Specification Inclinometer NS-5/DMG2-x

Version 1.0

Customer Acceptance

Company: .....

Address: .....

Date: .....

Signature: .....

Printed Name: .....

Function: .....

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Table of Contents

History

Ver.	Date	Treatment	Author
1.0	24.11.2005	First Draft	M.Zürn, K.Schink

1 General

The NS-5/DMG2- X is a new dual axis inclinometer based on a tilt sensor, which works on the conductivity principle. This inclinometer is microprocessor controlled with a 16 Bit A/D converter capable of producing a linearized and temperature compensated angle output. We have four type of inclinometer, with analog voltage output, current output , PWM output or switch output. All inclinometer has a RS 232 interface on board as a standard.

1.1 Delivery description and Part Number

This product of inclinometer can be ordered using the part number:

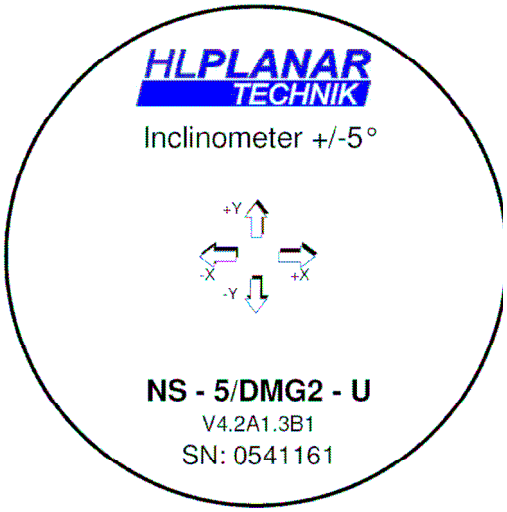
type	measurement angle	output signal	order number
NS - 5/DMG2 - U	+/- 5°	RS 232, Voltage 0.5 ...4.5V	2.000.592.146.000
NS - 5/DMG2 - I	+/- 5°	RS 232, Current 4...20 mA	2.000.592.166.000
NS - 5/DMG2 - PWM	+/- 5°	RS 232, PWM 1kHz, 20....80%	2.000.592.136.000
NS - 5/DMG2 - S	+/- 5°	RS 232, switch, open collector	2.000.592.156.000

2 Mechanics and Connections

2.1 Mounting

This inclinometer will be mount for horizontal position (x-y-plane), reference is the base plate.

2.2 Label information



Parts will be marked with a label glued on the top of the inclinometer.
The label contain following information:

HL-Planar Code :	see type in chapter 1.1
HL-Planar version :	internal HW/SW-Versions
Serial No.:	YYWWNNN

YYWWNNN consists of seven digits. YY shows the year of production (2005=05), WW the week of the production and NNN the number for identifying.

2.3 Mechanical data

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Weight				320		g
Dimensions		W x D x H		84 x 70 x 46		mm
Protection class				IP 67		

2.4 Outline drawing

The dimensional drawing shows the inclinometer and connector assembly.

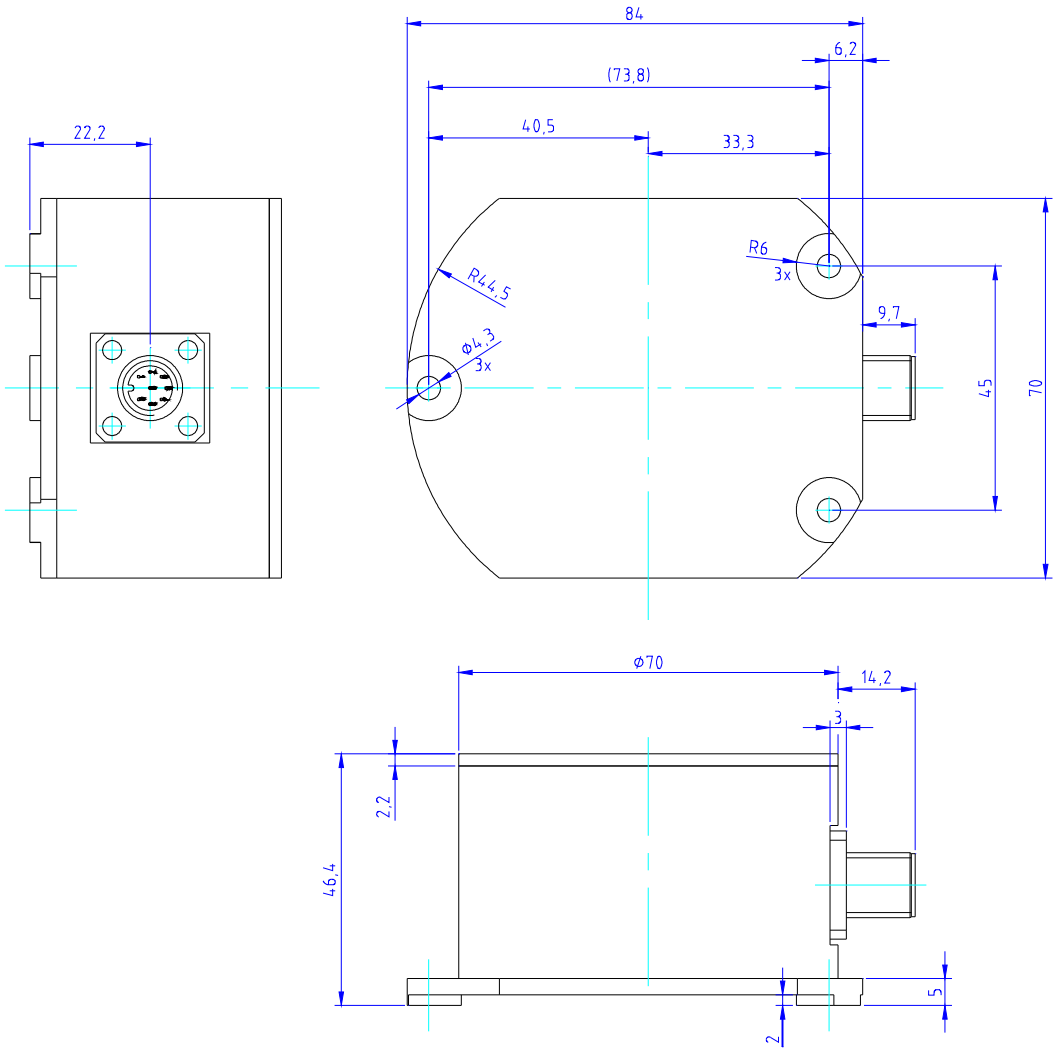


Fig. 2.1 Dimension housing (mm)

2.5 Reference edge of inclinometer

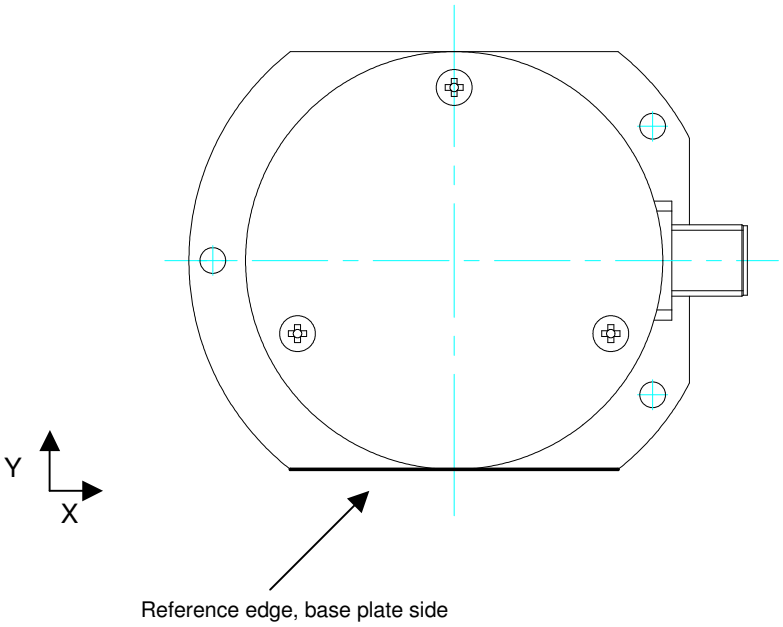


Fig. 2.2.1 Top view of inclinometer, reference edge

For a minimum of cross sensitivity, the reference edge of inclinometer must be parallel to the axis of measurement object.

2.6 Connection housing

- *This inclinometer owns an 8pin male connector of Company Binder type 763. M12x1,5*

2.7 Cable and Connector

The inclinometer will be deliver standard without a cable and connector.

Optional you can order a cable with one sided connector.

Type of cable:	LiYCY 7x0,14mm^2
Conductor resistance:	131 Ohm/km
Capacity:	90pF/m at 1kHz

2m cable with one sided Connector type 763 (M12x1):

with straight connector, order-no .: 2 000 000 000 001

with angle (90°) connector, order –no.: 2 000 000 000 002

For special length of cable, please contact us.

2.8 Terminal Connections

The connection allocation of the pencil socket sees we follows from:

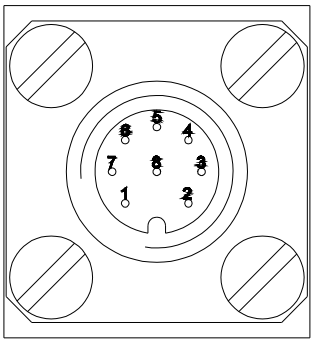


Fig. 6.6.1
Front view of housing connector inclinometer

Pin	Name	Description	Type	Colour schema (1)
1	+Ub	positive power supply +10...+30VDC	supply	white
2	RxD	Rx serial signal RS 232	input	brown
3	TxD	Tx serial signal RS232	output	green
4	GND	negative power supply, ground	supply	yellow
5	XOut	X-axis output (2)	output	grey
6	SGND	signal ground	supply	pink
7	YOut	Y- axis output (2)	output	blue
8	NC	NC	nc	red

(1) by using the standard cable of HL Planartechnik GmbH.

(2) dependent of inclinometer version:

NS-5/DMG2-U	output signal (X,Y)	analog voltage
NS-5/DMG2-I	output signal (X,Y)	analog current
NS-5/DMG2-PWM	output signal (X,Y)	PWM
NS-5/DMG2-S	output signal (X,Y)	switch

3 Specification

3.1 Absolute Maximum Ratings

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
power supply	+Ub	measured +Ub to GND, inverse-polarity protection	-30		+30	V
maximum rating of angle	φmax	by operating, under power supply. Don't exceed the maximum rating, or damage to the basic cells could result.	-15		+15	°
Storage temperature	Tstor		-55		+85	℃
Operation temperature	Ta		-40		+85	℃

3.2 Operating conditions

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
specified Measurement range	φspec		-5		+5	°
Measurement range	φop		-5.5		+5.5	°
Power voltage supply	+Ub		+10		+30	VDC
Current consumption	Ib			40		mA
Operation temperature range	Ta		-40		+85	℃

3.3 Sensor Characteristics

3.3.1 RS232 Output

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Resolution	Res		0.001			°
Precision (absolute)	Acc1 Acc2 Acc3	Ta_1 = +25°C Ta_2 = -25°C… +50°C Ta_3 = -40°C… +85°C		0.04	0.08 0.10 0.15	°
Initial Offset	φoff			+-0.1		°
Temperature drift Offset	Tφoff	Ta = -25°C … +85°C (2) Ta = -40°C … +85°C			0.05 0,06	° °
Cross sensitivity	CCAx, CCAy	See (1)			1,4	%
Settling time (after a rotation about 5°, at 25°C)	Ts	to 10% to 1% to 0.1%		 1.5 2	1 2 3	s s s
Noise RMS				0.001	0.002	°
Baud rate		default value, see (3)		9600		Bits/s
Rate of transmission		default value, see (3)		10		Strings/s

(1) CrossSens is defined by:
CCAx=Sensx(Inclinationy)/Sensx(Inclinationx)
CCAy=Sensy(Inclinationx)/Sensy(Inclinationy)

(2) Temperature drift Offset is defined by:
Tφoff = φoff(Ta)- φoff(25°C)

(3) These values are adjustable in the setup level

3.3.2 Voltage Output, only for NS - 5/ DMG2 – U

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Output Characteristics (1) specified performance Operating range sensitivity offset	 Vspec VOUT VSens Voff		 0.5 0.3	 0.4 2.5	 4.5 (2) 4.7 (2)	 V V V/° V
Resolution	Res			0.001		°
Precision (absolute)	Acc1 Acc2 Acc3	Ta1 = +25°C Ta2 = -25°C… +50°C Ta3 = -40°C… +85°C		0.04	0.09 0.11 0.16	°
Initial Offset	φoff			+-0.1		°
Temperature drift Offset	Tφoff	Ta = -25°C … +85°C (3) Ta = -40°C … +85°C			0.06 0,07	° °
Cross sensitivity	CCAx, CCAy	See (4)			1,4	%
Settling time (after a rotation about 5°, at 25°C)		to 10% to 1% to 0.1%		1 1.8 2.3		s s s

(1) Φ[°] = (U[V] - 2.5) * 2,5

(2) max Vcc-0,3V

(3) Temperature drift Offset is defined by:
Tφoff = φoff(Ta)- φoff(25°C)

(4) CrossSens is defined by:
CCAx=Sensx(Inclinationy)/Sensx(Inclinationx)
CCAy=Sensy(Inclinationx)/Sensy(Inclinationy)

3.3.3 Current Output, only for NS - 5/ DMG2 – I

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Output Characteristics (1): specified performance Operating Current range sensitivity offset	 I_{spec} I_{OUT} I_{Sens} I_{off}		 4 3.2	 -1.6 12	 20 20.8	 mA mA mA/° mA
load resistor	R_L				300	Ohm
Resolution	Res			0.001		°
Precision (absolute)	Acc1 Acc2 Acc3	Ta_1 = +25°C Ta_2 = -25°C… +50°C Ta_3 = -40°C… +85°C		0.04	0.09 0.11 0.16	°
Initial Offset	φoff			+-0.1		°
Temperature drift Offset	Tφoff	Ta = -25°C … +85°C (2) Ta = -40°C … +85°C			0.06 0,07	° °
Cross sensitivity	CCAx, CCAy	See (3)			1,4	%
Settling time (after a rotation about 5°, at 25°C)		to 10% to 1% to 0.1%		1 1.8 2.3		s s s

(1) Φ[°] = -(I[mA] - 12) / 1.6

(2) Temperature drift Offset is defined by:
Tφoff = φoff(Ta)- φoff(25°C)

(3) CrossSens is defined by:
CCAx=Sensx(Inclinationy)/Sensx(Inclinationx)
CCAy=Sensy(Inclinationx)/Sensy(Inclinationy)

3.3.4 PWM Output, only for NS - 5/ DMG2 – PWM

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Output Characteristics (2) specified performance Operating range sensitivity offset	 PWMspec PWMOUT PWMSens PWMoff		 20 17	 6 50	 80 83	 %(1) %(1) %(1) / ° %(1)
Output level High	VOH	IOH = -1 mA	+Vcc-0.3		+Vcc	V
Output level Low	VOL	IOL = 1 mA	0		0.3	V
Output frequency	Fout			1000		Hz
Resolution	Res			0.001		°
Precision (absolute)	Acc1 Acc2 Acc3	Ta1 = +25°C Ta2 = -25°C… +50°C Ta3 = -40°C… +85°C		0.04	0.09 0.11 0.16	°
Initial Offset	Φoff			+-0.1		°
Temperature drift Offset	Tφoff	Ta = -25°C … +85°C (3) Ta = -40°C … +85°C			0.06 0,07	° °
Cross sensitivity	CCAx, CCAy	See (4)			1,4	%
Settling time (after a rotation about 5°, at 25°C)		to 10% to 1% to 0.1%		1 1.8 2.3		s s s

(1) % = %Duty cycle = TH / (TH + TL) x 100%

(2) Φ[°] = (PWM[%Duty Cycle] -50) * 6

(3) Temperature drift Offset is defined by:
Tφoff = φoff(Ta)- φoff(25°C)

(4) CrossSens is defined by:
CCAx=Sensx(Inclinationy)/Sensx(Inclinationx)
CCAy=Sensy(Inclinationx)/Sensy(Inclinationy)

3.3.5 Switch Output, only for NS - 5/ DMG2 – S

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Output Characteristics specified performance Operating range	spec		 -5 -5.5		 5 5.5	 ° °
V active	Vxon, Vyon	responding Output x active IOut <= 50 mA,			1,2V	V
I inactive	Ixoff, Iyoff	responding Output inactive 0V < Vout < 140V			0,02	mA
Resolution	Res			0.001		°
Precision (absolute)	Acc1 Acc2 Acc3	Ta1 = +25°C Ta2 = -25°C… +50°C Ta3 = -40°C… +85°C		0.04	0.09 0.11 0.16	°
Initial Offset	φoff			+-0.1		°
Temperature drift Offset	Tφoff	Ta = -25°C … +85°C (3) Ta = -40°C … +85°C			0.06 0,07	° °
Cross sensitivity	CCAx, CCAy	See (4)			1,4	%
Settling time (after a rotation about 5°, at 25°C)		to 10% to 1% to 0.1%		1 1.8 2.3		s s s

(1) Output state active: |φ| > S of the corresponding axis
Output state inactive: |φ| < S of the corresponding axis
with S = switch angle, see programming instructions in setup level

switchover from state inactive to state active: : |φ| > S + SH/2
switchover from state active to state inactive: : |φ| < S - SH/2
with SH = hysteresis, see programming instructions in setup level

(2) Temperature drift Offset is defined by:
Tφoff = φoff(Ta)- φoff(25°C)

(3) CrossSens is defined by:
CCAx=Sensx(Inclinationy)/Sensx(Inclinationx)
CCAy=Sensy(Inclinationx)/Sensy(Inclinationy)

4 Serial Interface

Communication with the sensor is done through a standardized RS-232 interface. Data transmission is effected in duplex mode. The baud rate is fixed by 9600 baud.
After Power On the sensor is sending continuous the angle values in degrees (°).
In the setup level several settings can be permanently modified.
If the continuous mode was permanently changed to the polling mode, the sensor will send after "Power On" a start information with actual parameters.
On error no angle values are sending and after "Power On" a error message was add to the start information.

4.1 Interface parameter

Baud rate:	9600 baud (default value, modifiable in Setup level)
Format:	ASCII, 8 data bits, 1 stop bit, parity even (fixed)
String length:	22 byte
Layout:	< D0 ... D21>
	D0 ... D10 = "X=±xx.xxx", <CR>, <LF>
	with D2 = sign (+ or -)
	with D5 = point
	D11 ... D21 = "Y=±xx.xxx", <CR>, <LF>
	with D13 = sign (+ or -)
	with D16 = point

Example:

```
…
X=+00.430
Y=-00.084
…
```

5 Programming instructions

5.1.1 User level (default after power on)

Table 1: instructions at user level

instruction	to the sensor	response sensor	explanation
activate temporary polling mode (1) (2)	**”f”**	“f“	the continuous sending of angle values are stopped, instructions can send to the sensor
activate temporary continuous mode (1) (2)	**”F”**	„X=±xx.xxx“, CR, LF, ”Y=±xx.xxx“, CR, LF, ”X= . . .	X angle in ° Y angle in ° with „±” = „+“ or „-“, one string contains x and y value
read angle values at one-time (3)	**”R”**	“X=±xx.xxx“, CR, LF, ”Y=±xx.xxx“, CR, LF,	X angle in ° Y angle in ° with „±” = „+“ or „-“
switch to the setup level (3) (4)	**”prog”**	”P“	Sensor is at setup level
show active level (3)	**“*“**	“Ux“ or ”Sx“	„U“ means Sensor is at User level „S“ means Setup-level is active, with „x“ Output-Mode of Sensors „U“ / „I“ / „P“ / „S“

(1) in the continuous mode the sensor is sending continuous angle values, in the polling mode the sensor is sending one answer after an instruction.

(2) after Power On or Reset the sensor is in user level with the default settings or the settings changed at setup level.

(3) only possible at polling mode

(4) the input of the password “prog“ must happen within 20 sec.

5.1.2 Setup level

The Setup level is active until ”Power On” or Reset. All settings taken in the setup level are stored in the EEPROM and permanent available also after Power down.

Table 2 instructions at Setup level

instruction	to the sensor	response sensor	explanation
activate permanent polling mode (1)	**“f“**	“f“	the continuous sending of angle values are permanent stopped, instructions can send to the sensor
activate permanent continuous mode (1)	**“F“**	„X=±xx.xxx“, CR, LF, ”Y=±xx.xxx“, CR, LF, ”X= . . .	continuous sending of X angle in ° Y angle in ° with „±” = „+“ or „-“
set rate of data transmission for continuous mode (2) (3) (4)	**“O“ <Code transmission rate>**	“O” <Code transmission rate>	Echo, Code transmission rate or „E“ for Error, if the code is outside defined values
read angle values at one-time (2)	**“R“**		same as at user level
read version (2)	**“V“**	“NS-xx/DMG2-x“, CR, LF ”SN:xxxxxxx“, CR, LF ”HV:xx.x“ , CR, LF ”SV:xx.x“ , CR, LF	type of Sensor serial number HW Version internal sensor SW Version
offset adjust of the specified axis (2) (3)	**“n“ ”x“ or ”y“**	“n“ ”OffsetX=±xx.xxx“ or ”OffsetY=±xx.xxx“	the actual angle of specified axis is set to zero, ±xx.xxx is the internal offset in degree
reset offset adjust (2) (3)	**“N“**	“N“	the offset adjust was reset to the original value
Set Baud rate (2) (3) (5)	**“B“ <Code Baud rate>**	“B“ <Code Baud rate>	Echo, Code Baud rate or „E“ for Error, if the code is outside defined values
Set switch angle for one axis (2) (3) (6) (7)	**“Sx“ <switch angle> or “Sy“ <switch angle>**	“Sx“ or “Sy” <switch angle>	Echo, switch angle or „E“ for Error, if the angle is outside admissible range
Set hysteresis for switching point in both axis (2) (3) (6) (8)	**“Sh“ <hysterese>**	“Sh“ <hysterese>	Echo, hysterese or „E“ for Error, if the angle is outside admissible range
show active level (2)	**“*“**		same as at user level
Reset (2)	**“q“**	“q“	Software-Reset will be executed

(1) in the continuous mode the sensor is sending continuous angle values, in the polling mode the sensor is sending one answer after an instruction

(2) only possible at polling mode.

(3) for activating a reset or power fail restart is necessary

(4) for Code transmission rate see Table 3 <Code transmission rate >

(5) for Code baud rate see Table 4 <Code Baud rate>
Attention! A reset of the baud rate to a default value is not possible. If the user forgets the adjusted baud rate, the new value must be detected by testing.

(6) this instruction is only effectual at sensors with switch output,

(7) <switch angle>: three digits from “001” until “300” for the angle in tenths of a degree, max working range of the sensor. Default value is 025 == 2,5°

(8) <hysterese>: two digits from “01” until “99” for the stitching hysterese in tenths of a degree, max working range of the sensor , Default value is 01 == 0,1°

Table 3 <Code transmission rate >

<Code transmission rate >	**strings per second, 1 string contains x and y-value**
“0“	reserved
“1“	25 Strings/s (1)
“2“	10 Strings/s, Default value (2)
“3“	5 Strings/s
“4“	2 Strings/s
“5“	1 Strings/s
“6“	0,2 Strings/s
“7“	0,1 Strings/s
“8“, “9”	not defined

(1) only allowed with baud rate of at least 9600 Bd

(2) only allowed with baud rate of at least 4800 Bd

Table 4 <Code Baud rate>

<Code Baud rate>	**baud rate**
“0“	2400 Baud
“1“	4800 Baud
“2“	9600 Baud, Default value
“3“	19200 Baud
“4“	38400 Baud
“5“	57600 Baud
“6“, “7“, ”8“, ”9“	not defined

5.2 Example for setting the Output rate

In the following example the output rate is set to 1 string per second

instruction	**to the sensor**	**response sensor**	**explanation**
		„X=±xx.xxx“, CR, LF, ”Y=±xx.xxx“, CR, LF, ”X= . . .	continuous sending of angles
activate temporary polling mode	**”f”**	“f“	the continuous sending of angle values are stopped, instructions can send to the sensor
switch to the setup level	**”prog”**	”P“	Sensor is at setup level
set rate of data transmission for continuous mode	**“O5“**	“O5”	Code transmission rate is set to 1Strings/s
Reset	**“q“**	“q“	Software-Reset will be executed, the new settings are guilty
		„X=±xx.xxx“, CR, LF, ”Y=±xx.xxx“, CR, LF, ”X= . . .	continuous sending of angles at 1 Strings/s

6 Test Requirements

100% of delivered pieces were tested as follows:
The sensor circuit board, the part of the complete sensor on which the conversion of the angle in electrical signal is done, were separately measured at 7 angles in both axes to in order to determine corresponding values for acc1 and CCA.
The complete sensor were checked at -5°, 0° and 5° in direction x (axis y = 0°) and at -5°, 0° and 5° in direction y (axis x = 0°) to verify the values for acc1.

Measurements on 0°C, 25°C and 50°C at –5°, -4°, -3°, … +3°, +4°, +5° in direction x (axis y = 0°) and in direction y (axis x = 0°) were done on four (two) pieces for a fabrication lot between 51 and 200 (2 and 50) pieces in order to determine the parameters Acc1, Acc2, Acc3, Tφoff, CCA

7 Standards

The sensor NS-5/DMG2-RXA was tested to fulfill following standards:

- IEC/EN 61000-6-4 EMC – emitted interference industry
- IEC/EN 61000-6-2 EMV – interference resistance industry
- IEC/EN 60068-2-27 Mechanical shock test
- IEC/EN 60068-2-6 Vibration loading
- IEC/EN 60068-2-14 Thermo shock
- DIN EN 60068-2-1 Cold, static
- DIN EN 60068-2-78 Damp heat, steady state
- DIN 40050-9 Spraying water, protection class IP 67

8 Packaging for Delivery

Safe single package “Blitz Versandbox”, company “Ratioform”, type CVB (150x110x67 mm, for one piece) type will used for the delivery of the product.

9 Definitions and Disclaimers

- Application information – Applications that are described herein for any of these products are for illustrative purpose only. HL Planartechnik GmbH makes no representation or warranty that such applications will be suitable for the specified use without further testing or modification.

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