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NSPDSx Series

Integrated Differential Low Pressure Sensor

Datasheet (EN) 0.6

Product Overview

NSPDSx is a calibrated differential 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 ±125Pa differential to ± 350kPa differential can be converted into an analog output signal (0~5V) or I^2C 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.

Features

- Large pressure range
  - Minimum differential pressure range -125Pa to 125Pa
  - Maximum differential pressure range -350kPa to 350kPa
- Operating temperature range -20°C to 70°C
- High accuracy over the life
  - Digital output better than ±1%F.S.
  - Analog output better than ±1.5% F.S.
- 24bit I^2C digital and 16bit analog output
- Vertical port

Applications

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

Outline

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1. Pin Definition

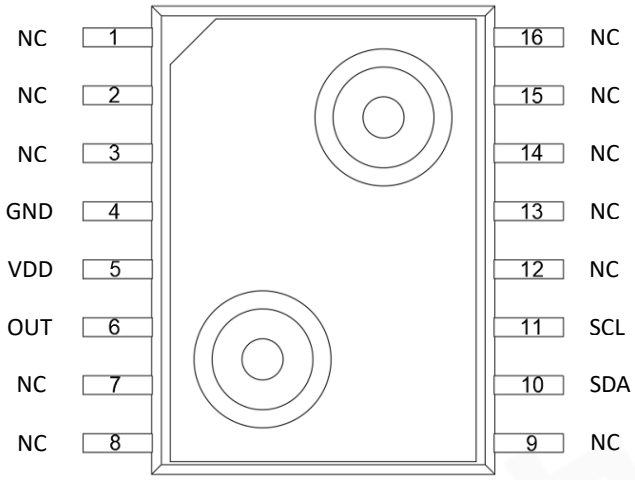

Fig 1.1 NSPDS5/9 series pin definition (Top view)

Tab 1.1 NSPDS5/9 pin description

Pin NO.	*Pin name*	*Description*
1	NC	No connect
2	NC	No connect
3	NC	No connect
4	GND	Ground
5	VDD	Power supply
6	OUT	Analog output
7	NC	No connect
8	NC	No connect
9	NC	No connect
10	SDA	I^2C data signal
11	SCL	I^2C clock signal
12	NC	No connect
13	NC	No connect
14	NC	No connect
15	NC	No connect
16	NC	No connect

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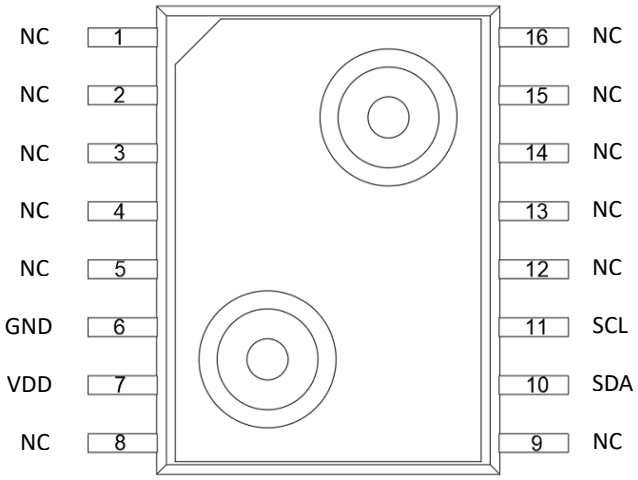

Fig 1.2 NSPDS7 series pin definition (Top view)

Tab 1.2 NSPDS7 pin description

Pin NO.	*Pin name*	*Description*
1	NC	No connect
2	NC	No connect
3	NC	No connect
4	NC	No connect
5	NC	No connect
6	GND	Ground
7	VDD	Power supply
8	NC	No connect
9	NC	No connect
10	SDA	I^2C data signal
11	SCL	I^2C clock signal
12	NC	No connect
13	NC	No connect
14	NC	No connect
15	NC	No connect
16	NC	No connect

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2. Absolute maximum ratings

Parameters	*Symbol*	*Min*	*Typ*	*Max*	*Unit*	*Comments*
Supply voltage	VDD_{max}	-0.3		6.5	V	
Analog output current limit				25	mA	
Digital pin voltage		-0.3		VDD+0.3	V	25℃
Proof pressure	P_{proof}	3X		500	kPa	3 times the maximum operating pressure
Burst pressure	P_{burst}	5X		600	kPa	5 times the maximum operating pressure
ESD susceptibility	HBM		2		kV	
Storage temperature	Tstg	-40		100	℃	

3. Operating range

Parameters	*Symbol*	*Min*	*Typ*	*Max*	*Unit*	*Comments*
Supply voltage	VDD	3	3.3	3.6	V	VDD=3.3V
		4.5	5	5.5	V	VDD=5V
Operating pressure	P_{amb}	-350		350	kPaD	Differential pressure
Operating pressure range	P_{range}	0.25		450	kPa	$P_{max} - P_{min}$
High level voltage at digital I/O	VIH	2			V	
Low level voltage at digital I/O	VIL			0.8	V	
I^2C clock frequency	Fsclk			400	kHz	
Operating temperature	T_{opr}	-20		70	℃	

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4. Characteristic

4.1. Electrical characteristic

Parameters	*Symbol*	*Min*	*Typ*	*Max*	*Unit*	*Comments*
Power on reset	VDD_{POR}		2		V	
Operating current	I_{avdd}		2.4		mA	Operation mode
				200	nA	Standby mode
ADC resolution	RES_{RAW}		24		Bits	
PSRR	PSRR	90	120		dB	
DAC resolution			12		Bits	
Output load resistance	R_{load}	1			kOhm	Analog output
Output load capacitance	C_{load}			15	nF	Analog output
NSPDS9 series full life accuracy[1,2]	ACC	-1%		1%	%FS	Digital output
	ACC	-1.5%		1.5%	%FS	Analog output
NSPDS5 series accuracy (digital output)	ACC	-1%		1%	%FS	Pressure range>1kPa, full life accuracy; Pressure range<1kPa, factory out accuracy;
NSPDS5 series accuracy (analog output)	ACC	-1.5%		1.5%	%FS	Pressure range>1kPa, full life accuracy; Pressure range<1kPa, factory out accuracy;
Power up time	T_{UP}		100		ms	
EEPROM data retention	T_{live}	10			years	@125℃

1. Accuracy includes non-linearity, temperature, pressure hysteresis, temperature hysteresis;
2. Full life accuracy based on the 500 hour of HTOL, LTOL, HTSL, TH(40℃/90%RH) and PCT testing;

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4.2. I²C interface

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

5. Function description

5.1. Overview

NSPDSx uses a MEMS piezoresistive absolute 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 signal that is linear with the applied pressure.

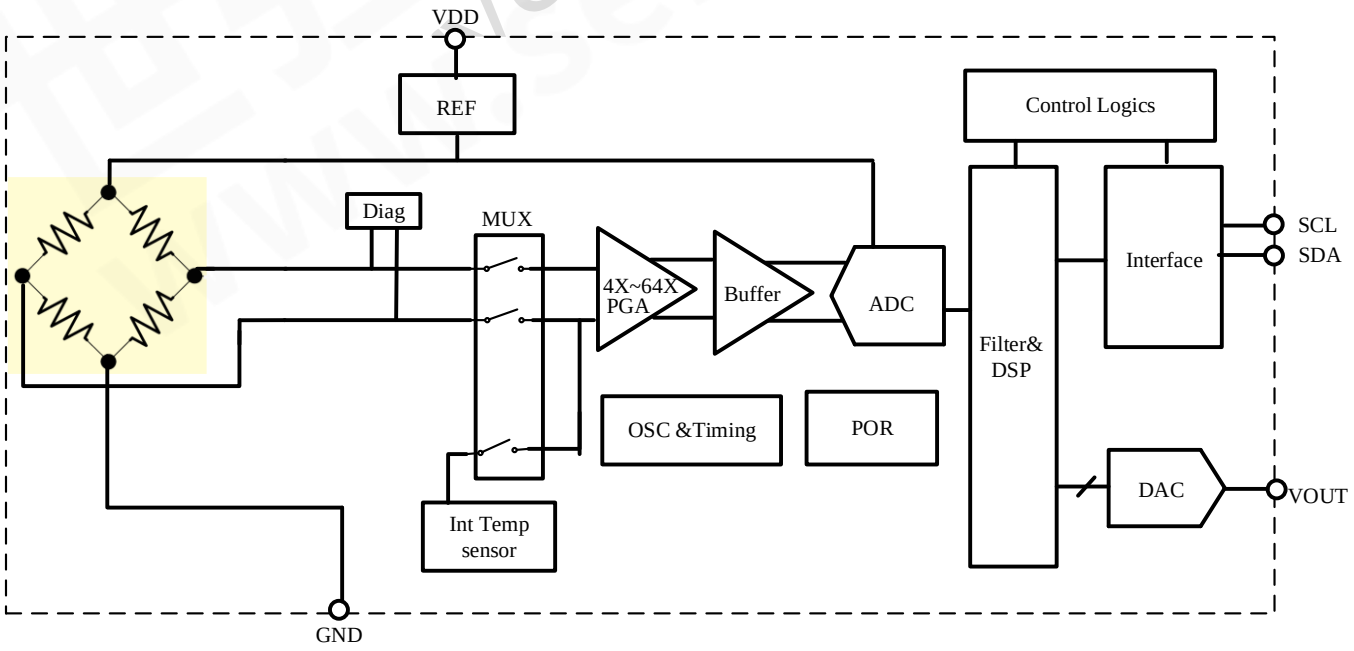

Fig 5.1 Product Function Block Diagram

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5.2. Digital output transfer function

$$P = A * code/8388608 + B$$

Code is the register 0x06~0x08 value;

P is the pressure value, differential pressure ,unit is Pa/kPa;

Tab5.1 Digital Output Transfer Function Coefficient

Product NO.	Pressure range		Output code range		Gain and offset	
	P_L	P_H	O_L	O_H	A	B
NSPDS5F001DT02	-0.5kPa	0.5kPa	838861	7549746	1.250	-0.625

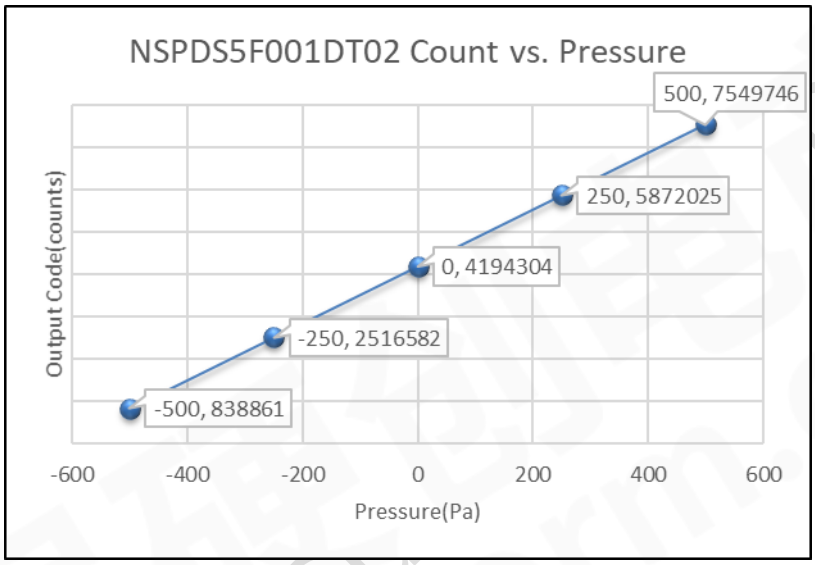

Fig 5.2 Transfer Function

5.3. Register Map

Addr	Bit Addr	Description	Default	Description
0x30	7 – 4	Reserve	4'b0000	Write with 0x0A to start a conversion, automatically come back to 0x02 after conversion ends.
	3	Sco	1'b0	
	2 – 0	Measurement_ctrl<2:0>	3'b000	
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 NSPDS5F001DT02 transfer function, Code = 4194303, P(Pa) = 4194303/8388607*A+B, and finally get the value of pressure about 0kPa.

5.4. I²C interface

I²C 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 I²C device address of NSPDSx is shown below.

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Tab 5.2 I²C address

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

The IIC 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.

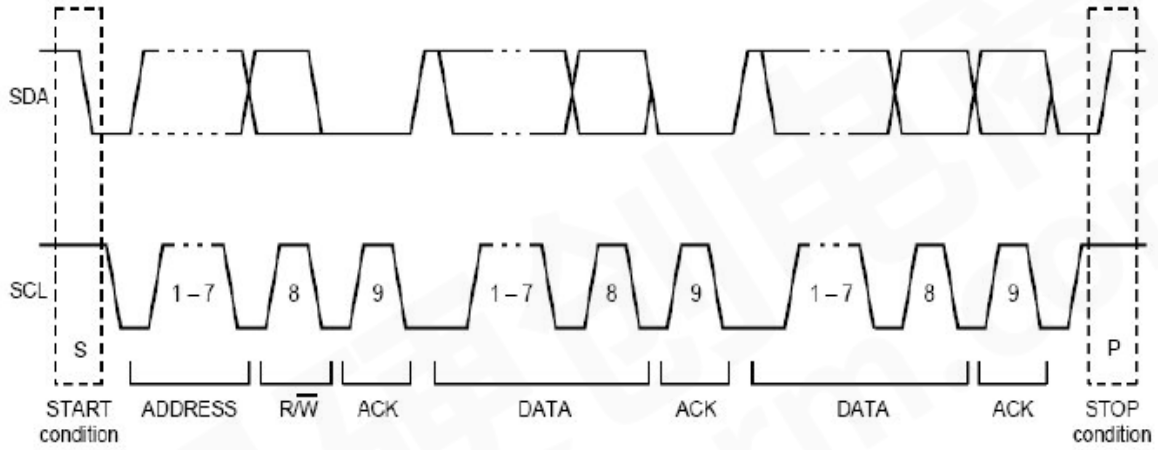

Fig 5.3 I²C Protocol

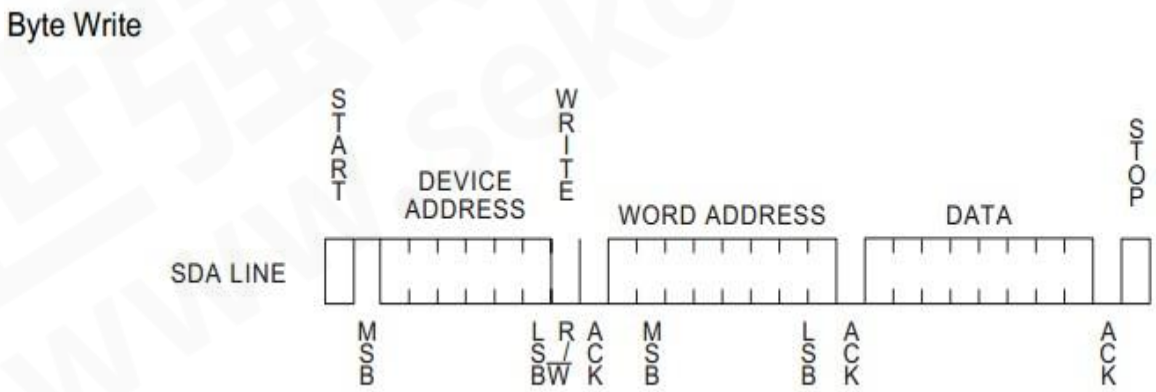

Fig 5.4 I²C Write Byte

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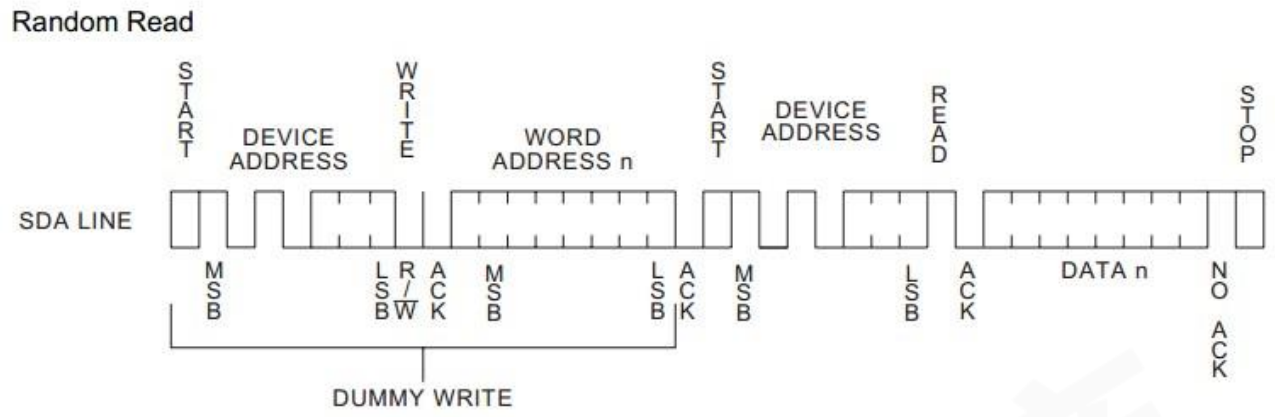

Fig5.4 I²C Read Byte

6. Typical Application

6.1. Application circuit

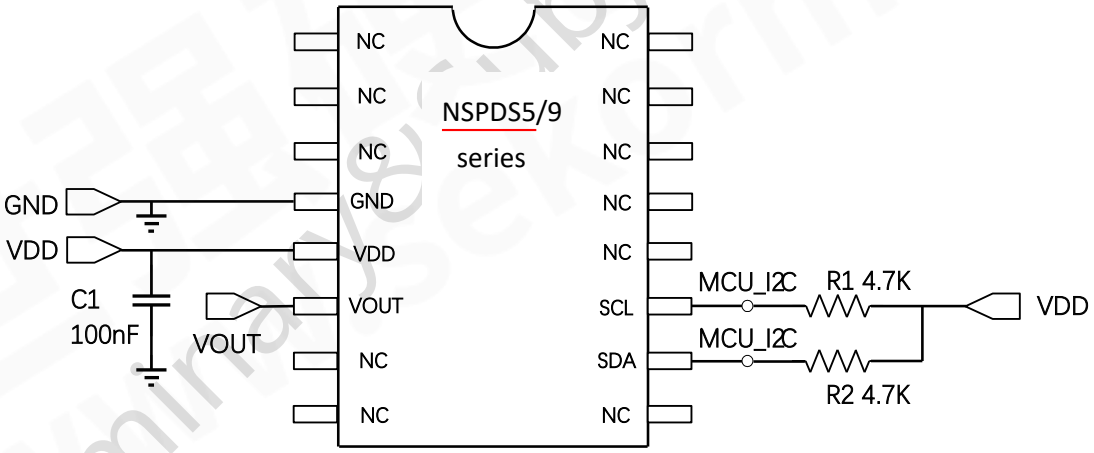

Fig 8.1 I²C Output Application Circuit

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7. Package Information

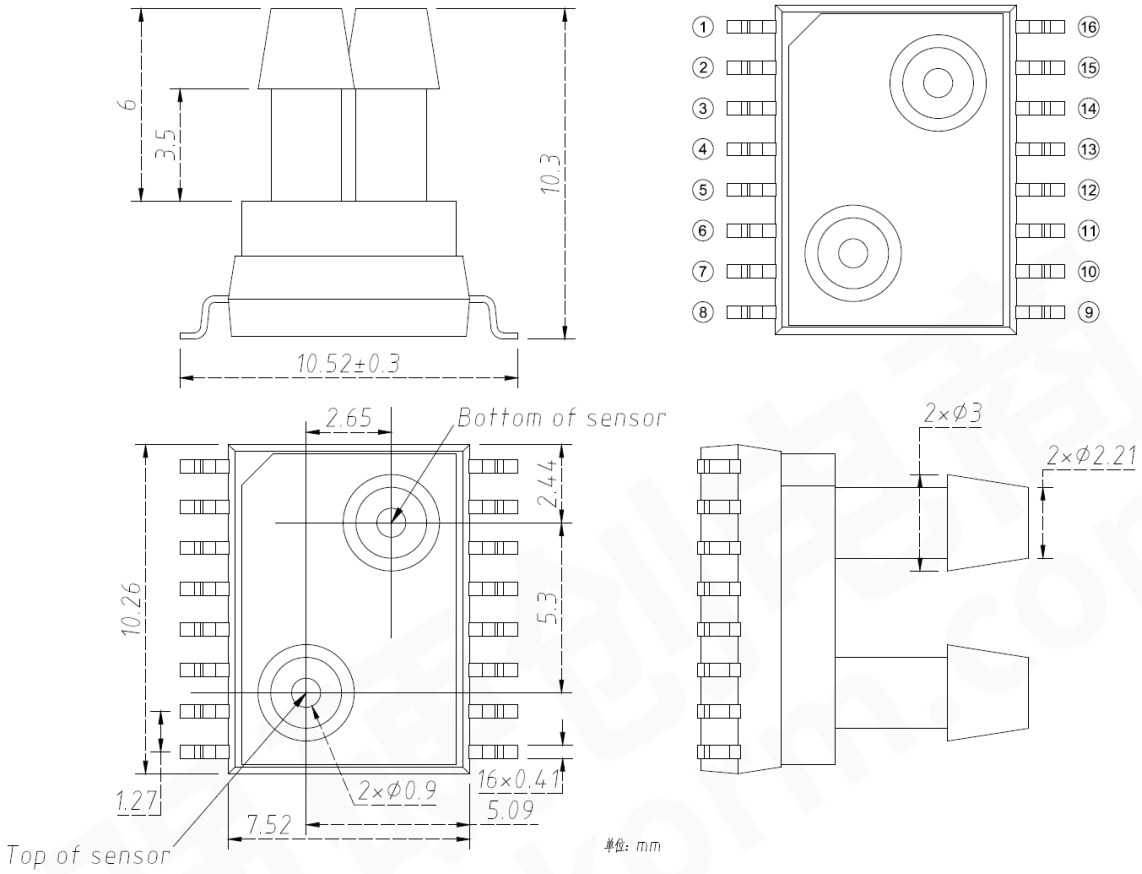

Fig 7.1 SOIC16 Package Outline mm

1. Top of sensor is tube connected to top side of sensor die. Topside pressure is positive pressure. An increase in topside pressure will result in a increase in sensor output.
2. Bottom of sensor is tube connected to bottom side of sensor die.

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8. Order Information

Product No.	Output type	Pressure range		Output range		Gain and offset		Supply voltage
		P_L	P_H	O_L	O_H	A	B	
NSPDS9F250DTA1[1] NSPDS5F250DTA1[2]	I²C output	0	250Pa	838861	7549746	312.5	-31.25	3.3V
NSPDS9F250DTB1[1] NSPDS5F250DTB1[2]		0	250Pa			312.5	-31.25	5V
NSPDS9F250DTA2[1] NSPDS5F250DTA2[2]		-125Pa	125Pa			312.5	-156.25	3.3V
NSPDS9F300DTA5[1] NSPDS5F300DTA5[2]		0	300Pa			375	-37.5	3.3V
NSPDS9F300DTB2[1] NSPDS5F300DTB2[2]		0	300Pa			375	-37.5	5V
NSPDS9F600DTA6[1] NSPDS5F600DTA6[2]		0	600Pa			750	-75	3.3V
NSPDS9F600DTB3[1] NSPDS5F600DTB3[2]		0	600Pa			750	-75	5V
NSPDS9F500DTA8[1] NSPDS5F500DTA8[2]		-250Pa	250Pa			625	-312.5	3.3V

1. The initial total error range is ±0.5% and ±1% shift during the operating life;
2. The initial total error range is ±1%;

Product No.	Output type	Pressure range		Output range		Gain and offset		Supply voltage
		P_L	P_H	O_L	O_H	A	B	
NSPDS5F001DT02	I²C output	-0.5kPa	0.5kPa	838861	7549746	1.25	-0.625	3.3V
NSPDS5F001DT03		0	1kPa			1.25	-0.125	
NSPDS5F002DT04		-1kPa	1kPa			2.5	-1.25	
NSPDS5F002DT05		0	2.5kPa			3.125	-0.3125	
NSPDS5F004DT06		0	4kPa			5	-0.5	
NSPDS5F005DT07		-2.5kPa	2.5kPa			6.25	-3.125	
NSPDS5F008DT08		-4kPa	4kPa			10	-5	
NSPDS5F007DT09		0	7kPa			8.75	-0.875	
NSPDS5F010DT10		0	10kPa			12.5	-1.25	
NSPDS5F014DT11		-7kPa	7kPa			17.5	-8.75	
NSPDS5F020DT12		-10kPa	10kPa			25	-12.5	
NSPDS5F001RT13	Analog output	-0.5kPa	0.5kPa	10%VDD	90%VDD	1.25	-0.625	
NSPDS5F001RT14		0	1kPa			1.25	-0.125	
NSPDS5F002RT15		-1kPa	1kPa			2.5	-1.25	
NSPDS5F002RT16		0	2.5kPa			3.125	-0.3125	
NSPDS5F004RT17		0	4kPa			5	-0.5	
NSPDS5F005RT18		-2.5kPa	2.5kPa			6.25	-3.125	
NSPDS5F008RT19		-4kPa	4kPa			10	-5	
NSPDS5F007RT20		0	7kPa			8.75	-0.875	
NSPDS5F010RT21		0	10kPa			12.5	-1.25	
NSPDS5F014RT22		-7kPa	7kPa			17.5	-8.75	
NSPDS5F020RT23		-10kPa	10kPa			25	-12.5	
NSPDS5F035DT24	I²C output	0	35kPa	838861	7549746	43.75	-4.375	

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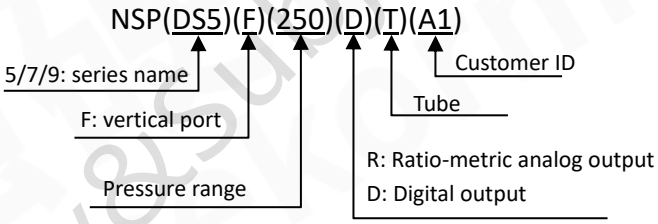
NSPDS5F070DT25		-35kPa	35kPa			87.5	-43.75
NSPDS5F093DT26		-46.6kPa	46.6kPa			116.5	-58.25
NSPDS5F105DT27		0	105kPa			131.25	-13.125
NSPDS5F310DT28		-105kPa	105kPa			262.5	-131.25
NSPDS5F035RT29	Analog output	0	35kPa	10%VDD	90%VDD	43.75	-4.375
NSPDS5F070RT30		-35kPa	35kPa			87.5	-43.75
NSPDS5F093RT31		-46.6kPa	46.6kPa			116.5	-58.25
NSPDS5F105RT32		0	105kPa			131.25	-13.125
NSPDS5F210RT33		-105kPa	105kPa			262.5	-131.25
NSPDS5F350DT34	I²C output	0	350kPa	838861	7549746	437.5	-43.75

Product No.	Output type	Pressure range		Output range		Gain and offset		Supply voltage
		P_L	P_H	O_L	O_H	A	B	
NSPDS7F004DT41	I²C output	-0.5kPa	4kPa	838861	7549746	5.625	-1.0625	3.3V
NSPDS7F002DT42	I²C output	-0.1kPa	2kPa	838861	7549746	2.625	-0.3625	3.3V
NSPDS7F070DT43	I²C output	-35kPa	35kPa	838861	7549746	87.5	-43.75	3.3V
NSPDS7F210DT44	I²C output	-105kPa	105kPa	838861	7549746	262.5	-131.25	3.3V
NSPDS7F001DT45	I²C output	-0.5kPa	0.5kPa	838861	7549746	1.25	-0.625	3.3V

Naming Convention:



9. Package Information

This series product using tube package, each tube contains 50ea devices. The minimum order quantity is 500pcs.

10. Revision

Revision	Description	Date
0.1	Initial Version.	2020/11/27
0.2	Add part NO. NSPDS5F400DT02; change operating temperature range to -20~85℃; Change the initial accuracy to ±1%, and the full temperature error to ±1.5%;	2021/02/24
0.3	Change the font and logo;	2021/02/24
0.4	Add part NO.	2021/8/11
0.5	Add NSPDS9 series, English initial version.	2021/9/9
0.6	Add NSPDS7 series, update part NO.	2021/11/8

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11. Notes

1. I²C 例程

```
void IIC_Init(void)
{
    SCL_H;
    SDA_H;
    SCL_W;
    SDA_W;
}

void IIC_Start(void)
{
    SDA_W;
    SCL_H;
    SDA_H;
    delay10us();
    SDA_L;
    delay10us();
}

void IIC_Stop(void)
{
    SCL_L;
    delay10us();
    SCL_H;
    SDA_W;
    SDA_L;
    delay10us();
    SDA_H;
    delay10us();
}

void IIC_ACK(void)
{
    SDA_W;
    SDA_L;
    SCL_H;
    delay10us();
    SCL_L;
}

void IIC_NACK(void)
{
    SDA_W;
    SDA_H;
    SCL_H;
    delay10us();
    SCL_L;
}

uchar IIC_Wait_ACK(void)
{
    int ErrTime=0;
    SDA_R;
    SCL_H;
    delay10us();
```

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```
        while(Read_SDA)
        {
                ErrTime++;
                if(ErrTime>200)
                {
                        IIC_Stop();
                        return 1;
                }
        }
        SCL_L;
        SDA_W;
        SDA_L;
        delay10us();
        return 0;
}

void IIC_Send(uchar IIC_Data)
{
        uchar i;
        SDA_W;
        SCL_L;
        delay10us();
        for(i=0;i<8;i++)
        {
                if((IIC_Data&0x80)>>7)
                        SDA_H;
                else
                        SDA_L;
                IIC_Data<<=1;
                SCL_H;
                delay10us();
                SCL_L;
                delay10us();
        }
}

uchar IIC_Receive(uchar ACK)
{
        uchar i,Receive_Data=0x00;
        SDA_R;
        for(i=0;i<8;i++)
        {
                SCL_L;
                delay10us();
                SCL_H;
                Receive_Data<<=1;
                if(Read_SDA==1)
                        Receive_Data++;
                else
                        ;
                delay10us();
        }
        SCL_L;
        delay10us();
        if(ACK==0x01)
                IIC_ACK();
        else
                IIC_NACK();
```

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```
    return Receive_Data;
}

void NSPDS5_Write_Byte(uchar WriteAddr,uchar WriteData)
{
    uchar flag;
    IIC_Start();
    IIC_Send(0xFE|0x00);
    IIC_Wait_ACK();
    IIC_Send(WriteAddr);
    IIC_Wait_ACK();
    IIC_Send(WriteData);
    IIC_Wait_ACK();
    IIC_Stop();
}

void NSPDS5_Read_Byte(uchar ReadAddr, uchar *pBuffer)
{
    IIC_Start();
    IIC_Send(0xFE|0x00);
    IIC_Wait_ACK();
    IIC_Send(ReadAddr);
    IIC_Wait_ACK();
    IIC_Start();
    IIC_Send(0xFE|0x01);
    IIC_Wait_ACK();
    pBuffer[0]=IIC_Receive(0);
    IIC_Stop();
}

void NSPDS5_Read_3Byte(uchar ReadAddr,uchar *pBuffer)
{
    IIC_Start();
    IIC_Send(0xFE|0x00);
    IIC_Wait_ACK();
    IIC_Send(ReadAddr);
    IIC_Wait_ACK();
    IIC_Start();
    IIC_Send(0xFE|0x01);
    IIC_Wait_ACK();
    pBuffer[0]=IIC_Receive(1);
    pBuffer[1]=IIC_Receive(1);
    pBuffer[2]=IIC_Receive(0);
    IIC_Stop();
}

Void Main()
{
      uChar PData[3]={0,0,0};
       IIC_Init();
      NSPDS5_Write_Byte(0x30,0x0A);
      Delay_3ms();
      NSPDS5_Read_3Byte(0x06,PData);
}
```

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