

## Product Overview

NSPGS5 is a calibrated gauge pressure sensor series product launched by NOVOSENSE for low pressure measurement market. This series use a high-performance ASIC to calibrate and compensate the MEMS sensor element. While ensuring the reliability of the product, the two chips are integrated and packaged, reduces the package size greatly, this series provide JEDEC standard SOIC-16 package with vertical porting. The pressure signal from -10kPa ~ 10kPa gauge can be converted into an analog output signal (0~5V) or I<sup>2</sup>C output signal with a customizable output range. The pressure sensor can be directly mounted on a standard printed circuit board very suitable for ventilators, sleep apnea and IOT applications.

## Key Features

- Custom range -10kPa to 10kPa
- Operating temperature range -20°C to 85°C
- High accuracy
  - Total error band initially better than ±1%
  - Full life accuracy better than ±2%
- 16bit analog output
- 24bit I<sup>2</sup>C digital output
- Vertical port
- RoHS & REACH-compliant packages: SOIC-16

## Applications

- CPAP/sleep apnea
- Fire pressure monitoring
- Ventilators
- HVAC/VAV
- Safety cabinets
- Pressure switches

## Device Information

Part Number	Package	Body Size
NSPGS5	SOIC16	10.26mm*7.52mm

## Outline



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### 1. Pin Configuration and Functions

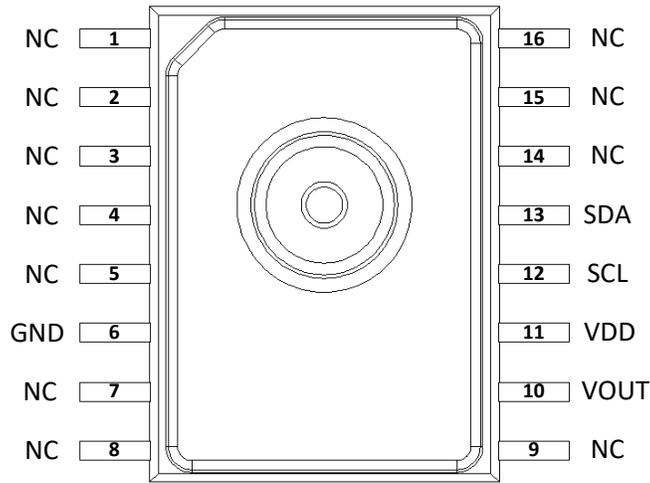


Figure 1.1 NSPGS5 series pin definition (Top view)

Table 1.1 NSPGS5 pin description

<b>Pin No.</b>	<b>Pin Name</b>	<b>Description</b>
1	NC	No connect
2	NC	No connect
3	NC	No connect
4	NC	No connect
5	NC	No connect
6	GND	Ground
7	NC	No connect
8	NC	No connect
9	NC	No connect
10	VOUT	Analog output
11	VDD	Power supply
12	SCL	I <sup>2</sup> C clock signal
13	SDA	I <sup>2</sup> C data signal
14	NC	No connect
15	NC	No connect
16	NC	No connect

## 2. Absolute Maximum Ratings

Parameters	Symbol	Min	Typ	Max	Unit	Comments
Supply voltage	VDD <sub>max</sub>	-0.3		6.5	V	
Analog pin voltage	VOUT	-0.3		5.3	V	25°C, VDD>5V
Analog output current limit				25	mA	
Proof pressure	P <sub>proof</sub>	30			kPa	
Burst pressure	P <sub>burst</sub>	50			kPa	
Storage temperature	T <sub>stg</sub>	-40		105	°C	

## 3. ESD Ratings

	Ratings	Value	Unit
Electrostatic discharge	Human body model (HBM), per AEC-Q100-002-RevE	±2.5	kV
	Charged device model (CDM), per AEC-Q100-011-RevB	±500	V
	Latch up (LU), per JESD78F	±100	mA

## 4. Recommended Operating Conditions

Parameters	Symbol	Min	Typ	Max	Unit	Comments
Supply voltage	VDD	3	3.3	3.6	V	
		4.5	5	5.5		
Operating pressure range	Prange	-10		10	kPaG	
High level voltage at digital I/O	VIH	2			V	
Low level voltage at digital I/O	VIL			0.8	V	
I2C clock frequency	Fsclk			400	kHz	
Operating temperature	Topr	-20		85	°C	

## 5. Specifications

### 5.1. Electrical Characteristic

Parameters	Symbol	Min	Typ	Max	Unit	Comments
Output voltage range	VOUT	0.01		4.99	V	
Operating current	I <sub>avdd</sub>	2.5	2.9	3.3	mA	@VDDHV=5V
Output RMS noise	V <sub>rms</sub>		0.5		mV	
Output load resistance	R <sub>load</sub>	1			kOhm	
Output load capacitance	C <sub>load</sub>			150	nF	
Accuracy <sup>1,2,3,4</sup>	ACC	-1%		1%	%FS	Initially accuracy
		-2%		2%	%FS	Full life accuracy
Bandwidth	BW		500			Hz
Power up time	T <sub>UP</sub>		100		ms	
Response time	T <sub>RESP</sub>		1		ms	
I <sup>2</sup> C data update time	T <sub>data update</sub>		1		ms	
EEPROM data retention	T <sub>live</sub>	10			years	@125°C

- Accuracy includes non-linearity, temperature, pressure hysteresis, temperature hysteresis.
- Full life accuracy based on the part number NSPGS5F004RT01 500 hour HTOL, LTOL, HTSL, TH(85°C/85%RH), TC and 3x reflow testing.
- For pressure accuracy of different part number, please refer to complete part number list at chapter 8.
- Unless otherwise specified, the accuracy is based on typical operating voltage.

### 5.2. I<sup>2</sup>C Timing Diagram

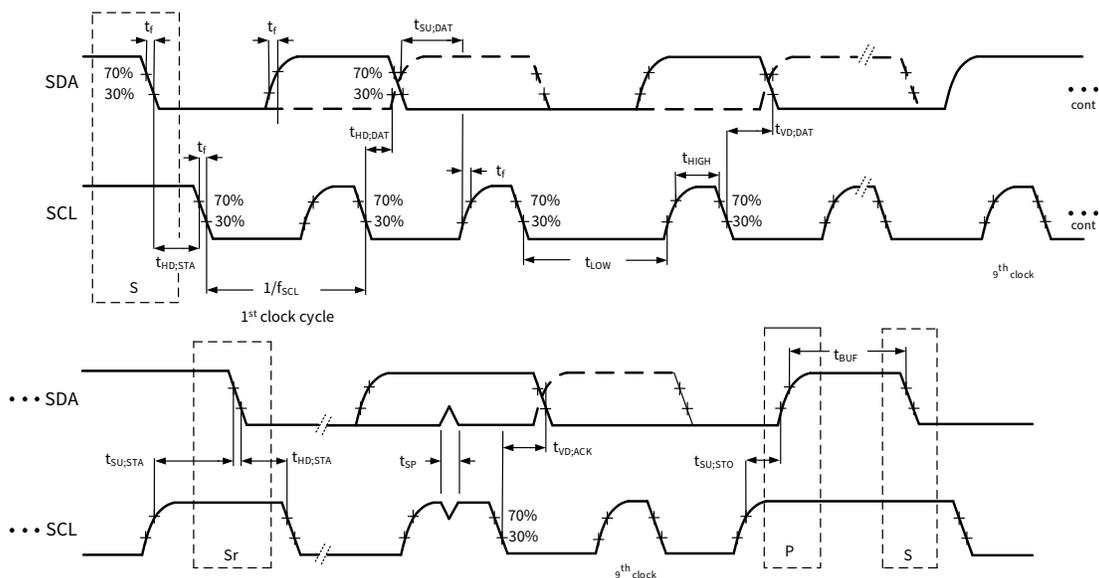


Figure 5.1 I<sup>2</sup>C Timing Diagram

### 5.3. I<sup>2</sup>C Interface

<i>Parameters</i>	<i>Symbol</i>	<i>Min</i>	<i>Typ</i>	<i>Max</i>	<i>Unit</i>	<i>Comments</i>
Clock frequency	$f_{\text{scl}}$			400	kHz	
SCL low pulse	$t_{\text{LOW}}$	1.3			us	
SCL high pulse	$t_{\text{HIGH}}$	0.6			us	
SDA setup time	$t_{\text{SUDAT}}$	0.1			us	
SDA hold time	$t_{\text{HDDAT}}$	0.0			us	
Setup time for a repeated start condition	$t_{\text{SUSTA}}$	0.6			us	
Hold time for a start condition	$t_{\text{HDSTA}}$	0.6			us	
Setup time for a stop condition	$t_{\text{SUSTO}}$	0.6			us	
Time before a new transmission can start	$t_{\text{BUF}}$	1.3			us	

## 6. Function Description

### 6.1. Overview

NSPGS5 uses a MEMS piezoresistive differential pressure sensor element as a pressure sensitive component that provide an original signal output that is proportional to ambient pressure. The built-in conditioning IC drives the sensitive component and amplifies, temperature compensates, and linearizes the original signal to output a voltage or I<sup>2</sup>C signal that is linear with the applied pressure.

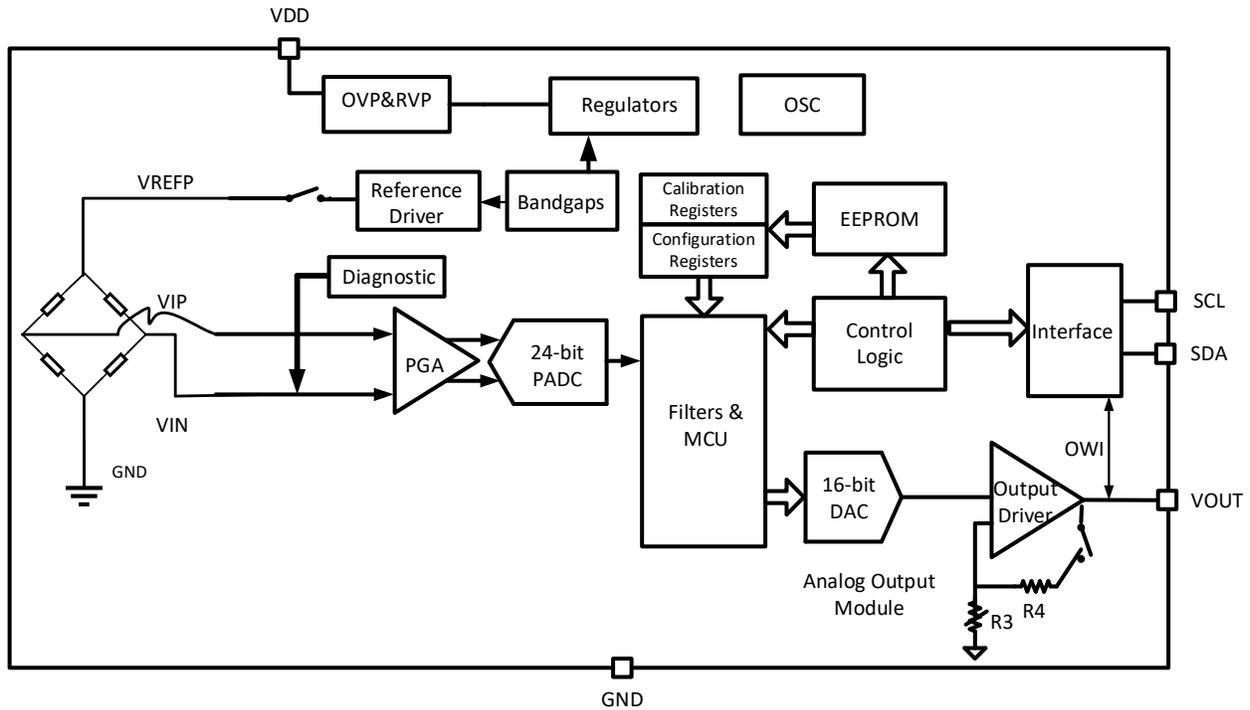


Figure 6.1 Product Function Block Diagram

### 6.2. Analog Output Transfer Function

NSPGS5 series device is fully calibrated on delivery. The sensor has a linear transfer function between the applied pressure and the output signal:

$$\text{Ratiometric : } V_{OUT} = (A \times P + B) \times V_{DD}$$

$$\text{Absolute: } V_{OUT} = (A \times P + B) \times 5 \text{ @ } V_{DD} = 5V$$

$$\text{Absolute: } V_{OUT} = (A \times P + B) \times 3.3 \text{ @ } V_{DD} = 3.3V$$

V<sub>OUT</sub> is the analog output, unit is V.

V<sub>DD</sub> is the supply voltage, unit is V.

P is the pressure value, gauge pressure, unit is kPa/cmH<sub>2</sub>O.

Table 6.1 Analog Output Transfer Function Coefficient

Product No.	Pressure Range		Output Range		Gain and Offset	
	P <sub>L</sub>	P <sub>H</sub>	O <sub>L</sub>	O <sub>H</sub>	A	B
NSPGS5F004RT01	0cmH <sub>2</sub> O	40cmH <sub>2</sub> O	0.1*V <sub>DD</sub>	0.9*V <sub>DD</sub>	0.02	0.1

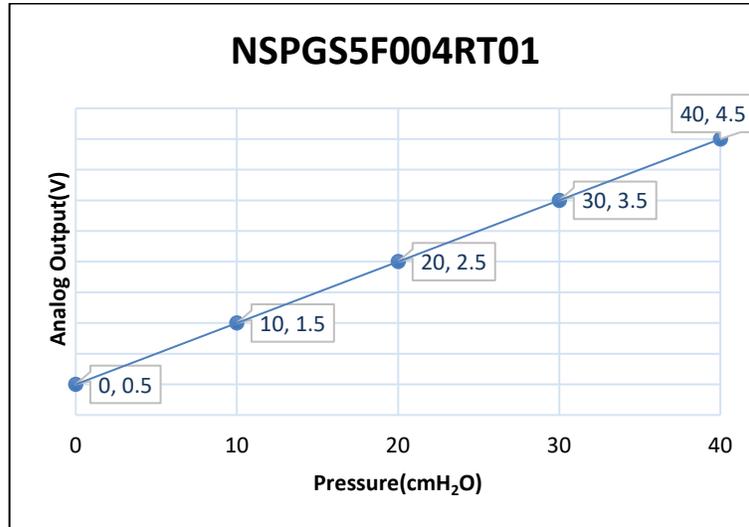


Figure 6.2 Analog Output Transfer Function

### 6.3. I<sup>2</sup>C output Transfer Function

$$\text{Code} = (A \times P + B) \times 8388607$$

Code is the register 0x06~0x08 value.

P is the pressure value, gauge pressure, unit is kPa/cmH<sub>2</sub>O.

Table 6.2 I<sup>2</sup>C Output Transfer Function Coefficient

Product No.	Pressure Range		Output Code Range		Gain and Offset	
	P <sub>L</sub>	P <sub>H</sub>	O <sub>L</sub>	O <sub>H</sub>	A	B
NSPGS5F004DT05	0cmH <sub>2</sub> O	40cmH <sub>2</sub> O	838861	7549746	0.02	0.1

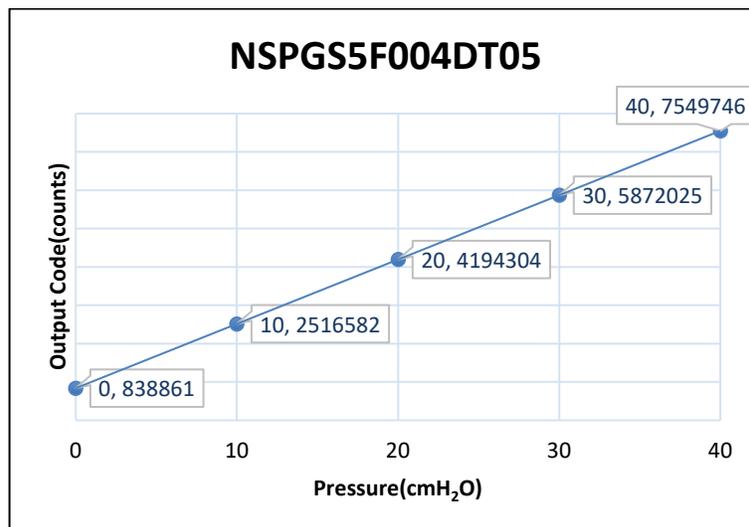


Figure 6.3 Digital Output Transfer Function

Register Map:

Addr	Bit Addr	Description	Default	Description
0x06	7 - 0	PDATA<23:16>	0x00	Output Pressure Data. Code = Data0x06*2^16+ Data0x07*2^8+ Data0x08;
0x07	7 - 0	PDATA<15:8>	0x00	
0x08	7 - 0	PDATA<7:0>	0x00	

For example:

If the value of the registers 0x06, 0x07, 0x08 are 0x3F, 0xFF, 0xFF, according to NSPGS5F004DT05 transfer function, Code = 4194303,  $P(\text{cmH}_2\text{O}) = (4194303/8388607-B)/A$ , and finally get the value of pressure about 20cmH<sub>2</sub>O.

### 6.4. I<sup>2</sup>C Interface

I<sup>2</sup>C bus uses SCL and SDA as signal lines. Both lines are connected to VDD externally via pull-up resistors so that they are pulled high when the bus is free. The I<sup>2</sup>C device address of NSPGS5 is shown below.

Table 6.3 I<sup>2</sup>C Address

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

The I<sup>2</sup>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.

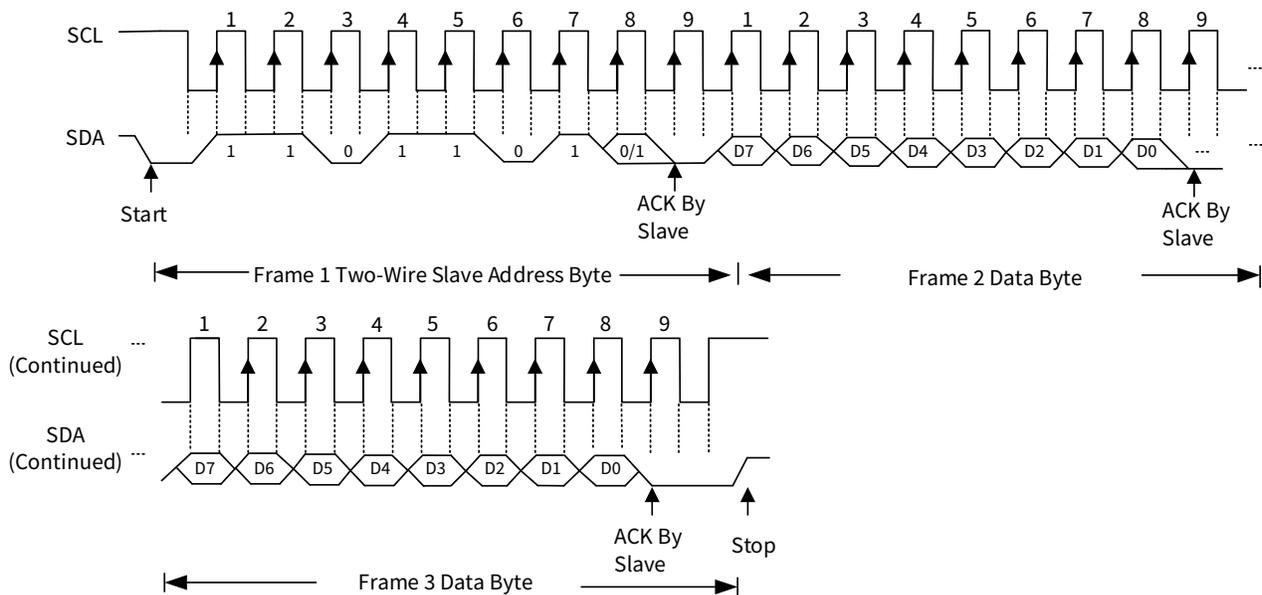


Figure 6.4 I<sup>2</sup>C Protocol

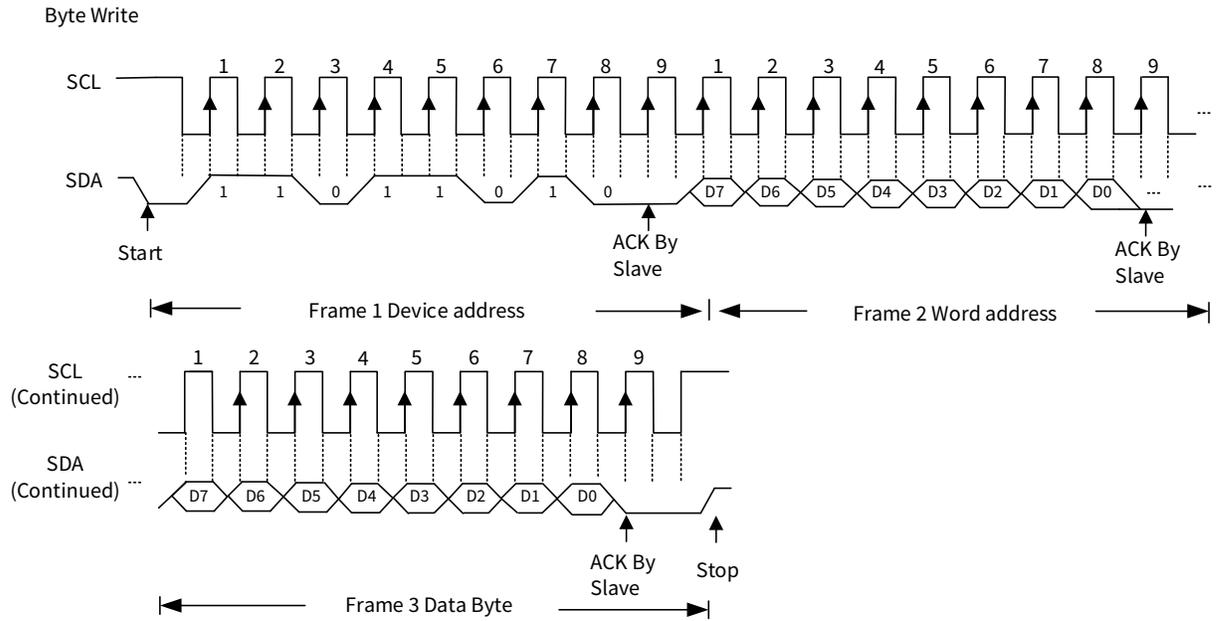


Figure 6.5 I<sup>2</sup>C Write Byte

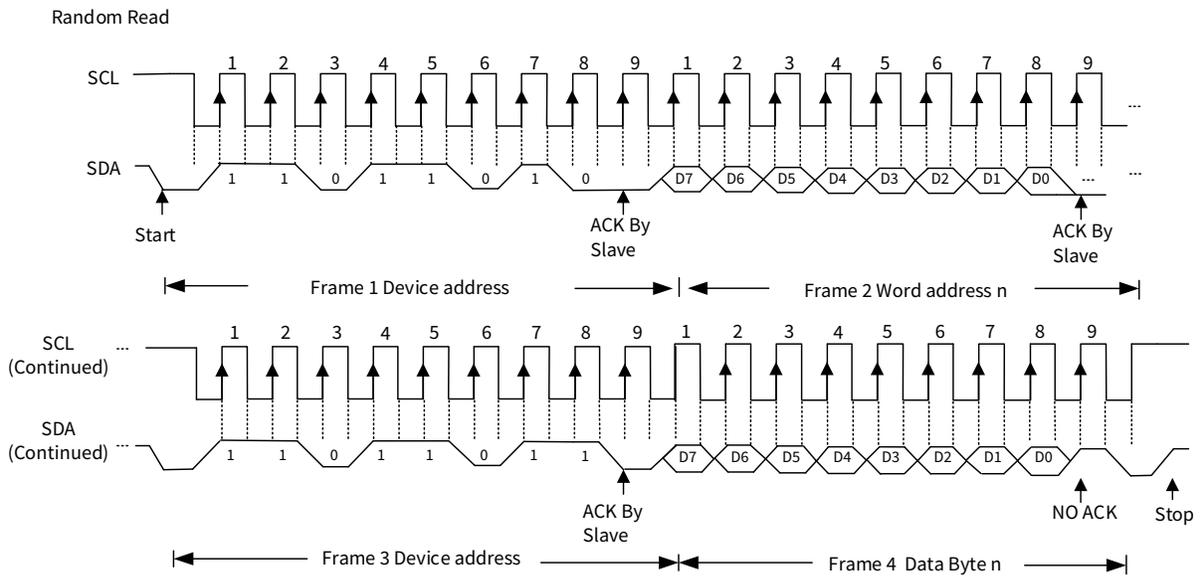


Figure 6.6 I<sup>2</sup>C Read Byte

## 7. Typical Application

### 7.1. Application Circuit

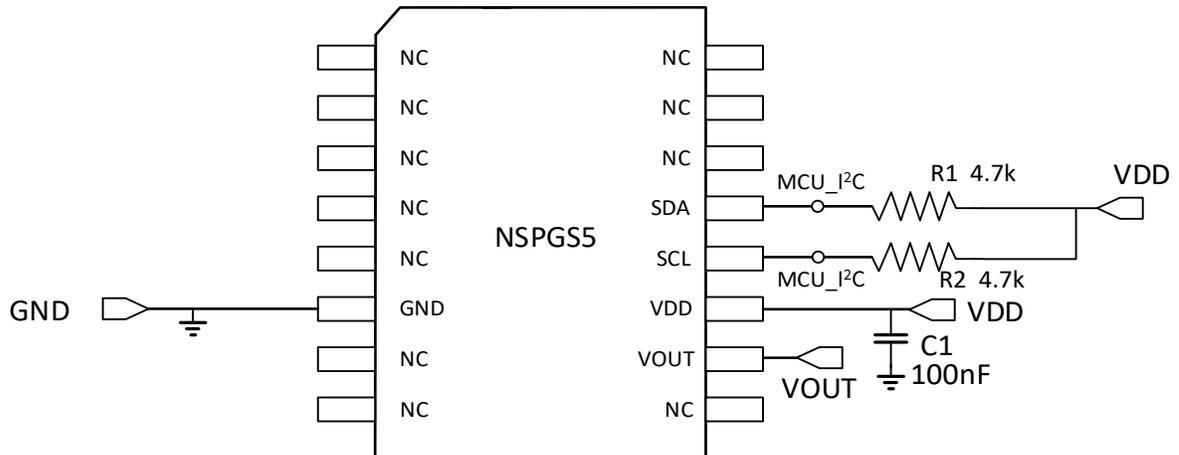


Figure 7.1 NSPGS5 Application Circuit

Note :

- 1) For applications with higher ESD requirements, can add TVS between VOUT and GND and between VDD and GND.
- 2) Please contact NOVOSENSE for detailed peripheral recommended circuit.

### 8. Package Information

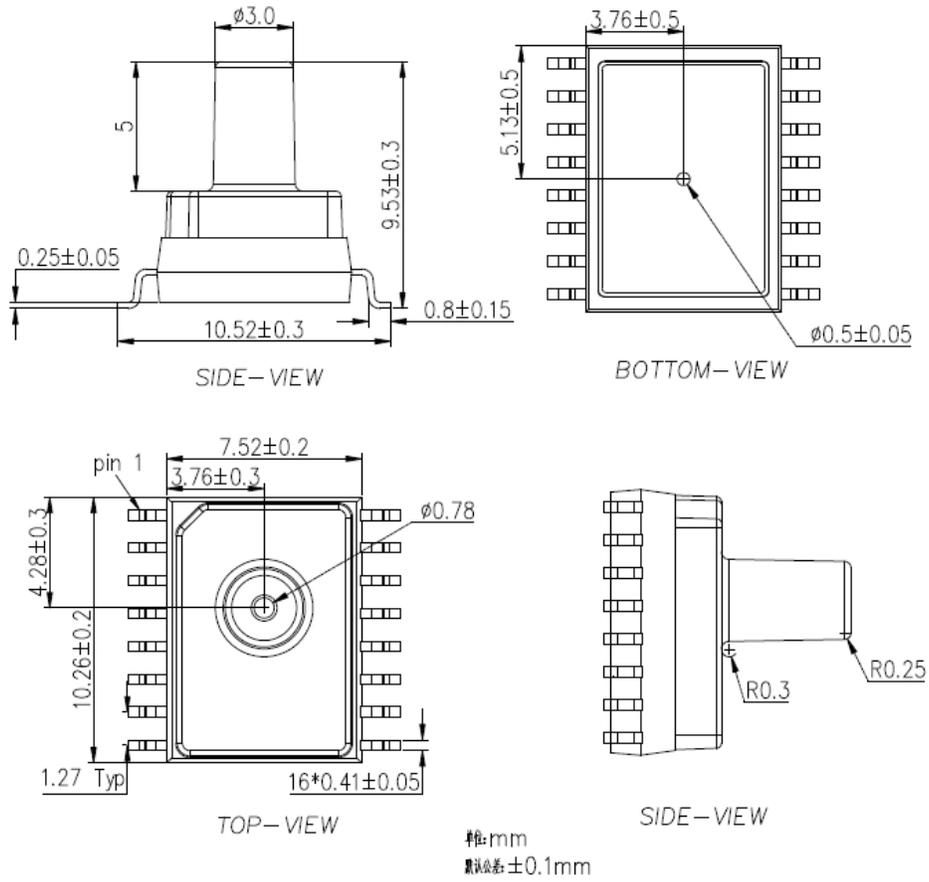


Figure 8.1 SOIC16 Package Outline mm

**9. Order Information**

Product No.	Output Type	Pressure Range		Output Range		Gain and Offset		Supply Voltage	Accuracy	
		P <sub>L</sub>	P <sub>H</sub>	O <sub>L</sub>	O <sub>H</sub>	A	B		Initially	Full life
NSPGS5F004RT01	Ratiometric	0cmH <sub>2</sub> O	40cmH <sub>2</sub> O	0.50V	4.50V	0.020000	0.100000	5.00V	±1%	±2%
NSPGS5F004AT02	Absolute	0cmH <sub>2</sub> O	40cmH <sub>2</sub> O	0.33V	2.97V	0.020000	0.100000	3.30V	±1%	±2%
NSPGS5F007RT03	Ratiometric	0cmH <sub>2</sub> O	70cmH <sub>2</sub> O	0.50V	4.50V	0.011400	0.100000	5.00V	±1%	±2%
NSPGS5F010AT04	Absolute	0kPa	10kPa	0.33V	2.97V	0.080000	0.100000	3.30V	±1%	±2%
NSPGS5F004DT05	I <sup>2</sup> C	0cmH <sub>2</sub> O	40cmH <sub>2</sub> O	838861	7549746	0.020000	0.100000	5.00V	±1%	±2%
NSPGS5F008AT06	Absolute	0kPa	8kPa	0.50V	4.50V	0.100000	0.100000	5.00V	±1%	±2%
NSPGS5F010DT07	I <sup>2</sup> C	0kPa	10kPa	838861	7549746	0.080000	0.100000	3.30V	±1%	±2%

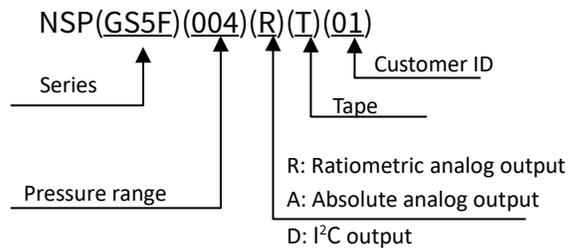
Please scan the following QR code or visit the download link for complete part number list.

<https://novosns.com/Public/Uploads/uploadfile4/nspgs5-series.pdf>



NSPGS5 Series

Naming Convention:

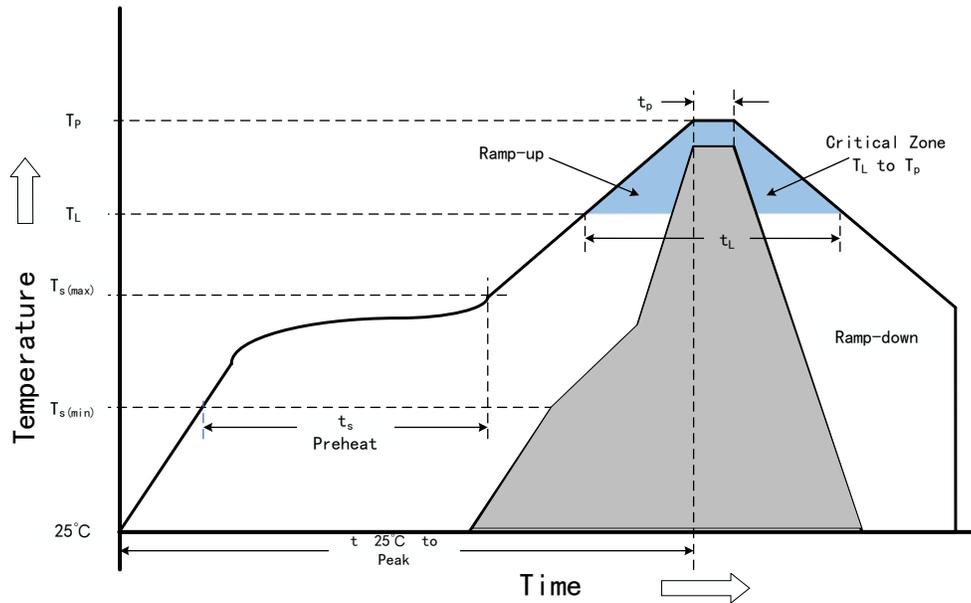


## 10. Soldering Parameters

### 10.1. Reflow Soldering (SMD Terminal)

Table 10.1 Soldering Parameters

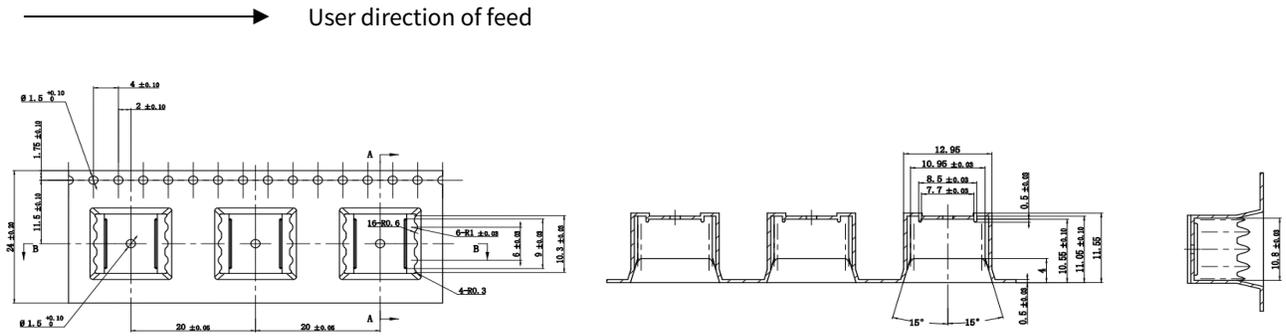
Reflow Condition		Lead-free assembly
Pre Heat	Temperature Min ( $T_{s(min)}$ )	150°C
	Temperature Max ( $T_{s(max)}$ )	180°C
	Time (min to max) ( $t_s$ )	60 – 150 secs
Average ramp up rate (Liquidus Temp ( $T_L$ ) to peak)		2°C/second max
$T_{s(max)}$ to $T_L$ - Ramp-up Rate		2°C/second max
Reflow	Temperature ( $T_L$ ) (Liquidus)	210°C
	Time (min to max) ( $t_L$ )	60 – 220 seconds
Peak Temperature ( $T_P$ )		240°C
Time within 5°C of actual peak Temperature ( $t_p$ )		12 – 30 seconds
Ramp-down Rate		6°C/second max
Time 25°C to peak Temperature ( $T_P$ )		230 seconds Max.
Do not exceed		240°C



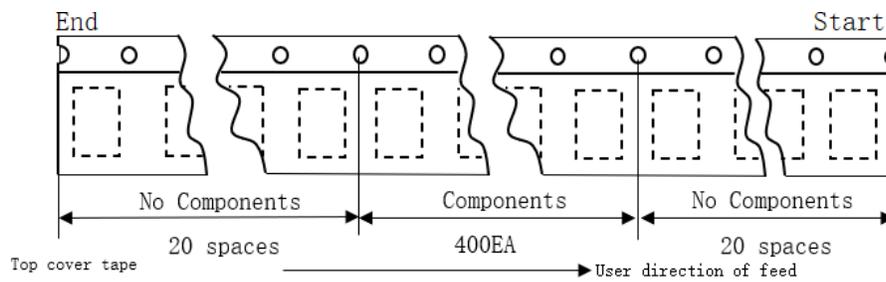
### 10.2. Manual Soldering

- Raise the temperature of the soldering tip between 260 °C and 300 °C and solder within 5 seconds.
- Use a flattened soldering tip when performing rework on the solder bridge.
- Complete rework in one time

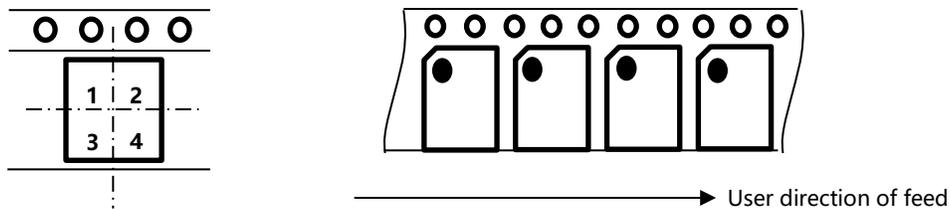
### 11. Packing Information



There is no component at the head and tail of each tape, with a spacing of 20 spaces, as shown in the following figure.



Pin1 is located at the first quadrant, as shown in the following figure.



Minimum ordering quantity (MOQ): 400EA.  
Standard pack quantity (SPQ): 400EA.

## 12. Revision History

<b>Revision</b>	<b>Description</b>	<b>Date</b>
0.1	Initial Version.	2020/12/19
1.0	Update Operating temperature range, package outline, delete the description of accuracy.	2022/11/16
2.0	Update order information and add barcode, I <sup>2</sup> C Timing Diagram, I <sup>2</sup> C code, electrical characteristic and order information and packing information.	2023/12/04
2.1	Update I <sup>2</sup> C Timing Diagram.	2024/05/21

**Notes:**1. I<sup>2</sup>C code

```
#define ACK 1
#define NACK 0
uchar REG06=0,REG07=0,REG08=0;
uchar number=1;
uchar Reg30[1];
int PCode=0, Pdata=0;
float Pressure=0.0;
void IIC_Start(void) //Start the IIC, SDA High-to-low when SCL is high
{
    IIC_SCL(1); //SCL output high level
    SDA_OUT(1); //SDA output high level
    Delay_us(2); //Delay 2us
    SDA_OUT(0); //SDA output low level
    Delay_us(2);
}

void IIC_Stop(void) //Stop the IIC, SDA Low-to-high when SCL is high
{
    IIC_SCL(0);
    Delay_us(2);
    IIC_SCL(1);
    SDA_OUT(0);
    Delay_us(2);
    SDA_OUT(1);
    Delay_us(2);
}

void IIC_ACK(void) //Send ACK (LOW)
{
    SDA_OUT(0);
    IIC_SCL(1);
    Delay_us(2);
    IIC_SCL(0);
}

void IIC_NACK(void) //Send No ACK (High)
{
    SDA_OUT(1);
    IIC_SCL(1);
    Delay_us(2);
    IIC_SCL(0);
}

uchar IIC_Wait_ACK(void) //Check ACK, if return 0, then right, if return 1, then error
{
```

```
int ErrTime=0;
SDA_IN(); //SDA set as input
IIC_SCL(1);
Delay_us(2);
while(Read_SDA)
{
    ErrTime++;
    if(ErrTime>200)
    {
        IIC_Stop();
        return 1;
    }
}
IIC_SCL(0);
SDA_OUT(0);
Delay_us(2);
return 0;
}

void IIC_Send(uchar IIC_Data) //Send a byte to IIC
{
    uchar i;
    IIC_SCL(0);
    Delay_us(2);
    for(i=0;i<8;i++)
    {
        if((IIC_Data&0x80)>>7)
            SDA_OUT(1);
        else
            SDA_OUT(0);
        IIC_Data<<=1;
        IIC_SCL(1);
        Delay_us(2);
        IIC_SCL(0);
        Delay_us(2);
    }
}

uchar IIC_Receive(uchar ACK) //Receive a byte from I2C
{
    uchar i,Receive_Data=0;
    SDA_IN();
    for(i=0;i<8;i++)
    {
        IIC_SCL(0);
        Delay_us(2);
        IIC_SCL(1);
        Receive_Data<<=1;
        if(Read_SDA==1)
```

```
        Receive_Data++;
        Delay_us(2);
    }
    IIC_SCL(0);
    Delay_us(2);
    if(ACK==0x01)
        IIC_ACK();
    else
        IIC_NACK();
    return Receive_Data;
}

void NSPGS5F004DT05_Write_Byte(uchar WriteAddr,uchar WriteData)
{
    IIC_Start();
    IIC_Send(0xDA|0x00);
    IIC_Wait_ACK();
    IIC_Send(WriteAddr);
    IIC_Wait_ACK();
    IIC_Send(WriteData);
    IIC_Wait_ACK();
    IIC_Stop();
}

void NSPGS5F004DT05_Read_Byte(uchar ReadAddr, uchar *pBuffer)
{
    IIC_Start();
    IIC_Send(0xDA|0x00);
    IIC_Wait_ACK();
    IIC_Send(ReadAddr);
    IIC_Wait_ACK();
    IIC_Start();
    IIC_Send(0xDA|0x01);
    IIC_Wait_ACK();
    pBuffer[0]=IIC_Receive(0);
    IIC_Stop();
}

void NSPGS5F004DT05_Read_3Byte(uchar ReadAddr,uchar *pBuffer)
{
    IIC_Start();
    IIC_Send(0xDA|0x00);
    IIC_Wait_ACK();
    IIC_Send(ReadAddr);
    IIC_Wait_ACK();
    IIC_Start();
    IIC_Send(0xDA|0x01);
    IIC_Wait_ACK();
    pBuffer[0]=IIC_Receive(ACK);
}
```

```
pBuffer[1]=IIC_Receive(ACK);
pBuffer[2]=IIC_Receive(NACK);
IIC_Stop();
}

void main()
{
    uchar PData[3]={0,0,0};
    delay_ms(7);
    NSPGS5F004DT05_Read_3Byte(0x06,PData);
    REG06 = PData [0];           //Register 0x06
    REG07 = PData [1];           //Register 0x07
    REG08 = PData [2];           //Register 0x08
    PCode=(REG06*65536+REG07*256+REG08); //PCode = Data0x06*2^16+ Data0x07*2^8+ Data0x08
    if (PCode >8388607)
        Pdata= PCode-16777216;    //Symbol processing
    else
        Pdata= PCode;
    Pressure =((float)Pdata/8388607-0.1)/( 0.02); //PCode=(AxP+B)*8388607  P=(PCode/8388607-B)/A
                                                //PNormalized=PCode/8388607
}
}
```

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