Specification
DPN-Series
Inclinometer Module

Version 1.3

Contents

1.1 History

Ver.	Date	Purpose	Author
1.0	2008-06-06	Creation for NS-xx/DPN2-XXX	M.Zürn
1.1	2010-06-16	Update parameter	M.Zürn
1.2	2011-12-21	Add options, layout	M.Zürn
1.3	2016-09-09	Add options, layout	M.Zürn

2 General Information

The NS-xx/DPN2-xxx is a µC controlled inclinometer equipped with a biaxial inclination sensor and integrated temperature sensor for OEM use. All types are named NSxxDPN2 in the following.
The NSxxDPN features a measuring range up to ± 30°.

2.1 Key Features

- Two inclination basic cells based on the conductance measurement principle
- µC controlled inclinometer on board level
- Linearization
- Temperature compensation
- Programmable digital filtering
- Interface option A: output 1 via RS 232 interface
- Interface option B: output 2 analogue voltage output 0.3…4.7 V

2.2 Part Number

These products can be ordered by following part number:

type	measurement angle	output	supply	order number
NS-2/DPN2-RXD	- 2°... + 2°	RS 232	+7 ... +28 VDC	G-NSDPL2-008
NS-2/DPN2-RUD	- 2°... + 2°	RS 232, voltage	+7 ... +28 VDC	G-NSDPL2- 022
NS-5/DPN2-RXD	- 5°... + 5°	RS 232	+7 ... +28 VDC	G-NSDPL2-010
NS-5/DPN2-RUD	- 5°... + 5°	RS 232, voltage	+7 ... +28 VDC	G-NSDPL2- 024
NS-10/DPN2-RXG	- 10°... +10°	RS 232	+7 ... +28 VDC	G-NSDPL2-005
NS-10/DPN2-RUG	- 10°... + 10°	RS 232, voltage	+7 ... +28 VDC	G-NSDPL2- 025
NS-15/DPN2-RXG	- 15°... +15°	RS 232	+7 ... +28 VDC	G-NSDPL2-006
NS-15/DPN2-RUG	- 15°... + 15°	RS 232, voltage	+7 ... +28 VDC	G-NSDPL2- 026
NS-30/DPN2-RXN	- 30°... + 30°	RS 232	+7 ... +28 VDC	G-NSDPL2-012
NS-30/DPL2-RUN	- 30°... + 30°	RS 232, voltage	+7 ... +28 VDC	G-NSDPL2- 027

3 Mechanics and Connections

3.1 Mounting

This inclinometer is mounted parallel to the xy-plane, reference is the base plate.
To minimize the mechanical offset, please use the `reference edge ´of the board (fig. 3.4).

3.2 Label information

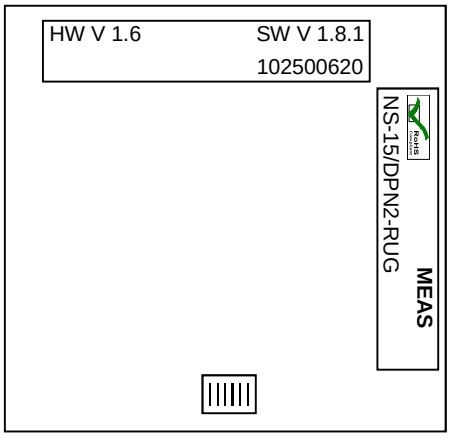

Fig. 3.2: top view, position of cells and labels

Parts are marked with two labels glued on top of the inclinometer basic cells.
These labels contain following information:

Model:	NS-xx/DPN2-xxx
Meas version:	internal HW/SW-Versions
Serial No.:	YYWWNNNNN

YYWWNNNNN consists of nine digits. YY shows the year of production (2010=10), WW the week of the production and NNNNN the number for identifying.

3.3 Mechanical data

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Weight				20	25	g
Dimensions		W x D x H	45 x 45 x 15 (21)			mm

3.4 Mechanical Dimensions

The mechanical dimensions of the board are shown in **[mm]**.
The board is made of FR4-Epoxy with a thickness of 1.5 +/-0.15 mm.

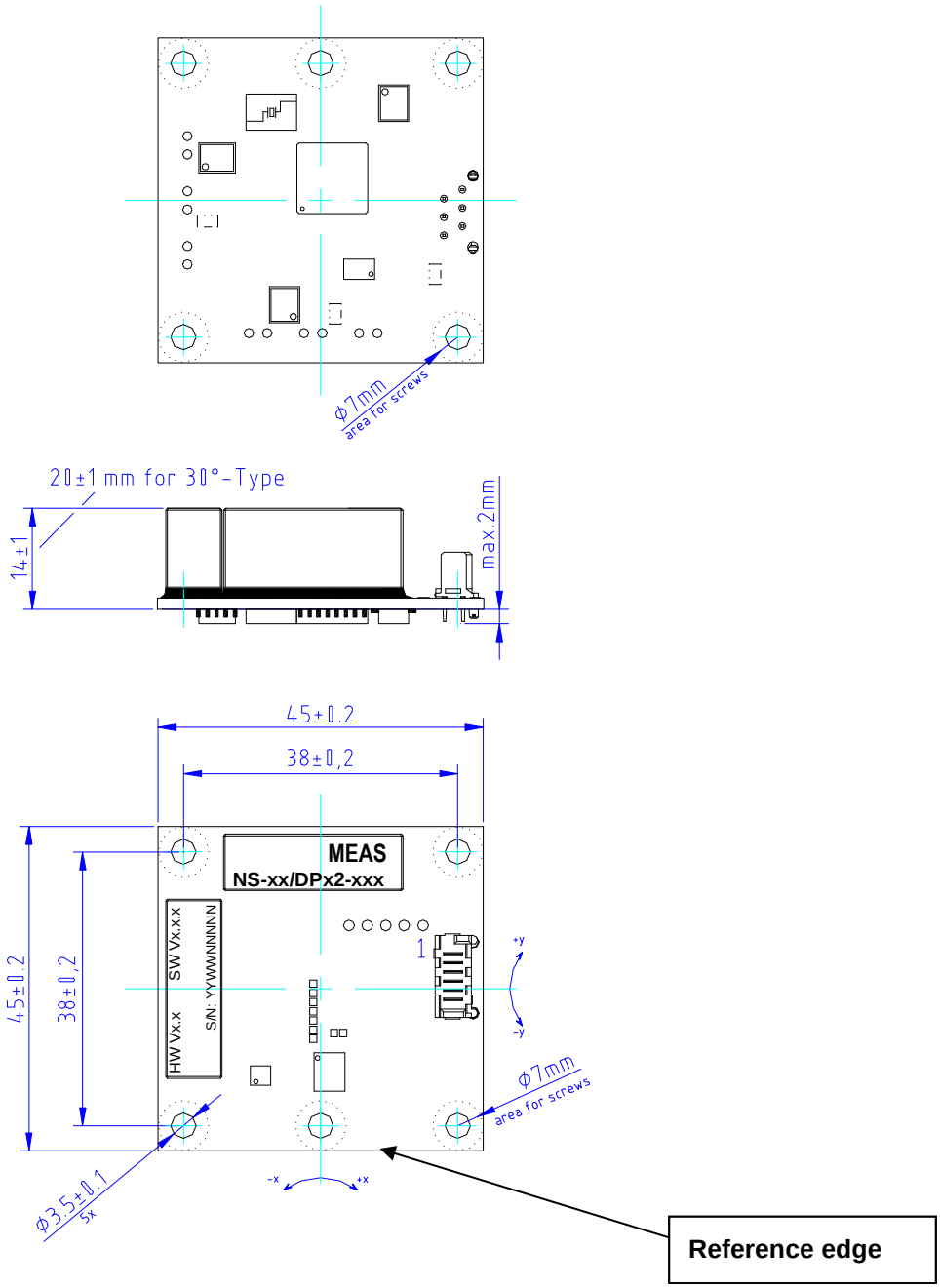

Fig. 3.4 : Top view, cross sectional and bottom view (top-down) of the board with dimensions and placement of the connector

3.5 Connector

The following connector has to be used: Molex, Picoflex PF-50 6-Pin Jack (90325-0006).

3.6 Terminal Connections

3.6.1 Unit with RS 232 interface

	Sensor type NS-xx/DPN2-RXX		
Pin	**Name**	**Description**	**Type**
1	Vcc	Positive power supply	Supply, Input
2	RxD	RS 232 input	Input 1
3	GND	Ground	Supply, Input
4	N.C.	reserved	do not connect
5	N.C.	reserved	do not connect
6	TxD	RS 232 output	Output 1

3.6.2 Unit wit RS 232 interface and analog output voltage 0.3…4.7V

	Sensor type NS-xx/DPN2-RUX		
Pin	**Name**	**Description**	**Type**
1	Vcc	Positive power supply	Supply, Input
2	RxD	RS 232 input	Input 1
3	GND	Ground	Supply, Input
4	Vxout	analogue output x-axis	Output 2
5	Vyout	analogue output y-axis	Output 2
6	TxD	RS 232output	Output 1

4 Absolute Maximum Ratings

CAUTION: Exceeding these values may destroy this part!

Parameter	**Symbol**	**Conditions**		**Min**	**Typ**	**Max**	**Unit**
Supply Voltage	Vcc	Measured versus GND, $t_{DURATION}$<5s	NS-xx/DPN2-xxx	-30		+30	V V
Storage temperature	T_{ST}			-55		+85	℃
Operation temperature	T_a			-40		+85	℃
Maximum angle	φ_{max}	Do not exceed maximum angle while under power supply for extended period of time. Irreversible damage may occur.		-10 -10 -30 -30 -60	2 5 10 15 30	+10 +10 +30 +30 +60	◦

4.1 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. Except for a maximum output voltage rating (often done as a leakage current test), production testing of the absolute maximum ratings is not usually performed.

5 Operating Conditions

Parameter	Symbol	Conditions		Min	Typ	Max	Unit
Ambient temperature	T_{amb}			-40		+85	℃
Supply Voltage	Vcc	Measured versus GND	NS-xx/DPN2-xxx	+7		+30	V
Operating range	φ_{op}	Without additional zeroing by the user	NS- 2/DPN2-xxx NS- 5/DPN2-xxx NS-10/DPN2-xxx NS-15/DPN2-xxx NS-30/DPN2-xxx	- 2 - 5 -10 -15 -30		+ 2 + 5 +10 +15 +30	°
Displayed maximum range	φ_{disp}	Without additional zeroing by the user	NS- 2/DPN2-xxx NS- 5/DPN2-xxx NS-10/DPN2-xxx NS-15/DPN2-xxx NS-30/DPN2-xxx	- 2.2 - 5.5 -11 -16.5 -32		+ 2.2 + 5.5 +11 +16.5 +32	°
Supply Current	Icc				15		mA

6 Sensor Characteristics

(SC): Special Characteristic

6.1 Sensor NS-2/DPN2-RXD Output RS 232, -RUD Output RS232 + Voltage

If not otherwise noted, 25℃ ambient temperature, + 7…+28VDC supply voltage were applied.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Resolution	Res			0.001		°
Initial offset	φ_{off}	(SC)		+/-0.06		°
Temperature drift offset (1)	$T\varphi_{off}$	Ta_2 = 0℃…+50℃ Ta_3 = -40℃…+85℃		0.03 0.10		° °
Accuracy (absolute incl. $T\varphi_{off}$)	Acc1 Acc2 Acc3	Ta_1 = +25℃ (SC) Ta_2 = 0℃… +50℃ Ta_3 = -40℃… +85℃			0.05 0.08 0.15	° ° °
Cross sensitivity (2)	CCAx, CCAy				1.4	%
Settling time (5°step)	Ts90 Ts99	with default filter settings: to 90% (=final value ±0,5°) to 99% (=final value ±0,05°)		1.6	1 2	s s
Noise RMS				0.001	0.002	°
Output rate digital		typ = default settings, other adjustable	0.5	10	25	measure-ments/s
Output analogue	Vxout, Vyout	nominal up to +/-2°	0.5		4.5	V
Output analogue	Vxout, Vyout	overtravel	0.3		4.7	V

(1) Temperature drift Offset is defined by:
$T\varphi_{off} = \varphi_{off}(Ta) - \varphi_{off}(25℃)$

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

6.2 Sensor NS-5/DPN2-UXD Output RS 232, -RUD Output RS232 + Voltage

If not otherwise noted, 25℃ ambient temperature, + 7…+28V supply voltage applied.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Resolution	Res			0.001		°
Initial offset	φ_{off}	(SC)		+/-0.08		°
Temperature drift offset (1)	$T\varphi_{off}$	Ta_2 = 0℃… +50℃ Ta_3 = -40℃… +85℃		0.03 0.10		° °
Accuracy (absolute incl. $T\varphi_{off}$)	Acc1 Acc2 Acc3	Ta_1 = +25℃ (SC) Ta_2 = 0℃… +50℃ Ta_3 = -40℃… +85℃			0.05 0.08 0.15	° ° °
Cross sensitivity (2)	CCAx, CCAy				1.4	%
Settling time (5°step)	Ts90 Ts99	with default filter settings: to 90% (=final value ±0,5°) to 99% (=final value ±0,05°)		1.6	1 2	s s
Noise RMS				0.001	0.002	°
Output rate digital		typ = default settings, other adjustable	0.5	10	25	measure-ments/s
Output analogue	Vxout, Vyout	nominal up to +/-5°	0.5		4.5	V
Output analogue	Vxout, Vyout	overtravel	0.3		4.7	V

(1) Temperature drift Offset is defined by:
$T_{\varphi off} = \varphi_{off}(Ta) - \varphi_{off}(25℃)$

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

6.3 Sensor NS-10/DPN2-RXG Output RS 232, -RUG Output RS232 + Voltage

If not otherwise noted, 25℃ ambient temperature, + 7… +28V supply voltage were applied.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Resolution	Res			0.001		°
Initial offset	φ_{off}	(SC)		+/-0.08		°
Temperature drift offset (1)	$T\varphi_{off}$	Ta_2 = 0℃… +50℃ Ta_3 = -25℃… +85℃		0.05 0.10		° °
Accuracy (absolute incl. $T\varphi_{off}$)	Acc1 Acc2 Acc3	Ta_1 = +25℃ (SC) Ta_2 = 0℃… +50℃ Ta_3 = -40℃… +85℃			0.06 0.09 0.15	° ° °
Cross sensitivity (2)	CCAx, CCAy				1.4	%
Settling time (5°step)	Ts90 Ts99	with default filter settings: to 90% (=final value ±0,5°) to 99% (=final value ±0,05°)		1.6	1 2	s s
Noise RMS				0.001	0.002	°
output rate digital		typ = default settings, other adjustable	0.5	10	25	measure-ments/s
Output analogue	Vxout, Vyout	nominal up to +/-10°	0.5		4.5	V
Output analogue	Vxout, Vyout	overtravel	0.3		4.7	V

(1) Temperature drift Offset is defined by:
$T_{\varphi off} = \varphi_{off}(Ta) - \varphi_{off}(25℃)$

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

6.4 Sensor NS-15/DPN2-RXG Output RS 232, -RUG Output RS232 + Voltage

If not otherwise noted, 25℃ ambient temperature, + 7…+28V supply voltage were applied.

Parameter	Symbol	Conditions	Min	Typ	Max		Unit
Resolution	Res			0.001			°
Initial offset	φ_{off}	(SC)		+/-0.08			°
Temperature drift offset (1)	$T\varphi_{off}$	Ta_2 = 0℃… +50℃ Ta_3 = -40℃… +85℃		0.05 0.10			° °
					|φ| ≤ 10°	**10° < | φ|**	
Accuracy (absolute incl. $T\varphi_{off}$)	Acc1 Acc2 Acc3	Ta_1 = +25℃ (SC) Ta_2 = 0℃… +50℃ Ta_3 = -40℃… +85℃			0.06 0.09 0.15	0.17 0.20 0.25	° ° °
Cross sensitivity (2)	CCAx, CCAy				1.4		%
Settling time (5°step)	Ts90 Ts99	with default filter settings: to 90% (=final value ±0,5°) to 99% (=final value ±0,05°)		 1.6	 1 2		 s s
Noise RMS				0.001	0.002		°
Output rate digital		typ = default settings, other adjustable	0.5	10	25		measure-ments/s
Output analogue	Vxout, Vyout	nominal up to +/-15°	0.5		4.5		V
Output analogue	Vxout, Vyout	overtravel	0.3		4.7		V

(1) Temperature drift Offset is defined by:
$T_{\varphi off} = \varphi_{off}(Ta) - \varphi_{off}(25℃)$

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

6.5 Sensor NS-30/DPN2-RXN Output RS 232, -RUN Output RS232 + Voltage

If not otherwise noted, 25℃ ambient temperature, + 7…+28V supply voltage were applied.

Parameter	Symbol	Conditions	Min	Typ	Max		Unit
Resolution	Res			0.001			°
Initial offset	φ_{off}	(SC)		+/-0.08			°
Temperature drift offset (1)	$T\varphi_{off}$	Ta_2 = 0℃… +50℃ Ta_3 = -40℃… +85℃		0.1 0.15			° °
					|φ| ≤ 10°	**10° < | φ|**	
Accuracy (absolute incl. $T\varphi_{off}$)	Acc1 Acc2 Acc3	Ta_1 = +25℃ (SC) Ta_2 = 0℃… +50℃ Ta_3 = -40℃… +85℃			0.06 0.09 0.15	0.3 0.5 0.8	° ° °
Cross sensitivity (2)	CCAx, CCAy				1.4		%
Settling time (5°step)	Ts90 Ts99	with default filter settings: to 90% (=final value ±0,5°) to 99% (=final value ±0,05°)		 2	 1 2		 s s
Noise RMS				0.002	0.005		°
Output rate digital		typ = default settings, other adjustable	0.5	10	25		measure-ments/s
Output analogue	Vxout, Vyout	nominal up to +/-30°	0.5		4.5		V
Output analogue	Vxout, Vyout	overtravel	0.3		4.7		V

(1) Temperature drift Offset is defined by:
$T_{\varphi off} = \varphi_{off}(Ta) - \varphi_{off}(25℃)$

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

6.5.1 Step response/filtering NS-15/DPL(N)2-UXG

Step response NS-15/DPL(N)2-UXG, fast change from angle 5° to 0°, at Ta=25℃
Measured at Output rate 25Hz*.

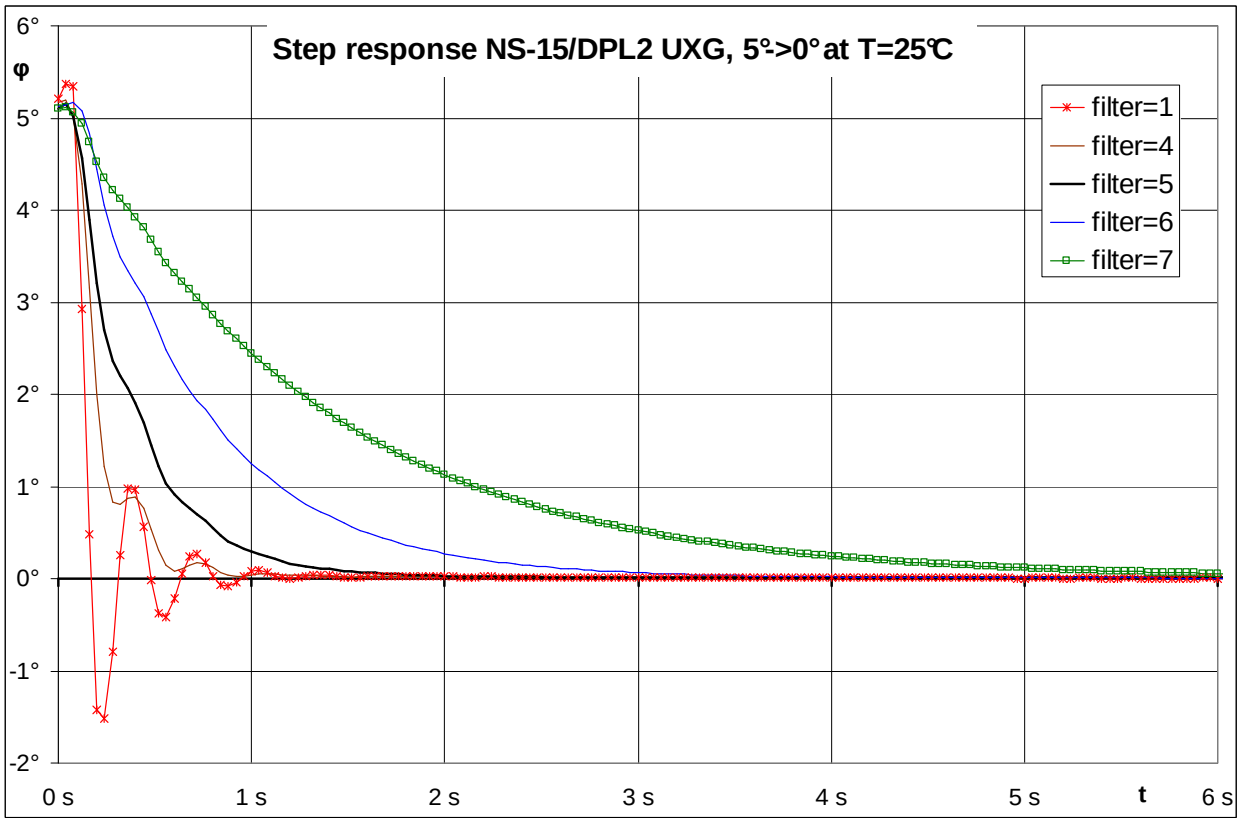

Fig. 6.5.1: step response of NS-15/DPL(N)2 UXG, 5° -> 0° @ Ta=25℃

*For filter settings see command “M” f in chapter 7.1.4 “Command reference setup level”

7 Interface

The NS-xx/DPN2 is available with RS232 only or with RS232+analog voltage output interface.

7.1 RS232

For digital communication, the standardized RS 232-Interface (V24) is used in duplex mode.
After startup the sensor transmits the angle values in degrees (°) continuously.

7.1.1 Electrical Levels

RS232:

PARAMETER	TEST CONDITIONS	MAX	TYP(†)	MIN	UNIT
V_{OH} High-level output voltage	D_{OUT} at R_L = 3 kΩ to GND, D_{IN} = GND		9	5	V
V_{OL} Low-level output voltage	D_{OUT} at R_L = 3 kΩ to GND, D_{IN} = VCC	−5	−9		V
I_{IH} High-level input current	V_I = VCC	200	15		µA
I_{IL} Low-level input current	V_I at 0 V		−15	−200	µA
I_{OS}(‡) Short-circuit output current	Vcc = 5.5 V, V_O = 0 V	60	±10	−60	mA
$Ω_O$ Output resistance	Vcc, V+, and V− = 0 V, V_O = ±2 V	300			Ω

(†) TA = 25°C.
(‡) Short-circuit durations should be controlled to prevent exceeding the device absolute power-dissipation ratings, and no more than one output

7.1.2 Interface parameters for NS–xx/DPN2–RXX

Baud rate: 9600 Baud
Format: ASCII, 8 data bits, 1 stop bit, no parity
String length: 22 Byte
Layout: < D0 ... D21>

D0 ... D10	= “X=±xx.xxx“, <CR>, <LF>	with D2 = sign (+ or -), D5 = decimal point
D11 ... D21	= “Y=±xx.xxx“, <CR>, <LF>	with D13= sign (+ or -), D16 = decimal point

Example:

```
…
X=+00.430
Y=-00.084
…
```

7.1.3 Command Reference USER level

Default after power on or software reset.

Commands in user level	Input	Output	Comment
Stop continuous output of inclination values	"**s**"	"s"	Stops the continuous output of angle results or raw values, required for input of commands, terminated by "S" or reset or power on, mode temporary
Start continuous output of values	"**S**"	"X=+01.234", CR, LF, "Y=-00.007", CR, LF, "X=……"	Starts the continuous output of angle results or raw values, mode temporary
Version and serial number	"**V**"	"DPL2 V1.8.0", CR, LF, "SN:123456789", CR, LF,	Output of SW-Version and serial number, use in stopped mode only
Read one value	"**R**"	"X=+01.234", CR, LF, "Y=-00.007", CR, LF,	Output of 1 complete string, 1 x-value and 1 y-value, only in stopped mode
Activate setup level	"**f**" "**i**" "**m**" "**a**"	"f" "i" "m" "a"	Activate the setup level, chapter 7.1.4. Setup level can be deactivated by sending "K" or resetting with "q". The controller automatically exits this level after about 10 minutes of user inactivity with a reset.
	any other	no reaction	No reaction for commands from setup level

7.1.4 Command Reference SETUP level

Setup level will be used for permanent settings, stored.

Commands in setup level	Input	Output	Comment
			This level will be terminated (reset) automatically after about 10 minutes of user inactivity.
Stop continuous output of inclination values	"**c**"	"c"	Stops the continuous output of angle results or raw values, required for input of commands, terminated by "C", mode permanent, query with "R", see chapter 7.1.3.
Start continuous output of values	"**C**"		Starts the continuous output of angle results or raw values, mode permanent, valid after reset.
Set zero	"**N**"	"N"	Define 0° position. Offset is stored and used even after reset.
Setback zero	"**n**"	"n"	Resets the offset displacement
Set low pass filter	"**M**", **f**	"M", f	Input filter settings with count f = "0"..."7", other characters were answered with "E", see item 1) below.
Set output rate	"**O**", **o**	"O", o	Set Output rate with count o = "1"..."6", other characters were answered with "E", see item 2) below.
Show internal settings	"*****"	"O123 M123", CR, LF "OffX=+00.000 OffY=+00.000", CR, LF "Erase Cycl SegF: +00255", CR, LF	"O123": internal setting of output rate in 10ms, "M123": internal filter setting; both values 255 => default settings "Off..": stored Offset values "Erase Cycl Seg…": active Segment and number of erasure procedures for this segment
Show currently temperature [℃]	"**T**"	"T= 00.00", CR,LF	Readout the currently temperature in ℃. Usable at > software version 2.0.2. Without sign, positive temperature. With sign `- `, negative temperature.
Software reset	"**q**"	"q"	Reset the sensor
Erase both Info segments, (switch to default settings)	"**E**"	"Seg A deleted" , CR, LF "Seg B deleted" , CR, LF	Erases the info segments of flash storage banks, InfoA and InfoB. This set all changed user values to default settings
Forbidden command	"**#**"	"#"	Reserved for factory communication

1) **Set low pass filter exponential, with count f =**
"0": Out value = current value
"1": Out value = (current value + old out value) /2
"2": Out value = (current value + 3 * old out value) /4
"3": Out value = (current value + 7 * old out value) /8
"4": Out value = (current value + 15 * old out value) /16
"5": Out value = (current value + 31 * old out value) /32, default
"6": Out value = (current value + 63 * old out value) /64
"7": Out value = (current value + 127 * old out value) /128
"8"..9: reserved, undefined.
Above calculation was made every 10ms.
For example of time response see chapter 6.1.1: "Step response NS-15/DPL2-UXG"

2) **Set output rate (strings per second, 1 string contains x and y-value) with count o =**
"1": 40ms (==25Hz)
"2": 100ms (==10Hz), default
"3": 250ms (==4Hz),
"4": 500ms (==2Hz)
"5": 1000ms (==1Hz)
"6": 2000ms (==0,5Hz)
"0", "7", "8", "9": not defined

8 Test Requirements

8.1 100% Series Test

100% of delivered parts are measured at 31 inclinations each (x-axis and y-axis) in order to determine corresponding values for Acc1, CCAx and CCAy at a distinct temperature in the range of 18℃ to 30℃.

8.2 Statistical Test

Four (two) parts of each fabrication lot between 51 and 160 (1 and 50) are tested at five temperatures:
-25℃, 0℃, 25℃, 50℃, 85℃

Measured, respectively calculated and checked are:
$T\varphi_{off}$, Acc2, Acc3

9 Qualification Testing

9.1 EMC

Due to the use of these modules for OEM application no CE declaration is done.

Especially line coupled disturbances like surge, burst, r.f. etc. cannot be removed by the module due to the small board area and low price feature. There is no protection circuit against reverse polarity or over voltage implemented.

The module will be designed using capacitors for blocking and ground plane areas in order to prevent wireless coupled disturbances as good as possible.

9.2 Periodical Testing

The periodical testing is done every 3 years in terms of a product audit.

9.3 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 Additional Information

ORDERING INFORMATION

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TE Connectivity Sensors, Inc. 1000 Lucas Way Hampton, VA 23666 United States Phone: +1-800-745-8008 Fax: +1-757-766-4297 Email: customercare.hmpt@te.com Web: www.te.com	TE Connectivity Sensors Germany GmbH Hauert 13 D-44227 Dortmund Germany Phone: +49-(0)231-9740-0 Fax: +49-(0)231-9740-200 Email:customercare.dtmd@te.com Web: www.te.com	TE Connectivity Sensors China Ltd. No. 26, Langshan Road High-tech Park (North) Nanshan District, Shenzhen 518057 China Phone: +86-755-33305088 Fax: +86-755-33305099 Email: customercare.shzn@te.com Web: www.te.com