

USER MANUAL

QG65N2 SAE J1939 Inclinator (Type JB)

V1.1, Mar-22



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1. Safety information

1.1. Intended use

The QG65N2 J1939 Inclinometer is a MEMS-based inclination sensor with J1939 interface. This device provides precise and reliable inclination measurement in (semi)static conditions. The use of this device in a machine or system is permitted only under the following conditions:

- The user is trained and competent in the integration and use of inclination sensors in machinery.
- The user is familiar with the contents of both the datasheet and user manual.
- The user has a full understanding of CAN and J1939.
- The device is used within the specified environmental conditions.
- The device is properly configured for its intended use.
- The device is mounted correctly as described in the datasheet and user manual.
- The device data is expressly not interpreted as safety data, except when used redundantly in a control system that is designed and tested for cross-check functionality between the primary and redundant devices.

1.2. Incorrect use

- Use of non-standard CAN cables.
- Device mounted incorrectly.
- Zero adjustment outside the specified range.
- Incorrect or absent CAN bus termination.
- Device used outside the specifications.

1.3. Sensor defective

The sensor is considered “defective” when

- No CAN output can be detected.

In the event of uncertainty, contact the distributor or manufacturer. Any unauthorised modification or unapproved use will void both the warranty and any liability on the part of the manufacturer.

2. About this manual



2.1. Intended use

This manual applies solely to the QG65N2 J1939 inclinometer (Type JB) with the following model designations:

- QG65N2-KIXv-360-CANJ-C(F)M-UL — 1 axis, $\pm 180^\circ$, vertical mounting, std. accuracy.
- QG65N2-KDXYh-090-CANJ-C(F)M-UL — 2 axes, $\pm 90^\circ$, horizontal mounting, std. accuracy.
- QG65N2-KDXYh-030-CANJ-C(F)M-UL — 2 axes, $\pm 30^\circ$, horizontal mounting, std. accuracy.
- QG65N2-KIXv-360H-CANJ-C(F)M-UL — 1 axis, $\pm 180^\circ$, vertical mounting, high accuracy.
- QG65N2-KDXYh-090H-CANJ-C(F)M-UL — 2 axes, $\pm 90^\circ$, horizontal mounting, high accuracy.
- QG65N2-KDXYh-030H-CANJ-C(F)M-UL — 2 axes, $\pm 30^\circ$, horizontal mounting, high accuracy.

DIS product code can be identified [here](#).

2.2. Symbols used in the text

- h Subscript for hexadecimal values.
- d Subscript for decimal values.
-  Caution that indicates either potential damage to the sensor or explains how to avoid a problem.
-  Important information.
- \rightarrow Cross-reference

2.3. Copyright

© Copyright 2022 DIS Sensors bv.

This manual is subject to change without notice.

All rights according to the copyright remain explicitly reserved for DIS Sensors bv.

2.4. Document revision control

Version	Date(y-m-d)	Revision
V1.0	2022-01-10	1 st release.
V1.1	2022-03-08	Certain indices are not supported in the J1939 interface. Removed from parameter list. Correct description of signal processing. Function mode etc not supported.

Table 1 - Document revision

3. Quick reference

General

- 1-axis $\pm 180^\circ$ and 2-axes $\pm 30^\circ/\pm 90^\circ$ inclinometer
- Output type: SAE J1939
- Internal sample rate MEMS: 1000Hz; output rate: 100 Hz
- 2nd order Low pass Bessel filter: 10Hz (\rightarrow [index 3014_h](#))
- Output filter: adjustable 1st order LPF (\rightarrow [index 300E_h](#))
- Approved for automotive use, approval number: E4-10R-05-4662

CAN, J1939

- CAN interface: CAN2.0 A/B (compliant with ISO11898-1&2)
- Application layer: SAE J1939 (29-bit CAN identifier)
- CAN bus bit rate: 250 kbit/s default, optional 500kbit/s
- Device address: 128_d (80_h) default
- PGN cycle time: 100ms default
- Output data: PGN 65280 (Inclination), PGN 65283 (Acceleration)
- Sensor configuration: PGN 61184 (EF00_h)
- Zero adjustment via index 300F_h
- Negative values: two's complement
- Byte-sequence on CAN bus: little-endian (least significant byte first)

4. Installation guide

4.1. Mechanical drawing

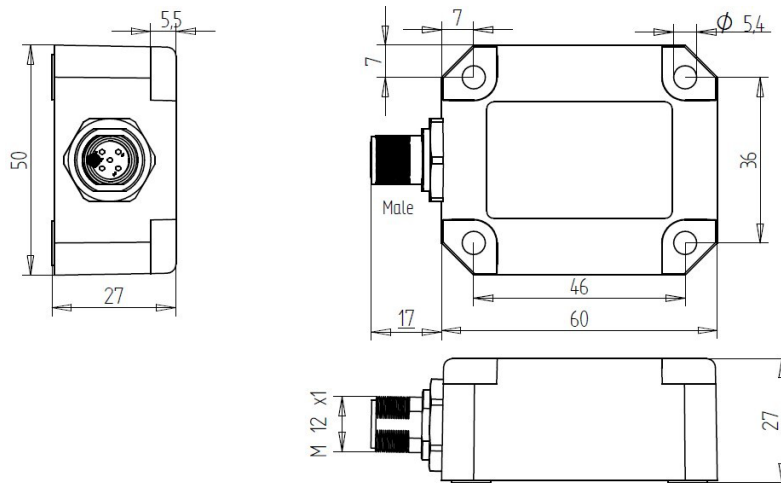


Figure 1 - Mechanical drawing of QG65N2 with a male M12.

4.2. Mounting

- Use the 4 screws provided (M5x25 mm zinc plated steel Pozidrive pan head screws with self-tapping PZ DIN7500CZ) to mount the device.
- If a software zero adjustment is impossible or undesirable, DIS provides an optional reference solution of replacing 2 of the provided screws with 2 optional 4mm \varnothing positioning pins, which can serve as mechanical reference.
- Tightening torque max. 2.5 Nm. A higher torque can cause damage to the housing or the internal electronics.
- Fix the sensor to a perfectly flat surface.
- A 1-axis inclinometer must be mounted vertically. The factory default zero position is with the male connector pointing down as shown in Figure 2 . Sensor can be zero adjusted at any position within the full range.
- A 2-axis inclinometer must be mounted horizontally. The factory default zero position is shown in Figure 2. After installation, sensor can be zero adjusted to eliminate the mechanical offsets within a $\pm 5^\circ$ offset range.



Figure 3 - Vertical mounting 1-axis inclination

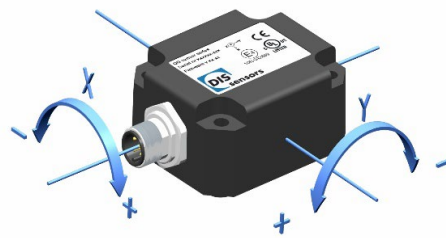


Figure 2 - Horizontal mounting 2-axes inclination

4.3. Connection

The sensor is equipped with either a single 5-pole M12 (A-coded) male connector according to IEC 61076-2-101, or with an additional 5-pole M12 (A-coded) female connector. This is specified in the suffix of the device model designation: suffix CM indicates single male connector; suffix CFM indicates both a female and a male connector.

The advantage of two connectors is that devices can be daisy-chained in the CAN network. The voltage supply is forwarded from the male to the female connector, providing both power and bus-connection to the next sensor with a single cable harness. The connection between male and female connector acts as an internal T-junction.

The pin assignment is according to CiA 303-1 V1.8.0.

Pin	Assignment
Pin 1	Shield
Pin 2	Vcc
Pin 3	Gnd & CAN_GND
Pin 4	CAN_H
Pin 5	CAN_L

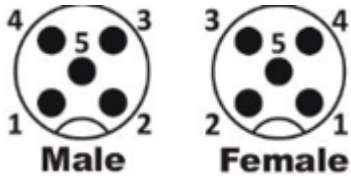


Figure 4 - Pin definition



- The maximum current for the internal T-junction is 2.5 A. This must be taken into account when using daisy-chained connections.
- The voltage supply must be dimensioned to prevent exceeding the specified voltage limits.
- The power consumption is about 50mA typical.
- This device must be connected to a class 2 power supply.
- Connect the sensor only to an approved CAN controller which must have a grounded shield. Alternative: connect the sensor housing to a grounded shield. All mentioned EMC standards that are met (see Declaration of Conformity) have been done with the housing connected to a grounded shield.



Installation of wiring and the opening and closing of electrical connections must only be carried out in de-energized state! Short-circuits, voltage spikes, etc. can cause malfunctions and/or cause the installation to become uncontrolled, creating a serious risk of injury or damage to property.

4.4. CAN termination

A CAN bus should be terminated properly to prevent signal reflections. The QG65N2 J1939 Inclinometer has an internal 120 Ohm termination resistor. By default, this is disabled.

A separate M12 termination resistor and T-connector are also available as accessories.



Figure 5 - M12 CAN terminator male 5p.
Order code: 10217



Figure 6 - M12 CAN terminator female 5p.
Order code: 10194



Figure 7 - M12 T-connector 5p.
Order code: 11822

The advantage of using a separate termination plug instead of the internal termination resistor is that an external termination plug is clearly visible. This helps to prevent an inadvertent double termination that could cause the entire CAN bus to malfunction.

5. Technical data

Please refer to the datasheet of your product.

6. Functional description

6.1. Inclination measurement principle

QG65N2 Inclinometers measure inclination by measuring static acceleration of gravity using an accelerometer MEMS. In static conditions, inclination measurement by this principle is accurate and reliable.

However, the vibrations or movements present on almost all industrial machines generate undesirable g-forces. These dynamic g-forces accumulate and overlay the static g-forces, causing a 'dirty' inclination output that includes spurious or noise components.

A low-pass filter can stabilize the output, that can be enough for some applications. The downside of this filtering is that it increases the reaction time (latency) of the inclinometer. In a control system this results in a limit on the speed of movements, and reduced machine efficiency.

If the dynamic effects are dominant and acceptable delay time is limited, please consider our Dynamic inclinometer, where with the help of a gyroscope a sort of filtering is achieved without having the downside of delay time.

6.2. Measuring axis and direction

6.2.1. Measuring axis and direction for Inclination

A single-axis inclinometer (vertical mount) measures the inclination in the vertical plane over the full range 0-360° (X-output). The default 0° position and the measuring direction are shown in Figure 8.



Figure 8 - Measuring axis and direction of 1-axis inclination.

A dual-axis inclinometer (horizontal mount) measures the inclination on both X and Y axis. Measuring range is up to 90°. Due to the measurement principle, only one axis may tilt more than 45°.

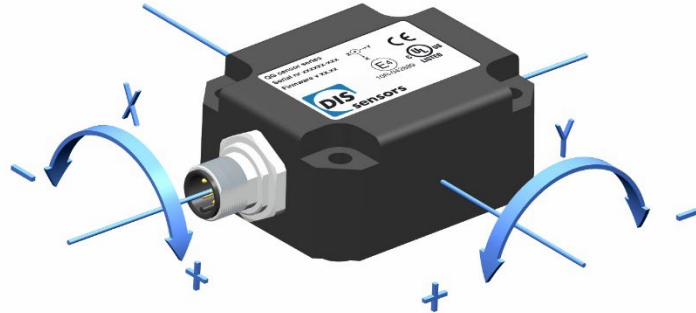



Figure 9 – Measuring axis and direction of 2-axis inclination.

 **Cross-tilt error:** when the cross axis (axis perpendicular to the measuring axis) tilts more than 45° during the measurement, the measuring axis will be disabled. The sensor will send a fixed CAN output to indicate that the sensor is now at a cross-tilt error position (→ [Knowledgebase](#)): 20000_d (200°) for the measuring range ±180°, ±30°/±90°, and 40000_d (400°) for the measuring range 0°-360°.

6.2.2. Measuring axis and direction for acceleration

The device measures the acceleration values on all 3 axes. The measuring direction of three axes in the factory default setting is shown in Figure 10. Raw acceleration value range are up to ±1.5/±2.0 g with resolution of 0.001g.

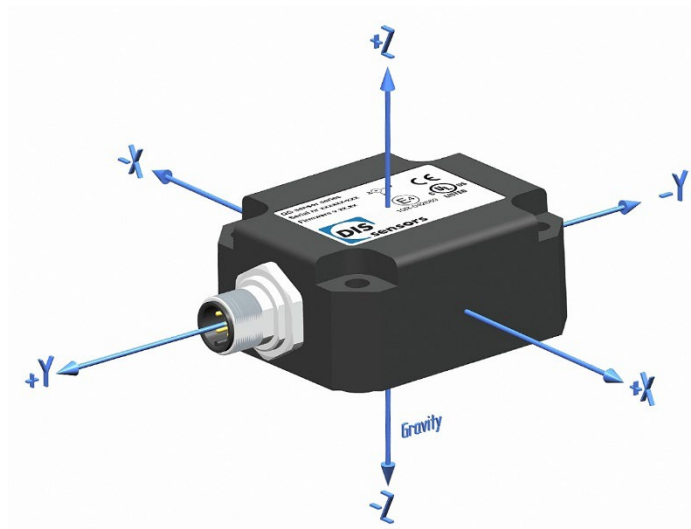


Figure 10 – Measuring axis and direction of acceleration.

6.3. Signal processing

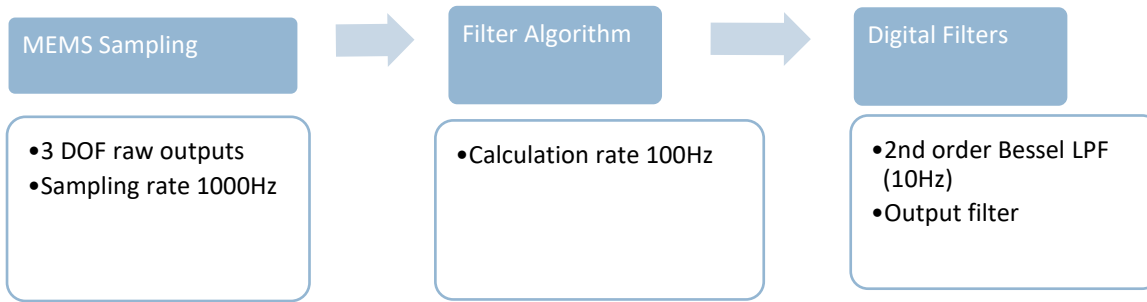


Figure 11 - Signal processing

6.3.1. Sampling rate

Each axis of the acceleration MEMS is sampled by the internal microcontroller at a rate of 1000 Hz. Those samples are fed into the filter algorithm and will be processed further.

6.3.2. Filter algorithm

Filter algorithm is implemented to improve the quality of the sampled raw data. The calculation rate is 100Hz.

6.3.3. Digital filters

To eliminate noise or reduce the bandwidth, the inclination values can be further processed with extra digital filters. The values are predefined by DIS.

6.4. Boot-up procedure

When the device is powered on, the device will be initialised with the last-stored parameters. When initialisation is complete, an Address Claim Message (ACM) containing the address used and NAME will be sent. (→7.5 NAME and ACM (PGN 60928))

Bus	CAN-ID (h...)	Type	Prio.	PGN	PGN (hex)	Len...	Symbol	Data	Source	Source (hex)
1	18EEFF80	J1939	6	60928	EE00h	8	ACM	NAMEOfControllerApplication = 922533667373223231 IdentityNumber = 199999 ManufacturerCode = DIS Sensors B.V. ECUInstance = 0 FunctionInstance = 0 Function = 147 VehicleSystem = 0 VehicleSystemInstance = 0 IndustryGroup = Global, applies to all ArbitraryAddressCapable = CA is capable	128	80h

Figure 12 – example ACM at boot-up

The CAN-ID 18EEFF80 shows that the sensor has a default source address of 80_h.

The data of the ACM is

Hex View: Rx, Bus 1, 18EEFF80h (ACM), DLC 8, Length 8	
0	3F 0D A3 89 00 93 00 80

Figure 13 - ACM data

This is the 64-bit device NAME for DIS sensors which contains the following fields:

MSB										64 bits										LSB									
1 bit			3 bit			4 bit			7 bit			1 bit			8 bit			5 bit			3 bit			11 bit			21 bit		
Arbitrary Address Capable			Industry group			Vehicle system Instance			Vehicle System			Reserved			Function			Function Instance			ECU Instance			Manufacturer Code			Identify Number		
1			000			0000			0000000			0			10010011			00000			000			10001001101			000110000110100111111		

Table 2 – NAME definition and data example

Bit length	Definition	Data	Meaning
21 bits	Identify Number	000110000110100111111 _b	The least 21 bits of the 32-bit serial number of the sensor
11 bits	Manufacturer Code	10001001101 _b = 1101 _d	DIS Sensors B.V.
3 bits	ECU Instance	000 _b	
5 bits	Function Instance	00000 _b	
8 bits	Function	10010011 _b = 147 _d	Inertial Sensor
1 bit	Reserved	0 _b	
7 bits	Vehicle System	0000000 _b	
4 bits	Vehicle system Instance	0000 _b	
3 bits	Industry group	000 _b	Global, applies to all industries
1 bit	Arbitrary Address	1 _b	yes

Table 3 - NAME explanation

6.5. Output format

The device supports 2 different parameter groups (Tx PGNs):

- Proprietary B Tx PGN1 65280 for Longitudinal, Lateral Inclination (Availability of lateral information depends on sensor type)
- Proprietary B Tx PGN2 65283 for X, Y, Z Acceleration

6.5.1. Inclination outputs PGN 65280 (FF00h).

PGN	Name	Priority	SPN position(bit)	SPN Width(bit)	Resolution	Offset	Data Range
65280 _d FF00 _h	X axis (Longitudinal)	3	0	16	0.01°/bit	-	-90° - +90°
	Y axis (Lateral)	3	16	16	0.01°/bit	-	-90° - +90°

Table 4 – Transmit PGN1 inclination 2-axis

PGN	Name	Priority	SPN position(bit)	SPN Width(bit)	Resolution	Offset	Data Range
65280 _d FF00 _h	X axis (Longitudinal)	3	0	16	0.01°/bit	-	-180° - +180°

Table 5 - Transmit PGN1 inclination 1-axis

The angle can be calculated with formula: $\alpha = \text{J1939 output} / 100$. (α = angle in degrees, factory resolution is 0.01°)

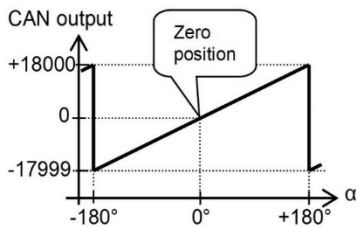


Figure 14 - Output 1-axis ±180° sensor

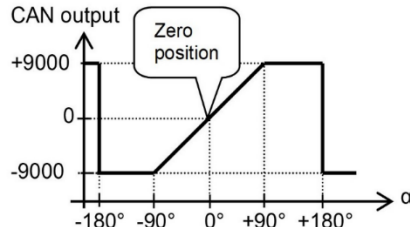


Figure 15 - Output 2-axis ±90° sensor

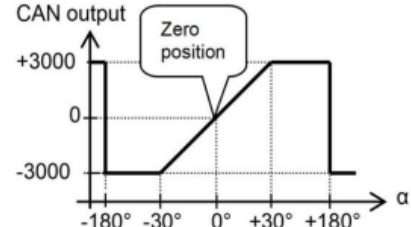


Figure 16 - Output 2-axis ±30° sensor

Example – Inclination output of a 1-axis sensor.

Time (rel.)	Bus	ID (hex.)	Symbol	Rx/Tx	Type	Prio	PGN	SA	DA	Length	Data (hex.)
0,1217	1	0CFF0080	Inclination Output	Rx	Data	3	65280	128	255	8	0A 0A FF FF FF FF FF FF
0,2217	1	0CFF0080	Inclination Output	Rx	Data	3	65280	128	255	8	30 0A FF FF FF FF FF FF
0,3217	1	0CFF0080	Inclination Output	Rx	Data	3	65280	128	255	8	44 0A FF FF FF FF FF FF

The first 2 bytes are the angle value, the rest 6 bytes are not used.

Byte0	Byte1
0Ah	0Ah
Inclination output: 0A0Ah = 2570 _d = 25.70°	

Table 6 - Output 1-axis ±180° sensor explanation

Example – Inclination output of a 2-axis sensor

Time (diff.)	Bus	ID (hex.)	Symbol	Rx/Tx	Type	Prio	PGN	SA	DA	Length	Data (hex.)
-	1	00FF0080	Inclination Output	Rx	Data	0	65280	128	255	8	8E FC 4B 08 FF FF FF FF
0,1000	1	00FF0080	Inclination Output	Rx	Data	0	65280	128	255	8	F4 FB 7A 08 FF FF FF FF

The first 2 bytes are X inclination, and the second 2 bytes are Y inclination. The rest 4 bytes are not used.

Byte0	Byte1	Byte2	Byte3
X inclination		Y inclination	
8E _h	FC _h	4B _h	08 _h
FC8E _h = -882 _d = -8.82°		084B _h = 2123 _d = 21.23°	

Table 7 – Output 2-axis 90° sensor explanation

6.5.2. Acceleration outputs PGN 65283 (FF03h).

PGN	Name	Priority	SPN position(bit)	SPN Width(bit)	Resolution	Offset	Data Range
65283_d	X axis (Longitudinal)	3	0	16	0.001g/bit	-	H series: -1.5g to +1.5g Std. series: -2.0g to +2.0g
FF03_h			16	16	0.001g/bit	-	H series: -1.5g to +1.5g Std. series: -2.0g to +2.0g
			32	16	0.001g/bit	-	H series: -1.5g to +1.5g Std. series: -2.0g to +2.0g

Table 8 - Transmit PGN2 acceleration

Acceleration can be calculated with formula: $a = \text{J1939 output} / 1000$. (a = acceleration in g, factory resolution is 0.001g)

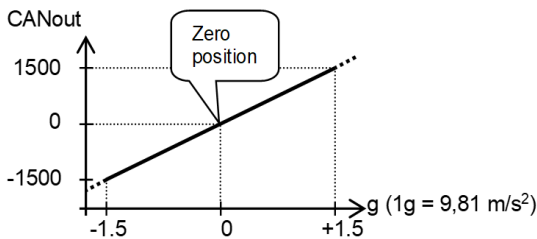


Figure 17 - Output acceleration high accuracy series

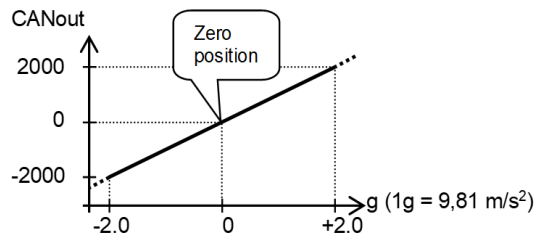


Figure 18 - Output acceleration std. accuracy series

For example:

Time (diff.)	Bus	ID (hex.)	Symbol	Rx/Tx	Type	Prio	PGN	SA	DA	Length	Data (hex.)
-	1	00FF0380	Acceleration Output	Rx	Data	0	65283	128	255	8	EA FF 0A 00 18 FC FF FF
0,1000	1	00FF0380	Acceleration Output	Rx	Data	0	65283	128	255	8	EA FF 0A 00 18 FC FF FF

Figure 19 - Acceleration output trace

The 6 bytes data are defined as below.

Byte0	Byte1	Byte2	Byte3	Byte4	Byte5
X acceleration		Y acceleration		Z acceleration	
EA _h	FF _h	0A _h	00 _h	18 _h	FC _h
FFEA _h = -22 _d = -0.022g		000A _h = 10 _d = 0.010g		FC18 _h = -1000 _d = -1.000g	

6.6. Sensor configuration (PGN 61184)

For reading and writing the sensor configuration, Prop A PGN 61184 (EF00_n) (->PGN (Parameter Group Number)) is used.

Example – Read serial number.

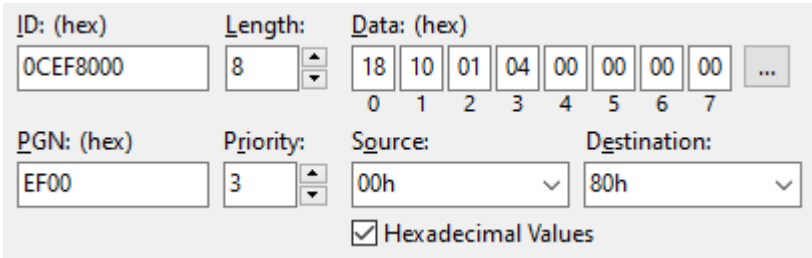


Figure 20 - CMD read serial number

The 8 bytes data are defined as below:

D0	D1	D2	D3	D4	D5	D6	D7
Parameter Index		CMD	Sub index /Status	Data0	Data1	Data2	Data3
Parameter index	Index of the PGN parameter. (→ 8 Parameter overview)						
CMD	01 _h = Command for read data 02 _h = Command for write data						
Sub Index:	message to the sensor: Sub index of the PGN parameter. (→ 8 Parameter overview) message from the sensor: Status reply						
	Message		Description				
	00 _h		Ok processing successfully				
	F0 _h		Invalid index				
	F1 _h		Invalid parameter, parameter out of range				
	F2 _h		EEPROM error				
Data0 to Data3	0 to 4 data bytes (Number of valid bytes depends on the parameter)						

Table 9 - PGN 61184 data definition

More configuration examples can be found in 9 Configuration examples.

6.7. Load factory default settings

Factory reset or load factory default settings allows users to restore the device to its original manufacturer settings. The customer settings which were saved to the EEPROM will be overwritten by the factory default settings.

With index 1011h, the factory default settings below can be restored. Customised products may have different factory default values, which may deviate from this manual. See the datasheet of your customized products for these customized factory default values.

DIS factory default

Parameters	Index	DIS standard default value
Device Address	3101h	80h
Baud Rate	3001h	03h - 250 kBit/s
PGN1 (65280)	3102h	Cycle time = 100 _d = Enabled
PGN2 (65283)	3103h	Cycle time = 0 _d = Disabled

Table 10 – DIS standard factory default communication parameters

Procedures:



- Write “load” to sub-index 01h = All parameters will be restored.
- Write “load” in ASCII or “64616F6Ch” have the same effect.

Example:

Command: ID: (hex) 0CEF8000 Length: 8 Data: (hex) 11 10 02 01 6C 6F 61 64 ...

Response: Hex View: Rx, Bus 1, 00EF0080h (PropA), DLC 8, Length 8
 0 11 10 02 00 6C 6F 61 64load

Figure 21 - Restore default settings

A new power cycle is required to enable the factory default settings after a “load”. Do not execute “save” before you restart the device, as this will cause the current working environment settings to overwrite (i.e. store) the default factory settings.

6.8. Zero adjustment

Zero adjustment allows users to compensate for mechanical offsets of a horizontally mounted 2-axis device or set a customised 0° position of a vertically mounted 1-axis sensor. The measured inclination value at the 0° position will be stored in the device as a permanent offset, which is used to calculate the actual inclination output of the device. The zero offset value can be read from Index 6013_h, 6023_h.

Zero adjustment can be done in two ways and can be repeated at any time.

1. Via Index 300F_h Zero adjustment.

To perform a zero adjustment, write the corresponding value to index 300F_h subindex 00_h. The zero adjustment can be done for each axis separately or for all axes at the same time. Status information of the result is available from index 300F_h.

Value		Response
01 _h	Start zero adjustment X-axis - inclination	00 _h = Successful; FF _h = Failed
02 _h	Start zero adjustment Y axis - inclination	00 _h = Successful; FE _h = Failed
03 _h	Start zero adjustment X and Y axis - inclination	00 _h = Successful; FD _h = Failed

Table 11 - Definition index 300F_h

For example:

Write 03_h to zero both X and Y axis.

Figure 22 - commands to zero both X and Y axis

The sensor returns 00_h in the data byte4 indicating that the zero adjustment is successful.

```
Hex View: Rx, Bus 1, 00EF0080h (PropA), DLC 8, Length 8
0 0F 30 01 00 00 00 00
```

Figure 23 - response from the sensor indicating that zero is successful (data=00)

And the live output shows the sensor is indeed zeroed.

Bus	CAN-ID (h...)	Type	Prio.	PGN	PGN (hex)	Len...	Symbol	Data
1	0CFF0080	J1939	3	65280	FF00h	8	Inclination Output	Long = 0,00 deg lateral = 0,00 deg

Figure 24 - sensor live output

If the sensor is zeroed at an illegal position, the response (byte4) will be FF/FE/FD_h

```
Hex View: Rx, Bus 1, 00EF0080h (PropA), DLC 8, Length 8
0 0F 30 01 00 FD 00 00
```

Figure 25 - response shows that zero at X and Y axis both failed.

The offset value will be stored permanently in the device without "save" to index 1010_h.

2. Via Index 6012h, 6022h Pre-set inclination value.

To set the output of X/Y axis to 0°, write 0000h to index 6012h / 6022h at your desired 0° position. The offset will be stored in Index 6012h, 6022h . Those parameters must be saved to the device.

Index	Sub-index	Definition	Value Example
6012h	00h	Pre-set inclination X-axis	0000 _d - 0°
6022h	00h	Pre-set inclination Y axis	0100 _d - 1°

Table 12 - Index 6012/6022h definition

Example - Pre-set the X axis to 0°

ID: (hex) Length: Data: (hex)

OCEF8000 8 12 60 02 00 00 00 00 ...

0 1 2 3 4 5 6 7

Figure 26 - commands to pre-set X axis to 0°

```
Hex View: Rx, Bus 1, 00EF0080h (PropA), DLC 8, Length 8
0 12 60 02 00 00 00 00
```

Figure 27 - response from the sensor indicating pre-set is successful (Byte3=00h)

Bus	CAN-ID (h...)	Type	Prio.	PGN	PGN (hex)	Len...	Symbol	Data
1	0CFF0080	J1939	3	65280	FF00h	8	Inclination Output	Long = 0,00 deg lateral = -6,23 deg

Figure 28 - sensor live output shows that The X axis is zeroed

When an out-of-range pre-set value is sent, the sensor sends “F1” as response indicating “Invalid parameter, parameter out of range” (->6.6 Sensor configuration)

ID: (hex) Length: Data: (hex)

OCEF8000 8 12 60 02 00 94 11 00 ...

0 1 2 3 4 5 6 7

Figure 29 - pre-set X angle to 1194h/45°

```
Hex View: Rx, Bus 1, 00EF0080h (PropA), DLC 8, Length 8
0 12 60 02 F1 94 11 00
```

Figure 30 - response from sensor indicating that pre-set is failed. (Byte3=F1h)



1-axis ±180° sensors can be zero adjusted over the full range, the position of the male connector is at customer discretion.

2-axis ±30°/±90° sensors can only be zero adjusted in a horizontal position within an offset limit of ±5°.



After you load factory default settings, the sensor will be restored with the factory zero offset, which means the pre-set inclination value will be restored to 00h, index 6013h and 6023h will be rewritten to a factory default value and you need to zero your sensor again.

6.9. Firmware management

If a firmware version is mentioned on the label, it is the factory-installed firmware number.

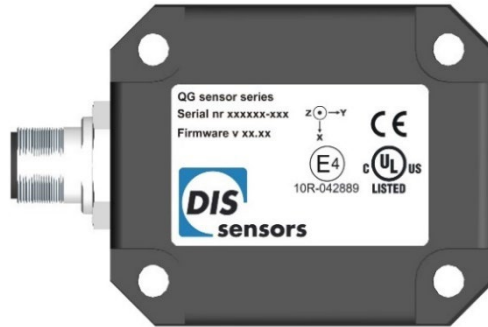



Figure 31 - Firmware version

It can also be requested with index 100A_h, Manufacturer software version. The message format is “Vx.x.x” in ASCII, for example: V1.0.0.

 *The currently-installed firmware version might vary from the version on the sticker due to a firmware update.*

The firmware release notes are available at www.dis-sensors.com under “downloads/user manuals”.

7. SAE J1939 specification

The QG65D J1939 series of devices communicates with the SAE J1939 interface. SAE J1939 uses the CAN protocol to transmit a message on the network. Every message includes an identifier which defines the message priority, who sent it, and what data is contained within it.

More knowledge of J1939 can be found in our [Knowledgebase](#).

7.1. PDU (Protocol Data Unit)

The Protocol Data Unit provides a framework for organizing the key information that is sent with every CAN data frame.

PDU format												
SOF	Identifier	SRR	IDE	Identifier	RTR	r1	r0	DLC	Data	CRC	ACK	EOF + IFS
1 bit	11 bits	1 bit	1 bit	18 bits	1 bit	2 bits	4 bits	0 - 8*8 bits	16 bits	2 bits	10 bits	

Figure 32 - J1939 PDU format

7.2. CAN-ID (CAN Identifier)

The Extended CAN data frame (CAN 2.0B Frame) with 29-bit identifier is used in the SAE J1939 protocol.

PDU format												
SOF	Identifier	SRR	IDE	Identifier	RTR	r1	r0	DLC	Data	CRC	ACK	EOF + IFS
1 bit	11 bits	1 bit	1 bit	18 bits	1 bit	2 bits	4 bits	0 - 8*8 bits	16 bits	2 bits	10 bits	

29-bit CAN-ID

28		25										8	7							0
priority			Parameter Group Number (PGN)												Source Address (SA)					

Table 13 - CAN-ID definition

Priority (3 bits)	Message priority during the arbitration process. 0= high and 7=low. Not used by receiver.
PGN (18 bits)	The PGN uniquely identifies the parameter group (PG) that is being transmitted in the message.
SA (8 bits)	This field defines the specific address to which the message is being sent. All other destinations should ignore this message. In the case of the global destination address (255), all devices are required to listen and respond as message recipients

Table 14 - CAN-ID explanation

0CFF0080h

28		25																		8	7										0
0	1	1	0	0	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	
priority = 3			Parameter Group Number (PGN) = 0FF00h												Source Address (SA) = 80h																

Figure 33 - Example CAN-ID of inclination output

11-bit identifier devices can be used within the same network without conflict, but it's not defined in J1939 standards.

7.3. PGN (Parameter Group Number)

The J1939 PGN comprises an 18-bit subset of the 29-bit extended CAN ID. The PGN uniquely identifies the parameter group (PG) that is being transmitted in the message. Every PG (grouping of specific parameters) has its own specific definition comprising the assignment of each parameter within an 8-byte data field (size in bytes, location of the LSB), and the transmission rate and priority of the message.

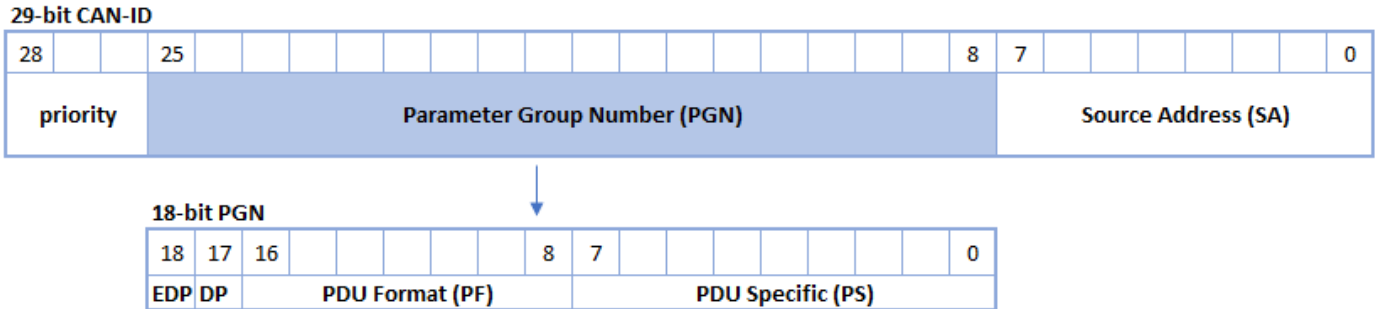


Figure 34 - PGN format

EDP (Extended Data Page)	Select a page for the PGNs.															
DP (Data Page)	<table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <thead> <tr> <th>EDP</th> <th>DP</th> <th>Definition</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>0</td> <td>J1939 Page 0 PGNs</td> </tr> <tr> <td>0</td> <td>1</td> <td>J1939 Page 1 PGNs</td> </tr> <tr> <td>0</td> <td>0</td> <td>Reserved</td> </tr> <tr> <td>0</td> <td>1</td> <td>Diagnostic message</td> </tr> </tbody> </table>	EDP	DP	Definition	0	0	J1939 Page 0 PGNs	0	1	J1939 Page 1 PGNs	0	0	Reserved	0	1	Diagnostic message
EDP	DP	Definition														
0	0	J1939 Page 0 PGNs														
0	1	J1939 Page 1 PGNs														
0	0	Reserved														
0	1	Diagnostic message														
PDU format (PF):	Defines whether a PGN has a PDU1 or PDU2 format. Determines the PGN assigned to the Data field. <table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <thead> <tr> <th></th> <th>Format 1</th> <th>Format 2</th> </tr> </thead> <tbody> <tr> <td>PF value</td> <td>$0 - 239_d / EF_h$</td> <td>$240_d / F0_h - 255_d / FF_h$</td> </tr> <tr> <td>PGNs</td> <td>$2 * 240 = 480$</td> <td>$2 * 16 * 256 = 8192$</td> </tr> <tr> <td>Usage</td> <td>point-to-point messages or global message</td> <td>Global message only Broadcast message etc.</td> </tr> </tbody> </table>		Format 1	Format 2	PF value	$0 - 239_d / EF_h$	$240_d / F0_h - 255_d / FF_h$	PGNs	$2 * 240 = 480$	$2 * 16 * 256 = 8192$	Usage	point-to-point messages or global message	Global message only Broadcast message etc.			
	Format 1	Format 2														
PF value	$0 - 239_d / EF_h$	$240_d / F0_h - 255_d / FF_h$														
PGNs	$2 * 240 = 480$	$2 * 16 * 256 = 8192$														
Usage	point-to-point messages or global message	Global message only Broadcast message etc.														
PS – PDU Specific	This field depends on the value of PDU Format and contains either a destination address or a group extension, depending on PDU Format.															

18	17	16						8	7							0
EDP	DP	PDU Format 1(PF) < 240						Destination Address (DA)								
18	17	16						8	7							0
EDP	DP	PDU Format 2 (PF) >= 240						Group Extension								

DA: defines the specific address to which the message is being sent.
GE: provides extra 4096 PGNs per data page.

Table 15 - PGN definition

PGNs used by DIS J1939 sensors are explained as below:

PGN	PG Name	J1939 Definition	DIS
61184_d (00EF00_h)	PropA	This PG uses the destination-specific PDU1 Format allowing manufacturers to direct their proprietary communications to a specific destination node. How the Data field of this message is used is up to each manufacturer.	Sensor configuration is sent with PGN 61184
65280_d (00FF00_h)	PropB	This PG uses the PDU2 Format message allowing manufacturers to define the PS (GE) field content as they desire.	Inclination output is sent by PGN 65280.
65283_d (00FF03_h)	PropB	This PG uses the PDU2 Format message allowing manufacturers to define the PS (GE) field content as they desire.	Acceleration output is sent by PGN 65283.
60928_d (00EE00_h)	AC	The Address Claimed PGN may be used in two ways: to claim an address, and to announce that a CA was unable to claim an address.	ACM
59904_d	Request Message	The request message (PGN 59904) for the Address Claimed message (PGN 60928) is used by any CA to request the NAMEs and addresses of CAs in ECUs attached to the network.	RQST

Table 16 - PGN examples

7.4. SPN (Suspect Parameter Number)

SPN is a 19-bit identifier for the CAN signals (parameters) contained in the data. SPNs are grouped by PGNs and can be described in terms of their bit start position, bit length, scale, offset and unit - information required to extract and scale the SPN data to physical values.

The assignment of SPNs can be found in SAE J1939-21 documents. DIS sensors B.V. is using PGN 2551 for definition of inclination and acceleration outputs.

	PGN 65280 to 65535 Proprietary B	Manufacturer Defined Usage (PropB_PDU2)	2551	64 to 14280
--	-------------------------------------	--------------------------------------------	------	----------------

Example – SPN 2551 by PGN 65280 Inclination output defined by DIS Sensors B.V.

PGN	Name	Priority	Position in PG	Bit Size	Resolution (scale)	Offset	Data Range
65280 _d FF00 _h	X axis (Longitudinal)	3	0	16	0.01°/bit		-90° - +90°
	Y axis (Lateral)		16	16	0.01°/bit		-90° - +90°

7.5. NAME and ACM (PGN 60928)

Every device shall have one address and an associated **NAME** to communicate on the SAE J1939 network.

SAE J1939 defines a 64-bit NAME to identify the primary function of a controller application. The NAME consists of fields shown in table below.

MSB										64 bits										LSB									
1 bit	3 bit	4 bit	7 bit	1 bit	8 bit	5 bit	3 bit	11 bit	21 bit	1 bit	8 bit	5 bit	3 bit	11 bit	21 bit	1 bit	8 bit	5 bit	3 bit	11 bit	21 bit								
Arbitrary Address Capable	Industry group	Vehicle system Instance	Vehicle System	Reserved	Function	Function Instance	ECU Instance	Manufacturer Code	Identify Number																				

Table 17 - NAME format

Address Claim, defined in SAE J1939-81, is the process for claiming a network address and associating the NAME, or vehicle function, to that address.

Upon power-up or whenever requested, a device must send an ACM to claim an address. Other devices must compare the newly claimed address with their own to avoid conflicts. When multiple devices claim the same address, the device with lower NAME value uses the address, the others must claim a different address or stop communicating on the network.

A device can send request for the ACM to determine whether addresses claimed by other devices. PGN 59904 (RQST) for ACM (PGN 60928) is described as below:

ID: (hex)	Length:	Data: (hex)			
18EAFFFE	3	00	EE	00	...
		0	1	2	
PGN: (hex)	Priority:	Source:	Destination:		
EA00	6	Null	Global		
<input checked="" type="checkbox"/> Hexadecimal Values					

All requested devices send their ACMs so that you know which devices are currently on the network.

Any CA that is unable to successfully claim an address shall respond with a Cannot Claim Address message. It has the same PGN as ACM but has a source address of 254d (the NULL address).

8. Parameter overview

Some CAN open objects are kept for J1939 sensors for the configuration purpose. Use PGN 61184 to read/write those index. (→ 6.6 Sensor configuration (PGN 61184))

Index	Subindex	Data Type	Access	Object Name and description	Factory Default	Detail
1010 _h	01 _h			Save all parameters Write "save" or "65766173 _h "		9.4
1011 _h	01 _h			Restore all parameters Write "load" or "64616F6C _h "		
1018 _h				Identity		
	00 _h	U8	const	Highest subindex supported	04 _h	
	01 _h	U32	r	Vendor ID	000001BD _h	
	02 _h	U32	r	Product code	08000001 _h – 1-axis inclination 360° 08000002 _h – 2-axes inclination ±90° 08000003 _h – 2-axes inclination ±30°	
	03 _h	U32	r	Revision number	00010000 _h – V1.0.0	
3001 _h	00 _h	U8	rw	Baud Rate 02 _h = 500 kBit/s 03 _h = 250 kBit/s	03 _h	
3003 _h	00 _h	U8	rw	CAN bus termination resistor 120Ω 00 _h = Disable 01 _h = Enable	00 _h	
300F _h	00 _h	U8	rw	Zero adjustment Inclination		
				01 _h Zero X-axis 00 _h =successful FF _h =failed		
				02 _h Zero X-axis 00 _h =successful FE=failed		
				03 _h Zero X and Y axis 00 _h =successful FD _h =failed		
				Zero adjustment Acceleration		
				01 _h Zero X-axis 00 _h =successful FF _h =failed		
				02 _h Zero Y-axis 00 _h =successful FE=failed		
				03 _h Zero Z-axis 00 _h =successful FD _h =failed		
				07 _h Zero all axis 00 _h =successful F9 _h =failed		
				3101 _h	00 _h	U8
3102 _h				PGN 65280 Angle output		
	01 _h	U32	r	Priority (range: 0-7)	03 _h	
	02 _h	U32	r	Cycle time [ms] 0 = deactivated	0064 _h = 100ms	
3103 _h				PGN 65283 Acceleration output		
	01 _h	U32	r	Priority (range: 0-7)	03 _h	
	02 _h	U32	r	Cycle time [ms] 0 – deactivated	0064 _h = 100ms	

Index	Subindex	Data Type	Access	Object Name and description	Factory Default	Detail
6000 _h	00 _h	U16	r	Resolution 10 _d =0.01, 100 _d =0.1, 1000 _d =1.0	10 _d	
6012 _h	00 _h	S16	rw	Pre-set Inclination X-axis	0000 _h	
6013 _h	00 _h	S16	rw	Offset Inclination X-axis	0000 _h	
6022 _h	00 _h	S16	rw	Pre-set Inclination Y-axis	0000 _h	
6023 _h	00 _h	S16	rw	Offset Inclination Y-axis	0000 _h	

Table 18 - Communication Profile



Use index 1010 to permanently save communication parameters in the EEPROM of the device, otherwise the changes will be lost after a power cycle. All indices and/or subindices not described in the table are reserved exclusively for factory use.

Data types used in the application layers are explained in the following table.

Data type	Definitions
U8	Unsigned 8-bit number (0 – 255 _d)
U16	Unsigned 16-bit number (0 – 65535 _d)
U32	Unsigned 32-bit number (0 – 4294967295 _d)
S8/Integer 8	Signed integer 8-bit number (-128 _d – +127 _d)
S16/Integer 16	Signed integer 16-bit number (-32768 _d – +32767 _d)
S32/Integer 32	Signed integer 16-bit number (-2147483648 _d – +2147483647 _d)

Table 19 - Data type

9. Configuration examples

9.1. Change device address

Use index 3101_h sub-index 00_h to change the device address.

ID: (hex)	Length:	Data: (hex)								
OCEF0000	8	01	31	02	00	80	00	00	00	...
		0	1	2	3	4	5	6	7	
PGN: (hex)	Priority:	Source:	Destination:							
EF00	3	00h	00h							
<input checked="" type="checkbox"/> Hexadecimal Values										

Byte 0-1	Index = 3101 _h
Byte 2	CMD = 02 _h , write to the sensor.
Byte 3	Sub index = 00 _h
Byte 4	New Device address = 80 _h
Byte 5-7	00 = Not used

9.2. Change baud rate

Use index 3001_h sub-index 00_h to change the baud rate.

ID: (hex)	Length:	Data: (hex)								
OCEF8000	8	01	30	02	00	03	00	00	00	...
		0	1	2	3	4	5	6	7	
PGN: (hex)	Priority:	Source:	Destination:							
EF00	3	00h	80h							
<input checked="" type="checkbox"/> Hexadecimal Values										

Byte 0-1	Index = 3001 _h
Byte 2	CMD = 02 _h , write to the sensor.
Byte 3	Sub index = 00 _h
Byte 4	03 _h = 250 kbit/s 02 _h = 500 kbit/s
Byte 5-7	00 = Not used

9.3. Enable/Disable/Set cycle time PGNs

Use PGN cycle time to enable or disable PGNs. Index 3102_h is used for PGN 65280 and index 3103_h is used for PGN 65283. Below is an example for PGN 65280.

ID: (hex)	Length:	Data: (hex)								
OCEF8000	8	02	31	02	02	64	00	00	00	...
		0	1	2	3	4	5	6	7	
PGN: (hex)	Priority:	Source:	Destination:							
EF00	3	00h	80h							
<input checked="" type="checkbox"/> Hexadecimal Values										

Byte 0-1	Index = 3102 _h (parameter used for PGN 65280)
Byte 2	CMD = 02 _h , write to the sensor.
Byte 3	Sub index = 02 _h
Byte 4	PGN cycle time = 64 _h = 100ms Setting PGN cycle time to a non-zero value will enable PGN
Byte 5-7	00 = Not used

Table 20 - Example enable PGN 65280

Disable PGN

ID: (hex)	Length:	Data: (hex)								
OCEF8000	8	02	31	02	02	00	00	00	00	...
		0	1	2	3	4	5	6	7	
PGN: (hex)	Priority:	Source:	Destination:							
EF00	3	00h	80h							
<input checked="" type="checkbox"/> Hexadecimal Values										

Byte 0-1	Index = 3102 _h
Byte 2	CMD = 02 _h , write to the sensor.
Byte 3	Sub index = 02 _h
Byte 4	PGN cycle time = 00 _h Setting PGN cycle time to zero will disable PGN
Byte 5-7	00 = Not used

Table 21 - Example disable PGN 65280

9.4. Save changes to the sensor

Use index 1010_h sub-index 01_h

ID: (hex)	Length:	Data: (hex)								
0CEF0000	8	10	10	02	01	73	61	76	65	...
		0	1	2	3	4	5	6	7	
PGN: (hex)	Priority:	Source:	Destination:							
EF00	3	00h	00h							
<input checked="" type="checkbox"/> Hexadecimal Values										

Byte 0-1	Index = 1010 _h
Byte 2	CMD = 02 _h , write to the sensor.
Byte 3	Sub index = 01 _h
Byte 4-7	Write 65766173 _h (save)

9.5. Restore factory default

Use index 1011_h sub-index 01_h

ID: (hex)	Length:	Data: (hex)								
0CEF8000	8	11	10	02	01	6C	6F	61	64	...
		0	1	2	3	4	5	6	7	
PGN: (hex)	Priority:	Source:	Destination:							
EF00	3	00h	80h							
<input checked="" type="checkbox"/> Hexadecimal Values										

Byte 0-1	Index = 1011 _h
Byte 2	CMD = 02 _h , write to the sensor.
Byte 3	Sub index = 01 _h
Byte 4-7	Write 64616F6C _h (load)

9.6. Read vendor ID

Vendor ID can be read by index 1018_h sub-index 01_h

ID: (hex)	Length:	Data: (hex)									
0CEF8000	8	18	10	01	01	00	00	00	00	...	
		0	1	2	3	4	5	6	7		
PGN: (hex)	Priority:	Source:	Destination:								
EF00	3	00h	80h								
<input checked="" type="checkbox"/> Hexadecimal Values											

Byte 0-1	Index = 1018 _h
Byte 2	CMD = 01 _h , read sensor
Byte 3	Sub index = 01 _h
Byte 4-7	00 _h = Not used

The status reply from the sensor is

```
Hex View: Rx, Bus 1, 00EF0080h (PropA), DLC 8, Length 8
0 | 18 10 01 00 BD 01 00 00
```

Byte 0-1	Index = 1018 _h
Byte 2	CMD = 01 _h , read sensor
Byte 3	Status reply = 00 _h = Read successful
Byte 4-7	Data = 000001BD _h = DIS Sensors B.V.

9.7. Zero adjustment

Use index 300F_h sub-index 00_h to zero the sensor. Below is an example of zeroing X and Y axis for a 2-axis sensor.

ID: (hex)	Length:	Data: (hex)								
OCEF8000	8	0F	30	02	00	03	00	00	00	...
		0	1	2	3	4	5	6	7	
PGN: (hex)	Priority:	Source:	Destination:							
EF00	3	00h	80h							
<input checked="" type="checkbox"/> Hexadecimal Values										

Byte 0-1	Index = 300F _h																					
Byte 2	CMD = 02 _h , write to the sensor																					
Byte 3	Sub-index = 00 _h																					
Byte 4-7	<p>Data = 03_h = Inclination Zero adjustment for X and Y axis.</p> <p>Zero adjustment Inclination</p> <table> <tr> <td>01_h</td> <td>Zero X-axis</td> <td>00_h=successful FF_h=failed</td> </tr> <tr> <td>02_h</td> <td>Zero Y-axis</td> <td>00_h=successful FE=failed</td> </tr> <tr> <td>03_h</td> <td>Zero X and Y axis</td> <td>00_h=successful FD_h=failed</td> </tr> </table> <p>Zero adjustment Acceleration</p> <table> <tr> <td>01_h</td> <td>Zero X-axis</td> <td>00_h=successful FF_h=failed</td> </tr> <tr> <td>02_h</td> <td>Zero Y-axis</td> <td>00_h=successful FE=failed</td> </tr> <tr> <td>03_h</td> <td>Zero Z-axis</td> <td>00_h=successful FD_h=failed</td> </tr> <tr> <td>07_h</td> <td>Zero all axis</td> <td>00_h=successful F9_h=failed</td> </tr> </table>	01 _h	Zero X-axis	00 _h =successful FF _h =failed	02 _h	Zero Y-axis	00 _h =successful FE=failed	03 _h	Zero X and Y axis	00 _h =successful FD _h =failed	01 _h	Zero X-axis	00 _h =successful FF _h =failed	02 _h	Zero Y-axis	00 _h =successful FE=failed	03 _h	Zero Z-axis	00 _h =successful FD _h =failed	07 _h	Zero all axis	00 _h =successful F9 _h =failed
01 _h	Zero X-axis	00 _h =successful FF _h =failed																				
02 _h	Zero Y-axis	00 _h =successful FE=failed																				
03 _h	Zero X and Y axis	00 _h =successful FD _h =failed																				
01 _h	Zero X-axis	00 _h =successful FF _h =failed																				
02 _h	Zero Y-axis	00 _h =successful FE=failed																				
03 _h	Zero Z-axis	00 _h =successful FD _h =failed																				
07 _h	Zero all axis	00 _h =successful F9 _h =failed																				

10. Abbreviations and definitions

ACM	Address Claimed Message
CAN	Controller Area Network
CAN-ID	CAN Identifier
PGN	Parameter Group Number
PDU	Protocol Data Unit
SPN	Suspect Parameter Number
MEMS	Microelectromechanical system
DOF	Degrees of freedom
PropA	Proprietary A, PGN 61184
PropB	Proprietary B

11. Normative references

ISO11898-1	Controller area network (CAN) —Data link layer and physical signalling
ISO11898-2	Controller area network (CAN) —High-speed medium access unit
SAE J1939	SAE's family of standards relating to the Controller Area Network (CAN) for heavy-duty vehicles.
IEC 61076-2-101	Connectors for electronic equipment - Part 2-101: Circular connectors – Detail specification for circular connectors M8 with screw- or snap-locking, M12 with screw locking for low voltage applications