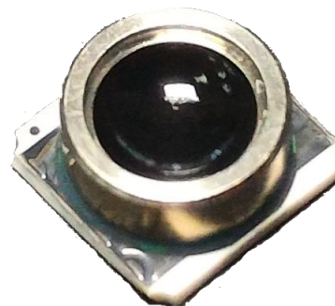## PBM220 series
Digital barometer

Features

- Supply voltage:
    1.7 to 5.5V(V_{DD})
    1.2 to 5.5V(V_{DDIO})
- 300 to 1100 hPa pressure range
- 8cm altitude resolution (RMS)
- 2.2ms fastest conversion time
- Standby current <0.1µA
- I^2C and SPI interfaces
- Calibrated and temperature compensated

Application Examples

- Outdoor PND
- Sport watch
- Diving watch
- Weather forecast device
- Smart watch
- Altimeter and barometer for portable device
- Bike computer

Descriptions

The PBM220 is a new generation of high resolution digital barometer. The PBM220 is a digital pressure sensor which consists of a MEMS piezoresistive pressure sensor and a signal conditioning ASIC. The ASIC include a 24bits sigma-delta ADC, OTP memory for calibration data, and serial interface circuits. The PBM220 could provide both I^2C and SPI interface to communicate with microcontroller.

Pressure calibrated and temperature compensated were key features of the PBM220. The data stored in OTP memory could be used to calibrate the PBM220. The calibration procedure should be implemented by an external microprocessor. The PBM220 is low power and supply voltage designed and suitable for portable devices or battery-supplied ones. The PBM220 is designed for water resistant applications. It could meet the criterion of 100m water resistant according to ISO 2281 standard.
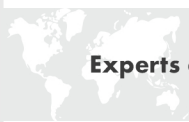
Ordering information

Part No.	Pressure type	Pressure range	Digital interface	Package	Note
PBM220-A11KDT	Absolute	300-1100hPa	SPI / I^2C	SMD	JEDEC tray
PBM220-A11KDR	Absolute	300-1100hPa	SPI / I^2C	SMD	Tape & Reel
PBM220-A11KDU	Absolute	300-1100hPa	SPI / I^2C	SMD	Tube

Experts on Design-In

Angst+Pfister
Sensors and Power

Index of contents

Experts on Design-In

Angst+Pfister
Sensors and Power

1   Functional Block and Pin Descriptions
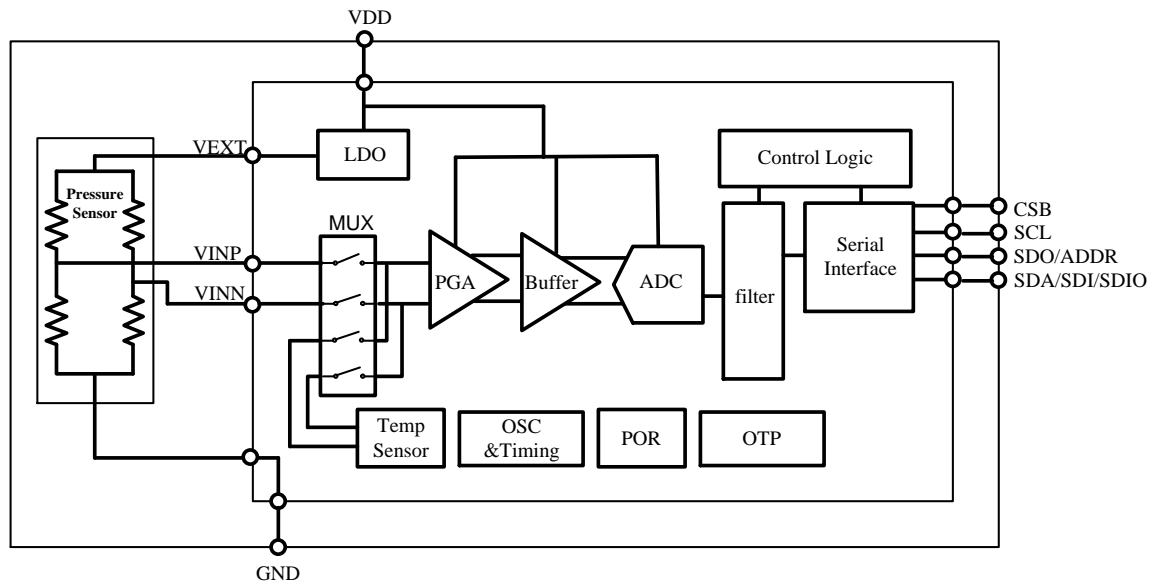
Fig. 1 Functional Block Diagram of PBM220

TOP VIEW
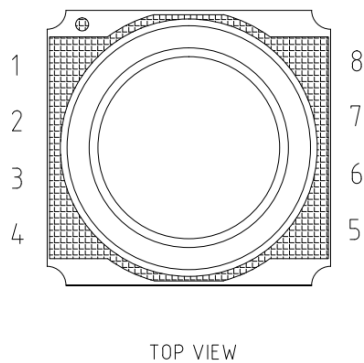
Pin No.	Pin Name	Description
1	SCL	Serial clock
2	GND	Ground supply
3	CSB	Chip Select
4	NC	Not connected
5	VDD	Power supply
6	NC	Not connected
7	SDA/SDI/SDIO	Serial data input/output in I^2C mode(SDA) Serial data input in 4-wire SPI mode(SDI) Serial data input/output in 3-wire SPI mode (SDIO)
8	SDO/ADDR	Serial data output in 4-wire SPI mode Address select in I^2C mode

Experts on Design-In

Angst+Pfister
Sensors and Power

2   Electrical Characteristic

Parameter	Symbol	Conditions	Min	Typ	Max	Units	Notes
Pressure range			300		1100	hPa	mbar
Operating temperature range			-40		85	°C	
Supply voltage	V_{DD}		1.7	3	5.5	V	
	V_{DDIO}		1.2		5.5	V	

Supply current
  Pressure measurement
    Ultra low power
    Standard
    High resolution
    Ultra high resolution
  Temperature measurement
	I_{DD}	V_{DD}=3V
		1 conversion/sec.
				3.0
				4.7
				7.7
				13.9
				1.9
					3.5
					6.4
					8.9
					16.0
					2.2
						µA	

Peak current during conversion
  Pressure measurement
  Temperature measurement
	I_{peak}	V_{DD}=3V		1.51
				0.95
						mA	

Standby current	I_{sd}			<0.1		µA	

Conversion time
  Pressure measurement
    Ultra low power
    Standard
    High resolution
    Ultra high resolution
  Temperature measurement
				2.2
				3.3
				5.4
				9.8
				2.2
					2.5
					3.7
					6.0
					10.7
					2.5
						ms	

Relative pressure accuracy V_{DD}=3V		750～1100 hPa 25℃	-0.5		0.5	hPa	2
		300～1000 hPa 0～50℃	-1		1	hPa	
		300～1100 hPa -40～85℃	-2		5	hPa	
Absolute pressure accuracy V_{DD}=3V		750～1100 hPa 25℃	-1.5		1.5	hPa	3
Resolution in ultra high resolution mode		Pressure Temperature		0.01 0.01		hPa ℃	4

Noise in pressure
  Ultra low power
  Standard
  High resolution
  Ultra high resolution
				1.97
				1.46
				1.16
				0.98
						Pa	RMS
							noise

Absolute temperature accuracy V_{DD}=3V		@25℃ 0～65℃	-1.5 -2	±0.5 ±1	1.5 2	℃	
Maximum error over supply voltage		VDD=1.8～3.6V	-1		1	hPa	
Soldering drift		After solder reflow	-2		2	hPa	
Long term stability		12 months	-1		1	hPa	

1. All the data were measured with 3V supply voltage at a temperature of 25±3℃, unless otherwise noted.
2. Maximum error of pressure reading over the pressure range after offset adjusted at one pressure point.
3. Maximum error of pressure reading over the pressure range.
4. According to 32 bit integer compensation formula.

3   Absolute Maximum Conditions

Parameter	Symbol	Conditions	Min	Typ	Max	Units	Notes
Supply Voltage	AVDD		-0.3		6.5	V	

Experts on Design-In

Angst+Pfister
Sensors and Power

	VDDIO		-0.3		6.5	V	
Analog pin voltage			-0.3		AVDD+0.3	V	
Digital output voltage			-0.3		VDDIO+0.3	V	
Storage Temperature Range			-40		125	^{o}C	
Maximum Overpressure	100m, ISO 2281				10	bar	Water resistant
ESD Rating HBM				2		kV	

4   Application Information

Owing to state of the art, the PBM220 build a new standard of digital barometer. A 24bits sigma-delta ADC and a MEMS pressure sensor are integrated in a LGA substrate. Pressure calibrated and temperature compensated were key features of the PBM220. The PBM220 is low power and supply voltage designed and suitable for portable devices or battery-supplied ones.

The data stored in OTP memory could be used to calibrate the PBM220. The calibration procedure should be implemented by a external microprocessor. By I^{2}C or SPI interface, you can get the calibration data stored in OTP and the raw data of pressure and temperature. In order to get the correct pressure and temperature reading, the calculating procedure must be implemented in a microprocessor.
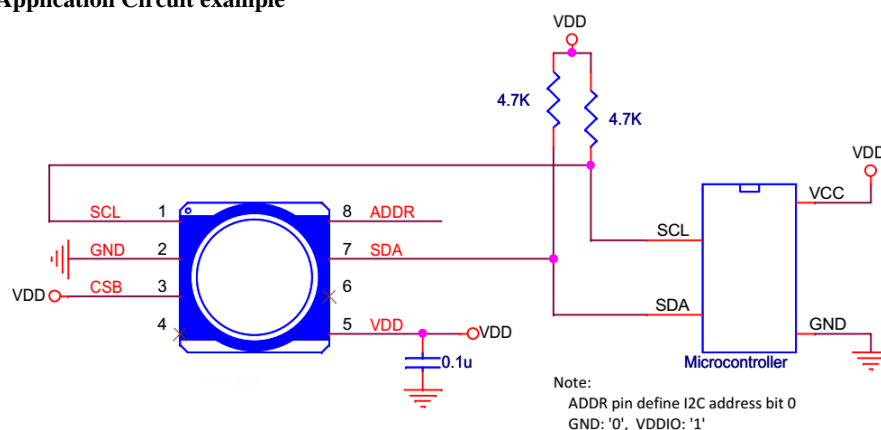
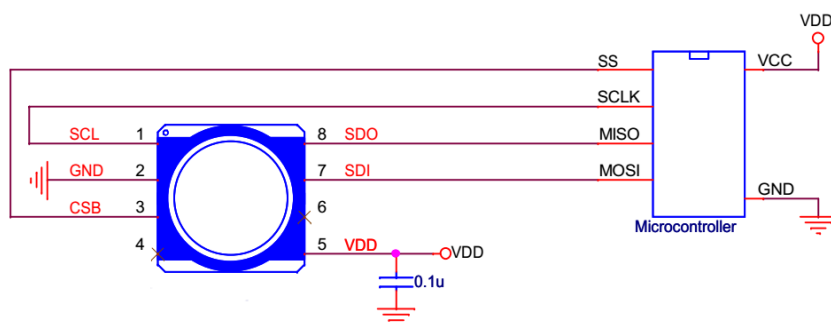**Application Circuit example**

Figure. 4.1 Application circuit for I^{2}C interface

Figure 4.2 Application circuit for SPI interface

5 Control registers

Table 5.1 control registers

Addr	Description	R/W	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0	Default
0xF8	DATA_LSB	R	Data out<7:0>								0x00
0xF7	DATA_CSB	R	Data out<15:8>								0x00
0xF6	DATA_MSB	R	Data out<23:16>								0x00
0xF4	CONFIG_1	RW	OSR<1:0>		Measurement_control<5:0>						0x00
0xF1	Cal_coeff	R	Calibration Registers								N/A
0xE0	Soft_reset	W	Softreset<7:0>								0x00
0xD0	Cal_coeff	R	Calibration Registers								N/A
0xBB-0xAA	Cal_coeff	R	Calibration Registers								N/A
0x6B	Part ID	R	PartID<7:0>								0x42
0x00	SPI_Ctrl	RW	SDO_active	LSB_first					LSB_first	SDO_active	0x00

Reg 0xF6–0xF8

    Data_out: 24 bits ADC output data

Reg 0xF4

    OSR<1:0>: 00:1024X, 01:2048X, 10:4096X, 11:8192X

    Measurement_control<5:0>: 101110, indicate a temperature conversion. 110100, indicate a pressure conversion.

Reg 0xE0

    Softreset : Write only register. If set to 0xB6, will perform a power on reset sequence. Auto returned to 0 after the soft reset completed.

Reg {0xF1, 0xD0, 0xBB:0xAA}

    Calibration Registers : Total 20bytes calibration registers used for sensor calibration.

Reg 0x6B

    PartID: 8 bits Part ID, the default value is 0x42.

Reg 0x00

    SDO_active: 1: 4-wire SPI, 0: 3-wire SPI

    LSB_first: 1: LSB first for SPI interface, 0: MSB first for SPI interface

Experts on Design-In

Angst+Pfister
Sensors and Power

Table 5.2 Summary of instructions

Instruction	Register address	Value
Pressure measurement, OSR1024	0xF4	0x34
Pressure measurement, OSR2048	0xF4	0x74
Pressure measurement, OSR4096	0xF4	0xB4
Pressure measurement, OSR8192	0xF4	0xF4
Temperature measurement	0xF4	0x2E
Softreset	0xE0	0xB6
3-wire SPI, MSB first	0x00	0x00
4-wire SPI, MSB first	0x00	0x81

6   SPI Interface

PBM220 provides both SPI and I^2C interface for serial communication and 'CSB' pin is used to switch between these two protocols. Pulling 'CSB' pin low selects the SPI interface, leaving 'CSB' pin float or pulling it high selects the I^2C interface. The SPI interface is compatible with SPI mode 0 (CPOL=0, CPHA=0).

Table 6.1 SPI interface specifications

Symbol	Parameter	Condition	Min	Max	Unit
f_{sclk}	Clock frequency	Max load on SDIO or SDO = 25pF		10	MHz
t_{sclk_l}	SCLK low pulse		20		ns
t_{sclk_h}	SCLK high pulse		20		ns
T_{sdi_setup}	SDI setup time		20		ns
T_{sdi_hold}	SDI hold time		20		ns
T_{sdo_od}	SDO/SDI output delay	Load = 25pF		30	ns
		Load = 250pF		40	ns
T_{csb_setup}	CSB setup time		20		ns
T_{csb_hold}	CSB hold time		40		ns

The figure below shows the definition of the SPI timing given in table 6.1

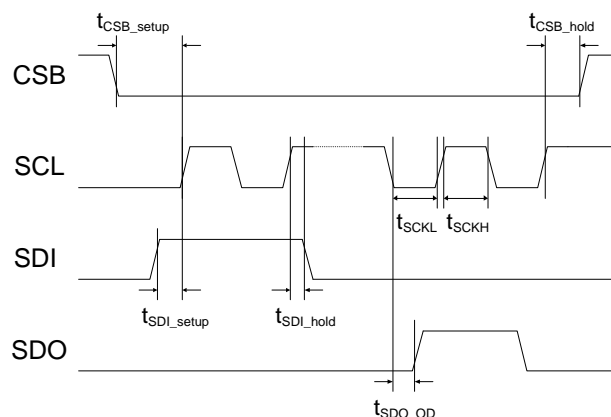**Experts on Design-In**

Angst+Pfister
Sensors and Power

Figure 6.1 SPI timing diagram

The falling edge of CSB, in conjunction with the rising edge of SCLK, determines the start of framing. Once the beginning of the frame has been determined, timing is straightforward. The first phase of the transfer is the instruction phase, which consists of 16 bits followed by data that can be of variable lengths in multiples of 8 bits. If the device is configured with CSB tied low, framing begins with the first rising edge of SCLK.

The instruction phase is the first 16 bits transmitted. As shown in Figure 5.2, the instruction phase is divided into a number of bit fields.
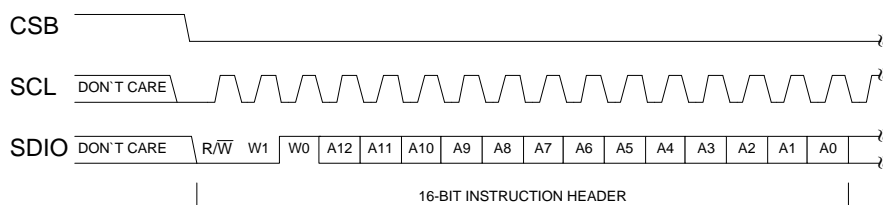
Figure 6.2 Instruction Phase Bit Field

The first bit in the stream is the read/write indicator bit (R/W). When this bit is high, a read is being requested, otherwise indicates it is a write operation.

W1 and W0 represent the number of data bytes to transfer for either read or write (Table 6.2). If the number of bytes to transfer is three or less (00, 01, or 10), CSB can stall high on byte boundaries. Stalling on a nonbyte boundary terminates the communications cycle. If these bits are 11, data can be transferred until CSB transitions high. CSB is not allowed to stall during the streaming process.

The remaining 13 bits represent the starting address of the data sent. If more than one word is being sent, sequential addressing is used, starting with the one specified, and it either increments (LSB first) or decrements (MSB first) based on the mode setting.

Table 6.2 W1 and W0 settings

W1:W0	Action	CSB stalling
00	1 byte of data can be transferred.	Optional
01	2 bytes of data can be transferred.	Optional
10	3 bytes of data can be transferred.	Optional
11	4 or more bytes of data can be transferred. CSB must be held low for entire sequence; otherwise, the cycle is terminated.	No

Angst+Pfister
Sensors and Power

Data follows the instruction phase. The amount of data sent is determined by the word length (Bit W0 and Bit W1). This can be one or more bytes of data. All data is composed of 8-bit words.

Data can be sent in either MSB-first mode or LSB-first mode (by setting 'LSB_first' bit). On power up, MSB-first mode is the default. This can be changed by programming the configuration register. In MSB-first mode, the serial exchange starts with the highest-order bit and ends with the LSB. In LSB-first mode, the order is reversed. (Figure 6.3)
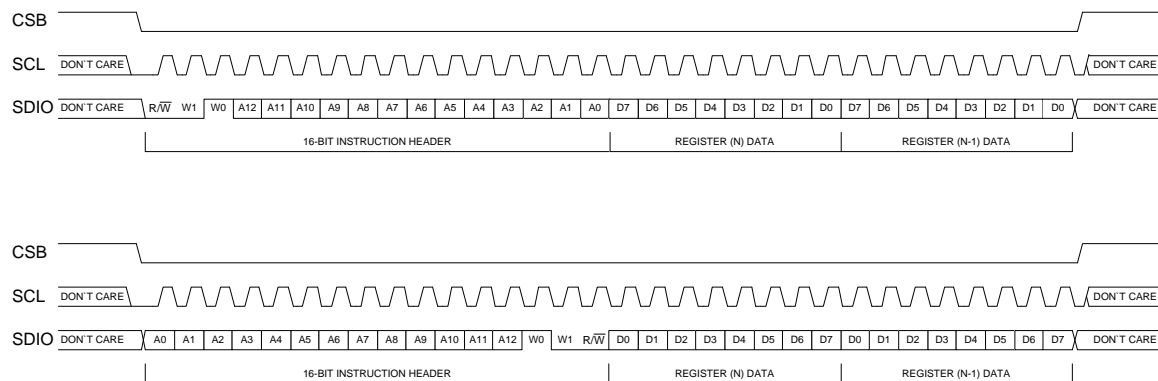
Figure 6.3 MSB First and LSB First Instruction and Data Phases

Register bit 'SDO_active' is responsible for activating SDO on devices. If this bit is cleared, then SDO is inactive and read data is routed to the SDIO pin. If this bit is set, read data is placed on the SDO pin. The instruction and data phase is as shown in figure 6.4. The default for this bit is low, making SDO inactive.
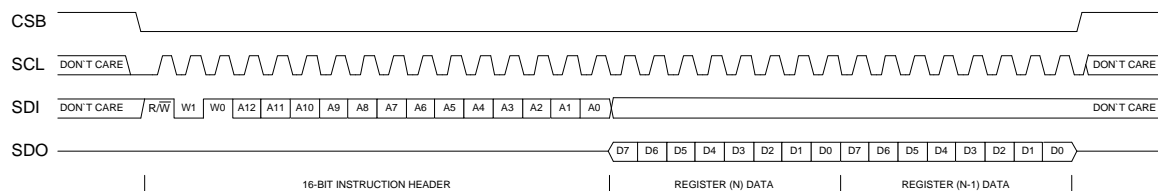

Figure 6.4 MSB First Instruction and Data Phases for 4-wires SPI Mode

7   I^{2}C Interface

I^{2}C bus uses SCL and SDA as signal lines. Both lines are connected to VDDIO externally via pull-up resistors so that they are pulled high when the bus is free. The I^{2}C device address of PBM220 is shown below. The LSB bit of the 7bits device address is configured via SDO/ADDR pin. If the SDO/ADDR pin was left not connected or pulled high, the A1 bit is "1". And the device address is "1101101". For I^{2}C bus application,' CSB' pin have to be left float or pulled high.

Table 7.1 I^{2}C Address.

A7	A6	A5	A4	A3	A2	A1	W/R
1	1	0	1	1	0	SDO/ADDR	0/1

Table 7.2 Electrical specification of the I^{2}C interface pins

Symbol	Parameter	Condition	Min	Max	Unit
f$_{scl}$	Clock frequency			400	kHz
t$_{LOW}$	SCL low pulse		1.3		us
t$_{HIGH}$	SCL high pulse		0.6		us
t$_{SUDAT}$	SDA setup time		0.1		us
t$_{HDDAT}$	SDA hold time		0.0		us
t$_{SUSTA}$	Setup Time for a repeated start condition		0.6		us
t$_{HDSTA}$	Hold time for a start condition		0.6		us
t$_{SUSTO}$	Setup Time for a stop condition		0.6		us
t$_{BUF}$	Time before a new transmission can start		1.3		us
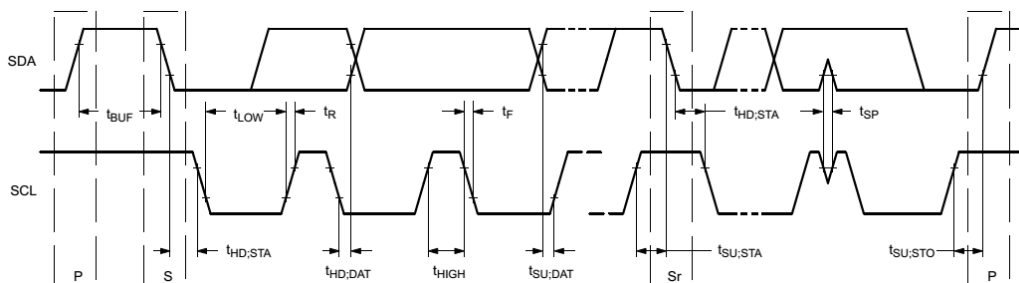
Figure 7.1 I^{2}C Timing Diagram

The I^{2}C interface protocol has special bus signal conditions. Start (S), stop (P) and binary data conditions are shown below. At start condition, SCL is high and SDA has a falling edge. Then the slave address is sent. After the 7 address bits, the direction control bit R/W selects the read or write operation. When a slave device recognizes that it is being addressed, it should acknowledge by pulling SDA low in the ninth SCL (ACK) cycle.

At stop condition, SCL is also high, but SDA has a rising edge. Data must be held stable at SDA when SCL is high. Data can change value at SDA only when SCL is low.
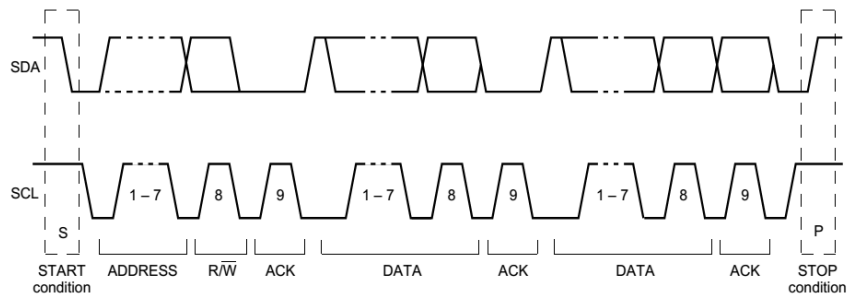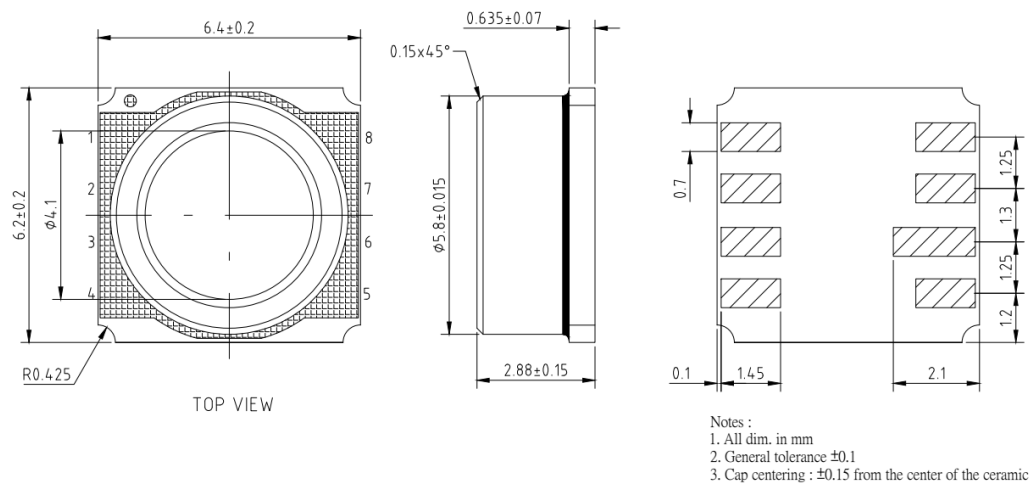
Angst+Pfister
Sensors and Power

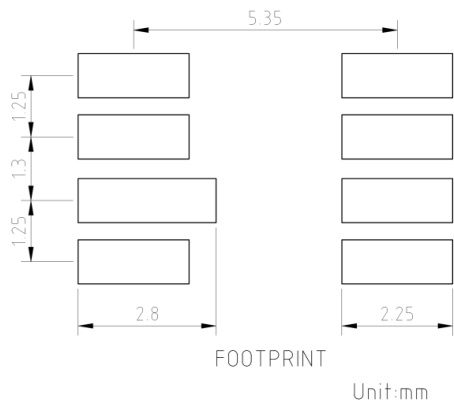Figure 7.2 I²C Protocol

8   Package Information
8.1   Outline dimensions

TOP VIEW

Notes :
1. All dim. in mm
2. General tolerance ±0.1
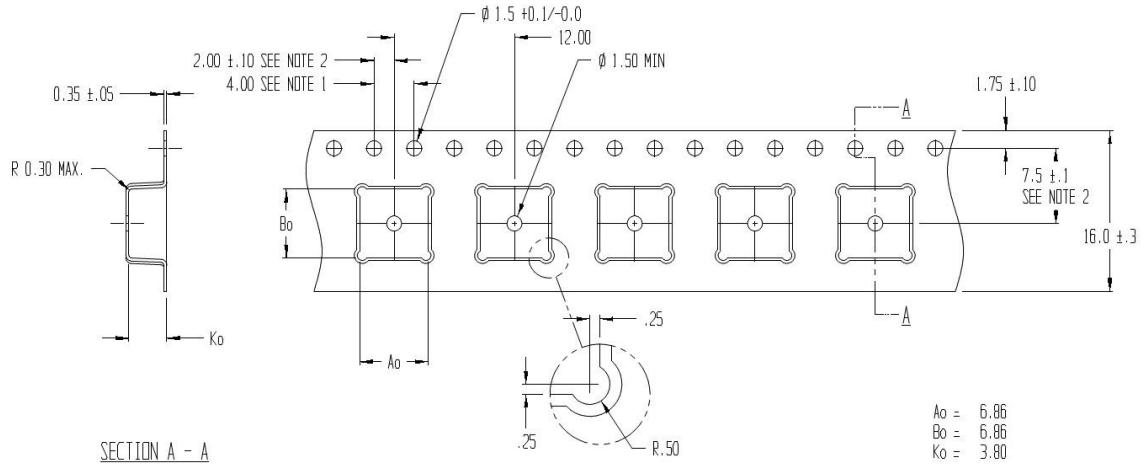3. Cap centering : ±0.15 from the center of the ceramic

◺ Contact pads
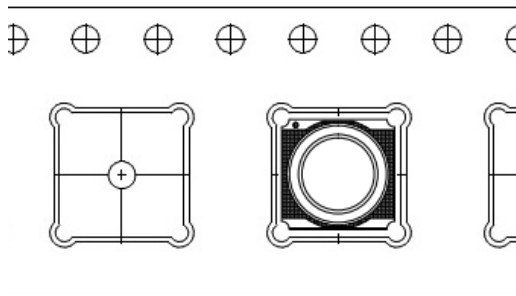▦ Dielectric

8.2   Recommended footprint

FOOTPRINT

Unit:mm

Experts on Design-In

Angst+Pfister
Sensors and Power

8.3 Tape and Reel specification

8.3.1 Tape dimensions

All dimensions are in mm.

8.3.2 Sensor orientation relative to the tape

Experts on Design-In

Angst+Pfister
Sensors and Power

9   Document history and modification

Rev.	Description	Date
0.1	First edition (Preliminary)	2014/9/10
0.2	Added: Filled in the spec. of Maximum error over supply voltage, page 4	2014/9/18
0.3	Modified: SPI waveform, Fig. 6.1, Fig. 6.2, Fig. 6.3, Fig. 6.4 Register table, description related to 0xF4, page 6 I^2C address "1101111"→"1101101", page 9	2014/10/7
0.4	Modified: Figure. 4.1 Application circuit for I^2C interface, page 5	2014/11/26
0.5	Added: 100m water resistant, ISO 2281, page 1, 5	2014/12/10
0.6	Added: 8ms pressure conversion time, page 1 Modified: Function block diagram: Control Logics→Control Logic, page 3 Application circuit: Microcontrillor→Microcontroller, page 5 Reg0xF6-0xF8 → Reg 0xF6–0xF8, page 6 Reg 0xE0 RW→W, page 6 Rearrange register map, page 6	2015/1/15
1.0	Added: 8.3 Tape and Reel specification, page 12 Modified: (see table below)	2015/3/31

Part No.	Pressure type	Pressure range	Digital interface	Note
PBM220-A11KDT	Absolute	300-1100hPa	SPI / I^2C	JEDEC tray
PBM220-A11KDR	Absolute	300-1100hPa	SPI / I^2C	Tape & Reel
PBM220-A11KDU	Absolute	300-1100hPa	SPI / I^2C	Tube

Rev.	Description	Date
1.1	Added: Package: SMD, page 1, 11	2015/4/15
1.2	Modified: 8.1 Outline dimensions, ϕ4.4 ϕ→4.1, page 11 1.8 to 5.5V(V_{DD})→ 1.7 to 5.5V(V_{DD}), page 1 1.6 to 5.5V(V_{DDIO})→ 1.2 to 5.5V(V_{DDIO}), page 1 The photo of PBM220, page 1 Page 4: (see table below)	2015/8/4

Symbol	Conditions	Min	Typ	Max	Units
		300		1100	hPa
		-40		85	°C
V_{DD}		1.7	1.8	5.5	V
V_{DDIO}		1.2		5.5	V

    The values of conversion time in electrical characteristic table, page 4
     2.2ms fastest conversion time, page1

Experts on Design-In

Angst+Pfister
Sensors and Power

1.3	Modified: 8.1 Outline dimensions, removed the solder layer, page 11	2015/10/16
1.4	Modified: The photo of PBM220, page 1 The picture of pin definition table, page 3 Fig4.1 & Fig4.2, page 5 8.1 Outline dimensions, page 11 8.3.2 Sensor orientation relative to the tape, page 12	2016/12/2

Experts on Design-In

Angst+Pfister
Sensors and Power

We are here for you. Addresses and Contacts.

Headquarter Switzerland:

Angst+Pfister Sensors and Power AG

Thurgauerstrasse 66
CH-8050 Zurich

Phone +41 44 877 35 00
sensorsandpower@angst-pfister.com

Office Germany:

Angst+Pfister Sensors and Power Deutschland GmbH

Edisonstraße 16
D-85716 Unterschleißheim

Phone +49 89 374 288 87 00
sensorsandpower.de@angst-pfister.com

Office North America:

Angst+Pfister North America Inc.

10391 Brecksville Rd.
US-Brecksville, OH 44141

Phone +1 440 375-5212
info.apus@angst-pfister.com

Scan here and get an overview of personal contacts!

https://sensorsandpower.angst-pfister.com/en/

Experts on Design-In
for sensors and power solutions