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1 History

Ver.	Date	Purpose / Description of changes	Author
0.1	2014-05-14	Begin of creation, document not released yet	M. Kalinowski
0.2	2014-07-07	Change of CAN H & L Position	F. Schwieger

2 Applicable Documents

#	Document title	Originator	Description
1	CiA 301	CiA	CANopen application layer and communication profile
2	CiA 302, Part 3	CiA	Configuration and program download
3	CiA 305	CiA	Layer setting services (LSS) and protocols
4	CiA 410	CiA	Device profile for inclinometer

3 Description of the G-NSDOG2-200 inclinometer

The inclinometer is based on a micro machined accelerometer (MEMS). This sensor includes 3 acceleration sensing axes that form a nearly orthogonal 3d coordinate system. A microcontroller reads the sensor information as voltage signal. The amplified signal is digitized with a 12bit ADC using oversampling to increase resolution. Pitch and Roll data is calculated from sensor signals after digital temperature compensation is applied. Misalignment error is minimized by application of a full 3d corrective algorithm.

For this sensor module a CAN 2.0A interface according to CANopen is used. The protocol is detailed in this document.

MEAS part number	related drawing	description
G-NSDOG2-201	tbd	dual axis CAN Inclinometer, DOG series

4 Mechanics and Connections

4.1 Mechanical data

parameter	symbol	conditions	min	typ	max	unit
weight	m			60		g
width	d_{Width}			70.5		mm
length	d_{Length}			45		mm
height	d_{Height}			15		mm

4.2 Dimensions

The dimensions of the inclinometer are depicted by Figure 4.2.1.

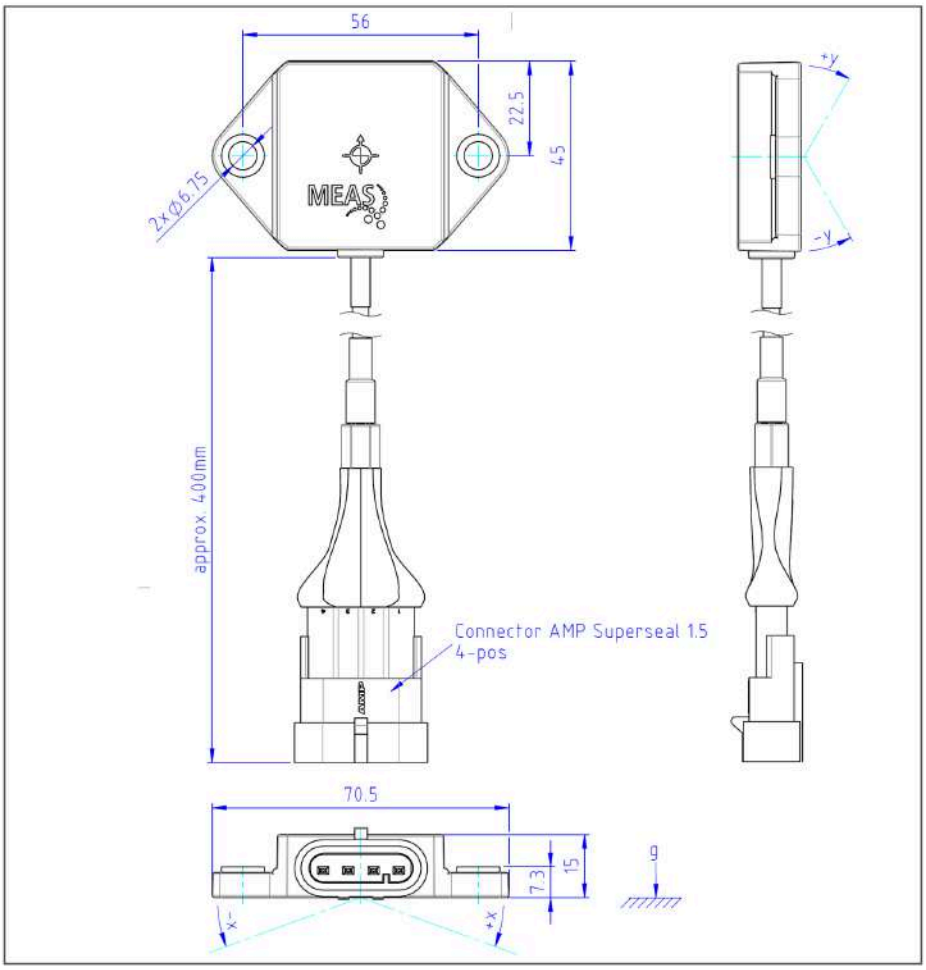

Figure 4.2.1: inclinometer and connector, g arrow indicates acceleration of gravity in neutral/zero position.

4.3 Connector

The inclinometer has an AMP Superseal 1.5 series connector with 4 terminals. It mates with TE Connectivity part number 282088-1.

The pin assignment is described below.

pin	function	description	direction
1	supply voltage	8~30V	in
2	ground/ earth	0V, ref. voltage	in
3	CAN_H	CAN high line	in/out
4	CAN_L	CAN low line	in/out

5 Absolute maximum ratings

CAUTION: Exceeding these values may permanently damage the device!

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Supply voltage	V_{CC}	reference: GND	-0.3		35	VDC
Operating temperature	T_{OP}		-40		85	°C
Storage temperature	T_{STO}		-40		85	°C

5.1 Definition of Absolute Maximum Ratings

Absolute maximum ratings are limiting values of permitted operation and should never be exceeded under the worst possible conditions either initially or consequently. If exceeded by even the smallest amount, instantaneous catastrophic failure can occur. And even if the device continues to operate satisfactorily, its life may be considerably shortened. Operation at an absolute maximum rating is permitted (although not desirable-even a short test is believed by some to cause incipient failure) but operation at two or more limits (i.e., output current and ambient temperature) almost always means that some other limit has been exceeded (in this instance, probably package power dissipation). In certain ICs that include an internal thermal shutdown, fault conditions will generate higher than permitted (steady-state) temperatures and activate device thermal shutdown circuitry. These fault conditions can be tolerated for short periods of time, but they will affect life expectancy and should be avoided.

6 Operating Conditions

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Operating temperature	T_a		-40		85	°C
Angular Range		Both axes	-90		90	deg

7 Electrical Characteristics

If not otherwise noted, 12 VDC supply voltage applied at an ambient temperature of 25°C.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Supply voltage	V_{cc}		8	12 or 24	30	V
Supply current	I_{cc1}			20	30	mA
CAN speed	f_{CAN}			250		h
MTBF		Calculated with Telcordia 2 for ground mobile at 50°C permanent op. temperature		>4*10^5		h

8 Inclinometer characteristics

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Start up time	t_s	V_{CC}=0V to V_{CC}=12V transition			1	s
Temperature Offset Drift	T_{off}	φx= φy=0° -40°C ≤ T ≤ 85°C	-0.5	-0.4< T_{off} <0.4	0.5	deg
Accuracy I, [1]	$A_{CC,<8°}$	|φx| < 8° |φy| < 8°	-0.2	-0.1< $A_{CC,<8°}$ <0.1	0.2	deg
Accuracy II, [1]	$A_{CC,>8°}$	|φx| > =8° |φy| > =8°	-0.5	-0.4< $A_{CC,>8°}$ <0.4	0.5	deg
Resolution	Res			0.001		deg
Update Rate	f_u	Independent of op. condition		100		Hz
Settling time, [3]	t_{SET}	To 90% of final reading	0.1	0.2	2	s
Cross sensitivity, [2]	CCA				0.25	deg

1. Accuracy is verified by an end of line measurement after calibration without sensor module being removed in between. As the inclinometer is designed to be fixed with M6 screws, there is some mechanical clearance that may lead to a small misalignment and offset. For some applications it may be reasonable to implement an in-application offset or/and span correction to attain best overall accuracy.

2. CCA is defined as maximum difference between actual and expected angle on passive axis for whole angular range of active axis and full temperature range.

3. Depends on filter setting; for default configuration response time is 0.2s

9 Electrical interface

The Inclinometer has a CANopen interface implementing the CiA 410 device profile for inclinometer.
Additionally bootloader and layer setting services (LSS) are implemented.

9.1 Conventions

ID = Node ID; default is 01h. The node ID can be set using LSS.
All below CAN messages are displayed in hexadecimal notation.

9.2 Inclinometer Initialization

After power cycle the sensor module starts in bootloader mode. The application can be started using the following command:

Address	Command	Index: 1F51h		Sub-Index	Data			
600_h+ID	$2F_h$	51_h	$1F_h$	01_h	01_h	00_h	00_h	00_h

The application can be brought into operational mode by sending:

Address	Data	
600_h+ID	01_h	01_h

9.3 Reading sensor values

Longitudinal slope and lateral slope in 16 bit resolution are can be read as follows:

Address	Command	Index: 6010h		Sub-Index	Data			
600_h+ID	40_h	10_h	60_h	00_h	00_h	00_h	00_h	00_h

Address	Command	Index: 6020h		Sub-Index	Data			
600_h+ID	40_h	20_h	60_h	00_h	00_h	00_h	00_h	00_h

Address	Command	Index: 6110h		Sub-Index	Data			
600_h+ID	40_h	10_h	61_h	00_h	00_h	00_h	00_h	00_h

Address	Command	Index: 6120h		Sub-Index	Data			
600_h+ID	40_h	20_h	61_h	00_h	00_h	00_h	00_h	00_h

The values are given in degree (angle) with the resolution given in object 6000h

9.4 Automatic value sending

The module supports two TPDOs.
TPDO 1 contains the values of longitudinal slope and lateral slope in 16 bit resolution.
TPDO 2 contains the values of longitudinal slope and lateral slope in 32 bit resolution.
After entering operational mode the TPDO sending can be started by setting the event timers of the corresponding communication parameters for example to 1000ms

Address	Command	Index: 1800h		Sub-Index	Data			
600_h+ID	$2B_h$	00_h	18_h	05_h	$E8_h$	03_h	00_h	00_h

Address	Command	Index: 1801h		Sub-Index	Data			
600_h+ID	$2B_h$	00_h	18_h	05_h	$E8_h$	03_h	00_h	00_h

9.5 Related Documents

There is further information in the applicable documents.
Furthermore, if any open questions remain please contact the customer support.

10 Qualification and Test

10.1 Vibration

The DOG2 inclinometer survives exposure to vibration according to Figure 10.1.1 and Figure 10.1.2. Duration of the test has been 8h each Cartesian axis.

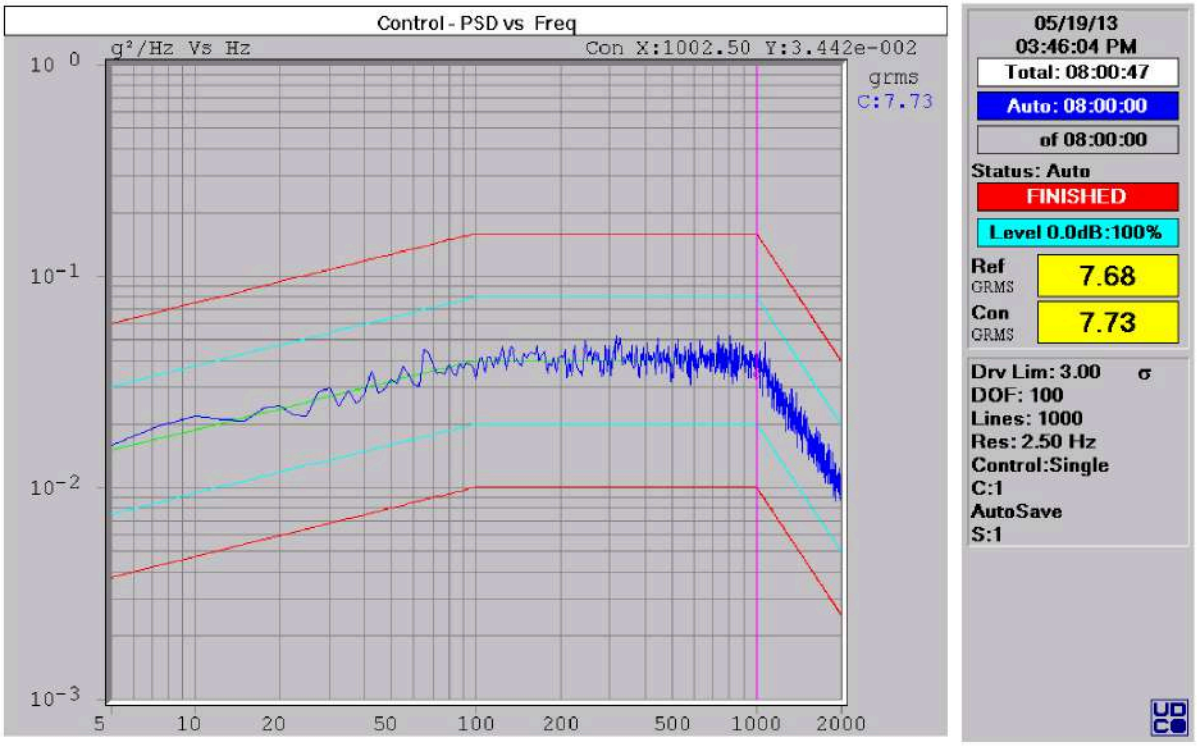

Figure 10.1.1: Random vibration profile used for testing, green trace: ideal excitation, blue trace: actual excitation during test

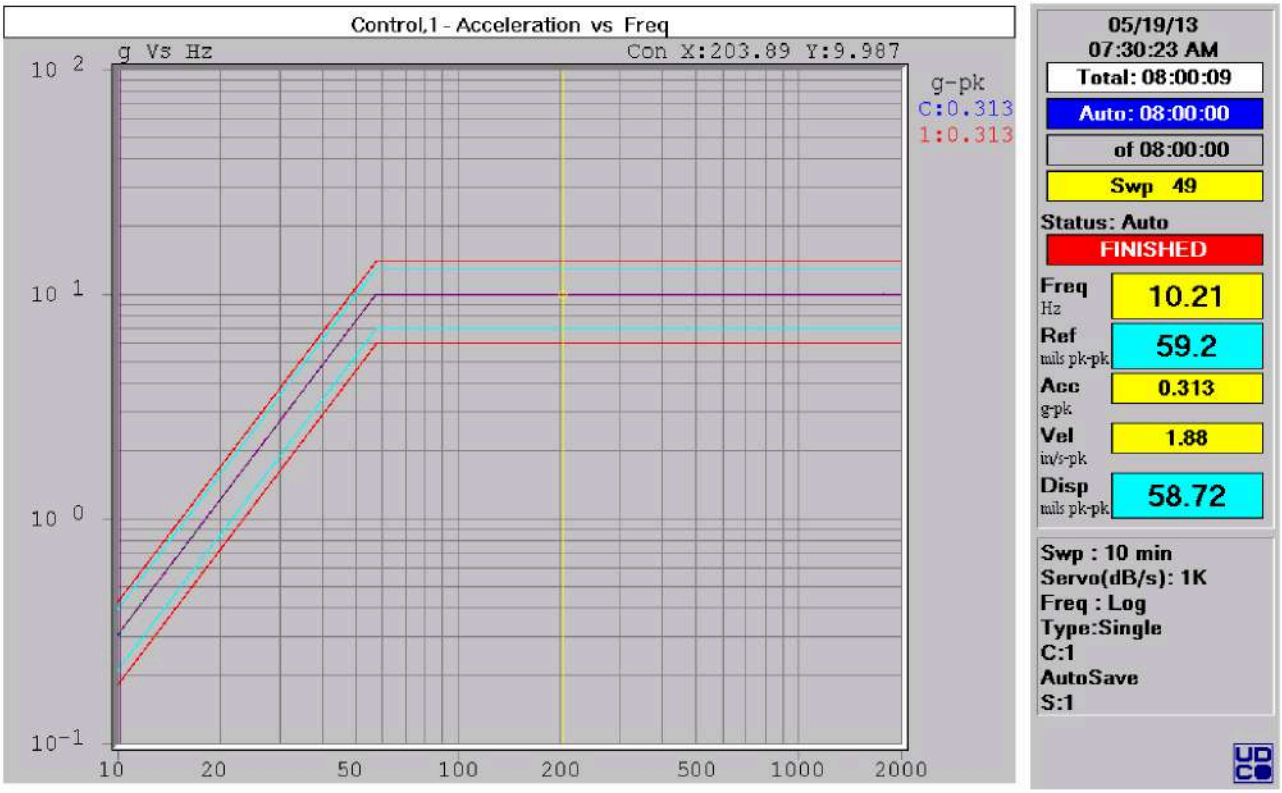

Figure 10.1.2: Sine vibration profile for testing, purple trace: ideal excitation

10.2 Drop

The unit withstands a drop of height 1m onto a concrete surface.

10.3 End of line test

Each unit is end of line tested. After calibration, each inclinometer is tested at different angles at 25°C (±5°C).

10.4 Statistical test

On demand of the customer, a statistical temperature test can be offered.

10.5 Material Testing

All materials used in the process are released by checking the corresponding supplier certificates if available. A regular material analysis from an independent laboratory will not be scheduled.

10.6 Electromagnetic compatibility

This is work in progress. EMC testing already passed for other interface options such as analog voltage.

11 Packaging

The inclinometer is shipped in a cardboard box where the size depends on quantity of ordered parts. For transport safety these are boxed in additional transport packaging.

12 RoHS and REACH

The inclinometer complies with current RoHS and REACH requirements.

13 Customer Acceptance

Preliminary Specification
G-NSDOG2-201

Version 0.2

Customer Acceptance

Company: .....

Address: .....

Date: .....

Signature: .....

Name: .....

Function: .....