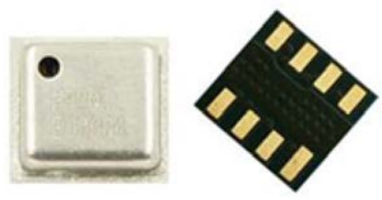
HIGH-PRECISION BAROMETER & ALTIMETER SENSOR

Features

Supply voltage: 1.8V to 3.6V
Pressure range: 300mbar~1200mbar
Fully compensated data
Direct Reading, compensated:
-Pressure: 20-bit measurement (Pascals)
-Altitude: 20-bit measurement (Meters)
-Temperature: 20-bit measurement (Degrees Celsius)
Altitude Resolution down to 0.2 meter
Standby current: <0.1μA
Operation temperature: -40 to +85℃
High-speed I²C digital interface
Size: 3.8 × 3.6 × 1.15 mm



3.8 × 3.6 × 1.15 mm

Applications

Mobile altimeter / barometer
Industrial pressure and temperature sensor system
Adventure and sports watches
Weather station equipment
Data loggers for pressure, temperature and altitude

Descriptions

The HP203N 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 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. 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 a Pascal, and altitude can be resolved in 0.1 meter. Package is surface mount with a stainless steel cap and is RoHS compliant.

1. Block Diagram

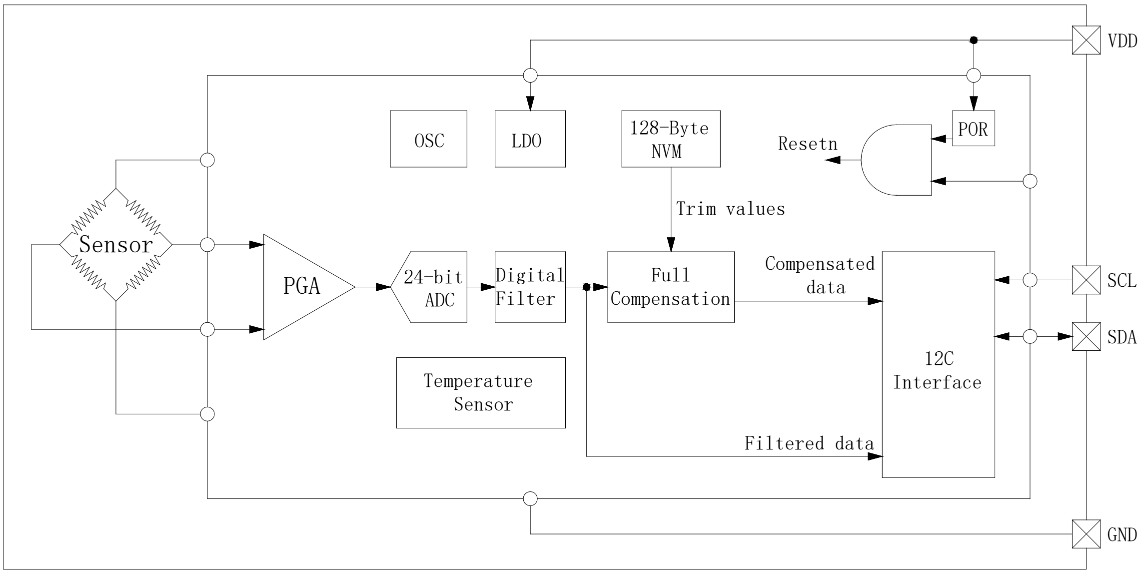


Figure 1: Block Diagram

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
Pressure Measurement Range	P_{FS}		300		1200	mbar
Pressure Absolute Accuracy		300 to 1100mbar from 0°C to 60°C		±2.0		mbar
Pressure Relative Accuracy		300 to 1100mbar from 0°C to 60°C		±1.0		mbar
Max Error with Power Supply		Power supply from 1.8V to 3.6V	-2.5		+2.5	mbar
Pressure/Altitude Resolution		Pressure Mode		0.01		mbar
		Altimeter Mode		0.20		m
Long Term Drift		After a period of 1 year		±2.0		mbar
Reflow Soldering Impact		IPC/JEDEC J-STD-020C		±1.0		mbar

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	°C
Temperature Absolute Accuracy		At +25°C		±0.5		°C
		From 0°C to +60°C		±1.5		°C
Max Error with Power		Power supply from 1.8V to 3.6V	-0.5		+0.5	°C
Temperature Resolution				0.01		°C

2.2 Electrical Characteristics

Table 3: DC Characteristics @VDD=3 V, T=25°C unless otherwise noted

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	°C
Average Operation Current (Pressure Measurement under One Conversion per Second)	I_{DDAVP}	OSR*	4096		91.8		µA
			2048		45.9		
			1024		22.9		
			512		11.4		
			256		5.7		
			128		2.9		
Average Operation Current (Temperature Measurement under One Conversion per Second)	I_{DDAVT}	OSR*	4096		75.4		µA
			2048		37.7		
			1024		18.8		
			512		9.4		
			256		4.7		
			128		2.4		
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°C				0.1	µA
Serial Data Clock Frequency	f_{SCLK}	I^2C protocol, pull-up resistor of 10k		0	100	400	kHz
Digital Input High Voltage	V_{IH}			0.8			V_{DD}
Digital Input Low Voltage	V_{IL}					0.2	V_{DD}
Digital Output High	V_{OH}	I_O = 0.5 mA		0.9			V_{DD}
Digital Output Low	V_{OL}	I_O = 0.5 mA				0.1	V_{DD}
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}			5	bar
Supply Voltage	V_{DD}		-0.3	3.6	V
Interface Voltage	V_{IF}		-0.3	V_{DD}+0.3	V
Storage Temperature Range	T_{STG}		-40	125	℃
Maximum Soldering Temperature	T_{MS}	40 seconds 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 HP203N is a high precision barometer and altimeter that measures the pressure and the temperature by an internal 24-bit ADC and compensates them by a 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.

3.2 Factory Calibration

Every device is individually factory calibrated for sensitivity and offset for both 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

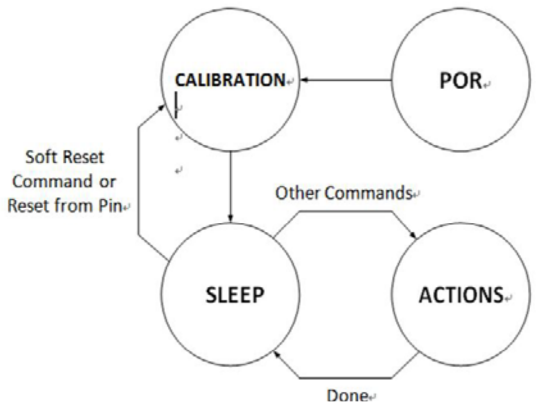
OSR	Conversion Time (ms)	
	Temperature	Temperature and Pressure (or Altitude)
128	2.1	4.1
256	4.1	8.2
512	8.2	16.4
1024	16.4	32.8
2048	32.8	65.6
4096	65.6	131.1

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.

Table 6: The Command Set

Name	Hex Code	Binary Code	Descriptions
SOFT_RST	0x06	0000 0110	Soft reset the device
ADC_CVT	NA	010_dsr_chnl	Perform ADC conversion
READ_PT	0x10	0001 0000	Read the temperature and pressure values
READ_AT	0x11	0001 0001	Read the temperature and altitude values
READ_P	0x30	0011 0000	Read the pressure value only
READ_A	0x31	0011 0001	Read the altitude value only
READ_T	0x32	0011 0010	Read the temperature value only
ANA_CAL	0x28	0010 1000	Re-calibrate the internal analog blocks
READ_REG	NA	10_addr	Read out the control registers
WRITE_REG	NA	11_addr	Write in the control registers

4. 2.1 Soft Reset

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 Temperature and Pressure Values

READ_PT (0x10)

This command allows the user to read out the 24-bit temperature conversion result and 24-bit pressure conversion result in sequence, starting from the MSB of the temperature data and ending with the LSB of the pressure data.

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: (Pressure)

Hex Value	OUT_ P _MSB	OUT_ P_CSB	OUT_ P_LSB	Dec Value
0x018A9E	0x01	0x8A	0x9E	101022
101022 / 100 = 1010.22 mBar				

4. 2.4 Read Temperature and Altitude Values

READ_AT (0x11)

This command allows the user to read out the 24-bit temperature conversion result and 24-bit altitude conversion result in sequence, starting from the MSB of the temperature data and ending with the LSB of the altitude data.

For Example: (Altitude)

Hex Value	OUT_A_MSB	OUT_A_CSB	OUT_A_LSB	Dec Value
0x001388	0x00	0x13	0x88	50.00
0xFFEC78	0xFF	0xEC	0x78	-50.00

4. 2.5 Read Pressure Value

READ_P (0x30)

This command allows the user to read out the 24-bit pressure conversion result, starting from the MSB.

4. 2.6 Read Altitude Value

READ_A (0x31)

This command allows the user to read out the 24-bit altitude conversion result, starting from the MSB.

4. 2.7 Read Temperature Value

READ_T (0x32)

This command allows the user to read out the 24-bit temperature conversion result, starting from the MSB.

4. 2.8 Re-calibrate Internal Analog Blocks

ANA_CAL (0x28)

This command allows the user to re-calibrate the internal circuitries in a shorter time compare to soft resetting the device. It is designed for the applications where the device needs to work in a rapidly changed environment. In those environments, since the temperature and supply voltage may have changed significantly since the first power-up sequence during which the calibrations have been performed, the circuitries may not adept to the world as better as they were just calibrated. Therefore, in this case, re-calibrating the circuitries before performing any sensor conversions can give a more accurate result.

Once the device received this command, it calibrates all the circuitries and enters the sleep state when it finishes. The user can simply send this command to the device before sending the ADC_CVT command. However, it is not necessary to use this command when the environment is stable.

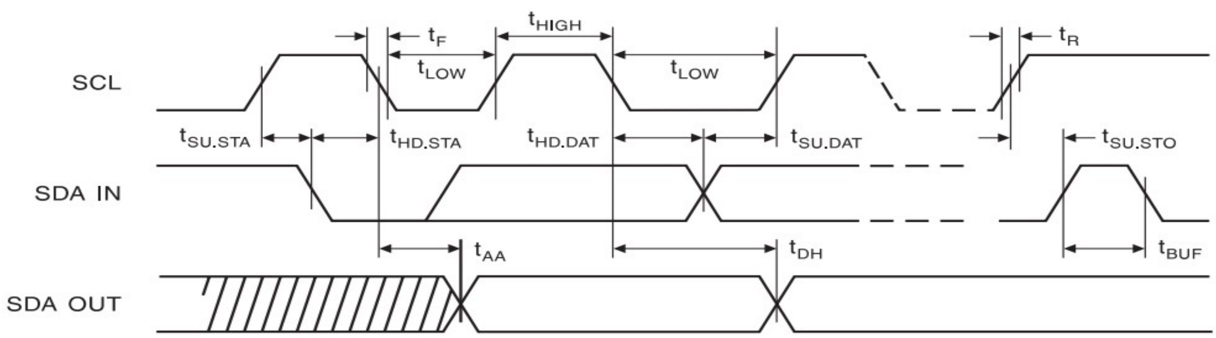
5. I²C Interface

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				Unit
		Condition	Min	Typ	Max	
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 determined by the status of the CSB pin:

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

<table>
<tr><th>A7</th><th>A6</th><th>A5</th><th>A4</th><th>A3</th><th>A2</th><th>A1</th><th>W/R</th></tr>
<tr><td rowspan="2">1</td><td rowspan="2">1</td><td rowspan="2">1</td><td rowspan="2">0</td><td rowspan="2">1</td><td rowspan="2">1</td><td>CSB = 0 : 1</td><td rowspan="2">0/1</td></tr>
<tr><td>CSB = 1 : 0</td></tr>
</table>

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 correct Device Address followed by a Read Bit.

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

Bit Descriptions

(blank box)	From Host	(shaded box)	From Chip
S	Start Bit	P	Stop Bit
W	Write	R	Read
A	ACK	N	NACK
CSB	Sensor CSB PIN		

6. Typical Application Circuit

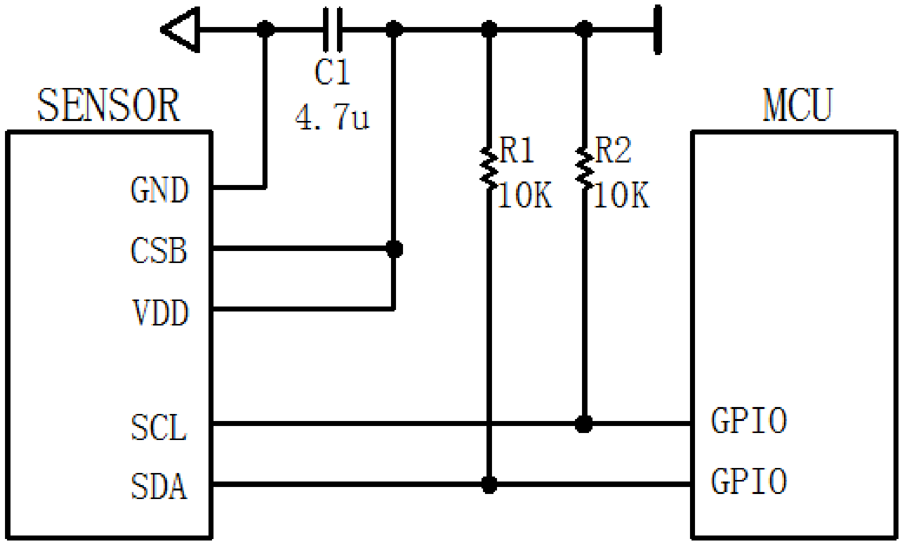
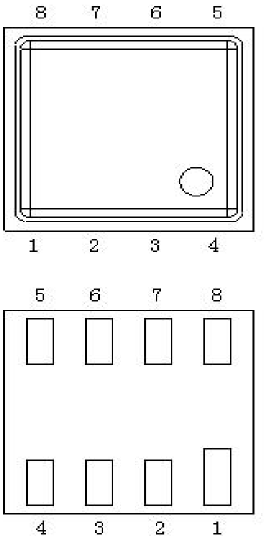


Figure 2: Typical Application Circuit

7. Pin Configuration

Table 8 Pin Descriptions

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



8. Package Information

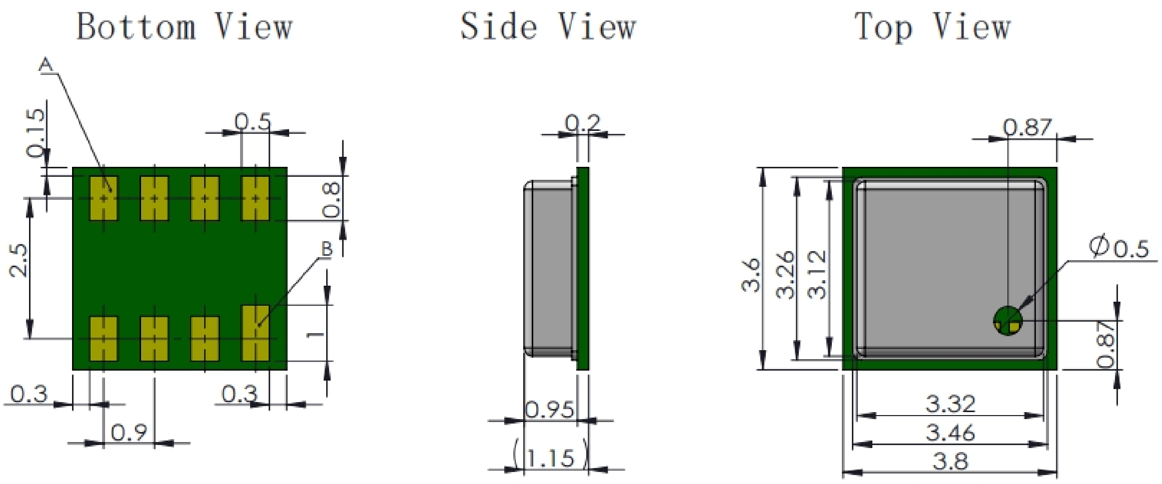
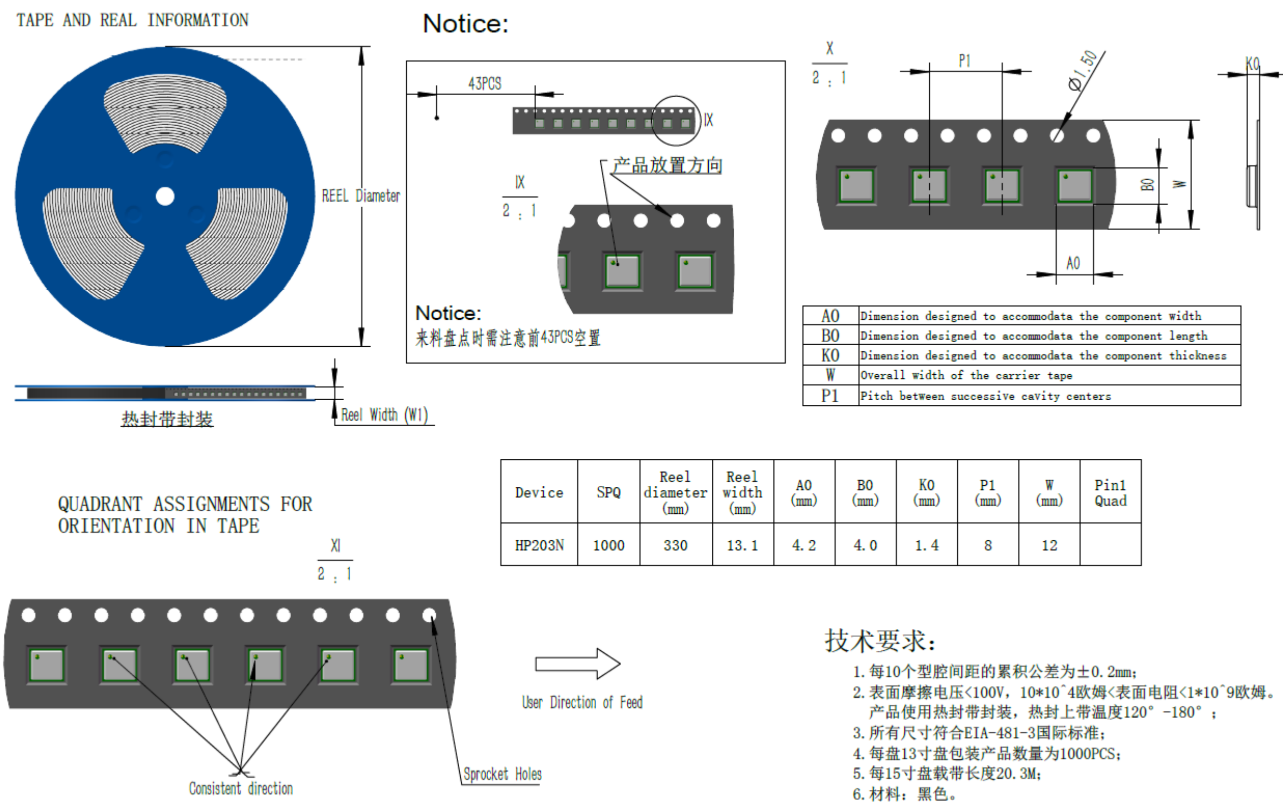


Figure 3: Package Dimension (Unit: mm)

Notes: General Tolerance: ±0.10mm

9. Tape and Reel Specification

Carrier Tape Dimension (Unit： mm).
Quantity per Reel: 3000 pcs.



Device	SPQ	Reel diameter (mm)	Reel width (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quad
HP203N	1000	330	13.1	4.2	4.0	1.4	8	12	

Figure 4: Tape and Reel Specification

10. Publication History

Version	Date	Description
V1.0	2017.7.10	New release
V2.0	2018.3.19	Update pin descriptions
V2.1	2023.1.9	Update pressure and temperature characteristics
V2.2	2024.2.6	Update package information and tape & reel specification