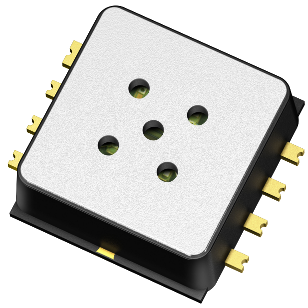
This document is only an extract of the datasheet which can be provided by Infineon in its full version upon request

Features

- Several PSI5-modes selectable by EEPROM bit
- Transmission of temperature and p_0 pressure information via PSI5 i/f during normal operation
- Two pressure ranges selectable by EEPROM bit
- Transmission of two $\Delta p/p_0$ values with different sensitivities in two time slots
- ISO 26262 Safety Element out of Context for safety requirements up to ASIL B(D)
- Compatible to AK-LV 29 and AK-LV 38
- Compatible to the AK-LV 38 addendum with extended measurement range
- End-of-line EEPROM programming via PSI5 interface
- EEPROM for ID number, calibration and mode selection
- Relative pressure signal ($\Delta p/p_0$-signal)
- Application compatible to KP20x and KP30x



RoHS

AEC Qualified

ISO 26262 compliant

Potential applications

Pressure sensor for side crash, pedestrian impact and front crash detection

Product validation

Product validation according to AEC-Q100 (Grade 1) and AEC-Q103-002 (Grade M1).

Qualified for automotive applications.

Description

The device is a pressure sensor for the detection of side crashes in passenger cars and for other pressure based collision detection systems like pedestrian or front crash protection. In these applications the pressure sensor is assembled in a door module located within the car's side door or connected to an other crash sensitive air volume like a tube in the bumper of the car. When the air volume is compressed due to the collision, the device provides an output, which is proportional to the pressure change inside the sensitive air volume ($\Delta p/p_0$). The amplitude of the output is independent of the ambient pressure but is dependent on the relative pressure change. The device provides the relative pressure as a digital Manchester encoded output signal. This cost optimized configuration allows autonomous operation of the sensor without any further logic ICs in the pressure satellite.

Product type	Package	Marking	Ordering code
KP405	PG-DFN-8-1	KP405	SP005414529

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1 Product description

1.1 Functional safety features

Several functional safety features are implemented by the device to ensure safe operation in the respective applications.

1.2 Operating modes

The device supports the following operating modes and can be selected by EEPROM.

Table 1 Definition of valid operating modes

Mode	Dynamic range	Sensitivity	Available protocols	p_0 range	p_0 or T_j transmission
Mode 1	-5 ... +15%	20.48 LSB/%	P10P-500/3L P10P-500/4H P16CRC-500/3H P16CRC-500/2L	45.5 ... 110 kPa	no
Mode 2	-15 ... +23.4%	20.48 LSB/%	P10P-500/3L P10P-500/4H P16CRC-500/3H P16CRC-500/2L P10P-250/1L P10P-250/2H A10P-250/1L	45.5 ... 110 kPa 45.5 ... 140 kPa	in additional time slot
Mode 3	-15 ... +23.4% -15 ... +100%	20.48 LSB/% 4.80 LSB/%	P10P-500/3L P10P-500/4H transmission in different time slots	45.5 ... 110 kPa 45.5 ... 140 kPa	in additional time slot
Mode 4	-15 ... +100%	20.48 LSB/%	P16CRC-500/3H P16CRC-500/2L	45.5 ... 110 kPa 45.5 ... 140 kPa	in additional time slot

***Note**:*
- *The parameters "Dynamic range" (clipping limits) and "Sensitivity" are linked with the selected operating mode.*
- *Only the here specified protocols in combination with the operating modes are allowed and verified. For maximum number of allowed time slots refer to section "PSI5 protocols" in datasheet (Rev. 1.10), 2024-08-23*
- *For some operating modes with additional time slots, the maximum supply voltage VDD is reduced. For details see Table 4.*

2 Pin configuration

The figure below shows the pin configuration.

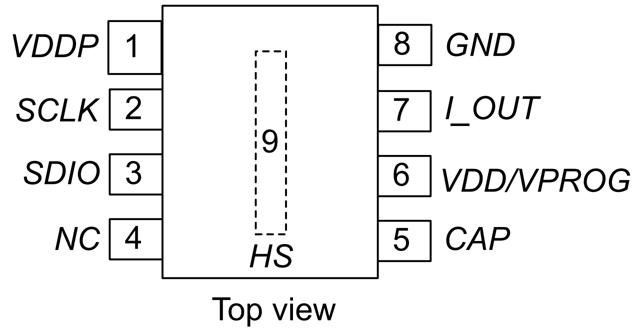

Figure 1 Pin configuration (PG-DFN-8-1)

The table below shows the pin description.

Table 2 Pin description

Pin No.	Symbol	Function	Comment
1	VDDP	power supply for serial i/f drivers	+5V, internal pull down
2	SCLK	serial interface clock	internal pull up
3	SDIO	input and output pin for serial interface	internal pull up
4	NC	not connected	
5	CAP	buffer capacitance	optional
6	VDD/VPROG	supply voltage / EEPROM Programming voltage	–
7	I_OUT	current modulator output	–
8	GND	sensor ground	–
9	HS	heat sink	on bottom side of package

***Note**: Pins 1 ... 4 must be kept on a floating potential in the application.*
Pin 9 must be kept on a floating potential and it must not be soldered to the PCB. For that purpose a keep-out area shall be placed around the heat sink during board design (see Chapter 6.2).

3 General product characteristics

3.1 Absolute maximum ratings

Table 3 Absolute maximum ratings

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
Voltage on VDD	V_{DD}	-16.5	–	24	V	$\|V_{DD} - V_{iout}\| \leq 24$ V	REQ-2581
Voltage on I_OUT	V_{iout}	-16.5	–	24	V	$\|V_{DD} - V_{iout}\| \leq 24$ V	REQ-2582
Voltage on CAP	V_{CAP}	-16.5	–	24	V	$\|V_{DD} - V_{iout}\| \leq 24$ V	REQ-2583
Voltage on serial pins (VDDP, SCLK, SDIO, NC)	V_{dig_pin}	-0.3	–	5.5	V		REQ-2584
Current on serial pin (SCLK, SDIO)	I_{dig_out}	–	–	0.1	mA		REQ-2585
Supply current on VDDP pin	I_{VDDP}	–	–	1	mA		REQ-2586
Maximum operating temperature	T_{Op_max}	–	–	135	°C	time limited for 30 minutes maximum	REQ-2587
Ambient storage temperature	T_{st}	-55	–	135	°C		REQ-2588
Input pressure range	p_{range}	10	–	300 600 *)	kPa kPa	*) limited time: max. 300 s	REQ-2589
ESD robustness according to Human Body Model (HBM) HV-pins: VDD, GND, I_OUT, CAP	$V_{ESD\text{-}HV}$	–	–	4	kV	according to ANS/ ESDA/ JEDEC JS-001	REQ-2590
ESD robustness according to Human Body Model (HBM) LV-pins: VDDP, SCLK, SDIO, NC	$V_{ESD\text{-}LV}$	–	–	2	kV	according to ANS/ ESDA/ JEDEC JS-001	REQ-2591
Latch-up robustness for each pin	$I_{latchup}$	±100	–	–	mA	according to EIA/ JESD78	REQ-2592
Lid pull-off force	$F_{pull\_off\_lid}$	1	–	–	N	only valid at 0h and during module assembly	REQ-2593
Lid push-in force	$F_{push\_in\_lid}$	–	–	10	N	max. allowed force on top of the lid without damaging the sensor	REQ-2594

(table continues...)

Table 3 **(continued) Absolute maximum ratings**

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
Mechanical shock survival	g_{st}	-6000	–	6000	g	unpowered, 0.3 ms	REQ-2595
Differential pressure between inside and outside of package	p_{diff}	-90		300	kPa	the minimum absolute pressure of p_{range} must not be violated	REQ-2596

Attention: ***Stresses above the max. values listed in this chapter may cause permanent damage to the device. Exposure to absolute maximum rating conditions for extended periods may affect device reliability. Maximum ratings are absolute ratings; exceeding only one of these values may cause irreversible damage to the integrated circuit.***

3.2 Operating conditions

Table 4 **Operating conditions**

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
Supply voltage at pin VDD	V_{DD}	4.5	–	11.0	V	V_{DD_max} = 9V for operation in triple slot mode with P10P-500/3L; V_{DD_max} = 8.4V for operation in dual slot mode with P16CRC-500/2L	REQ-2598
Voltage at pin I_OUT	V_{iout}	3.5	–	11.0	V		REQ-2600
Voltage at pin CAP	V_{CAP}	–	–	V_{sync}	V	pin only defined to connect with a capacitor; connection with a constant voltage source not allowed	REQ-2602
Voltage during sync pulse at pin VDD & pin I_OUT	V_{sync}	–	–	16.5	V		REQ-2603
Supply voltage power up/down gradient	V_{grad}	1E-5	–	1E4	V/ms		REQ-2604
Ambient operating temperature	T_{Op}	-40	–	125	°C	temperature outside the sensor	REQ-2606

(table continues...)

Table 4 (continued) Operating conditions

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
Absolute operating pressure range	p_{abs}	38.7	–	280.0	kPa	range for pressure pulses during a crash	REQ-2610
Ambient operating pressure for p0-range1	p_{amb_1}	45.5	–	110.0	kPa	range for p_0 value in p_0-range1	REQ-2611
Ambient operating pressure for p0-range 2	p_{amb_2}	45.5	–	140.0	kPa	range for p_0 value in p_0-range2	REQ-2612
Lifetime	t_{live}	15	–	–	years		REQ-2613
Operating time 1	t_{Op_1}	–	–	12000	h	valid for temperature mission profile as specified in AK LV29 (SAB) [4]	REQ-2614
Operating time 2	t_{Op_2}	–	–	8000	h	valid for temperature mission profile as specified in AK LV38 (PED PRO) [5]	REQ-2615

***Note**: Outside the normal operation supply voltage range the overvoltage detection disables the Manchester communication. As long as the overvoltage detection has not detected an overvoltage, the sensor operates inside the specified operating range.*

***Attention**: The device is sensitive to light entering through the pressure port. All specifications are valid for a illuminance of less than 1 lx.*

3.3 Electrical characteristics

Product characteristics involve the spread of values ensured within the specified voltage and ambient temperature range. Typical characteristics are the median of the production.

3.3.1 Power supply and micro break circuitry

Table 5 Power supply and micro break circuitry

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
Supply current into VDD	I_{VDD}	3.5	–	5.5	mA		REQ-2617
Supply current into I_OUT	$I_{I\_OUT\_idle}$	0.0	–	0.8	mA		REQ-2618
Common supply current into VDD & I_OUT	I_{idle}	4.0	–	6.0	mA		REQ-2619

(table continues...)

Table 5 (continued) Power supply and micro break circuitry

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
Current during Manchester communication	I_{Man}	26	31	36	mA	$I_{Man} = I_{idle} + \Delta I_{mod}$	REQ-2620
Ripple current on supply voltage	I_{ripple}	-0.5	–	0.5	mA	0 Hz - 2 MHz; I_{ripple} is max AC amplitude and only valid with application circuit	REQ-2622
Supply current drift rate	I_{idle_drift}	–	–	1.0	mA/s	characterized by the average of minimum 1s	REQ-2623
Voltage level for activating micro break function	$V_{\mu b}$	3.1	–	4.1	V		REQ-2628
Microcut rejection time	t_{CAP}	10	–	–	µs	Time below Vµb where no sensor reset is allowed; C_{buf} > 100 nF	REQ-2630
Micro break hysteresis	$V_{\mu b\_hys}$	0.4	–	0.9	V	application resistors: 47 Ω ±5%	REQ-2631
Load resistor for Cbuf	R_{CAP}	1.4	2.0	2.6	kΩ	resistor value between VDD and CAP pin	REQ-2633
External buffer capacitor	C_{buf}	0	–	1	µF	no capacitor needed to avoid oscillation of regulator; [1)]	REQ-2634
Allowed range for Cbuf to pass buffer-cap-diagnosis-test	C_{buf_test}	33	–	C_{buf}	nF	VDD = 6 V; CAP-pin discharged to GND before start-up; At values below, buffer-cap-diagnosis-test might diagnose a missing C_{buf}	REQ-2636

[1)] If a capacitor value below $C_{buf\_test\_min}$ is used, the buffer-cap-diagnosis-test must be disabled in EEPROM; a value larger than given here can lead to a violation of the PSI5 specification parameter t_{Th};

3.3.2 Data range and accuracy

Table 6 Data range and accuracy

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
Nominal measurement range1 (Mode 1)	$range_{nom1}$	-5.0	–	+15.0	%	outside the specified nominal measurement range the output value is clipped	REQ-2637
Nominal measurement range2 (Mode 2)	$range_{nom2}$	-15.0	–	+23.4	%	outside the specified nominal measurement range the output value is clipped	REQ-2638
Nominal measurement range3 (Mode 3 or Mode 4)	$range_{nom3}$	-15.0	–	+100	%	outside the specified nominal measurement range the output value is clipped	REQ-2639
Δp/p0 output data range1 (Mode 1)	$\Delta p/p_{0\_dat1}$	-102	–	307	LSB	outside this defined output data range the output value is clipped	REQ-2640
Δp/p0 output data range2 (Mode 2 and Mode 3-slot1)	$\Delta p/p_{0\_dat2}$	-307	–	480	LSB	outside this defined output data range the output value is clipped	REQ-2641
Δp/p0 output data range3 (Mode 3-slot2)	$\Delta p/p_{0\_dat3}$	-72	–	480	LSB	outside this defined output data range the output value is clipped	REQ-2642
Δp/p0 output data range4 (Mode 4)	$\Delta p/p_{0\_dat4}$	-307	–	2048	LSB	outside this defined output data range the output value is clipped	REQ-2643
Nominal sensitivity1 (Mode 1, Mode 2, Mode 3-dp/p0_1, Mode 4)	$sense_{out1}$	–	2.048	–	LSB/‰	output signal $\Delta p/p_0$	REQ-2645

(table continues...)

Table 6 (continued) Data range and accuracy

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
Nominal sensitivity2 (Mode 3-dp/p0_2)	$sense_{out2}$	–	0.480	–	LSB/‰	output signal $\Delta p/p_0$ in additional time slot	REQ-2646
Pressure data offset	$\Delta p/p_{0\_off}$	-0.5	–	0.5	LSB	average value at constant pressure	REQ-2647
Sensitivity error at 0h	$sense_{err1\_0h}$	-6.0	–	+6.0	%	$\Delta p/p_0$ > 10.0% (over full temperature range)	REQ-2648
Sensitivity error over lifetime (-40°C … +105°C)	$sense_{err}$	-7.0	–	+7.0	%	$\Delta p/p_0$ > 10.0%; (overall sensitivity error: incl. temperature, non-linearity etc.)	REQ-2650
Sensitivity error over lifetime (+105° … +125°C)	$sense_{err\_HT}$	-10.0	–	+10.0	%	$\Delta p/p_0$ > 10.0%; (overall sensitivity error: incl. temperature, non-linearity etc.)	REQ-2651
Δp/p0 noise (RMS) (sensitivity1, p0 = 53.6 … 110 kPa)	$noise_{rms,1}$	0	–	1.5	LSB	standard deviation of $\Delta p/p_0$ at constant pressure (e.g. 99.7% of the values inside the ±4.5 LSB range)	REQ-2652
Δp/p0 noise (RMS) (sensitivity1, p0 = 45.5 … 53.6kPa)	$noise_{rms,1\_LP}$	0	–	2.0	LSB	standard deviation of $\Delta p/p_0$ at constant pressure (e.g. 99.7% of the values inside the ±6 LSB range)	REQ-2653
Δp/p0 noise (Peak)	$noise_{peak,1}$	-6	–	+6	LSB	during characterization only: Peak value for 10k samples; 0h & 25°C, sensitivity1	REQ-2654

(table continues...)

Table 6 (continued) Data range and accuracy

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
Δp/p0 noise (RMS) (sensitivity2)	$noise_{rms,2}$	0	–	0.5	LSB	standard deviation of $\Delta p/p_0$ at constant pressure (e.g. 99.7% of the values inside the ±1.5 LSB range)	REQ-2655
Non-linearity for pressure pulses up to 23.4%	$sense_{n\_lin1}$	-1.0	–	+1.0	‰	difference between actual characteristics and best fit quantized line	REQ-2656
Non-linearity for pressure pulses > 23.4%	$sense_{n\_lin2}$	-2.5	–	+2.5	‰	difference between actual characteristics and best fit quantized line	REQ-2657
Pressure offset during acceleration	p_{acc}	–	–	3.5	Pa/g	ensured by design	REQ-2658
p0 data output range in Phase 4	$p_{0\_word\_p4\_lim}$	0	–	480	LSB	outside this defined pressure data range the output value is clipped	REQ-2660
p0 data transmission sensitivity (p0 range1)	$p_{0\_sens\_r1}$	–	0.01868	–	kPa/LSB	valid for Phase 3 and Phase 4	REQ-2661
p0 data transmission sensitivity (p0 range2)	$p_{0\_sens\_r2}$	–	0.02310	–	kPa/LSB	valid for Phase 3 and Phase 4	REQ-2662
p0 data transmission offset	p_{0_offset}	–	50	–	kPa	valid for Phase 3 and Phase 4	REQ-2663
p0 data error (p0 range1)	p_{0_err1}	-3.5	–	3.5	kPa	valid for Phase 3 and Phase 4	REQ-2664
p0 data error (p0 range2)	p_{0_err2}	-3.5	–	3.5	kPa	valid for Phase 3 and Phase 4	REQ-2665
Tj data output range in Phase 4	$T_{word\_p4\_lim}$	-425	–	-70	LSB_{10}	outside this defined temperature data range the output value is clipped	REQ-2667
Tj data transmission sensitivity	T_{j_sens}	–	0.61162	–	°C/LSB	valid for Phase 3 and Phase 4	REQ-2668

(table continues...)

Table 6 **(continued) Data range and accuracy**

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
Tj data transmission offset	T_{j_offset}	–	-94	–	°C	valid for Phase 3 and Phase 4	REQ-2669
Tj error (Tj = 0°C ... 100°C)	T_{j_err}	-5	–	+5	°C	valid for Phase 3 and Phase 4	REQ-2670
Tj error (Tj < 0°C; Tj > 100°C)	T_{j_err2}	-10	–	10	°C	valid for Phase 3 and Phase 4	REQ-2671

3.3.3 Digital core and signal path filter

Table 7 **Digital core and signal path filter**

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
Internal clock frequency	f_{clk}	–	16.0	–	MHz		REQ-2676
Clock variation	CLK_{tol}	-4.0	–	4.0	%		REQ-2677
Clock variation during Manchester frame	$CLK_{var/frame}$	–	–	0.1	%	maximum allowed temperature gradient is +/- 1 K/min	REQ-2678
Clock drift rate	CLK_{drift}	–	–	1.0	%/s	average of min. 1s; maximum allowed temperature gradient is +/-1 K/min	REQ-2679
Sigma delta sample frequency	f_{cic}	–	1	–	MHz	average over 1 second	REQ-2680
p & p0 register update	f_{preg}	–	31.25	–	kHz	proportional to clock frequency	REQ-2681
Cut-off frequency p filter	f_{cp}	–	370	–	Hz	2nd order low pass filter proportional to clock frequency	REQ-2682
p0 filter gradient	$\|\Delta p_0/\Delta t\|$	0.39	0.44	0.49	kPa/s		REQ-2685

3.3.4 PSI5 interface

Table 8 **PSI5 interface**

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
Bit time in 125 kbps mode	t_{Bit}	–	8.0	–	µs	proportional to clock frequency	REQ-2687
Bit time in 189 kbps mode	t_{Bit_H}	–	5.3	–	µs	proportional to clock frequency	REQ-2688
Signal modulation current	ΔI_{mod}	22	26	30	mA		REQ-2689
Fall/rise time current slope	$t_{Man\_R/F}$	0.33	–	1.0	µs	$t_{rise\ 20,\ 80}$ & $t_{fall\ 80,\ 20}$, according to the PSI5 reference network, the PSI5 sensor reference tests conditions A & B [1] and the application circuit example	REQ-2691
Duty cycle ratio Manchester	r_{Man_duty}	47	50	53	%	$(t_{fall,80} - t_{rise,20})$ / t_{Bit} $(t_{fall,20} - t_{rise,80})$ / t_{Bit} according to the PSI5 reference network, the PSI5 sensor reference tests conditions A [2] and the application circuit example	REQ-2692
Sync pulse detection threshold	V_{trig}	1.4	2.0	2.6	V	The absolute sync pulse detection voltage is calculated by adding V_{trig} to the supply voltage V_{idle} (see Chapter 4.1.1.2)	REQ-2693

(table continues...)

Table 8 (continued) PSI5 interface

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
Time between detected rising edge of sync pulse and start of 1st Manchester bit in the PSI5-P10P-500/3L slot1 mode	$t_{Slot1,frame}$	44.1	46.4	48.7	µs	1st Manchester bit starts with nom. 4µs low time; the trigger detection tolerance (t_{tol_detect}) is not included in this timing.	REQ-2704
Time between detected rising edge of sync pulse and start of 1st Manchester bit in the PSI5-P10P-500/3L slot2 mode	$t_{Slot2,frame}$	181.3	190.9	200.4	µs	1st Manchester bit starts with nom. 4µs low time; the trigger detection tolerance (t_{tol_detect}) is not included in this timing	REQ-2705
Time between detected rising edge of sync pulse and start of 1st Manchester bit in the PSI5-P10P-500/3L slot3 mode	$t_{Slot3,frame}$	328.9	346.3	363.6	µs	1st Manchester bit starts with nom. 4µs low time; the trigger detection tolerance (t_{tol_detect}) is not included in this timing	REQ-2706
Time between detected rising edge of sync pulse and start of 1st Manchester bit in the PSI5-P10P-250/1L mode	$t_{Slot,frame}$	71.4	75.2	78.9	µs	1st Manchester bit starts with nom. 4µs low time; the trigger detection tolerance (t_{tol_detect}) is not included in this timing	REQ-2707

(table continues...)

Table 8 (continued) PSI5 interface

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
Time between detected rising edge of sync pulse and start of 1st Manchester bit in the PSI5-P10P-250/2H slot1 mode	$t_{2H\_Slot1,frame}$	44.1	46.4	48.7	µs	1st Manchester bit starts with nom. 2.65µs low time; the trigger detection tolerance (t_{tol_detect}) is not included in this timing	REQ-2708
Time between detected rising edge of sync pulse and start of 1st Manchester bit in the PSI5-P10P-250/2H slot2 mode	$t_{2H\_Slot2,frame}$	141.0	148.4	155.8	µs	1st Manchester bit starts with nom. 2.65µs low time; the trigger detection tolerance (t_{tol_detect}) is not included in this timing	REQ-2709
Time between detected rising edge of sync pulse and start of 1st Manchester bit in the PSI5-P10P-500/4H slot1 mode	$t_{4H\_Slot1,frame}$	44.1	46.4	48.7	µs	1st Manchester bit starts with nom. 2.65µs low time; the trigger detection tolerance (t_{tol_detect}) is not included in this timing	REQ-2710
Time between detected rising edge of sync pulse and start of 1st Manchester bit in the PSI5-P10P-500/4H slot2 mode	$t_{4H\_Slot2,frame}$	139.5	146.9	154.2	µs	1st Manchester bit starts with nom. 2.65µs low time; the trigger detection tolerance (t_{tol_detect}) is not included in this timing	REQ-2711

(table continues...)

Table 8 **(continued) PSI5 interface**

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
Time between detected rising edge of sync pulse and start of 1st Manchester bit in the PSI5-P10P-500/4H slot3 mode	$t_{4H\_Slot3,frame}$	245.5	258.4	271.4	µs	1st Manchester bit starts with nom. 2.65µs low time; the trigger detection tolerance (t_{tol_detect}) is not included in this timing	REQ-2712
Time between detected rising edge of sync pulse and start of 1st Manchester bit in the PSI5-P10P-500/4H slot4 mode	$t_{4H\_Slot4,frame}$	362.5	381.6	400.7	µs	1st Manchester bit starts with nom. 2.65µs low time; the trigger detection tolerance (t_{tol_detect}) is not included in this timing	REQ-2713
Time between detected rising edge of sync pulse and start of 1st Manchester bit in the PSI5-P16CRC-500/3H slot1 mode	$t_{3H\_Slot1,frame}$	44.5	46.4	48.3	µs	1st Manchester bit starts with nom. 2.65µs low time; the trigger detection tolerance (t_{tol_detect}) is not included in this timing	REQ-2714
Time between detected rising edge of sync pulse and start of 1st Manchester bit in the PSI5-P16CRC-500/3H slot2 mode	$t_{3H\_Slot2,frame}$	183.2	190.9	198.5	µs	1st Manchester bit starts with nom. 2.65µs low time; the trigger detection tolerance (t_{tol_detect}) is not included in this timing	REQ-2715

(table continues...)

Table 8 (continued) PSI5 interface

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
Time between detected rising edge of sync pulse and start of 1st Manchester bit in the PSI5-P16CRC-500/3H slot3 mode	$t_{3H\_Slot3,frame}$	332.4	346.3	360.1	µs	1st Manchester bit starts with nom. 2.65µs low time; the trigger detection tolerance (t_{tol_detect}) is not included in this timing	REQ-2716
Time between detected rising edge of sync pulse and start of 1st Manchester bit in the PSI5-P16CRC-500/2L slot1 mode	$t_{2L\_Slot1,frame}$	44.1	46.4	48.7	µs	1st Manchester bit starts with nom. 4µs low time; the trigger detection tolerance (t_{tol_detect}) is not included in this timing	REQ-2717
Time between detected rising edge of sync pulse and start of 1st Manchester bit in the PSI5-P16CRC-500/2L slot2 mode	$t_{2L\_Slot2,frame}$	252.8	266.1	279.4	µs	1st Manchester bit starts with nom. 4µs low time; the trigger detection tolerance (t_{tol_detect}) is not included in this timing	REQ-2718
Transmission rate in asynchronous mode	t_{async}	–	228.0	–	µs	proportional to clock frequency	REQ-2719
Filter sample time before start of frame for time slot 1	$t_{filter\_freeze1}$	–	32	–	µs	proportional to clock frequency; valid for 1st slot transmission in PSI5-P10P-500/3L and PSI5-P10P-500/4H modes only	REQ-2720
Filter sample time before start of frame for time slot 2 and 3 and 4	t_{filter_freeze}	–	40	–	µs	proportional to clock frequency	REQ-2721
Gap time in 125kHz modes	t_{GAP_L}	8.4	–	–	µs	proportional to clock frequency	REQ-2722

(table continues...)

Table 8 (continued) PSI5 interface

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
Gap time in 189kHz modes	t_{GAP_H}	5.6	–	–	µs	proportional to clock frequency	REQ-2723
Trigger detection tolerance	t_{tol_detect}	0	–	3	µs		REQ-2724
Duration of phase 1	t_{P1}	90.0	–	110.0	ms		REQ-2725
Duration of phase 2a	t_{P2a}	–	256	–	frame		REQ-2726
Duration of phase 2b	t_{P2b}	0	–	768	frame		REQ-2727
Duration of phase 3a	t_{P3a}	–	5	–	frame		REQ-2728
Duration of phase 3b	t_{P3b}	–	14	–	frame		REQ-2729
Repetition of ID data	k	–	4	–			REQ-2730
Time threshold for the sensor to declare a gap	t_{sync_max}	–	576	–	µs	proportional to clock frequency	REQ-2731

3.3.5 EEPROM and load characteristics

Table 9 EEPROM and load characteristics

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
No. of EEPROM programming cycles	n_{prog}	–	–	3	–	a programming cycle is defined as applying the programming pulse once in order to change the state of at least one EEPROM cell	REQ-2736
Programming temperature	T_{prog}	10	–	30	°C		REQ-2741
Margin voltage “1”	V_{margin_1}	–	0	0.25	V	0h value, directly after programming	REQ-2742
Margin voltage “0”	V_{margin_0}	2.0	–	5.0	V	0h value, directly after programming	REQ-2743

4 Functional block description

4.1 PSI5 interface: Sensor-to-ECU communication

The physical link between ECU and the satellites is a two-wire, twisted pair connection according to the PSI5 standard ([2] and [3]). It provides the supply voltage to the satellite and is also used for the data transmission between the satellite and the ECU.

The communication between satellite and ECU can be unidirectional (asynchronous communication) or bidirectional (synchronous communication).

4.1.1 Physical layer

For data transmission from the sensor to the ECU, a Manchester-coded current modulation is used.

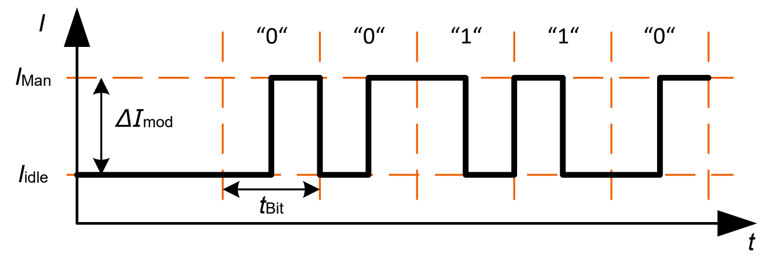

Figure 2 **Manchester based current modulation**

4.1.1.1 Synchronous communication

In the synchronous communication mode a short voltage pulse (sync pulse), generated by the receiver, is used as a synchronization event. The sensor detecting this sync pulse starts its data transmission after a defined period of time. This operation mode supports more than one satellite per physical channel.

If the sensor is configured to synchronous mode, synchronization pulses from the ECU are expected. In synchronous mode the sensor only transmits the data message after recognizing a sync pulse.

In PSI5-P10P-500/3L mode for example, the sensor can transmit the Manchester frames in the 1st, 2nd or 3rd slot ($t_{Slot1,frame}$, $t_{Slot2,frame}$, $t_{Slot3,frame}$).

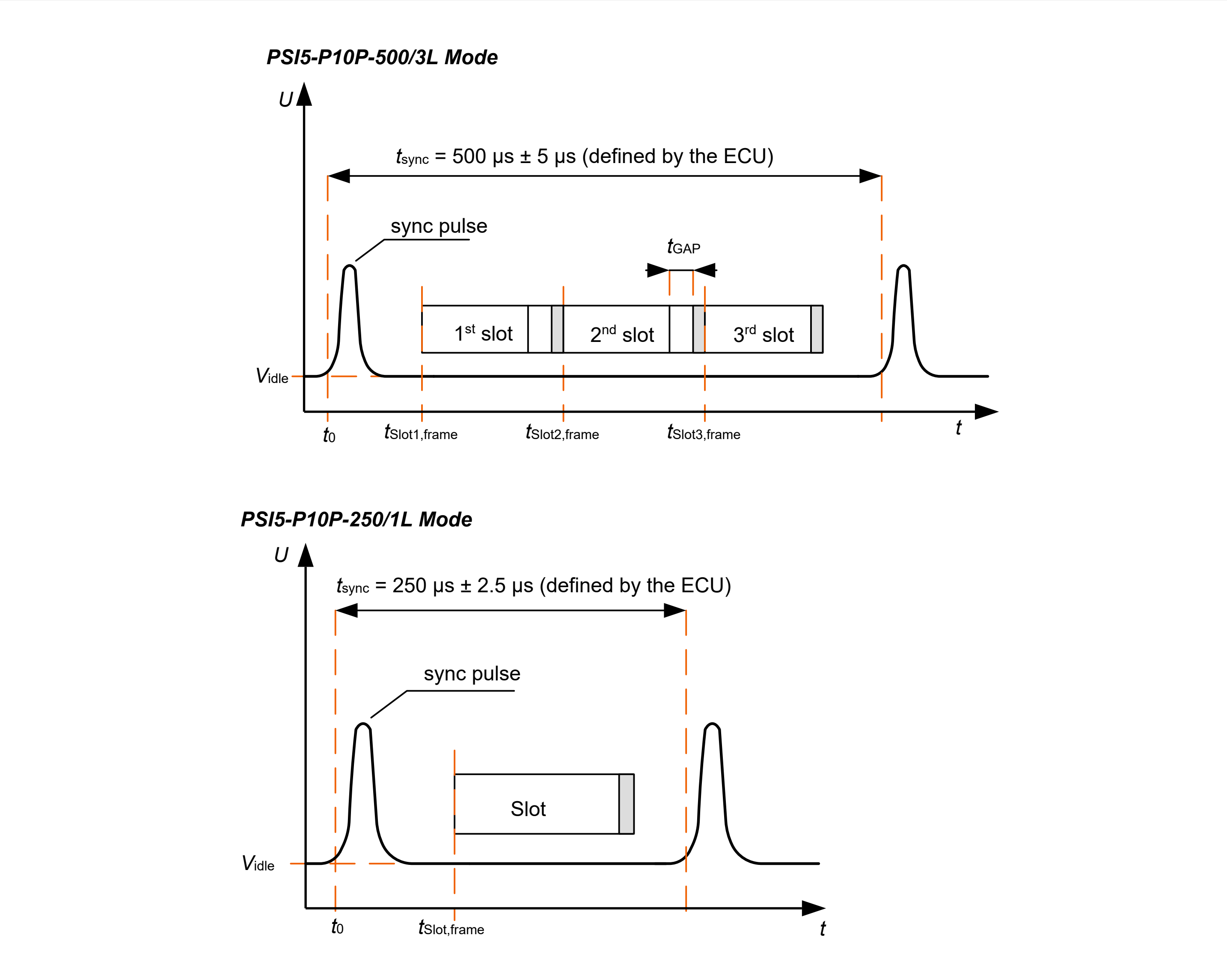

Figure 3 **Timing in synchronous mode**

4.1.1.2 Synchronization pulse detection

The externally generated synchronization pulse is detected by the integrated sync pulse detection circuit. The output of a comparator, which is part of the sync pulse detection circuit, provides a digital signal whether a valid synchronization pulse voltage is detected or not.

This digital signal is sampled at the time when the rising edge of the synchronization pulse is inside the sync pulse detection window and has a delay of t_{tol_detect}.

Figure 4 shows the time correlation of the PSI5 output to the sync pulse.

The trigger detection time T_{TRIG} on system level is determined by adding up the sensors trigger detection tolerance t_{tol_detect} and the contributions from the system, as defined in the PSI5 specification [2].

Note: The system contributions to the trigger detection time T_{TRIG} are not shown in Figure 4.

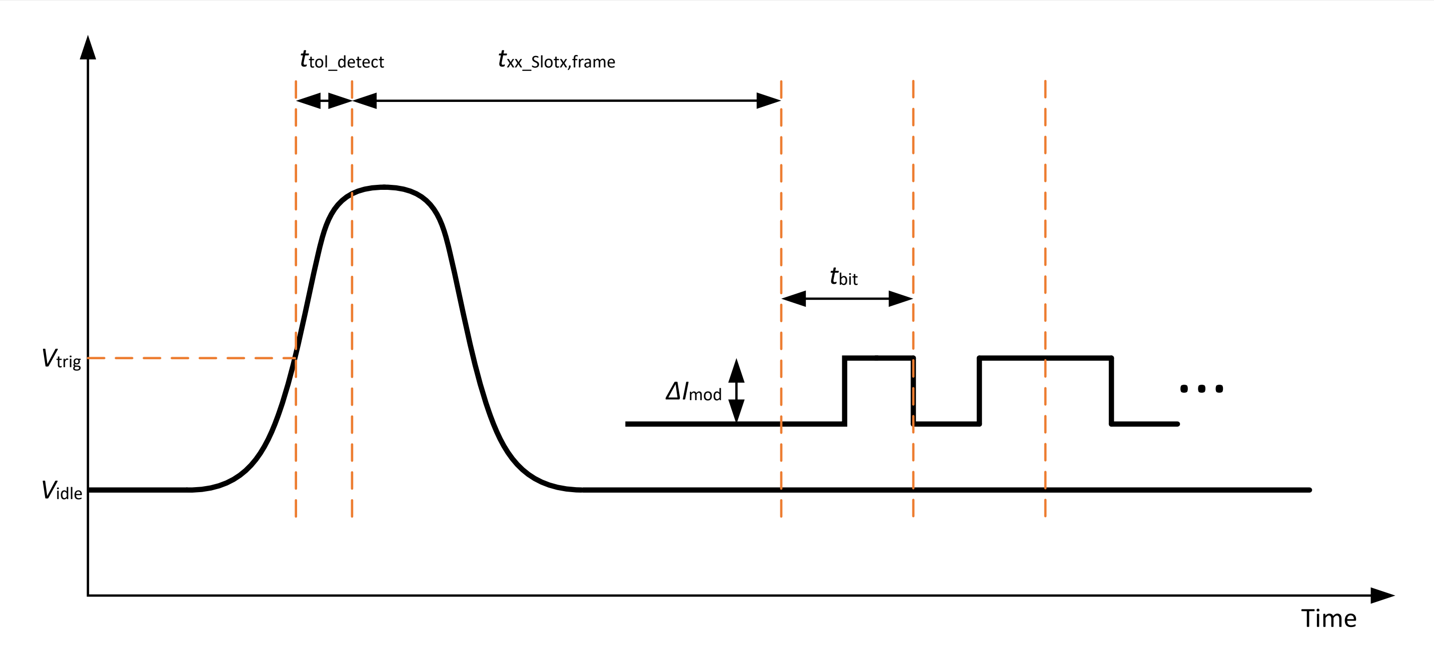

Figure 4 **PSI5 slot timing**

After detecting the rising edge of a sync pulse the sensor observes the voltage level of the synchronization pulse for n_{sync_det} samples with a sampling frequency of f_{sync_sampl}. If the sample voltage observed is above the specified sync pulse detection threshold V_{trig} an up-counter is incremented by "1". If the line voltage is less than the detection threshold voltage V_{trig} the counter is not incremented. After n_{sync_det} samples the status of the up-counter is readout. Only if the counter is inside the n_{sync_detval} range, a valid sync pulse is detected. Otherwise no sync pulse will be detected and the up-counter will be reset.

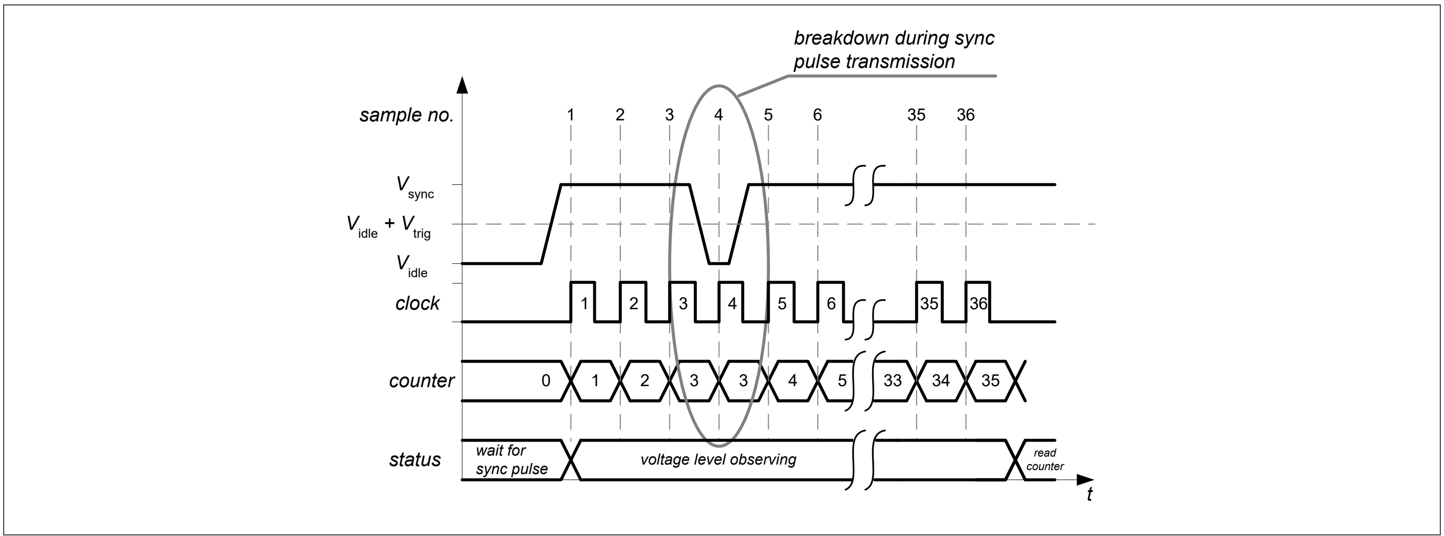

Figure 5 **Sync pulse counter functionality**

If a valid sync pulse is detected then a Manchester frame is sent out in the programmed time slot. During this time ($t_{sync\_off\_xxx}$) no further sync pulses can be detected.
A sync pulse of minimum 9µs in normal duration is recommended.

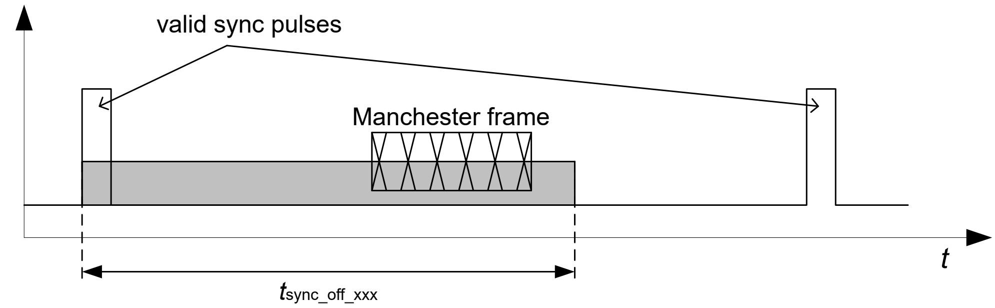

Figure 6 **Sync pulse detection off time**

4.1.1.3 Asynchronous communication

If the sensor is configured to asynchronous mode, the sensor operates with a defined data rate. The specified data message will be continuously transmitted from the sensor at fixed time intervals (t_{async}). In this mode, only one satellite can be connected per physical channel.

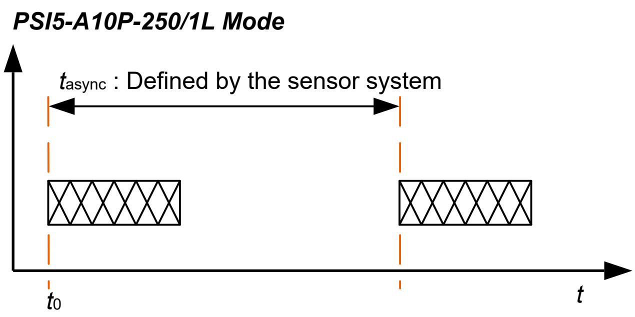

Figure 7 **Timing in the asynchronous mode**

4.1.2 Data link layer

4.1.2.1 PSI5 protocols

The data link layer is based on PSI5 specified modes described in the technical specification for a peripheral sensor interface [2].

The following modes are available (selectable by EEPROM bit):

Synchronous modes:

- PSI5-P10P-250/1L
- PSI5-P10P-250/2H - single slot mode - 1st or 2nd slot
- PSI5-P10P-500/3L - single slot mode - 1st or 2nd or 3rd slot
- PSI5-P10P-500/3L - dual slot mode
- PSI5-P10P-500/3L - triple slot mode (reduced VDD only; see Table 4)
- PSI5-P10P-500/4H - single slot mode - 1st or 2nd or 3rd or 4th slot
- PSI5-P10P-500/4H - dual slot mode
- PSI5-P10P-500/4H - triple slot mode
- PSI5-P16CRC-500/2L - single slot mode - 1st or 2nd slot
- PSI5-P16CRC-500/2L - dual slot mode (reduced VDD only; see Table 4)

- PSI5-P16CRC-500/3H - single slot mode - 1st or 2nd or 3rd slot
- PSI5-P16CRC-500/3H - dual slot mode

Asynchronous modes:

- PSI5-A10P-250/1L

***Note**: Only the here specified protocols in combination with the operating modes specified in Chapter 1.2 are allowed and verified.*

In multi slot mode, the sensor can transmit sensor information in several time slots. The user can select between the transmission of additional p_0 or T_j data or also between transmission of two $\Delta p/p_0$ data sets with different sensitivity. It is possible to select either p_0 or T_j data or to alternate between the two values for each transmission. For details please refer to the full version of the datasheet.

4.1.2.2 Data protocol (10-bit format)

The default data frame structure is defined by a 13-bit message format. The message consists of two (2) start bits, ten (10) data bits and one (1) parity bit (number of high bits in the binary data and parity value).

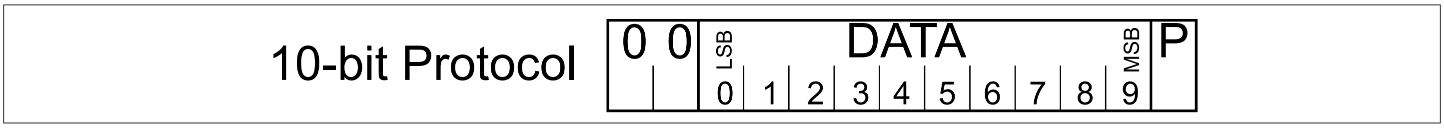

Figure 8 **10-bit protocol (13-bit message)**

The message bits are described in the table below:

Table 10 **Data field 13-bit message**

Message Bit	Definition	Logic Level
0 ... 1	start bit 1 and 2	0
2 ... 11	data bit 0 (LSB) ... data bit 9 (MSB)	0, 1
12	parity (even)	0, 1

4.1.2.2.1 Data range

The operation of the device is divided into four phases. Each phase will use its own data range for transmission of data from the sensor to the ECU. The figure below describes the separate data ranges of the 10-bit protocol (13-bit data message). For details on the four phases, please refer to Chapter 4.1.3.

Range		dec	hex	Phase 1	Phase 2 2a	Phase 2 2b optional	Phase 3 3a / 3b	Phase 4 dp/p0 data	Phase 4 p0 and T data	PSI5 test mode
2	Status & Error Messages	511	1FF	reserved (no data)	reserved	reserved	reserved	reserved	reserved	reserved
		...	...							
		501	1F5							
		500	1F4				sensor defect	sensor defect	sensor defect	
		499	1F3				reserved	reserved	reserved	
		...	...							
		489	1E9							
		488	1E8			sensor busy				
		487	1E7			reserved	sensor ready			
		...	...				reserved			
		482	1E2							error
		481	1E1							OK
1	Sensor Output Signal	480	1E0					$\Delta p/p_0$ maximum (Mode 2 & 3)	p_0 = max	reserved
		...	...					...	...	
		307	133					$\Delta p/p_0$ maximum (Mode 1)		
		...	...					...		
		1	001							
		0	000					$\Delta p/p_0$ = 0%	p_0 = min	
		-1	3FF					...	reserved	
		...	...							
		-70	3BA						T_j = max	
		-72	3B8					$\Delta p/p_0$ minimum (Mode 3)	...	
		-102	39A					$\Delta p/p_0$ minimum (Mode 1)		
		...	...					...		
		-307	2CD					$\Delta p/p_0$ minimum (Mode 2 & 3)		
		...	...					reserved		
		-425	257						T_j = min	
		...	...						reserved	
		-480	220							
3	Block ID's and Data for Initialization	-481	21F		status 1111		nibble 11111			status 1111
		...	...		...		...			...
		-492	214					protocol error	protocol error	
		...	...					reserved	reserved	
		-496	210		status 0000		nibble 10000			status 0000
		-497	20F		ID code 16		nibble 01111			ID code 16
		-498	20E		ID code 15		nibble 01110			ID code 15
		-499	20D		ID code 14		nibble 01101			ID code 14
		-500	20C		ID code 13		nibble 01100	sensor cell error	sensor cell error	ID code 13
		-501	20B		ID code 12		nibble 01011	reserved	reserved	ID code 12
		-502	20A		ID code 11		nibble 01010			ID code 11
		-503	209		ID code 10		nibble 01001			ID code 10
		-504	208		ID code 9		nibble 01000	signal chain error	signal chain error	ID code 9
		-505	207		ID code 8		nibble 00111	reserved	reserved	ID code 8
		-506	206		ID code 7		nibble 00110			ID code 7
		-507	205		ID code 6		nibble 00101			ID code 6
		-508	204		ID code 5		nibble 00100	p_0 init error	p_0 init error	ID code 5
		-509	203		ID code 4		nibble 00011	reserved	reserved	ID code 4
		-510	202		ID code 3		nibble 00010			ID code 3
		-511	201		ID code 2		nibble 00001	p_0 out of range error	p_0 out of range error	ID code 2
		-512	200		ID code 1		nibble 00000	reserved	reserved	ID code 1

Figure 9 **Data content overview (10-bit protocol)**

4.1.2.3 Data protocol (16-bit format)

When operating in 16-bit operating mode, the data frame structure is defined by a 21-bit message format. The message consists of two (2) start bits, two (2) serial channel bits, fourteen (14) data bits and three (3) CRC check bits.

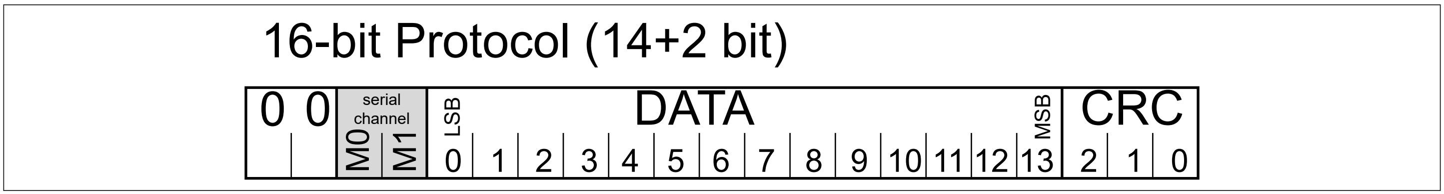

Figure 10 **16-bit protocol (21-bit message) in Phase 4**

The message bits are described below.

Table 11 **Data field 21-bit message**

Message Bit	Definition	Logic Level
0 ... 1	start bit 1 and 2	0
2 ... 3	serial channel bits	0, 1
4 ... 17	data bit 0 (LSB) ... data bit 13 (MSB)	0, 1
18 ... 20	CRC check bits (C2, C1, C0)	0, 1

***Note**: The serial messaging channel is not used and the two bits are fixed to zero ("0").*

4.1.2.3.1 CRC calculation

Error detection is realized by a three bit CRC, calculated from the full 16-bit payload bits (14+2 bits). The generator polynomial of the CRC is $g(x) = 1 + x + x^3$ with a binary CRC initialization value "111". Start bits are ignored in the CRC check. The three check bits are transmitted in reverse order (MSB first: C2, C1, C0).

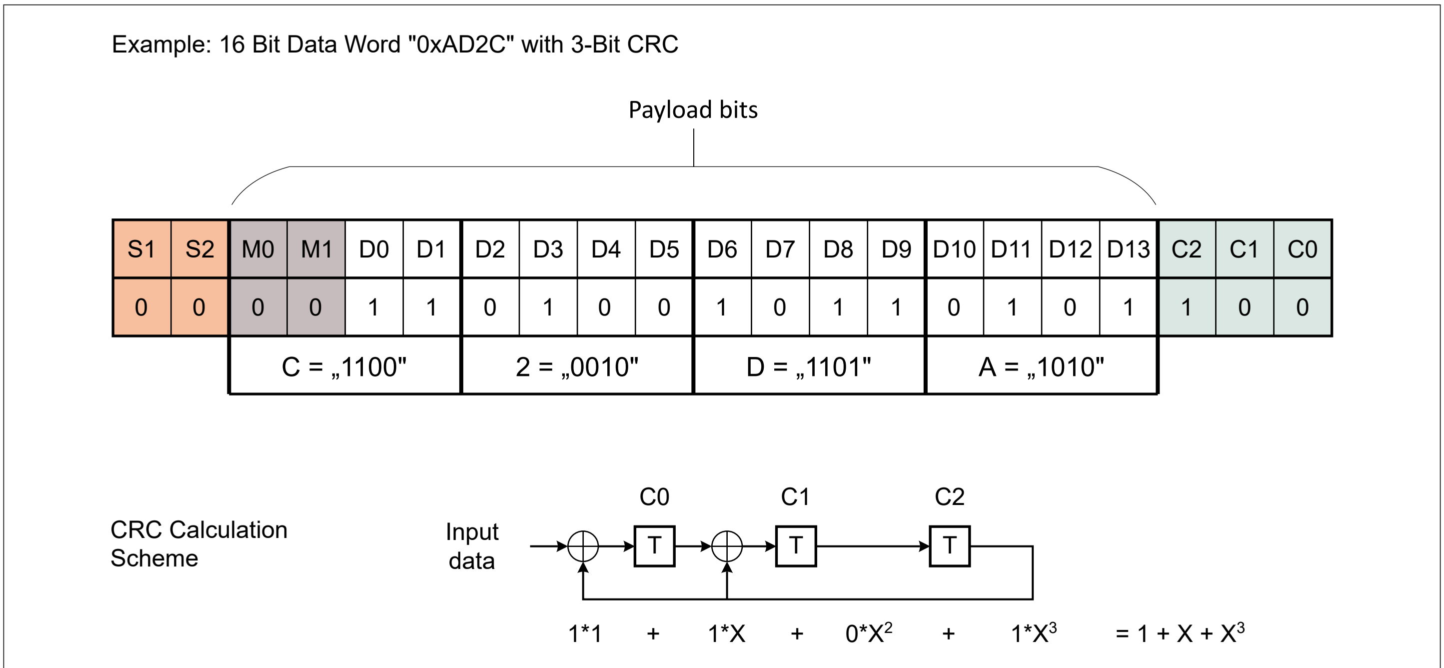

Figure 11 **Example for CRC calculation**

4.1.2.3.2 Data range scaling

During Phase 2 and Phase 3 as well as for error messages, the serial channel bits are not transmitted. Instead, the full 16-bit word is used to transmit data in the following format:

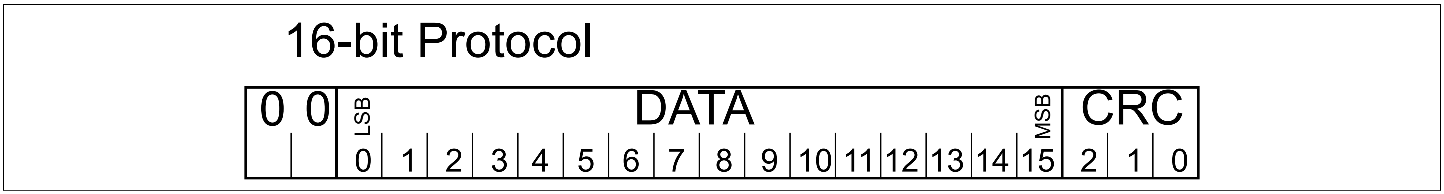

Figure 12 **16-bit protocol (21-bit message) in Phase 2 and Phase 3**

As data content, the 10-bit status and initialization words are used and extended to the 16-bit word by the following rule:

- The 10-bit word is transmitted in the MSB section of the 16-bit frame
- The 6 LSBs (D5 ... D0) are filled up with the value of the bit corresponding to the "D0" bit in the 10-bit data word.

This allows the possibility to check for stuck bits in the receiver. An example is shown below.

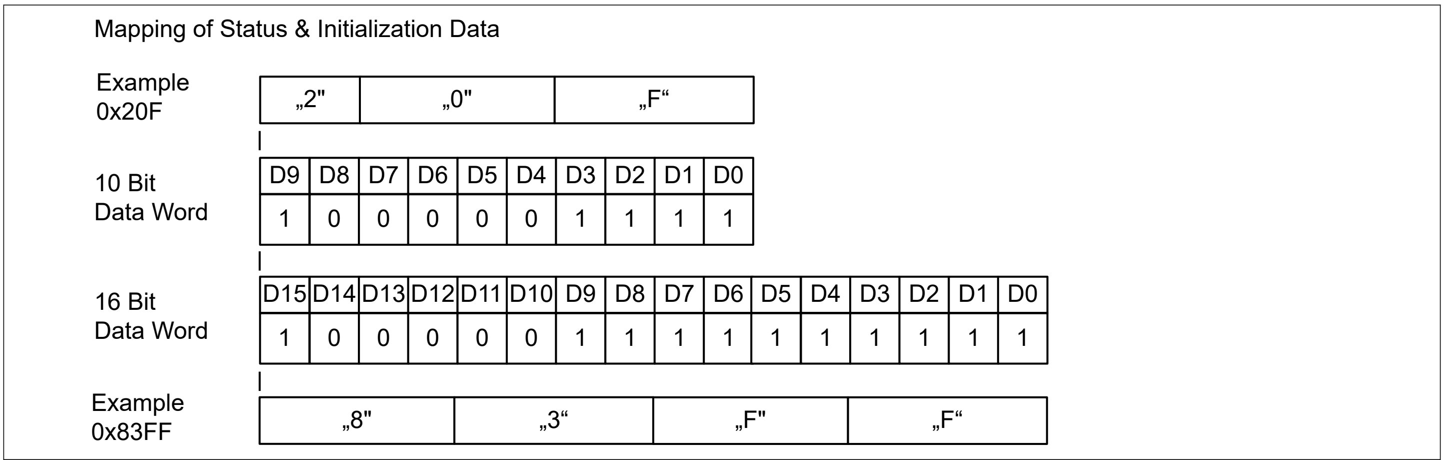

Figure 13 **Example: mapping of status and initialization data into a data word**

4.1.2.3.3 Data range

The operation of the device is divided into four phases. Each phase will use its own data range for transmission of data from the sensor to the ECU. The figure below describes the separate data ranges of the 16-bit protocol. For details on the four phases, please refer to Chapter 4.1.3.

Range		dec	hex	Phase 1	Phase 2		Phase 3	Phase 4
					2a	2b optional	3a / 3b	dp/p0 data
		+32767	0x7FFF					
		...	...				reserved	reserved
		+32000	0x7D00			reserved	sensor defect	sensor defect
2	Status & Error Messages (16-bit)	...	...				reserved	
		+31232	0x7A00			sensor busy		
		+31231	0x79FF				sensor ready	reserved
		...	...					
		+30721	0x7801					
		+7680	0x1E00					
		...	...					
		+2048	0x0800					Δp/p₀ maximum (Mode 4)
		...	...		reserved			...
		+480	0x01E0					Δp/p₀ maximum (Mode 2 & 3)
		...	...					...
		+307	0x0133					Δp/p₀ maximum (Mode 1)
	Sensor Output Signal (14-bit)	...	...				reserved	...
1		1	0x0001					
		0	0x0000					Δp/p₀ = 0%
		-1	0x3FFF	reserved (no data)				...
		...	...					
		-102	0x039A					Δp/p₀ minimum (Mode 1)
		...	...			reserved		...
		-307	0x3ECD					Δp/p₀ minimum (Mode 2 & 3 & 4)
		...	...					
		-7680	0x2200					reserved
		-30721	0x87FF		status 1111		nibble 11111	
		...	...					
		-31488	0x8500		...		...	protocol error
		...	...					
		-31744	0x8400		status 0000		nibble 10000	
		-31745	0x83FF		ID code 16		nibble 01111	reserved
	Block ID's and Data for Initialization (16-bit)	...	...					
3		-32000	0x8300					sensor cell error
		...	...					reserved
		-32256	0x8200		...		...	signal chain error
		...	...					reserved
		-32512	0x8100					p₀ init error
		...	...					reserved
		-32641	0x807F					p₀ out of range error
		-32768	0x8000		ID code 1		nibble 00000	reserved

Note: For data in range 2 and 3, the full 16-bit data word is used.

Figure 14 Data content overview (16-bit message)

4.1.3 PSI5 interface application layer

The following chapter describes the different operation phases of the device in detail.

4.1.3.1 Phase 1

During Phase 1 there is no data transmission.

- Duration: t_{P1}
- No reaction on sync pulses
- Reset and sensor self tests
- Initialization of the p_0 filter (start time is defined with $t_{p0\_init\_start}$ after internal reset, duration: t_{p0_init}). After the initialization, the decrement / increment filter for p_0 calculation is internally clocked.
- Check for the entry key of the PSI5 test mode.
- Check for test mode entry key, set via SPI command.

Only during Phase 1 it is possible to enter the PSI5 test mode. In order to do this, the ECU has to send a predefined entry key sequence. After successful entry into the PSI5 test mode, the sensor will not continue with Phase 2, but stay in this mode until a reset is issued from the ECU. For details about the PSI5 test mode, please refer to the full version of the datasheet.

***Note**: A reset from the ECU can be triggered by cycling the voltage on the VDD-pin.*

4.1.3.2 Phase 2

During Phase 2 the sensor transmits identification tests and runs internal self tests

- Duration: $t_{P2a} + t_{P2b}$
- Phase 2a: Transmission of sensor identification data; repetition of ID data: k
- Phase 2b: based on the test result of the p_0 filter initialization test

Additional information about phase 2b is given in the full version of the datasheet.

4.1.3.2.1 Identification data content

During Phase 2a the sensor transmits identification data. The data blocks correspond to D1...D32 as given in the PSI5 standard.

Table 12 Phase 2a data content

Data Field	Identifier	Data block	Parameter	Content	Value	Comment
F1	PSI5 protocol version	D1	PSI5 spec	V1.3 or V2.1	xxxx	V1.3 is pre-programmed, but is re-programmable by the customer
F2	number of data blocks	D2, D3	number of blocks	32 * 4-bit data blocks	0010 0000	fixed in ROM
F3	satellite manufacturer code 1	D4, D5	satellite manufacturer code 1	customer programming	xxxx xxxx	customer programmable
F4	sensor type	D6	sensor type	pressure sensor	xxxx	customer programmable
		D7			1000_b	fixed for $\Delta p/p_0$ data in $sense_{out1}$

(table continues...)

Table 12 (continued) Phase 2a data content

Data Field	Identifier	Data block	Parameter	Content	Value	Comment
					1100_b	fixed for $\Delta p/p_0$ data in $sense_{out2}$
					xxxx	customer programmable for p_0 or T_j data
F5	sensor parameter	D8, D9	sensor parameter	customer specific parameters	xxxx xxxx	customer programmable
F6	satellite manufacturer code 2	D10, D11	satellite manufacturer code 2	sensor specific definition	xxxx xxxx	customer programmable
F7	sensor code	D12-D14	sensor code	AK-wide defined device index	xxxx xxxx xxxx	customer programmable
F8	production date	D15	year	Yn: 7 bit (0...99) Mn: 4 bit (1...12) Dn: 5 bit (1...31)	Y6 Y5 Y4 Y3	supplier production date is pre-programmed, but is re-programmable by the customer
		D16	year / month		Y2 Y1 Y0 M3	
		D17	month / day		M2 M1 M0 D4	
		D18	day		D3 D2 D1 D0	
F9	serial number	D19-D20	serial number	IFX line/lot/serial number	0000 0000	fixed
		D21-D32			xxxx	programmed and locked by the supplier

***Note**: In multi slot mode, each time slot sends its own ID data. They are identical for each sync pulse and differ only in field D7.*

The field F9 contains an unique serial number for each sensor and allows complete tracing of the sensor.
This serial number is different from all previous SAB sensor devices (e.g. KP106 ... KP109, KP20x, KP30x). The device can be identified by the product-ID in nibble D24.

Table 13 Product IDs (D24)

Product name	Product ID
KP405	0010_b

4.1.3.3 Phase 3

During phase 3, the sensor transmits diagnostics data.

- Duration: $t_{P3a} + t_{P3b}$
- Phase 3a: send status information "sensor ok" (0x1E7) or error sequence (sensor defect (0x1F4) and error classification frame)
- Phase 3a: p_0 transmission
- Phase 3b is optional: Transmission of sensor specific diagnosis data (more information about phase 3b can be found in the full version of the datasheet)

With the 1st frame during Phase 3a the sensor transmits sensor ready (OK, 0x1E7) or in case of a detected error the error sequence (see Chapter 4.1.3.5). The decision about the sensor status is based on the test results done before.

If no error is detected, the next 4 frames transmit the $p_{0\_word\_p3}$ value (12 bit value, separated in four 5 bit nibbles).

Table 14 Phase 3a data content

Frame No.	Normal operation		Error	
	Function	Code	Function	Code
1	Sensor ready	0x1E7	Sensor defect	0x1F4
2	nibble 0	0x200 ... 0x207	Error Code	0x20x
3	nibble 1	0x208 ... 0x20F	Sensor defect	0x1F4
4	nibble 2	0x210 ... 0x217	Error Code	0x20x
5	nibble 3	0x218 ... 0x21F	...	...

4.1.3.3.1 Ambient pressure transmission structure

The $p_{0\_word\_p3}$ is defined as follows and based on the output of the p_0 filter.

$$
\begin{aligned}
p_{0\_word\_p3} &= d_{11}\ d_{10}\ d_9\ d_8\ d_7\ d_6\ d_5\ d_4\ d_3\ d_2\ d_1\ d_0 \\
nibble_0 &= 0\,0\ \ d_{11}\ d_{10}\ d_9 \\
nibble_1 &= 0\,1\ \ d_8\ d_7\ d_6 \\
nibble_2 &= 1\,0\ \ d_5\ d_4\ d_3 \\
nibble_3 &= 1\,1\ \ d_2\ d_1\ d_0
\end{aligned}
$$

Figure 15 $p_{0\_word\_p3}$ definition

4.1.3.4 Phase 4

During normal operation the $\Delta p/p_0$ output value is transmitted via the PSI5 interface. If the normalized relative pressure ($\Delta p/p_0$) under- or overshoots the measurement range ($range_{nomx}$), the $\Delta p/p_0$ value is clipped to the minimum/maximum allowed $\Delta p/p_0$ output value ($\Delta p/p_{0\_datx}$). The limit and value depends on the selected operating mode.

In case p_0 is out-of-range or if an error is detected, which still allows Manchester communication, the error sequence is sent. Details see Chapter 4.1.3.5.

***Note**: As long as the sensor transmits Manchester data, the data is inside the specified range. No incorrect data will be sent, even in the range between the operating voltage and the reset voltage level.*

Depending on the selected protocol mode the actual p_0 value or the junction temperature T_j will be transmitted in an additional time slot, in parallel to the $\Delta p/p_0$ value. If the values are outside the output range, the values are clipped to the minimum/maximum allowed output values ($T_{word\_p4\_lim}$ or $p_{0\_word\_p4\_lim}$).

$$p_0 = 8 \times p_{0\_word\_p4} \times p_{0\_sens\_rx} + p_{0\_offset}$$

Figure 16 Formula for p0 data in phase 4

$$T_j = (T_{word\_p4} + 512) \times T_{j\_sens} + T_{j\_offset}$$

Figure 17 Formula for T_j data in phase 4

4.1.3.5 Error sequence

In case of a detected error and Manchester communication is still enabled, the error sequence is sent in Phase 3 and Phase 4. The error sequence consists of the following two frames:

- 1st frame: "Sensor defect" message (0x1F4)
- 2nd frame: Error code (see more information in the full version of the datasheet)

This error sequence is sent until a power down is triggered. In case of more than one error at the same time, only the error with the highest priority is reported in the PSI5 error sequence.

4.2 Micro break functionality

The micro break control is optional and can be achieved by connecting an external buffer capacitor to the CAP pin of the device. This buffer capacitor provides energy for correct operation during micro breaks. The capacitor is charged to maximum $V_{DD} - V_{drop}$. The load current for the buffer capacitor is limited by the resistor R_{CAP}.

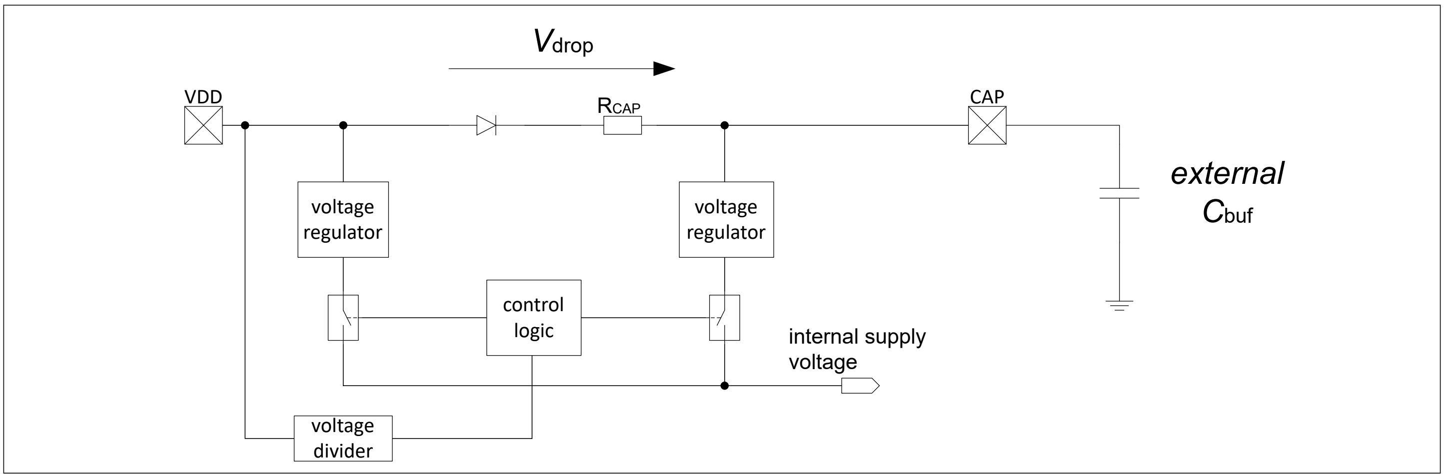

Figure 18 Simplified block level diagram for micro break functionality

A diode prohibits current from conducting into the wrong direction, possibly interfering with the data transmission. The micro break control is part of the voltage regulator concept.

As long as the sensor transmits Manchester data, the data is inside the specified range. No incorrect data will be sent, even in the range between the operating voltage and the reset voltage level.

The size of the capacitor depends on the required micro break timing $t_{\mu b}$ and can be calculated by the following formula:

$$t_{\mu b} = \frac{(VDD - V_{drop} - V_{\mu b\_drop}) \cdot C_{buf}}{I_{VDD}}$$

Figure 19 Formula for micro break time calculation

The micro break function is activated when the voltage on the V_{DD} pin is below $V_{\mu b}$. Then the voltage regulator is supplied from the C_{buf} capacitor.

In the synchronous mode the sync pulse voltage is also used to charge the buffer capacitor. Therefore the buffer capacitor's charge is higher than in the asynchronous mode, where only the supply voltage is provided. The given formula is not considering the additional charge by the sync pulse, this formula is only valid for a direct current supply. The influence of the sync pulse charging the buffer capacitor depends on the sync pulse duration and voltage level, as well as the type of buffer capacitor used and the internal resistance of the capacitor. Therefore, a formula is not given.

Manchester modulation is interrupted during the active micro break mode. The energy of the buffer capacitor is not spend for the Manchester modulation. As soon as V_{DD} returns to normal operating conditions, the current modulator starts working immediately.

If the ECU wants to force a reset of the sensor, the voltage on the supply pin must be hold below $V_{\mu b\_min}$ for a time longer than $t_{\mu b}$.

4.3 Test modes

The device has two different test modes:

- The PSI5 test mode is the main customer interface to program the EEPROM during production.
- The SPI test mode is used by Infineon only.

Entry into test mode is only possible during Phase 1. While being in test mode, no normal sensor operation is possible and the sensor will stop sending $\Delta p/p_0$ data.

5 Application information

5.1 Potential target applications

The device is used to detect the pressure change inside a door during a side crash, in tube systems used for pedestrian protection- or front crash detection systems and other similar applications.

5.2 Application circuit example

The capacitors C_1 and C_2 have to be placed as close to the device as possible. Any long distances may have an influence on the EMC performance. C_{buf} is only necessary to prevent voltage loss during micro breaks.

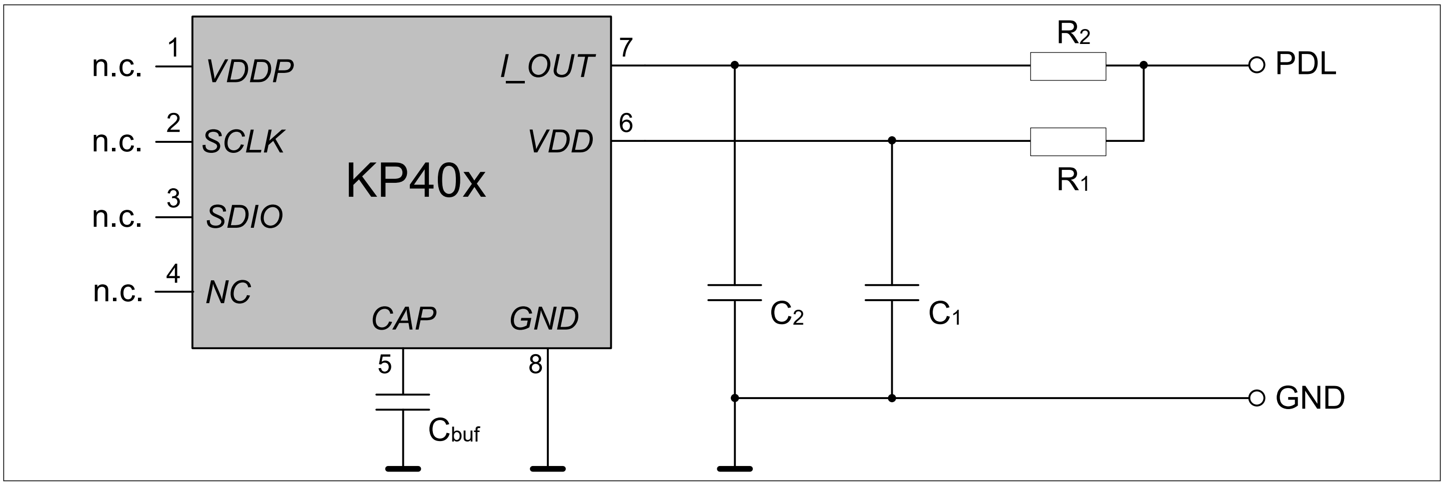

Figure 20 **Application circuit example**

The digital pins (VDDP, SCLK, SDIO) have an internal pull-up or pull-down resistor (R_{pu}, R_{pd}) and therefore normal operation must be with floating pins (in case of an open GND wire, the floating pins prevent from a cross grounding through the corresponding ESD diodes). The traces should be spaced sufficiently to avoid shorts between the serial interface and the high voltage pins of the device.

To avoid overheating of the sensor, a maximum temperature difference from sensor-ambient to module-ambient of T_{rise_mod} has to be ensured by the satellite design.

Table 15 **Application circuit components**

Component	Value	Unit	Tolerance
R_1	47	Ω	+/-5%
R_2	47	Ω	+/-5%
C_1	15	nF	+/-20%
C_2	2.2	nF	+/-20%
C_{buf}	see Table 5		

5.3 Electro magnetic compatibility (EMC)

The device is characterized according to the EMC requirements described in the "Generic IC EMC Test Specification" [7].

System EMC performance on system level is dependent on the module design and the ECU implementation. The device is capable to pass the system tests according to the AK-LV - EMC specification [8] with the application circuit defined in Chapter 5.2.

6 Package information

For passivation the sensor die is covered with a transparent silicone gel. Bubbles adjacent to the bond wires are not allowed (delivery status). The bond wires will be completely covered by gel. The surface of the gel is smooth.

The sensor package is compliant to RoHs.

6.1 Package outline

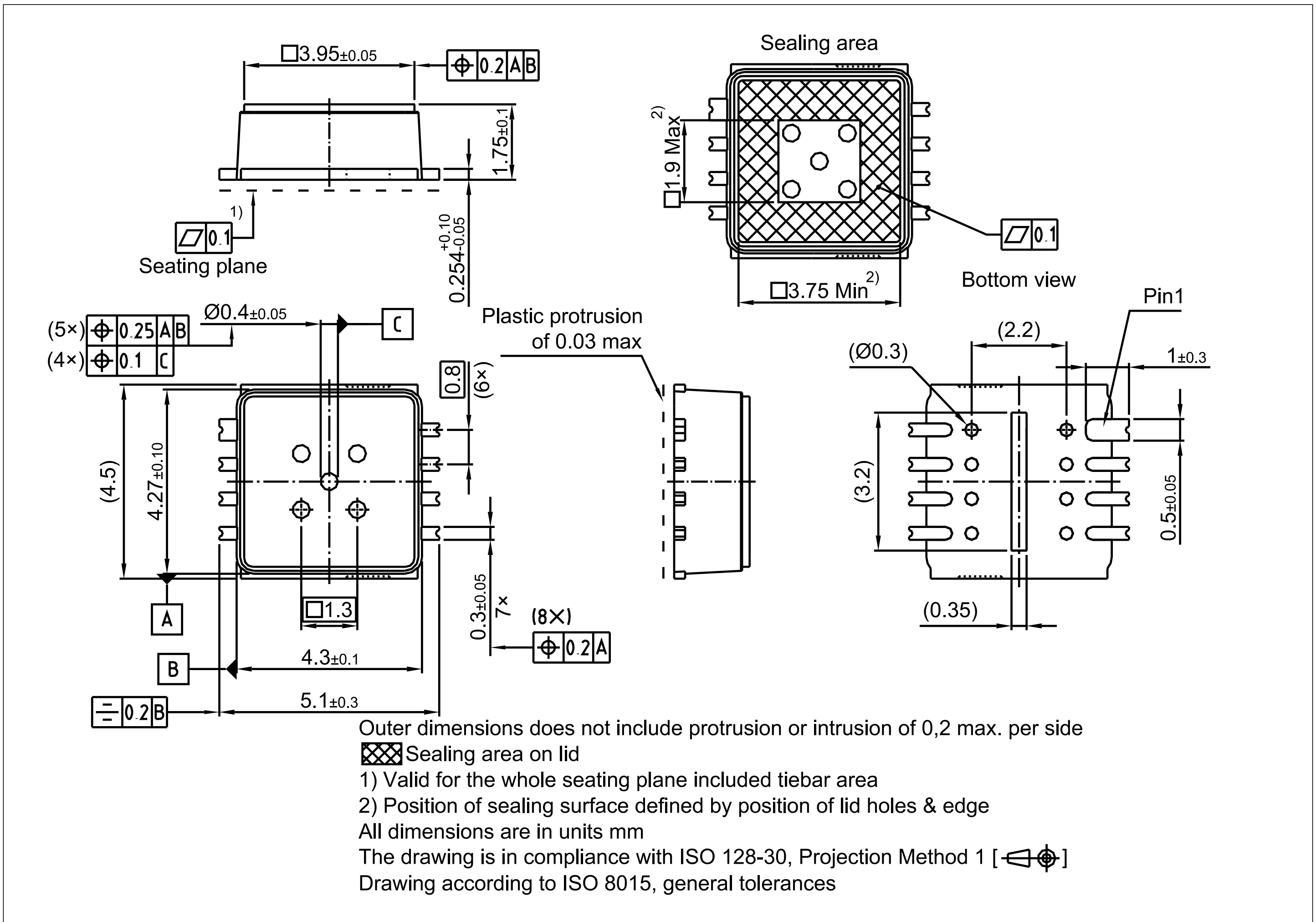

Figure 21 **PG-DFN-8-1 package outline**

6.2 Package footprint drawing

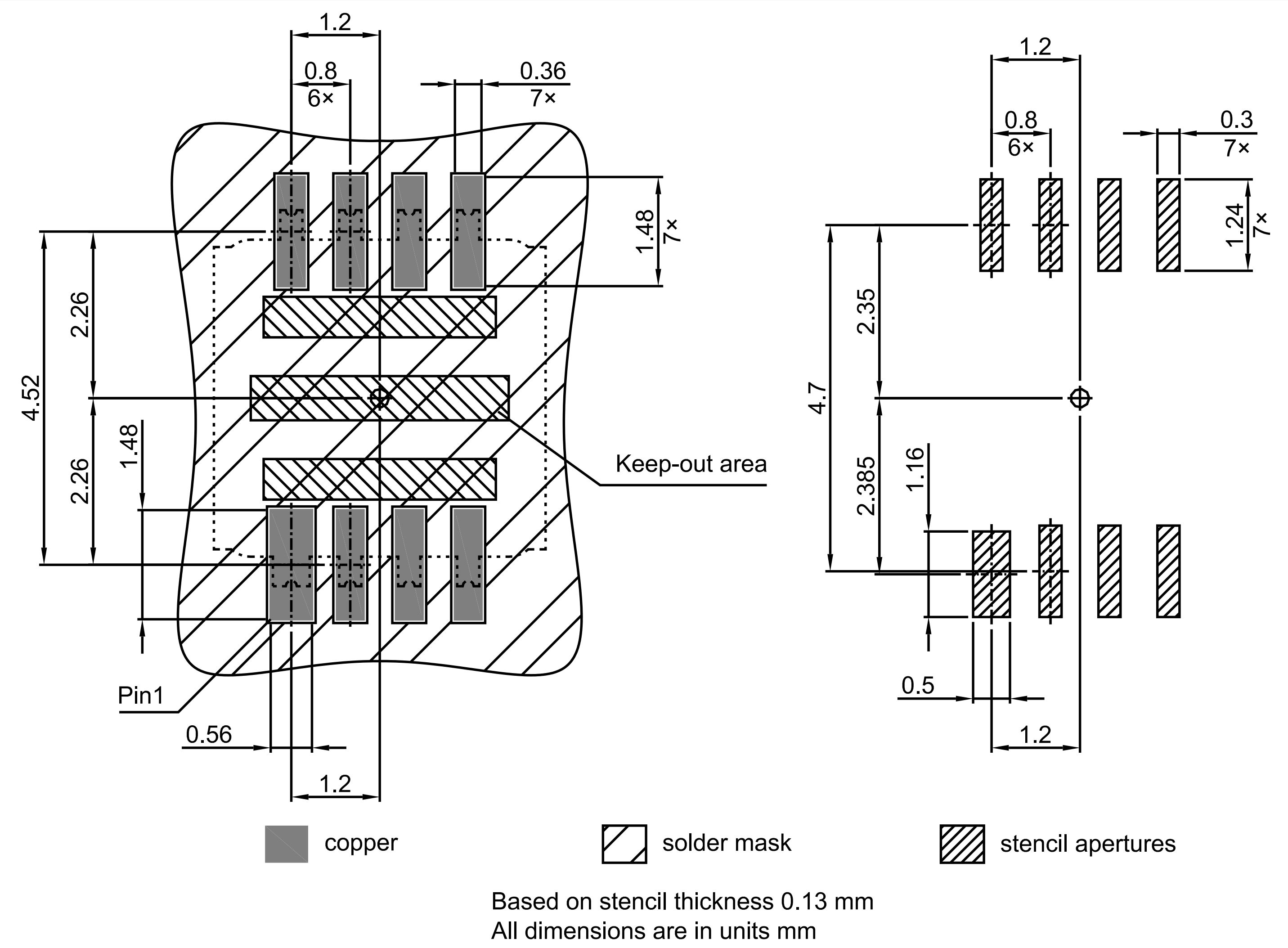

Figure 22 **PG-DFN-8-1 package footprint drawing**

6.3 Pick and place info

The following chapter gives information about the pick and place capability of the PG-DFN package.
Detailed information can be found in an additional document including board assembly recommendations [12].

6.3.1 Component placement

Although the self-alignment effect due to the surface tension of the liquid solder will support the formation of reliable solder joints, the components have to be placed accurately according to their geometry. Manual positioning of the package is not recommended, but it is possible.

For the PG-DFN package with a pad width of 0.3 mm and a pitch of 0.8 mm, an automatic pick-and-place machine is recommended to achieve reliable solder joints.

The device is delivered in tape and reel packing which is suitable for being used in pick-and-place equipment.

The pressure difference between the inside and the outside of the package should not exceed p_{diff} (see Table 3).

6.4 Identification code

The identification code for the device is on the same side of the package as pin 1.

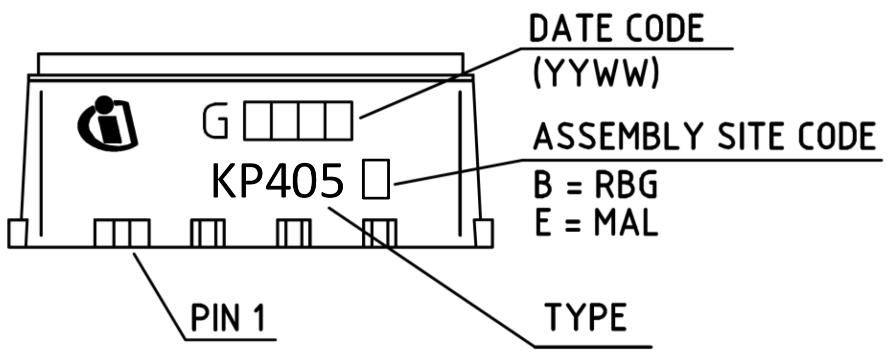

Figure 23 Identification code for KP405

7 References

Table 16 References

Number	Bibliography
[1]	PSI5 Specification, V1.3, 29.07.08
[2]	PSI5 Specification, V2.1, 08.10.2012
[3]	PSI5 Substandard Airbag, V2.1, 05.10.2012
[4]	AK-LV 29, V1.4, 03/2011, "Standard AK-Pressure Sensors for Crash Detection"
[5]	AK-LV 38, V1.0, 13.02.2014, "Druckbasierter Aufprallsensor"
[6]	AK-LV 38 Addendum, Zusatzblatt_20161021_entwurf.pdf, Draft-Version 21.10.2016
[7]	BISS, "Generic IC EMC Test Specification", Version 1.0, July, 6th 2004
[8]	AK-LV 27 / AK-LV 29, Part 3 "EMC Requirements", V2.06, March, 9th 2011
[9]	Siemens Norm SN 29500-2, Edition 2010-09, Siemens AG Munich
[10]	Declaration of Compliance to the RoHS Directive for Infineon "Green Products", MatQ-2013-103-RoHS, Nov. 2013
[11]	ISO 26262, Vehicles Functional Safety, Version 2018
[12]	Recommendations for board assembly of Infineon pressure sensor packages for automotive applications, Revision 1.0, Infineon Technologies AG

8 Revision history

Table 17 Revision history

Revision number	Date of release	Description of changes
1.0	2025-01-31	• Initial release of technical product description extracted from the datasheet of KP405, Rev. 1.10

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