TLE4803
Datasheet

XENSIV™ inductive position sensors

RoHS

AEC Qualified

ISO 26262 compliant

Features

- Inductive based measurement principle
- Angle measurements from 2 internally processed angles
- Intrinsic stray field robust according to ISO 11452-8:2015
- ISO 26262:2018 Safety Element out of Context for safety requirements up to ASIL D
- SENT (based on SAE J2716-2016) and SPC interfaces
- PG-TSSOP-16 SMD package, Grade 0: -40°C to 150°C (ambient temperature)
- Overvoltage and reverse polarity protection
- Integrated memory for calibration & configuration
- RoHS compliant and halogen-free package

Potential applications

The TLE4803 is an inductive sensor IC designed for angular position sensing in the automotive field. Its target applications are linear position and steering angle sensor.

- Electric power steering (torque & angle steering sensor)
- Pedal sensing
- Chassis height
- Active suspension

Product validation

Product validation according to AEC-Q100, Grade 0. Qualified for automotive applications.

Description

The TLE4803 is an inductive sensor IC for angular position sensing in automotive applications. It uses the eddy current method to sense the position of a metallic target placed above a set of PCB printed coils. The TLE4803 includes a digital signal processing unit (DSP) for signal compensation, and angle calculation. The TLE4803 is offered as derivatives with SENT or SPC interface in order to enable for a broad variety of use case in a flexible way.

Product type	Package	Marking	Ordering code
TLE4803S16-S0000	PG-TSSOP-16	4803S	SP006068562
TLE4803C16-S0000	PG-TSSOP-16	4803C	SP006068564

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1 Block diagram

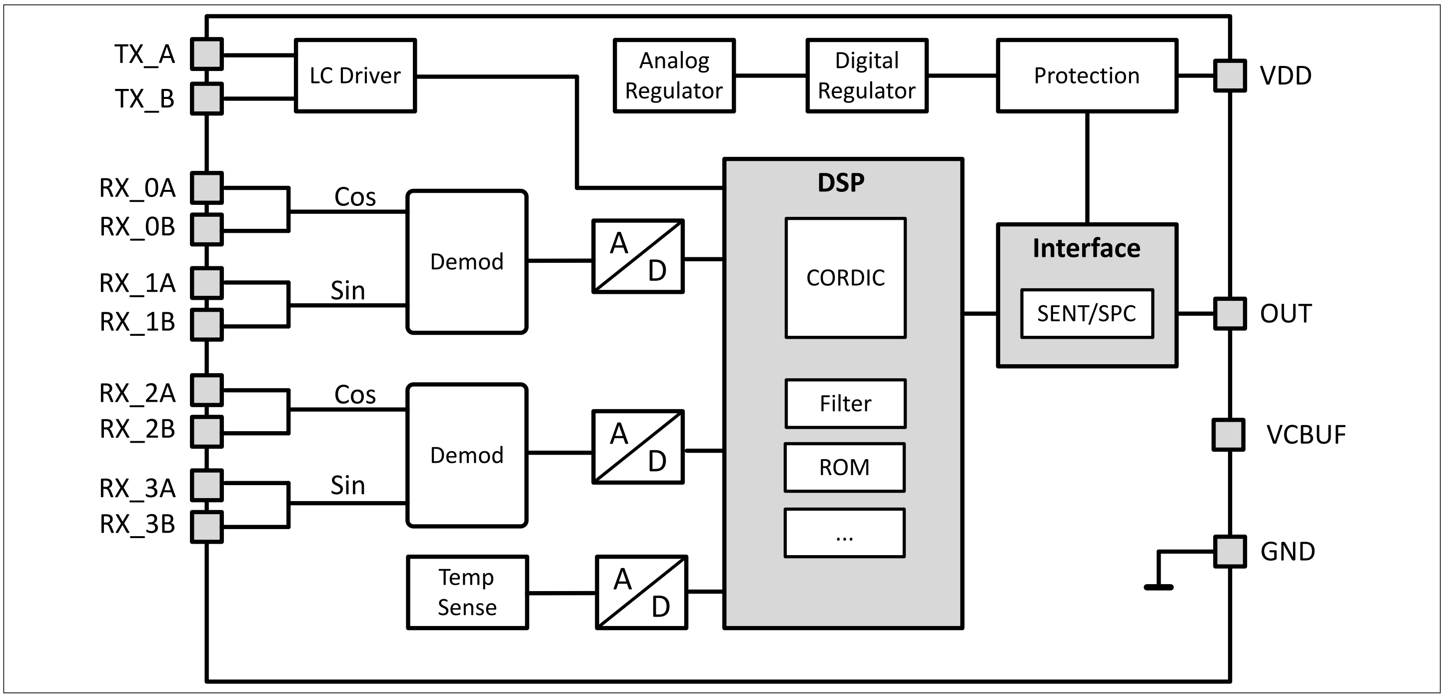


Figure 1 Functional block diagram

2 Pin configuration

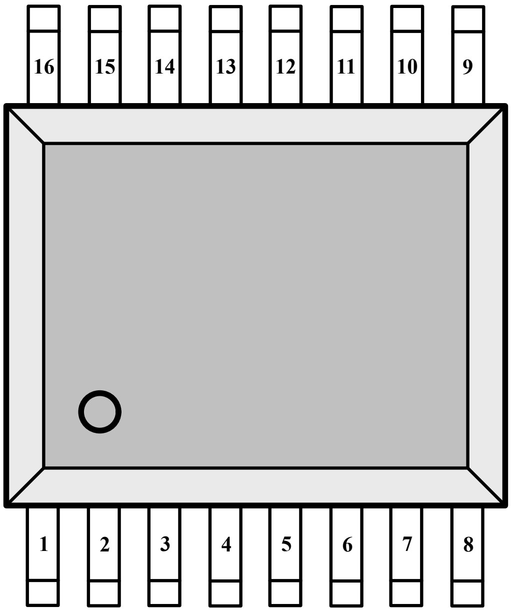


Figure 2 **Pin-out package**

Table 1 **Pin configuration**

PIN number	Symbol	Description
1	RX_0A	Receiver coil 0, pin A
2	RX_1A	Receiver coil 1, pin A
3	RX_0B	Receiver coil 0, pin B
4	RX_1B	Receiver coil 1, pin B
5	RX_2A	Receiver coil 2, pin A
6	RX_3A	Receiver coil 3, pin A
7	RX_2B	Receiver coil 2, pin B
8	RX_3B	Receiver coil 3, pin B
9	TX_A	Transmitter pin A, oscillator out
10	TST2	Test 2 out
11	TX_B	Transmitter pin B, oscillator out
12	VDD	Supply voltage
13	VCBUF	Buffer capacitor pin
14	OUT	SENT / SPC / SICI
15	TST1	Test 1 out
16	GND	Ground

3 General product characteristics

3.1 Absolute maximum ratings

Attention: ***Stresses above those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions above those indicated in the section "functional range" of this data sheet is not implied. Furthermore, only single error cases are assumed. More than one stress/error case may also damage the device. Exposure to absolute maximum rating conditions for extended periods may affect device reliability. During absolute maximum rating overload conditions the voltage on VDD pins with respect to ground (GND) must not exceed the values defined by the absolute maximum ratings. Lifetime statements are an anticipation based on an extrapolation of Infineon’s qualification test results. The actual lifetime of a component depends on its form of application and type of use etc. and may deviate from such statement. Lifetime statements shall in no event extend the agreed warranty period.***

Table 2 Absolute maximum ratings

Parameter	Symbol	Values			Unit	Note or condition
		Min.	Typ.	Max.		
Maximum supply voltage	V_{DD_max}	-18	-	18	V	max. 40 h
Maximum voltage OUT	V_{OUT_max}	-18	-	18	V	max. 40 h
Maximum voltage on Rx & Tx	V_{RxTx_max}	-0.3	-	5.5	V	max. 40 h
Maximum voltage VCBuf	V_{CBuf_max}	-0.3	-	18	V	max. 40 h
Maximum pin-to-pin voltage difference	V_{PP_max}	-	-	18	V	for global pins
Voltage peaks VDD	V_{DD_peak}	-	-	28	V	max. 50 µs, no current limitation
Voltage peaks OUT	V_{OUT_peak}	-	-	28	V	max. 50 µs, no current limitation
Maximum current OUT pin	I_{OUT_max}	-80	-	80	mA	max. 1 h; current > 0 means short to GND, current < 0 means short to V_{DD}
Maximum junction temperature	T_{J_max}	-40	-	175	°C	max. 1000 h at T_J = 175°C (not additive); maximum exposure time at other junction temperatures shall be calculated using the Arrhenius-model
Storage & shipment temperature	$T_{storage}$	5	-	40	°C	Relative humidity < 90%, storage time < 3 a; see Infineon Application Note: “Storage of Products Supplied by Infineon Technologies”

3.2 ESD Immunity

Table 3 ESD immunity

Parameter	Symbol	Values			Unit	Note or condition
		Min.	Typ.	Max.		
HBM ESD Immunity	V_{HBM}	-	-	±4	kV	Electro-Static-Discharge voltage (HBM) according to AEC-Q100-002; for pins VDD, GND, OUT
HBM ESD immunity		-	-	±2	kV	Electro-Static-Discharge voltage (HBM) according to AEC-Q100-002; for all pins except VDD, GND, OUT
CDM ESD immunity	V_{CDM}	-	-	±0.5	kV	The product withstands the specified minimum Electro-Static-Discharge voltage (CDM) according to AEC-Q100-011; for all pins except corner pins
		-	-	±0.75	kV	The product withstands the specified minimum Electro-Static-Discharge voltage (CDM) according to AEC-Q100-011; for corner pins only

3.3 Stray field robustness

Table 4 Stray field robustness

Parameter	Symbol	Values			Unit	Note or condition
		Min.	Typ.	Max.		
Stray field robustness DC	H_{EXT_DC}	-	-	5000	A/m	According ISO 11452-8:2015
Stray field robustness AC	H_{EXT_AC}	-	-	1000	A/m	According ISO 11452-8:2015

3.4 Lifetime & Ignition cycles

Table 5 Lifetime & ignition cycles

Parameter	Symbol	Values			Unit	Note or condition
		Min.	Typ.	Max.		
Operating lifetime	t_{op_life}	17000	-	-	h	max 1000 h at T_{J_max} = 175°C (not additive)
Total lifetime	t_{tot_life}	15	-	-	a	additional 3 a storage time
Ignition cycles	$N_{ignition}$	200	-	-	1000x	during operating lifetime t_{op_life}

3.5 Functional range

The following operating conditions must not be exceeded in order to ensure correct operation of the device. All parameters specified in the following sections refer to these operating conditions, unless otherwise noted.

Table 6 **Functional range**

Parameter	Symbol	Values			Unit	Note or condition
		Min.	Typ.	Max.		
Operating supply voltage	V_{DD}	4.4	5	6	V	-
Programming supply voltage	V_{PROG}	15.5	-	18	V	Only required to perform a write-cycle
Supply voltage slew rate	V_{DD_slew}	0.1	-	10^8	V/s	If the sensor needs longer than t_{PON} to reach the operating voltage the SSM bits are suppressed by the undervoltage condition in the sensor. No SENT/SPC message including the SSM is sent to the ECU.
Operating ambient temperature	T_A	-40	-	150	°C	max. 1000 h at T_A = 150°C (not additive); Grade 0 qualification
Internal angular resolution	*RES*	-	-	16	bit	-
Power-on time	t_{PON}	-	-	5	ms	Time until the sensor is ready for operation after start-up or reset
Angle range	α	0	-	360	°elec	Electrical angle range from one sin/cos coil period.
Differential angle range	Δ_{angle}	-	-	360	°	Uniqueness depends on wings setup
Internal clock tolerance	Δf_{clock}	-	-	±3.5	%	including temperature and lifetime

3.6 Thermal resistance

Table 7 **Thermal resistance**

Parameter	Symbol	Values			Unit	Note or condition
		Min.	Typ.	Max.		
Thermal resistance	R_{thJA}	-	-	150	K/W	Junction to ambient; measured on 2s2p PCB board

3.7 Current consumption

Table 8 **Current consumption**

Parameter	Symbol	Values			Unit	Note or condition
		Min.	Typ.	Max.		
LC driver current	I_{LC}	-	-	9.6	mA	

(table continues...)

Table 8 **(continued) Current consumption**

Parameter	Symbol	Values			Unit	Note or condition
		Min.	Typ.	Max.		
Operating supply current	I_{DD}	-	-	20	mA	Excluding LC coil driver current and output driver current.

4 Product features

4.1 Functional description

4.1.1 ADC accuracy

Table 9 **ADC accuracy**

Parameter	Symbol	Values			Unit	Note or condition
		Min.	Typ.	Max.		
ADC Integral non-linearity	*INL*	-	10	200	LSB_{16}	-
ADC Noise (RMS)	*Noise*	-	-	1	LSB_{16}	standard deviation: 1σ
ADC Bandwidth	*Bandwidth*	600	-	-	Hz	-

4.2 Electrical characteristics

4.2.1 Input / output characteristics

Table 10 **Input / output characteristics**

Parameter	Symbol	Values			Unit	Note or condition
		Min.	Typ.	Max.		
Output low level	V_{OL}	-	-	$0.2*V_{DD}$	V	Isink = 4mA
Output high level	V_{OH}	$0.8*V_{DD}$	-	-	V	Isource = 4 mA
Input low level	V_{IL}	-	-	$0.3*V_{DD}$	V	valid in normal operating range
Input high level	V_{IH}	$0.7*V_{DD}$	-	-	V	valid in normal operating range
Leakage current	I_{leak}	-40	-	40	µA	-

4.2.2 Coils characteristics

Table 11 **Coils characteristics**

Parameter	Symbol	Values			Unit	Note or condition
		Min.	Typ.	Max.		
Resonance admittance	G_{RLC}	0	-	6	mA/V	when G_{RLC} maximum is reached, A_{Tx} is allowed to drop below minimum value
Inductance transmitter coil	L_{Tx}	1	6	10	µH	-
Capacitance transmitter coil	C_{Tx}		0.5	2.8	nF	Depending on used frequency and inductance
Frequency transmitter coil	f_{Tx}	3	4	5.5	MHz	Excitation frequency resulting from inductance and capacitance

(table continues...)

Table 11 (continued) Coils characteristics

Parameter	Symbol	Values			Unit	Note or condition
		Min.	Typ.	Max.		
Operating amplitude transmitter coil	A_{Tx}	2.0	2.4	3	Vpp	Peak-to-peak; differential.
Relative amplitude transmitter coil	$A_{TX\_relative}$	1.14	1.225	1.31	V	Relative amplitude; differential.
Q factor transmitter coil	Q_{Tx}	10	20	-	-	Temperature depending
Frequency receiver coil	f_{Rx}	3	4	5.5	MHz	-
Amplitude receiver coil	A_{Rx}	5		100	mVpp	Peak-to-peak; differential
Asymmetry caused by receiver	A_{Asym}	-	-	2	mV	Measured in absence of rotor
LC driver current range	I_{LC}	0.2		6	mA	

4.2.3 Undervoltage and overvoltage conditions

Table 12 Undervoltage and overvoltage conditions

Parameter	Symbol	Values			Unit	Note or condition
		Min.	Typ.	Max.		
Undervoltage detection on VDD	V_{UV}	3.8	-	4.4	V	in case of an undervoltage the device disables the output
Overvoltage detection on VDD	V_{OV}	6	-	7.5	V	in an overvoltage condition the device disables the output
Overvoltage detection on OUT	V_{OV_OUT}	6	-	10	V	in an overvoltage condition the output switches to High-Z.
Undervoltage reset time	t_{UV}	-	-	50	µs	Time below threshold for the sensor to initiate a safe reaction
Overvoltage recovery time	t_{OV}	-	-	50	µs	Time after overvoltage condition to enable protocol output
Microbreak immunity	t_{MB}	5	-	-	µs	Min. value is only applicable if no boundary conditions (L_min,Q_min,U_low,Cbuf_low) are applied.

The device behaves in the Extended range same as in the Operating range. However depending on the actual UV/OV thresholds, the device can switch to no output mode.

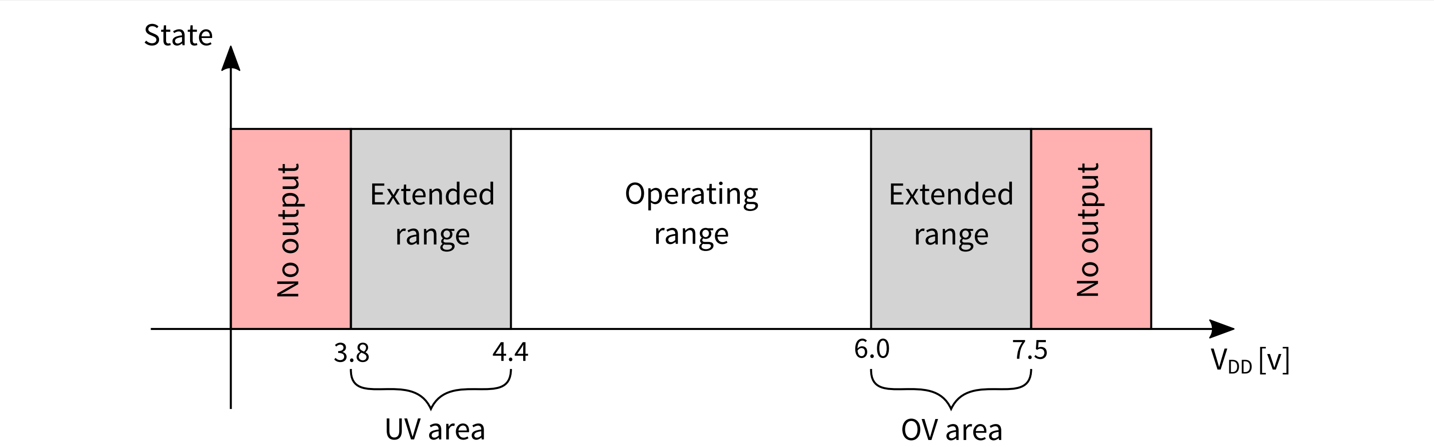


Figure 3 **Operating range**

***Note**: In the extended range, the sensor fulfills the full specification.*

4.2.4 External circuitry

Table 13 **External circuitry**

Parameter	Symbol	Values			Unit	Note or condition
		Min.	Typ.	Max.		
Line capacitor	C_L	1	-	3.9	nF	Including external circuit and cable
Supply capacitance	C_S	70	100	150	nF	Related to EMC requirements
Buffer capacitance	C_{Buf}	70	100	150	nF	Related to EMC requirements
Pull-Up resistor SENT	R_P	10	-	55	kΩ	-
Pull-Up resistor SPC		1.45	2.2	10	kΩ	-
EMC Filter on Rx pins	$C0_A$ to $C3_B$	-	-	250	pF	Depending on application EMC requirements we recommend filter capacitors on each Rx-pin to improve EMC behaviour. To maintain a symmetry of the capacitors used on corresponding RX-pins it is recommended to use capacitors with tolerance window typical < 20%.
Tank capacitor	C_{L1}, C_{L2}	-	1	5.6	nF	Related to C_{Tx}

4.2.4.1 LC oscillator

The LC oscillator driver excites the external resonance LC circuit. The excitation frequency f_{Tx} is defined by the external inductance L_{Tx} and the tank capacitor C_{Tx}. Ohmic resistances are neglected in frequency calculation below.

$$f_{Tx} = \sqrt{\frac{1}{4\pi^2 L_{Tx} C_{Tx}}} = \sqrt{\frac{1}{4\pi^2 L_{Tx} \frac{C_{L1} * C_{L2}}{C_{L1} + C_{L2}}}} \quad (1)$$

4.3 Interfaces

4.3.1 SENT

This chapter describes the SENT Interface of the device. It contains the following section:

- Parameters
- Frame format
- Serial message description
- Error indication
- CRC

4.3.1.1 Parameters

The parameters below can be modified according to the application requirements. Some parameters (e.g. UT = 1 µs or t_{low} = 3 UT) are not compliant with the SENT standard: SAE J2716.

Table 14 Interface Configuration Parameters

Configuration Parameter	Symbol	Nominal Range	Unit	Step width	Default	Note
Unit time	UT	1.0* to 3.0	µs	0.5	3.0	Tolerance given by clock tolerance.
Unit time	*UT*	1.0* to 3.0	µs	0.5	3.0	Tolerance given by clock tolerance.
Low time	t_{low}	3 to 5	UT	1	5	Including the fall time of the edge.
Pause pulse		0 to 1		1	0	0: Disable, 1: Enable
Status nibble in CRC		0 to 1		1	1	0: Disable, 1: Enable
Rolling counter		0 to 1		1	1	0: Disable, 1: Enable

4.3.1.1.1 Definition of tlow

The parameter t_{low} can be configured. Because it includes the fall time of the edge, it has to be ensured that the fall of the edge is fast enough to reach the low level within the configured low time.

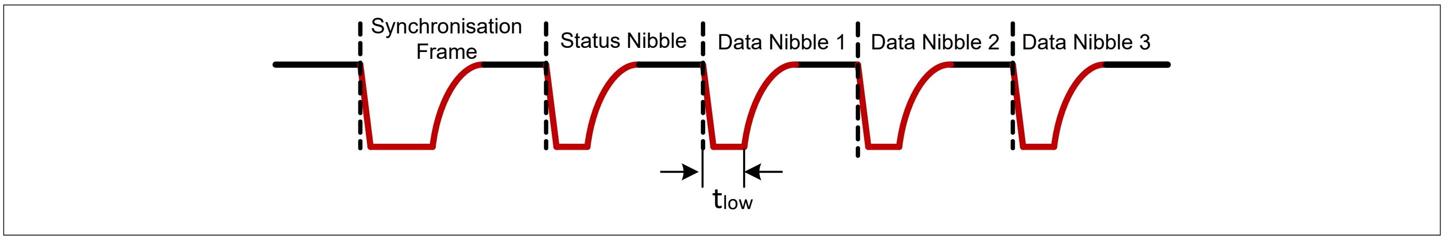


Figure 4 Definition of t_{low}

4.3.1.1.2 Status Nibble

The Status nibble transmits extra serial data such as part numbers or diagnostic information. Data bits from this nibble are constructed across multiple SENT frames to form a Short Serial Message. The 1-bit rolling counter automatically toggles after each transmitted frame. It is used for verification purposes (e.g. missing frame). After start-up or a reset, the next transmitted status nibble indicates the reset via the reset flag. When the reset flag is set, valid angle and torque values are transmitted.

Table 15 Status nibble description

Bits	Description
Status[3]	SSM (bit #3)
Status[2]	SSM (bit #2)
Status[1]	Rolling counter or '0' if disable
Status[0]	Reset flag or error indication

Short Serial Message

The Short Serial Message (SSM) is using the Enhanced Serial Message standard defined in the SAE J2716. It is using the configuration 16-bit data and 4-bit message ID (configuration bit = 1).

<table>
<tr><td>Serial communication</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td><td>10</td><td>11</td><td>12</td><td>13</td><td>14</td><td>15</td><td>16</td><td>17</td><td>18</td></tr>
<tr><td>Serial Data (bit #3)</td><td>1</td><td>1</td><td>1</td><td>1</td><td>1</td><td>1</td><td>0</td><td>1</td><td colspan="4">4-bit ID (3-0)</td><td>0</td><td colspan="4">4-bit data (15-12)</td><td>0</td></tr>
<tr><td>Serial Data (bit #2)</td><td colspan="6">6-bit CRC</td><td colspan="12">12-bit data (11-0)</td></tr>
</table>

Figure 5 Short Serial Message bit mapping

The following table describes the message-ID and the associated data. Data are transmitted with the convention: MSB first. ID8 to ID15 contains the data of ID0 to ID7.

Table 16 Message-ID Overview

Message-ID	Data
0	Sensor ID[47:32]
1	Sensor ID[31:16]
2	Sensor ID[15:0]
3	0x0000 | Temp[7:0]
4	Customer register 1[15:0]
5	Customer register 2[15:0]
6	Customer register 3[15:0]
7	Vector length RX_2/3 [15:8] | Vector length RX_0/1 [7:0]
8-15	ID0 to ID7

4.3.1.1.3 Frame format

Table 17 Frame format

Frame format	Channel 1	Channel 2	CRC	SAE J2716 Compliant
A (Default)	12-bit value	12-bit value	8-bit	No
B	12-bit value	10-bit value	6-bit	No
C	12-bit value	12-bit value	4-bit	Yes

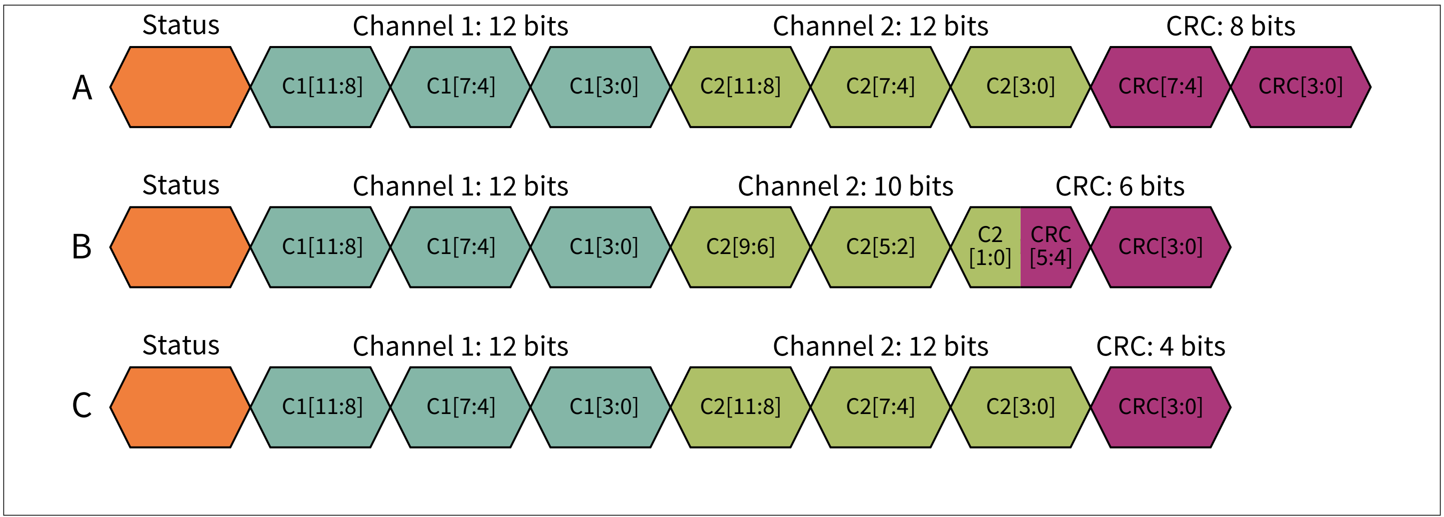


Figure 6 Different frame formats

4.3.1.1.4 Data selection

Table 18 Data selection

Frame format	Channel 1	Channel 2
A,B or C	Angle1	Angle 2

4.3.1.2 Error indication

The angle and torque values are mapped within the range 1 .. 4088 (12 bit). In case of an internal sensor error or start-up error (BIST error), the status nibble (status[0]) is set to one and the following messages are transmitted:

- Supply/temperature monitoring raises an error
  - "4089" is transmitted in the 12 bit channel.
- Transceiver coils monitoring (open, short and resistance measurement), Transceiver coils external parameters monitoring (frequency)
  - "4090" is transmitted in the 12 bit channel.
- Transceiver coils amplitude cross check: amplitude measurement
  - "4091" is transmitted in the 12 bit channel.
- Receiver coils monitoring (open, short, resistance measurement)
  - "4092 is transmitted in the 12 bit channel.

- Receiver coils contact monitoring (vector length)
  - “4093” is transmitted in the 12 bit channel.
- ADC/angle/torque crosscheck
  - “4094” is transmitted in the 12 bit channel.

In a 10 bit channel no error codes are transmitted.

In the case of a reset the value "0" is transmitted in the 12 bit channels. The value "0" is sent after the reset instead of an angle value or error code in all 12 bit channels of a frame.

4.3.1.3 CRC

4-bit CRC

The 4-bit CRC is calculated using the polynomial $x^4 + x^3 + x^2 + 1$ with a seed value of 0101B (5) but also augments the message data with an extra 4 zero bits in the CRC calculation. It corresponds to the Recommended Implementation defined in the SENT standard.

6-bit CRC (Fast channel & SSM)

The 6-bit CRC is calculated using the polynomial $x^6 + x^4 + x^3 + 1$ with a seed value of 010101B (21) but also augments the message data with an extra 6 zero bits in the CRC calculation. It corresponds to the implementation defined in the SENT standard.

8-bit CRC

The 8-bit CRC is calculated using the polynomial $x^8 + x^5 + x^3 + x^2 + x + 1$ with a seed value of 01010101B (85) but also augments the message data with an extra 8 zero bits in the CRC calculation.

4.3.2 SPC

The device supports the Short PWM Code (SPC) interface.

The Short PWM Code (SPC) is a synchronized data transmission based on the SENT protocol (Single Edge Nibble Transmission) defined by SAE J2716. As opposed to SENT, which implies a continuous transmission of data, the SPC protocol transmits data only after receiving a specific trigger pulse also called trigger nibble from the MCU. The required length of the trigger pulse depends on an address, which is configurable. Up to four addresses are available. In bus mode configuration, these addresses allow the operation of up to four sensors on one bus line. In synchronous mode, these addresses transmit different kinds of data.

4.3.2.1 Parameter

The parameters below can be modified according to the application requirements.

Table 19 Interface Configuration Parameters

Configuration Parameter	Symbol	Nominal Range	Unit	Step width	Default	Note
Unit time	*UT*	1.0* to 3.0	µs	0.5	3.0	Tolerance given by clock tolerance.
Low time	t_{low}	3 to 5	UT	1	5	Including the fall time of the edge.
Rolling counter		0 to 1		1	1	0: Disable, 1: Enable
Bus mode		0 to 1		1	1	0: Disable, 1: Enable
Variable trigger length		0 to 1		1	0	0: Disable, 1: Enable

4.3.2.1.1 Definition of tlow

The parameter t_{low} can be configured. Because it includes the fall time of the edge, it has to be ensured that the fall of the edge is fast enough to reach the low level within the configured low time.

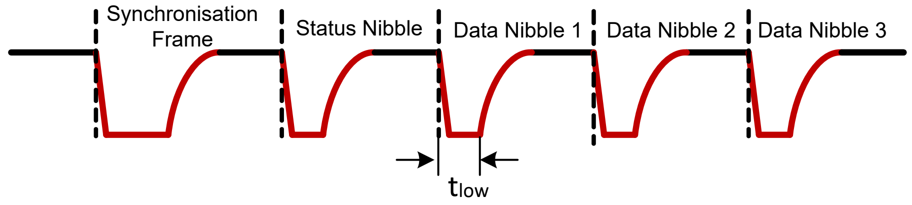


Figure 7 **Definition of t_{low}**

4.3.2.1.2 Status Nibble

The Status nibble transmits extra serial data such as part numbers or diagnostic information. Data bits from this nibble are constructed across multiple SPC frames to form a Short Serial Message. The 1-bit rolling counter automatically toggles after each transmitted frame. It is used for verification purposes (e.g. missing frame). After start-up or a reset, the next transmitted status nibble indicates the reset via the reset flag. When the reset flag is set, valid angle and torque values are transmitted.

Table 20 **Status nibble description (SENT implementation)**

Bits	Description
Status[3]	SSM (bit #3)
Status[2]	SSM (bit #2)
Status[1]	Rolling counter or '0' if disable
Status[0]	Reset flag or error indication

Table 21 **Another bit mapping is available to comply with the SPC standard. Status nibble description (SPC implementation)**

Bits	Description
Status[3]	Reset flag or error indication
Status[2]	Rolling counter or '0' if disable
Status[1]	SSM (bit #3)
Status[0]	SSM (bit #2)

Short Serial Message

The Short Serial Message (SSM) is using the Enhanced Serial Message standard defined in the SAE J2716. It is using the configuration 16-bit data and 4-bit message ID (configuration bit = 1).

Serial communication	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Serial Data (bit #3)	1	1	1	1	1	1	0	1	4-bit ID (3-0)				0	4-bit data (15-12)				0
Serial Data (bit #2)	6-bit CRC						12-bit data (11-0)											

Figure 8 **Short Serial Message bit mapping**

The following table describes the message-ID and the associated data. Data are transmitted with the convention: MSB first. ID8 to ID15 contains the data of ID0 to ID7.

Table 22 Message-ID Overview

Message-ID	Data
0	Sensor ID[47:32]
1	Sensor ID[31:16]
2	Sensor ID[15:0]
3	0x0000 | Temp[7:0]
4	Customer register 1[15:0]
5	Customer register 2[15:0]
6	Customer register 3[15:0]
7	Vector length RX_2/3 [15:8] | Vector length RX_0/1 [7:0]
8-15	ID0 to ID7

4.3.2.1.3 Frame format

Table 23 Frame format

Frame format	Channel 1	Channel 2	CRC	SAE J2716 Compliant
A (Default)	12-bit value	12-bit value	8-bit	No
B	12-bit value	10-bit value	6-bit	No
C	12-bit value	12-bit value	4-bit	Yes

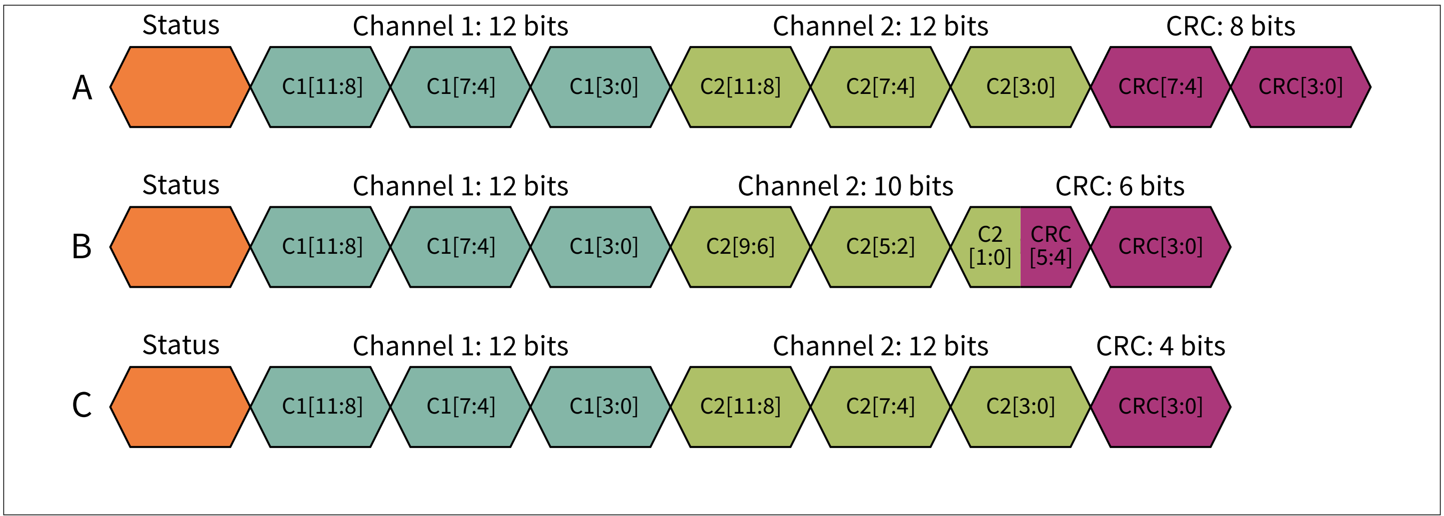


Figure 9 Different frame formats

4.3.2.1.4 Data selection

Table 24 Data selection

Frame format	Channel 1	Channel 2
A,B or C	Angle 1	Angle 2

4.3.2.1.5 Trigger nibble

The transmission is initiated by a master trigger nibble on the output pin. To detect a low level, the voltage must be below the threshold V_{IL}. The sensor detects that the output line has been released as soon as V_{IH} is crossed. The total trigger time, t_{mtr}, depends on the address triggered and the selected configuration between constant trigger length or variable trigger length.

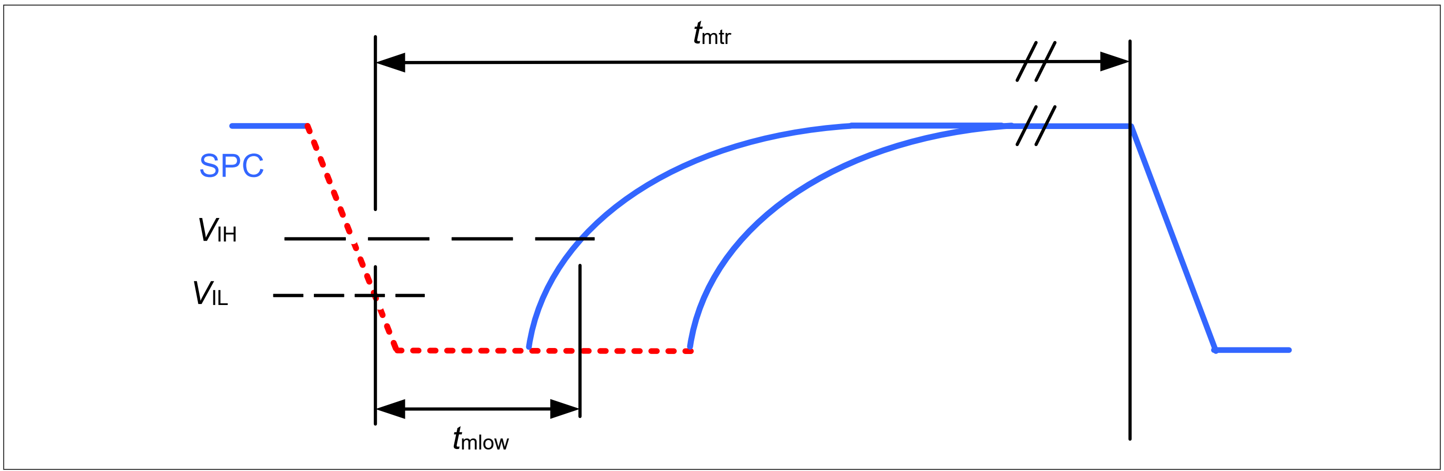


Figure 10 Definition of t_{mlow}

Table 25 Master pulse parameters

Parameter	Symbol	Values			Unit	Note or condition
		Min.	Typ.	Max.		
Total trigger time (constant)	t_{mtr}	85.5	90	94.5	UT	for constant trigger length [1)]
Total trigger time (variable)	t_{mt}	t_{mlow} + 11.4	t_{mlow} + 12	t_{mlow} + 12.6	UT	for variable trigger length [1)]

1) Trigger time in the sensor is fixed to the number of units specified in the “typ.” column, but the effective trigger time varies due to the sensor’s clock variation.

4.3.2.1.6 Bus mode / Synchronization mode

Based on the application requirements, it is possible to configure the sensor in bus mode or synchronous mode. The configuration bit is stored in the NVM. In bus mode, each sensor connected to the bus needs a unique and individual address. The microcontroller can trigger on-request any sensor based on the addressing scheme. In synchronous mode, only one sensor can be connected to the line, in this case, the master pulse is shortened.

Table 26 Sensor SPC trigger parameters

Parameter	Symbol	Values			Unit	Note or condition
		Min.	Typ.	Max.		
Master nibble low time	t_{mlow}	2	-	7	UT	Sync. mode enabled
		8	-	15	UT	addr./ID = 0
		16	-	28	UT	addr./ID = 1
		29	-	49	UT	addr./ID = 2
		50	-	82	UT	addr./ID = 3

4.3.2.2 Error indication

The angle and torque values are mapped within the range 1 .. 4088 (12 bit). In case of an internal sensor error or start-up error (BIST error), the status nibble (status[0]) is set to one and the following messages are transmitted:

- Supply/temperature monitoring raises an error
  - "4089" is transmitted in the 12 bit channel.
- Transceiver coils monitoring (open, short and resistance measurement), Transceiver coils external parameters monitoring (frequency)
  - "4090" is transmitted in the 12 bit channel.
- Transceiver coils amplitude cross check: amplitude measurement
  - "4091" is transmitted in the 12 bit channel.
- Receiver coils monitoring (open, short, resistance measurement)
  - "4092 is transmitted in the 12 bit channel.
- Receiver coils contact monitoring (vector length)
  - "4093" is transmitted in the 12 bit channel.
- ADC/angle/torque crosscheck
  - "4094" is transmitted in the 12 bit channel.

In a 10 bit channel no error codes are transmitted.

In the case of a reset the value "0" is transmitted in the 12 bit channels. The value "0" is sent after the reset instead of an angle value or error code in all 12 bit channels of a frame.

4.3.2.3 CRC

4-bit CRC

The 4-bit CRC is calculated using the polynomial $x^4 + x^3 + x^2 + 1$ with a seed value of 0101B (5) but also augments the message data with an extra 4 zero bits in the CRC calculation. It corresponds to the Recommended Implementation defined in the SENT standard.

6-bit CRC (Fast channel & SSM)

The 6-bit CRC is calculated using the polynomial $x^6 + x^4 + x^3 + 1$ with a seed value of 010101B (21) but also augments the message data with an extra 6 zero bits in the CRC calculation. It corresponds to the implementation defined in the SENT standard.

8-bit CRC

The 8-bit CRC is calculated using the polynomial $x^8 + x^5 + x^3 + x^2 + x + 1$ with a seed value of 01010101B (85) but also augments the message data with an extra 8 zero bits in the CRC calculation.

4.3.3 SICI

The Serial Inspection and Configuration Interface (SICI) enables the programming of the device internal memory. Customer and application-specific parameters such as calibration, interface settings, and customer area can be modified according to the application requirements. SICI is available on the OUT pin. Further details about SICI can be found in the corresponding user manual.

The device supports the Serial Inspection and Configuration Interface (SICI) to program/communicate with the internal memory.

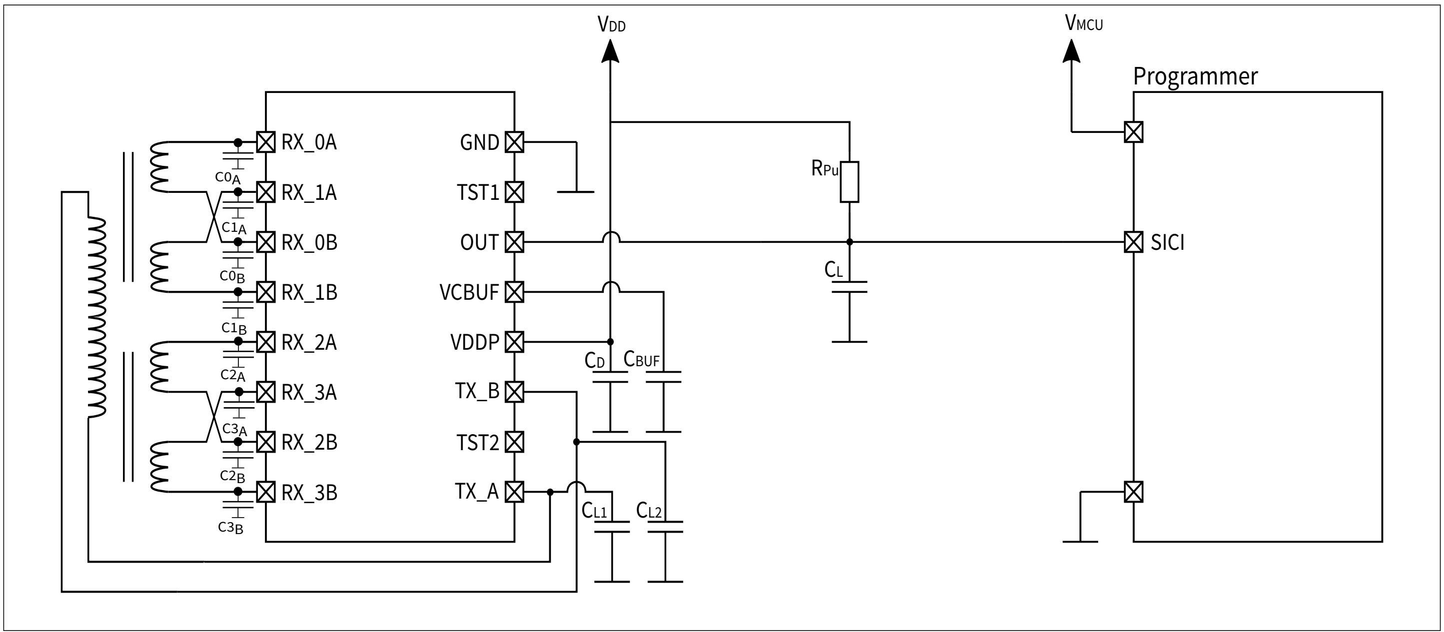


Figure 11 **Application circuit for SICI (SICI line on V_{PROG})**

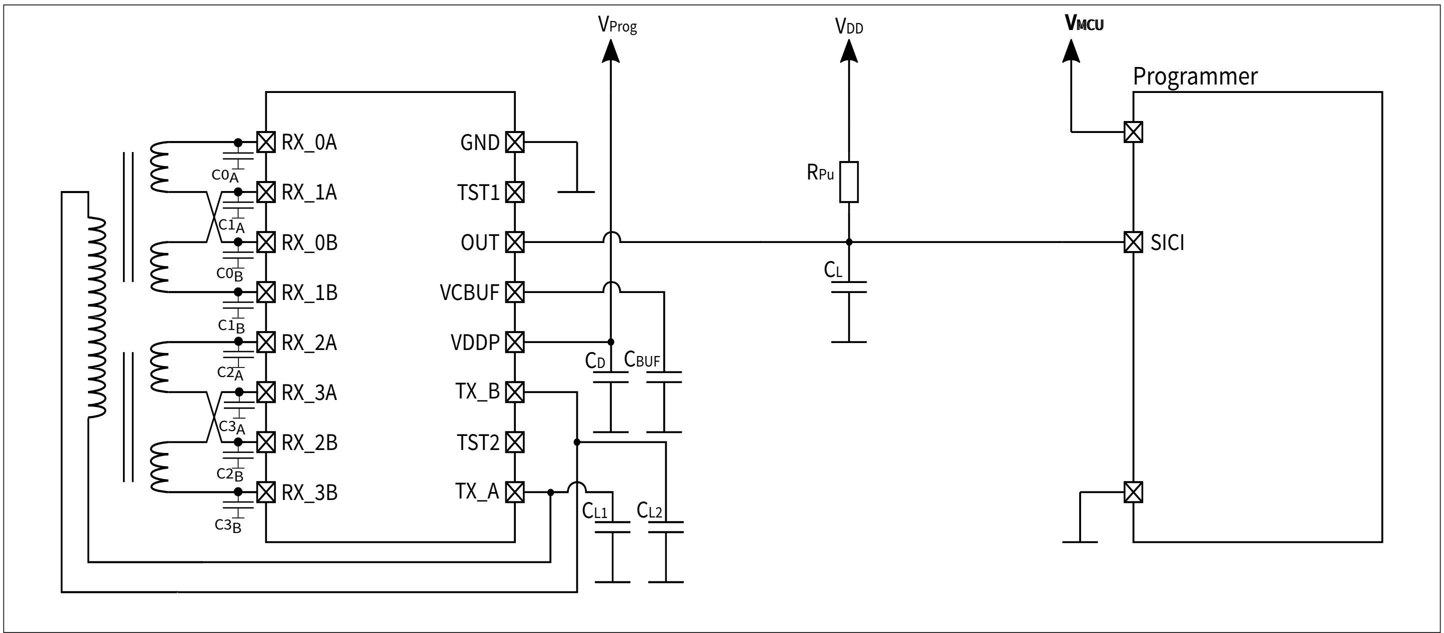


Figure 12 **Application circuit for SICI (SICI line on V_{DD})**

Table 27 SICI electrical and timing characteristics

Parameter	Symbol	Values			Unit	Note or condition
		Min.	Typ.	Max.		
Programmer PWM period	T	40	-	120	µs	Determines interface transmission rate, minimum PWM periode rate of 2 µs might be achievable if lines with low parasitic capacities can be used.
Programmer low time to transmit "0"	t_{1_0}	0.28*T	0.33*T	0.38*T	µs	$t_{2\_0} = T - t_{1\_0}$
Programmer low time to transmit "1"	t_{1_1}	0.62*T	0.67*T	0.72*T		$t_{2\_1} = T - t_{1\_1}$
Time difference between Programmer low and high level	t_4	0.48*T	0.66*T	0.88*T	µs	$t_4 = 2 * \|t_{1\_x} - t_{2\_x}\|$
Programmer-Sensor response time	t_r	50	-	80	% of t_4	
Programmer low pulse after PWM bit	t_3	0.07*T	-	0.2*T	µs	
Interface reset time	T_{Res}	1.7	-	5	ms	
Input signal low level	V_{low_in}		-	0.3*V_{DD}	V	
Input signal high level	V_{high_in}	0.7*V_{DD}	-		V	
Output signal low level	V_{low_out}=V_{OL}		-	0.2*V_{DD}	V	Isink = 4 mA
SICI line pull-up resistor	R_{pu}	1.45	-	2	kΩ	Limited due to SPC/SENT input

Table 28 Timing specification for frame pause and programming mode activation

Parameter	Symbol	Values			Unit	Note or condition
		Min.	Typ.	Max.		
Pause between frames	t_{pause}	5	-	-	µs	time between frames to ensure correct processing
Time window for activation of programming interface	$t_{activate}$	-	-	4500	µs	time after power-up of the sensor to enter the programming mode with the command.

(table continues...)

Table 28 (continued) Timing specification for frame pause and programming mode activation

Parameter	Symbol	Values			Unit	Note or condition
		Min.	Typ.	Max.		
Duration of the CMTP programming pulse	t_{prog_pause}	1	-	-	ms	

4.4 Lookup table

The device embeds a linearization block to compensate for non-linearity behavior (e.g. coils/rotor misalignment). Two options are possible:

- An 8-point look-up table using a 2D implementation where the x and y values can be written independently. This implementation allows the use of non-equidistant points to optimize the linearization process only where it is required.
- Two 8-point look-up tables using a 1D implementation where the x values are equidistant.

With both options, between the pivot points P_n (n_x,y_n), a piece-wise linear interpolation is performed. More details about the look-up table can be found in the user manual.

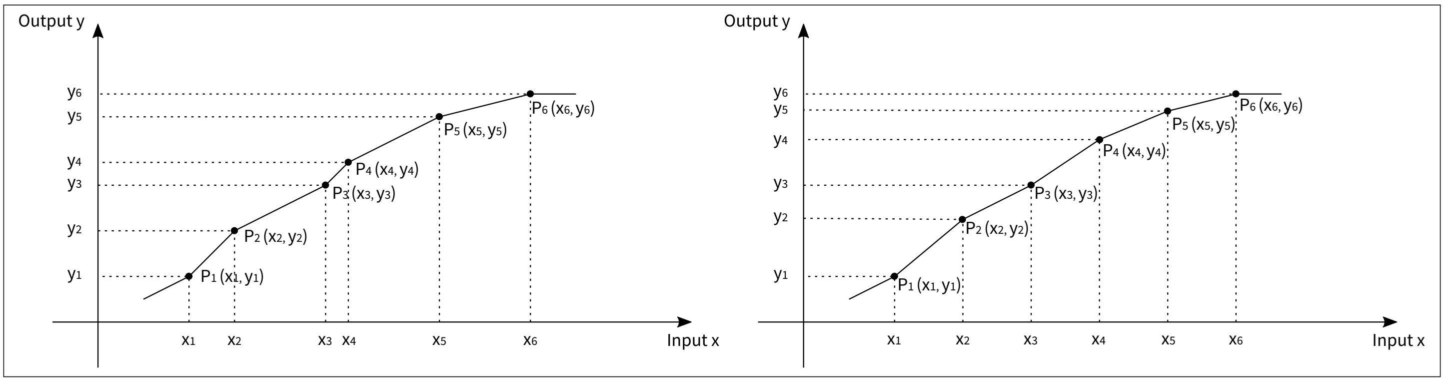


Figure 13 2D look-up table (left) and 1D look-up table (right)

5 Application information

5.1 SENT

Interfaces overview:

- SENT: Angle information and diagnostic interface.
- SICI: Programming interface.

External components:

- A decoupling capacitor C_S of 100nF must be located as close as possible to the sensor supply pin.
- A buffer capacitor C_{BUF} of typ. 100nF must be located as close as possible to the VCBUF pin.
- C_L represents the maximum capacitance of the line (e.g. 50pF/meter)
- A pull-up resistor R_P. The maximum value is determined by the unit time and the total capacitance of the line. The minimum value is determined by the V_{OL} specification.
- Values in the application circuit are typical values from SAE J2716 SENT Filter.
- C_{L1} and C_{L2} capacitors depend on the T_X coil excitation frequency.
- Depending on application EMC requirements we recommend filter capacitors ($C0_A$ to $C3_B$) on each Rx-pin to improve EMC behaviour.

Coils:

- For applications using two sets of receiving coils (2x SIN, 2x COS). The application diagram below applies.
- For applications using only one set of receiving coils (1x SIN, 1x COS). The remaining pins have to be shorted.

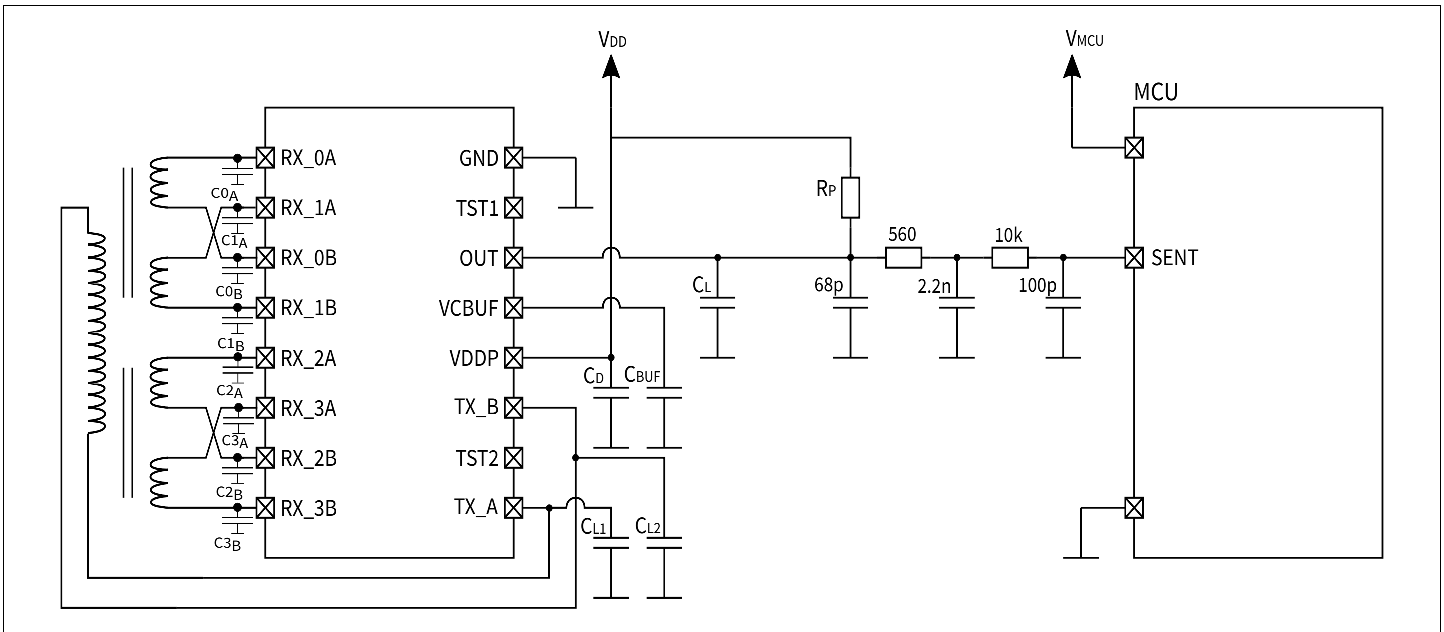


Figure 14 **Application circuit for SENT interface**

5.2 SPC

Interfaces overview:

- SPC: Angle information and diagnostic interface.
- SICI: Programming interface.

External components:

- A decoupling capacitor C_S of 100nF must be located as close as possible to the sensor supply pin.
- A buffer capacitor C_{BUF} of typ. 100nF must be located as close as possible to the VCBUF pin.

- C_L represents the maximum capacitance of the line (e.g. 50pF/meter)
- A pull-up resistor R_P. The maximum value is determined by the unit time and the total capacitance of the line. The minimum value is determined by the V_{OL} specification.
- C_{L1} and C_{L2} capacitors depend on the T_X coil excitation frequency.
- Depending on application EMC requirements we recommend filter capacitors ($C0_A$ to $C3_B$) on each Rx-pin to improve EMC behaviour.

Coils:

- For applications using two sets of receiving coils (2x SIN, 2x COS). The application diagram below applies.
- For applications using only one set of receiving coils (1x SIN, 1x COS). The remaining pins have to be shorted.

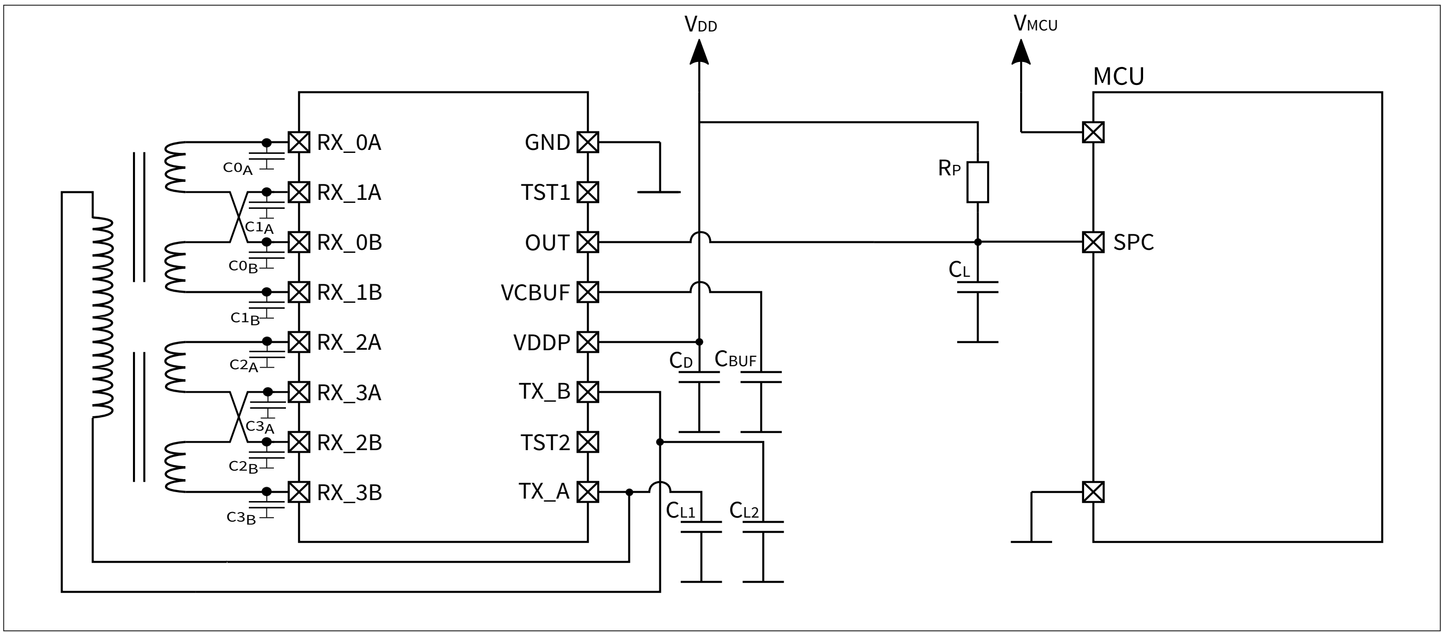
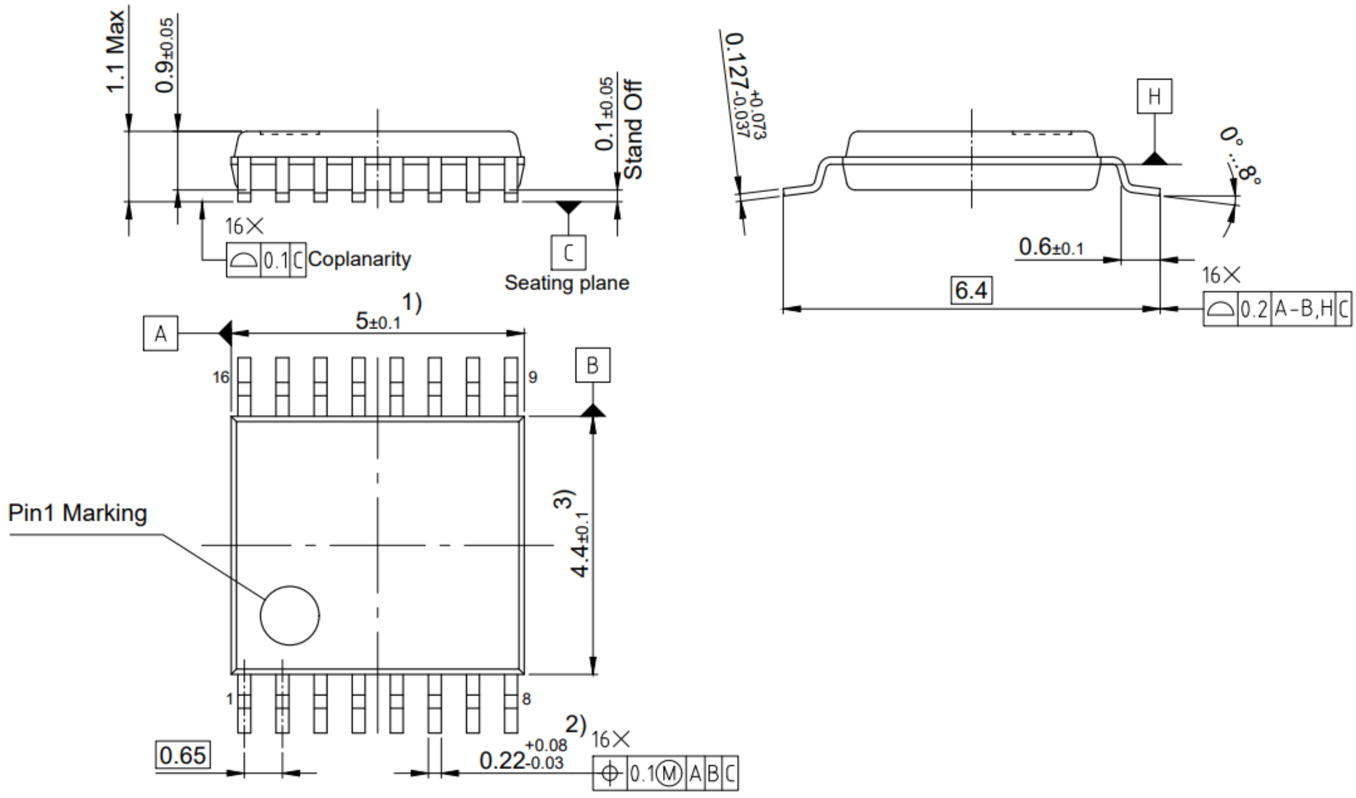


Figure 15 **Application circuit for SPC interface**

6 Package



1) Does not include plastic or metal protrusion of 0.15 max. per side
2) Does not include dambar protrusion of 0.08 max. per side
3) Does not include interlead flash or protrusion of 0.25 max. per side
All dimensions are in units mm
The drawing is in compliance with ISO 128-30, Projection Method 1 [ ]

Figure 16 **TSSOP-16 package outline**

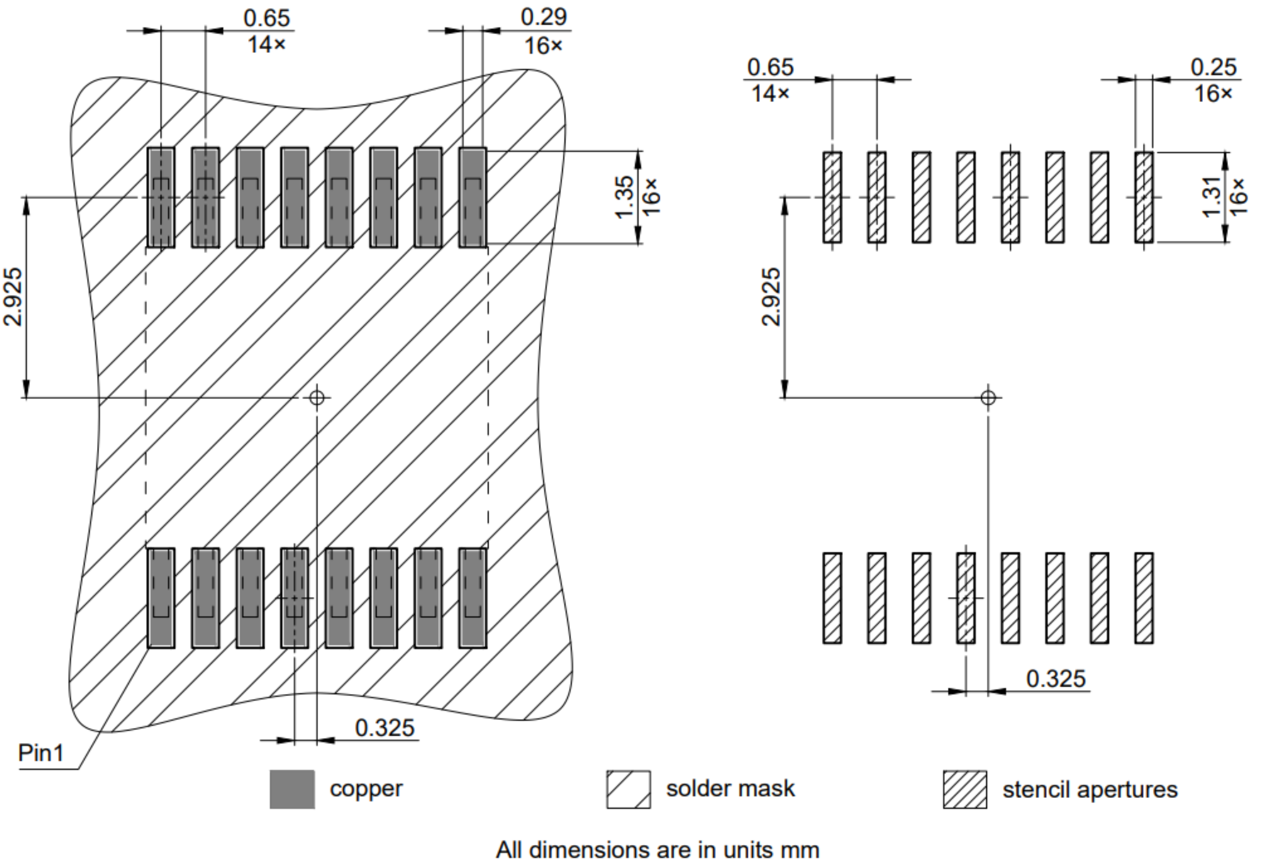


Figure 17 **TSSOP-16 footprint**

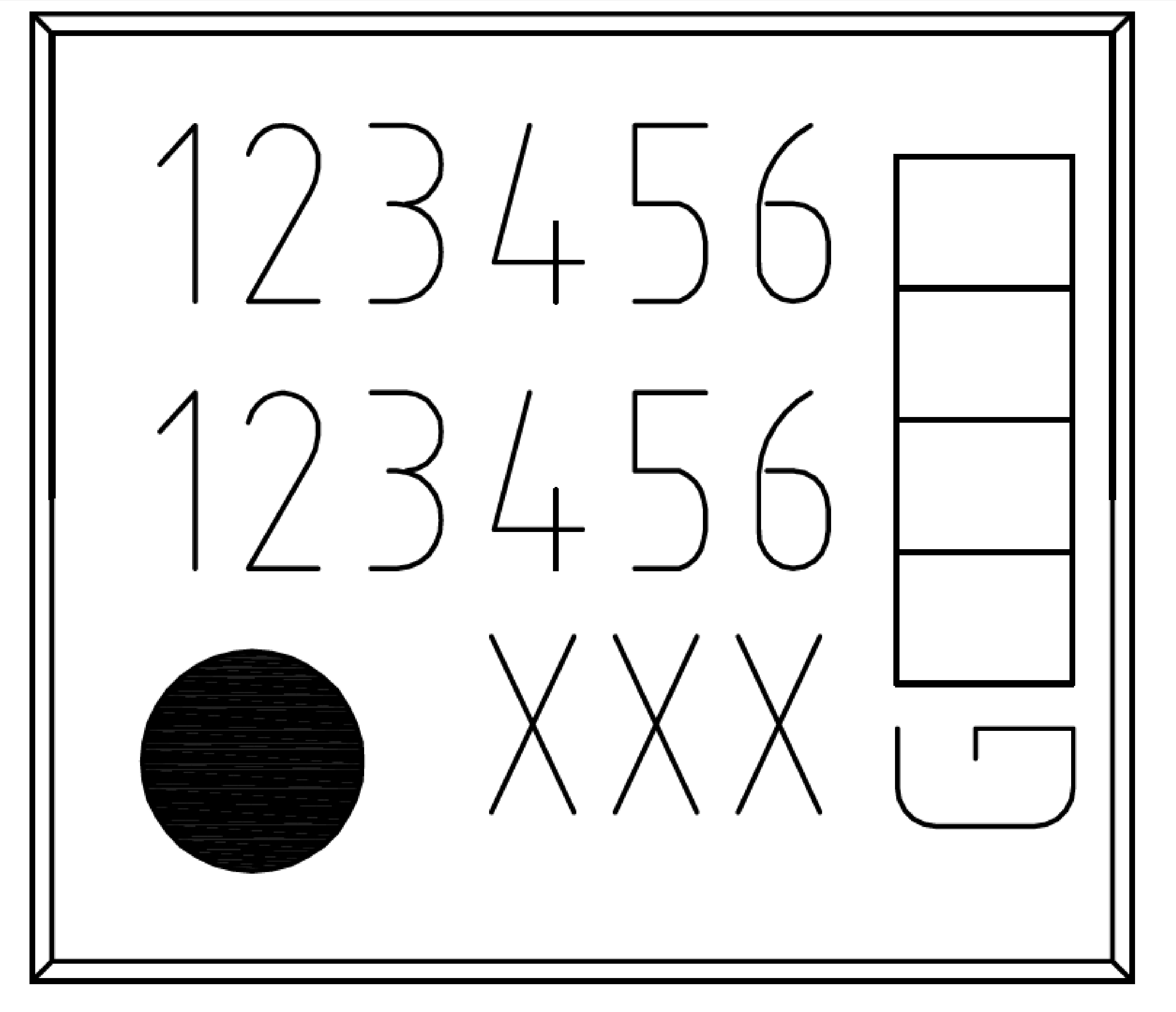


Figure 18 **Package surface: Marking area**

Position	Marking	Description
1st Line	480xXX	Variant number and S for SENT, C for SPC
2nd Line		
3rd Line	xxx	Lot code
	Gxxxx	G: green, 4-digit date code: YYWW e.g. "2401": 1st week in 2024

7 Revision history

Revision	Date	Change description
1.0	2024-06-27	B11 product release
1.01	2024-12-02	B21 product release

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