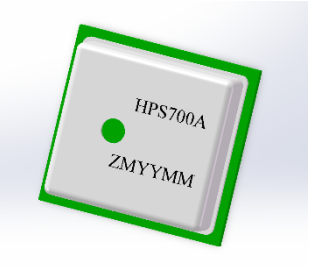
PRESSURE SENSOR

Features



- Operating voltage: 1.8V to 3.6V
- Pressure range: 0Kpa to 1600Kpa
- Fully compensated data
- Standby current: <0.1μA
- Operating temperature: -40℃ to +85℃
- Interface: I²C
- Size: 3.8 × 3.6 × 1.15mm

Applications

- Portable air pump
- Mobile barometer
- Industrial pressure and temperature monitor
- Adventure and sports watches
- Weather station

Descriptions

The HPS700A-ZM employs a MEMS pressure sensor with an I²C interface to provide accurate temperature, pressure data. The pressure and temperature outputs are digitized by a high resolution 24-bit ADC. Data compensation is integrated internally to save the effort of the external host MCU system.

Block Diagram

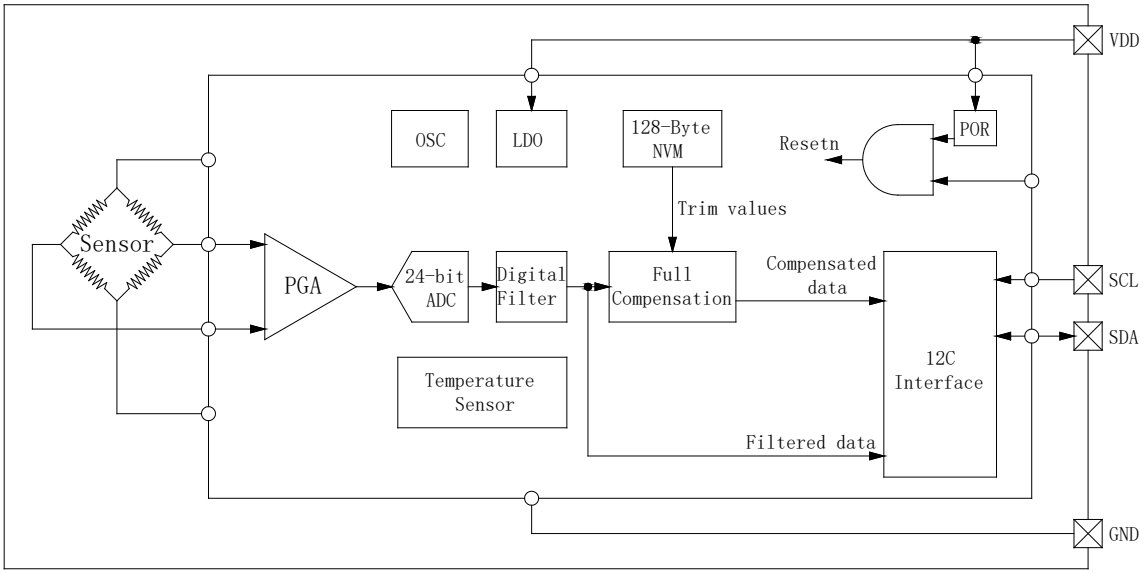


Figure 1: Block Diagram

Pressure and Temperature Characteristics

Table 1: Pressure Characteristics @ VDD = 3.0V, T = 25℃

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Pressure Measurement Range	P_{FS}		0		1600	Kpa
Pressure Absolute Accuracy		0 to 700 Kpa from -20℃ to 60℃		±2.0		Kpa
Pressure Relative Accuracy		0 to 700 Kpa from -20℃ to 60℃		±1.5		Kpa
Maximum Error with Power Supply		Power supply from 1.8V to 3.6V	-2.5		+2.5	Kpa
Pressure Resolution				0.02		Kpa
Long Term Drift		After a period of 1 year		±2.0		Kpa
Reflow Soldering Impact		IPC/JEDEC J-STD-020C		±1.0		Kpa

Table 2: Temperature Characteristics @ VDD = 3.0V, T = 25°C

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Operation Temperature Range	T_{OP}		-40		+85	℃
Temperature Absolute Accuracy		At +25℃		±0.5		℃
		From 0℃ to +60℃		±2.0		℃
Maximum Error with Power Supply		Power Supply from 1.8V to 3.6V	-0.5		+0.5	℃
Temperature Resolution				0.01		℃

Electrical Characteristics

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

Parameter	Symbol	Conditions		Min.	Typ.	Max.	Unit
Operating Voltage	V_{DD}			1.8	3.0	3.6	V
Operating Temperature	T_{OP}			-40		+85	℃
Average Operating 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 Operating 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 Current	I_{DDSTB}	At 25℃				0.1	μA
Serial Clock Frequency	F_{SCLK}	I²C bus with 10k pull-up resistor		0	100	400	kHz
Digital Input High Voltage	V_{IH}			0.8			VDD
Digital Input Low Voltage	V_{IL}					0.2	VDD
Digital Output High Voltage	V_{OH}	IO = 0.5mA		0.9			VDD
Digital Output Low Voltage	V_{OL}	IO = 0.5mA				0.1	VDD
Input Capacitance	C_{IN}				4.7		pF

Note: *OSR stands for over sampling rate.

Absolute Maximum Rating

Table 4 Absolute Maximum Rating

Parameter	Symbol	Conditions	Min.	Max.	Unit
Overpressure	P_{MAX}			20	bar
Supply Voltage	V_{DD}		-0.3	3.6	V
Interface Voltage	V_{IF}		-0.3	VDD+0.3	V
Storage Temperature	T_{STG}		-40	125	℃
Soldering Temperature	T_{MS}	Within 40 Seconds		250	℃
ESD Rating		HBM	-2	+2	kV
Latch-up Current		At +85℃	-100	100	mA

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

Function Description

General Description

The HPS700A-ZM is a high precision barometer that measures pressure and the temperature by an internal 24-bit ADC and compensates them by the special algorithm. The compensated values can be read out via the I²C interface by the external MCU. The uncompensated values can also be read out in case the user wants to perform their own data compensation.

Factory Calibration

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

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-on initialization sequence. After that the device will enter the sleep state. Normally the entire power-on sequence consumes about 400us. The user can scan a DEV_RDY bit in the INT_SRC register to know whether the device has finished its power-on 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.

Conversion Time

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 OSR value within the ADC_CVT register. The OSR value can be chosen from 128 to 4096. The below table shows the conversion time according to the different OSR value.

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

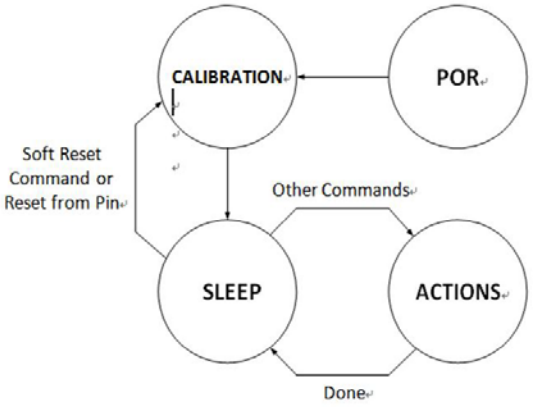
The higher OSR value will normally achieve higher measuring precision but consume more time and more power.

The conversion results can be compensated or uncompensated. The user can enable/disable the compensation by setting the PARA register before performing the conversions.

Access Modes & Commands

Workflow

During each power-on 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 proper commands and re-enter the SLEEP state when it finishes the jobs.



The Command Set

The Command Set allows the user to control the device to perform the measurement, reading results and other normal operations.

Table 6: The Command Set

Name	Hex Code	Binary Code	Descriptions
SOFT_RST	0x06	0000 0110	Soft reset the device
ADC_CVT		010 xxx(OSR) xx(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

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-on sequence which will be automatically performed.

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 CHNL tells the device the data from which channel shall be converted by the internal ADC. The options are shown below.

00: 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
001: OSR = 2048
010: OSR = 1024
011: OSR = 512
100: OSR = 256
101: OSR = 128

Note: setting the CHNL bits to the value of 01 or 11 or setting the OSR bits to the value of 110 or 111 will lead to failure of conversion.

Read Temperature and Pressure Values

READ_PT (0x10)
This command allows the user to read out the 24-bit temperature conversion result and the 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
Pressure Calculation Formula: 101022 / 100 = 1010.22 Kpa				

Read the Pressure Value

READ_P (0x30)
This command allows the user to read out the 24-bit pressure conversion result, starting from the MSB.

Read the Temperature Value

READ_T (0x32)
This command allows the user to read out the 24-bit temperature conversion result, starting from the MSB.

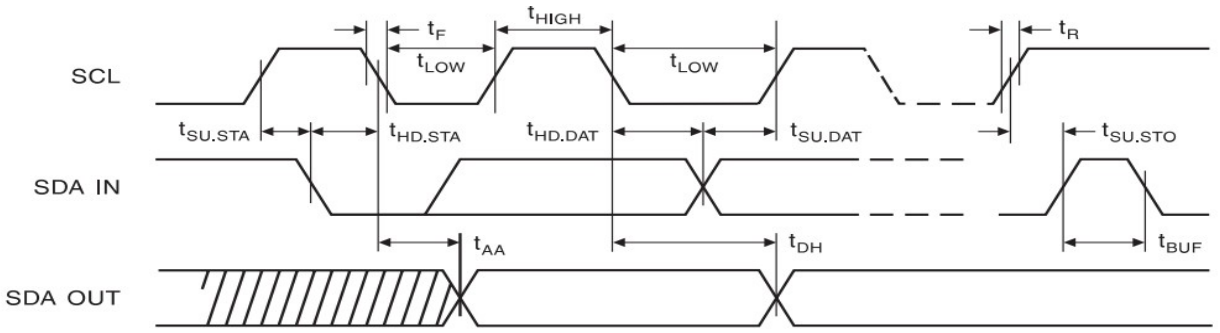
I²C Interface

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 four types of protocol introduced below.

I²C Specification

Table 7 I²C Slave Timing Values

Parameter	Symbol	I²C				Unit
		Conditions	Min.	Typ.	Max.	
SCL Clock Frequency	S_{CL}	Rpull-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



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 device address 0xEE (write) and 0xEF (read).
CSB pin = 1: corresponding to device 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

I²C Protocol

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

The host shall issue the Device Address followed by a Write Bit before sending a Command byte. The device will reply with 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

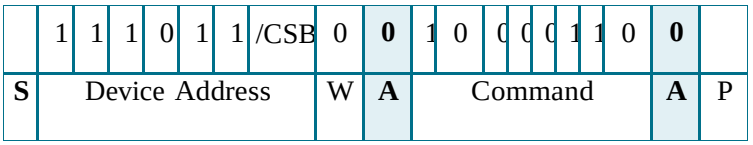
The 2nd type: the host writing a register to the device.

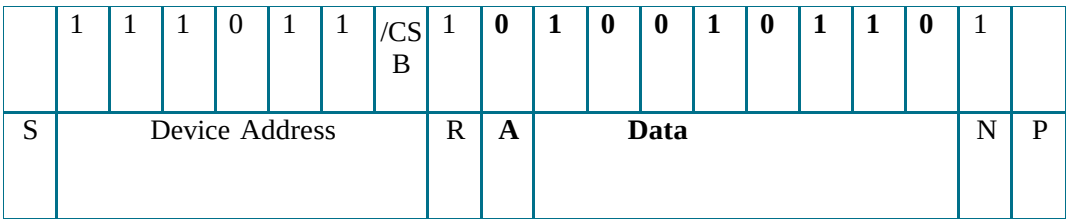
The host shall issue the Device Address followed by a Write Bit before sending a Command byte and a Data byte. This format only applies while the user wants to send the WRITE_REG command.

	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.

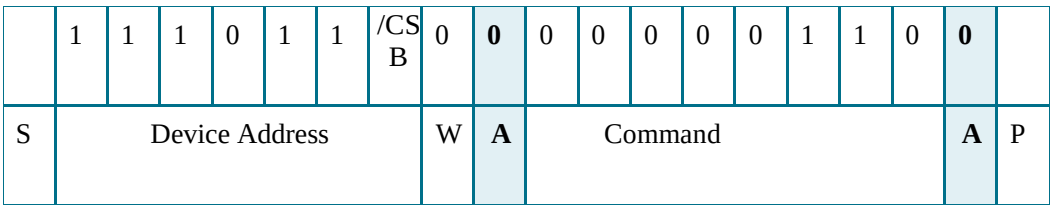
In this activity, there are two frames that are sent separately. The first frame is to send the READ_REG command which contains a 2-bit binary number of 10 followed by a 6-bit register address. The format of the first frame is identical to the 1st type activity.
In the second frame, the device will send 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.

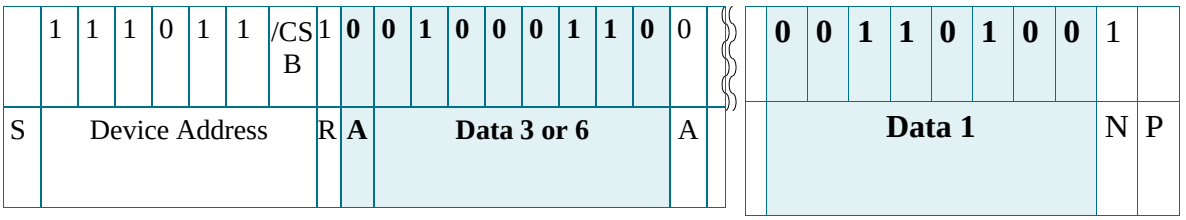




The 4th type: the host reading the 3-byte or 6-byte ADC data from the device.

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.





Bit Description
S: Start
P: Stop
W: Write
R: Read
A: Ack
N: NACK
CSB: CSB pin

Typical Application

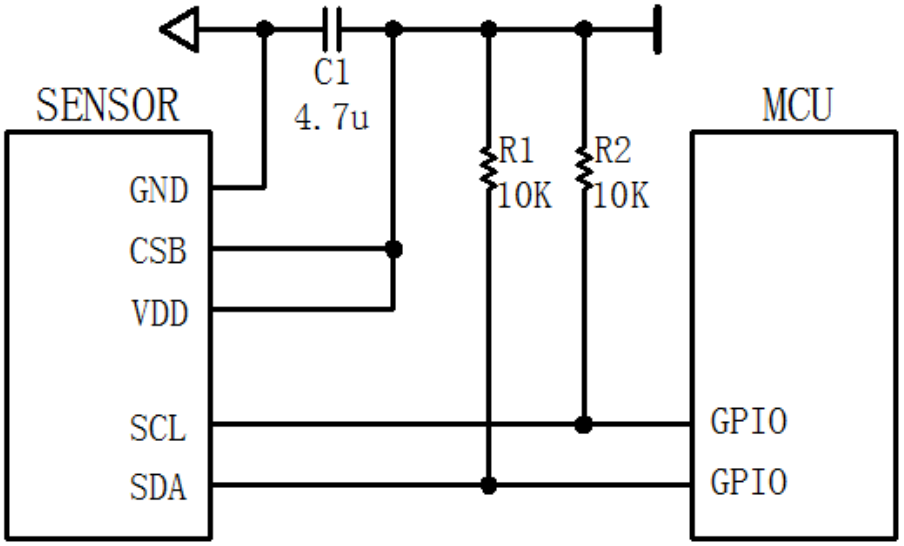
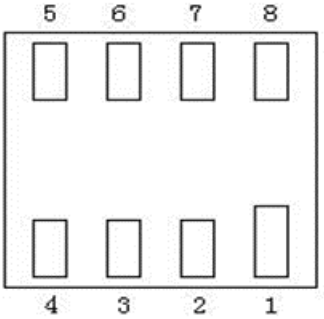


Figure 2: Typical Application

Pin Description



Bottom View

Table 8: Pin Description

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

Package Information

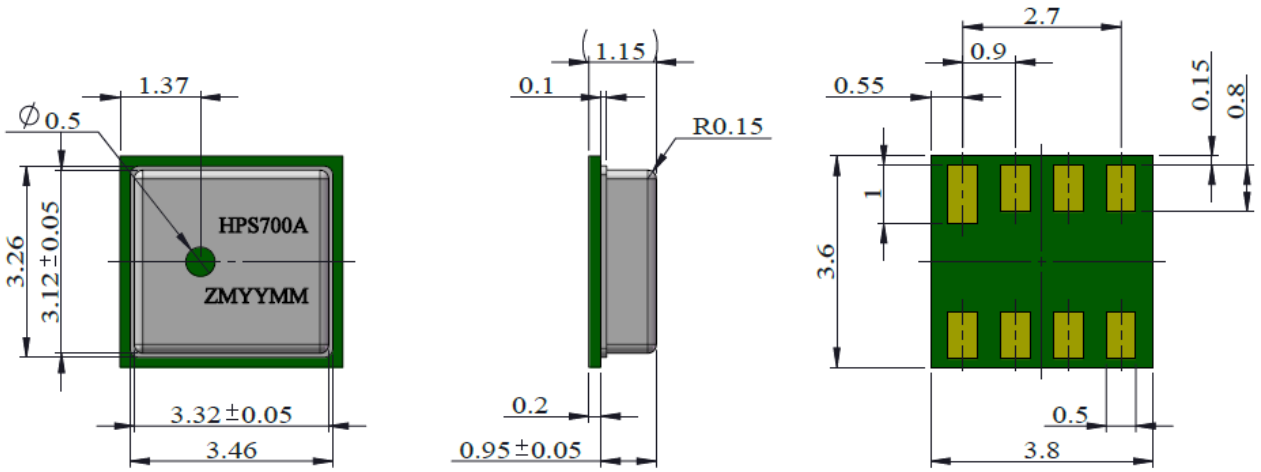
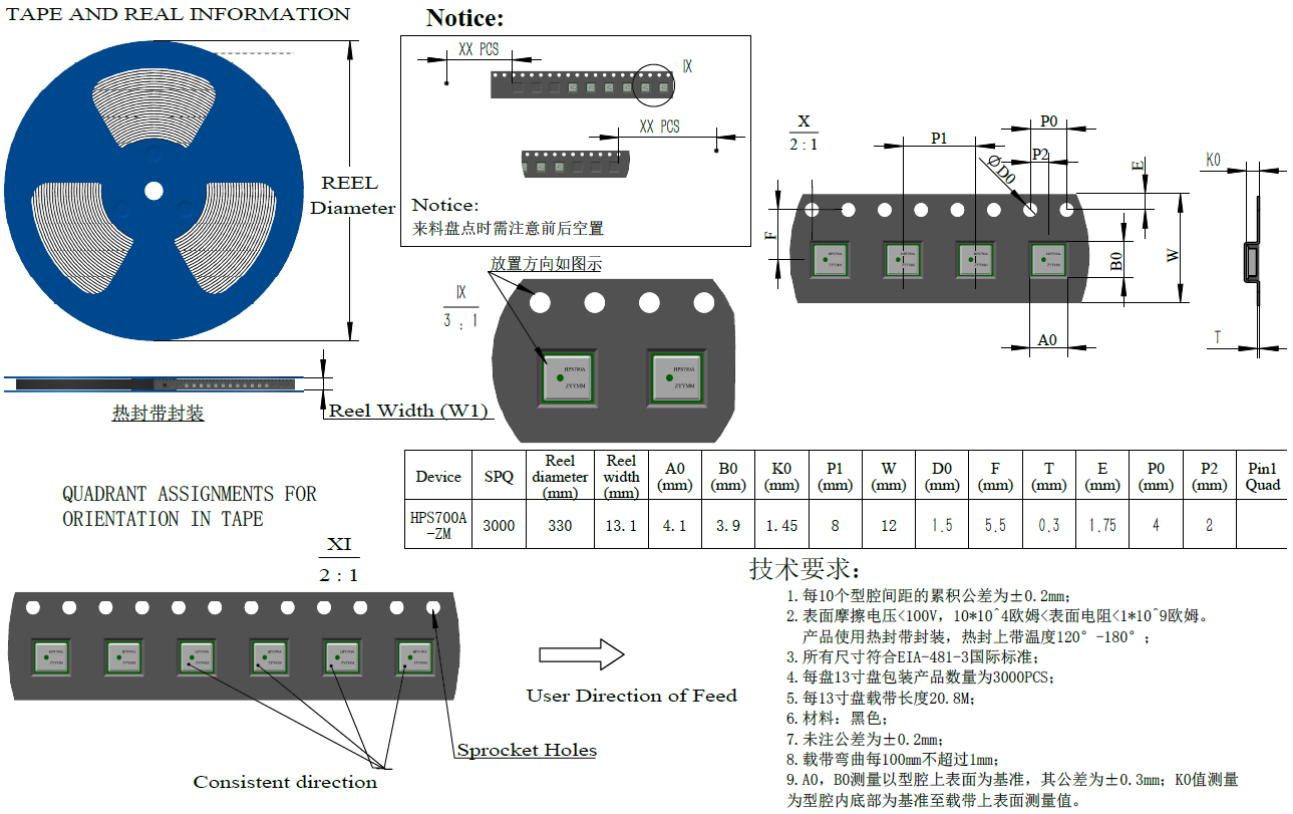


Figure 3: Package Information (Unit: mm)

Notes: General Tolerance: ±0.10mm

Tape & 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)	D0 (mm)	F (mm)	T (mm)	E (mm)	P0 (mm)	P2 (mm)	Pin1 Quad
HPS700A-ZM	3000	330	13.1	4.1	3.9	1.45	8	12	1.5	5.5	0.3	1.75	4	2	

技术要求：

1. 每10个型腔间距的累积公差为±0.2mm;
2. 表面摩擦电压<100V，10*10^4欧姆<表面电阻<1*10^9欧姆。
   产品使用热封带封装，热封上带温度120°-180°；
3. 所有尺寸符合EIA-481-3国际标准;
4. 每盘13寸盘包装产品数量为3000PCS;
5. 每13寸盘载带长度20.8M;
6. 材料：黑色;
7. 未注公差为±0.2mm;
8. 载带弯曲每100mm不超过1mm;
9. A0，B0测量以型腔上表面为基准，其公差为±0.3mm；K0值测量为型腔内底部为基准至载带上表面测量值。

Figure 4: Tape & Reel Specification

Publication History

Version	Date	Description
V1.0	2022.3.21	New release
V1.1	2023.1.9	Update pressure and temperature characteristics
V1.2	2024.2.6	Update package information and tape & reel specification