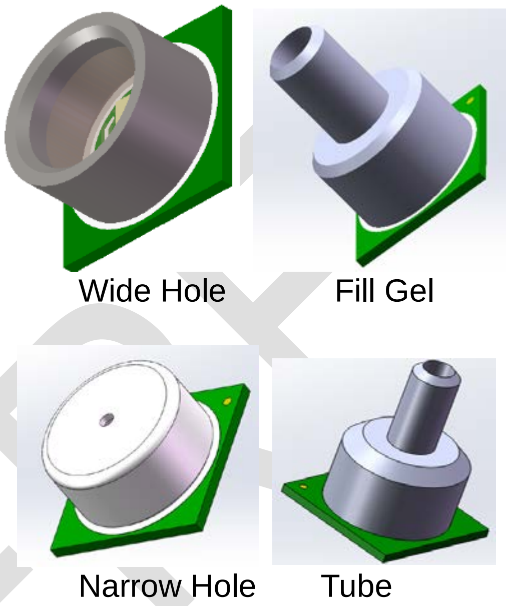
PRECISION BAROMETER AND ALTIMETER SENSOR

Features

- Supply voltage: 1.8V to 3.6V
- Pressure Ranges from 0 to 2,4……200Kpa
- Fully data compensated
- Direct Reading, compensated：
  – Pressure: 20-bit measurement
  – Temperature: 20-bit measurement
- Standby current<0.1μA
- Operation temperature: -40 to +85℃
- High-speed I²C digital output interface
- Size: 9.0 x 9.0 mm



Applications

- Panel Meter
- Industrial Pressure and Temperature Sensor System
- Automotive Systems
- Medical Gas Control System
- Fire Suppression System
- Blocked Filter Detection
- Heating, Ventilation, Air Conditioning
- White Goods
- Tank Level Measurement

Descriptions

The HP209 employs a MEMS pressure sensor with an I²C interface to provide accurate temperature, pressure or altitude data. The sensor pressure and temperature outputs are digitized by a high resolution 24-bit ADC. The altitude value is calculated by a specific patented algorithm according to the pressure and temperature data. Data compensation is integrated internally to save the effort of the external host MCU system. Easy command-based data acquisition interface and programmable interrupt control is available. Typical active supply current is 5.3μA per measurement-second while the ADC output is filtered and decimated by 256. Pressure output can be resolved with output in fractions of 0.1 Pascal.

1. Block Diagram

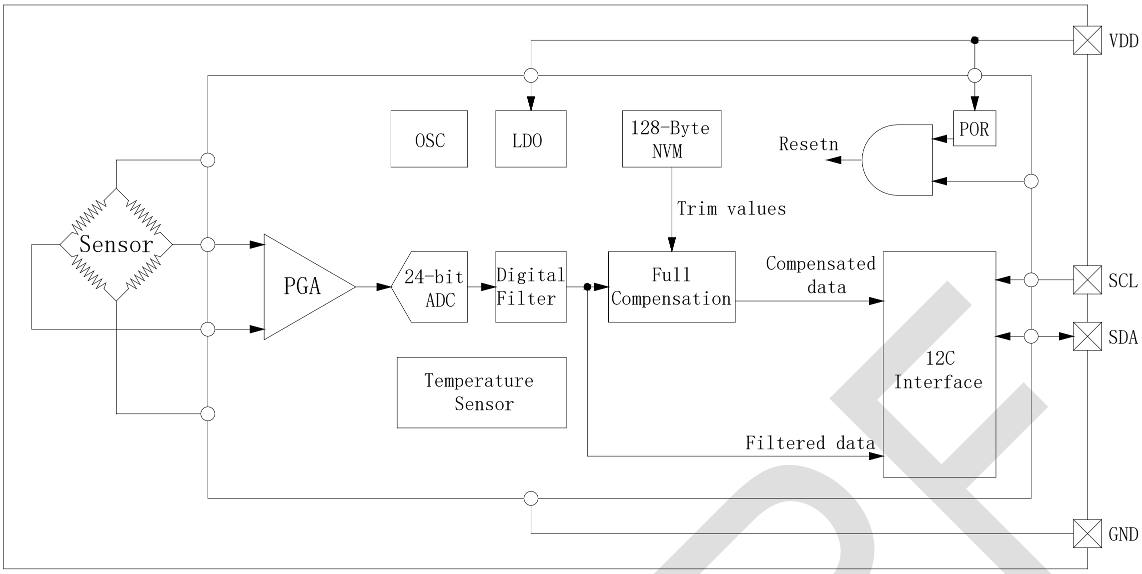


Figure 1: Functional block diagram

2. Mechanical and Electrical Specifications

2.1 Pressure and Temperature Characteristics

Table 1: Pressure Output Characteristics @ VDD = 3.0V, T = 25°C unless otherwise noted

Parameter	Symbol	Conditions	Min	Typ.	Max	Unit
Operation Temperature Range			-40		+85	℃
Total Error Band		from -10℃ to 60℃	-1.0		+1.0	%FS
		from -40℃ to 85℃	-1.5		+1.5	%FS
Total Error Band		4 Kpa and Below	-3.0		3.0	%FS
Max Error with Power Supply		Power supply from 1.8V to 3.6V	-0.3		+0.3	%FS
Pressure Resolution		Pressure Mode		0.01		%FS
Compensated Temperature			0		60	℃
Long-term stability				0.2		%FS
Reflow soldering impact		IPC/JEDEC J-STD-020C		0.5		%FS

Table 2: Temperature Output Characteristics @ VDD = 3.0V, T = 25°C unless otherwise noted

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Operation Temperature Range	T_{OP}		-40		85	℃
Temperature Absolute Accuracy		25℃		±1.5		℃
		-10℃ to +70℃		±4.0		℃
Max Error with Power		Power supply from 1.8V to 3.6V			±0.5	℃
Temperature Resolution of Output Data				0.01		℃

2.2 Electrical Characteristics

Table 3: DC Characteristics @VDD=3.0 V, T=25℃ unless otherwise note

Parameter	Symbol	Conditions		Min	Typ.	Max	Unit
Operation Supply Voltage	V_{DD}			1.8	3.0	3.6	V
Operation Temperature	T_{OP}			-40		+85	℃
Average Operation Current (Pressure Measurement under One Conversion per Second)	I_{DDAVP}	OSR*	4096		85.2		µA
			2048		42.6		
			1024		21.3		
			512		10.7		
			256		5.3		
			128		2.7		
Average Operation Current (Temperature Measurement under One Conversion per Second)	I_{DDAVT}	OSR*	4096		68.8		µA
			2048		34.4		
			1024		17.2		
			512		8.6		
			256		4.3		
			128		2.2		
Conversion Time of Pressure or Temperature	t_{CONV}	OSR*	4096		65.6		ms
			2048		32.8		
			1024		16.4		
			512		8.2		
			256		4.1		
			128		2.1		
Peak Current	I_{PEAK}	During conversion			1.3		mA
Standby Supply Current	I_{DDSTB}	At 25℃				0.1	µA
Serial Data Clock Frequency	f_{SCLK}	I^2C protocol, pull-up resistor of 10k			100	400	kHz
Digital Input High Voltage	V_{IH}			0.8			V
Digital Input Low Voltage	V_{IL}					0.2	V
Digital Output High Voltage	V_{OH}	IO = 0.5 mA		0.9			V
Digital Output Low Voltage	V_{OL}	IO = 0.5 mA				0.1	V
Input Capacitance	C_{IN}				4.7		pF

*OSR stands for over sampling rate

2.3 Absolute Maximum Rating

Table 4: Absolute Maximum Rating

Parameter	Symbol	Conditions	Min	Max	Unit
Overpressure	P_{MAX}			3X	
Supply Voltage	V_{DD}		-0.3	3.6	V
Interface Voltage	V_{IF}		-0.3	VDD+0.3	V
Storage Temperature Range	T_{STG}		-50	150	℃
Maximum Soldering Temperature	T_{MS}	10 second maximum		250	℃
ESD Rating		Human body model	-2	+2	kV
Latch-up Current		At 85℃	-100	100	mA

Stresses above those listed as “absolute maximum ratings” may cause permanent damage to the device. This is a stress rating only and functional operation of the device under these conditions is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.

3. Function Descriptions

3.1 General Description

The HP209 is a high precision measures the pressure and the temperature by an internal 24-bit ADC and compensates them by a patented algorithm. The fully-compensated values can be read out via the I²C interface by external MCU. The uncompensated values can also be read out in case the user wants to perform their own data compensation. The devices can also compute the value of altitude according to the measured pressure and temperature.
Furthermore, the device allows the user to setup the temperature, pressure and altitude threshold values for various events. Once the device detects that a certain event has happened, a corresponding interrupt will be generated and sent to the external MCU. Also, multiple useful interrupt options are available to be used by the user.

3.2 Factory Calibration

Every device is individually factory calibrated for sensitivity and offset for both of the temperature and pressure measurements. The trim values are stored in the on-chip 128-Byte Non-Volatile Memory (NVM). In normal situation, further calibrations are not necessary to be done by the user.

3.3 Automatic power on initialization

Once the device detects a valid VDD is externally supplied, an internal Power-On-Reset (POR) is generated and the device will automatically enter the power-up initialization sequence. After that the device will enter the sleep state. Normally the entire power-up sequence consumes about 400 us.
The user can scan a DEV_RDY bit in the INT_SRC register in order to know whether the device has finished its power-up sequence. This bit appears to 1 when the sequence is done. The device stays in the sleep state unless it receives a proper command from the external MCU. This will help to achieve minimum power consumptions.

3.4 Sensor Output Conversion

For each pressure measurement, the temperature is always being measured prior to pressure measurement automatically, while the temperature measurement can be done individually. The conversion results are stored into the embedded memories that retain their contents when the device is in the sleep state. The conversion time depends on the value of the OSR parameter sent to the device within the ADC_CVT command. Six options of the OSR can be chosen, range from 128, 256 … to 4096. The below table shows the conversion time according to the different values of OSR:

Table 5: Conversion Time VS OSR

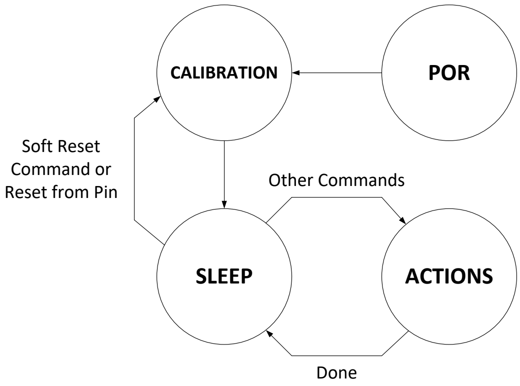
OSR	Conversion Time (ms)	
	Temperature	Temperature and Pressure
128	2.1	4.1
256	4.1	8.2
512	8.2	16.4
1024	16.4	32.8
2048	32.8	65.6
4096	65.6	131.1

The higher OSR will normally achieve higher measuring precision, but consume more time and power.
The conversion results can be compensated or uncompensated. The user can enable/disable the compensation by setting the PARA register before performing the conversions.

4. Access Modes & Commands

4.1 Operation Flow

During each power-up/reset cycle, the device will only perform one calibration. After that it will enter the SLEEP state waiting for any incoming commands. It will take actions after receiving different proper commands, and re-enters the SLEEP state when it finishes the jobs.



4.2 Command

The Command Set (Table 6) allows the user to control the device to perform the measuring, results reading and the miscellaneous normal operations.

4.2.1 Soft Reset the Device

.SOFT_RST (0x06)

Once the user issues this command, the device will immediately be reset no matter what it is working on. Once the command is received and executed, all the memories (except the NVM) will be reset to their default values following by a complete power-up sequence to be automatically performed.

4. 2.2 OSR and Channel Setting

.ADC_CVT (010, 3-bit OSR, 2-bit CHNL)

This command let the device to convert the sensor output to the digital values with or without compensation depends on the PARA register setting. The 2-bit channel (CHNL) parameter tells the device the data from which channel(s) shall be converted by the internal ADC. The options are shown below:

00: sensor pressure and temperature channel
10: temperature channel

The 3-bit OSR defines the decimation rate of the internal digital filter as shown below:

000:	OSR = 4096	011:	OSR = 512
001:	OSR = 2048	100:	OSR = 256
010:	OSR = 1024	101:	OSR = 128

Setting the CHNL bits to the value of 01 or 11, or the OSR bits to the values of 110 or 111 will lead to failure of conversion.

4. 2.3 Read the Temperature and Pressure Values

.READ_PT (0x10)

The temperature data is arranged as 20-bit 2's complement format and the unit is in degrees C. Temperature value is stored in all 24 bits of OUT_T_MSB, OUT_T_CSB and OUT_T_LSB. The 4 most significant bits of the 24-bit data is useless, while the 20 least significant bits represent the temperature value. The user shall convert this 20-bit 2's complement binary value into an integer, and then divide the integer by 100 to obtain the final result.
The pressure data is arranged as 20-bit 2's complement format and the unit is in Pascal. Pressure value is stored in all 24 bits of OUT_T_MSB, OUT_T_CSB and OUT_T_LSB. The 4 most significant bits of the 24-bit data is useless, while the 20 least significant bits represent the pressure value. The user shall convert this 20-bit unsigned binary value into an integer, and then divide the integer by 100 to obtain the final result.

For Example: (Temperature)

Hex value	OUT_T_MSB	OUT_T_CSB	OUT_T_LSB	Dec value
0x000A5C	0x00	0x0A	0x5C	26.52
0xFFFC02	0xFF	0xFC	0x02	-10.22

For Example: (Unsigned data pressure)

Hex value	OUT_ P _MSB	OUT_ P_CSB	OUT_ P_LSB	Dec value
0x00C326	0x00	0XC3	0x26	49958
40 Kpa and Below : P(unit: pa) =49958 / 10 -1000 = 3995.8				
100Kpa and 200Kpa: P(unit: Hpa) =49958/100 -100 = 399.58				

**1Hpa=100pa*

4. 2.4 Read the Pressure Value

.READ_P (0x30)

The pressure data is arranged as 20-bit 2's complement format and the unit is in Pascal. Pressure value is stored in all 24 bits of OUT_T_MSB, OUT_T_CSB and OUT_T_LSB. The 4 most significant bits of the 24-bit data is useless, while the 20 least significant bits represent the pressure value. The user shall convert this 20-bit unsigned binary value into an integer, and then divide the integer by 100 to obtain the final result.

4. 2.5 Read the Temperature Value

.READ_T (0x32)

The temperature data is arranged as 20-bit 2's complement format and the unit is in degrees C. Temperature value is stored in all 24 bits of OUT_T_MSB, OUT_T_CSB and OUT_T_LSB. The 4 most significant bits of the 24-bit data is useless, while the 20 least significant bits represent the temperature value. The user shall convert this 20-bit 2's complement binary value into an integer, and then divide the integer by 100 to obtain the final result.

Table 6: The Command Set

Name	Hex Code	Binary Code	Descriptions
SOFT_RST	0x06	0000 0110	Soft reset the device
ADC_CVT	NA	010_OSR_chnl	Perform ADC conversion
READ_PT	0x10	0001 0000	Read the temperature and pressure values
READ_P	0x30	0011 0000	Read the pressure value only
READ_T	0x32	0011 0010	Read the temperature value only

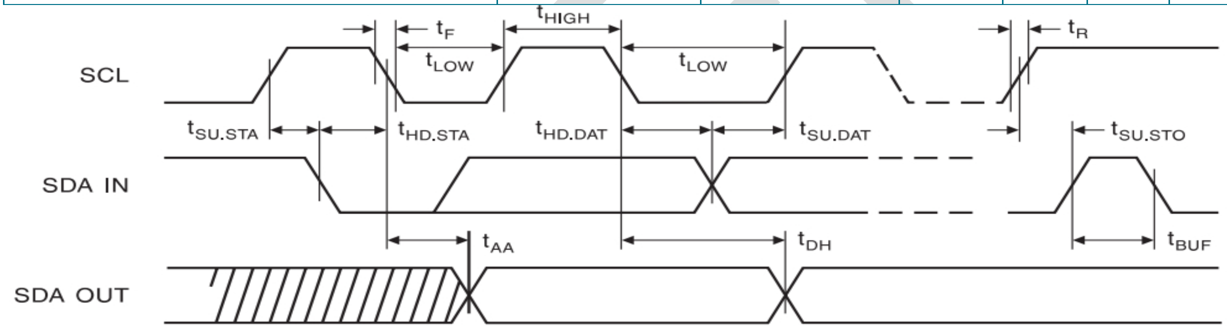
5. I²C Interface

The I²C interface is fully compatible to the official I²C protocol specification. All the data are sent starting from the MSB. Successful communication between the host and the device via the I²C bus can be done using the four types of protocol introduced below.

5.1 I²C Specification

Table 7: I²C Slave Timing Values

Parameter	Symbol	I²C Condition	Min	Typ.	Max	Unit
SCL Clock Frequency	S_{CL}	Pull-up = 10 kΩ	0		400	KHz
Bus free time between STOP and START condition	t_{BUF}		1.5			µs
Repeated START Hold Time	$t_{HD.STA}$		0.6			µs
Repeated START Setup Time	$t_{SU.STA}$		0.6			µs
STOP Condition Setup Time	$t_{SU.STO}$		0.6			µs
SDA Data Hold Time	$t_{HD.DAT}$		100			ns
SDA Setup Time	$t_{SU.DAT}$		100			ns
SCL Clock Low Time	t_{LOW}		1.5			µs
SCL Clock High Time	t_{HIGH}		0.6			µs
SDA and SCL Rise Time	t_R		30		500	ns
SDA and SCL Fall Time	t_F		30		500	ns



5.2 I²C Device and Register Address

The I²C device address is shown below. The LSB of the device address is corresponding to address 0XEC (write) and 0XED (read).

A7	A6	A5	A4	A3	A2	A1	W/R
1	1	1	0	1	1	CSB=0:1 CSB=1:0	0/1

CSB PIN=0: corresponding to address 0XEE (write) and 0XEF (read).
CSB PIN=1: corresponding to address 0XEC (write) and 0XED (read).

5.3 I²C Protocol

The 1st TYPE: the host issuing a single byte command to the device

The host shall issue the Device Address (ID) followed by a Write Bit before sending a Command byte. The device will reply an ACK after it received a correct SOFT_RST command.

	1	1	1	0	1	1	CSB	0	**0**	0	0	0	0	0	1	1	0	**0**	
S	Device Address							**W**	**A**	Command								**A**	P

The 2nd TYPE: the host writing a register inside the device

The host shall issue the Device Address (ID) followed by a Write Bit before sending a command byte and a data byte. This format only applies while the user wants to send the WRITE_REG command.

	1	1	1	0	1	1	CSB	0	**0**	1	1	0	0	1	0	1	0	**0**	0	0	0	0	0	1	1	0	**0**	
S	Device Address							**W**	**A**	Command								**A**	Data								**A**	P

The 3rd TYPE: the host reading a register from the device

In this activity there are two frames that are sent separately. The first frame is to send the READ_REG command which contains a 2-bit binary number of 10 followed by a 6-bit register address. The format of the first frame is identical to the 1st type activity. In the second frame, the device will send back the register data after receiving the correct device address followed by a read bit. This format only applies while the user wants to use the READ_REG command.

	1	1	1	0	1	1	CSB	0	**0**	1	0	0	0	0	1	1	0	**0**	
S	Device Address							W	**A**	Command								**A**	P

	1	1	1	0	1	1	CSB	1	**0**	**1**	**0**	**0**	**1**	**0**	**1**	**1**	**0**	1	
S	Device Address							R	**A**	**Data**								N	P

The 4th TYPE: the host reading the 3-byte or 6-byte ADC data from the device

In this activity there are two frames that are sent separately. The first frame is identical to sending a single command, which can be one of the conversion result reading commands. In the second frame, the device will send back the ADC data (either 3 bytes or 6 bytes depending on the commands) after receiving the

	1	1	1	0	1	1	CSB	0	**0**	0	0	0	0	0	1	1	0	**0**	
S	Device Address							W	**A**	Command								**A**	P

	1	1	1	0	1	1	CSB	1	**0**	**0**	**1**	**0**	**0**	**0**	**1**	**1**	**0**	0
S	Device Address							R	**A**	**Data Byte 6 or 3**								A

0	**0**	**1**	**1**	**0**	**1**	**0**	**0**	1	
Data Byte 0								N	P

Bit Descriptions

	From Host		From Chip
S	Start Bit	P	Stop Bit
W	Write	R	Read
A	ACK	N	NACK

6. Typical Application Circuit

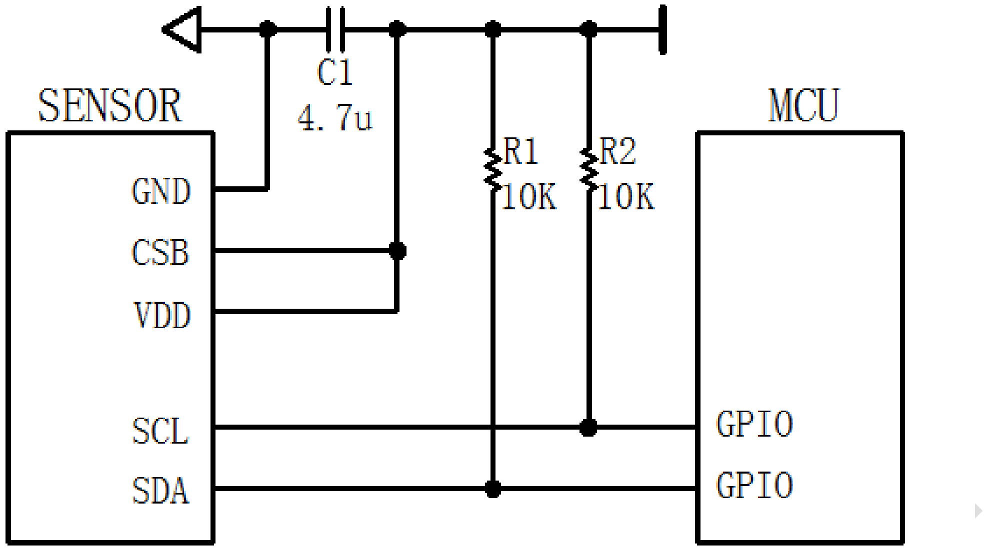


Figure2: Typical application circuit

7. Recommended PAD Layout

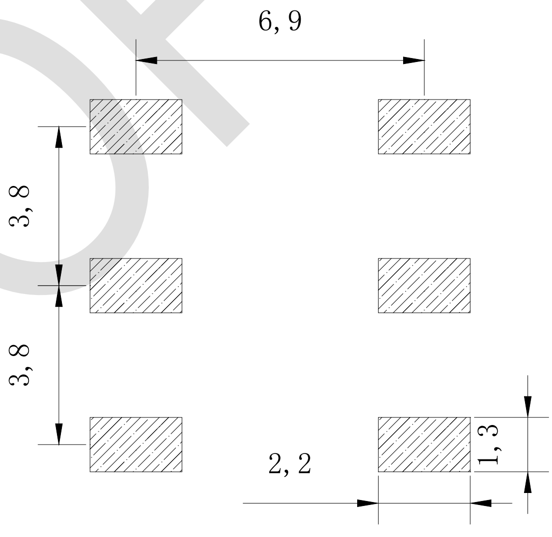
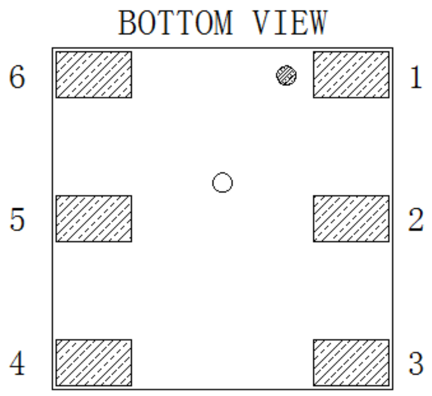


Figure3: HP209 pad layout (unit: mm)

8. Pin Configuration

Table 8 Pin Descriptions

Pin	Name	I/O	Function
1	GND	I	Ground
2	VDD	I	power supply
3	NC	-	NO Connect
4	SCL	I	I²C serial clock input pin
5	SDA	IO	I²C serial bi-directional data pin
6	CSB	I	I²C device address select pin



9. Ordering Guide

<u>HP209</u> – <u>004</u> <u>G</u> – <u>W</u>

Port (T = Tube, W = Wide Hole, F: Fill Gel, N: Narrow Hole)
G=Gage
Pressure Range (004: 0~4 Kpa)
Model

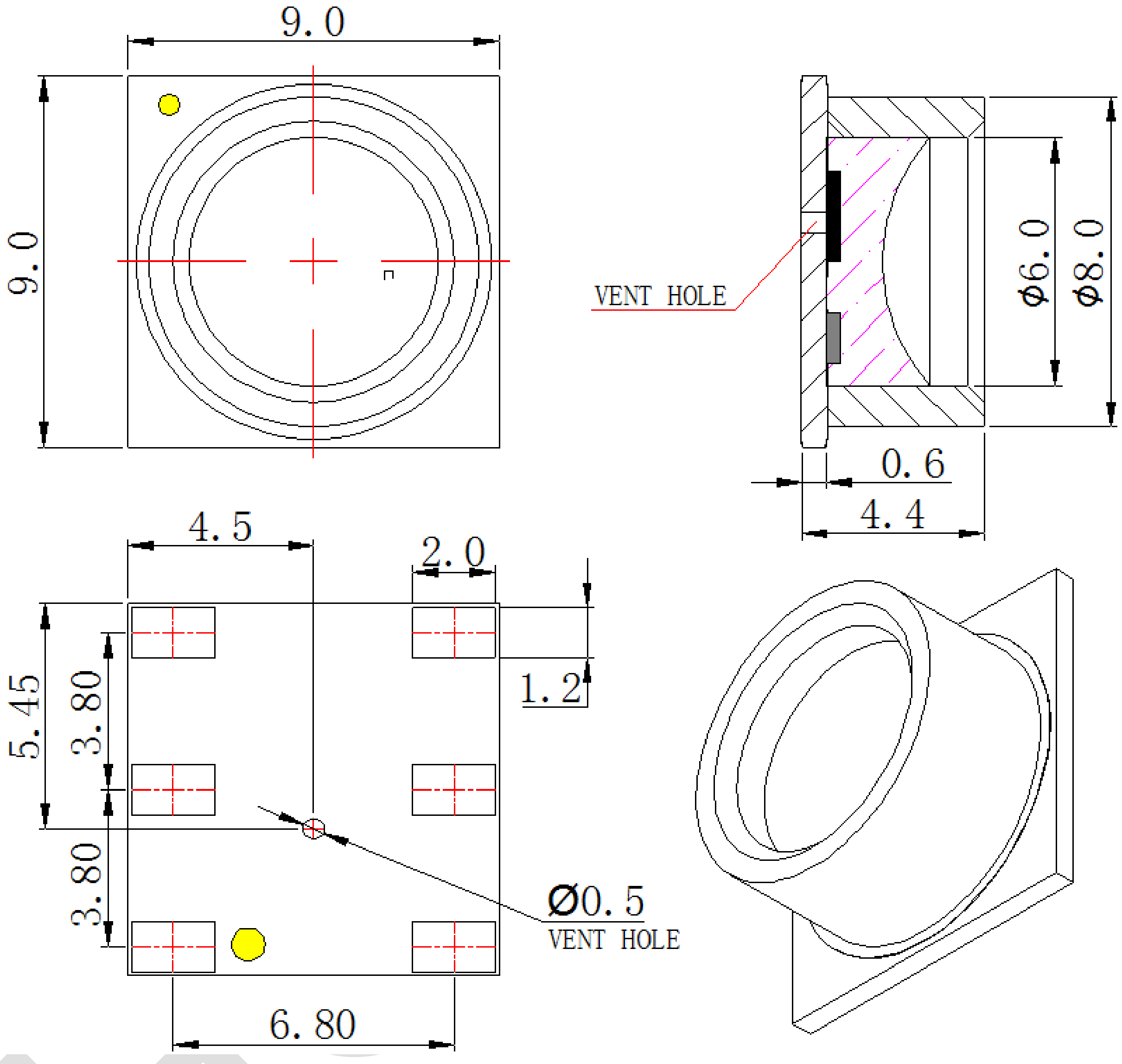
Table 9 Ordering Information

Part Number	Range	Unit
HP209-002G-W	2	Kpa
HP209-004G-W	4	Kpa
HP209-006G-W	6	Kpa
HP209-008G-W	8	Kpa
HP209-010G-W	10	Kpa
HP209-100G-W	100	Kpa
HP209-200G-W	200	Kpa
HP209-002G-T	2	Kpa
HP209-004G-T	4	Kpa
HP209-006G-T	6	Kpa
HP209-008G-T	8	Kpa
HP209-010G-T	10	Kpa
HP209-100G-T	100	Kpa
HP209-200G-T	200	Kpa
HP209-002G-F	2	Kpa
HP209-004G-F	4	Kpa
HP209-006G-F	6	Kpa
HP209-008G-F	8	Kpa
HP209-010G-F	10	Kpa
HP209-100G-F	100	Kpa
HP209-200G-F	200	Kpa
HP209-010G-N	10	Kpa
HP209-200G-N	200	Kpa

**-W and -F: Water proof*

10. Package Information

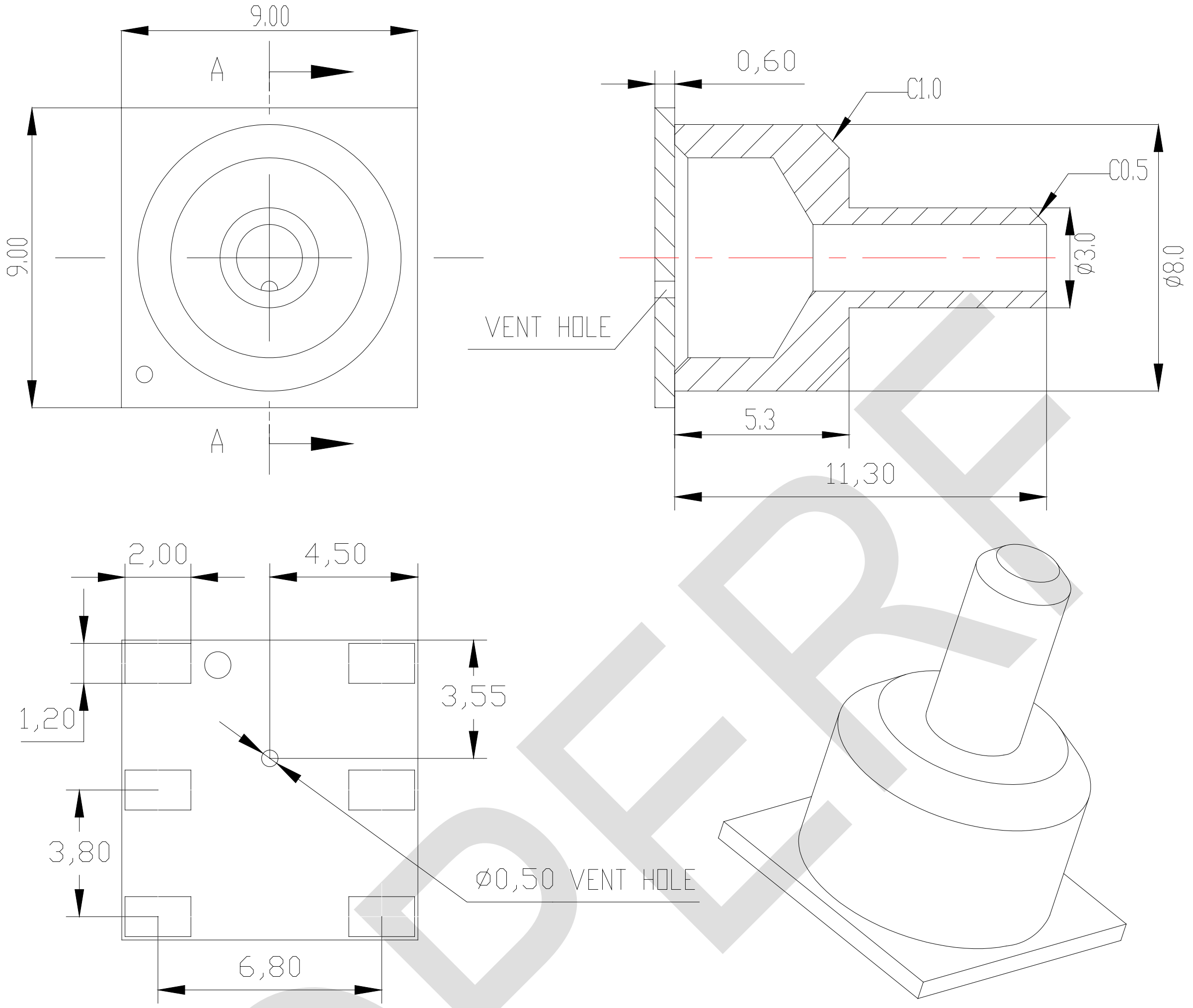
10.1 W: Wide Hole



Mechanical Dimension (unit: mm)
General tolerance (0.15mm)

Figure4: HP209 Wide Hole

10.2 T: Tube

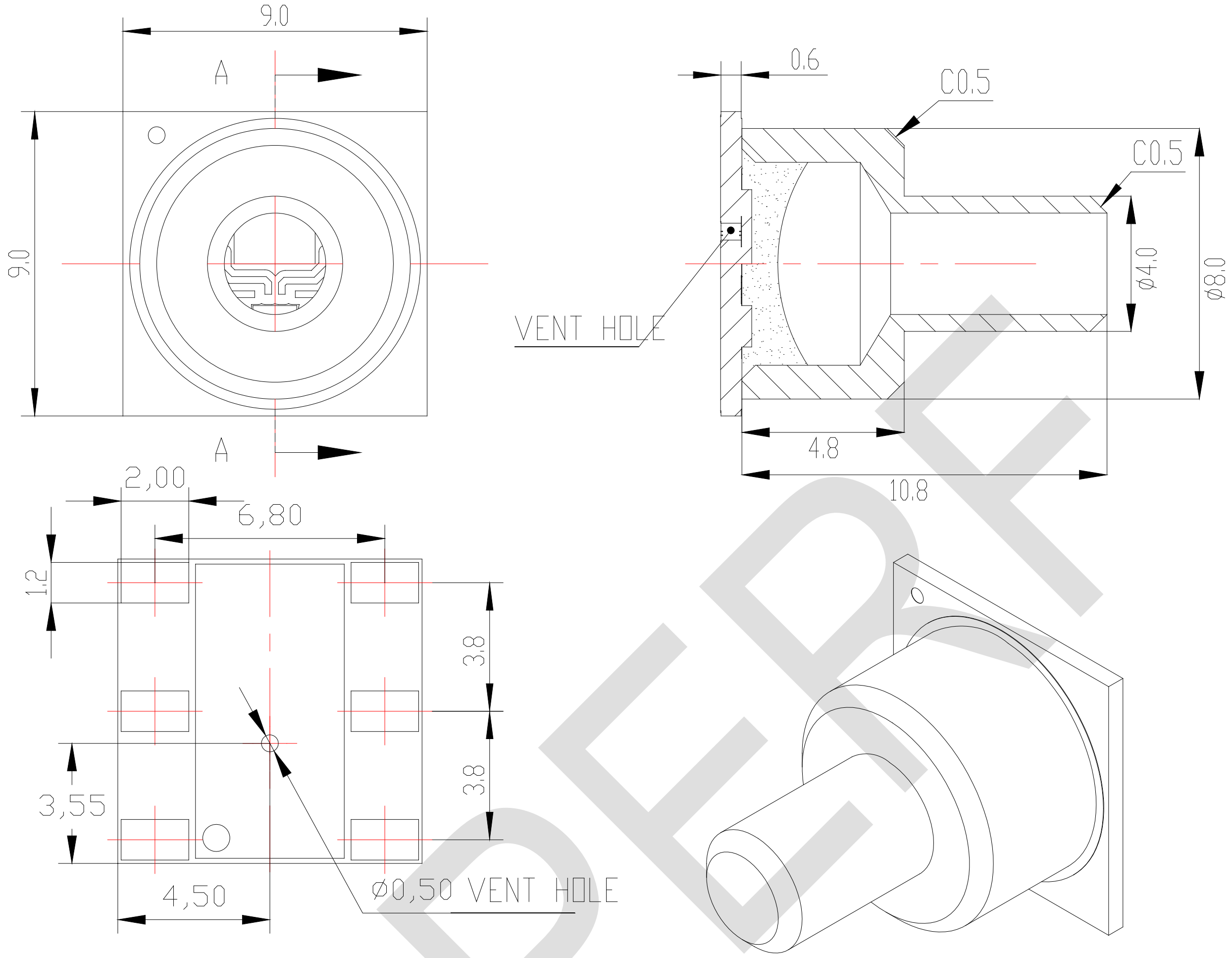


Mechanical Dimension (unit: mm)
General tolerance (0.15mm)

Figure 5: HP209 Tube

Note:
Since February 1, 2024, the tube has been welded to the PCB using reflow welding process, and the tube is no longer bonded by glue process.

10.3 F: Fill Gel

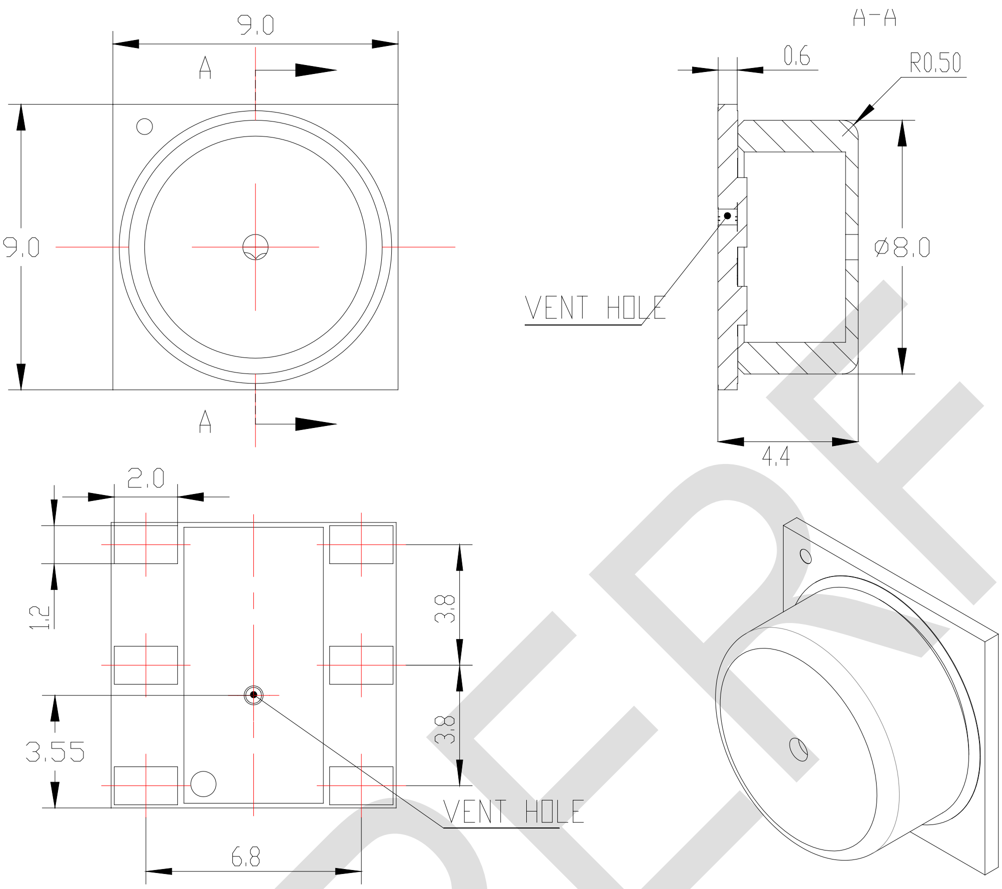


Mechanical Dimension (unit: mm)
General tolerance (0.15mm)

Figure 6: HP209 Fill Gel

Note:
Since February 1, 2024, the tube has been welded to the PCB using reflow welding process, and the tube is no longer bonded by glue process.

10.4 N: Narrow Hole



Mechanical Dimension (unit: mm)
General tolerance (0.15mm)

Figure 7: Narrow Hole

11. Revision History

Revision	Description	Date
1.0	Initial Release	2018/05/09
1.1	Update Table 6	2019/07/22
1.2	Add new part(Table 9 and 10.3)	2021/04/23
1.3	Update the reflow welding process for bonding the tube.	2024/02/01