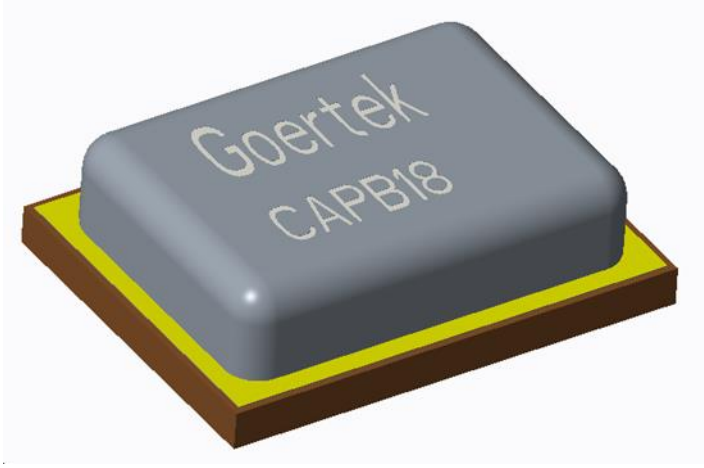
CAPB18-002

Integrated Environment Sensor Unit

Pb-free, halogen-free and RoHS compliant



Restricted

1. Security warning

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2. Publication history

Version	Date	Description
Ver1.0	2022.09.16	New design

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1. Introduction

The CAPB18-002 is an integrated environmental sensor unit with an ultra-small size. The unit combines digital high accuracy pressure sensor and high SNR analog microphone.

The pressure module highlights a capacitive sensing element, 24-bit results and FIFO output, which bring in high accuracy, ultra high precision during temperature changes and very low power consumption. Its I2C interface allows for easy system integration with microcontroller.

The microphone module features high sensitivity and high SNR with low power consumption. The analog output can trace change of environment sound signal timely.

Key features

- Package dimensions: 7-pin LGA, 3.5 mm x 2.65 mm x 1.0 mm
- Pb-free, halogen-free and RoHS compliant

Pressure sensor

- Operation range: Pressure: 300 ~ 1100 hPa. Temperature: -40 ~ +85 °C
- Supply voltage: P-VDD: 1.7 ~3.6 V
- Pressure sensor precision: ± 0.003hPa (or ±0.025 m) for high precision mode
- Pressure sensor accuracy: ± 0.03hPa (or ±0.25 m) (relative), ±0.5hPa (or ±0.6 m) (absolute)
- Temperature accuracy: ± 1.0°C
- Pressure temperature sensitivity: typ. 0.5Pa/K
- Measurement time: 3.1ms for low precision mode
- Average current consumption: 3 µA 1 sample / sec. in low power mode
- I2C interface (up to 3.4 MHz), Embedded 24-bit ADC
- FIFO: Stores latest 32 pressure or temperature measurements

Microphone

- Supply voltage: 1.6 ~3.6V (M-VDD)
- Low power: Current consumptions 120uA
- High sensitivity: -38±1dB
- High SNR : 65dB
- Analog Signal Interface

Typical applications

- Enhancement of GPS navigation (dead-reckoning, slope detection, etc.)
- In-door and out-door navigation
- Leisure and sports
- Weather forecast
- Vertical velocity indication (rise/sink speed)
- Analog Audio Signal

Specific notes

Particles can influence the performance of the pressure sensor, we strongly recommend you to introduce special measures to avoid deposition of particles on the MEMS membrane or screen particles after assembly as the assembly process is considered to be the main root cause for particle generation.

2. Test Condition

Table 1: Pressure Sensor Test Condition

Standard Conditions	Condition	Humidity	Max
Environment conditions	-40℃~+85℃	25%RH~75%RH	300hPa~1100hPa
Basic test conditions	+25℃	60%RH~70%RH	300hPa~1100hPa

Table 2: Microphone Test Condition

Standard Conditions	Condition	Humidity	Max
Environment conditions	+15℃~+35℃	25%RH~75%RH	860hPa~1060hPa
Basic test conditions	+20±2℃	60%RH~70%RH	860hPa~1060hPa

3. Absolute maximum ratings

Table 3: Absolute maximum ratings

Parameter	Condition	Min	Max	Units
Storage temperature		-40	+85	°C
Supply Voltage	All pins	-0.3	+3.6	V
ESD rating	JESD22-A114	-2	+2	kV
Overpressure			10000	hPa

4. Electrical characteristics

4.1 Pressure Sensor Characteristics

P-VDD = 1.8V, P-VDDIO=1.8V, T=25°C, unless otherwise noted. If not stated otherwise, the given values are ±3-Sigma values over temperature/voltage range in the given operation mode.

Table 4: Operating conditions, output signal and mechanical characteristics

Parameter	Symbol	Condition	Min	Type	Max	Units
Operating temperature	TA	Operational	-40	25	85	°C
		Full accuracy	0	25	65	°C

Operating Pressure	P			300		1100	hPa
Supply voltage	VDD			1.7		3.6	V
Supply current (with 1 measurement per second.)	Idd	1 Hz	Low Power		3	5	μA
			Standard		11	15	
			High precision		40	50	
Note: The current consumption depends on both pressure measurement precision and rate. Please refer to the Pressure Configuration (PRS_CFG) register description for an overview of the current consumption in different combinations of measurement precision and rate.							
Peak current	Ipeak	During conversion			400	500	μA
Standby current	Iddsbm					1	μA
Relative accuracy pressure	P_R	950…1050hPa +25…+40°C			±3		Pa
					±0.25		m
Absolute accuracy pressure	P_A	300...1100hPa 0…+65℃			±0.5		hPa
Resolution of output data		Pressure			0.06		Pa
		Temperature			0.01		°C
Noise in pressure	P_Noise	Low Power mode				5	PaRMS
		Standard mode				1.2	
		High precision mode				0.6	
Note: Pressure noise is measured as the average standard deviation. Please refer to the Pressure Configuration (PRS_CFG) register description for all precision mode options.							
Offset temperature coefficient	TCO	1000hPa +25…+40°C			±0.5		Pa/K
					±4.2		cm/K
Absolute accuracy temperature		0…+65℃			±1		°C
Pressure/Temperature measurement rate	f			1		128	Hz
Pressure measurement time	t	Low Power mode			5	8	ms
		Standard mode			28	35	
		High precision mode			105	115	
Note: The pressure measurement time (and thus the maximum rate) depends on the pressure measurement precision. Please refer to the Pressure Configuration (PRS_CFG) register description for an overview of the possible combinations of measurement precision and rate.							
Supply voltage ramp-up time	t vddup	Time for supply voltage to reach 90% of final value		0.001		5	ms
Time to sensor ready	TSensor_rdy	The SENSOR_RDY bit in the Measurement Configuration register will be set when the sensor is ready				12	ms

Time to coefficients are available	TCoef_rdy	The COEF_RDY bit in the Measurement Configuration register will be set when the coefficients can be read out			40	ms
Serial data clock	f_{I2C}	For I2C			3.4	MHz
Long term stability		12month		±1		hPa

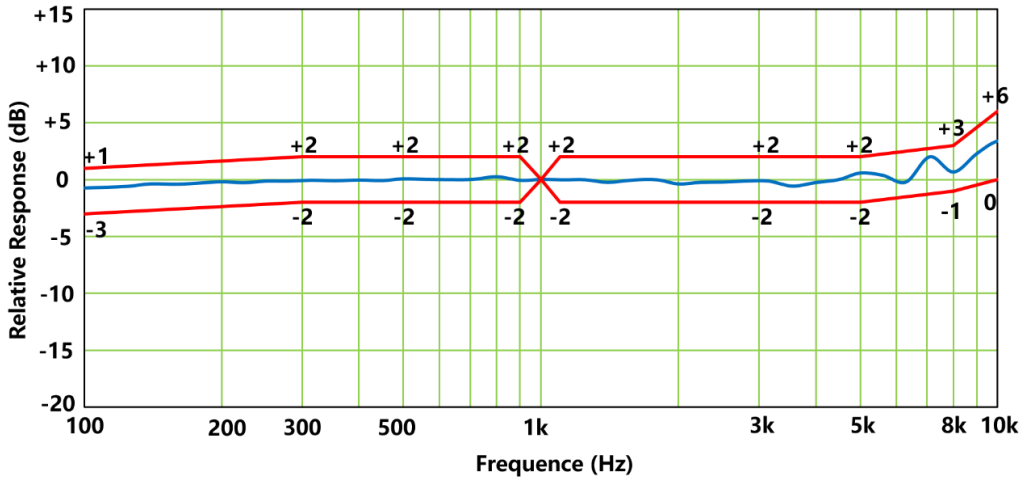
4.2 Microphone Characteristics

M-VDD = 2.0V, unless otherwise noted.

Table 5: Operating conditions, output signal and mechanical characteristics

Parameter	Symbol	Condition	Min	Type	Max	Units
Directivity	Omni directional					
Supply voltage	VDD		1.6	2.0	3.6	V
Output impedance	Zout	f=1kHz, Pin=1Pa			400	Ω
Current consumption	IDD			120	150	μA
Sensitivity	S	f=1kHz,pin=1Pa	-39	-38	-37	dB
Decreasing voltage characteristic	△S	f=1kHz,pin=1Pa Vs=3.6→1.6V	No Change			
S/N ratio	S/N	f=1kHz,pin=1Pa A-weighted curve		65		dB
Power supply rejection	PSR	100mVpp square wave@217Hz VDD=2.0V, A-weighted		-96		dBV
Total harmonic distortion	THD	94dB SPL@1kHz			1	%
Acoustic overload point	AOP	10% THD@1kHz		120		dB SPL

Frequency Response Curve and Limits:



4.3 Crosstalk Characteristics

The CAPB18-002 allows the pressure sensor to be used in the same package as a MEMS microphone with little causing interference or crosstalk.

Parameter	Symbol	Condition	Min	Type	Max	Units
Crosstalk	S/N	Only MIC working		65		dB
		MIC and pressure sensor working at the same time; pressure sensor working mode OSR=2，ODR=8		64.5		
		MIC and pressure sensor working at the same time; pressure sensor working mode OSR=2，ODR=16		64		
		MIC and pressure sensor working at the same time; pressure sensor working mode OSR=2，ODR=32		62.5		
		MIC and pressure sensor working at the same time; pressure sensor working mode OSR=16，ODR=8		64.5		
		MIC and pressure sensor working at the same time; pressure sensor working mode OSR=64，ODR=8		64.5		

5. Operation of Pressure Module

5.1 Operating Modes

The CAPB18-002 supports 3 different modes of operation: Standby, Command, and Background mode.

- Standby Mode
  - Default mode after power on or reset. No measurements are performed.
  - All registers and compensation coefficients are accessible.
- Command Mode
  - One temperature or pressure measurement is performed according to the selected precision.
  - The sensor will return to Standby Mode when the measurement is finished, and the measurement result will be available in the data registers.
- Background Mode
  - Pressure and/or temperature measurements are performed continuously according to the selected measurement precision and rate. The temperature measurement is performed immediately after the pressure measurement.
  - The FIFO can be used to store 32 measurement results and minimize the number of times the sensor must be accessed to read out the results.

Note: *Operation mode and measurement type are set in the Sensor Operating Mode and Status (MEAS_CFG) register.*

5.2 Measurement Precision and Rate

Different applications require different measurement precision and measurement rates. Some applications, like weather stations, require lower precision and measurement rates than for instance indoor navigation and sports applications.

The CAPB18-002's measurement precision and rate (in background mode) can be configured to match the requirements of the application in which it is being used. This reduces current consumption of the sensor and the system.

In order to achieve a higher precision, the CAPB18-002 will read the sensor multiple times (oversampling), and combine the readings into one result. This increases the current consumption and the measurement time, which again reduces the maximum measurement rate.

The measurement precision, rate and time is set in the *Pressure Configuration (PRS_CFG)* and *Temperature Configuration (TMP_CFG)* registers. The register descriptions contain information about the current consumption and the possible combinations of measurement precision, time, and rate.

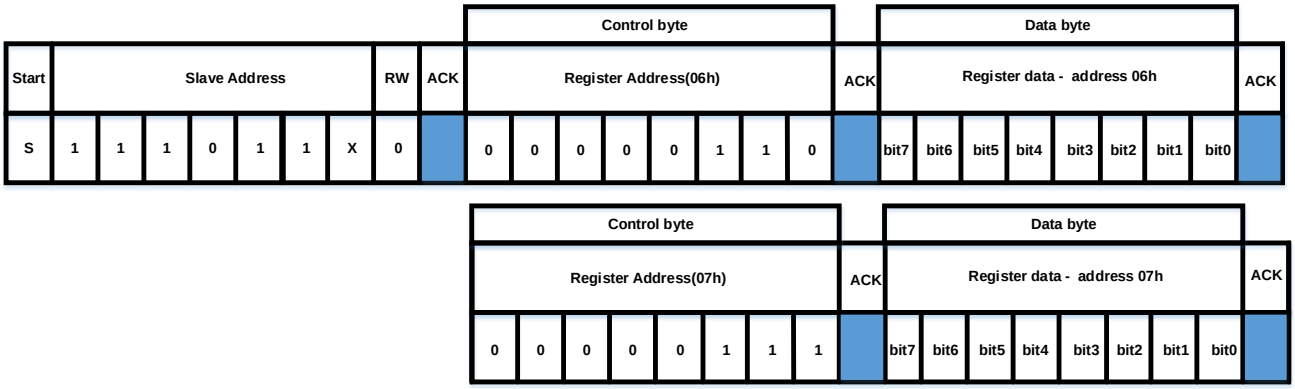
Please note that the pressure sensor is temperature dependent. Temperature measurements must be made together with the pressure measurements in order to compensate for the temperature dependency. This reduces the maximum pressure measurement rate, *since: Ratetemperature*Timetemperature + Ratepressure*Timepressure< 1 second.* Measurement Settings and Use Case Examples contains a table with examples of combinations of pressure and temperature precision and rates for different use cases.

5.3 Sensor I2C Interface

The CAPB18-002 can be accessed as a slave device through I2C serial interface. And the sensor's address is 0x77 (default).

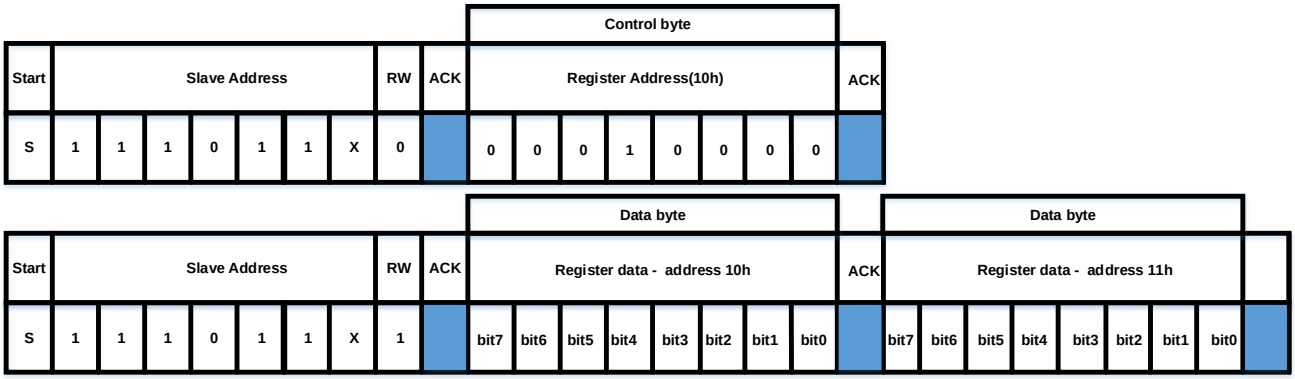
I2C write

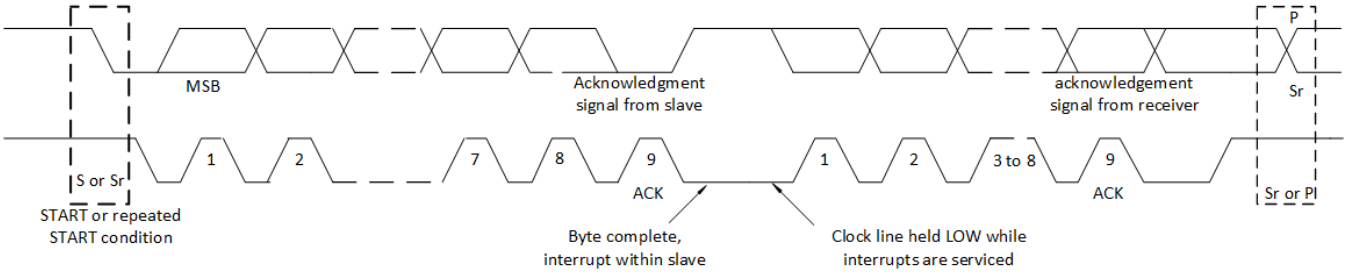
Writing is done by sending the slave address in write mode (RW=’0’), resulting in slave address 11101110. Then the master sends pairs of register addresses and register data. The transaction is ended by a stop condition.



I2C read

To be able to read registers, first the register address must be sent in write mode (slave address 11101110). Then either a stop or a repeated start condition must be generated. After this the slave is addressed in read mode (RW='1') at address 11101111, after which the salve sends out data from auto-incremented register addresses until a NOACKM and stop condition occurs.





Data transfer on the I2C-bus

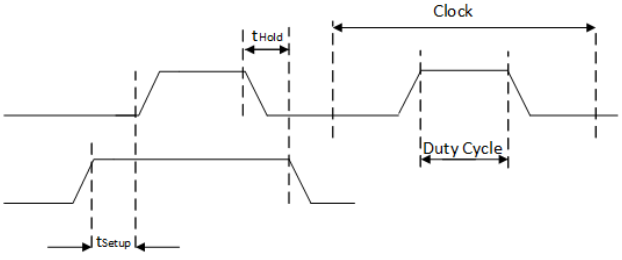


Table 6: I2C timings

Parameter	Symbol	Values			Unit	Note
		Min.	Typ.	Max.		
Data setup time on SDA pin	T_{Setup}	20			ns	S&F mode
		5			ns	HS mode
Data hold time on SDA pin	T_{Hold}	0			ns	S&F&HS mode
Duty cycle	DCt_{Low}			70	%	S&F mode
				55	%	HS mode

5.4 FIFO Operation

The CAPB18-002 FIFO can store the last 32 measurements of pressure or temperature. This reduces the overall system power consumption when the host processor does not need to continuously pull data from the sensor but can go into standby mode for longer periods of time.

The FIFO will store any combination of temperature and pressure measurements since the measurement rate of temperature and pressure can be set up independently in Background Mode. The pressure rate can for instance be set 4 times higher than the temperature rate and thus only every fifth result will be a temperature result. The measurement type can be seen in the result data. The sensor will set the least significant bit to:

- '1' if the result is a pressure measurement.
- '0' if it is a temperature measurement.

- The sensor uses 24 bits to store the measurement result. Because this is more bits than is needed to cover the full dynamic range of the pressure sensor, using the least significant bit to label the measurement type will not affect the precision of the result.

The FIFO can be enabled in the Interrupt and *FIFO configuration (CFG_REG) register.* The data from the FIFO is read out from the *Pressure Data (PRS_Bn) registers* regardless of the next result in the FIFO is a temperature or a pressure measurement.

When a measurement has been read out, the FIFO will auto increment and place the next result in the data register. A flag will be set in the *FIFO Status (FIFO_STS) register* when the FIFO is empty and all following reads will return 0x800000.

If the FIFO runs full a flag will be set in the *FIFO Status (FIFO_STS) register* and the sensor will generate an interrupt if this has been enabled in the Interrupt and *FIFO configuration (CFG_REG) register.*

5.5 Calibration and Measurement Compensation

The CAPB18-002 is a calibrated sensor and contains calibration coefficients. These are used in the

application (for instance by the host processor) to compensate the measurement results for sensor non-linearity's.

The sections that follow, describe how to calculate the compensated results and convert them into Pa and °C values.

5.5.1 How to Calculate Compensated Pressure Values

1. Read the calibration coefficients (c00, c10, c20, c30, c40, c01, c11, c21 and c31) from the Calibration Coefficient register.

Note: *The coefficients c00 is 20 bit 2´s complement numbers, c10 is 19 bit 2´s complement numbers, c20, c01 are 16 bit 2´s complement numbers, c30 is 15 bit 2´s complement numbers, c40, c21 are 12 bit 2´s complement numbers, and c11, c31 are 13 bit 2´s complement numbers.*

2. Choose scaling factors kT (for temperature) and kP (for pressure) based on the chosen precision rate. The scaling factors are listed in Table 7.

3. Read the pressure and temperature result from the registers or FIFO.

Note: The measurements read from the result registers (or FIFO) are 24 bit 2´s complement numbers.

Depending on the chosen measurement rates, the temperature may not have been measured since the last pressure measurement.

4. Calculate scaled measurement results.

$T_{raw\_sc} = T_{raw}/kT$

$P_{raw\_sc} = P_{raw}/kP$

5. Calculate compensated measurement results.

$$P_{comp}(Pa) = c00 + c10*P_{raw\_sc} + c20*P^2_{raw\_sc} + c30*P^3_{raw\_sc} + c40*P^4_{raw\_sc} + T_{raw\_sc}* (c01 + c11*P_{raw\_sc} + c21* P^2_{raw\_sc} + c31* P^3_{raw\_sc})$$

5.5.2 How to Calculate Compensated Temperature Values

1. Read the calibration coefficients (c0 and c1) from the Calibration Coefficients (COEF) register.

Note: The coefficients read from the coefficient register are 12 bit 2´s complement numbers.

2. Choose scaling factor kT (for temperature) based on the chosen precision rate. The scaling factors are listed in Table 7.

3. Read the temperature result from the temperature register or FIFO.

Note: The temperature measurements read from the temperature result register (or FIFO) are 24 bit 2´s complement numbers.

4. Calculate scaled measurement results.

$T_{raw\_sc} = T_{raw}/kT$

5. Calculate compensated measurement results

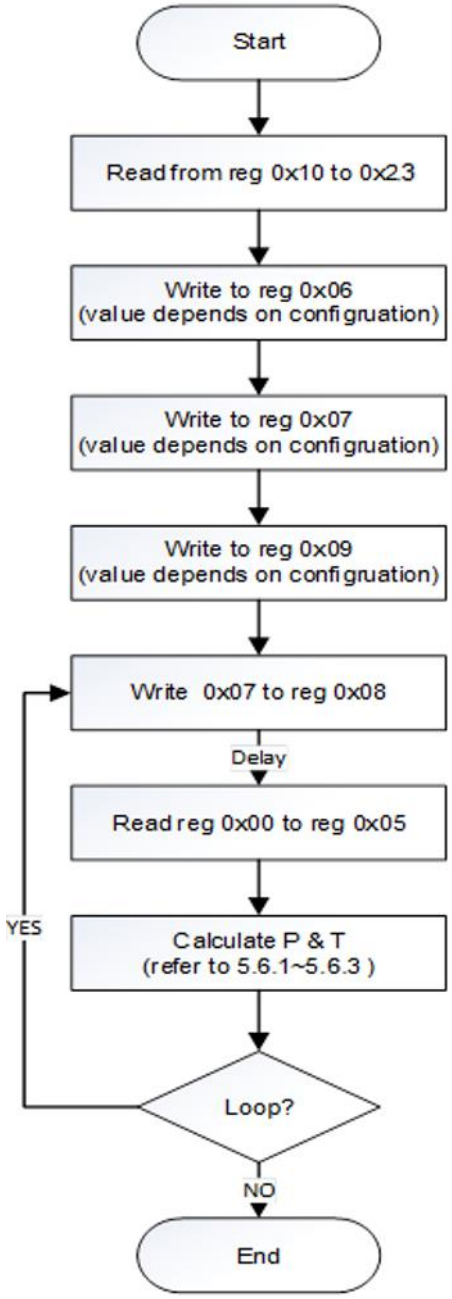
$T_{comp}(°C) = c0*0.5 + c1* T_{raw\_sc}$

5.5.3 Compensation Scale Factors

Table 7: Compensation Scale Factors

Oversampling Rate	Scale Factor (kP or kT)
1 (single)	524288
2 times (Low Power)	1572864
4 times	3670016
8 times	7864320
16 times (Standard)	253952
32 times	516096
64 times (High Precision)	1040384
128 times	2088960

5.5.4 Pressure and Temperature calculation flow



5.6 Applications

5.6.1 Measurement Settings and Use Case Examples

Table 8: Measurement Settings and Use Case Examples (TBD)

Use Case	Performance	Pressure Register Configuration Address: 0x06	Temperature Register Configuration Address: 0x07	Other
Weather Station (Low power, Background mode)	5 Pa precision. 1 pr sec. 6 μA	0x01	0x00	Start background measurements (addr 0x08)
Indoor navigation (Standard precision, Background mode)	10 cm precision. 2 pr sec. 30 μA	0x14	0x00	Enable P shift (addr 0x09) Start background measurements (addr 0x08)
Sports (High precision, high rate, background mode)	5 cm precision 4 pr sec. 200 μA	0x26	0x20	Enable P shift (addr 0x09) Start background measurements (addr 0x08)

5.6.2 Calculating absolute altitude and calculating pressure at sea level

With the measured pressure P and the pressure at sea level P0=1013.25hPa, the altitude in meters can be calculated with the international barometric formula:

$$\text{Altitude} = 44330 \times \left[1 - \left(\frac{P}{P_0}\right)^{\frac{1}{5.255}}\right]$$

Thus, a pressure change of Δ*p* = 1hPa corresponds to 8.43m at sea level.

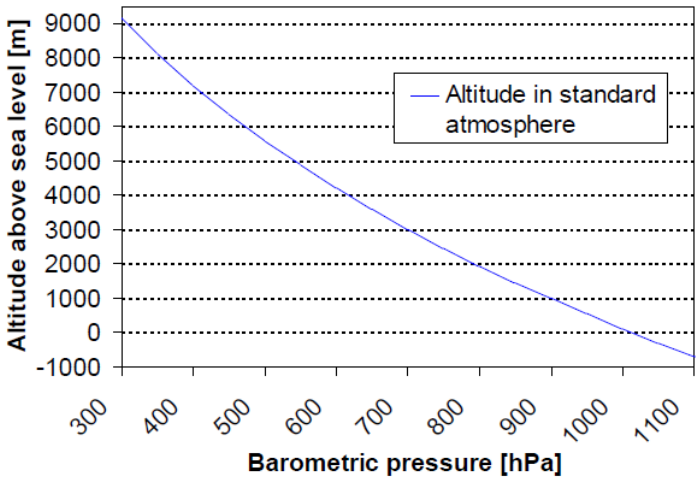


Figure 1: Transfer function: Altitude over sea level – Barometric pressure

With the measured pressure *p* and the absolute altitude the pressure at sea level can be calculated:

$$P_0 = \frac{p}{\left(1 - \frac{\text{altitude}}{44330}\right)^{5.255}}$$

Thus, a difference in altitude of Δaltitude = 10m corresponds to 1.2hPa pressure change at sea level.

5.7 Register Map

Table 9: Register Map

Register Name	Addr.	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	Reset State
PSR_B2	0x00	PSR[23:16] (r)								00h
PSR_B1	0x01	PSR[15:8](r)								00h
PSR_B0	0x02	PSR[7:0](r)								00h
TMP_B2	0x03	TMP[23:16] (r)								00h
TMP_B1	0x04	TMP[15:8] (r)								00h
TMP_B0	0x05	TMP[7:0] (r)								00h
PRS_CFG	0x06	-	PM_RATE [2:0] (rw)			PM_PRC [3:0] (rw)				00h
TMP_CFG	0x07	TMP_EXT (rw)	TMP_RATE [2:0] (rw)			-	TM_PRC [2:0] (rw)			00h
MEAS_CFG	0x08	COEF_ RDY (r)	SENS OR _RDY	TMP _RDY (r)	PRS_ RDY (r)	-	MEAS_CRTL [2:0] (rw)			00h

CFG_REG	0x09	INT_ HL (rw)	INT_ SEL [2:0] (rw)			TMP_ SHIFT_ EN (rw)	PRS_ SHIFT _EN	FIFO_ EN (rw)	SPI_ MODE (rw)	00h
INT_STS	0x0A	-	-	-	-	-	INT_ FIFO_ FULL()	INT_ TMP (r)	INT_ PRS (r)	00h
FIFO_STS	0x0B	-	-	-	-	-	-	FIFO_ FULL (r)	FIFO_ EMPTY (r)	00h
RESET	0x0C	FIFO_ FLUSH (w)	-	-	-	SOFT_RST [3:0] (w)				00h
Product ID	0x0D	REV_ID [3:0] (r)				PROD_ID [3:0] (r)				10h
COEF	0x10-0x21	< see register description >								XXh
Reserved	0x22-0x27	Reserved								XXh

5.8 Register Description

5.8.1 Pressure Data (PRS_Bn)

The Pressure Data registers contains the 24 bit (3 bytes) 2's complement pressure measurement value. If the FIFO is enabled, the register will contain the FIFO pressure and/or temperature results (please see *FIFO Operation*). Otherwise, the register contains the pressure measurement results and will not be cleared after read.

5.8.1.1 PRS_B2

The highest byte of the three bytes measured pressure value.

PRS_B2 Address 00H

Pressure (MSB data) Reset value: 00H

7	6	5	4	3	2	1	0
PRS23	PRS22	PRS21	PRS20	PRS19	PRS18	PRS17	PRS16
r							

Field	Bits	Type	Description
PRS[23:16]	7:0	r	MSB of 24 bit 2´s complement pressure data.

5.8.1.2 PRS_B1

The middle byte of the three bytes measured pressure value.

PRS_B1				Address			01H
Pressure (LSB data)				Reset value:			00H
7	6	5	4	3	2	1	0
PRS15	PRS14	PRS13	PRS12	PRS11	PRS10	PRS9	PRS8
r							

Field	Bits	Type	Description
PRS[15:8]	7:0	r	LSB of 24 bit 2´s complement pressure data.

5.8.1.3 PRS_B0

The lowest byte of the three bytes measured pressure value.

PRS_B0				Address			02H
Pressure (XLSB data)				Reset value:			00H
7	6	5	4	3	2	1	0
PRS7	PRS6	PRS5	PRS4	PRS3	PRS2	PRS1	PRS0
r							

Field	Bits	Type	Description
PRS[7:0]	7:0	r	XLSB of 24 bit 2´s complement pressure data.

5.8.2 Temperature Data (TMP_Tn)

The Temperature Data registers contain the 24 bit (3 bytes) 2's complement temperature measurement value (unless the FIFO is enabled, please see *FIFO Operation*) and will not be cleared after the read.

5.8.2.1 TMP_B2

The highest byte of the three bytes measured temperature value.

TMP_B2				Address			03H
Temperature (MSB data)				Reset value:			00H
7	6	5	4	3	2	1	0
TMP23	TMP22	TMP21	TMP20	TMP19	TMP18	TMP17	TMP16
r							

Field	Bits	Type	Description
TMP[23:16]	7:0	r	MSB of 24 bit 2´s complement temperature data.

5.8.2.2 TMP_B1

The middle byte of the three bytes measured temperature value.

TMP_B1				Address			04H
Temperature (LSB data)				Reset value:			00H
7	6	5	4	3	2	1	0
TMP15	TMP14	TMP13	TMP12	TMP11	TMP10	TMP9	TMP8
r							

Field	Bits	Type	Description
TMP[15:8]	7:0	r	LSB of 24 bit 2´s complement temperature data.

5.8.2.3 TMP_B0

The lowest part of the three bytes measured temperature value.

TMP_B0				Address			05H
Temperature (XLSB data)				Reset value:			00H
7	6	5	4	3	2	1	0
TMP7	TMP6	TMP5	TMP4	TMP3	TMP2	TMP1	TMP0
r							

Field	Bits	Type	Description
TMP[7:0]	7:0	r	XLSB of 24 bit 2´s complement temperature data.

5.8.3 Pressure Configuration (PRS_CFG)

Configuration of pressure measurement rate (PM_RATE) and resolution (PM_PRC).

PRS_CFG Address: 06H

Pressure measurement configuration Reset value: 00H

7	6	5	4	3	2	1	0
-	PM_RATE[2:0]			PM_PRC[3:0]			
-	rw			rw			

Field	Bits	Type	Description
-	7	-	Reserved
PM_RATE[2:0]	6:4	rw	Pressure measurement rate: 000 - 1 measurements pr. sec. 001 - 2 measurements pr. sec. 010 - 4 measurements pr. sec. 011 - 8 measurements pr. sec. 100 - 16 measurements pr. sec. 101 - 32 measurements pr. sec. 110 - 64 measurements pr. sec. 111 - 128 measurements pr. sec. *Applicable for measurements in Background mode only*
PM_PRC[3:0]	3:0	rw	Pressure oversampling rate: 0000 - Single. (Low Precision) 0001 - 2 times (Low Power). 0010 - 4 times. 0011 - 8 times. 0100 *) - 16 times (Standard). 0101 *) - 32 times. 0110 *) - 64 times (High Precision). 0111 *) - 128 times. 1xxx – Reserved

*) Note: Use in combination with a bit shift. See *Interrupt and FIFO configuration (CFG_REG)* register

Table 10: Pressure measurement time (ms) and precision (PaRMS)

Oversampling (PRC[3:0])	Single (0000)	2 times (0001)	4 times (0010)	8 times (0011)	16 times (0100)	32 times (0101)	64 times (0110)	128 times (0111)
Measurement time (ms)	3.6	5.2	8.4	14.8	27.6	53.2	104.4	206.8
Precision (PaRMS)	5		2.5		1.2	0.9	0.5	

Table 11: Estimated current consumption (μA)

Oversampling (PRC[3:0]) / Measurements pr sec.(PM_RATE([2:0])	Single (0000)	2 times (0001)	4 times (0010)	8 times (0011)	16 times (0100)	32 times (0101)	64 times (0110)	128 times (0111)
1 (0000)	2.1	2.7	3.8	6.1	11	20	38	75
2 (0001)								
4 (0010)								
8 (0011)	Note: The current consumption can be calculated as the Measurement Rate * Current Consumption of 1 measurement							n.a.
16 (0100)							n.a.	n.a.
32 (0101)						n.a.	n.a.	n.a.
64 (0110)					n.a.	n.a.	n.a.	n.a.
128 (0111)			n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

Note: The table shows the possible combinations of Pressure Measurement Rate and oversampling when no temperature measurements are performed. When temperature measurements are performed the possible combinations are limited to $Rate_{temperature}$ *x Measurement* $Time_{temperature}$ + $Rate_{pressure}$ *x Measurement* $Time_{pressure}$ < *1 second.*

5.8.4 Temperature Configuration (TMP_CFG)

Configuration of temperature measurement rate (TMP_RATE) and resolution (TMP_PRC).

TMP_CFG Address: 07H

Temperature measurement configuration Reset value: 00H

7	6	5	4	3	2	1	0
TMP_ EXT	TMP_RATE[2:0]			-	TMP_PRC[2:0]		

rw	rw	-	rw
Field	Bits	Type	Description
TMP_ EXT	7	rw	Temperature measurement 0 - Internal sensor (in ASIC) 1 - External sensor (in pressure sensor MEMS element) Note: This bit **must** be set to '0'.
TMP_RATE[2:0]	6:4	rw	Temperature measurement rate: 000 - 1 measurement pr. sec. 001 - 2 measurements pr. sec. 010 - 4 measurements pr. sec. 011 - 8 measurements pr. sec. 100 - 16 measurements pr. sec. 101 - 32 measurements pr. sec. 110 - 64 measurements pr. sec. 111 - 128 measurements pr. sec. *Applicable for measurements in Background mode only*
-	3	-	Reserved
TMP_PRC[2:0]	2:0	rw	Temperature oversampling (precision): 000 - single. (Default) - Measurement time 3.6 ms. *Note: Following are optional, and may not be relevant*: 001 - 2 times. 010 - 4 times. 011 - 8 times. 100 - 16 times. 101 - 32 times. 110 - 64 times. 111 - 128 times.

5.8.5 Sensor Operating Mode and Status (MEAS_CFG)

Setup measurement mode.

MEAS_CFG				Address			08H
Measurement configuration				Reset value:			c0H
7	6	5	4	3	2	1	0

COEF_RDY	SENSOR_RDY	TMP_RDY	PRS_RDY	-	MEAS_CTRL
r	r	r	r		rw

Field	Bits	Type	Description
COEF_RDY	7	r	Coefficients will be read to the Coefficients Registers after start- up: 0 - Coefficients are not available yet. 1 - Coefficients are available.
SENSOR_RDY	6	r	The pressure sensor is running through self-initialization after start-up. 0 - Sensor initialization not complete 1 - Sensor initialization complete It is recommend not to start measurements until the sensor has completed the self-initialization.
TMP_RDY	5	r	Temperature measurement ready 1 - New temperature measurement is ready. Cleared when temperature measurement is read.
PRS_RDY	4	r	Pressure measurement ready 1 - New pressure measurement is ready. Cleared when procurement measurement is read.
-	3	-	Reserved.
MEAS_CTRL	2:0	rw	Set measurement mode and type: Standby Mode 000 - Idle / Stop background measurement Command Mode 001 - Pressure measurement 010 - Temperature measurement 011 - na. 100 - na. Background Mode 101 - Continuous pressure measurement 110 - Continuous temperature measurement 111 - Continuous pressure and temperature measurement

5.8.6 Interrupt and FIFO configuration (CFG_REG)

Configuration of interrupts, measurement data shift, and FIFO enable.

CFG_REG				Address			09H
Configuration register				Reset value:			00H
7	6	5	4	3	2	1	0
INT_HL	INT_FIFO	INT_TMP	INT_PRS	T_SHIFT	P_SHIFT	FIFO_EN	SPI_MODE-
rw	rw	rw	rw	rw	rw	rw	rw

Field	Bits	Type	Description
INT_HL	7	rw	Interrupt (on SDO pin) active level: 0 - Active low. 1 - Active high.
INT_FIFO	6	rw	Generate interrupt when the FIFO is full: 0 - Disable. 1 - Enable.
INT_TMP	5	rw	Generate interrupt when a temperature measurement is ready: 0 - Disable. 1 - Enable.
INT_PRS	4	rw	Generate interrupt when a pressure measurement is ready: 0 - Disable. 1 - Enable.
T_SHIFT	3	rw	Temperature result bit-shift 0 - no shift. 1 - shift result right in data register. Note: Must be set to '1' when the oversampling rate is >8 times.
P_SHIFT	2	rw	Pressure result bit-shift 0 - no shift. 1 - shift result right in data register. Note: Must be set to '1' when the oversampling rate is >8 times.

FIFO_EN	1	rw	Enable the FIFO: 0 - Disable. 1 - Enable.
SPI_MODE	0	rw	Set SPI mode: 0-4-wire interface. 1-3-wire interface.

5.8.7 Interrupt Status (INT_STS)

Interrupt status register. The register is cleared on read.

INT_STS						Address		0AH
Interrupt status						Reset		00H
7	6	5	4	3	2	1	0	
-					INT_FIFO_FULL	INT_TMP	INT_PRS	
-					r	r	r	

Field	Bits	Type	Description
-	7:3	-	Reserved.
INT_FIFO_FULL	2	r	Status of FIFO interrupt 0 - Interrupt not active 1 - Interrupt active
INT_TMP	1	r	Status of temperature measurement interrupt 0 - Interrupt not active 1 - Interrupt active
INT_PRS	0	r	Status of pressure measurement interrupt 0 - Interrupt not active 1 - Interrupt active

5.8.8 FIFO Status (FIFO_STS)

FIFO status register

FIFO_STS	Address	0BH
FIFO status register	Reset value:	00H

7	6	5	4	3	2	1	0
-						FIFO_FULL	FIFO_EMPTY
-						r	r

Field	Bits	Type	Description
-	7:2	-	Reserved.
FIFO_FULL	1	r	0 - The FIFO is not full 1 - The FIFO is full
FIFO_EMPTY	0	r	0 - The FIFO is not empty 1 - The FIFO is empty

5.8.9 Soft Reset and FIFO flush (RESET)

Flush FIFO or generate soft reset.

RESET	Address:	0CH
FIFO flush and soft reset	Reset value:	00H

7	6	5	4	3	2	1	0
FIFO_FLUSH	-			SOFT_RST			
w	-			w			

Field	Bits	Type	Description
FIFO_FLUSH	7	w	FIFO flush 1 - Empty FIFO After reading out all data from the FIFO, write '1' to clear all old data.
-	6:4	-	Reserved.
SOFT_RST	3:0	w	Write '1001' to generate a soft reset. A soft reset will run through the same sequences as in power-on reset.

5.8.10 Product and Revision ID (ID)

Product and Revision ID.

ID	Address	0DH
Product and revision ID	Reset value:	0x10H

7	6	5	4	3	2	1	0

REV_ID	PROD_ID
r	r

Field	Bits	Type	Description
REV_ID	7:4	r	Revision ID
PROD_ID	3:0	r	Product ID

5.8.11 Calibration Coefficients (COEF)

The Calibration Coefficients register contains the 2´s complement coefficients that are used to calculate the compensated pressure and temperature values.

Table 12: Calibration Coefficients

Coefficient	Addr.	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
c0	0x10	c0 [11:4]							
c0/c1	0x11	c0 [3:0]				c1 [11:8]			
c1	0x12	c1[7:0]							
c00	0x13	c00 [19:12]							
c00	0x14	c00 [11:4]							
c00/c10	0x15	c00 [3:0]				c10 [18:15]			
c10	0x16	c10 [14:7]							
c10/c11	0x17	c10 [6:0]							c11 [12]
c11	0x18	c11 [11:4]							
c11/c21	0x19	c11 [3:0]				c21 [11:8]			
c21	0x1A	c21 [7:0]							
c20	0x1B	c20 [15:8]							
c20	0x1C	c20 [7:0]							
c01	0x1D	c01 [15:8]							
c01	0x1E	c01 [7:0]							

c30	0x1F	c30 [14:7]	
c30/C31	0x20	c30 [6:0]	C31 [12]
c31	0x21	c31 [11:4]	
c31/c40	0x22	c31 [3:0]	c40 [11:8]
c40	0x23	c40 [7:0]	

6. Application Circuit Example

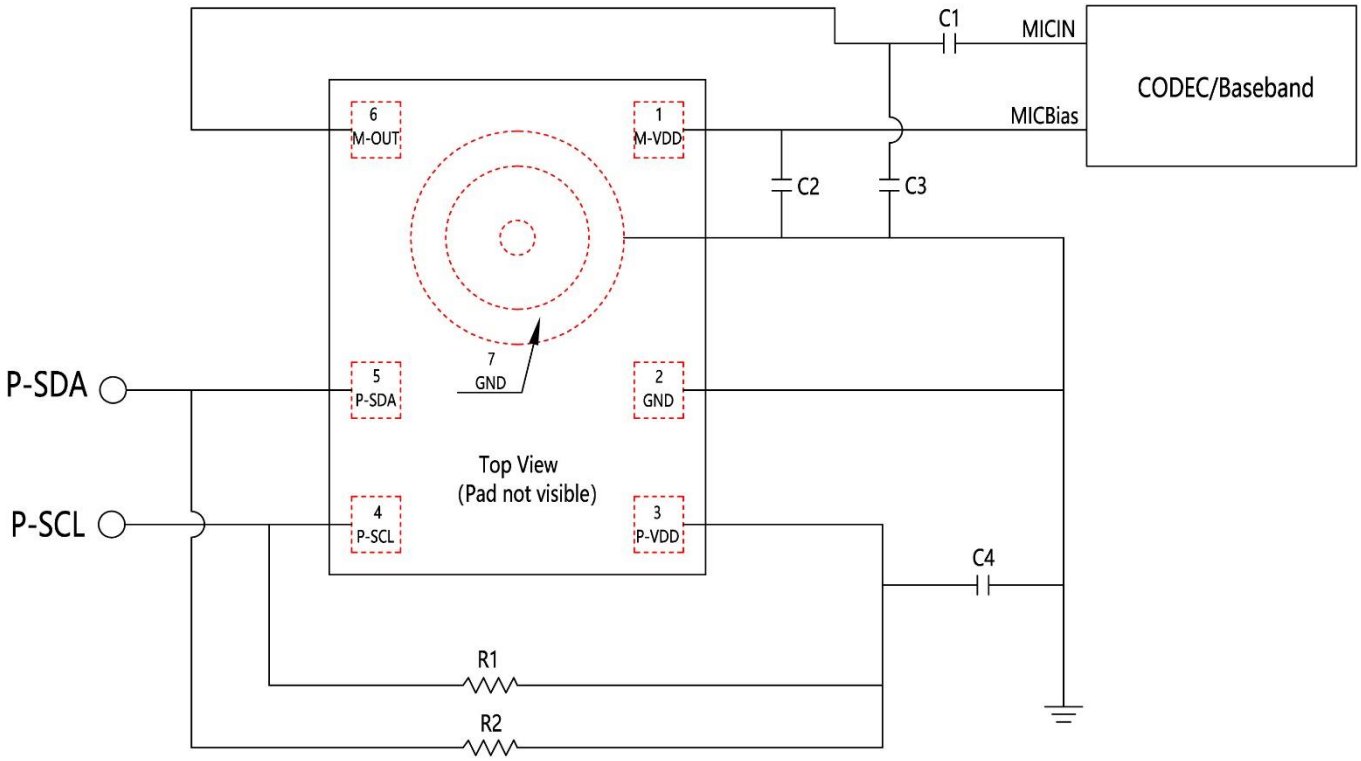


Figure 2: Typical Application Circuit

Table13: Component Values

Component	Symbol	Values			Note / Test Condition
		Min.	Typ.	Max.	
	C1	Depending on codec			
Supply Blocking Capacitor	C2		100nF		placed as close to the package pins as
RF Filter Capacitor	C3		33pF		

Pull-up Resistor	R_1, R_2	2.2kΩ	4.7 kΩ		R2 is optional
Supply Blocking Capacitor	C4		100nF		The blocking capacitors should be placed as close to the package pins as possible.

7 Mechanical characteristics

7.1 Pin configuration

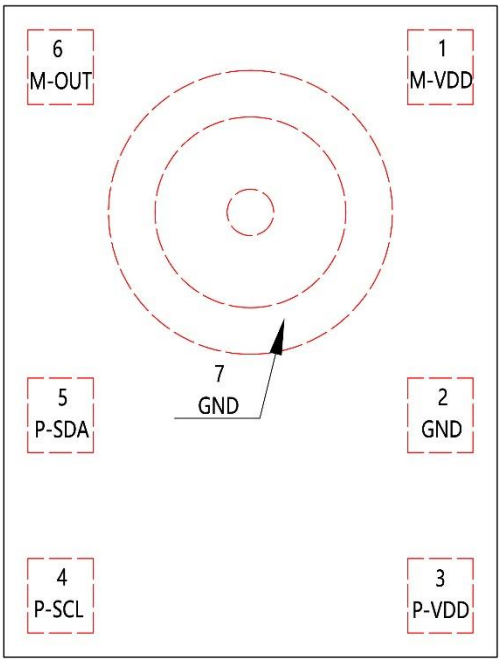


Figure 3: Layout pin configuration CAPB18-002（Top View, PAD Not Visible）

Table14: Pin configuration of CAPB18-002

Pin No.	Name	Function
1	M-VDD	Microphone Power
2	GND	Ground for MIC and pressure
3	P-VDD	Pressure Power
4	P-SCL	Pressure Serial Clock
5	P-SDA	Pressure Serial data in/out
6	M-OUT	Microphone Output
7	GND	Ground for MIC and pressure

7.2 Outline dimensions

The sensor housing is a 7 Pin LGA package with metal lid. Its dimensions are 3.5mm (±0.1 mm) x 2.65mm (±0.1 mm) x1.0mm (±0.1mm), undeclared tolerance (±0.1mm)

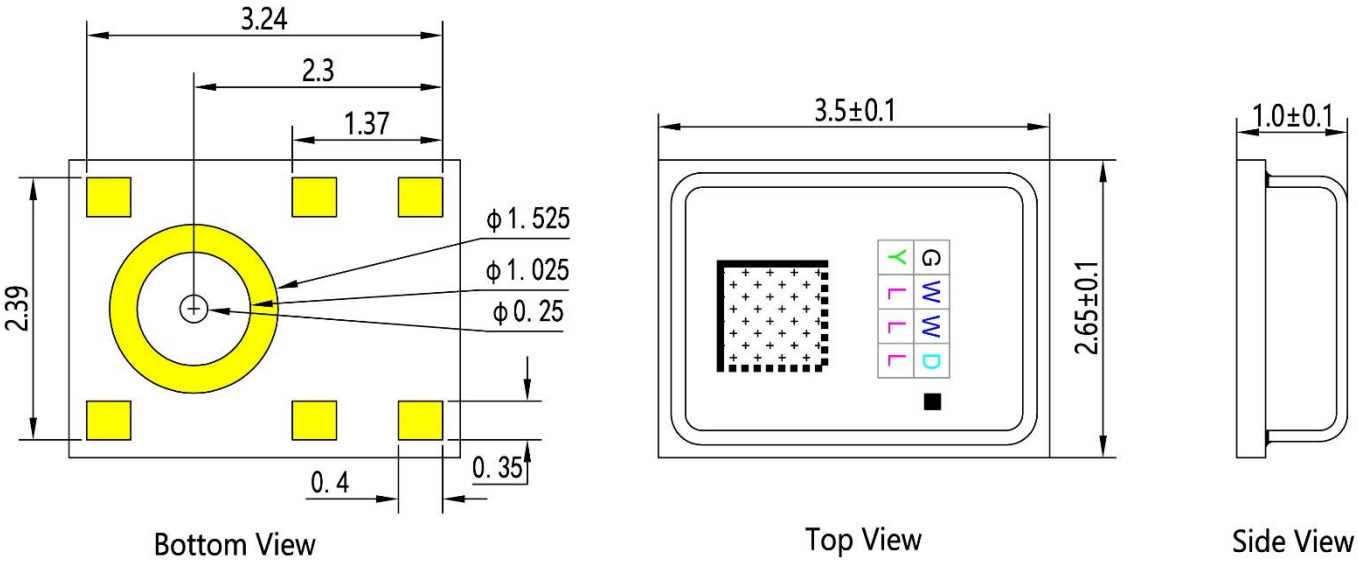


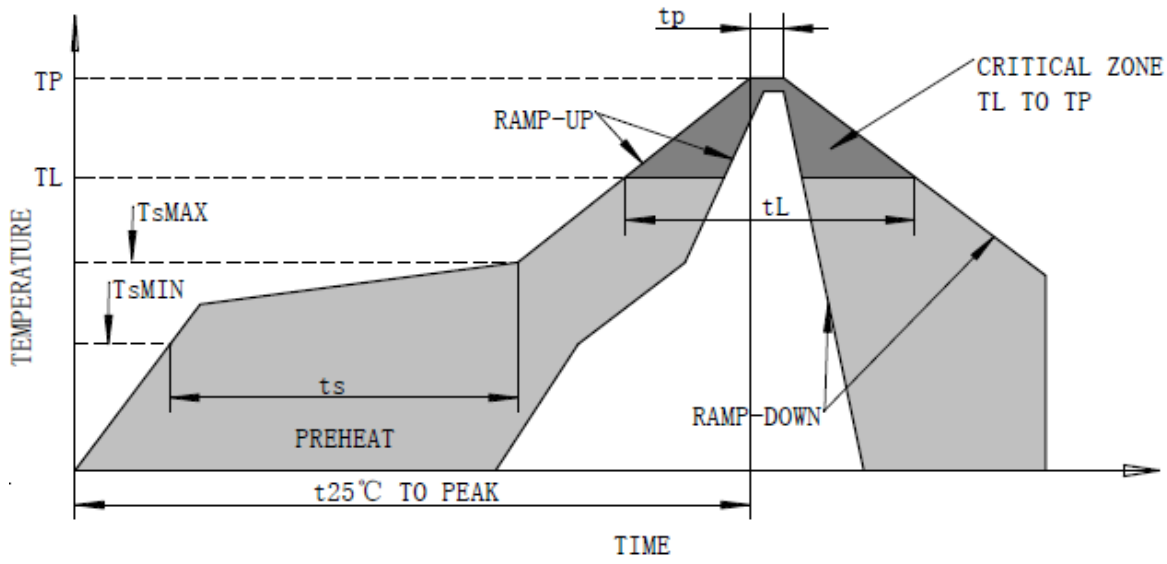
Figure 4: CAPB18-002 outline and size

8 Storage and transportation

- Keep in warehouse with less than 75% humidity and without sudden temperature change, acid air, any other harmful air or strong magnetic field. Recommend storage period no more than 1 year and floor life(out of bag) at factory no more than 4 weeks.
- The MEMS pressure sensor with normal pack can be transported by ordinary conveyances. Please protect products against moist, shock, sunburn and pressure during transportation.
- Storage Temperature Range：-40℃～+85℃
- Operating Temperature Range：-40℃～+85℃

9 Soldering recommendation

Recommended Solder Reflow



Profile Feature	Pb-Free Assembly
Average ramp-up rate(TsMAX to TP)	3℃/seconds max.
Preheat -Temperature Min.(TsMIN) -Temperature Max.(TsMAX) -Time(TsMIN to TsMAX)(Ts)	 150℃ 200℃ 60～80seconds
Time maintained above: -Temperature(TL) -Time(tL)	 217℃ 60～150seconds
Peak temperature(TP)	260℃
Time within 5℃ of actual peak temperature(TP)2	20～40seconds
Ramp-down rate	4℃/seconds max
Time 25℃ to peak temperature	8 minutes max

10 Package Specifications

Carrier Tape Information [Unit: mm]
Quantity per reel: 5kpcs.

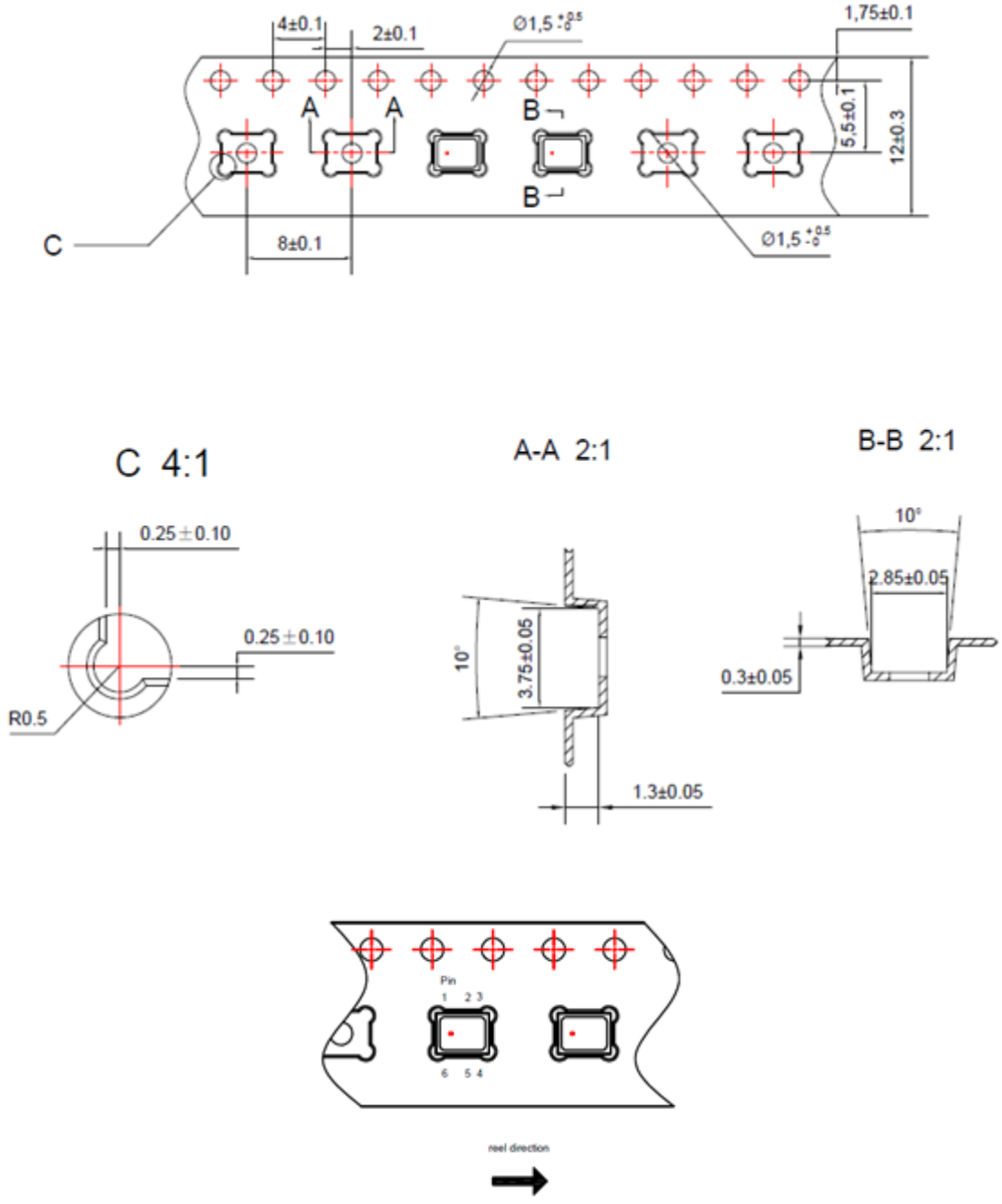


Figure 5: Carrier Tape

11 Cautions When Using Sensor Unit

- Board Wash Restrictions
  It is very important not be subjected to any liquid or gaseous cleaning methods, otherwise this may damage the sensor.
- Strong airflow(such as nozzle) Restrictions
  It is very important not to be pull a nozzle over the acoustic port of the microphone module or blow the acoustic port, otherwise this may damage the microphone.
- Away from dust or particle
  It is very important to protect the sensor from dust or particle, otherwise this may pollute the membrane of microphone module, and lower the performance of sensor.
- Away from Mechanical stress
  It is very important to set the sensor away from mechanical stress from assembling process or mechanical structure, otherwise this may make the pressure module swift from calibration value.
- Ultrasonic Restrictions
  It is very important not to use ultrasonic procedures, otherwise this may damage the microphone module.

Please refer to Design Guide of CAPB18-002 for detailed information**.**

12 Land Pattern and Stencil Design

12.1 Pin configuration

The following figure shows the design recommendations for the client PCB pad.

- The sound hole of the product is designed at the bottom to prevent too much solder paste from remaining around the sound hole, which hinders the acoustic channel.
- PCB sound hole size design needs to meet acoustic requirements to ensure better MIC frequency response. At the same time, it is necessary to ensure that there is a wide enough welding ring pad around the sound hole, so that the welding between microphone and PCB pad is completely sealed to avoid sound leakage.
- PCB sound hole should be non-metallic through-hole to avoid solder paste flowing into the sound hole, resulting in sound hole blockage.

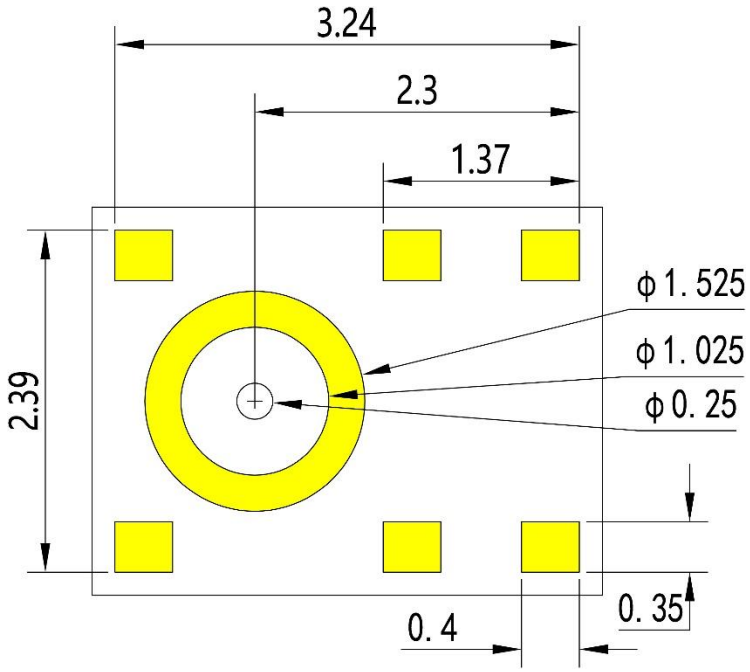


Figure 6: Land Pattern

***Note**: the yellow area is PCB pad (1:1 window opening)*
It is recommended to open the window 1:1 for solder paste screen

12.2 Stencil Design

- When applying solder paste, stainless steel template is recommended;
- The recommended stencil for silk screen printing is 90-150 μ m (3.5-6 mil);
- The stencil opening of signal pad should account for 70-90% of PCB pad area;
- In order to release the solder paste better, the hole wall should be trapezoidal and the corners should be rounded.
- Tight IC lead arrangement requires accurate alignment of stencil and PCB. Before using solder paste, the assembly accuracy of stencil and printed circuit should be within 25 μ m (1 mil).

13 Reliability Specifications

No.	Test Items	Test condition
1	High Temperature Storage	125℃,1000h（JESD22-A103）
2	High Temperature & Humidity Test	85℃, 85%R.H, 1000h, V=Vcc max（JESD22-A101）
3	Thermal Shock Test	-40℃/0.5 hours ~125℃/0.5 hours, 500 cycles（JESD22-A106）
4	Mechanical Shock Test	3000g,0.3ms,6axes*3 times（JESD22-B110）
5	Vibration Test	From 20 to 2000Hz peak acceleration 20g,16min/axis(4 cycles),X,Y and Z axis total 48 minutes（JESD22-B103）
6	ESD-HBM	±2KV,3 times for each pad（JESD22-A114）