



D-Series Inclinometer

**Specification
D-Series
Inclinometer**

Type: NS-5/DMG2-x

Version 1.3



D-Series Inclinometer

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History

Ver.	Date	Treatment	Author
1.0	Nov., 24 th , 2005	First Draft	M.Zürn, K.Schink
1.1	Oct., 10 th , 2007 Mar., 7 th , 2008 Aug., 24 th , 2009	- Maximum rate of data transmission reduced to maximum sample rate. - Low pass filter added - Display info RS232 +/-110% - Chapter 3.3: characteristics curves added, equation for PWM corrected - Chapter 5.1: info setup information added - change part no - details standards	K.Schink, M.Zürn
1.2	July, 19 th , 2011	- add options, layout	M.Zürn
1.3	Aug., 26 th , 2016	- add options, corrections, layout	M.Zürn

1 General

The D-Series Dual Axis Inclinometer, type NS-5/DMG2-x, incorporates a tilt sensor, microprocessor and 16 Bit A/D converter. The result is a fully linearized and temperature-compensated output.

The D-Series is available in four output configurations.

- Analog voltage
- Current output
- PWM output
- Switch output

Note: All models have a RS 232-interface on board.

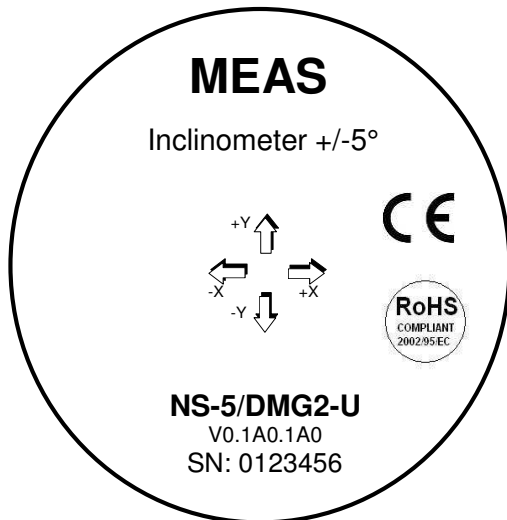
1.1 Ordering Information

D-Series Type	Measurement Angle	Output Signal	Order Number
NS - 5/DMG2 - U	+/- 5°	RS 232, Voltage 0.5 ...4.5V	G-NSDMG-015
NS - 5/DMG2 - I	+/- 5°	RS 232, Current 4...20 mA	G-NSDMG-017
NS - 5/DMG2 - PWM	+/- 5°	RS 232, PWM 1kHz, 20....80%	G-NSDMG-014
NS - 5/DMG2 - S	+/- 5°	RS 232, switch, open collector	G-NSDMG-016

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2 Mechanical Specifications

2.1 Unit Identification



Each sensor is labeled with the following information:

Unit Type: see chapter 1.1
 Version: HW/SW-Version
 Serial No.: YYWWNNN

YYWWNNN consists of seven characters:

- YY: year of production (2011 = 11)
- WW: calendar-week of production (CW 12 = 12)
- NNN: identity-number

2.2 Mechanical

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Weight				290		g
Dimensions		W x D x H		84 x 70 x 46		mm
Protection class				IP 67/68		

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2.3 Dimensions

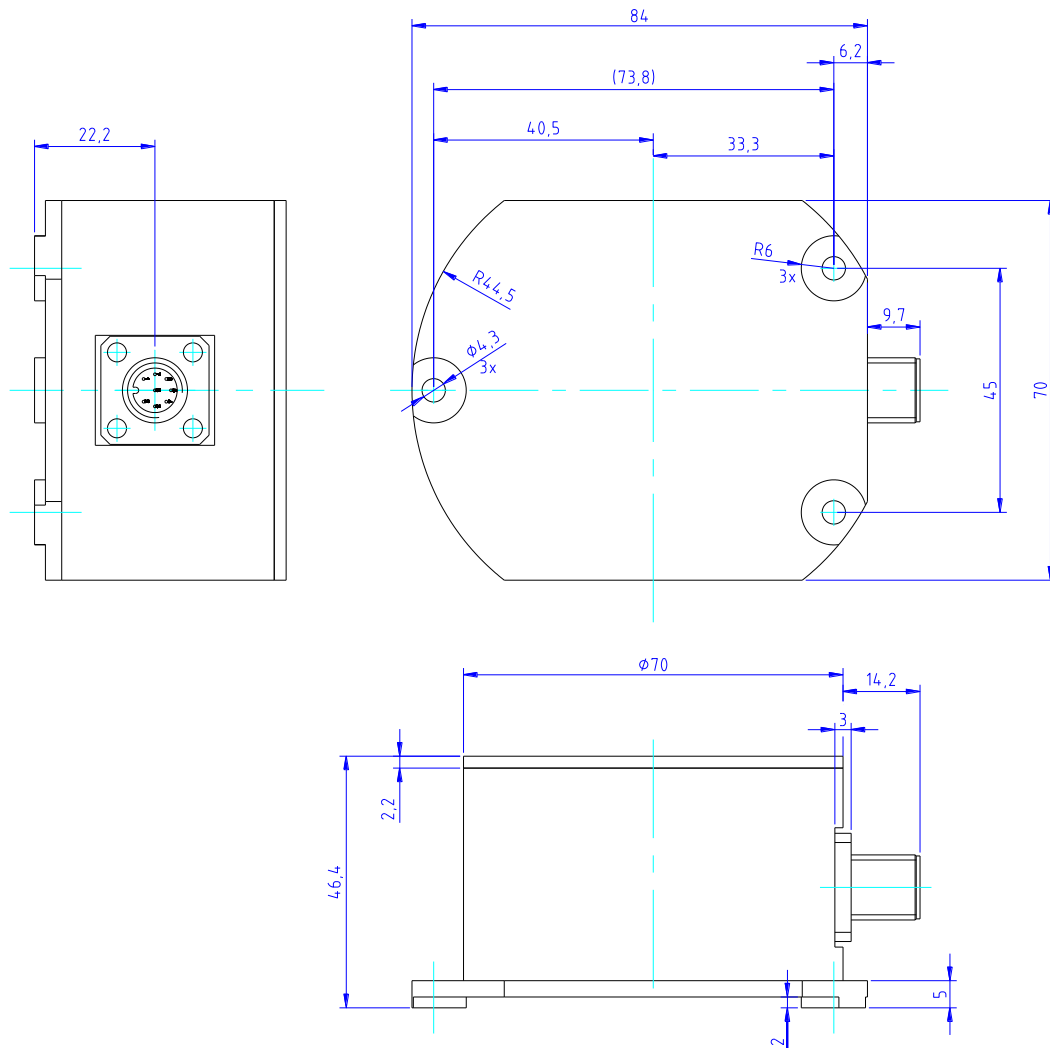


Fig. 2.3.1 Dimension housing (mm)

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2.4 Mounting

This inclinometer will be mounted for horizontal position (x-y-plane), reference is the base plate. The measurement of the tilt angle of the single measurement axis is carried out over the respective longitudinal and lateral axis of the inclination sensor. Reference is always the horizontal plane.

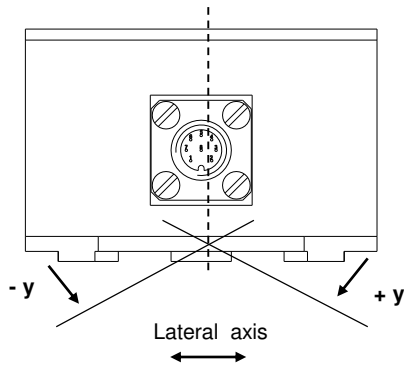


Fig. 2.4.1 View of male socket

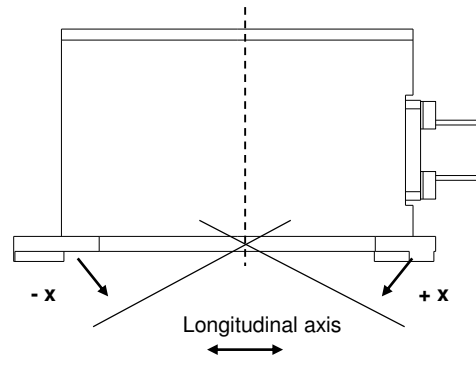


Fig. 2.4.2 Side view

2.5 Reference Surface

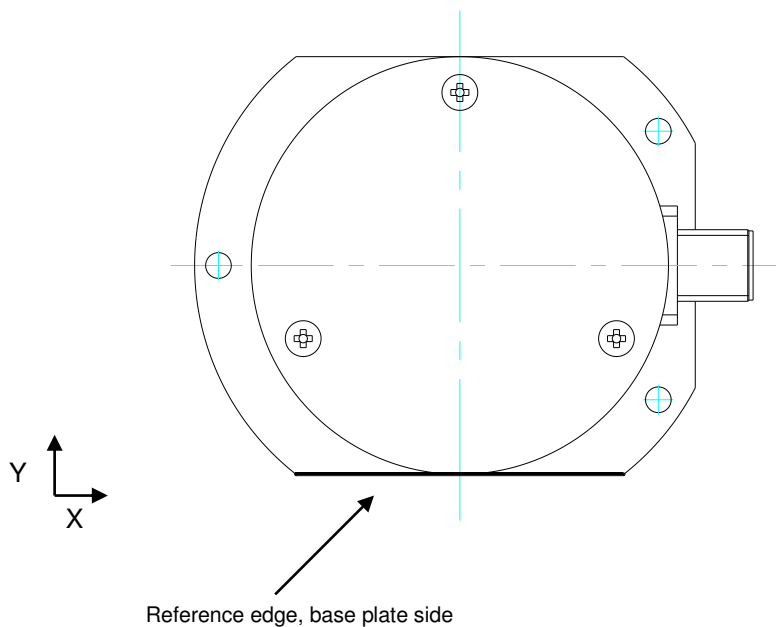


Fig. 2.5.1 Top view of inclinometer, reference surface

To minimize cross axis sensitivity, the reference surface of the inclinometer must be parallel to the axis of measurement object.

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2.6 Electrical Connection

- 8pin male socket. Manufacturer = 'Binder – Connectors', type 763, M12x1.5

2.7 Cable/Connector Assembly (optional)

Type of cable:	LiYCY 7x0.14mm ²
Conductor resistance:	131 Ohm/km
Capacity:	90pF/m at 1kHz
Length:	2m
Shielded:	Yes

Connector: 763 (M12x1.5):

- Straight connector, order-no.: G-NSMIS-008
- Angle (90°) connector, order-no.: G-NSMIS-009

Please contact us, if you need a special cable-length.

- **Connector only (optional)**

- Straight connector, order-no.: G-NSMIS-036
- Angle 90° connector, order-no.: G-NSMIS-013

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2.8 Terminal Connections

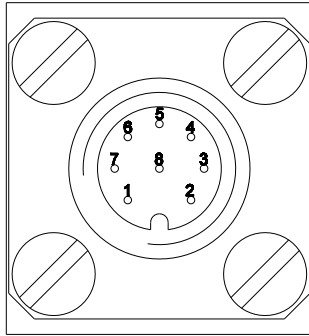


Fig. 2.8.1
Front view into the socket connector of the inclinometer housing

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	n.c.	red

(1) by using the standard cable of MEAS Deutschland 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

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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 angle	φ_{max}	Do not exceed maximum angle while under power supply for extended period of time. Irreversible damage may occur.	-15		+15	°
Storage temperature	Tstor		-55		+85	°C
Operation temperature	Ta		-40		+85	°C

3.2 Operating conditions

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Specified measurement range	φ_{spec}	100%	-5		+5	°
Total measurement range	φ_{op}	110%	-5.5		+5.5	°
Power voltage supply	+Ub		+10		+30	VDC
Current consumption	Ib			40		mA
Operation temperature range	Ta		-40		+85	°C

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3.3 Performance Specifications

3.3.1 RS232 Output (all models)

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Resolution	Res		0.001			°
Accuracy (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 (1) Ta = -40°C ... +85°C			0.05 0.06	° °
Cross sensitivity	CCAx, CCAy	See (2)			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	16	Strings/s
Internal data acquisition rate				16		Samples/s

- (1) Temperature drift Offset is defined by:
 $T\phi_{off} = \phi_{off}(T_a) - \phi_{off}(25^\circ\text{C})$
- (2) CrossSens is defined by:
 $CCAx = \text{Sens}_x(\text{Inclination}_y) / \text{Sens}_x(\text{Inclination}_x)$
 $CCAy = \text{Sens}_y(\text{Inclination}_x) / \text{Sens}_y(\text{Inclination}_y)$
- (3) These values are adjustable in the setup level

Parameter explanations:

- Accuracy: Absolute accuracy over all errors (temperature, drift).
- Initial offset: The system starts the first operation, the offset value is fixed after that.
- Cross sensitivity: Divergence between x-axis and y-axis above full scale.
- Settling time: Transient effect, tilt the sensor e.g. 0° up to 5°, values goes up t90 (90%) in 1 sec.
- Temperature drift offset: Tolerance, if the ambient temperature will be changed in this range.

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3.3.2 Voltage Output, model NS - 5/ DMG2 – U

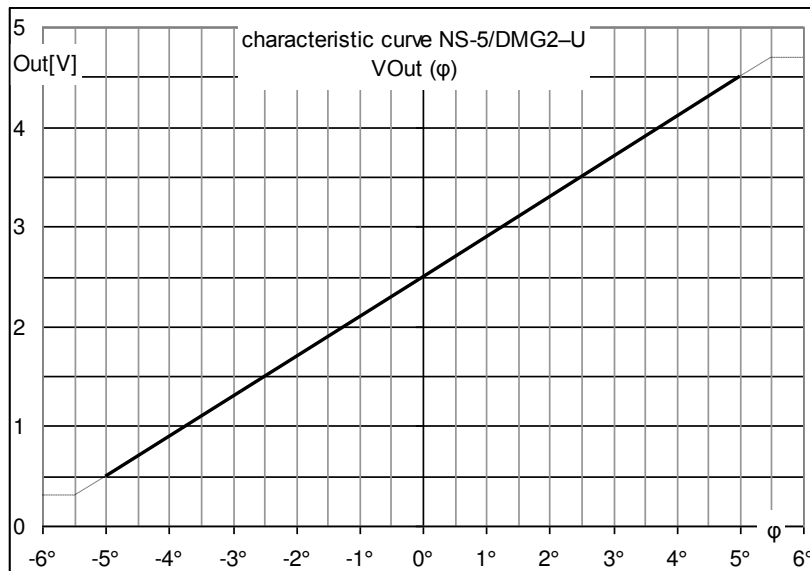
Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Output Characteristics(1): Specified performance	Vspec		0.5		4.5 (2)	V
Operating range	VOUT		0.3		4.7 (2)	V
Sensitivity	VSens			0.4		V/°
Offset	Voff			2.5		V
Resolution	Res		0.001			°
Accuracy (absolute)	Acc1 Acc2 Acc3	Ta1 = +25°C Ta2 = -25°C... +50°C Ta3 = -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	CCA _x , CCA _y	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) $\varphi[^\circ] = (U[V] - 2.5) * 2,5$

(2) max Vcc-0,3V

(3) Temperature drift Offset is defined by:
 $T\varphi_{off} = \varphi_{off}(T_a) - \varphi_{off}(25^\circ\text{C})$

(4) CrossSens is defined by:
 $CCA_x = \text{Sens}_x(\text{Inclination}_y) / \text{Sens}_x(\text{Inclination}_x)$
 $CCA_y = \text{Sens}_y(\text{Inclination}_x) / \text{Sens}_y(\text{Inclination}_y)$



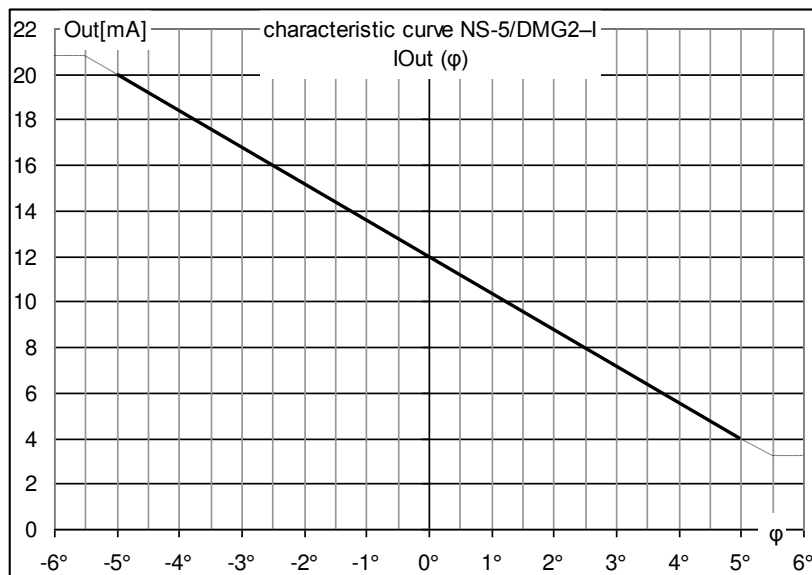
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3.3.3 Current Output, model NS - 5/ DMG2 – I

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Output Characteristics(1): Specified performance	I_{spec}		4		20	mA
Operating current range	I_{OUT}		3.2		20.8	mA
Sensitivity	I_{Sens}			-1.6		mA/°
Offset	I_{off}			12		mA
Load resistor	R_L				300	Ohm
Resolution	Res		0.001			°
Accuracy (absolute)	Acc1 Acc2 Acc3	$T_{a1} = +25^{\circ}C$ $T_{a2} = -25^{\circ}C \dots +50^{\circ}C$ $T_{a3} = -40^{\circ}C \dots +85^{\circ}C$		0.04	0.09 0.11 0.16	°
Initial offset	ϕ_{off}			+/-0.1		°
Temperature drift offset	$T\phi_{off}$	$T_a = -25^{\circ}C \dots +85^{\circ}C$ (2) $T_a = -40^{\circ}C \dots +85^{\circ}C$			0.06 0.07	° °
Cross sensitivity	CCA_x, CCA_y	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) $\phi[^\circ] = -(I[mA] - 12) / 1.6$
- (2) Temperature drift Offset is defined by:
 $T\phi_{off} = \phi_{off}(T_a) - \phi_{off}(25^{\circ}C)$
- (3) CrossSens is defined by:
 $CCA_x = Sens_x(Inclination_y) / Sens_x(Inclination_x)$
 $CCA_y = Sens_y(Inclination_x) / Sens_y(Inclination_y)$



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3.3.4 PWM Output, model NS - 5/ DMG2 – PWM

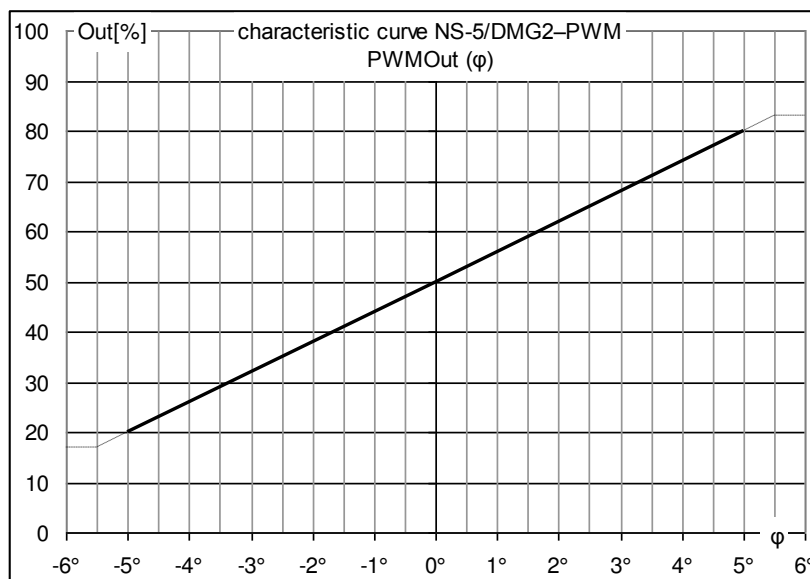
Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Output Characteristics (2): Specified performance	PWMSpec		20		80	%(1)
Operating range	PWMOUT		17		83	%(1)
Sensitivity	PWMSens			6		%(1) / °
Offset	PWMoff			50		%(1)
Output level high	VOH	IOH = -1 mA	+Vcc-0.3		+Vcc	V
Output level low	VOL	IOL = 1 mA	0		0.3	V
Output frequency	Fout			1000		Hz
Resolution	Res		0.001			°
Accuracy(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) $\varphi[^\circ] = (\text{PWM}[\% \text{Duty Cycle}] - 50) / 6$

(3) Temperature drift Offset is defined by:
 $T\varphi\text{off} = \varphi\text{off}(T_a) - \varphi\text{off}(25^\circ\text{C})$

(4) CrossSens is defined by:
 $CCAx = \text{Sens}_x(\text{Inclination}_y) / \text{Sens}_x(\text{Inclination}_x)$
 $CCAy = \text{Sens}_y(\text{Inclination}_x) / \text{Sens}_y(\text{Inclination}_y)$



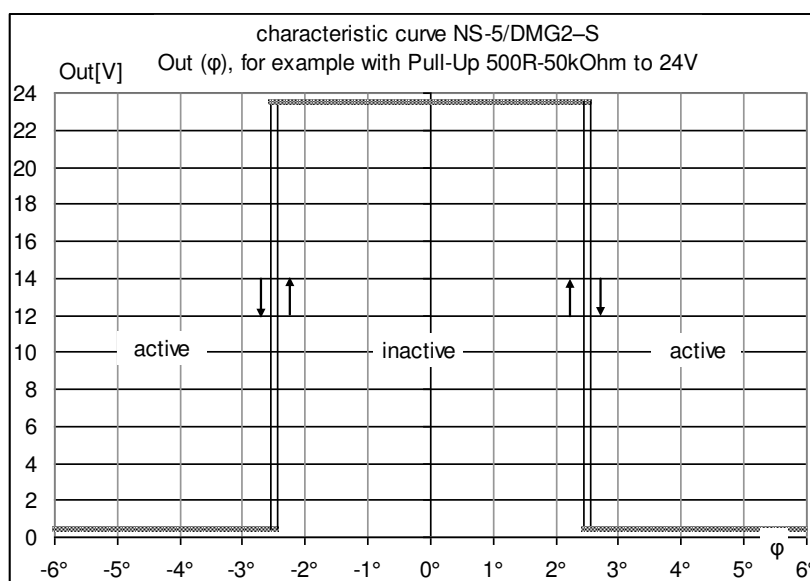
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3.3.5 Switch Output, model NS - 5/ DMG2 – S

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Output Characteristics: Specified performance Operating range	Spec		-5 -5.5		5 5.5	° °
V active (1)	Vxon, Vyon	responding Output x active IOut ≤ 50 mA,			1.2V	V
I inactive (1)	Ixoff, Iyoff	responding Output inactive 0V < Vout < 140V			0.02	mA
Resolution	Res			0.001		°
Accuracy (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 (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) Output state active: $|\varphi| > S$ of the corresponding axis
 Output state inactive: $|\varphi| < S$ of the corresponding axis
 with S = switch angle, see programming commands in setup level
 switchover from state inactive to state active: $|\varphi| > S + SH/2$
 switchover from state active to state inactive: $|\varphi| < S - SH/2$
 with SH = hysteresis, see programming commands in setup level
- (2) Temperature drift Offset is defined by:
 $T\varphi_{off} = \varphi_{off}(T_a) - \varphi_{off}(25^\circ\text{C})$
- (3) CrossSens is defined by:
 $CCAx = \text{Sens}_x(\text{Inclination}_y) / \text{Sens}_x(\text{Inclination}_x)$
 $CCAy = \text{Sens}_y(\text{Inclination}_x) / \text{Sens}_y(\text{Inclination}_y)$



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4 Serial Interface

The D-Series uses a standard RS-232 interface, duplex mode. The baud rate is 9600. After "Power On" the sensor sends continuously angle values in degrees (°). In the "Setup level" several settings can be permanently modified. If the "Continuous mode" has changed to the "Polling mode", the sensor will transmit after "Power On" and a start information with actual parameters. "On error" no angle values will be transmitted and after "Power On" an error message will be added 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  
...
```

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5 Programming commands

5.1.1 User level (default after power on)

Table 1: commands at user level

Command	To the sensor	Response sensor	Explanation
Activate temporary polling mode (1)(2)	"f"	"f"	The continuous transmission of angle values will be stopped. Commands could be sending 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 attention: at overflow a '!' was transmitted, see also footnote (6) in chapter 5.1.2 setup level
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 and setup information (3)	"**"	"Ux f HI O2 B2" , CR, LF, "OFFSETX+00.000" , CR, LF, "OFFSETY+00.000" , CR, LF, "M1mm M2tt"	„U“: 'U'/'S' = User/Setup level, „x“: Sensor output „U“ / „l“ / „P“ / „S“ “f”: f/F = permanent mode “HI”: 'HL'/'HI'= overflow limited / unlimited “O2 B2”: Output and Baud rate Offset x Offset y low pass filter if set

- (1) In the “Continuous mode” the sensor transmits continuously angle values; in the “Polling mode” the sensor transmits one answer after a command.
- (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”, the continuous transmission has to be stopped before command “f”
- (4) The input of the password “prog” has to be finished within 20 sec.

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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; they are permanently available, also after "Power down".

Table 2 commands at Setup level

Command	To the sensor	Response sensor	Explanation
Activate permanent polling mode (1)	"f"	"f"	The continuous transmission of angle values will be stopped. Commands could be sending to the sensor.
Activate permanent continuous mode (1)(1)	"F"	„X=±xx.xxx“, CR, LF, "Y=±xx.xxx“, CR, LF, "X= . . .	Continuous transmission of X angle in ° Y angle in ° with „±“ = „+“ or „-“
Set rate of data transmission for continuous mode (2)(2)(4)(5)	"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 (3)(4)	"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 (4)(4)	"N"	"N"	The offset adjust was reset to the original value
Set Baud rate (2)(4)(6)	"B" <Code Baud rate>	"B" <Code Baud rate>	Echo, code baud rate or „E“ for error, if the code is outside defined values
Reset low pass filter (7)	"M0"	"M0"	deactivate low pass filter
Set low pass filter moving average (7)	"M1mm"	"M1mm"	Activate filter moving average with mm values or "E" for error
Set low pass filter exponential (7)	"M2tt"	"M2tt"	Activate filter exponential
Set switch angle for one axis (2)(4)(8)(9)	"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)(4)(8)(10)	"Sh" <hysteresis>	"Sh" <hysteresis>	Echo, hysteresis or „E“ for error, if the angle is outside admissible range
Show active level (2)	"*"		same as at user level
RS232 display to a limit of 110%	" L "	"L" show "x+++++" at x> 110% "x-----" at x<-110%	More than -110%...+110% the value show an overflow letter. Valid from SW 1.8 version.
RS 232 display no limit	"l"	"l" show "x=05.482" or "x=-05.482"	Small letter "L", value maximum show approx. 8.0°
Reset (2)	"q"	"q"	Software-Reset will be executed

(1) In the "continuous mode" the sensor transmits continuous angle values, in the "polling mode" the sensor transmits one answer after a command

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- (2) The command-transmission is only possible at "polling mode", the continuous transmission has to be stopped before temporary in `user-level` or permanent in `setup-level` with command "f"
- (3) Zero point setting (offset) is only possible between a range of -3°0°+3°
- (4) For activating a reset or power fail restart is necessary
- (5) For code transmission rate see Table 3 <Code transmission rate >
- (6) 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.
 The internal output buffer is sized to 248 Byte. If there is an overflow (at low baud rate, high output rate and continuous sending), the internal output stops. When the puffer is completely transmitted, a '!' was transmitted as an info for lost data. Then the transmission starts again.
- (7) Equations for low pass filter, valid from software version SW 2.2:
 - moving average "M1", "mm":
 with mm = 02 ... 40, number of readings for average
 - exponential average "M2", "tt":
 with tt = 02 ... 40,
 Out value = (old out value * (tt-1) / tt) + (current value/tt)
 the rate of data acquisition and calculation out values is 16/sec
- (8) This command is only effective for sensors with switch output
- (9) <switch angle>: three characters from "001" up to "300" for the angle, one-tenth increments, maximal working range of the sensor. Default value is 025 == 2.5°
- (10) <hysteresis>: two characters from "01" up to "99" for the stitching hysteresis, one-tenth increments, maximal 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, fastest output
"1"	16 Strings/s since SW 2.1 version (25 Strings/s until SW 2.0 version)
"2"	10 Strings/s, Default value
"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

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

Notice: If a transmission rate of 16 Hz and a baud rate of 2400 Bd will be set, the system generates an overflow and the internal transmission stopped. The output buffer has a limit size of 248 Bytes.

Specification

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After an automatically emptying of the buffer, a sign of “!” will be sending as an information for an overflow and the output interface will be re-starting.

5.2 Example for setting the output rate

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

Command	To the sensor	Response sensor	Explanation
		„X=±xx.xxx“, CR, LF, ”Y=±xx.xxx“, CR, LF, ”X= . . .	Continuous transmission of angles
Activate temporary polling mode	”f”	“f”	The continuous transmission of angle values will be stopped. Commands could be sending 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 1String/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 String/s

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6 Test Requirements

All D-Series inclinometers are tested at seven different angles in both the x-axis and y-axis, and at temperatures of -20°C, 0°C, 25°C and 50°C .

7 Standards

The D-series sensor, type NS-5/DMG2-X, comply with the 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
A=30g, t=11ms, halfsine, 50 cycles per axis

- IEC/EN 60068-2-6 Vibration loading
10 to 150 Hz, 2.5mm amplitude, 5g const. acceleration,
1 octave/minute, 20 cycles per axis

- IEC/EN 60068-2-14 Thermo shock
T_{High}=85°C , T_{Low}=-40°C, medium: air-air, T_{dwell}: 15min,
T_{change}: 30sec, 100 cycles

- DIN EN 60068-2-1 Cold, static
T= -55°C, medium: air; 1008 hours

- DIN EN 60068-2-78 Damp heat, steady state
T_a=85°C , RH=85%, 1008hours

- DIN 40050-9 Spraying water, protection class IP 67/68

8 Packaging for Delivery

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



D-Series Inclinometer

9 Additional Information

ORDERING INFORMATION

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