

D-Series Inclinometer

Instruction Manual D-Series Inclinometer



Model

NS-5/DMG2-U,-I,-PWM,-S
NS-15/DMG2- U,-I,-PWM,-S
NS-30/DMG2-U,-I,-PWM,-S

Version 1.3

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1 Introduction

Thank you for purchase of a D-Series inclinometer from Measurement Specialties. This manual offers information on the proper installation and operation. For further technical information on the performance of the D-Series inclinometer, please see the 'Specification, D-Series Inclinometer'.

2 Notice



Please observe all proper safety rules and regulations for electrical devices when installing this inclinometer. In addition, the following recommendations are made.

1. Do not apply power to the inclinometer during installation.
2. Avoid applying any mechanical pressure or stress to the housing.
3. Do not operate an inclinometer beyond the maximum angular sensing range or threshold. Irreparable damage may occur.
4. Do not exceed the maximum fastening torque for the mounting screws, as the base plate may become warped and/or irreparably damaged.
5. Use detergents free of alcohol or acid for cleaning of the housing.
6. Avoid direct solar radiation.
7. Hand tighten mating connector. DO NOT use pliers as damage may occur.
8. Should the inclinometer fail to operate properly, consult this manual for possible solutions. Do not attempt to open the inclinometer, as damage may occur. For other troubleshooting measures, please contact our service team.

3 History

Ver.	Date	Treatment	Author
1.0	Jan, 20 th , 2006	First Draft	M.Zürn, K.Schink
1.1	Oct, 5 th , 2007	- details standards	M.Zürn, K.Schink
1.2	Apr, 16 th , 2009	- update drawings	M.Zürn
1.3	July, 25 th , 2011	- add options, layout	M.Zürn

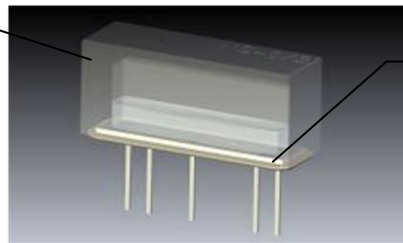
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4 General of the inclinometer system

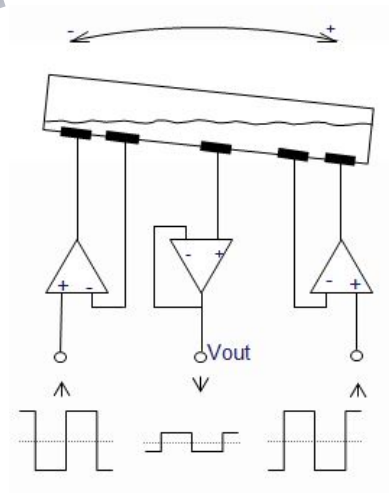
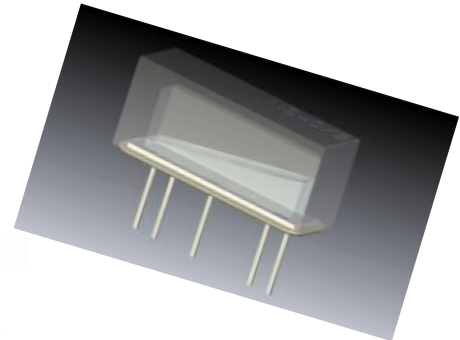
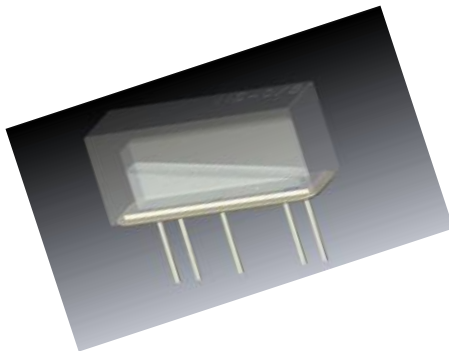
4.1 Description of the liquid/conductive measurement principle

Platinum electrodes are deposited in pairs on the base of the sensor's cell parallel to the sensitive axis. The chamber is partially filled with an electrolytic liquid. When an alternating voltage is passed between two electrodes, the electric current will create a dispersed field. By tilting the sensor and thereby reducing the level of liquid, it is possible to confine this stray field. Because of the constant, specific conductivity of the electrolytes a variance of resistance is formed in relation to the liquid level. A basic differential principle will yield an angle of inclination from the polarity signs.

Ceramic housing



Ceramic base plate with electrodes



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4.2 Ordering information

Measurement Specialties offers inclinometers of the D-series in the three different measurement ranges $\pm 5^\circ$, $\pm 15^\circ$ and $\pm 30^\circ$ with some output signals.

Model	Meas. Range	Output	Part-no.
NS - 5/DMG2 - U	$\pm 5^\circ$	RS 232, U 0.5 ...4.5V	G-NSDMG-015
NS - 5/DMG2 - I	$\pm 5^\circ$	RS 232, I 4...20 mA	G-NSDMG-017
NS - 5/DMG2 - PWM	$\pm 5^\circ$	RS 232, PWM 1kHz, 20....80%	G-NSDMG-014
NS - 5/DMG2 - S	$\pm 5^\circ$	RS 232, switch	G-NSDMG-016
NS - 15/DMG2 - U	$\pm 15^\circ$	RS 232, U 0.5 ...4.5V	G-NSDMG-019
NS - 15/DMG2 - I	$\pm 15^\circ$	RS 232, I 4...20 mA	G-NSDMG-021
NS - 15/DMG2 - PWM	$\pm 15^\circ$	RS 232, PWM 1kHz, 20....80%	G-NSDMG-018
NS - 15/DMG2 - S	$\pm 15^\circ$	RS 232, switch	G-NSDMG-020
NS-30/DMG2 -U	$\pm 30^\circ$	RS 232, U 0.5 ...4.5V	G-NSDMG-023
NS-30/DMG2 -I	$\pm 30^\circ$	RS 232, I 4...20 mA	G-NSDMG-025
NS-30/DMG2 -PWM	$\pm 30^\circ$	RS 232, PWM 1kHz, 20....80%	G-NSDMG-022
NS-30/DMG2 - S	$\pm 30^\circ$	RS 232, switch	G-NSDMG-024

4.3 Electrical Connection

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

4.4 Cable/Connector Assembly (optional)

Type of cable: LiYCY 7x0.14mm²
 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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5 Main product specification

5.1 Maximum values

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Supply Voltage	Ub	Measurement of Ub against GND, reverse polarity protection	-30		+30	V
Signal Voltage	UXout UYout	When used as switch, measured against SGND	0		100	V
Isolation Signal Voltage Circuit		When used as switch, measured UXOut, UYOut, SGND against all other connections	-125		+125	V
Switch current	IXout IYout	Xout, Yout to SGND			50	mA
Storage Temperature	Tstor		-55		+85	°C
Inclination angle in x and y	φ_{max}	NS – 5/DMG2-x NS – 15/DMG2-x NS – 30/DMG2-x	-15 -40 -60		+15 +40 +60	°

5.2 Short-time operation overview

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Supply Voltage	Ub	Measured Ub against GND	+10	+24	+30	VDC
Operating Temperature	Top	Inclination Sensor Unit	-40		+85°C	°C
Current Consumption	Icc	No load at Output			30	mA
Measurement Range		NS-05/DMG2-xx NS-15/DMG2-xx NS-30/DMG2-xx	- 5 -15 -30		+ 5 +15 +30	°
Resolution	Res	Digital Output RS 232		0.001		°
Accuracy	D1-Acc1	Digital Output RS 232 [Top=25°C] NS – 5/DMG2- U,-I,-PWM,- S		0.03		°
Accuracy	A1-Acc1	Analog Output [Top=25°C] NS – 5/DMG2- U,-I,-PWM,-S		0.04		°
Accuracy	D2-Acc1	Digital Output RS 232 [Top=25°C] NS – 15/DMG2- U,-I,-PWM,-S		0.1		°
Accuracy	A2-Acc1	Analog Output [Top=25°C] NS – 15/DMG2- U,-I,-PWM,-S		0.15		°
Accuracy	D3-Acc1	Digital Output RS 232 [Top=25°C] NS – 30/DMG2- U,-I,-PWM,-S		0.3		°
Accuracy	A3-Acc1	Analog Output [Top=25°C] NS – 30/DMG2- U,-I,-PWM,-S		0.4		°
Voltage Output	Ua	Inclination angle x,y = 5°,15°,30° - x,y°... + x,y°	0,5		4.5	V
Current output	Ia	Inclination angle x,y = 5°,15°,30° - x,y°... + x,y°	4		20	mA
PWM Output	PWMa	Inclination angle x,y = 5°,15°,30° - x,y°... + x,y° f _{PWM} = 1 kHz	20		80	%
Switch Output	Sa	Inclination angle x,y = 5°,15°,30° - x,y°... + x,y°, Step 0.1°		0.1		°

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6 Dimensions / Mounting/ Electrical Connections

6.1 Dimensions [mm]

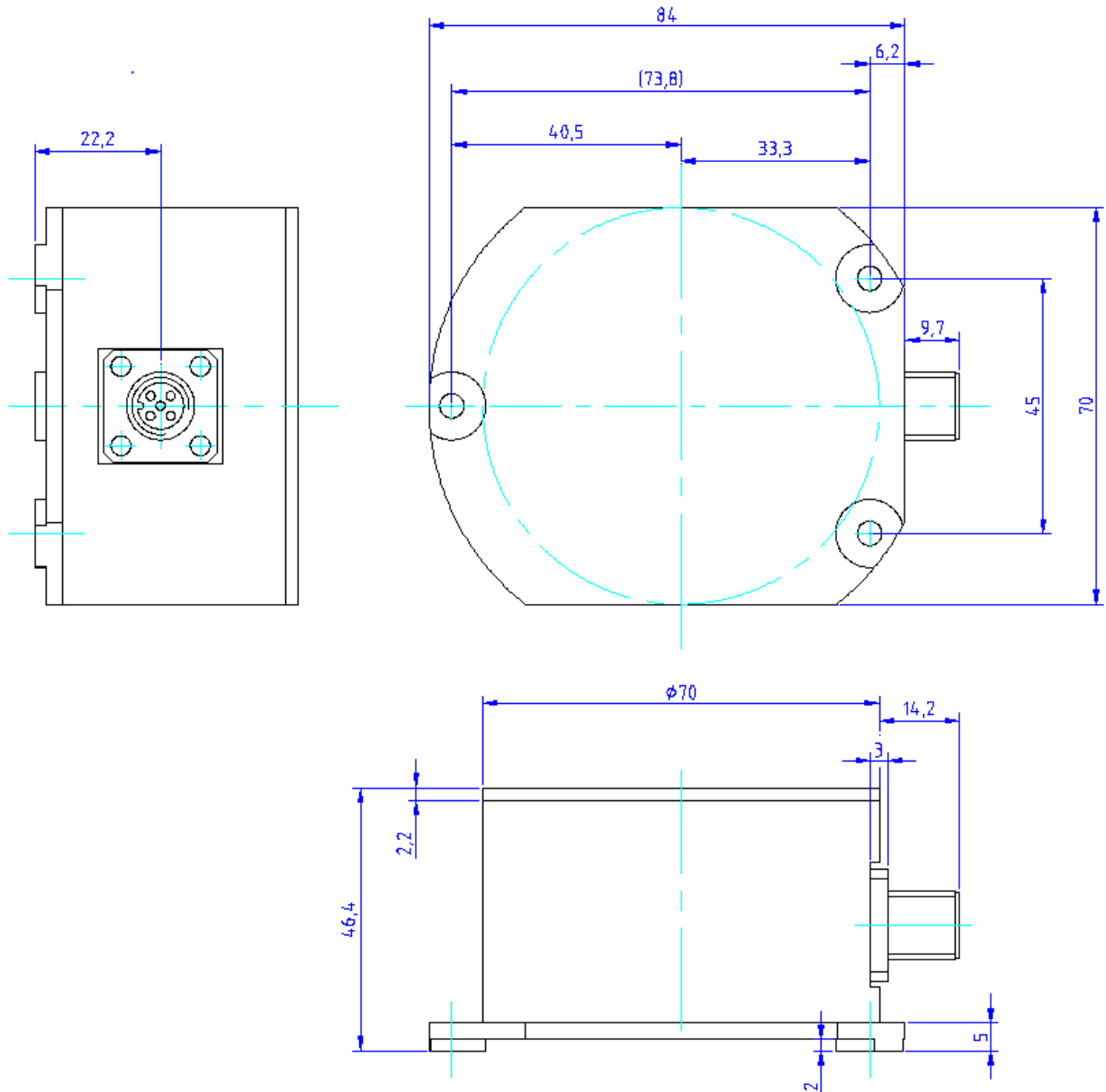


Fig. 6.1.1 View of the inclinometer housing and connector

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6.2 Mounting Instructions

The inclinometer is designed for horizontal mounting, meaning the base plate of the inclinometer with the three mounting holes needs to be placed on the horizontal plane of the object to be measured. The mounting surface must be smooth and free of dust and grease. Fasten inclinometer to the surface to be measured using three #M4 screws, and torque to a maximum of 10 Nm (do not exceed!!).

6.3 Installation

Prior to installation, please check for all connection and mounting instructions to be complied with. Please also observe the general rules and regulations on low voltage technical devices.

Avoid shock and vibration during measurement, as these could adulterate the measurement results. Inclination sensors that base on a fluidic measurement principle are optimal for static measurements and suitable to only a limited extent of dynamic measurement.

6.4 Measurement

Tilt angle measurements are made in the 'X' and 'Y' axis' (longitudinal and lateral respectively), with the reference being the horizontal plane.

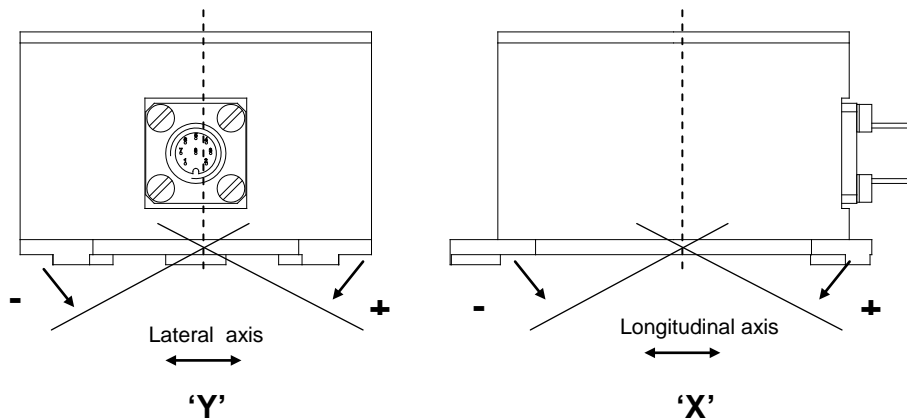


Fig. 6.4.1 X and Y axis identification

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6.5 Reference Surface

The D-Series Inclinometer incorporates a reference surface feature to aid in achieving optimal alignment with the sensitive axis'. This reference surface (identified below) is precision machined, and is parallel to the inclinometer's X axis. When mounting the inclinometer, it is imperative that this reference surface be positioned exactly parallel to the axis of the object to be measured. Failure to do so will introduce measurement inaccuracies and cross sensitivity.

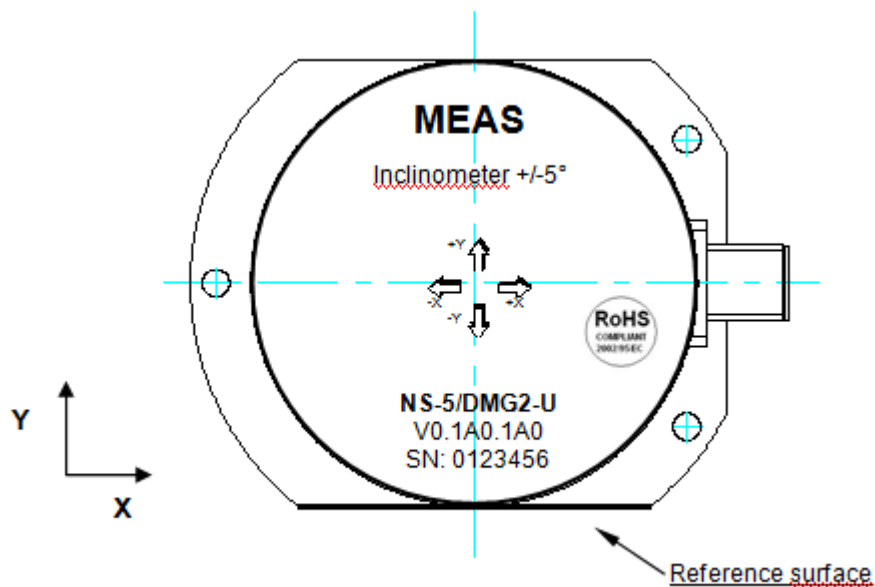


Fig. 6.5.1 Reference surface of the inclinometer, top view.

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6.6 Electrical Connections

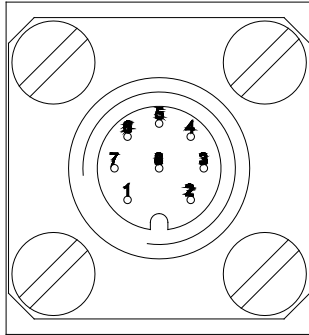


Fig. 6.6.1
Connector 8 pin identification

Pin	Name	Description	Type	Wire Colour ⁽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	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) Colour code is for a standard cable assembly (optional) provided by Meas Deutschland GmbH.

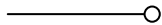
(2) dependent upon inclinometer version:


NS-xx/DMG2-U	output signal (X,Y) analog voltage 0.5...4.5V (- angle ... + angle)
NS-xx/DMG2-I	output signal (X,Y) analog current 4...20mA (- angle ... + angle)
NS-xx/DMG2-PWM	output signal (X,Y) PWM 1kHz, 20...80% (- angle ... + angle)
NS-xx/DMG2-S	output signal (X,Y) switch , 0.1° step (- angle ... + angle)

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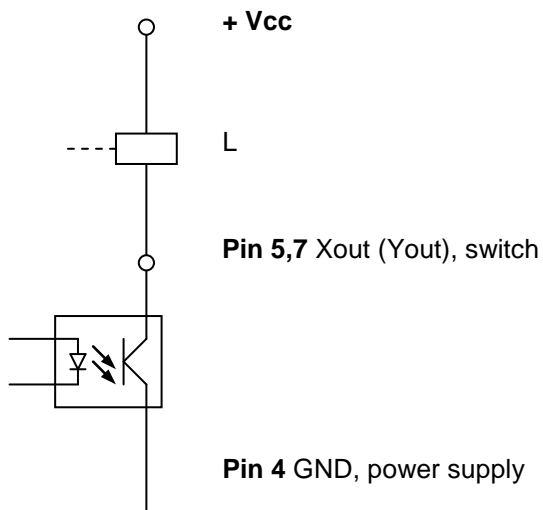
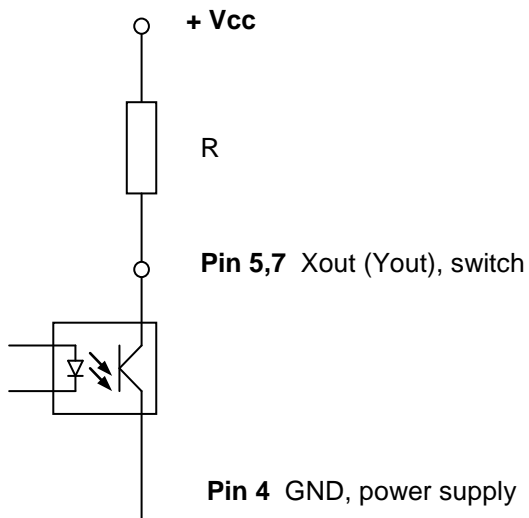
6.7 Sample switching circuit

6.7.1 Voltage, current, PWM circuit sample

 **Pin 5,6** Xout (Yout), voltage, current, PWM

 **Pin 6** SGND, signal ground

6.7.2 Switch circuit sample with resistance or relay (current maximum 50mA)



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6.8 Connecting to a PC using an RS 232 interface

PC side

9 Pin Sub D-connector

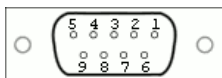
Plug in connector NS-xx/DMG2-x

8 pin Binder 763-series connector with MEAS cable

Pin 2 RxD

Pin 3 TxD

Pin 5 GND



1	white	+Ub	supply	positive power supply
2	brown	RxD	input	Rx serial signal RS 232
3	green	TxD	output	Tx serial signal RS 232
4	yellow	GND	supply	negative power supply, ground
5	grey	XOut	output	X-axis output signal
6	pink	SGND	supply	signal ground
7	blue	YOut	output	Y-axis output signal
8	red	nc	nc	nc

7 Serial Interface RS 232

The D-Series uses a standard RS-232 interface, duplex mode. The baud rate is 9600. After applying power, the sensor continuously sends angle data 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.

8 Programming Instructions

8.1 Basic Settings

After Power On, the sensor is in the user level. The factory default for this mode is 'Free running', meaning the inclinometer will continuously transmit angular data every 100ms, 9600 baud.

In the Setup-level several settings can be changed and stored in non-volatile memory such as query mode, free running mode, output rate, baud rate and angular offset. If query mode is selected, the sensor will send start information with the current settings after Power On.

Note: In case of errors no angle values will be provided and after Power On, and an error message will be added to the start information.

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Interface parameter:

- 9600 Baud , 8 data bits, parity even, 1 stop bit,

The baud rate can be adjusted to different values in the setup-level.

Structure:

Baud rate: 9600 Baud (factory setting, changes in setup-mode possible)

Format: ASCII, 8 data bits, 1 stop bit, parity even

Length: 22 byte

Display: <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

Display example:

```

...
X=+00.430
Y=-00.084
...

```

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8.2 Commands in user level (default after power on)

Table 1: instructions 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 0 in chapter 0
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“ / „I“ / „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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8.2.1 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 instruction of 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)	"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)(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)	"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

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- (1) In the "continuous mode" the sensor transmits continuous angle values, in the "polling mode" the sensor transmits one set of data after a command
- (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 $-3^{\circ} \dots 0^{\circ} \dots +3^{\circ}$
- (4) For activating a reset or power fail restart is necessary
- (5) For code transmission rate see
- (6) For code baud rate see

Attention! A reset of the baud rate to the default value is not possible. If the user forgets the adjusted baud rate, a new value must be determined and entered.

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 buffer is completely transmitted, a '!' is transmitted as an indication that data was lost. Data transmission will then start 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

e.g. filter=a without active filtering, parameter `0`.

filter=d active filtering, parameter moving average M1 20 and exponential M2 20.

Please notice, you must find your optimal values through your own tests.

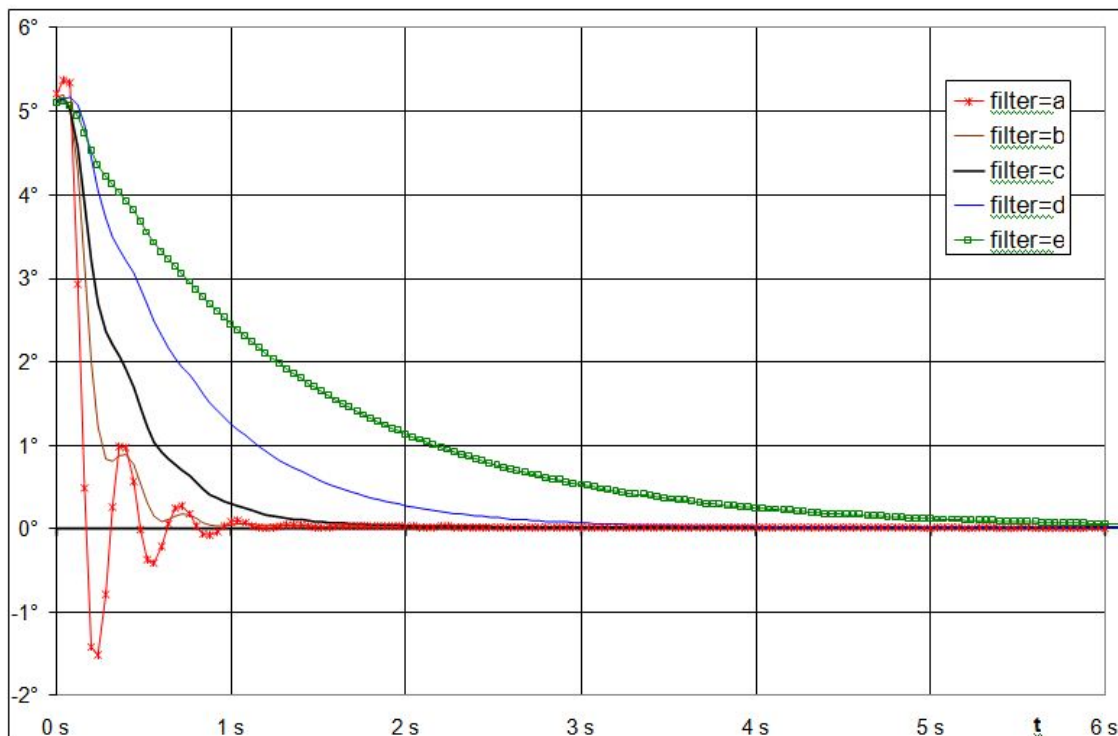


Fig. 7.1 Sample filter damping curve NS-5/DMG2-U, moving step $5^{\circ} \rightarrow 0^{\circ}$

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- (8) This command is only effective for sensors with a switching type 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°

- Set average switch angle (S=Sx,Sy)

001 = 0.1°
002 = 0.2°
...
300 = 30°

- Set hysteresis (Sh)

01 = 0.1°
02 = 0.2°
...
99 = 9.9°

Example: Need a switch point at $S_{on} \pm 2.4^\circ$ and $S_{off} \pm 0.8^\circ$

$$S_{on} = S + Sh/2$$

$$S_{off} = S - Sh/2$$

$$S = (S_{on} + S_{off})/2$$

$$Sh = S_{on} - S_{off}$$

- Calculation of S and Sh

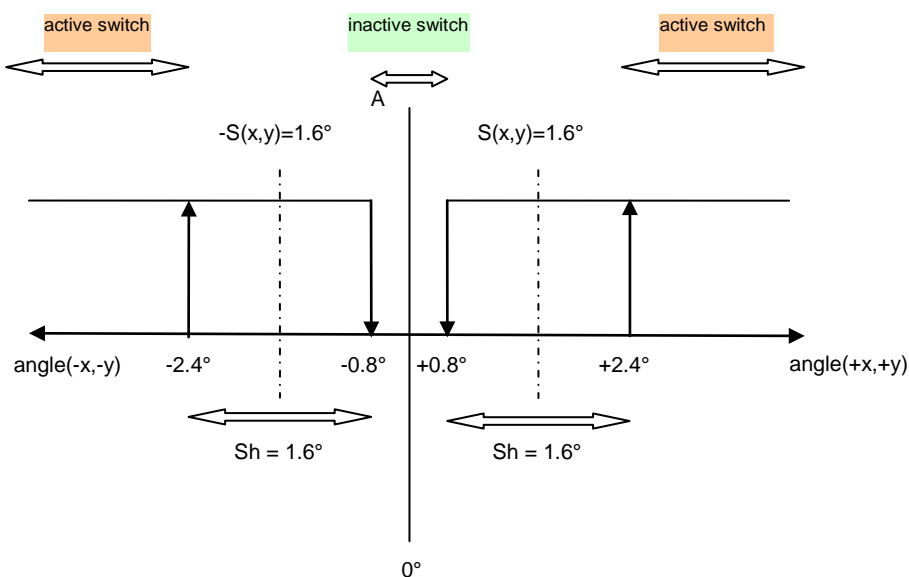
$$Sh = S_{on} - S_{off} = 2.4^\circ - 0.8^\circ = 1.6^\circ$$

$$S = S_{on} - Sh/2 = 2.4^\circ - 1.6^\circ/2 = 1.6^\circ$$

- Programming parameter

$$Sh = 1.6^\circ = 16$$

$$S = 1.6^\circ = 016$$



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Table 2 <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 Vers.2.1 (25 Strings/s until SW Vers 2.0)
"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 3 <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. 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.

8.3 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

D-Series Inclinometer

9 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

10 Standards

The D-series 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
 $T_{High}=85^{\circ}C$, $T_{Low}=-40^{\circ}C$, 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
 $T_a=85^{\circ}C$,RH=85%, 1008hours
- DIN 40050-9 Spraying water, protection class IP 67/68

11 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.

D-Series Inclinometer

12 Additional Information

ORDERING INFORMATION

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