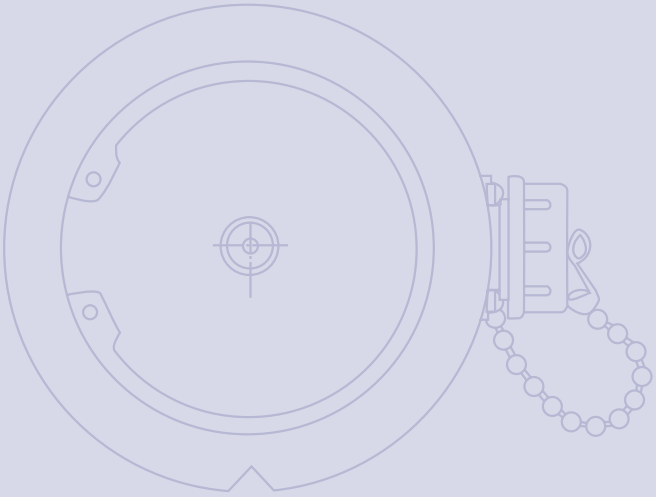
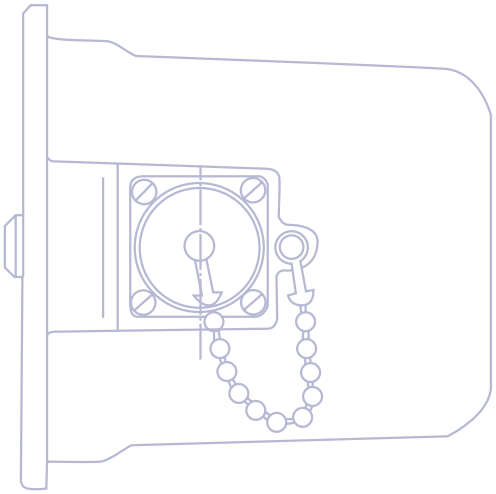
SAUER DANFOSS

MCX104-CAN Slope Sensor

Technical Information

E1™ COMPLIANT





Revision History

Table of Revisions

Date	Page	Changed	Rev
02 Dec, 2010		Initial Release	AA

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Product Overview

MCX104-CAN Slope Sensor

The *MCX104-CAN Slope Sensor* is designed for use as a component in mobile machine control systems that require a measurement of deviation from a gravity reference.

The *Sensor* electromagnetically measures its rotational displacement (deviation) and its mount from a gravity reference. The reference is an oil-damped pendulous mass having freedom of movement in one plane about a fixed center point. Nominal sensor range is +/- 10% slope from reference. The *Sensor's* output information is broadcast over a Controller Area Network (CAN) using Sauer-Danfoss proprietary and J1939 message protocols.

User Liability and Safety Statements

OEM Responsibility

The OEM of a machine or vehicle in which PLUS+1 electronic controls are installed has the full responsibility for all consequences that might occur. Sauer-Danfoss has no responsibility for any consequences, direct or indirect, caused by failures or malfunctions.

- The *Sensor* is not intended to be used as a stand-alone safety device in safety critical applications.
- Sauer-Danfoss has no responsibility for any accidents caused by incorrectly mounted or maintained equipment.
- Sauer-Danfoss does not assume any responsibility for PLUS+1 products being incorrectly applied or the system being programmed in a manner that jeopardizes safety.
- All safety critical systems shall include an emergency stop to switch off the main supply voltage for the outputs of the electronic control system. All safety critical components shall be installed in such a way that the main supply voltage can be switched off at any time. The emergency stop must be easily accessible to the operator.

Feature and Options

- Measures slope and angle
- Field proven measurement technology
- Compact design
- Rugged housing suitable for installation in harsh environments
- IP 67
- Excellent sensitivity
- Oil-damped to minimize vibration: 2 oil viscosities available
- PLUS+1 Compliant

Theory of Operation

The *Sensor* is designed to measure rotational deviation with respect to gravity. The gravity reference for the device is a pendulous mass having freedom of movement in one plane. The deviation with respect to gravity is measured using a Rotational Variable Differential Transformer (RVDT). The rotor of the 4-pole RVDT is rigidly attached to the pendulum shaft. The stator of the RVDT which is attached to the MCX014-CAN housing consists of 4 transformer coils mounted 90° apart on the pole faces of a magnetically permeable frame. Secondaries of the coils are 180° apart and are wired in series.

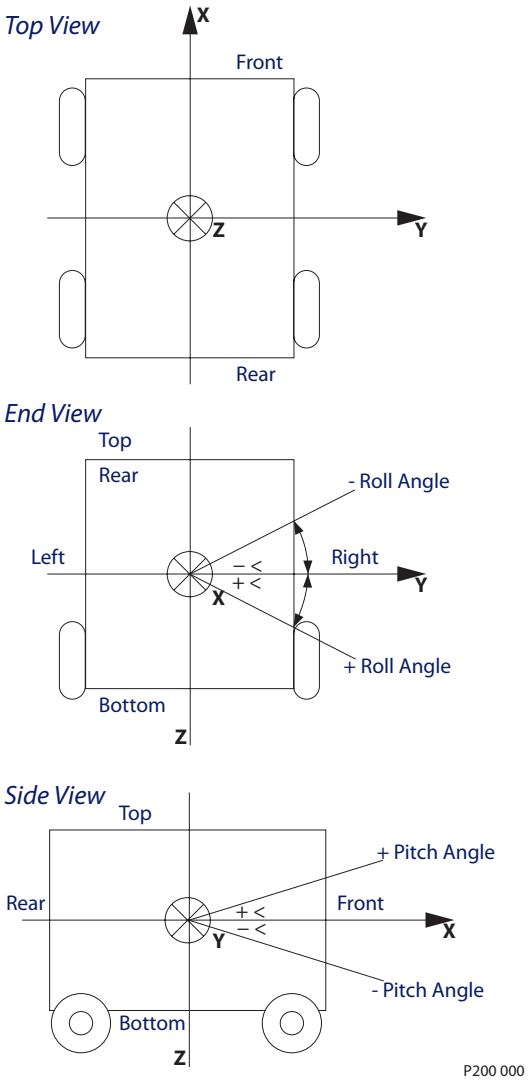
The primaries of the stator are excited with a small sinusoidal DC voltage. The position of the rotor with respect to the stator determines the number of flux linkages between the primary and secondary of each coil. This, in turn, determines the amount of voltage induced in each secondary. As the *Sensor* rotates, the voltage induced in one secondary will increase while the other will decrease. The difference between secondary voltages determines the magnitude and direction of rotation. An onboard microcontroller converts rotational information into CAN bus messages. The following rotational information is available:

- Slope angle in degrees
- Slope angle in percent
- Long slope (pitch angle)
- Cross slope (roll angle)

Theory of Operation (continued)

The images below define roll angle and pitch angle. Slope angle is defined as rise divided by run.

Vehicle Roll Angle and Pitch Angle Definitions



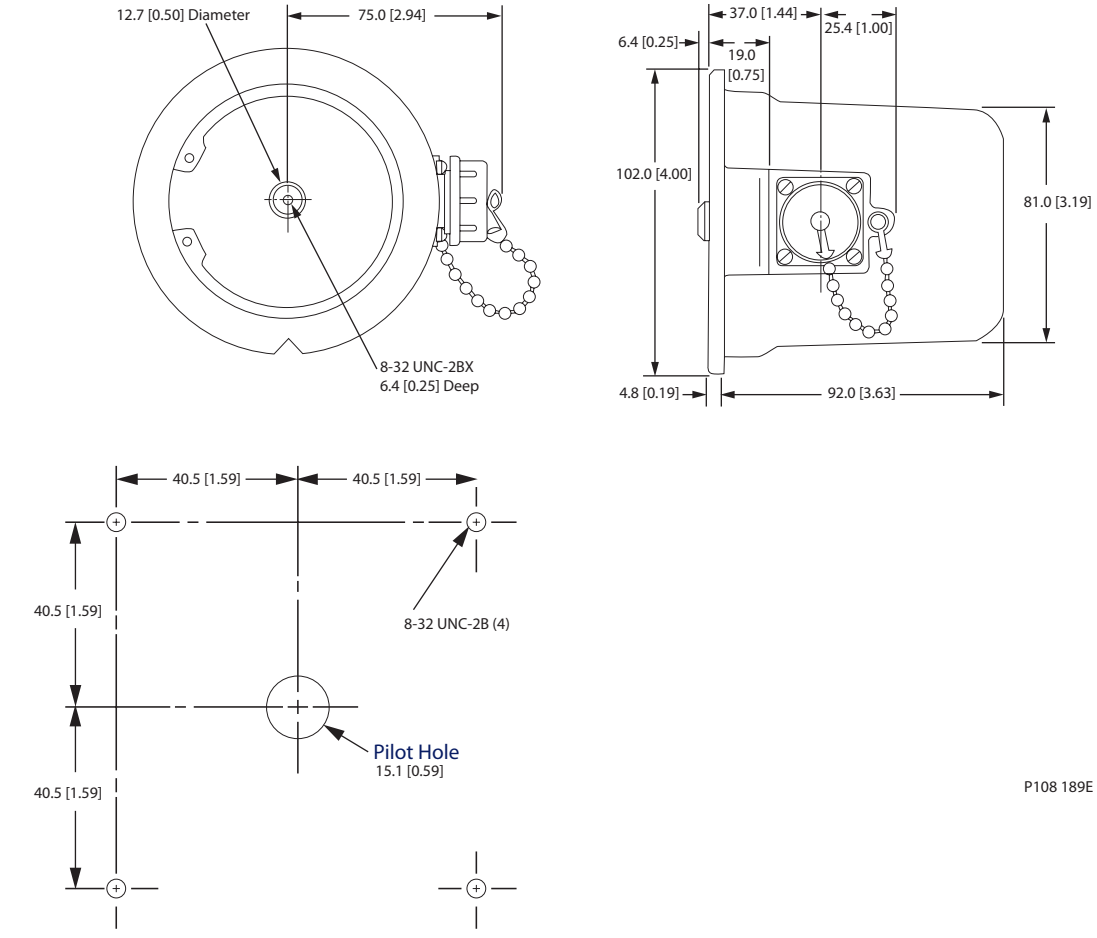
Ordering Information

Product Ordering Information

Product	Sauer-Danfoss part number
MCX104-CAN, 1000 cs oil fill	11072648
MCX104-CAN, 3000 cs oil fill	11072647
Amphenol Right Angle Mating Connector Kit	K33083
Amphenol Straight Mating Connector Kit	K33162
PLUS+1 Service Tool	10101745

Dimensions and Mounting

Millimeters [Inches]



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Mechanical Installation

The *Sensor* can be installed on any convenient vertical surface. Drill and tap four 8-32 UNC-2B holes in the locations shown in the *Dimensions and Mounting* drawing, above. Drill a 15.1 mm [0.59 in] pilot hole at the center of the four holes.

When the polarity indicator notch in the flange of the *Sensor* is at the bottom, the *Sensor* is approximately at null. If enough clearance exists above the *Sensor*, install the two bottom cleats, leaving the screws loose enough to lock the *Sensor's* flange beneath the cleat. The cleats and mounting screws are included with the *Sensor.* Slide the flange of the *Sensor* beneath these two cleats and install the other two. Tighten the four cleats so the *Sensor* is snug, but can still be turned by hand for final sloping

Rotational Polarity

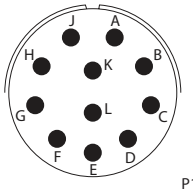
The indicated rotational direction of the *Sensor* (output) is defined by viewing the machined end with the polarity indicator notch pointing down and the connector located to the left. The axis of rotation is in a line that runs through the center of the alignment pin in the top of the device to the center of the bottom. Rotational polarity is positive when a counter-clockwise (CCW) rotation of the device results in a positive angle of rotation and a clockwise (CW) rotation results in a negative angle of rotation. Likewise, a negative rotational polarity will result in a CCW rotation having a negative angle of rotation and a CW rotation having a positive angle of rotation.

Connector Pin Assignments

Connector Pins

Pin	Function
A	Not used
B	Not used
C	CAN shield
D	CAN high
E	CAN low
F	Power (+)
G	Configuration input 1
H	Configuration input 2
J	Configuration input 3
K	Ground (-)
L	Configuration input 0

11 Pin Amphenol® MIL-C-26482 Connector



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Recommended Wiring Practices

- Protect all wires from mechanical abuse
- Use 85°C (185°F) wire with abrasion resistant insulation
- Use a wire gage that is appropriate for the *Sensor's* mating connector—18 to 22 AWG
- Separate high current wires such as feeds to solenoids, lights, alternators, or fuel pumps from CAN wires. Recommended minimum separation is 300mm (11.8 in)
- Run wires along the inside or close to metal machine frame surfaces were possible. This simulates a shield which minimizes the effects of EMI/RFI interference
- Do not run wires near sharp metal corners. Run wires through grommets when rounding a corner
- Provide stain relief for all wires
- Use wire harness anchors that will allow wires to float with respect to the machine frame rather than rigid anchors
- Avoid running wires near moving or vibrating components
- Avoid long, unsupported wire spans
- Twist CAN wires about one turn every 100 mm (3.94in)
- The *Sensor* should be grounded to a dedicated ground wire of sufficient size that is connected to the battery (-)

The *Sensor's* software parameters may be configured in one of two ways: Configuration through the use of the *Sensor's* four configuration pins or configuration through the use of the Sauer-Danfoss PLUS+1 Service Tool.

Using the Sensor's Configuration Input Pins

The *Sensor* has four configuration pins, each capable of detecting up to 32 distinct Configuration States. Each configuration pin can be connected directly to ground (State 0), left floating (State 31) or connected to ground through 1 of 30 different resistor values (States 1 through 30).

Resistance Values for Each Configuration State:

State	Resistance (Ω)	State	Resistance (Ω)
0	0	16	2430
1	77	17	2760
2	160	18	3140
3	249	19	3583
4	341	20	4104
5	441	21	4725
6	560	22	5480
7	670	23	6414
8	800	24	7602
9	940	25	9160
10	1100	26	11310
11	1260	27	14440
12	1445	28	19440
13	1650	29	28670
14	1890	30	51500
15	2140	31	open

The Configuration States are checked by the *Sensor's* microprocessor each time the *Sensor* is powered up. In order to change any configuration parameters via the configuration pins, the *Sensor* must be powered up with the configuration input in the desired Configuration State. Any changes made to the Configuration States while the *Sensor* is powered are ignored.

If, on power up, the parameters configured by the Configuration State differ from the parameters currently stored in the *Sensor*'s non-volatile (NV) memory, then the parameters in NV memory will be overwritten with the new parameters, as long as the selected Configuration State is allowed for the configuration parameter. The tables below define allowable Configuration States for each of the four configuration input pins.

Using the Sensor's Configuration Input Pins (continued)

Configuration Input Pin 0

—Designating the Sensor's Function and the Sensor's CAN bus Address

This configuration input pin sets the *Sensor's* function (cross slope/roll angle or long slope/pitch angle) and the *Sensor*'s CAN address.

The factory default parameter is state 0

The Sensor's Function and Source Address

State	Function	Address
0	Cross Slope/ Roll angle	0xA0
1		0xA1
2		0xA2
3		0xA3
4	Long Slope/ Pitch Angle	0xA4
5		0xA5
6		0xA6
7		0xA7
8		0xA8

Configuration Input Pin 1

—Designating the Sensor's CAN Message Protocol

This configuration input pin sets the CAN protocol broadcast by the *Sensor*.

The factory default parameter is State 1.

The Sensor's CAN Message Protocol

State	CAN Message Protocol
1	Sauer-Danfoss Proprietary
2	J1939

Using the Sensor's Configuration Input Pins (continued)

Configuration Input Pin 2

—Designating the Sensor's Signal Parameters

This configuration input pin sets the *Sensor's* rotational parameters and filter constants.

Signals from the *Sensor's* RVDT are sampled every 3ms and passed through a digital low-pass filter. The filter time constant is the filter constant times the sample rate (3ms). A larger filter constant provides a smoother sensor output but increases the response delay to a change in measured angle. A filter constant of 1 results in no filtering.

The factory default parameter is State 7.

The Sensor's CAN Message Protocol

State	Rotational polarity	Filter constant
0	Positive (CW-/CCW+)	1
1		2
2		4
3		8
4		16
5		32
6		64
7		128
8	Negative (CW+/CCW-)	1
9		2
10		4
11		8
12		16
13		32
14		64
15		128

Configuration Input Pin 3

—Designating the CAN bus data transfer rate

This configuration input pin sets the *Sensor's* CAN bus data transfer rate.

The factory default baud rate is State 29

The Sensor's CAN bus Data Rate

State	CAN bus data rate (Kbps)
30	125
29	250

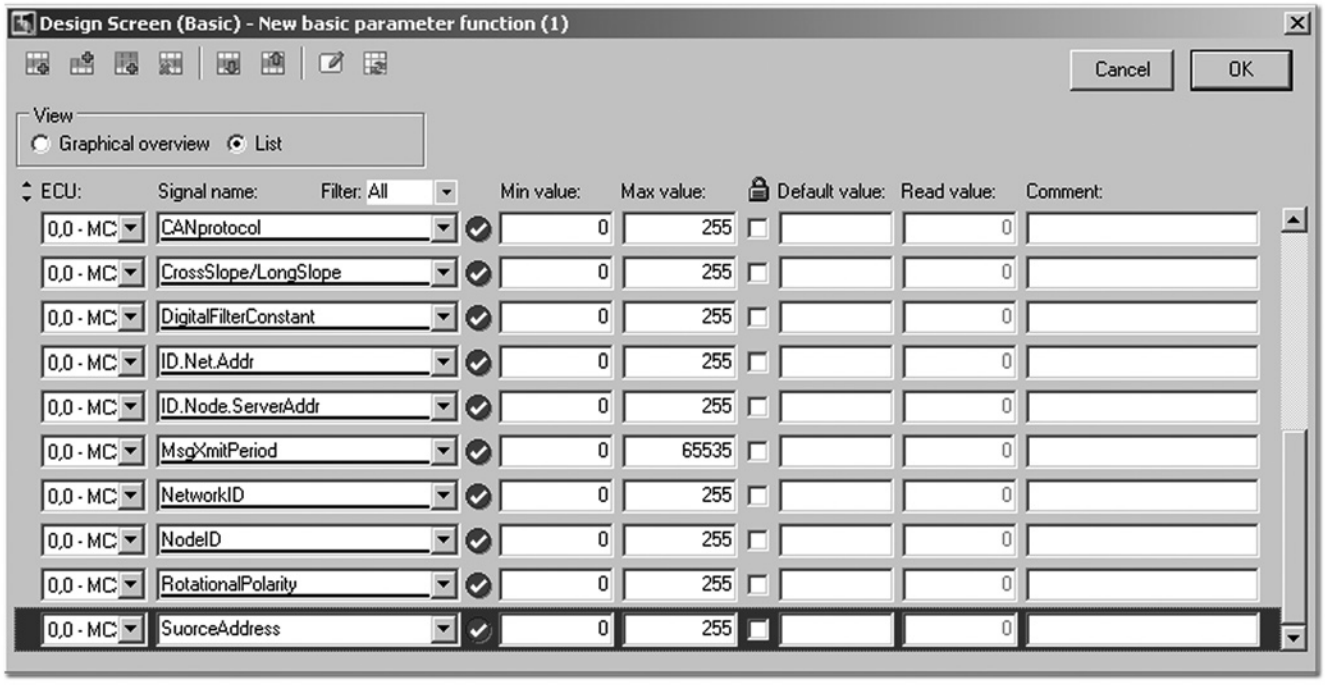
Using the PLUS+1 Service Tool

The *Sensor's* parameters can also be set-up using the PLUS+1 Service Tool.

When the Service Tool is used to set the *Sensor's* parameters in NV memory, each of the configuration pins must be in State 31 (open). As long as the configuration pins remain in State 31, there will be no change to parameters stored in NV memory each time the *Sensor* is powered up.

When the *Sensor* is connected to the PLUS+1 Service Tool, the parameters can be modified.

PLUS+1 Service Tool New Basic Parameter Function Screen



The table below defines the allowable values for each of the *Sensor's* parameters that can be modified using the PLUS+1 Service Tool.

Service Tool Parameter Allowable Values

Service Tool signal (sensor parameter)	Allowable values	Comments
CANbaudRate	30, 29	30 = 125K baud; 29 = 250K baud
CANprotocol	1, 2	1 = Sauer-Danfoss Proprietary; 2 = SAE J1939
CrossSlope/LongSlope	0, 1	0 = Cross slope; 1 = Long slope
DigitalFilterConstant	0 to 255	Time constant for digital filter
IDNetAddr	For Factory Use Only	
IDNodeServerAddr	For Factory Use Only	
MsgXmitPeriod	0 to 65535	Transmit rate in msec; 0 = Factory default
NetworkID	0 to 255	PLUS+1 Network ID
NodeID	0 to 255	PLUS+1 Node ID
RotationalPolarity	0, 1	0 = Negative; 1 = Positive
SourceAddress	0 to 255	For use in non-PLUS+1 Systems

The *Sensor* supports two Controller Area Network (CAN) protocols: Sauer-Danfoss Proprietary and J1939.

Either the state of configuration input pin 1 or the PLUS+1 Service Tool designates the CAN message protocol broadcast by the *Sensor*.

The CAN bus data rate is set by the state of configuration input pin 3 or the CAN bus data transfer rate set by the PLUS+1 Service Tool.

Sauer-Danfoss Proprietary Message Protocol

This protocol uses a 29-bit CAN message identifier that is compatible with the J1939 Proprietary-A PGN, allowing Sauer-Danfoss proprietary CAN messages to coexist with J1939 messages.

If the Sauer-Danfoss protocol is used on a CAN bus that is also broadcasting J1939 messages, the *Sensor* CAN bus data rate must be set at 250Kbps.

Message format:
The *Sensor's* source address: The Least Significant Bit (LSB) of the message identifier and is set by the state of configuration input pin 0 or through the use of the PLUS+1 Service Tool.

Identifier: 0x18EF2Exx (where xx is the source address designated by configuration input 0)

The *Sensor's* default message transmit rate: 15ms. The transmit rate can be changed using the PLUS+1 Service Tool

The *Sensor's* Data Messages: Four 16-bit proprietary messages are broadcast:

Rotational Angle (Data Bytes 0, 1)
Rotation angle is a 16- bit signed value where 7000 to 58000 counts correspond to a factory calibrated rotational angle of +/- 5.711°. The *Sensor* will broadcast a CAN message of OxFFFF if this range is exceeded.

Rotational Angle CAN Data Message Format

Byte#	1								0							
Bit#	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0

Percent Slope (Data Bytes 2, 3)—
Percent slope is a 16-bit signed value where 7000 to 58000 counts corresponds to a factory calibrated slope of +/- 10% of percent slope slope/bit). The *Sensor* electronics will broadcast a message of OxFFFF if this range is exceeded.

Percent Slope CAN Data Message Format

Byte#	3								2							
Bit#	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0

Sauer-Danfoss proprietary CAN messages three (data bytes 4, 5) and four (data bytes 6, 7) are for Sauer-Danfoss factory use only.

J1939 Message Protocol

The *Sensor* supports the SAE J1939 message protocol using a fixed addressing scheme. The source address is the LSB of the message identifier and is designated by the state of configuration input 0 or is set through the use of the PLUS+1 service tool.

SAE J1939 PGN 61459 defines the data portion of the *Sensor's* CAN message. The values in the pitch angle and roll angle message fields depend on the state of configuration input 0 or the parameters set using the PLUS+1 service tool. For States 0-3, the slope date is contained in the roll angle field and the pitch angle is set to 0. For States 4-7, the slope date is contained in the pitch angle field and the roll angle is set to 0. The generic J1939 CAN message data format for both data fields is 0.002 deg/bit with a -64 deg offset (e.g. 0 = -64 deg, 32000 = 0 degree, 65535 = 67.07 deg.). However, the measurement range of the *Sensor* limits the broadcast information to +/- 14.5% slope or +/- 7.5°. Any value outside of the *Sensor's* allowable measurement range will be broadcast as 0xFFFF

Message format:
Transmit rate: 10ms

Identifier: 0x0CF013xx (where xx is the source address set by configuration input 0)

Two data messages are broadcasted:

Pitch Angle/Cross Slope Data (Date bytes 0, 1)

The calibrated measurement range of the *Sensor* is +/- 5.711 degrees or +/- 10% slope. Any value outside of the *Sensor's* calibrated measurement range will be broadcast as 0xFFFF.

Pitch Angle/Cross Slope Data J1939 CAN Message Data Format:

Byte#	**1**								**0**							
Bit#	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0

Roll Angle/Cross Slope Data (Data Bytes 2, 3)

The calibrated measurement range of the *Sensor* is +/- 5.711 degrees or +/- 10% slope. Any value outside of the *Sensor's* calibrated measurement range will be broadcast as 0xFFFF.

Roll Angle/Cross Slope Data J1939 CAN Message Data Format

Byte#	**3**								**2**							
Bit#	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0

Data bytes 4,5,6,7 are not used.

Specifications

Mechanical Characteristics

Operational range, degrees	± 5.771°
Operational range, percent slope	± 10.51%
Accuracy, degrees	± 0.17°
Accuracy, percent slope	0.30%
Temperature drift, degrees	± 0.2° over operating range
Temperature drift, percent slope	0.35% over operating range
Repeatability (hysteresis)	
Degrees	0.023°
Percent slope	0.04%

Electrical Characteristics

Supply voltage	9 to 36 Vdc
Maximum current consumption	0.5 W at 9 Vdc; 10.0 W at 32 Vdc

Environmental Characteristics

Operating temperature range	0°C to 70°C (32°F to 158°F)
Storage temperature range	-40°C to 77°C (-40°F to 170°F)
Ingress Protection (IP) rating (with mating connector attached)	IP 67/ IEC 60529
EMI/RFI rating	ISO 13766/ EN 13309
Shock	50 G/ IEC 60068-2-27
Vibration	15.6 Grms/ IEC 60068-2-64

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Sauer-Danfoss is a global manufacturer and supplier of high-quality hydraulic and electronic components. We specialize in providing state-of-the-art technology and solutions that excel in the harsh operating conditions of the mobile off-highway market. Building on our extensive applications expertise, we work closely with our customers to ensure exceptional performance for a broad range of off-highway vehicles.

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