POSITAL

TILTIX MEMS AKS INCLINOMETER
WITH J1939 INTERFACE

SAE J1939

User Manual

POSITAL

TILTIX MEMS AKS INCLINOMETER
WITH J1939 INTERFACE

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TILTIX MEMS AKS INCLINOMETER
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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.

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

2020-11-12 – LED definition added

20200605 - Corrected Identifier for "Configuration Write"

2020-04-16 – Section 10.0 corrected according to priority change

2020-01-03 priority changed from 6 to 3 in the software; PGN priority and Identifier were updated accordingly

2.3 Imprint

FRABA B.V.
Jan Campertstraat 5,
NL-6416 SG Heerlen
T +49 221-96213-0
info@fraba.com, www.fraba.com

2.4 Copyright

2.5 User Annotation

All readers are highly welcome to send us feedback and comments about this document.
Depending on your region you can reach us by e-mail at the following e-mail addresses. For America info@posital.com, for Asia info@fraba.sg, for Europe info@posital.eu.

2.6 Document History

Document	TILTIX-AKS-J1939
Created	20190211
Author	TSC
Reviewers	
Versions	First Release – 20190211

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 Inclinomter

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 housing, and three measurement configuration variants. The single axis measurement variant with a range of 360°, a dual axis measurement capable TILTIX model with a range of ±90° and a dual axis version with pitch ±85° and roll ±180° 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 alrogithm 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

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

4.1 Programmable Parameters

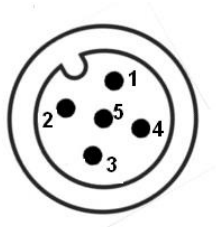
Node-ID	In the network, each device has a Node-ID that is used to address the device in the network and to define its priority
Baudrate	Baudrate can be programmed to 125 KBaud, 250 KBaud or 500 KBaud
Preset Value	The Preset value is the desired position value, which should be reached at a certain physical position of the axis. The position value is set to the desired process value by the preset parameter.
Termination Resistor	120 Ohm Termination Resistor can be activated via software (deactivated by default).
Direction	Counting direction can be changed
Cycle Time	The cycle time can be set

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.

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 ¼ for the best possible and secure mounting.

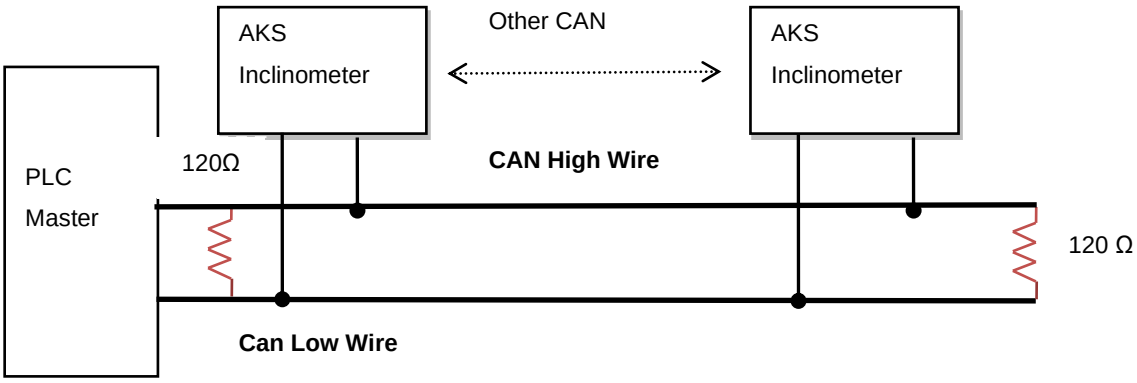
Use all four screws for mounting but restrict the tightening torque in the range of 1.5 – 2.5 Nm for the screws. The M12 connectors are to be perfectly aligned and screwed till the end with a tightening torque in the range of 0.4 – 0.6 Nm. Use all four screws for mounting and also note to use the same 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:



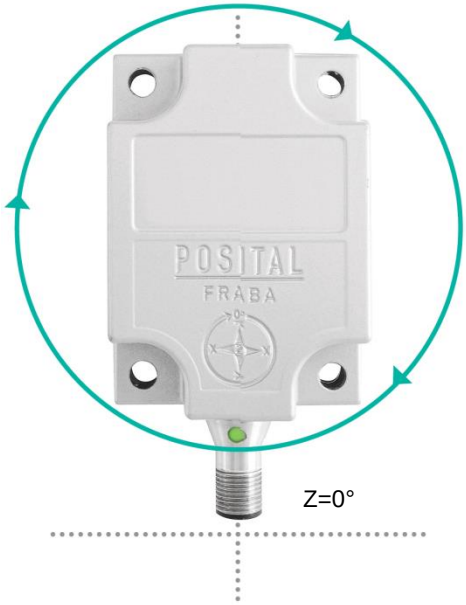
5.5 Measurement Axes

TILTIX AKS-090-2 – Dual Axis Inclinometer

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

TILTIX AKS-360-1 – Single Axis Inclinometer

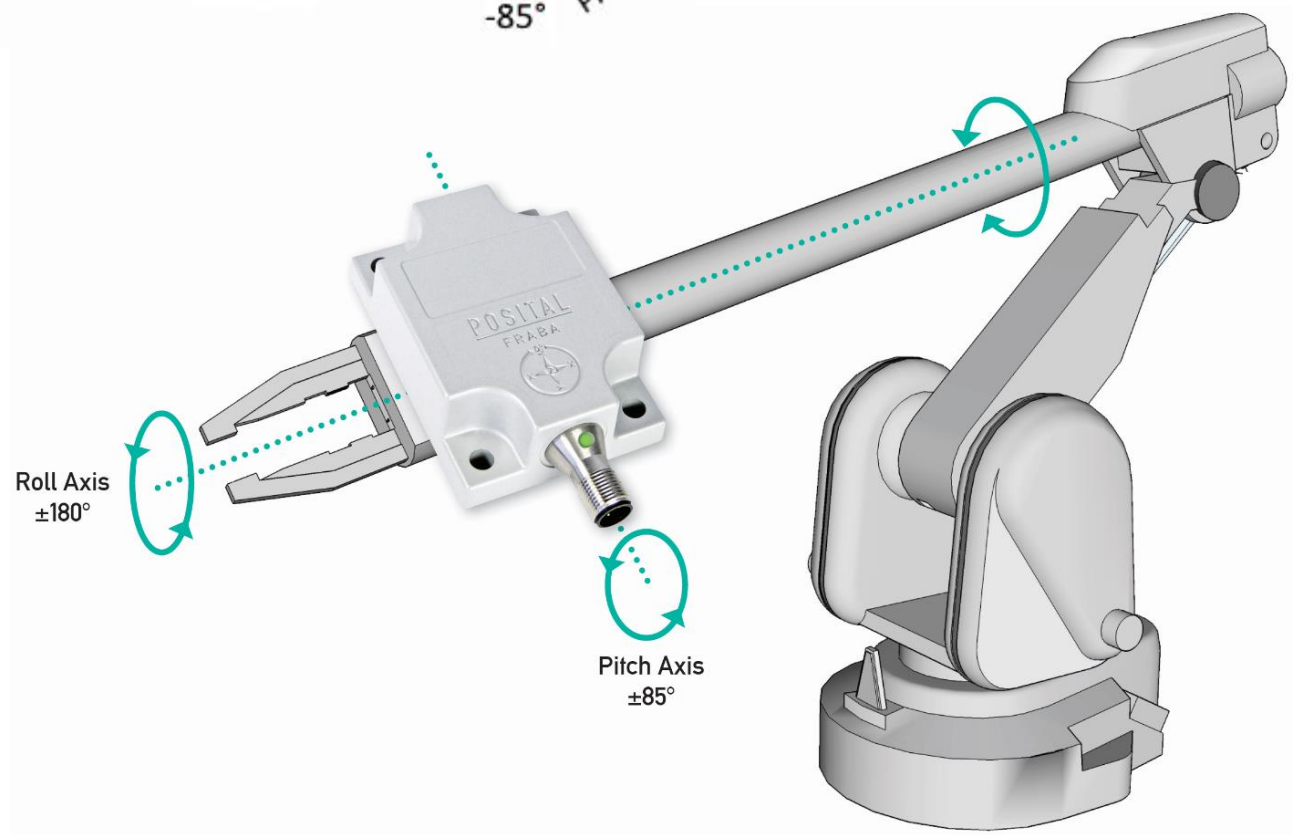
The sensor is mounted vertically. A clockwise rotation increases the angle value from 0°-360°. When the male connector is pointing downwards, the output is 0°.



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

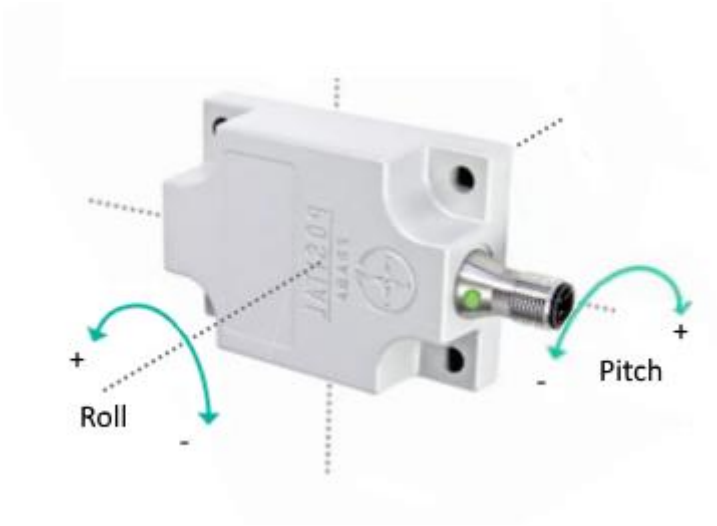
The Pitch axis monitors the position angle in space, while the Roll axis shows the rotation with respect to the pitch angle.
In case of a robot arm (graphic below), the pitch axis monitors the position angle in space and the roll axis measures the rotation of the robot head around the arm (just like a Singleturn encoder).

The Pitch and Roll version is very usefull for any machine where a part of the application is rotating around another segment.
The Pitch axis is limited to ± 85°, while the Roll axis is limited to ± 180°.



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.



5.6 LED Definition

Status LED (Dual colored) **Green / Red LED**	**Meaning**
Green off	No power supply
Green on	Normal operation mode
Red off	Normal operation mode
Red single flash	At least one of the error counters of the CAN controller has reached or exceeded the warning level (too many error frames)
Red blinking	General configuration error (e.g. wrong baud rate)
Red on	The can controller is in state bus off. No communication is possible anymore. Too many error frames in the network.

Since a dual color LED is used, only the red LED is shown in cases where both green and red LED would light up.

6.0 Default PGNs

The AKS sensor transmits 2 PGNs by default according to the table below. It is possible to only transmit 1 PGN or choose a different PGN. This needs to be configured during production and is not configurable by the end customer. Please get in contact with Posital before ordering to discuss the details.

AKS Version	1st PGN	2nd PGN
AKS-090-2-C901	65280	65281
AKS-360-1-C901	65282	65281
AKS-180-E-C901	65280	65281
AKS-180-F-C901	65280	65281

7.0 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)

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 repition 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)

8.0 Configuration Write Parameter

Identifier	CAN data	Meaning	Data type
0x0CEFC0xx	01 **00** xx xx xx xx xx xx	Index 0x01: Direction pitch/x-angle (0: SAE J670, 1: opposite direction)	UINT8
0x0CEFC0xx	02 **00** xx xx xx xx xx xx	Index 0x02: Direction roll/y-angle (0: SAE J670, 1: opposite direction)	UINT8
0x0CEFC0xx	03 xx xx xx xx xx xx xx	Index 0x03: Resolution pitch/x-angle (default: 100)	UINT8
0x0CEFC0xx	04 xx xx xx xx xx xx xx	Index 0x04: Resolution roll/y-angle (default: 100)	UINT8
0x0CEFC0xx	05 **0A** 00 xx xx xx xx xx	Index 0x05: Cycle time 1st PGN (1ms/count, default: 10)	UINT16
0x0CEFC0xx	06 **0A** 00 xx xx xx xx xx	Index 0x06: Cycle time 2nd PGN (1ms/count, default: 10)	UINT16
0x0CEFC0xx	07 **C0** xx xx xx xx xx xx	Index 0x07: Address (0-253 allowed, default: C0 h; 192d)	UINT8
0x0CEFC0xx	08 **04** xx xx xx xx xx xx	Index 0x08: Baudrate (default: 04: 250kBaud)	UINT8
0x0CEFC0xx	09 **00** xx xx xx xx xx xx	Index 0x09: Fast Bootup Enable (0: Disabled, 1: Enabled; default: 0)	UINT8
0x0CEFC0xx	0A **00 00 00 00** xx xx xx	Index 0x0A: Preset pitch/x-angle	INT32
0x0CEFC0xx	0B **00 00 00 00** xx xx xx	Index 0x0B: Preset roll/y-angle	INT32
0x0CEFC0xx	0E **00** xx xx xx xx xx xx	Index 0x0E: Termination resistor (0: off, 1: on; default: 0)	UINT8
0x0CEFC0xx	FA 73 61 76 65 xx xx xx	Index 0xFA: Save all parameter with reset (non-volatile)	UINT32
0x0CEFC0xx	FC 6C 6F 61 64 xx xx xx	Index 0xFC: Restore all parameter to factory default with reset	UINT32

xx: source/destination address

Resolution pitch/x-angle and roll/y-angle
The resolution changes the resolution of the related angle

Value	Resolution
1	1°
10	0.1°
100	0.01°

Cycle time
An unsigned 16-bit integer value (0-65535) can be programmed that sets the cycle time in ms. If two PGNs are used, the cycle times can be programmed for 1st and 2nd PGN individually. The default cycle time is 10 ms.

Baudrate
The Baud rate can be changed by writing the following values:

Value	Baudrate
3	125 kBaud
4 (default)	250 kBaud (default)
5	500 kBaud

Preset pitch/x-angle and roll/y-angle
Writing this parameter sets the current position of the sensor to the desired value.
Limitation for PGN 61481: In order to not exceed the pitch/roll 24 bit data value and to prevent any roll-over effects, the preset value needs to follow the following limitation:

|Preset Value – Physical Value| ≤ 155°

This equation is checked automatically when the preset is programmed and if the equation is violated, the preset will not be set.

Fast Bootup Enable
This write parameter changes the time duration from the moment power is applied until position data is send via the communication interface. After applying power, it takes ~1200 ms until the sensor outputs position data (blue graph of figure 1). For some applications it is important, that the sensor sends the data earlier. By setting the fast bootup enable parameter to 1, the fast bootup can be enabled. When this is done, the sensor transmits position data after 600 ms, but the position data for the following 600 ms are affected by an error. The red graph of figure 1 visualizes this behaviour.

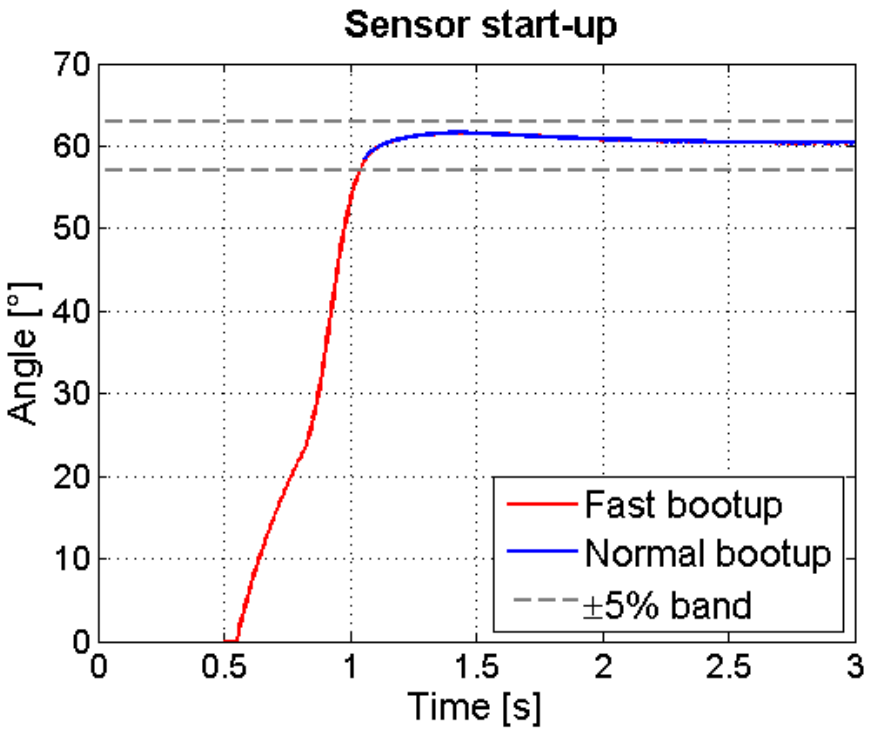


Figure 1 Start-up behaviour after applying power

9.0 Configuration Read Parameter

Direction	Identifier	CAN data	Meaning	Data type
Request	0x0CEAC0xx	00 EF 00	Read request	-
Response	0x0CEFxxC0	01 00 FF FF FF FF FF FF	Index 0x01: Direction pitch/x-angle (default: 0)	UINT8
Request	0x0CEAC0xx	00 EF 00	Read request	-
Response	0x0CEFxxC0	02 00 FF FF FF FF FF FF	Index 0x02: Direction roll/y-angle (default: 0)	UINT8
Request	0x0CEAC0xx	00 EF 00	Read request	-
Response	0x0CEFxxC0	03 00 80 FF FF FF FF FF	Index 0x03: Resolution pitch/x-angle	UINT16
Request	0x0CEAC0xx	00 EF 00	Read request	-
Response	0x0CEFxxC0	04 00 80 FF FF FF FF FF	Index 0x04: Resolution roll/y-angle	UINT16
Request	0x0CEAC0xx	00 EF 00	Read request	-
Response	0x0CEFxxC0	05 0A 00 FF FF FF FF FF	Index 0x05: Cycle time 1st PGN in ms (default: 10ms)	UINT16
Request	0x0CEAC0xx	00 EF 00	Read request	-
Response	0x0CEFxxC0	06 0A 00 FF FF FF FF FF	Index 0x06: Cycle time 2nd PGN in ms (default: 10ms)	UINT16
Request	0x0CEAC0xx	00 EF 00	Read request	-
Response	0x0CEFxxC0	07 C0 FF FF FF FF FF FF	Index 0x07: Address	UINT8
Request	0x0CEAC0xx	00 EF 00	Read request	-
Response	0x0CEFxxC0	08 04 FF FF FF FF FF FF	Index 0x08: Baud rate	UINT8
Request	0x0CEAC0xx	00 EF 00	Read request	-
Response	0x0CEFxxC0	09 00 FF FF FF FF FF FF	Index 0x09: Fast Bootup Enable	UINT8
Request	0x0CEAC0xx	00 EF 00	Read request	-
Response	0x0CEFxxC0	0A 00 00 00 00 FF FF FF	Index 0x0A: Preset pitch/x-angle	INT32
Request	0x0CEAC0xx	00 EF 00	Read request	-
Response	0x0CEFxxC0	0B 00 00 00 00 FF FF FF	Index 0x0B: Preset roll/y-angle	INT32
Request	0x0CEAC0xx	00 EF 00	Read request	-
Response	0x0CEFxxC0	0C 00 00 00 00 FF FF FF	Index 0x0C: Offset pitch/x-angle	INT32
Request	0x0CEAC0xx	00 EF 00	Read request	-
Response	0x0CEFxxC0	0D 00 00 00 00 FF FF FF	Index 0x0D: Offset roll/ys-angle	INT32
Request	0x0CEAC0xx	00 EF 00	Read request	-
Response	0x0CEFxxC0	0E 00 FF FF FF FF FF FF	Index 0x0E: Termination resistor	UINT8
Request	0x0CEAC0xx	00 EF 00	Read request	
Response	0x0CEFxxC0	0F 01 FF FF FF FF FF FF	Index 0x0F: Angle Mode	UINT8
Request	0x0CEAC0xx	00 EF 00	Read request	
Response	0x0CEFxxC0	10 31 2E 32 31 FF FF FF	Index 0x10: Software Version (version 1.21)	5 bytes (ASCII)
Request	0x0CEAC0xx	00 EF 00	Read request	

Direction	Identifier	CAN data	Meaning	Data type
Response	0x0CEFxxC0	11 50 4F 53 31 30 37 FF	Index 0x11: Hardware Version (default: "POS107")	6 bytes (ASCII)
Request	0x0CEAC0xx	00 EF 00	Read request	
Response	0x0CEFxxC0	12 FF FF FF FF FF FF FF	Index 0x12: Serial Number	UINT32
Request	0x0CEAC0xx	00 EF 00	Read request	
Response	0x0CEFxxC0	13 32 53 4B 41 FF FF FF	Index 0x13: Product Code (default: "AKS1/AKS2/AKSE/AKSF")	UINT32
Request	0x0CEAC0xx	00 EF 00	Read request	
Response	0x0CEFxxC0	14 41 4B 53 FF FF FF FF	Index 0x14: Device Name (default: "AKS")	3 bytes (ASCII)

xx: source/destination address

Angle Mode:

Value	Mode
1	AKS-180-E
2	AKS-090-2
3	AKS-360-1
4	AKS-180-F

Product Code:

Product	Value (in hex)	Value (in ASCII)
AKS-180-E	AKSE	414b5345
AKS-090-2	AKS2	414b5332
AKS-360-1	AKS1	414b5331
AKS-180-F	AKSF	414b5346

10.0 Example to Change Address of Device

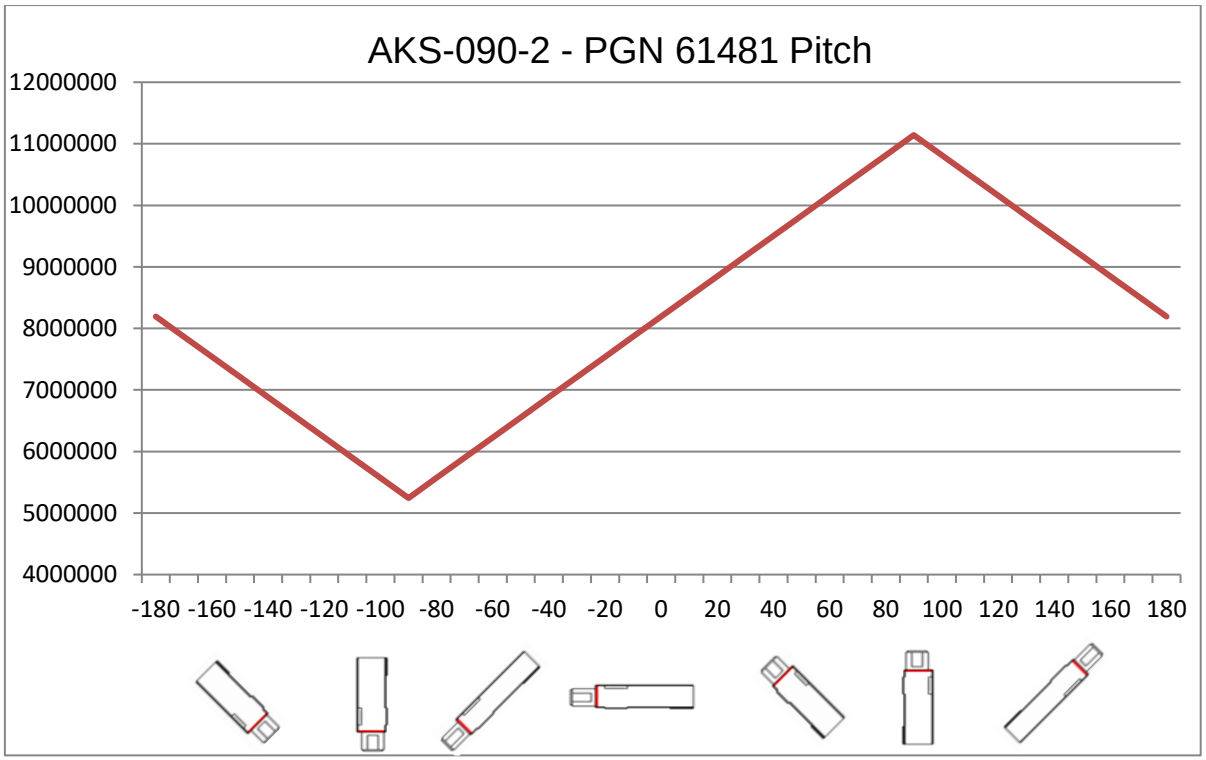
Original Address: 0xC0 (192d)
New Address: 0xC1 (193d)

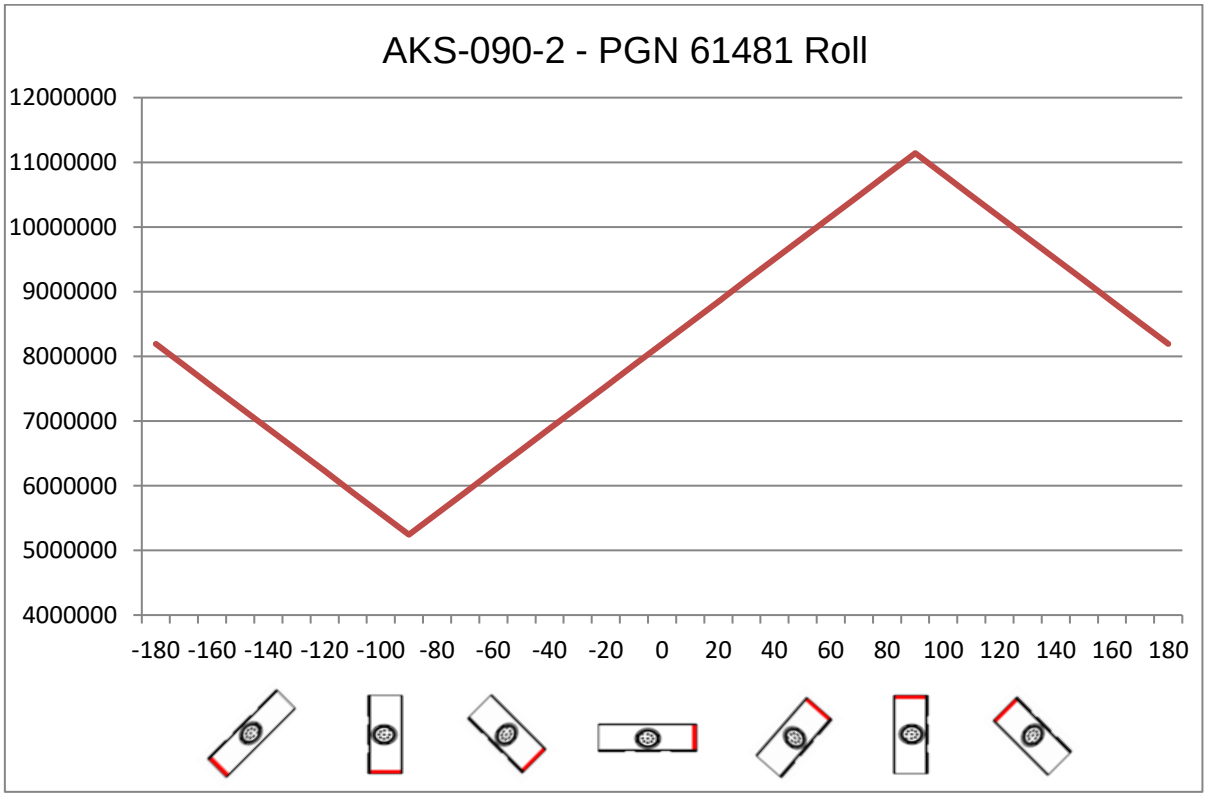
Identifier	DLC	Data
0x0CEFC0xx	8	07 C1 00 00 00 00 00 00
0x0CEFC0xx	8	FA 73 61 76 65 xx xx xx

Row1: Here we set the address to C1 (see table 7.0 Configuration Write Parameter for details). Hint: The Address will be changed after store and reset
Row2: Set the store and reset command

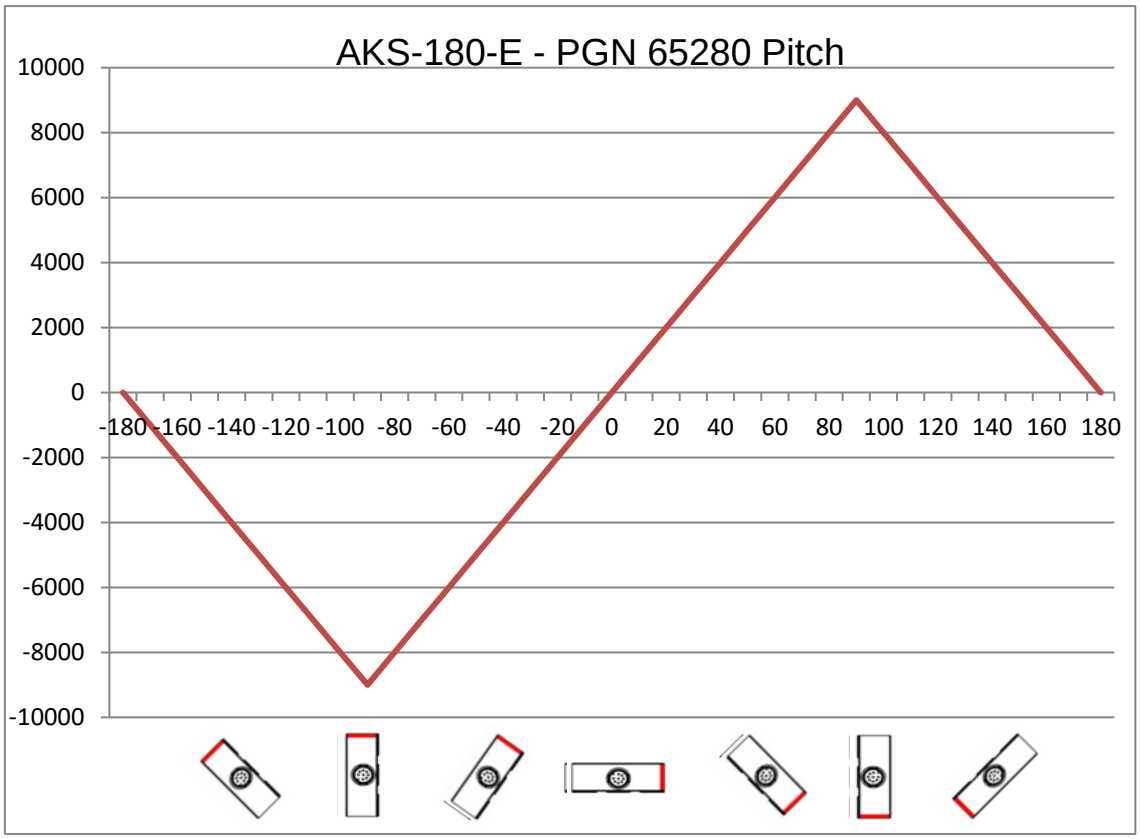
11.0 Output Graphs

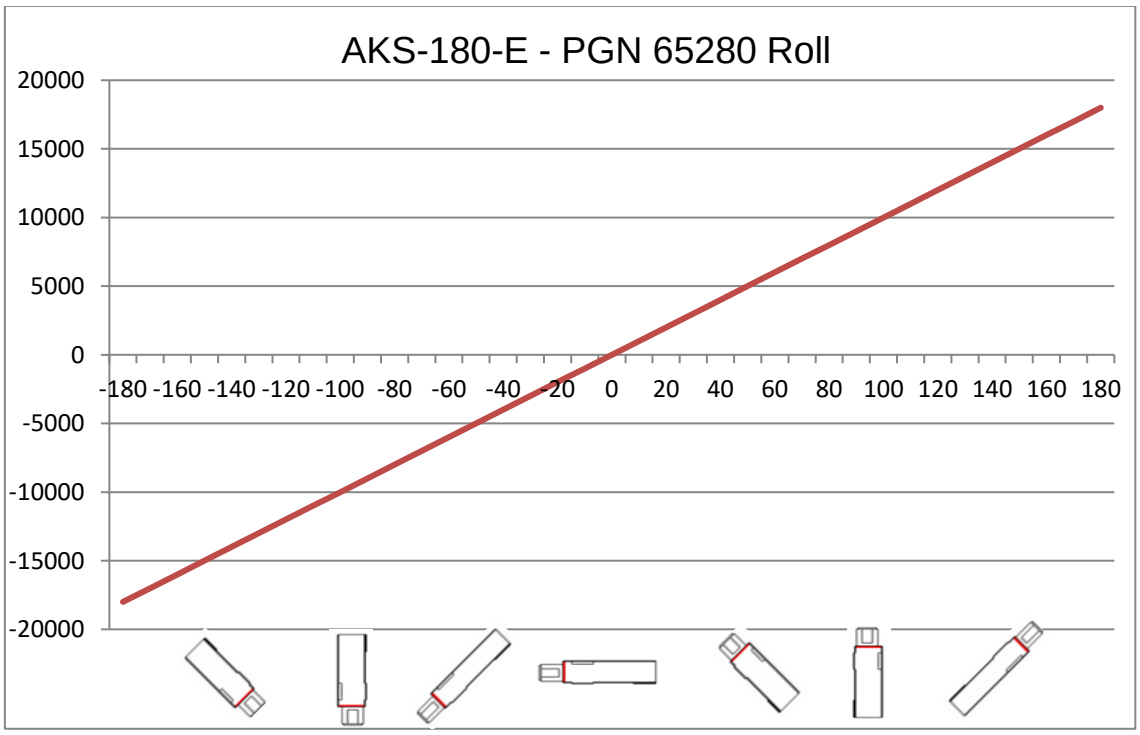
9.1 AKS-090-2: J1939 Output Values



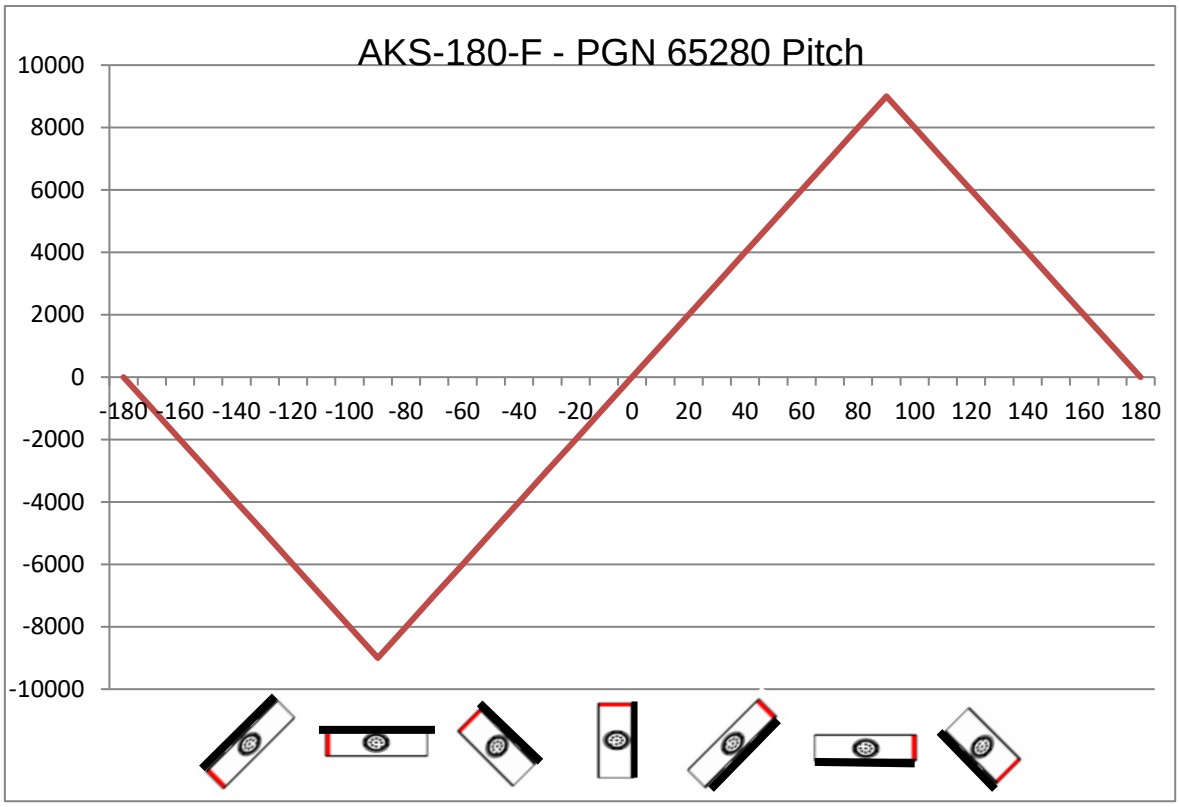


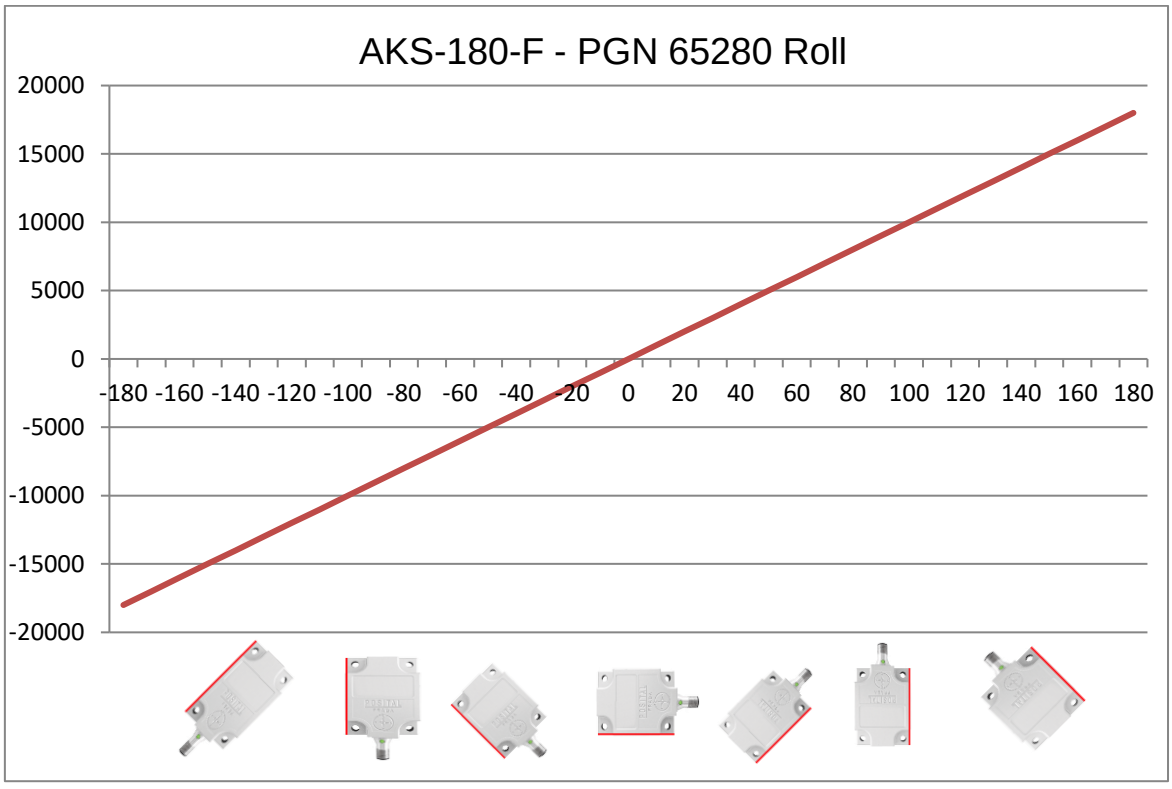
9.2 AKS-180-E: Output Values





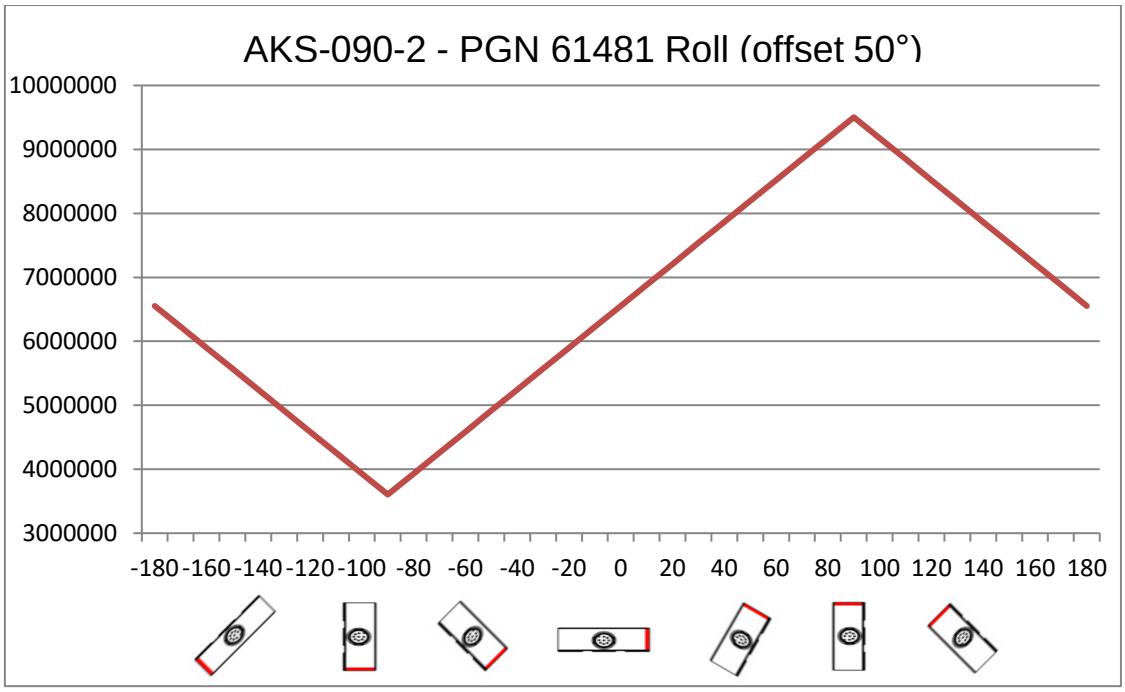
9.3 AKS-180-F: Output Values

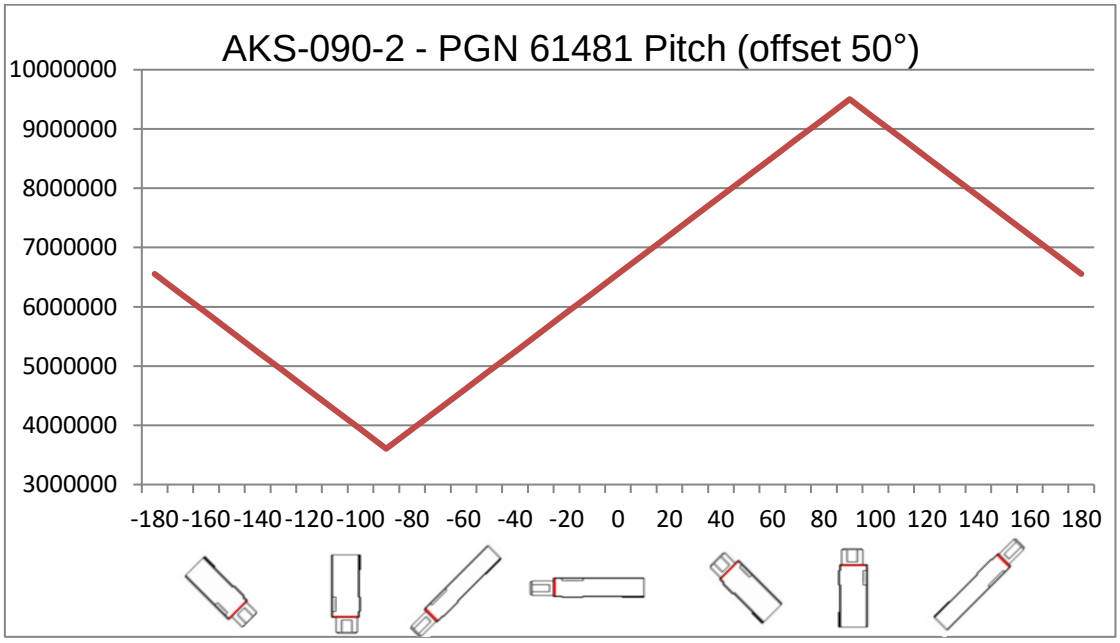




1.1.2 Appendix D: Output Graphs with Preset and Offset

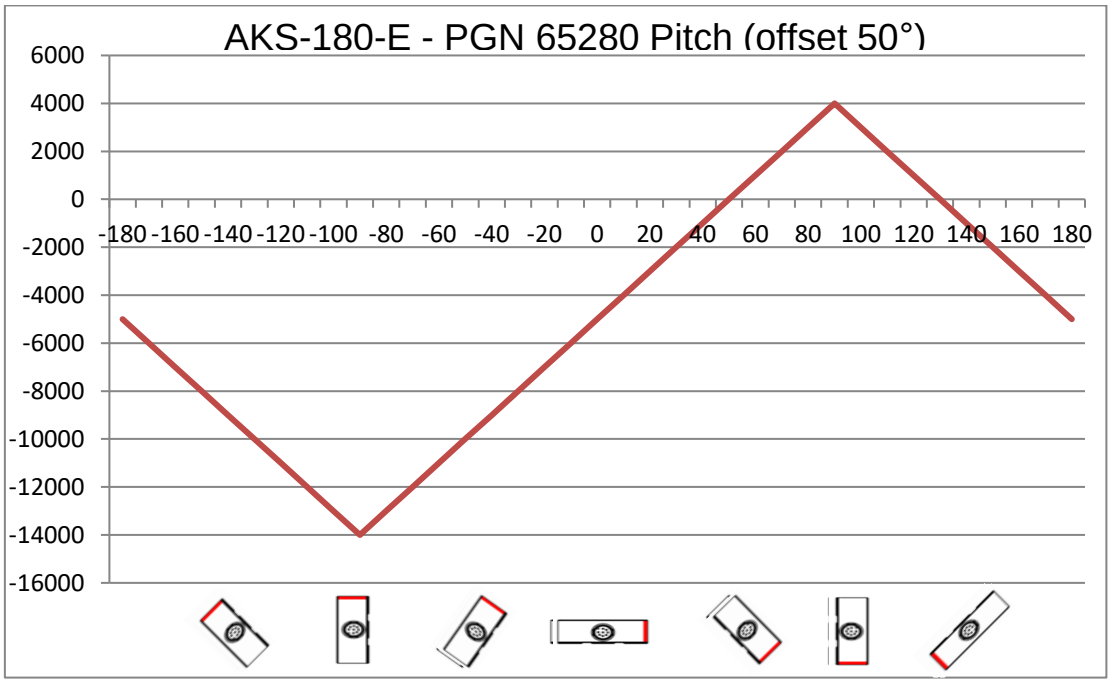
1.2 AKS-090-2 with programmed pitch and roll offset of 50°

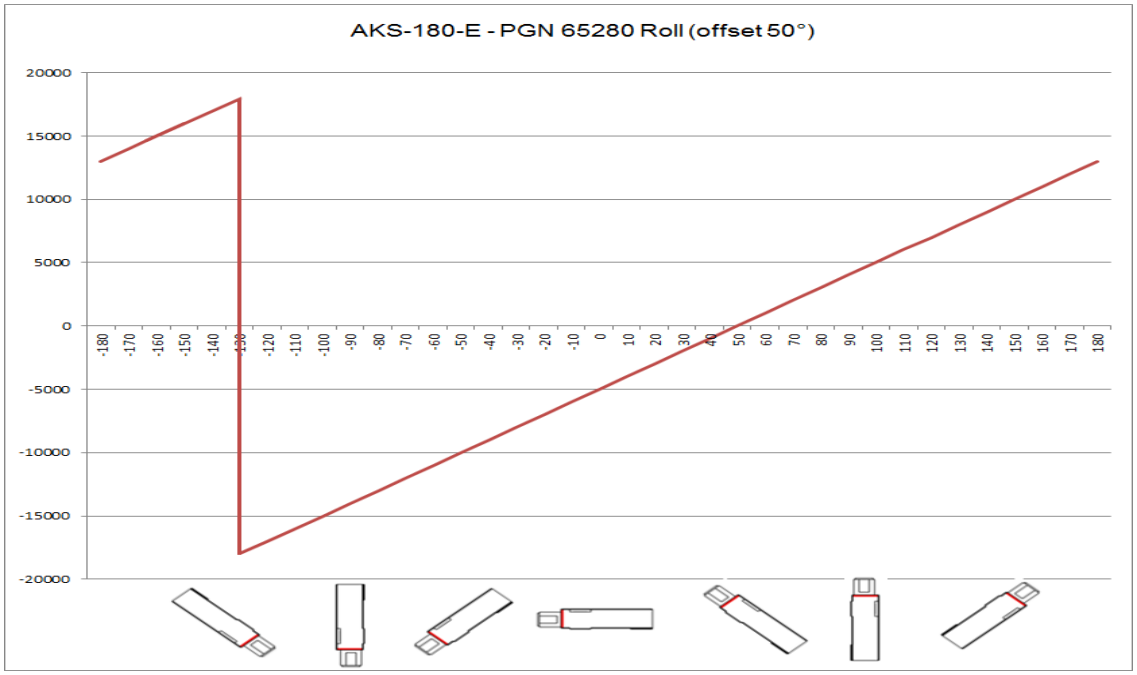




Hint: The turning point where the graph switches from positive to negative slope stay at the physical position of +/- 90°.

13.2 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.

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