2 MEMS differs too much	**0x3D**	Updating of EEPROM fails (related Manufacturer Data block)
0x01	Updating CRC on zero values fails	**0x3E**	Under- or overvoltage occured on the 5.0V voltage
0x02	Updating zero values in EEPROM fails	**0x3F**	Error occured during handling of SRDO message
0x03	Updating of RAM CRC value fails (related to Application Data block)	**0x40**	Error occured during handling of SRDO message
0x0A	Updating of RAM CRC value fails (related to EEPROM)	**0x41**	Error occured during handling of SRDO message
0x0B	Updating of RAM CRC value fails (related to EEPROM)	**0x42**	Error occured during handling of SRDO message
0x0C	Updating of RAM CRC value fails (related to EEPROM)	**0x43**	Updating of RAM CRC value fails (related to EEPROM Application Data block)
0x14	Device ID of MEMS_A is incorrect	**0x44**	Updating of RAM CRC value fails (related to EEPROM Application Data block)
0x15	Device ID of MEMS_B is incorrect	**0x45**	Updating of RAM CRC value fails (related to EEPROM Communication Data block)
0x16	Selftest error in X-axis of MEMS_A	**0x46**	Updating of RAM CRC value fails (related to EEPROM Communication Data block)
0x17	Selftest error in Y-axis of MEMS_A	**0x47**	Updating of Communication Data block in EEPROM fails
0x18	Selftest error in Z-axis of MEMS_A	**0x48**	Updating of Application Data block in EEPROM fails
0x19	Selftest error in X-axis of MEMS_B	**0x49**	Updating of Communication Data block in EEPROM fails
0x1A	Selftest error in Y-axis of MEMS_B	**0x4A**	Updating of Application Data block in EEPROM fails
0x1B	Selftest error in Z-axis of MEMS_B	**0x4B**	Updating of RAM CRC value fails (related to EEPROM Manufacturer Data block)
0x1C	SPI communication error MEMS_B	**0x4C**	Updating of RAM CRC value fails (related to EEPROM Manufacturer Data block)

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0x1D	SPI communication error MEMS_A and MEMS_B	**0x4D**	Updating of RAM CRC value fails (related to EEPROM Manufacturer Data block)
0x1E	SPI communication error MEMS_A	**0x4E**	Updating of RAM CRC value fails (related to EEPROM Manufacturer Data block)
0x1F	SPI communication verify error MEMS_A (acceleration range register)	**0x4F**	Updating of RAM CRC value fails (related to EEPROM Manufacturer Data block)
0x20	SPI communication verify error MEMS_B (acceleration range register)	**0x50**	Updating of RAM CRC value fails (related to EEPROM Manufacturer Data block)
0x21	SPI communication verify error MEMS_A (configuration register)	**0x51**	Updating of RAM CRC value fails (related to EEPROM Manufacturer Data block)
0x22	SPI communication verify error MEMS_B (configuration register)	**0x52**	Updating of RAM CRC value fails (related to EEPROM Application Data block)
0x23	SPI communication verify error MEMS_A (watermark level register)	**0x53**	Updating of RAM CRC value fails (related to EEPROM Communication Data block)
0x24	SPI communication verify error MEMS_B (watermark level register)	**0x54**	Updating of RAM CRC value fails (related to EEPROM Application Data block)
0x25	SPI communication verify error MEMS_A (power control register)	**0x55**	Updating of RAM CRC value fails (related to EEPROM Application Data block)
0x26	SPI communication verify error MEMS_B (power control register)	**0x56**	Updating of RAM CRC value fails (related to EEPROM Application Data block)
0x27	SPI communication verify error MEMS_A (power configuration register)	**0x57**	Updating of RAM CRC value fails (related to EEPROM Application Data block)
0x28	SPI communication verify error MEMS_B (power configuration register)	**0x58**	Updating of RAM CRC value fails (related to EEPROM Application Data block)
0x29	MEMS interrupt are not coming at a regular interval	**0x59**	Updating of RAM CRC value fails (related to EEPROM Application Data block)
0x32	RAM check error in AppSaveRam block	**0x5A**	Updating of RAM CRC value fails (related to EEPROM Application Data block)
0x33	CRC error in CAN Communication Data block	**0x5B**	Updating of RAM CRC value fails (related to EEPROM Application Data block)
0x34	CRC error in CAN Application Data block	**0x5C**	Updating of RAM CRC value fails (related to EEPROM Application Data block)
0x35	CRC error in CAN Manufacturer2 Data block	**0x5D**	Updating of RAM CRC value fails (related to EEPROM Application Data block)
0x36	CRC error in CAN Manufacturer Data block	**0x5E**	Unused interrupt was triggered
0x37	Voltage error occured on the 3.3V voltage	**0x5F**	Voltage error occured on the 3.3V voltage
0x38	Updating of RAM CRC value fails (related to voltage error)	**0x60**	Updating of RAM CRC value fails (related to EEPROM Manufacturer2 Data block)
0x39	Updating of RAM CRC value fails (related to voltage error)	**0x61**	Updating of RAM CRC value fails (related to EEPROM Manufacturer2 Data block)

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0x3A	Updating of RAM CRC value fails (related to EEPROM Manufacturer Data block)	**0x62**	Updating of Manufacturer2 Data block in EEPROM fails
0x3B	Updating of RAM CRC value fails (related to EEPROM Manufacturer2 Data block)	**0x64**	Watchdog expired
0x3C	Updating of RAM CRC value fails (related to EEPROM Manufacturer Data block)	**0x65**	Watchdog expired
		0x6E	Error occured in bessel-filter

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