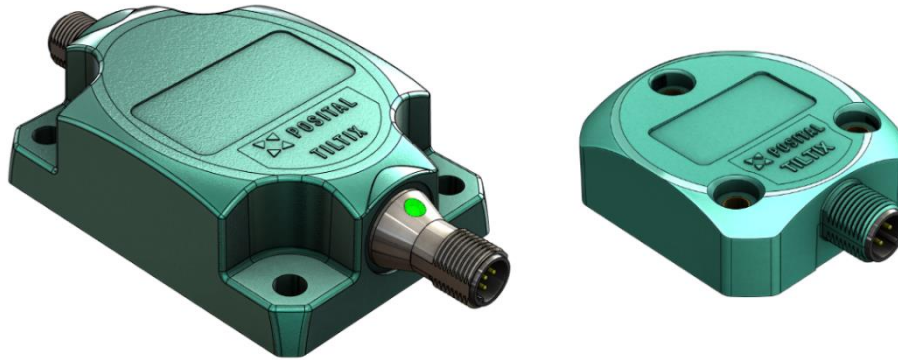




TILTIX MEMS DYNAMIC AKS-3 INCLINOMETER
WITH J1939 INTERFACE C903



SAE J1939

User Manual



TILTIX MEMS DYNAMIC AKS-3 INCLINOMETER
WITH J1939 INTERFACE C903

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1. General Safety Advice

1.1 Important Information

Read these instructions carefully, and have a look at the equipment to become familiar with the device before trying to install, operate, or maintain it.

The following special messages may appear throughout this documentation or on the equipment to warn of potential hazards or to call attention towards information that clarifies/simplifies a procedure.

Please Note: Electrical equipment should be serviced only by qualified personnel. No responsibility is assumed by POSITAL for any consequences arising out of the use of this material. This document is not intended as an instruction manual for untrained personnel.



The addition of this symbol to a Danger or Warning safety label indicates that an electrical hazard exists, which will result in personal injury if the instructions are not followed.



This is the safety alert symbol. It is used to alert you to potential personal injury hazards. Obey all safety messages that follow this symbol to avoid possible injury or death.

TILTIX MEMS DYNAMIC AKS-3 INCLINOMETER WITH J1939 INTERFACE C903

2. About this Manual

2.1 Background

This user manual explains how to install and configure the TILTIX inclinometer with J1939 interface.

2.2 Version Management

- Updated On: 20241023
- Manual_TILTIX-AKS3-J1939-C903

2.3 Imprint

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2.5 User Annotation

All readers are highly welcome to send us feedback and comments about this document.
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TILTIX MEMS DYNAMIC AKS-3 INCLINOMETER WITH J1939 INTERFACE C903

3. Introduction

This manual explains how to install and configure the TILTIX dynamic inclinometers with a J1939

interface, suitable for industrial, military and heavy duty applications.

3.1 TILTIX Inclinometer

TILTIX inclinometers sense and measure the angle of tilt (inclination/slope/elevation) of an object with respect to the force of gravity.

The basic principle behind this TILTIX inclinometer is a Micro-Electro-Mechanical Systems (MEMS) sensor cell that is embedded to a fully molded ASIC. The angle is measured with the relative change in electrical capacitance in the MEMS cell.

3.2 TILTIX J1939

The TILTIX J1939 inclinometer is available in a heavy-duty and fibre-reinforced plastic housing, and four measurement configuration variants. The single axis measurement variant with a range of 360°, a dual axis measurement capable TILTIX model with a range of $\pm 90^\circ$ and two dual axis version with pitch $\pm 85^\circ$ and roll $\pm 180^\circ$ angle. The pitch angle refers to extrinsic rotations and the roll angle refers to intrinsic rotations. In addition to high resolution, accuracy and protection class of IP69K,

it has built-in algorithm that compensates influences of external accelerations. This makes TILTIX AKS suitable for dynamic applications, rugged environments and mobile machines in industrial, heavy duty and military applications.

Various software tools for configuration and parameter-setting are available from different suppliers.

3.3 Typical Applications of TILTIX

- Cranes and Construction Machinery
- Mobile Machinery
- Agriculture Machinery
- Robotic Applications
- Medical Systems
- Elevated Platforms
- Mobile Lifts and Fire Engines
- Automated Guided Vehicles (AGV)
- Automatic Assembling Machinery
- Boring and Drilling Applications
- Leveling and Flattening



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4. Technical Data

Please refer to the product specific datasheet for technical, electrical and mechanical information at www.posital.com or directly at https://www.posital.com/en/products/inclinometers/tiltix-product-finder/product_finder_frontend_inclinometer.php

TILTIX MEMS DYNAMIC AKS-3 INCLINOMETER WITH J1939 INTERFACE C903

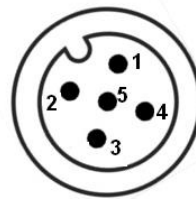
5. Installation

5.1 Pin Assignment

The inclinometer is connected via an integrated cable or a 5-pin round M12 connector. (Standard

M12, Male side at sensor, Female at connector counterpart or connection cable).

Signal	5 pin round connectors
CAN Ground	1
VS Supply Voltage	2
0 V Supply Voltage	3
CAN High	4
CAN Low	5



5.2 Installation Precautions



Warning: Do not remove or mount while the inclinometer is under power!



Avert any modifications to the housing!



Avoid mechanical load!

Prior to installation, please check for all connections and mounting instructions to be complied with. Please also observe the general rules and regulations on operating low voltage technical devices, for safety and sustainability of TILTIX Inclinometers over a long period of time.

Please read the installation leaflet for detailed instructions and precautions during mounting and installation.

TILTIX MEMS DYNAMIC AKS-3 INCLINOMETER WITH J1939 INTERFACE C903

5.3 Mounting Instructions

TILTIX is a pre-calibrated device which can be put into immediate operation, upon simple and easy installation with a four-point mount. The mounting surface must be plane and free of dust and grease. We recommend hex-head screws with M6 or UNCbolts $\frac{1}{4}$ for the best possible and secure mounting.

Use all four screws for mounting but restrict the tightening torque in the range of 1.5 – 2.5 Nm for

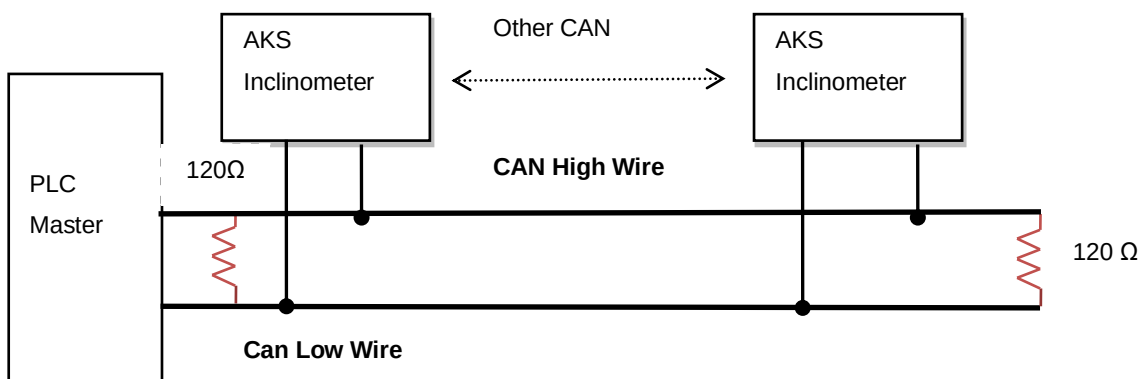
the screws. The M12 connectors are to be perfectly aligned and screwed till the end with a tightening torque in the range of 0.4 – 0.6 Nm. Use all four screws for mounting and also note to use the same tightening torque for all the screws. Prior to installation, please check for all connection and mounting instructions to be complied with. Please do also observe the general rules and regulations on low voltage technical devices.

5.4 Bus Termination

If the inclinometer is connected at the end or beginning of the bus or is used at transmission ≥ 50 kBaud a termination resistor of 120 Ohm must be used in order to prevent reflection of information back into the CAN bus. TILTIX sensors have built-in termination resistors that can be activated (1) or deactivated (0) by software if necessary.

The bus wires can be routed in parallel or twisted, with or without shielding in accordance with the electromagnetic compatibility requirements. A single line structure minimizes reflection.

The following diagram shows the components for the physical layer of a two-wire CAN bus:

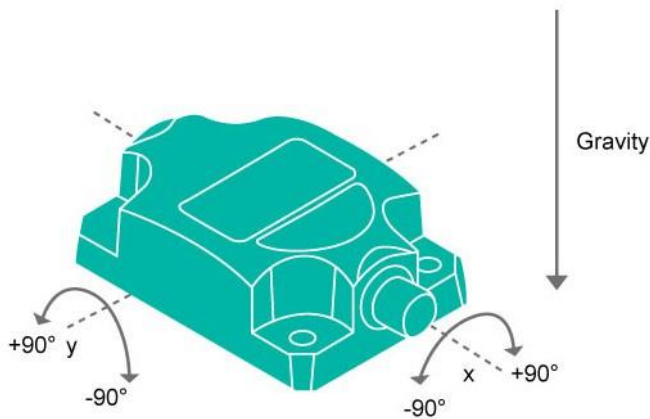


TILTIX MEMS DYNAMIC AKS-3 INCLINOMETER WITH J1939 INTERFACE C903

5.5 Measurement Axes

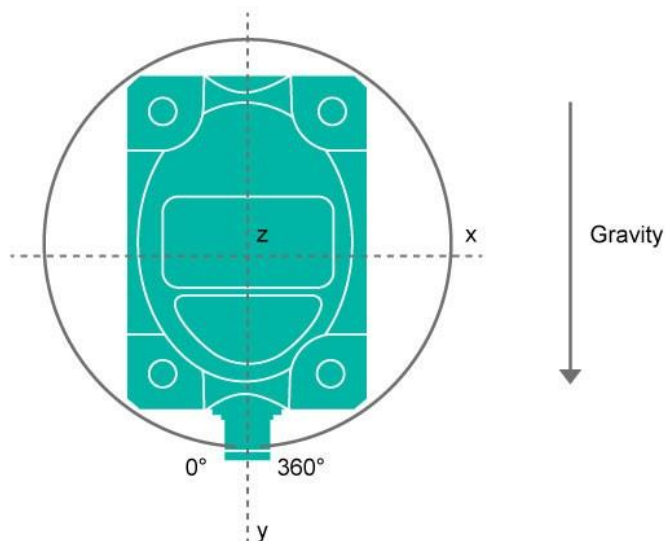
TILTIX AKS-090-2 – Dual Axis Inclinator

X- and Y-Axis measure the angle position in space. Both axes are limited to $\pm 90^\circ$. The sensor is mounted horizontally. The X- and Y-Axis output 0° , when the inclinometer is flat.



TILTIX AKS-360-1 – Single Axis Inclinator

The sensor is mounted vertically. A clockwise rotation increases the angle value from 0° - 360° . When the male connector is pointing downwards, the output is 0° .



TILTIX MEMS DYNAMIC AKS-3 INCLINOMETER WITH J1939 INTERFACE C903

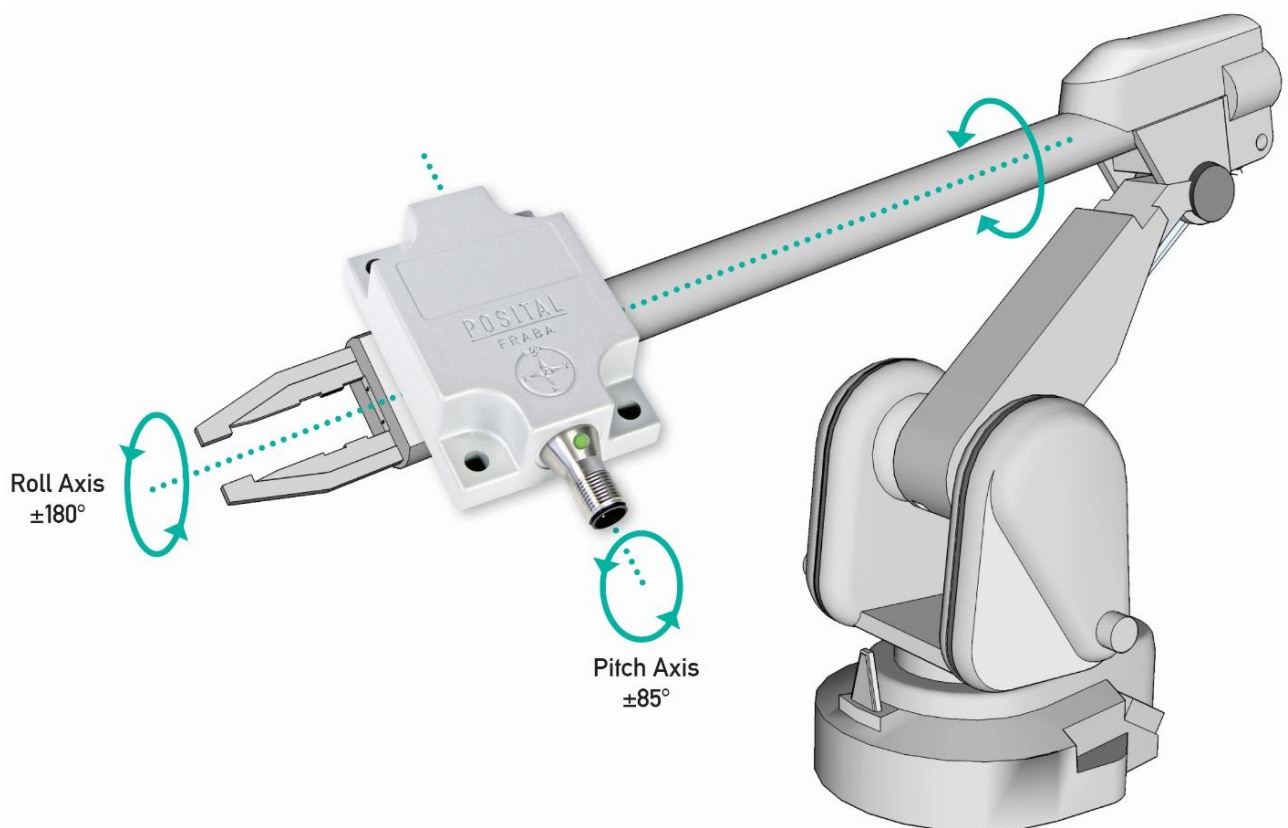
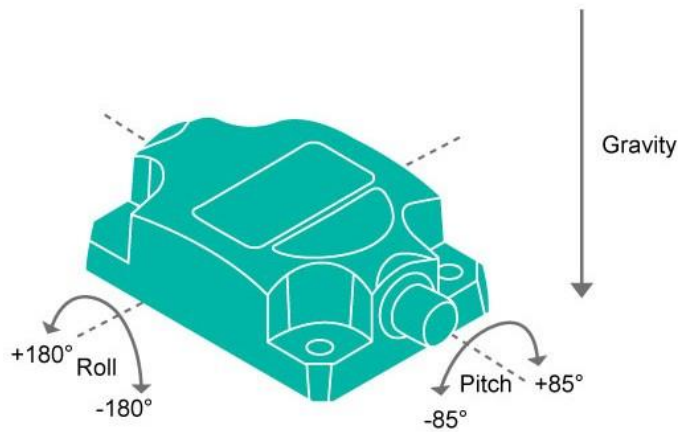
TILTIX AKS-180-E – Pitch and Roll Axis Inclinometer

The Pitch axis monitors the position angle in space, while the Roll axis shows the rotation with respect to the pitch angle.

In case of a robot arm (graphic below), the pitch axis monitors the position angle in space and the roll axis measures the rotation of the robot head around the arm (just like a Singleturn encoder).

The Pitch and Roll version is very useful for any machine where a part of the application is rotating around another segment.

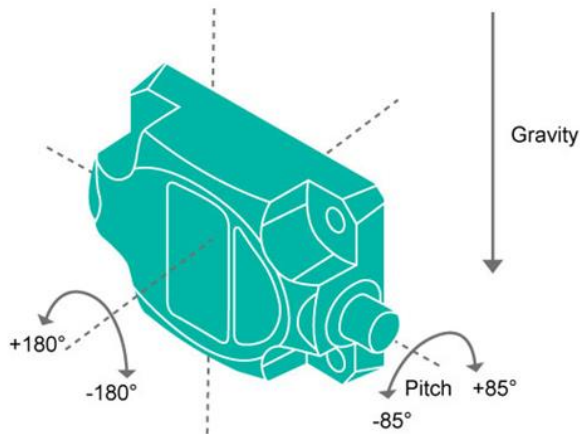
The Pitch axis is limited to $\pm 85^\circ$, while the Roll axis is limited to $\pm 180^\circ$.



TILTIX MEMS DYNAMIC AKS-3 INCLINOMETER WITH J1939 INTERFACE C903

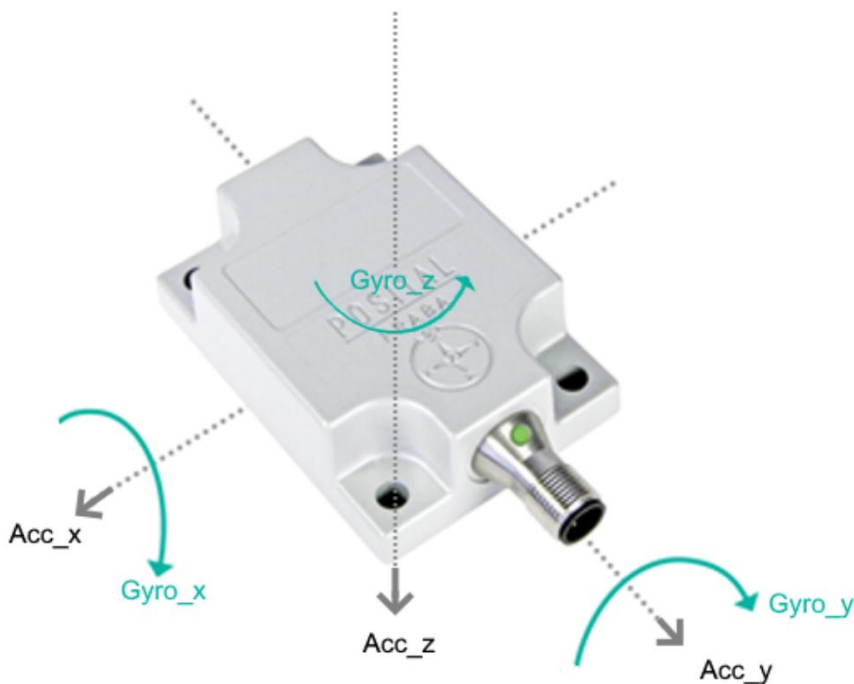
TILTIX AKS-180-F – Pitch and Roll Axis Inclinometer

This version is intended for vertical mounting. Like the AKS-180-E, the Pitch axis monitors the position angle in space, while the Roll axis shows the rotation with respect to the pitch angle.



6.1 Orientation and Direction of Accelerometer and Angular Rate

The axis orientation and direction can be derived from the image below. The direction is independent of the angle configuration and measuring range and is therefore the same for all inclinometer versions.





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7.0 J1939 Versions C901 and C903

The AKS J1939 is available in the two different versions which can be distinguished by the typekey AKS-xxx-x-**C901**-xx3-xx and AKS-xxx-x-**C903**-xx3-xx.

C901 represents the backward compatible J1939 version. These versions can be used as replacement for the older generation AKS-xxx-x-**C901**-xx2-xx versions, where the same dbc file and manual are valid.

C903 represents the J1939 version with new features like programmable angle versions and configurable PGNs that can be used



TILTIX MEMS DYNAMIC AKS-3 INCLINOMETER WITH J1939 INTERFACE C903

8.0 Default PGNs

The AKS sensor transmits 2 PGNs by default according to the table below.

PGNs can be disabled or additional PGNs can be configured and enabled. The configuration and selection process of a customized PGN with different SPNs is described in chapter Configurable PGNs.

AKS Version	1st PGN	2nd PGN
AKS-090-2-C903	65280	65281
AKS-360-1-C903	65282	65281
AKS-180-E-C903	65280	65281
AKS-180-F-C903	65280	65281

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8.1 Default PGN list

PGN 65280, 65281, 65282

Inclinometer position	Broadcast communication
Transmission repetition rate	10 ms (default)
Data Length	8 bytes for each PGN (Two PGNs are available at the same time)
PDU format PF	0xFF
PDU specific PS	0x00
Default priority	3

PGN 65280 (dual axis): Angle information + Acceleration x, y

SPN name	SPN position (bit)	SPN size (bit)	Resolution	Offset	Data range	Description
Pitch/X-Angle	0-15	16	0,01°	-	-90 to 90°	Pitch Angle Data (±90° range)
Roll/Y-Angle	16-31	16	0,01°	-	-180 to 180°	Roll Angle Data (±180° range)
Acceleration x	32-47	16	1 mg	-	-4000 to 4000 mg	X-axis acceleration (±4g range)
Acceleration y	48-63	16	1 mg	-	-4000 to 4000 mg	Y-axis acceleration (±4g range)

PGN 65281: Acceleration z + Gyro x, y, z

SPN name	SPN position (bit)	SPN size (bit)	Resolution	Offset	Data range	Description
Acceleration z	0-15	16	1 mg	-	-4000 to 4000 mg	Z-axis acceleration (±4g range)
Gyro x	16-31	16	0,1 °/s	-	-500,0 to 500,0 °/s	X-axis rate of rotation (±500°/s range)
Gyro y	32-47	16	0,1 °/s	-	-500,0 to 500,0 °/s	Y-axis rate of rotation (±500°/s range)
Gyro z	48-63	16	0,1 °/s	-	-500,0 to 500,0 °/s	Z-axis rate of rotation (±500°/s range)



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PGN 65282 (single axis): Angle information + Acceleration x, y

SPN name	SPN position (bit)	SPN size (bit)	Resolution	Offset	Data range	Description
Pitch/X-Angle	0-15	16	0,01°	-	0 to 360°	Pitch Angle Data 0°-360° range)
not used	16-31	16	-	-	-	Fixed Value: 0x00
Acceleration x	32-47	16	1 mg	-	-4000 to 4000 mg	X-axis acceleration (±4g range)
Acceleration y	48-63	16	1 mg	-	-4000 to 4000 mg	Y-axis acceleration (±4g range)

PGN 61481

Inclinometer position	Broadcast communication
Transmission repetition rate	10 ms (default)
Data Length	8 bytes
PDU format PF	0xF0
PDU specific PS	0x29
Default priority	3
Parameter group number PGN	61481

SAE standard PGN 61481 (dual axis): Slope Sensor Information (extended range)

SPN name	SPN position (bit)	SPN size (bit)	Resolution	Offset	Data range	Description
Pitch angle (extended range)	0-23	24	1/32768 °/bit	-250°	-250 to 252°	Pitch Angle Data (+-90° range)
Roll angle (extended range)	24-47	24	1/32768 °/bit	-250°	-250 to 252°	Roll Angle Data (+-90° range)
Pitch angle compensation	48-49	2	4 states	0	0 to 3	00b: ON (It is always ON) 01b: OFF
Pitch angle figure of merit (extended range)	50-51	2	4 states	0	0 to 3	00b: Pitch angle fully functional (It is always 00b since we cover the entire 360° range) 01b: Pitch angle degraded
Roll angle compensation	52-53	2	4 states	0	0 to 3	00b: ON (It is always ON) 01b: OFF
Roll angle figure of merit (extended range)	54-55	2	4 states	0	0 to 3	00b: Roll angle fully functional (It is always 00b since we cover the entire 360° range) 01b: Roll angle degraded
Roll and Pitch Measurement Latency (extended range)	56-63	8	0.5 ms/bit	0	0 to 125 ms	Estimated measurement latency (0.5 ms/bit ->fixed @ 10ms right now) (UINT8)

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8.2 Configuration via CAM11 / CAM21

CAN J1939 implements a CANopen dictionary that provides extended configuration of the sensor via SDO service, like CANopen. The CANopen Application Message CAM11 (PGN 1280) contains the SDO client/server protocol and CAM21 (PGN 1536) maps the SDO response

8.3 SDO read/write/abort object

The following SDO objects can be used as read, write and abort command

Master transmits

Identifier	DLC	Command	Index		Subindex	Service/Process data			
NN = 80		Download				Byte 4	Byte 5	Byte 6	Byte 7
0x1C0580xx	8	CS	00	00	00	00	00	00	00

xx - Source Address

Sensor transmits

Identifier	DLC	Command	Index		Subindex	Service/Process data			
NN = 80		Download				Byte 4	Byte 5	Byte 6	Byte 7
0x1C06xx80	8								

xx - Source Address

CS – Command Specifier	Identifier
40h	SDO read request
22h	SDO write request
80h	SDO abort

8.4 SDO Abort Codes:

If an error occurred while reading or writing an object, the transmitter answer with one of the following abort codes:

Sensor transmits

Identifier	DLC	Command	Index		Subindex	Service/Process data			
NN = 80		Download				Byte 4	Byte 5	Byte 6	Byte 7
0x1C06xx80	8	80	00	00	00	"Abort Code"			

xx - Source Address



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Abort Code	Description
0x05030000	Toggle bit not alternated
0x05040000	SDO protocol timed out
0x05040001	Client/server command specifier not valid
0x06010000	Unsupported access to an object
0x06010001	Attempt to read a write only object
0x06010002	Attempt to write a read only object
0x06020000	Object does not exist in the object dictionary
0x06040043	General parameter incompatibility reason
0x06060000	Access failed due to a hardware error
0x06070010	Data type does not match
0x06090011	Sub-index does not exist
0x06090030	Invalid value for parameter

8.5 Configurable PGNs and available SPNs

There are 8 PGNs available for configuration. The PGN configuration is the same for each PGN. An example for PGN1 configuration is given below

Index	Description
2101h	PGN 1 configuration
2102h	PGN 2 configuration
2103h	PGN 3 configuration
2104h	PGN 4 configuration
2105h	PGN 5 configuration
2106h	PGN 6 configuration
2107h	PGN 7 configuration
2108h	PGN 8 configuration

8.6 Object 2100h: PGN Mode Configuration

The PGN Mode Configuration switches the range of valid PGN Numbers for object PGN Number 2101h Sub 01h between SAE specific PGNs and customized PGNs. SAE specific PGNs have a fixed set of SPN according to SAE standard, that cannot be configured. With Customized PGNs, the PGN Number and SPN Content can be configured freely by the user.

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Subindex	Description	Data type	Access type	Default Value	Value Range
00h	PGN Mode Configuration	UINT8	Rw	0	1

Value	Description
00h	Customized PGNs
01h	SAE specific PGNs

Note: If SAE specific PGNs is selected, the default PGN Number object 2101h Sub 01h will be set to 61481d. SAE mode can only be selected if Angle Mode (object 3200h) is set to a “dual axis” axis type

8.7 Object 2101h: PGN1 Configuration

In this object, the user can configure the PGN number, SPN content, cycle time, inhibit time and priority of the desired PGN.

The PGN must be disabled (subindex 0Dh → 0) for configuration of the other subindexes. The data length of all active configured SPNs is limited to 8 bytes. If the length is less than that, the remaining bytes are automatically filled with “FF”. When the PGN is enabled (subindex 0Dh → 1) the sensor automatically checks, if the configured SPNs are valid and if the byte length is exceeded. An error message issued. PGNs/SPNs are reset to default upon angle mode (object 3200h) change.

Sub index	Description	Data type	Access type	Default Value	Value Range
00h	Highest sub-index supported	UINT8	Ro	13d	
01h	PGN Number	UINT32	Rw		
02h	SPN1	UINT8	Rw		
03h	SPN2	UINT8	Rw		
04h	SPN3	UINT8	Rw		
05h	SPN4	UINT8	Rw		
06h	SPN5	UINT8	Rw		
07h	SPN6	UINT8	Rw		
08h	SPN7	UINT8	Rw		
09h	SPN8	UINT8	Rw		
0Ah	Cycle time	UINT16	Rw		1-65535d
0Bh	Inhibit time	UINT16	Rw		1-65535d



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0Ch	Priority	UINT8	Rw		0-7
					0 - Disabled
0Dh	Enable	UINT8	Rw		1 – Enabled

8.8 Sub Index 01h PGN Number

The desired PGN number can be configured via this object.

Note: If a SAE specific PGN is used, the :PGN Mode Configuration 2100h needs to be set accordingly.

Description	Value
“Zero” PGN	00000
SAE PGNs	61459, 61481, 61482, 61485
Manufacturer specific PGNs	65280 - 65519

The “Zero” PGN number can be set, but it cannot be enabled. It is only included for consistency reasons as it is generally used for deactivated, empty PGNs.

8.9 Sub Index 02h-09h: SPN1-SPN8

The PGN content can be configured with the following available SPNs.

Index	Description	Data type	Axis type	Description
00h	Empty (no mapping)	-	Single, dual	
01h	Angle X-axis 16	INT16	Dual	
02h	Angle Y-axis 16	INT16	Dual	
03h	Angle Z-axis 16	UINT16	Single	
04h	Acceleration X-axis 16	INT16	Single, dual	Acceleration forces (calibrated) of acceleration sensor for each axis. Max range +/- 4000 mg
05h	Acceleration Y-axis 16	INT16	Single, dual	
06h	Acceleration Z-axis 16	INT16	Single, dual	
07h	Rate X-axis 16	INT16	Single, dual	Rotation rate (calibrated) of the gyroscope for each axis. Max range +/- 500°/s
08h	Rate Y-axis 16	INT16	Single, dual	
09h	Rate Z-axis 16	INT16	Single, dual	



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0Ah	Temperature	INT16	Single, dual	Temperature of the sensor (MEMS Sensor on the printed circuit board) Resolution 0,1 °C and accuracy of +/- 5°C
0Bh	Quaternion Scalar	INT16	Single, dual	
0Ch	Quaternion X	INT16	Single, dual	
0Dh	Quaternion Y	INT16	Single, dual	
0Eh	Quaternion Z	INT16	Single, dual	
0Fh	Angle X/Z-axis 32	INT32	Single, dual	
10h	Angle Y-axis 32	INT32	Dual	
11h	Rate Bias – X-axis	INT16	Single, dual	
12h	Rate Bias - Y-axis	INT16	Single, dual	
13h	Rate Bias - Z-axis	INT16	Single, dual	
14h	Gravity - X-axis 16	INT16	Single, dual	
15h	Gravity - Y-axis 16	INT16	Single, dual	
16h	Gravity - Z-axis 16	INT16	Single, dual	
17h	Non-gravitational Acc - X-axis 16	INT16	Single, dual	
18h	Non-gravitational Acc - Y-axis 16	INT16	Single, dual	
19h	Non-gravitational Acc - Z-axis 16	INT16	Single, dual	
1Ah	Rate - X-axis 32	INT32	Single, dual	
1Bh	Rate - Y-axis 32	INT32	Single, dual	
1Ch	Rate - Z-axis 32	INT32	Single, dual	
1Dh	Acceleration - X-axis 32	INT32	Single, dual	
1Eh	Acceleration - Y-axis 32	INT32	Single, dual	
1Fh	Acceleration - Z-axis 32	INT32	Single, dual	
20h	Gravity - X-axis 32	INT32	Single, dual	
21h	Gravity - Y-axis 32	INT32	Single, dual	
22h	Gravity - Z-axis 32	INT32	Single, dual	
23h	Non-gravitational Acc - X-axis 32	INT32	Single, dual	
24h	Non-gravitational Acc - Y-axis 32	INT32	Single, dual	
25h	Non-gravitational Acc - Z-axis 32	INT32	Single, dual	
26h	Diagnostics	UINT16	Single, dual	

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27h	reserved			
28h	Internal cycle counter	UINT8	Single, dual	1ms cycle time
...	reserved			
7Ah	Dummy 8 low	UINT8	Single, dual	
7Bh	Dummy 16 low	UINT16	Single, dual	
7Ch	Dummy 32 low	UINT32	Single, dual	
7Dh	Dummy 8 high	UINT8	Single, dual	
7Eh	Dummy 16 high	UINT16	Single, dual	
7Fh	Dummy 32 high	UINT32	Single, dual	
80h	4 bit counter in 8bit variable	UINT8	Single, dual	Nachrichtencounter, zählt bei jeder verschickten Nachricht hoch. Counter - Hohen bits
81h	CRC8 SAE J1850	UINT8	Single, dual	Muss als letztes byte gemapped werden. Checksumme CRC
...	reserved		Single, dual	

Note: Only SPNs matching the angle mode can be set e.g Angle Z-axis 16 can only be used for the single-axis inclinometer type. Enabling a PGN can fail, even if the SPNs were accepted, but they do not match the angle mode! If an SPN is set to 0 it is ignored. The inclinometer type can be change via object 3200h Angle Mode

8.10 Sub index 0Dh: Enable

The PGN is disabled if this subindex is 0 and the PGN is enabled if this subindex is 1. The PGN can only be enabled, if certain conditions are met. The following list describes the conditions and order in which they are checked:

1. "Zero" PGNs cannot be enabled, it will always fail.
2. If the same PGN number is already enabled in another PGN configuration (2101h – 2107h), it will fail.
3. For manufacturer specific PGNs: if at least one angle mode dependent SPN does not match the angle mode, it will fail.
4. For SAE PGNs: SSI and SSI2 are mutually exclusive. If one is already enabled, then it will fail to enable the other one.

Programming example PGN Configuration:

Configure PGN 1 to PGN 65295d with SPN Content Angle X-axis 16 + Angle Y-axis 16 + Rate X-axis 16 + Rate Y-axis 16 and a cycle time of 1ms



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Step 1: Set PGN Mode 2100h to Customized PGNs (skip if already configured)

Identifier	DLC	Command	Index		Subindex	Service/Process data			
NN = 80		Download				Byte 4	Byte 5	Byte 6	Byte 7
0x1C0580xx	8	22	00	21	00	01	00	00	00

Step 2: Disable PGN1 Configuration

Identifier	DLC	Command	Index		Subindex	Service/Process data			
NN = 80		Download				Byte 4	Byte 5	Byte 6	Byte 7
0x1C0580xx	8	22	01	21	0D	00	00	00	00

Step 3: Set PGN Number of PGN1 Configuration to 65295d -> FF0Fh

Identifier	DLC	Command	Index		Subindex	Service/Process data			
NN = 80		Download				Byte 4	Byte 5	Byte 6	Byte 7
0x1C0580xx	8	22	01	21	01	0F	FF	00	00

Step 4: Set SPN1 to Angle X-axis 16 (SPN Index 01h)

Identifier	DLC	Command	Index		Subindex	Service/Process data			
NN = 80		Download				Byte 4	Byte 5	Byte 6	Byte 7
0x1C0580xx	8	22	01	21	02	01	00	00	00

Step 5: Set SPN2 to Angle Y-axis 16 (SPN Index 02h)

Identifier	DLC	Command	Index		Subindex	Service/Process data			
NN = 80		Download				Byte 4	Byte 5	Byte 6	Byte 7
0x1C0580xx	8	22	01	21	03	02	00	00	00

Step 6: Set SPN3 to Rate X-axis 16 (SPN Index 07h)

Identifier	DLC	Command	Index		Subindex	Service/Process data			
NN = 80		Download				Byte 4	Byte 5	Byte 6	Byte 7
0x1C0580xx	8	22	01	21	04	07	00	00	00

Step 7: Set SPN4 to Rate Y-axis 16 (SPN Index 08h)

Identifier	DLC	Command	Index		Subindex	Service/Process data			
NN = 80		Download				Byte 4	Byte 5	Byte 6	Byte 7
0x1C0580xx	8	22	01	21	05	08	00	00	00

Step 8: Set Cycle time to 1 ms

Identifier	DLC	Command	Index		Subindex	Service/Process data			
------------	-----	---------	-------	--	----------	----------------------	--	--	--



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NN = 80		Download				Byte 4	Byte 5	Byte 6	Byte 7
0x1C0580xx	8	22	01	21	0A	01	00	00	00

Step 9: Enable PGN1

Identifier	DLC	Command	Index		Subindex	Service/Process data			
NN = 80		Download				Byte 4	Byte 5	Byte 6	Byte 7
0x1C0580xx	8	22	01	21	0D	01	00	00	00

9.0 Object 2150h: Name Parameter

This object contains the NAME of the device

Subindex	Description	Data Type	Default Value	Access
00h	Highest sub-index supported	Unsigned 8	10d	ro
01h	Identity Number	Unsigned 32	Last 6 digits of serial number	ro
02h	Manufacturer Code	Unsigned 16	1293d	ro
03h	ECU Instance	Unsigned 8	0	rw
04h	Function Instance	Unsigned 8	0	rw
05h	Function	Unsigned 8	85d	rw
07h	Vehicle System	Unsigned 8	0	rw
08h	Vehicle System Instance	Unsigned 8	0	rw
09h	Industry Group	Unsigned 8	0	rw
0Ah	Arbitrary Address Capable	Unsigned 8	1	rw

9.1 Object 2160h: Manufacturer device name

This object contains the Manufacturer device name of the device

Index	Description	Data Type	Default Value	Access
2160h	Manufacturer device name	String		ro



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9.2 Object 2161h: Manufacturer hardware version

This object contains the Manufacturer hardware version of the device

Index	Description	Data Type	Default Value	Access
2161h	Manufacturer hardware version	String		ro

9.3 Object 2162h: Manufacturer software version

This object contains the Manufacturer software version of the device

Index	Description	Data Type	Default Value	Access
2162h	Manufacturer software version	String		ro

9.4 Object 2170h: Product code

This object contains the Product code of the device

Index	Description	Data Type	Default Value	Access
2170h	Product code	UINT32		ro

9.5 Object 2171h: Serial Number

This object contains the Serial number of the device

Index	Description	Data Type	Default Value	Access
2171h	Serial Number	UINT32		ro

10.0 Object 2300h: Store parameters with Reset

This object is used to save all writable parameters in non-volatile memory. Writing 0x55aaaa55 to this object will store all parameters and initiates a reset of the device.

Index	Description	Data Type	Default Value	Access
2300h	Store parameters with Reset	Unsigned32	55aaaa55h	wo



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Programming example Save Configuration with Reset:

Identifier	DLC	Command	Index		Subindex	Service/Process data			
NN = 80		Download				Byte 4	Byte 5	Byte 6	Byte 7
0x1C0580xx	8	22	00	23	00	55	Aa	Aa	55

11.0 Object 2310h: Restore parameters with Reset

This object is used to restore device and J1939 related writeable parameters to default factory settings.

Index	Description	Data Type	Default Value	Access
2310h	Restore parameters with Reset	Unsigned32	0x55aaaa55	wo

11.1 Object 3000h: Node Number

This object contains the node number of the device.

Subindex	Description	Data Type	Default Value	Value Range	Access
0	Node Number	UINT8	80h	80h-F7h	Rw

Note: The new node number is only adopted after the device is reset, i.e. the node number needs to be saved prior to the reset to have an effect. If Address claiming (object 3004h) is disabled, the Node Number value range changes to 0-253d

Programming example: Set Node Number to 90h

Identifier	DLC	Command	Index		Subindex	Service/Process data			
NN = 80		Download				Byte 4	Byte 5	Byte 6	Byte 7
0x1C0580xx	8	22	00	30	00	90	00	00	00

Note: Save this configuration afterwards with object 2300h Save Configuration with Reset.

11.2 Object 3001h: Baudrate

This object contains the baud rate of the device. Valid value ranges from 0 to 7.

Subindex	Description	Data Type	Default Value	Access
0	Baud rate	Unsigned 8	04h	rw

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Eight different baud rates are provided. To adjust the baud rate only one byte is used.

Value	Baud rate in kB
00h	20
01h	50
02h	100
03h	125
04h	250
05h	500
06h	800
07h	1000

Note: The new baud rate is only adopted after the device is reset, i.e. the baud rate needs to be saved prior to the reset to have an effect.

Programming example: Set Baudrate to 500 kBaud

Identifier	DLC	Command	Index		Subindex	Service/Process data			
NN = 80		Download				Byte 4	Byte 5	Byte 6	Byte 7
0x1C0580xx	8	22	01	30	00	05	00	00	00

11.3 Object 3002h: Termination Resistor

This object is used to activate the termination resistor in case the TILTIX is used at the edges of the transmission line (to avoid reflection of data back into the line) and/or high transmission rates (>50kB).

Subindex	Description	Data Type	Default Value	Access
0	Activate Termination Resistor	Unsigned8	0	rw

Value	Baud rate in kB
00h	Deactivated
01h	Activated

Programming example: Activate Termination Resistor

Identifier	DLC	Command	Index		Subindex	Service/Process data			
NN = 80		Download				Byte 4	Byte 5	Byte 6	Byte 7
0x1C0580xx	8	22	02	30	00	01	00	00	00

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11.4 Object 3004h: Address claiming

J1939 Address Claiming is the process of address assignment for J1939 devices. At startup, each device sends a corresponding CAN message with the desired address. If no other device is using this address, the desired address can be assigned. Otherwise, the Address Claiming algorithm must determine which device is allowed to use the address.

Subindex	Description	Data Type	Default Value	Access
0	Address claiming	Unsigned 8	1	rw*

0 – off

1 – on

Note: If Address claiming is switched (on → off or off → on) the Node Number (3000h) is set to default 128d

11.5 Object 3200h: Angle Mode

The Angle Mode (measurement axis) of the inclinometer can be changed by setting of the Angle Mode Object 3200h, e.g. a single axis inclinometer can be re-configured as dual axis inclinometer and vice versa.

Whenever the angle mode is changed, the following objects are reset to default values:

- **PGN1-8 configuration 2101h-2108h**
- **Range limits 3300h and 3301h**
- **And all device profile objects used for configuration.**

For saving the angle mode change, the Save all parameters command of object 2300h must be used.

Resolution 6000h and Scaling 6011h, 6021h, 6111h, 6121h are not reset automatically after changing of angle mode and therefore must be adjusted manually.

Subindex	Description	Data Type	Min	Max	Default Value	Access
00h	Angle Mode	Unsigned 8	1	4	-	rw



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Value	Description	Axis Type	Related Type key
1	Pitch, Roll $\pm 85^\circ/\pm 180^\circ$ horizontal mounting	Dual Axis	AxS- 180-E -C903- H x3-xx
2	2 Axes $\pm 90^\circ$	Dual Axis	AxS- 090-2 -C903- H x3-xx
3	1 Axis 360°	Single Axis	AxS- 360-1 -C903- V x3-xx
4	Pitch, Roll $\pm 85^\circ/\pm 180^\circ$ vertical mounting	Dual Axis	AxS- 180-F -C903- V x3-xx

Note: If PGN mode is set to SAE specific PGNs, Angle mode “3” can not be set

11.6 Object 3250h: Preset Mode

There are two different preset modes available for the angle versions with pitch and roll output.

Subindex	Description	Data Type	Min	Max	Default Value	Access
00h	Preset Mode	Unsigned 8	0	1	0	rw/ro

0 = Backwards compatible preset logic. The preset is simply added to the output value.

1 = New preset logic based on preserved angle ranges with shifted 0 position. The position limits stay the same and the turning point where the graph switches from positive to negative slope moves across the physical position. This object is only available for AxS-xxx-x-C903 versions
Check diagram in appendix D: “Output Graphs with Preset and Offset” for reference.

12.0 Object 3300h: Range Limit Slope Long

With this object, the minimum and maximum output range of the inclinometers slope long angle can be limited. Range limits are set with the current resolution.

Subindex	Description	Data Type	Min	Max	Default Value	Access
00h	Number of Entries	Unsigned 8	-	-	2	ro
01h	Range Minimum	(Un)signed 32				rw
02h	Range Maximum	(Un)signed 32				rw

12.1 Object 3301h: Range Limit Slope Lateral

With this object, the minimum and maximum output range of the inclinometers slope lateral angle can be limited. Range limits are set with the current resolution.

Subindex	Description	Data Type	Min	Max	Default Value	Access
00h	Number of Entries	Unsigned 8	-	-	2	ro

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01h	Range Minimum	Signed 32				rw
02h	Range Maximum	Signed 32				rw

12.2 Object 3310h: Angle Hysteresis

With this object, the hysteresis can be set. Depending on the direction of rotation, the position value deviates from the physical position by the set hysteresis value [0.001°].

Subindex	Description	Data Type	Min	Max	Default Value	Access
00h	Angle Hysteresis [0.001°]	Unsigned 16	0	65535	0	rw

12.3 Object 3350h: Acc Butterworth cut-off frequency

With this object, a low pass Butterworth filter of first order can be applied for the acceleration data output of SPM Index 04h-06h and 1Dh-1Fh and the cut-off frequency of this Butterworth filter can be set.

Subindex	Description	Data Type	Min	Max	Default Value	Access
00h	Acc Butterworth cut-off frequency	Unsigned 16	0	65535	0	rw

Acc Butterworth cut-off frequency Value	Description
0	off
1-65535	Cut-off frequency [mHz]

12.4 Object 3351h Angular Rate Butterworth Filter

In this object, a Butterworth filter of first order and frequency can be set that affects the angular rate data output of the gyroscope of SPM Index 07h-09h and 1Ah-1Ch.

Subindex	Description	Data Type	Min	Max	Default Value	Access
00h	Highest sub-index supported	Unsigned 8	0	255	3	ro
01h	Filter Type	Unsigned 8	0	1	0	rw
02h	Cut-off Frequency	Unsigned 16	0	65535	0	rw

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Filter Type Value	Description
0	Low pass
1	High pass

Cut-off Frequency Value	Description
0	off
1-65535	Cut-off frequency [mHz]

12.5 Object 3390h: Resolution Acceleration

This object sets the resolution of the acceleration data output of SPM index 04h-06h, 14h-16h, 17h-19h, 1Dh-1Fh, 20h-22h and 23h-25h.

Subindex	Description	Data Type	Min	Max	Default Value	Access
00h	Resolution Acceleration [μg]	Unsigned 16	1	65535	1000	rw

Value	Description
10000	10000 μg (10 mg)
1000	1000 μg (1 mg)
100	100 μg (0,1 mg)
10	10 μg (0,01mg)
1	1 μg (0,001 mg)

12.6 Object 3391h: Resolution Angular Rate Gyroscope

This object sets the resolution of the Angular rate data output of the gyroscope of SPM index 07h-09h, 11h-13h, 1Ah-1Ch

Subindex	Description	Data Type	Min	Max	Default Value	Access
00h	Resolution Angular Rate Gyroscope [mdeg/s]	Unsigned 16	1	65535	100	rw

Resolution Angular Rate Gyroscope Value	Description
10000	10 °/s
1000	1 °/s
100	0,1 °/s



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10	0,01 °/s
1	0,001 °/s

12.7 Object 6000h: Resolution

This object shall indicate the resolution of Slope long16 (object 6010h) and Slope lateral16 (object 6020h) objects based on 0.01°.

Subindex	Description	Data Type	Default Value	Access
0	Resolution	Unsigned 16	–	rw

Three possible resolutions can be used:

Angular Resolution	Value decimal	Byte hex
0.01°	10	0Ah
0.1°	100	64h
1°	1000	3e8h

12.8 Object 6011h: Slope Long16 Operating Parameter

This object controls the scaling and inversion of SPN index 01h Angle X-axis 16, SPN index 03 Angle Z-axis 16 and SPN index 0Fh Angle X/Z-axis 32. If bit 0 is set, inversion is enabled. If bit 1 is set, offset and differential slope long16 offset are added to the angle value. Both bits can be set at the same time.

Subindex	Description	Data Type	Default Value	Access
0	Position Scaling and Inversion	Unsigned 8	00	rw

Calculation of position value based on the operating parameter:

Angle = [(Physical inclination angle * Multiplier) + angle Offset + Differential angle Offset]. With:

- Multiplier: if inversion is disabled: 1, if inversion is enabled: -1
- Slope Long16 Offset (6013) = Slope Long16 Preset (6012) – (Physical inclination of slope long16 (X) at tacc * Multiplier), with tacc = preset acquisition time
- Differential slope long16 offset (6014): Adds an absolute value (positive or negative) to the sensor

Bit 1	Bit 0	Position Calculation
0	0	X
0	1	-X
1	0	(X + Object 6013h + Object 6014h)



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1 | 1 | (-X + Object 6013h + Object 6014h)

For detailed explanation please see the corresponding objects.

12.9 Object 6012h: Slope Long16 Preset Value

This object is used to apply a preset value to SPN index 01h Angle X-axis 16, SPN index 03 Angle Z-axis 16 and SPN index 0Fh Angle X/Z-axis 32. The values will be set only according to the current resolution, so extreme care should be taken in order to be within the range of the position value limits.

Subindex	Description	Data Type	Default Value	Access
0	Preset Value	Integer 16	00	rw

Resolution	Preset Range (in decimal)	
Type	TILTIX090	Type
1°	± 90	360
0.1°	± 900	3600

Programming example #5 Set Preset Value (for NN=1):

Preset Value - Set the current position to 1°

Step 1: Set preset value to 64h. If the resolution is set to 0,01°, 64h is equal to 1° (Note: If the resolution is set to 0.1°, the preset value must be set to Ah to set the current position to 1°)

Identifier	DLC	Command	Index		Subindex	Service/Process data			
NN = 1		Download				Byte 4	Byte 5	Byte 6	Byte 7
0x1C0580xx	8	22	00	26	00	64	00	00	00

Step 2: Save this configuration

Identifier	DLC	Command	Index		Subindex	Service/Process data			
NN = 80		Download				Byte 4	Byte 5	Byte 6	Byte 7
0x1C0580xx	8	22	00	23	00	55	Aa	Aa	55

12.10 Object 6013h: Slope Long16 Offset

This is a read only parameter. The parameter is recalculated every time Slope Long16 preset (6012h), Slope Long32 Preset (6112) or Preset X (2600) objects are changed.

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Subindex	Description	Data Type	Default Value	Access
0	Offset Value	Integer 16	–	ro

Calculation of Slope Long16 Offset:

Offset Value = Preset Value – (Physical Value * Inversion)

[Inversion is -1 if activated; 1 if deactivated]

12.11 Object 6014h: Differential Slope Long16 Offset

This parameter adds an additional, independent offset to SPN index 01h Angle X-axis 16, SPN index 03 Angle Z-axis 16 and SPN index 0Fh Angle X/Z-axis 32, but only if scaling of slope long16 is enabled. Please note that the values should be within the range of position attribute according to the resolution already set.

Subindex	Description	Data Type	Default Value	Access
0	Offset Value	Integer 16	–	rw

The main difference between the objects 6013h and 6014h is that, 6013 is calculated automatically depending on the preset value whereas object 6014h is user defined.

12.12 Object 6021h: Slope Lateral16 Operating Parameter

This object controls the scaling and inversion of the SPN index 02h Angle Y-axis 16 and SPN index 10 Angle Y-axis 32. If bit 0 is set, inversion of slope lateral16 is enabled. If bit 1 is set, slope lateral16 offset and differential slope lateral16 offset are added to the slope lateral16. Both bits can be set at the same time.

Subindex	Description	Data Type	Default Value	Access
0	Position Scaling and Inversion	Unsigned 8	00	rw

Calculation of position value based on the operating parameter:

Slope Lateral16 = [(Physical inclination of slope lateral16 * Multiplier) + Slope lateral16 Offset + Differential Slope lateral16 Offset]

With:

- Multiplier: if inversion is disabled: 1, if inversion is enabled: -1
- Slope Lateral16 Offset (6023) = Slope Lateral16 Preset (6022) – (Physical inclination of slope lateral16 (X) at t_{acc} * Multiplier), with t_{acc} = preset acquisition time
- Differential slope lateral16 offset (6024): Adds an absolute value (positive or negative) to the sensor output.

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Bit 1	Bit 0	Position Calculation
0	0	X
0	1	-X
1	0	(X + Object 6023h + Object 6024h)
1	1	(-X + Object 6023h + Object 6024h)

For detailed explanation please see the corresponding objects.

12.13 Object 6022h: Slope Lateral16 Preset Value

This object is used to apply a preset value to SPN index 02h Angle Y-axis 16 and SPN index 10 Angle Y-axis 32. The values will be set only according to the current resolution, so extreme care should be taken in order to be within the range of the position value limits.

Subindex	Description	Data Type	Default Value	Access
0	Preset Value	Integer 16	00	rw

Resolution	Preset Range (in decimal)
Type	AxS090
1°	± 90
0.1°	± 900
0.01°	± 9000

12.14 Object 6023h: Slope Lateral16 Offset

This is a read only parameter. The parameter is (2601) objects are changed. This object does not recalculated everytime Slope Lateral16 preset exist for TILTIX360 (6022h), Slope Lateral32 Preset (6122) or Preset Y

Subindex	Description	Data Type	Default Value	Access
0	Offset Value	Integer 16	–	ro

Calculation of Slope Lateral16 Offset:

Offset Value = Preset Value – (Physical Value * Inversion) [Inversion is -1 if activated; 1 if deactivated]

12.15 Object 6024h: Differential Slope Lateral16 Offset

This parameter adds an additional, independent lateral16 is enabled. Please note that the values offset to SPN index 02h Angle Y-axis 16 and SPN should be within the range of position attribute index 10 Angle Y-axis 32, but only if scaling of slope according to the resolution already set.



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Subindex	Description	Data Type	Default Value	Access
0	Offset Value	Integer 16	–	rw

The main difference between the objects 6023h and 6024h is that, 6023h is calculated automatically depending on the preset value whereas object 6024h is user defined.

32-Bit Objects (61XX)

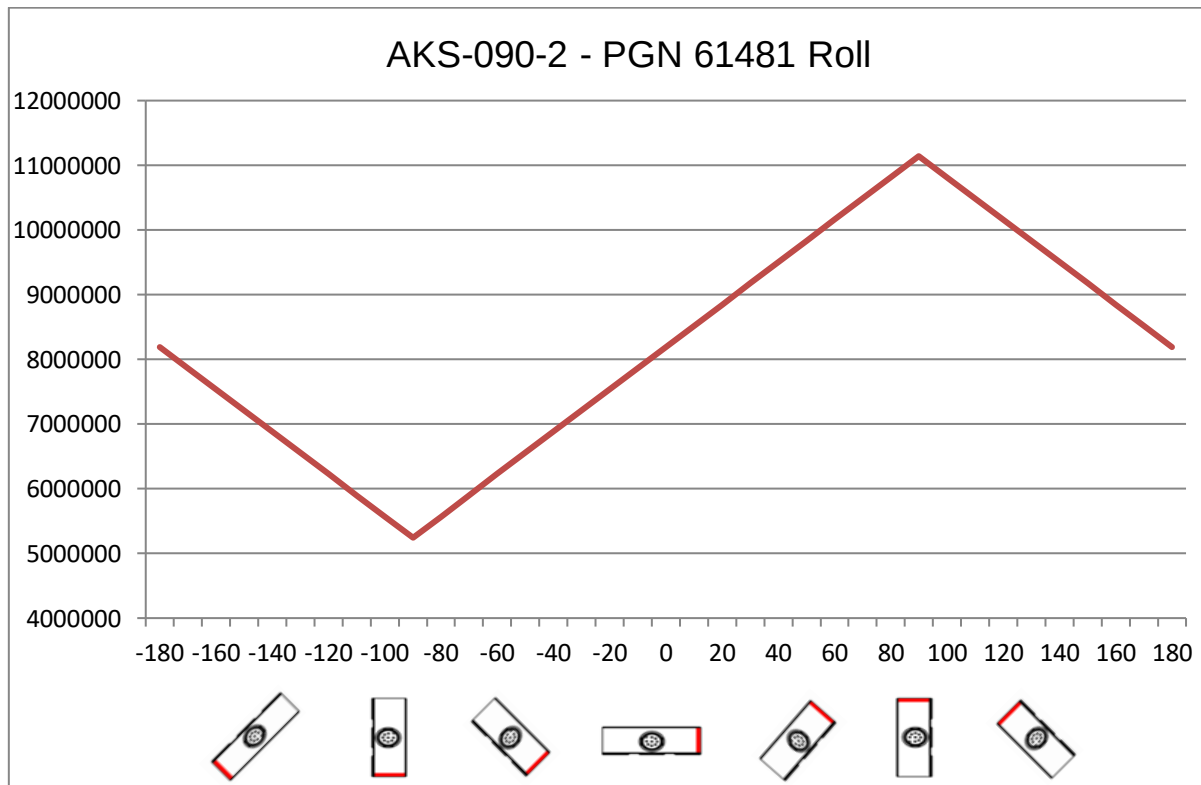
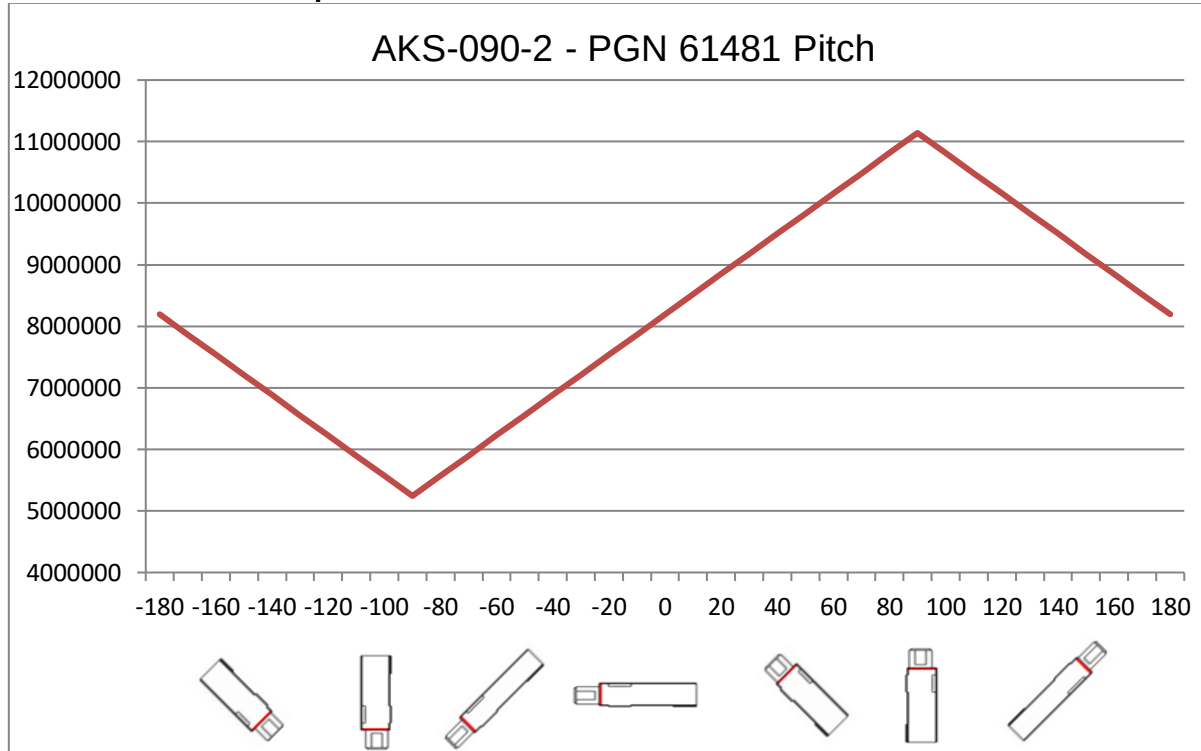
Object 6110 – 6114: Hardwired with 16-bit slope long16 objects.

Objects 6120 – 6124: Hardwired with 16-bit slope lateral16 objects.

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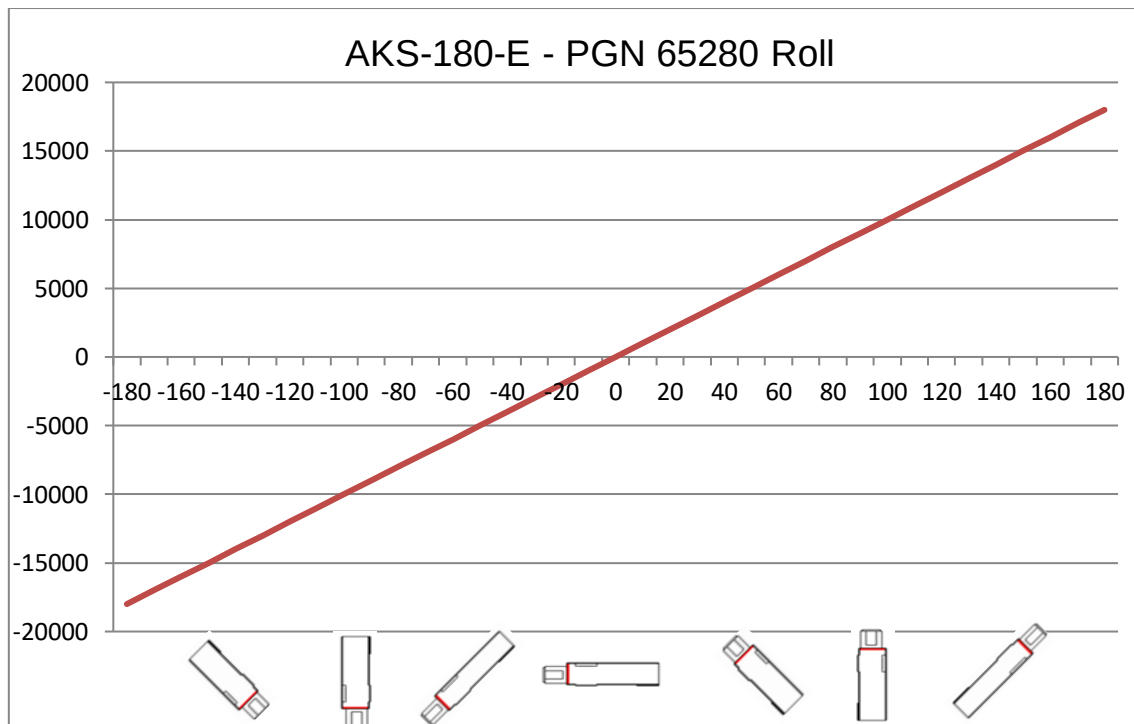
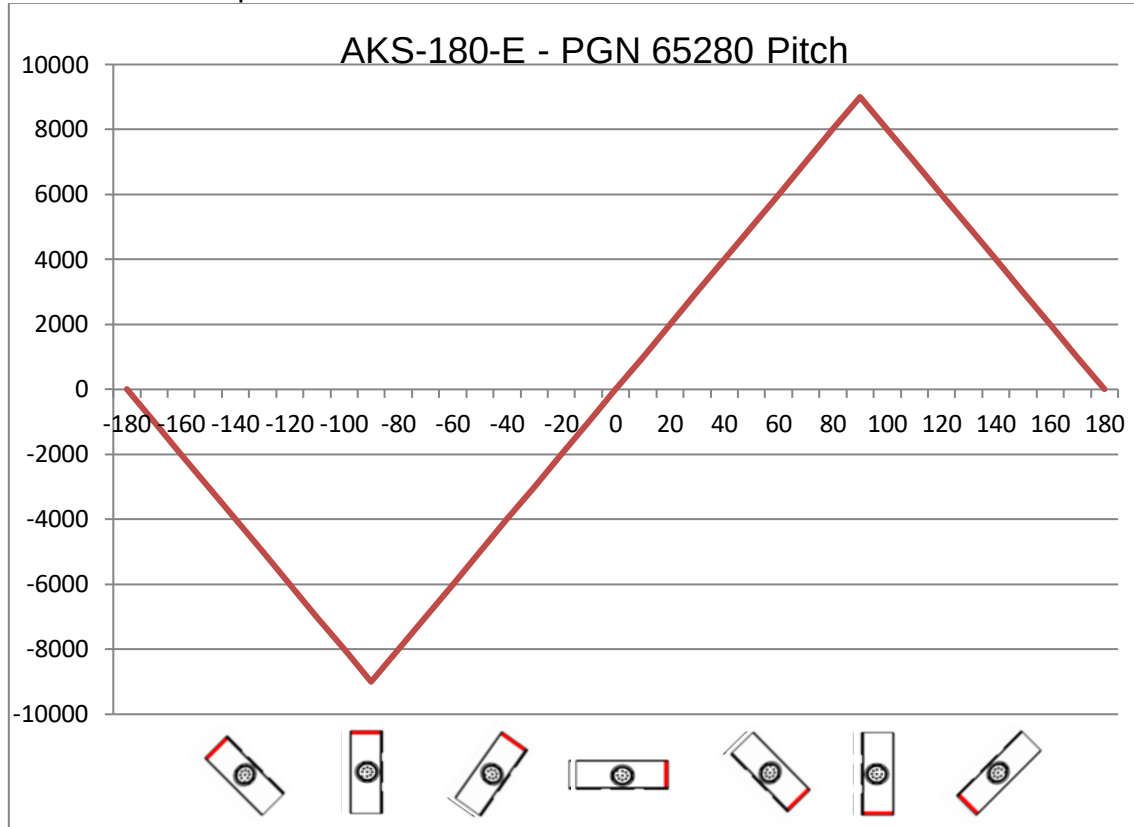
12.16 Output Graphs

AKS-090-2: J1939 Output Values



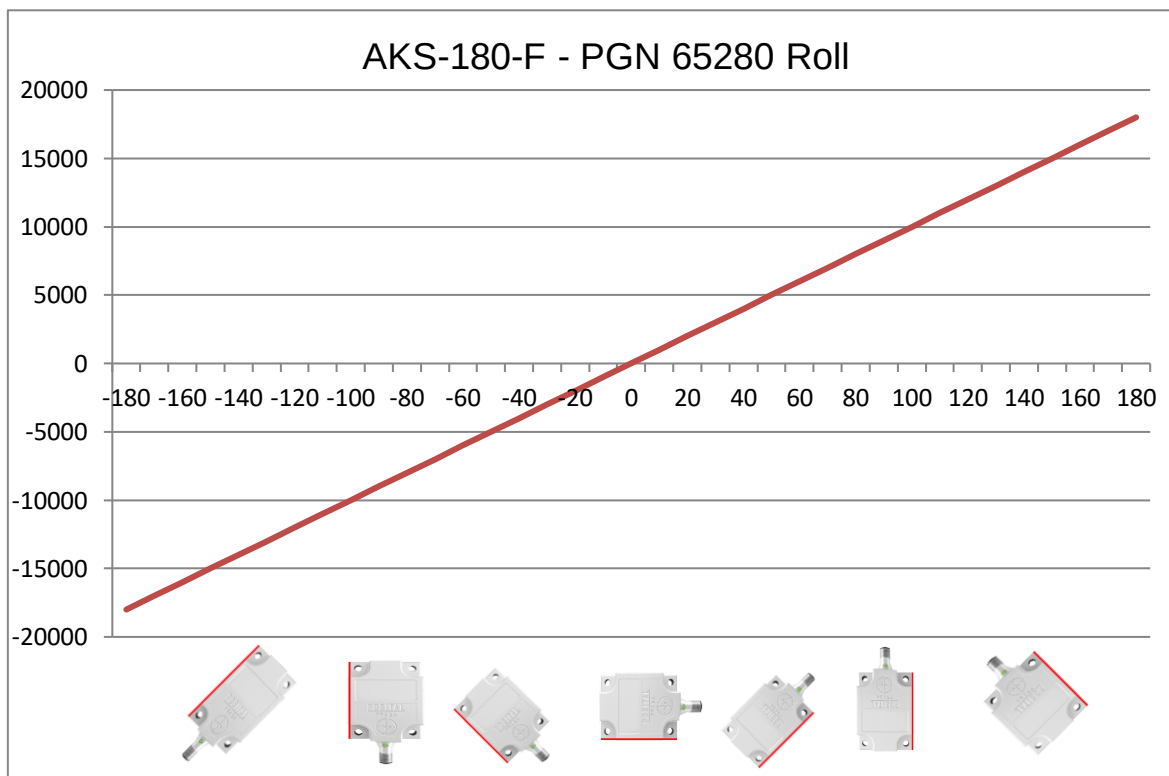
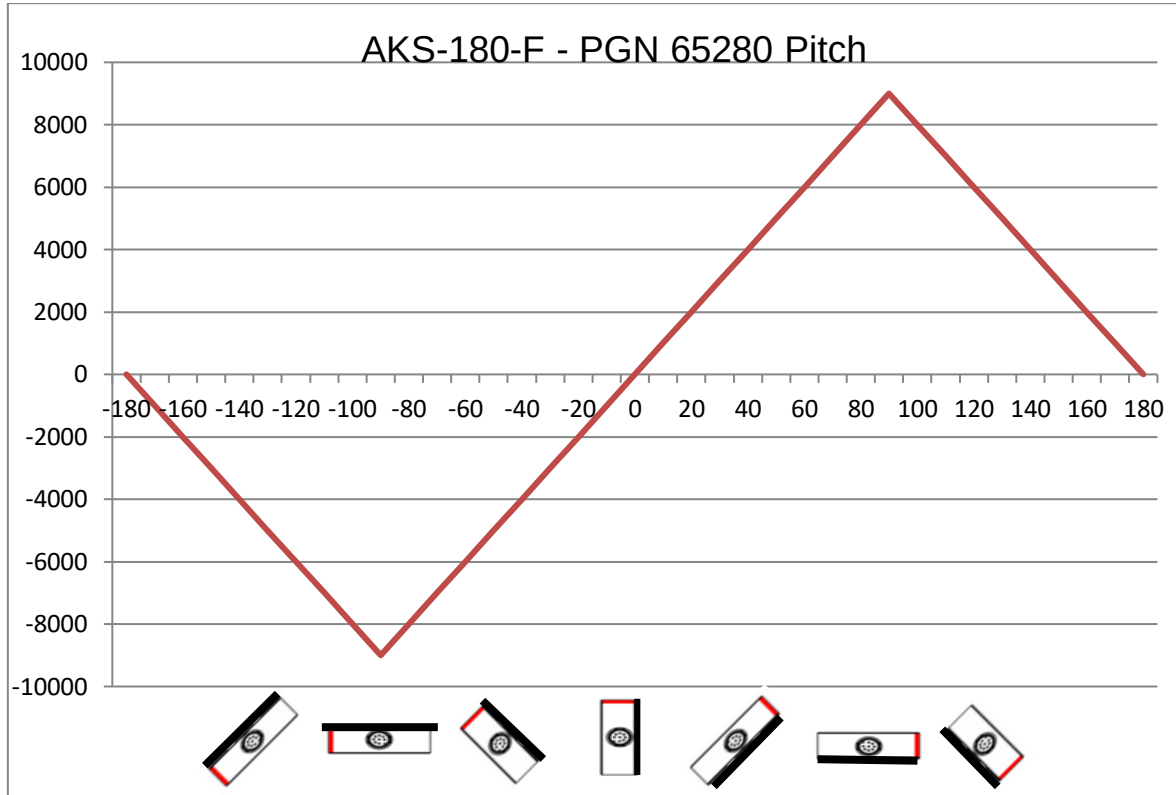
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AKS-180-E: Output Values



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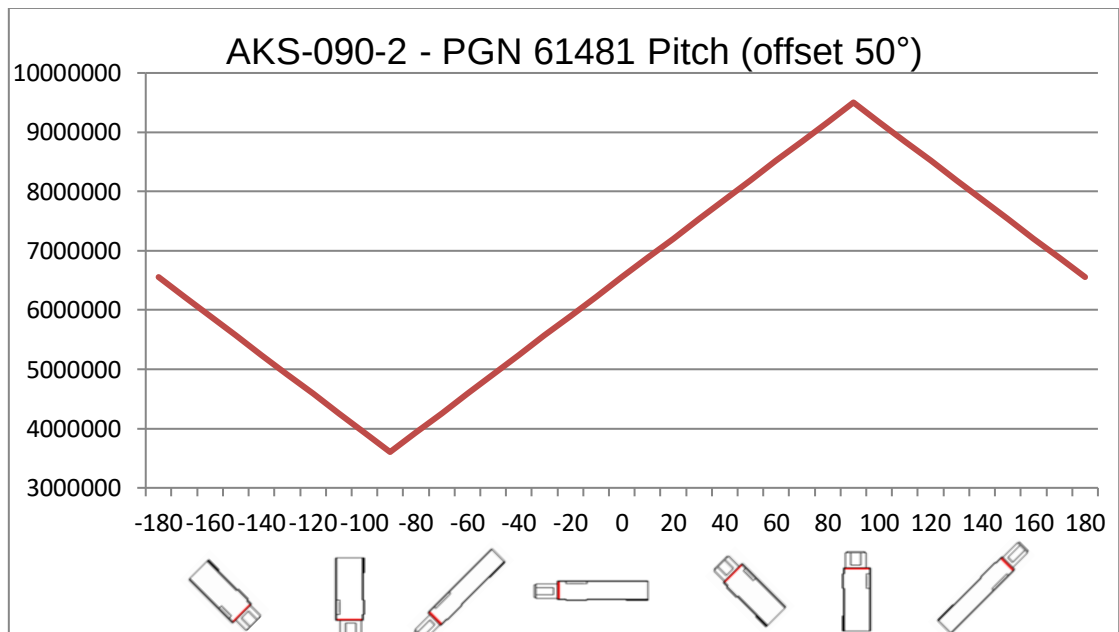
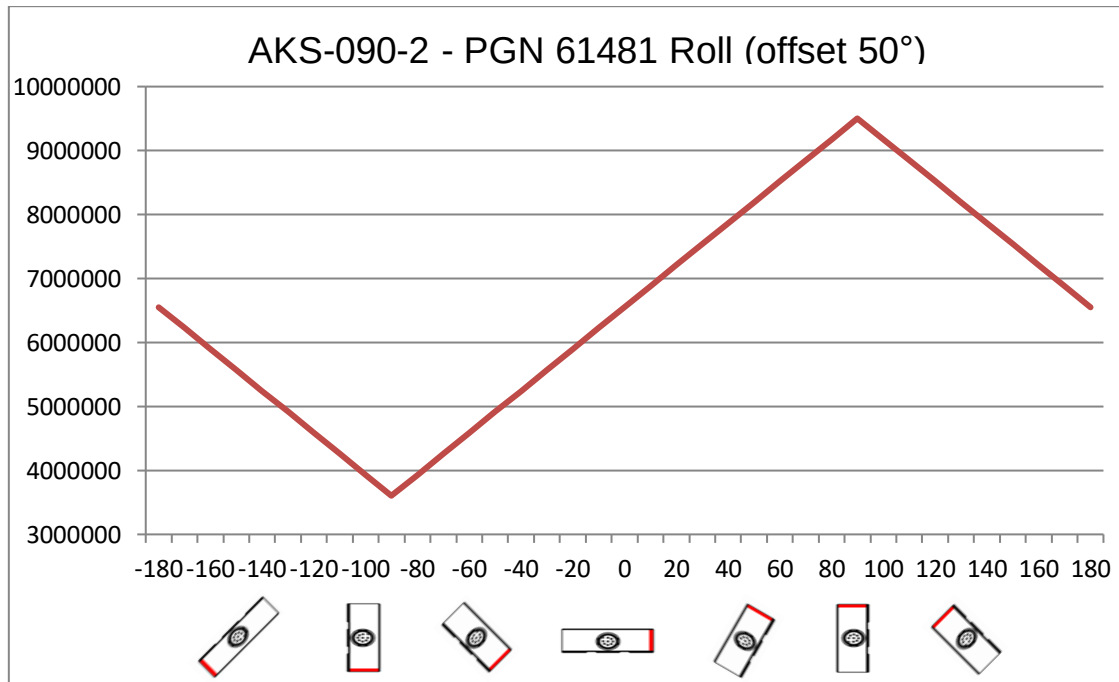
AKS-180-F: Output Values



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12.17 Appendix D: Output Graphs with Preset and Offset

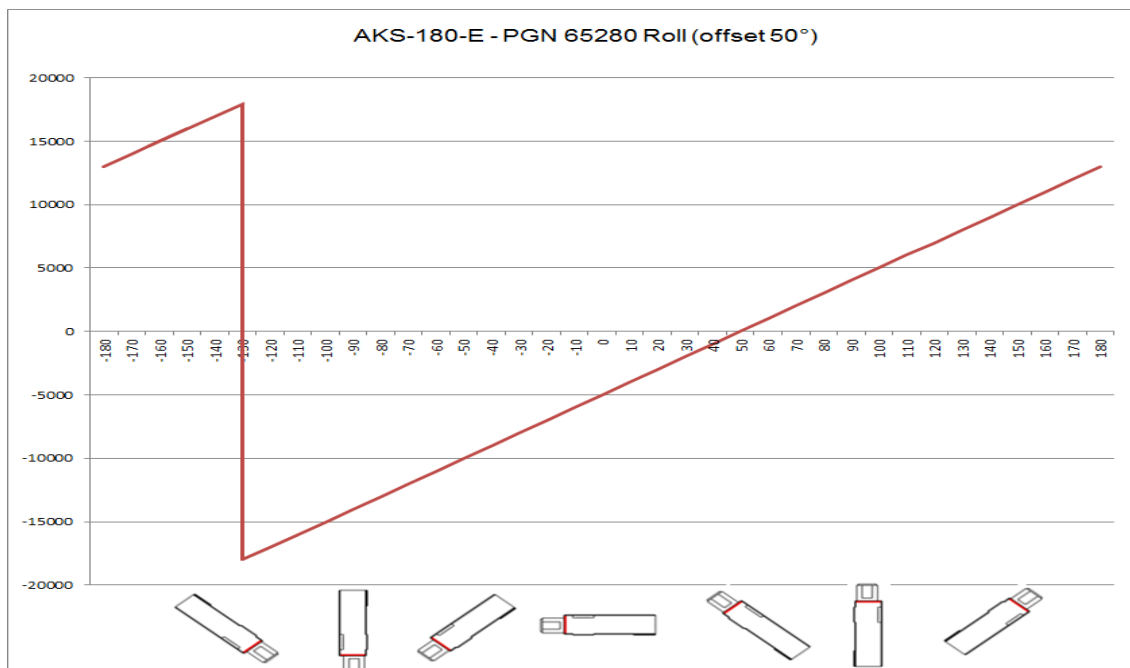
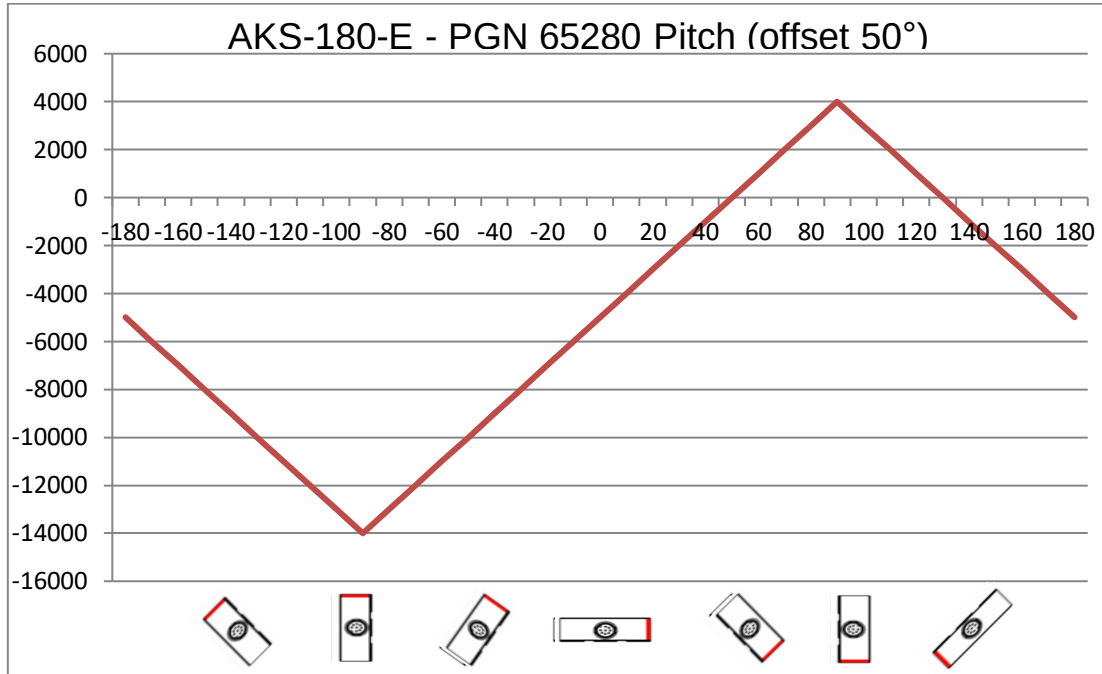
AKS-090-2 with programmed pitch and roll offset of 50°



Hint: The turning point where the graph switches from positive to negative slope stay at the physical position of +/- 90°.

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AKS-180-E with programmed offset of 50°



Hint: For the roll axis, the position limits stay +/- 180°. This way, that the jump from 180° to -180° will be shifted according to the programmed preset, as seen on the graph.



TILTIX MEMS DYNAMIC AKS-3 INCLINOMETER WITH J1939 INTERFACE C903

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