SPL06-001

Digital pressure sensor

Preliminary Datasheet- please see the Known Issues list

Restricted

1. Security warning

2. Publication history

Version	Date	Description	Author	Approved
1.0	2015.5.29	New design	Wiming	**Sammy**
2.0	2015.8.10	Update product name	Wiming	**Sammy**

Index of Contents

1. Product Overview

1.1 Product Description

The SPL06-001 is a miniaturized Digital Barometric Air Pressure Sensor with a high accuracy and a low current consumption. The SPL06-001 is both a pressure- and a temperature sensor. The pressure sensor element is based on a capacitive sensing principle which guarantees a high precision during temperature changes. The small package makes the SPL06-001 ideal for mobile applications and wearable devices.

The SPL06-001 ‘s internal signal processor converts the output from the pressure and temperature sensor elements to 24-bit results. Each pressure sensor has been calibrated individually and contains calibration coefficients. The coefficients are used in the application to convert the measurement results to true pressure and temperature values.

The SPL06-001 has a FIFO that can store the latest 32 measurements. By using the FIFO, the host processor can remain in a sleep mode for a longer period of time between readouts. This can reduce the overall system power consumption.

Sensor measurements and calibration coefficients are available through the serial I2C or SPI interface.

1.2 Features

- Operation range: Pressure: 300 – 1200 hPa. Temperature: -40 – 85 ℃.
- Pressure sensor precision: ±0.006 hPa (or ±5 cm) (high precision mode).
- Pressure sensor accuracy: ±0.06 hPa (or ±50 cm) (non-linearity), ±1 hPa (or ±8 m) (absolute).
- Temperature accuracy: ±0.5 ℃.
- Pressure temperature sensitivity: < 0.5Pa/K
- Measurement time: Typical: 28 ms. Minimum: 3 ms.
- Average current consumption: High precision: 60 μA, Low power: 3 μA, Standby: <1 μA.
- Supply voltage: VDDIO: 1.2 – 3.6 V, VDD: 1.7 – 3.6 V.
- Operating modes: Command (manual), Background (automatic), and Standby.
- Calibration: Individually calibrated with coefficients for measurement correction.
- FIFO: Stores latest 32 pressure or temperature measurements.
- Interface: I2C and SPI (both with optional interrupt)
- Package dimensions: 8-pin LGA, 2.0 mm x 2.5 mm x 0.95mm.

1.3 Typical Applications

- Indoor Navigation (floor detection e.g. in shopping malls and parking garages)
- Health and Sports (accurate elevation gain and vertical speed)
- Outdoor Navigation (GPS start-up time and accuracy improvement, dead-reckoning e.g. in tunnels)
- Weather Station ('Micro-weather' and local forecasts)

2. Definitions, acronyms and abbreviations

2.1 Definitions

An explanation of terms and definitions used in this datasheet.

Table 1

Term	Definition/explanation
Absolute accuracy	The absolute measurement accuracy over the entire measurement range.
Digital bit depth	The total bit depth used for conversion of the sensor input to the digital output. Measured in bits.
Digital resolution	The pressure value represented by the LSB change in output. This value should be much smaller than the sensor noise.
Full Scale Range (FSR)	The peak-to-peak measurement range of the sensor.
LSB	Least Significant Bit
Measurement time	The time required to acquire one sensor output result. This value determines the maximum measurement rate.
MSB	Most Significant Bit
Non-linearity	The deviation of measured output from the best-fit straight line, relative to 1000 hPa and 25 ℃.
Output compensation	The process of achieving more accurate results by compensating the measurement results for the sensor's inherent inaccuracy. The compensated results are calculated by applying a compensation algorithm (which includes the calibration coefficients) to the measured results.
Precision (noise)	The smallest measurable change, expressed as rms, after sensor oversampling.
Pressure temperature coefficient	The pressure measurement deviation, after compensation, from expected measurement value due to temperature change from 25 ℃. Measured in Pa/K.
Sensor calibration	The process, during the production test, where the sensor's measurement results are compared against reference values, and a set of calibration coefficients are calculated from the deviation. The coefficients are stored in the sensor's memory and are used in the output compensation.
Sensor oversampling rate	Specifies the number of sensor measurements used internally to generate one sensor output result.

3. Pin Configuration and Block Diagram

3.1 Pin Configuration and Description

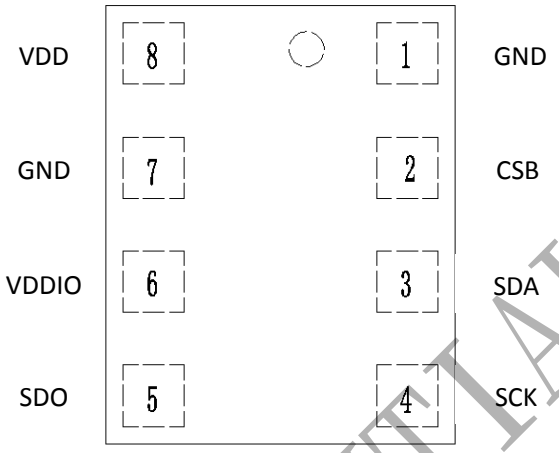


Figure 1 Pin configuration (top view, figure not to scale)

Table 2 Pin description

Pin	Name	SPI 3-wire	SPI 3-wire with interrupt	SPI 4-wire	I2C	I2C with interrupt
1	GND	Ground				
2	CSB	Chip select - active low	Chip select - active low	Chip select - active low	Not used - open (internal pull-up) or tie to VDDIO	Not used - open (internal pull- up) or tie to VDDIO
3	SDA	Serial data in/out	Serial data in/out	Serial data in	Serial data in/out	Serial data in/out
4	SCK	Serial Clock				
5	SDO	Not used	Interrupt	Serial data out	Least significant bit in the device address.	Interrupt pin and least significant bit in the device address.
6	VDDIO	Digital supply voltage for digital blocks and I/O interface				
7	GND	Ground				
8	VDD	Supply voltage for analog blocks				

3.2 Block Diagram

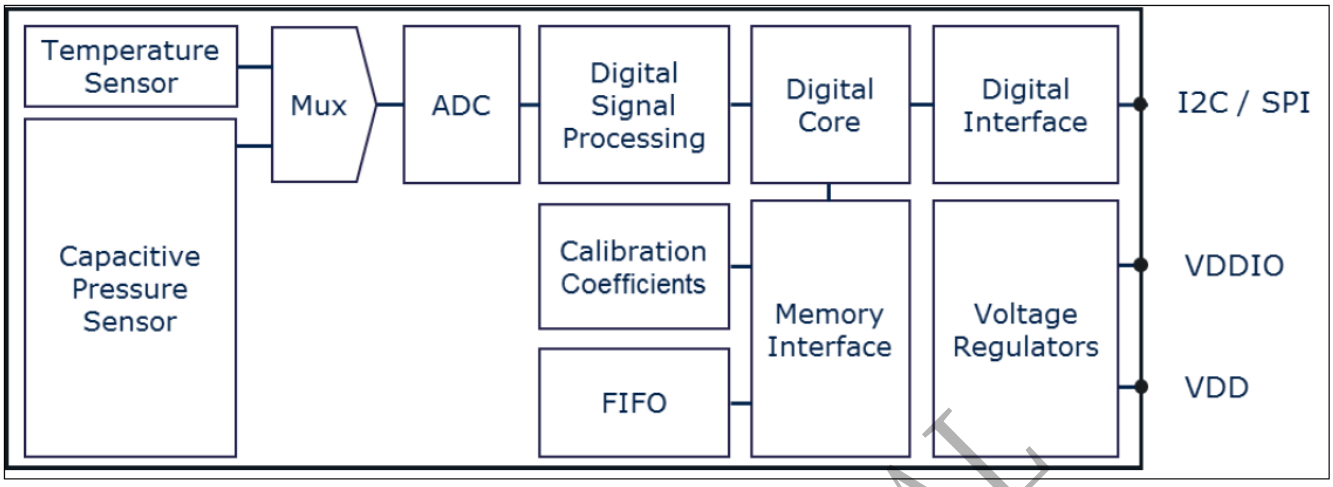


Figure 2

4. Specifications

4.1 Operating Range

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

Table 3 Operating Range

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Pressure	Pa	300		1200	hPa	
Temperature	Ta	-40		85	℃	
Supply voltage	VDD	1.7		3.6	V	
Supply voltage IO	VDDIO	1.2		3.6	V	
Supply voltage ramp-up time	t_{vddup}	0.001		5	ms	Time for supply voltage to reach 90% of final value.

4.2 Absolute Maximum Ratings

Maximum ratings are absolute ratings. Exceeding any one of these values may cause irreversible damage to the integrated circuit.

Attention: *Stresses above the values listed as "Absolute Maximum Ratings" may cause permanent damage to the*

devices. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Table 4 Absolute Maximum Ratings

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
VDD and VDDIO	VDDxx_max			4	V	
Voltage on any pin	Vmax			4	V	
Storage temperature	Ts	-40		125	℃	
Pressure	Pmax			10.000	hPa	
ESD	VESD_HBM	-2		2	KV	HBM (JESD22-A114)

4.3 Current Consumption

Test conditions (unless otherwise specified in the table): VDD= 1.8V and VDDIO=1.8V. Typ. values (PA=1000hPa and TA=25 ℃). Max./Min. values (PA= 950-1050hPa and TA=0...+65 ℃).

Table 5 Current Consumption

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Peak Current Consumption	Ipeak			360	μA	During conversion of measured value.
Standby Current Consumption	Istb			<1	μA	
Current Consumption. (with 1 measurement per second.)	I1Hz		3		μA	Low precision (Low Power)
			11			Standard precision
			40			High precision

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.

4.4 Temperature Transfer Function

Test conditions (unless otherwise specified in the table): VDD= 1.8V and VDDIO=1.8V. Typ. values (PA=1000hPa and TA=25 ℃). Max./Min. values (PA= 950-1050hPa and TA=0...+65 ℃).

Table 6 Temperature Transfer Function

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Temperature accuracy	At		+/-0.5		℃	
Temperature data resolution	At_res			0.1	℃	
Temperature measurement rate	f	1		128	Hz	

4.5 Pressure Transfer Function

Test conditions (unless otherwise specified in the table): VDD= 1.8V and VDDIO=1.8V. Typ. values (PA=1000hPa and TA=25 ℃). Max./Min. values (PA= 950-1050hPa and TA=0...+65 ℃).

Table 7 Pressure Transfer Function

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Absolute pressure accuracy	Ap_abs	-100		100	Pa	PA=300-1200hPa TA=0...+65 ℃
Relative pressure accuracy	Ap_rel	-6		6	Pa	Relative to absolute pressure accuracy typical value.
Pressure precision	Ap_prc		5.0		Pa_{RMS}	Low Power
			1.2			Standard
			0.6			High Precision
Note: Pressure precision is measured as the average standard deviation. Please refer to the Pressure Configuration (PRS_CFG) register description for all precision mode options.						
Power supply rejection	Ap_psr			0.063	Pa_{RMS}	Measured with 217Hz square wave and broad band noise, 100mVpp
Pressure temperature sensitivity of calibrated measurements	Ap_tmp			0.5	Pa/K	1000hPa, 25...+40 ℃.
Pressure data resolution	Ap_res			0.06	Pa_{RMS}	
Pressure measurement rate	f	1		128	Hz	
Pressure measurement time	t		5		ms	Low Power
			28			Standard
			105			High Precision
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.						

4.6 Timing Characteristics

Table 8 Timing Characteristics

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Start-up timing						
Time to sensor ready	T_{Sensor_rdy}			12	ms	The SENSOR_RDY bit in the Measurement Configuration register will be set when the sensor is ready.
Time to coefficients are available.	T_{Coef_rdy}			40	ms	The COEF_RDY bit in the Measurement Configuration register will be set when the coefficients can be read out.
Note: Start-up timing is measured from VDD > 1.2V & VDDIO > 0.6V or Soft Reset.						
I^2C Clock.	f_{I2C}			3.4	MHz	
SPI Clock	f_{SPI}			10	MHz	

5. Functional Description

5.1 Operating Modes

The SPL06-001 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 SPL06-001 '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 SPL06-001 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: $Rate_{temperature}$*$Time_{temperature}$ + $Rate_{pressure}$*$Time_{pressure}$< 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 Interface

The SPL06-001 can be accessed as a slave device through either SPI 3-wire, SPI 4-wire, or I^2C serial interface.

- I^2C interface
  - The sensor's default interface.
  - The sensor's address is 0x77 (default) or 0x76 (if the SDO pin is pulled-down to GND)
- SPI interface
  - The sensor will switch to SPI configuration, if it detects an active low on the CSB pin. SPI 4-wire is the default SPI interface.
  - To enable SPI 3-wire configuration, a bit must be set in the *Interrupt and FIFO configuration (CFG_REG)* register after start up.

5.4 Interrupt

The SPL06-001 can generate an interrupt when a new measurement result is available and/or when the FIFO is full. The sensor uses the *SDO* pin for the interrupt signal, and interrupt is therefore not supported if the interface is 4-wire SPI.

The interrupt is enabled and configured in the *Interrupt and FIFO configuration (CFG_REG)* register. In I^2C configuration the *SDO* pin serves as both interrupt and as the least significant bit in the device address. If the *SDO* pin is pulled low the interrupt polarity must be set to active high and vice versa.

The interrupt status can be read from the *Interrupt Status (INT_STS)* register.

5.5 FIFO Operation

The SPL06-001 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 poll data from the sensor but can go into standby mode for longer periods of time.

The SPL06-001 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 poll 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.

5.6 Calibration and Measurement Compensation

The SPL06-001 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-linearities.

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

5.6.1 How to Calculate Compensated Pressure Values

1. Read the calibration coefficients (c00, c10, c20, c30, c01, c11, and c21) from the Calibration Coefficient register.
   Note: The coefficients read from the coefficient register are 16 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 9*.
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.

$P_{comp}(Pa) = c00 + P_{raw\_sc}*(c10 + P_{raw\_sc}*(c20+ P_{raw\_sc}*c30)) + T_{raw\_sc}*c01 + T_{raw\_sc}*P_{raw\_sc}*(c11+P_{raw\_sc}*c21)$

5.6.2 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 ś complement numbers.*
2. Choose scaling factor kT (for temperature) based on the chosen precision rate. The scaling factors are listed in *Table 9*.
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 ś complement numbers.*
4. Calculate scaled measurement results.
   $T_{raw\_sc} = T_{raw}/kT$
5. Calculate compensated measurement results
   T_{comp} (°C) = $c0*0.5 + c1*T_{raw\_sc}$

5.6.3 Compensation Scale Factors

Table 9 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

6. Applications

6.1 Measurement Settings and Use Case Examples

Table 10 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 uA	0x01	0x00	Start background measurements (addr 0x08)
Indoor navigation (Standard precision, Background mode)	10 cm precision. 2 pr sec. 30 uA	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 uA	0x26	0x20	Enable P shift (addr 0x09) Start background measurements (addr 0x08)

6.2 Application Circuit Example

The example application circuit example uses the I²C serial interface. The *SDO* pin can be used for interrupt or to set least significant bit of the device address.

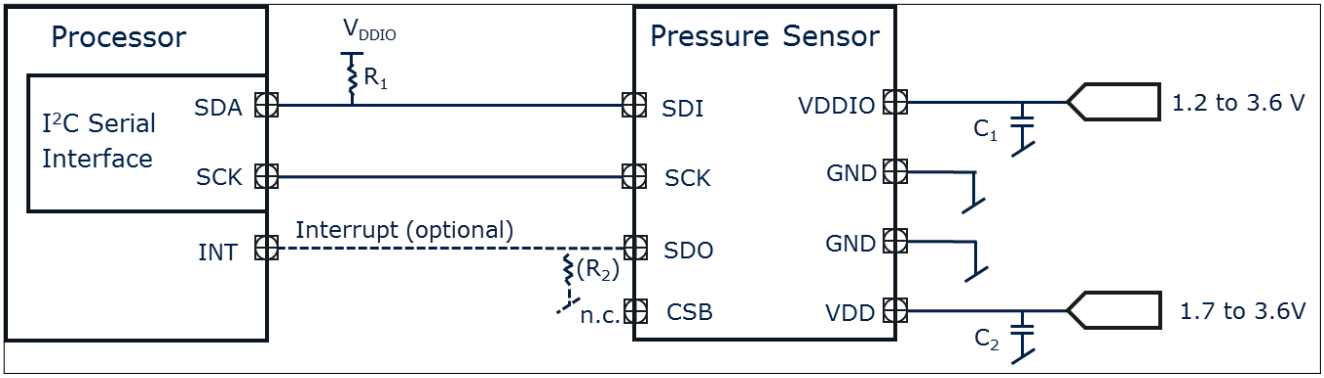


Figure 3 Application Circuit Example using the I²C serial interface.

Table 11 Component Values

Component	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Pull-up/down Resistor	R_1, R_2	5		100	KΩ	R_2 is optional and will set the address to 0x76 instead of 0x77.
Supply Blocking Capacitor	C_1, C_2	100	100		nF	The blocking capacitors should be placed as close to the package pins as possible.

7. Register Map

Table 12 Register Map

Register Name	Addr.	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	Reset State
PSR_B2	0x00	PSR[23:16] (r)								00_h
PSR_B1	0x01	PSR[15:8](r)								00_h
PSR_B0	0x02	PSR[7:0](r)								00_h
TMP_B2	0x03	TMP[23:16] (r)								00_h
TMP_B1	0x04	TMP[15:8] (r)								00_h
TMP_B0	0x05	TMP[7:0] (r)								00_h
PRS_CFG	0x06	-	PM_RATE [2:0] (rw)			PM_PRC [3:0] (rw)				00_h
TMP_CFG	0x07	TMP_EXT (rw)	TMP_RATE [2:0] (rw)			TM_PRC [3:0] (rw)				00_h
MEAS_CFG	0x08	COEF_RDY (r)	SENSOR_RDY (r)	TMP_RDY (r)	PRS_RDY (r)	-	MEAS_CRTL [2:0] (rw)			00_h
CFG_REG	0x09	INT_HL (rw)	INT_ SEL [2:0] (rw)			TMP_SHIFT_EN (rw)	PRS_SHIFT_EN (rw)	FIFO_EN (rw)	SPI_MODE (rw)	00_h
INT_STS	0x0A	-	-	-	-	-	INT_FIFO_FULL (r)	INT_TMP(r)	INT_PRS(r)	00_h
FIFO_STS	0x0B	-	-	-	-	-	-	FIFO_FULL(r)	FIFO_EMPTY(r)	00_h
RESET	0x0C	FIFO_FLUSH (w)	-	-	-	SOFT_RST [3:0] (w)				00_h
ID	0x0D	PROD_ID [3:0] (r)				REV_ID [3:0] (r)				00_h
COEF	0x10-0x21	< see register description >								XX_h

Reserved	0x22-0x27	Reserved		XX_h
COEF_SRCE	0x28	TMP_COEF_SRCE (r)	Reserved	XX_h

8. Register Description

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.

8.1.1 PRS_B2

The highest byte of the three bytes measured pressure value.

PRS_B2 Address: 00_H

Pressure (MSB data) Reset value: 00_H

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.

8.1.2 PRS_B1

The middle byte of the three bytes measured pressure value.

PRS_B1 Address: 01_H

Pressure (LSB data) Reset value: 00_H

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.

8.1.3 PRS_B0

The lowest byte of the three bytes measured pressure value.

PRS_B0	Address:	02_H
Pressure (XLSB data)	Reset value:	00_H

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.

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.

8.2.1 TMP_B2

The highest byte of the three bytes measured temperature value.

TMP_B2	Address:	03_H
Temperature (MSB data)	Reset value:	00_H

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.

8.2.2 TMP_B1

The middle byte of the three bytes measured temperature value.

TMP_B1 Address: 04_H

Temperature (LSB data) Reset value: 00_H

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 ś complement temperature data.

8.2.3 TMP_B0

The lowest part of the three bytes measured temperature value.

TMP_B0 Address: 05_H

Temperature (XLSB data) Reset value: 00_H

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 ś complement temperature data.

8.3 Pressure Configuration (PRS_CFG)

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

PRS_CFG Address: 06_H

Pressure measurement configuration Reset value: 00_H

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. 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 - TBD

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

Table 13 Pressure measurement time (ms) and precision (Pa_{RMS})

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 (Pa_{RMS})	5		2.5		1.2	0.9	0.5	

Table 14 Estimated current consumption (uA)

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 (000)	2.1	2.7	3.8	6.1	11	20	38	75
2 (001)								
4 (010)								

8 (011)	*Note: The current consumption can be calculated as the Measurement Rate * Current Consumption of 1 measurement per. sec.*							n.a.
16 (100)							n.a.	n.a.
32 (101)						n.a.	n.a.	n.a.
64 (110)					n.a.	n.a.	n.a.	n.a.
128 (111)			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.*

8.4 Temperature Configuration (TMP_CFG)

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

TMP_CFG Address: 07_H

Temperature measurement configuration Reset value: 00_H

7	6	5	4	3	2	1	0
TMP_EXT	TMP_RATE[2:0]			-	TMP_PRC[3:0]		
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: It is highly recommended to use the same temperature sensor as the source of the calibration coefficients. Please see the Coefficient Source register*
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*

TMP_PRC[3:0]	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. 1xxx - TBD.

8.5 Sensor Operating Mode and Status (MEAS_CFG)

Setup measurement mode.

MEAS_CFG — Address: 08_H

Measurement configuration — Reset value: 00_H

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

8.6 Interrupt and FIFO configuration (CFG_REG)

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

CFG_REG Address: 09_H

Configuration register Reset value: 00_H

7	6	5	4	3	2	1	0
INT_HL	INT_FIFO	INT_PRS	INT_TMP	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_PRS	5	rw	Generate interrupt when a pressure measurement is ready: 0 - Disable. 1 - Enable.
INT_TMP	4	rw	Generate interrupt when a temperature 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.

8.7 Interrupt Status (INT_STS)

Interrupt status register. The register is cleared on read.

INT_STS		Address:	$0A_H$
Interrupt status		Reset value:	00_H

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

8.8 FIFO Status (FIFO_STS)

FIFO status register

FIFO_STS Address: $0B_H$

FIFO status register Reset value: 00_H

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

8.9 Soft Reset and FIFO flush (RESET)

Flush FIFO or generate soft reset.

RESET Address: $0C_H$

FIFO flush and soft reset Reset value: 00_H

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 though the same sequences as in power-on reset.

8.10 Product and Revision ID (ID)

Product and Revision ID.

ID Address: $0D_H$

Product and revision ID Reset value: $0x00_H$

7	6	5	4	3	2	1	0
PROD_ID				REV_ID			
r				r			

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

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 15 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 [19:16]			
c10	0x16	c10 [15:8]							
c10	0x17	c10 [7:0]							
c01	0x18	c01 [15:8]							
c01	0x19	c01 [7:0]							
c11	0x1A	c11 [15:8]							
c11	0x1B	c11 [7:0]							
c20	0x1C	c20 [15:8]							
c20	0x1D	c20 [7:0]							
c21	0x1E	c21 [15:8]							
c21	0x1F	c21 [7:0]							
c30	0x20	c30 [15:8]							
c30	0x21	c30 [7:0]							

8.12 Coefficient Source

States which internal temperature sensor the calibration coefficients are based on: the ASIC temperature sensor or the MEMS element temperature sensor. The coefficients are only valid for one sensor and it is highly

recommended to use the same temperature sensor in the application. This is set-up in the Temperature Configuration register.

TMP_COEF_SRCE Address: 28_H

Temperature Coefficients Source Reset value: XX_H

7	6	5	4	3	2	1	0
TMP_COEF_SRCE	-						
r	-						

Field	Bits	Type	Description
TMP_COEF_SRCE	7	r	Temperature coefficients are based on: 0 - Internal temperature sensor (of ASIC) 1 - External temperature sensor (of pressure sensor MEMS element)
-	6:0	-	Reserved

9. Package Dimensions

The sensor housing is an 8Pin LGA package with metal lid. Its dimensions are 2mm (±0.1 mm) x 2.5mm (±0.1 mm) x 0.95mm (±0.05mm).

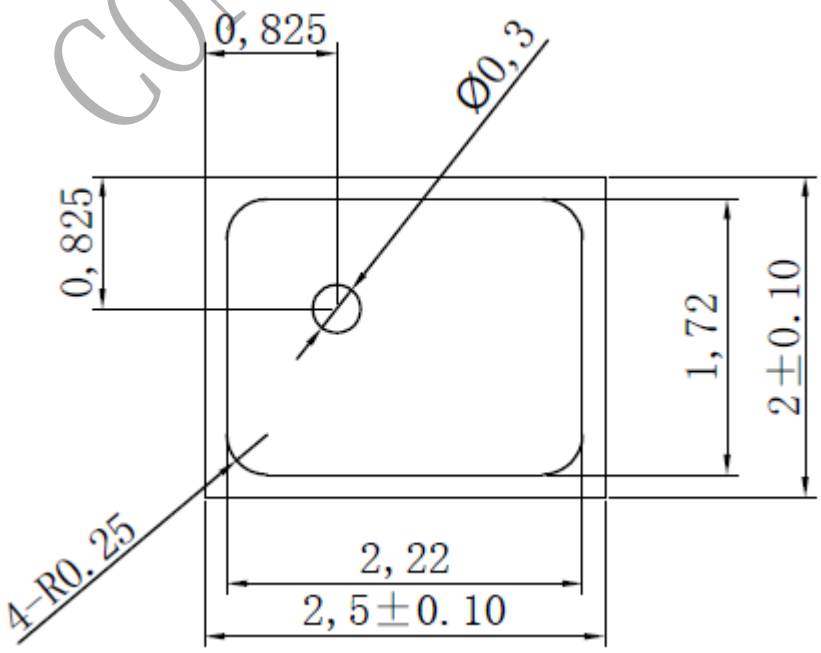


Figure 4: Top view of SPL06-001

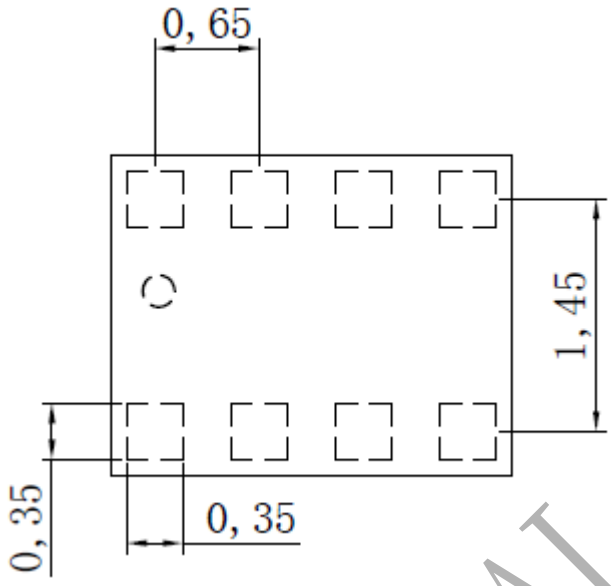


Figure 9: Top view of SPL06-001 (transparently)

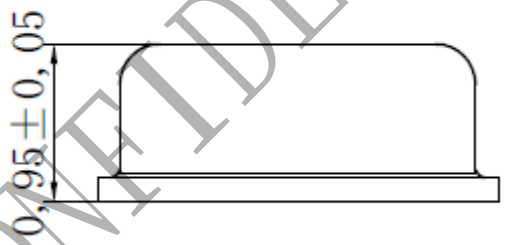


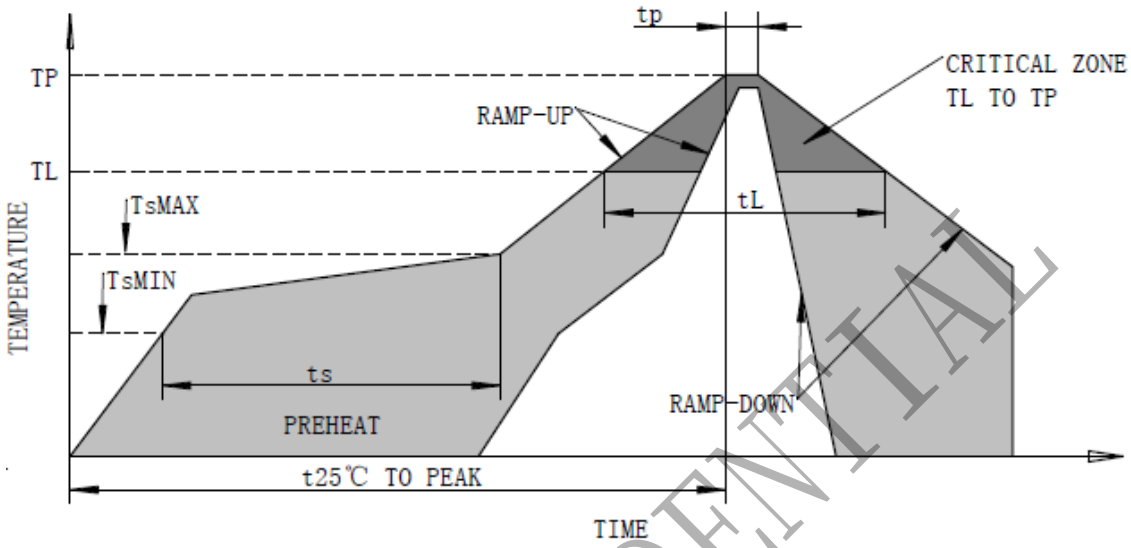
Figure 10: Side view of SPL06-001

10. 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.
- 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℃～+125℃
- Operating Temperature Range：-40℃～+85℃

11. 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.

12. Package Specifications

Carrier Tape Information [Unit: mm]
Quantity per reel: 10kpcs.

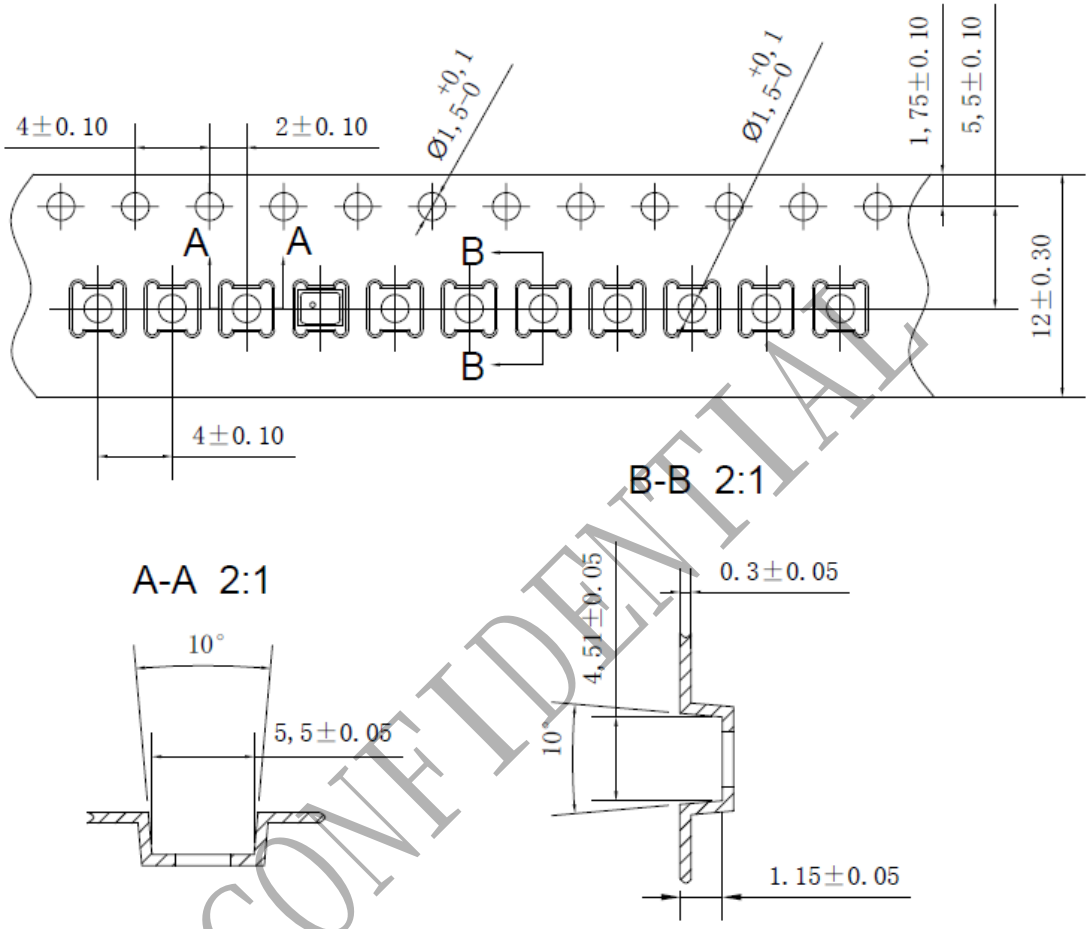


Figure 11: Carrier Tape （1）

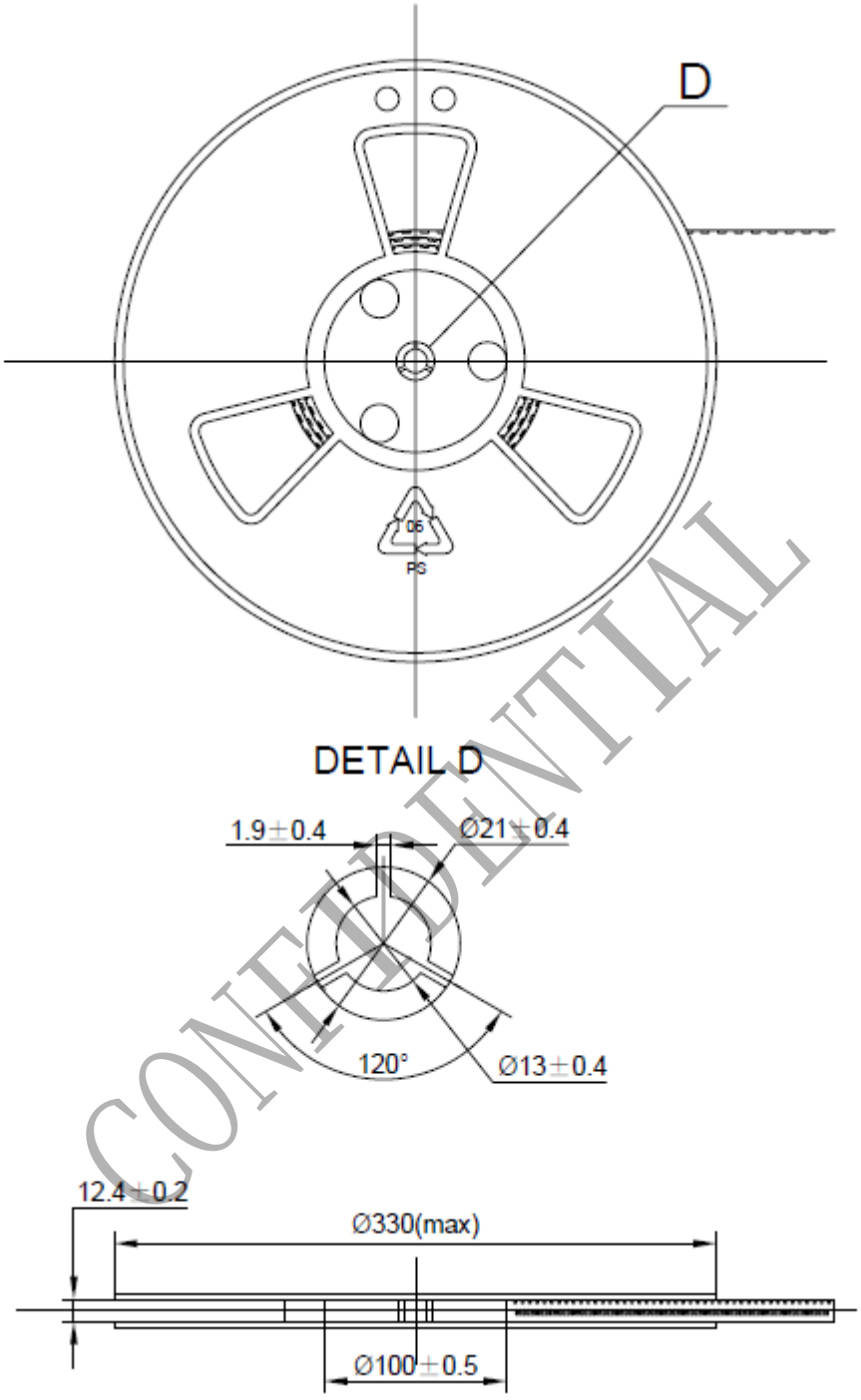


Figure 12: Carrier Tape （2）

13. Known Issues List

Known issues in the pre-release versions of the pressure sensor. The Product and Revision ID can be read from register 0x0D.

Known Issues	
Product and Revision ID	Description
00H	In I2C mode, reading of register CFG_REG (address 0x09) will clear the register INT_STS on address 0x0A.
00H	FIFO empty flag and empty data indication with returning "0x800000" is not fully functional. Depending on the use case, the software driver should be programmed according to solution A or solution B: Solution A: Read 32 values from FIFO after it is full, indicated by the FIFO full interrupt or the FIFO_FULL status bit. Don't rely on the FIFO_EMPTY bit. Solution B: Read FIFO anytime before full indication, then the FIFO_EMPTY bit and the empty indication ("0x800000") is functional..
00H	In I2C mode, the interrupt bits in register INT_STS (address 0x0A) are set to active ('1') after a measurement also if no interrupt is enabled. Before enabling interrupts, these bits must be cleared (read access to register INT_STS)