NOVOSENSE

NSPDS5 Series

Integrated Differential Low Pressure Sensor

Datasheet (EN) 1.1

Product Overview

NSPDS5 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 0.5kPa differential to 250kPa differential can be converted into an analog output signal (0~5V) or I²C 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

- Large pressure range
  Pressure range 0.5kPa to 250kPa
- Operating temperature range -20°C to 70°C
- Initial total error band
  Digital output better than ±1%F.S.
  Analog output better than ±1.5% F.S.
- 24bit I²C digital and 12bit analog output
- Vertical port
- RoHS & REACH-compliant

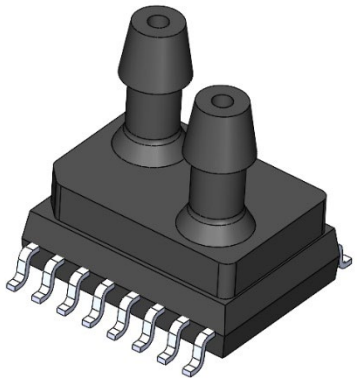
Applications

- Residual pressure for fire protection
- Ventilators
- CPAP/sleep apnea
- HVAC/VAV
- Safety cabinets
- Pressure switches

Device Information

Part Number	*Package*	*Body Size*
NSPDS5	SOIC16	10.26mm×7.52mm

Outline



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1. Pin Configuration and Functions

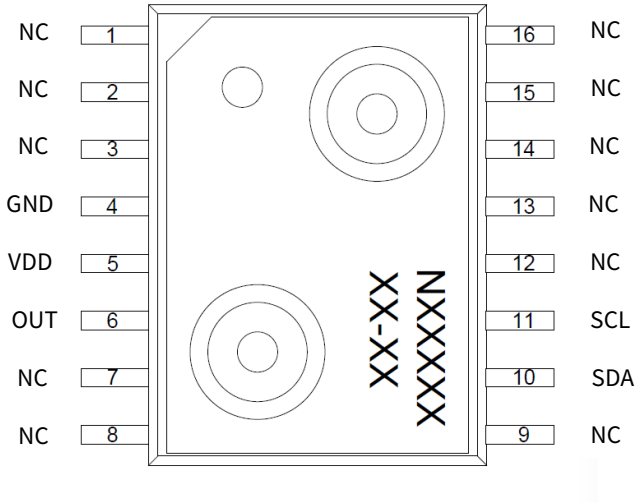


Figure 1.1 NSPDS5 Series Pin Definition (Top view)

Table 1.1 NSPDS5 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

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°C
Proof pressure	P_{Proof}	30			kPa	Operating pressure range ＜20kPa@25°C
		300				Operating pressure range ≥20kPa@25°C
Burst pressure	P_{Burst}	50			kPa	Operating pressure range ＜20kPa@25°C
		350				Operating pressure range ≥20kPa@25°C
Storage temperature	T_{stg}	-40		85	°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. 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 range	P_{range}	0.5		250	kPa	$P_{max} - P_{min}$
I^2C clock frequency	F_{sclk}			400	kHz	
Operating temperature	T_{opr}	-20		70	°C	

5. Specifications

5.1. Electrical Characteristics

Parameters	Symbol	Min	Typ	Max	Unit	Comments
Operating current	I_{avdd}	1.8	2.5	3	mA	Analog output@25°C
			0.3	30	uA	Standby mode in digital output@25°C
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
Initially accuracy	ACC	-1%		1%	%FS	Digital output
	ACC	-1.5%		1.5%	%FS	Analog output
Full life accuracy [1, 2, 3, 4]	ACC	-2%		2%	%FS	Digital output
	ACC	-2.5%		2.5%	%FS	Analog output
Power up time	T_{UP}		100		ms	

1. Accuracy includes non-linearity, temperature, pressure hysteresis, temperature hysteresis.
2. Full life accuracy based on the part number NSPDS5F001DT02 500 hour HTOL, LTOL, TH (40°C /90%RH), TC and 3x reflow testing.
3. For pressure accuracy of different part number, please refer to complete part number list at chapter 8.
4. Unless otherwise specified, the accuracy is based on typical operating voltage.

5.2. I²C Timing Diagram

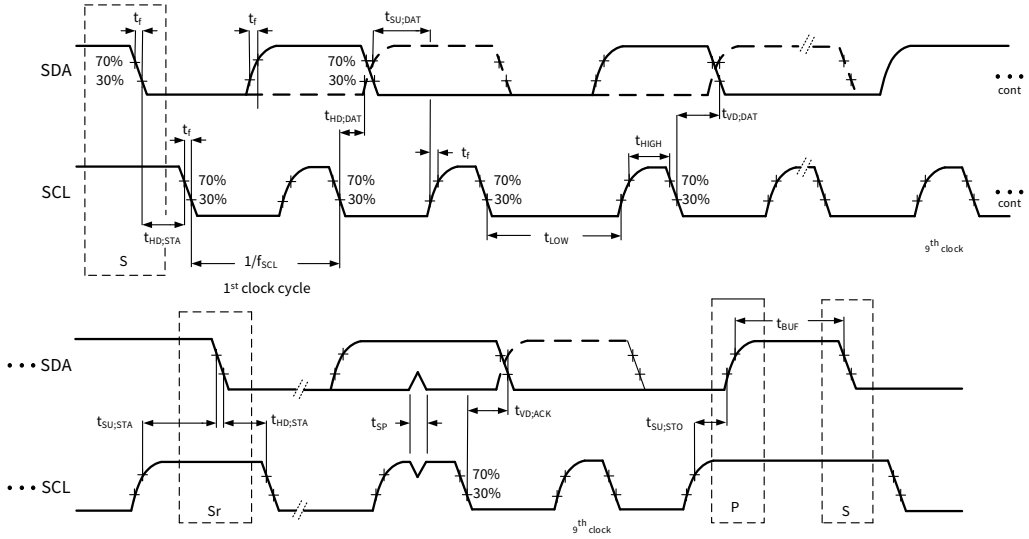


Figure 5.1 I²C Timing Diagram

5.3. I²C Electrical Characteristics

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

6. Function Description

6.1. Overview

NSPDS5 uses a MEMS piezoresistive differential pressure sensor element as a pressure sensitive component that provides 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 digital or voltage signal that is linear with the applied pressure.

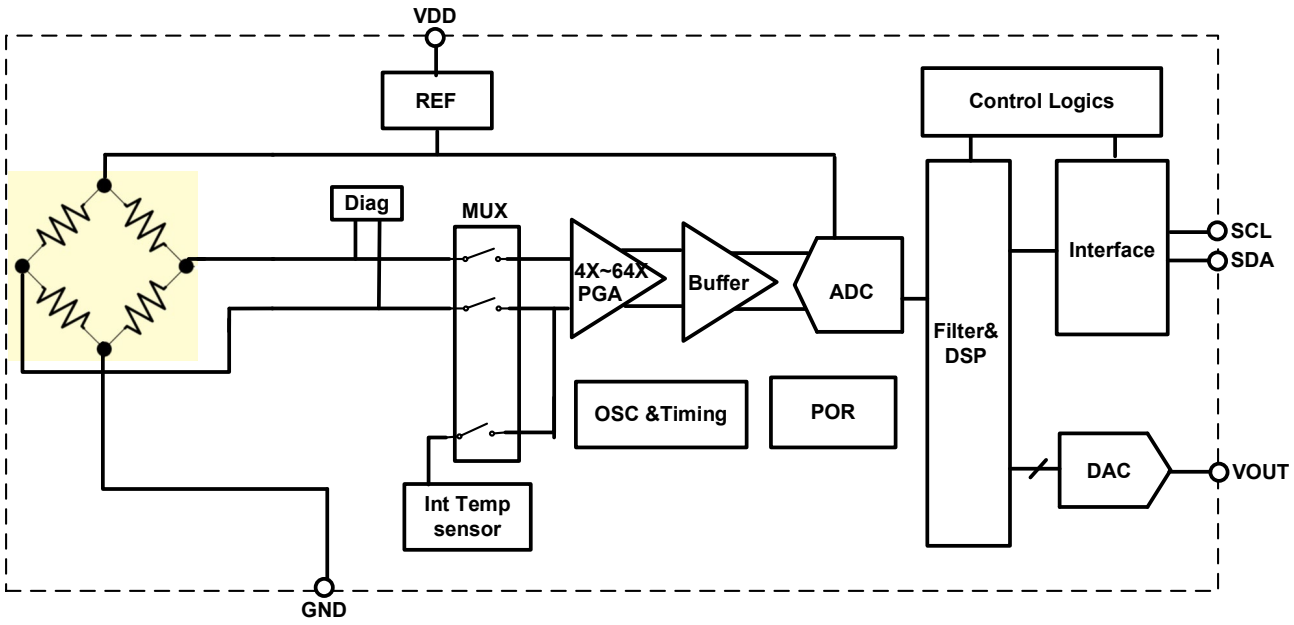


Figure 6.1 Product Function Block Diagram

6.2. Digital Output Transfer Function

$$P=A \times code/8388608+B$$

Code is the register 0x06~0x08 value;

P is the pressure value, differential pressure, unit is kPa.

Table 6.1 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

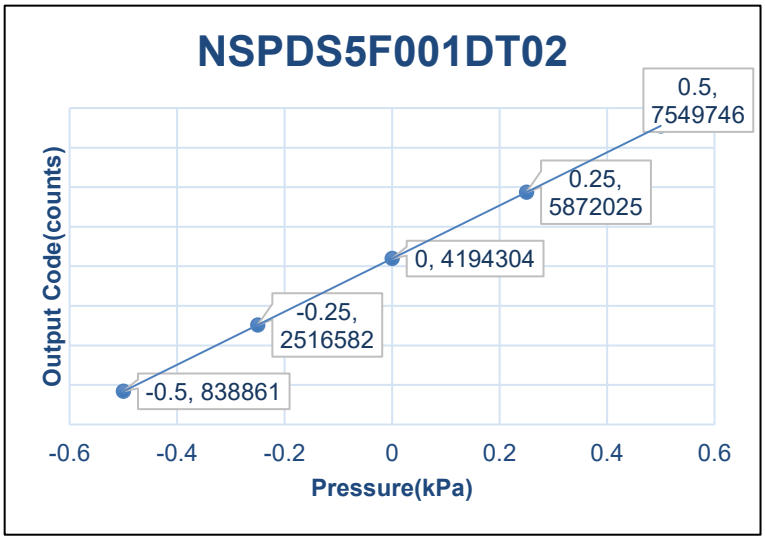


Figure 6.2 Digital Output Transfer Function

6.3. Analog Output Transfer Function

$$P= A \times OUT /VDD+B$$

Note:

OUT is the analog output, unit is V;

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

Table 6.2 Analog Output Transfer Function Coefficient

Product Type	Pressure Range		Output Range		Gain and Offset	
	P_L	P_H	O_L	O_H	A	B
NSPDS5F001RT13	-0.5kPa	0.5kPa	0.1*VDD	0.9*VDD	1.250	-0.625

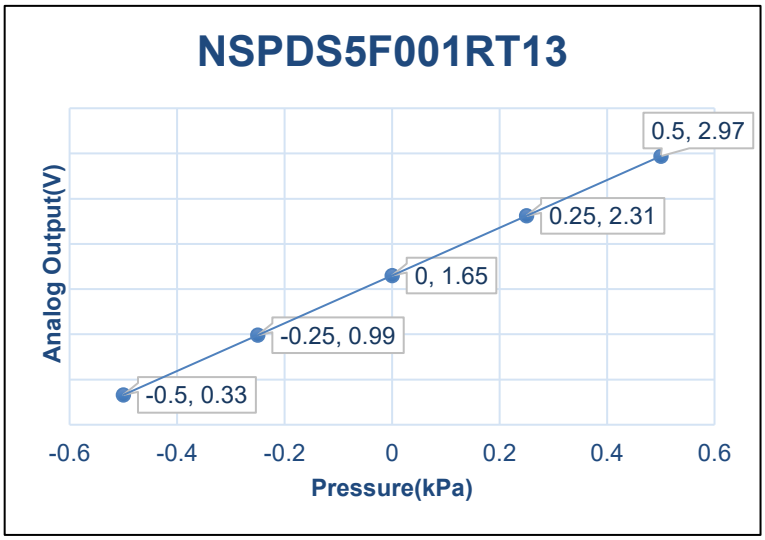


Figure 6.3 Analog Output Transfer Function

6.4. 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(kPa) = 4194303/8388607*A+B, and finally get the value of pressure about 0kPa.

6.5. 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 NSPDS5 is shown below.

Table 6.3 I²C Address

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

The I²C 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.

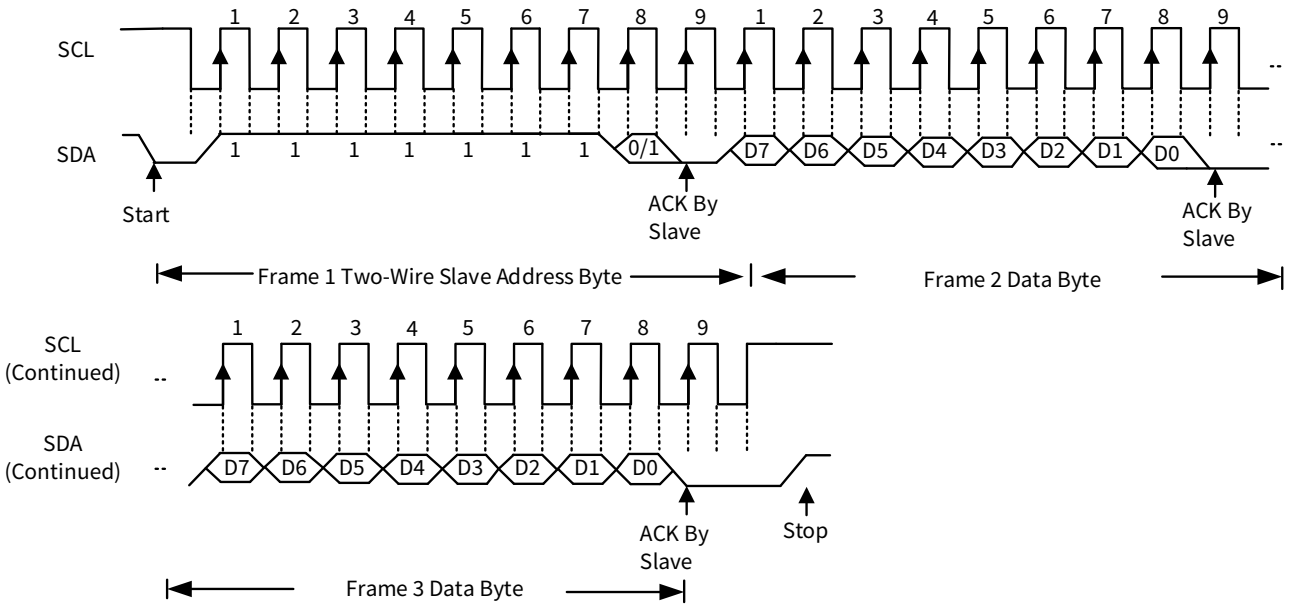


Figure 6.4 I²C Protocol

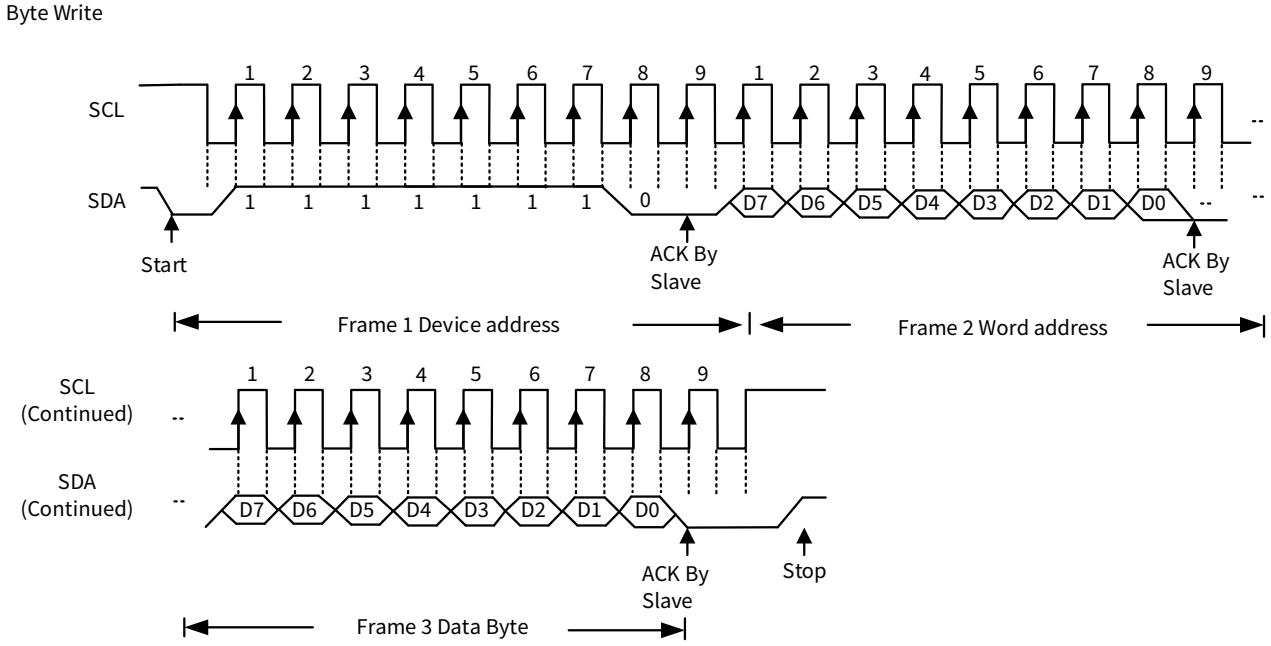


Figure 6.5 I²C Write Byte

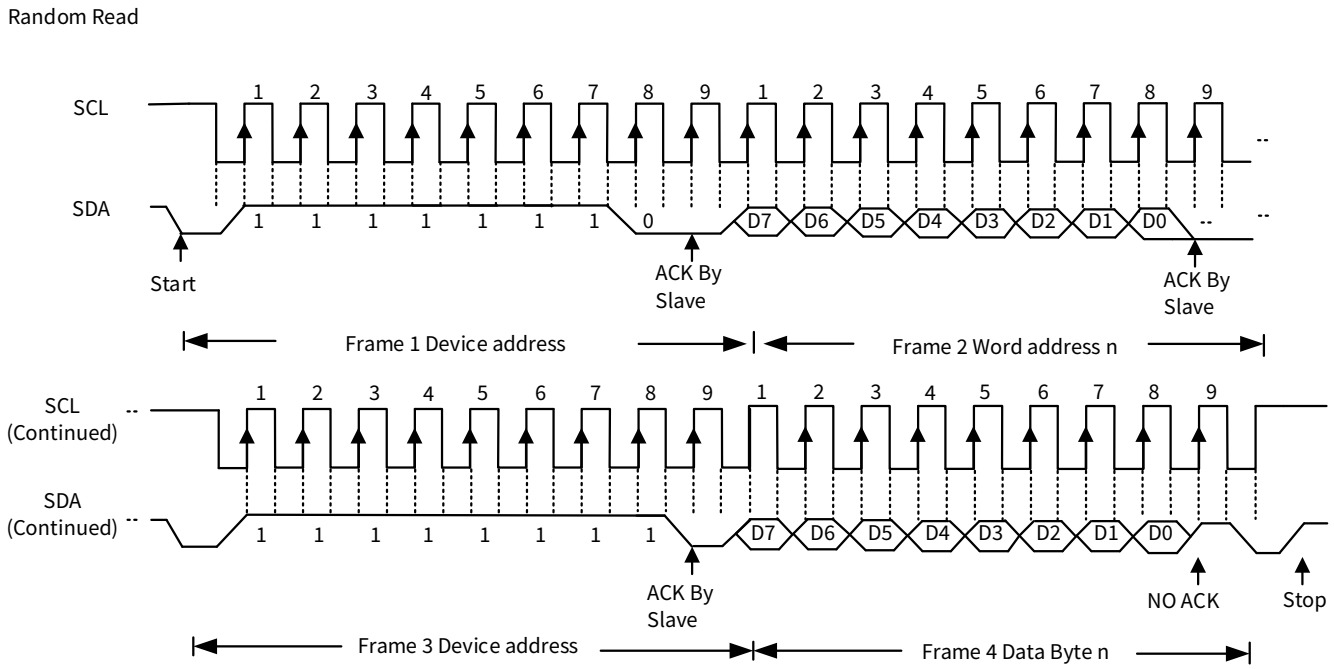


Figure 6.6 I²C Read Byte

7. Typical Application

7.1. Application Circuit

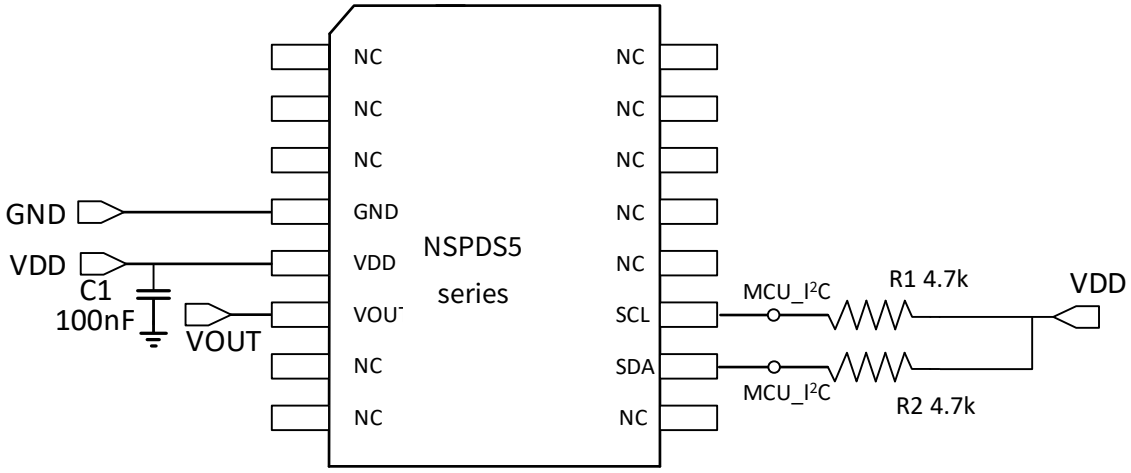


Figure 7.1 Typical Application Circuit

8. Package Information

8.1. Package Size

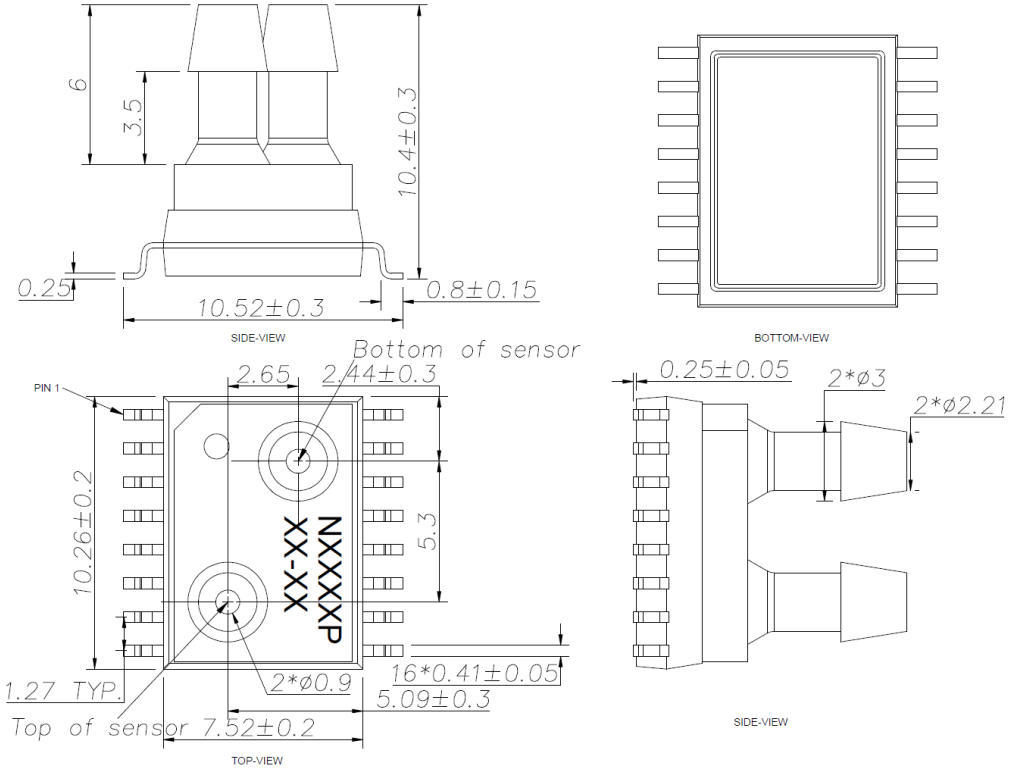


Figure 8.1 SOIC16 Package Outline mm

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.

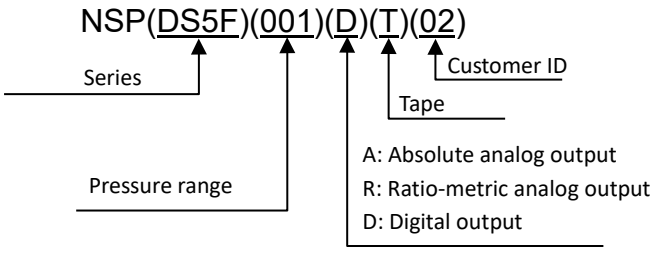
9. Order Information

Product No.	Output Type	Pressure Range		Output Range		Gain and Offset		Supply Voltage	Accuracy@ -20~70℃	
		P_L	P_H	O_L	O_H	A	B		Initially	Full life
NSPDS5F001DT02	I²C	-0.50kPa	0.50kPa	838861	7549746	1.250000	-0.6250000	3.3V	±1%	±2%
NSPDS5F002DT04	I²C	-1.00kPa	1.00kPa	838861	7549746	2.500000	-1.250000	3.3V	±1%	±2%
NSPDS5F010DT10	I²C	0.00kPa	10.00kPa	838861	7549746	12.500000	-1.250000	3.3V	±1%	±2%
NSPDS5F014DT11	I²C	-7.00kPa	7.00kPa	838861	7549746	17.500000	-8.750000	3.3V	±1%	±2%
NSPDS5F002RT15	Ratiometric	-1.00kPa	1.00kPa	10%VDD	90%VDD	2.500000	-1.250000	3.3V	±1.5%	±2.5%
NSPDS5F035DT24	I²C	0.00kPa	35.00kPa	838861	7549746	43.750000	-4.375000	3.3V	±1%	±2%
NSPDS5F210DT28	I²C	-105.00kPa	105.00kPa	838861	7549746	262.500000	-131.250000	3.3V	±1%	±2%
NSPDS5F010RT35	Ratiometric	-5.00kPa	5.00kPa	10%VDD	90%VDD	12.500000	-6.250000	3.3V	±1.5%	±2.5%
NSPDS5F024AT40	Absolute	-12.00kPa	12.00kPa	0.50V	4.50V	30.000000	-15.000000	5V	±1%	±2%
NSPDS5F020DT41	I²C	0.00kPa	20.00kPa	838861	7549746	25.000002	-2.500001	3.3V	±1%	±2%

Please scan the following QR code or visit the download link for complete part number list.
https://www.novosns.com/Public/Uploads/uploadfile4/NSPDS5.pdf

NSPDS5

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
TS (max)to TL – Ramp-up Rate		2°C/second max
Reflow	Temperature (T_L) (Liquidus)	210°C
	Time (min to max) (t_L)	60 – 120 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

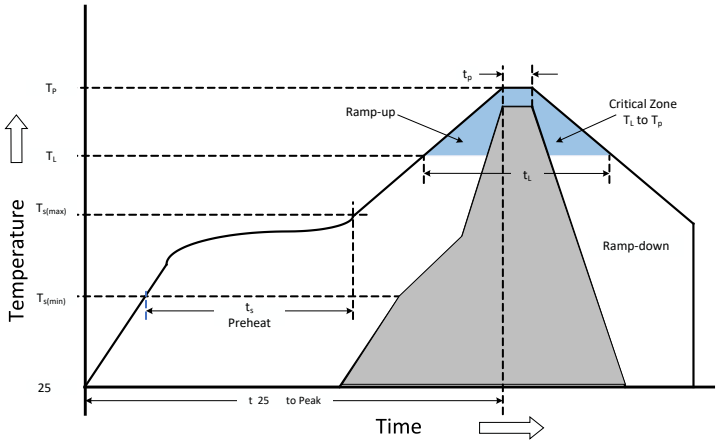
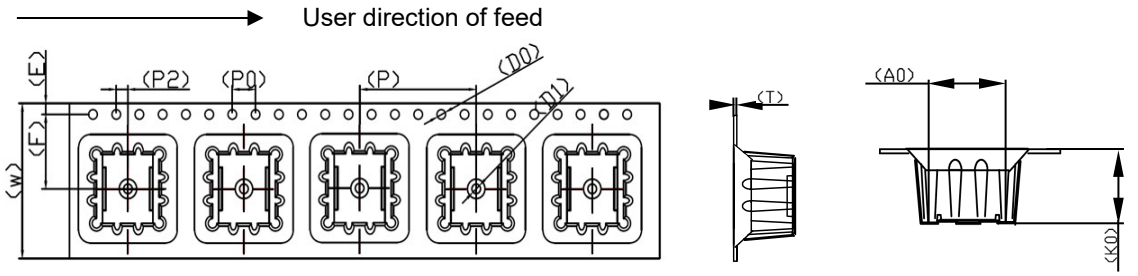


Figure 10.1 Reflow Soldering Curve

10.2. Manual Soldering

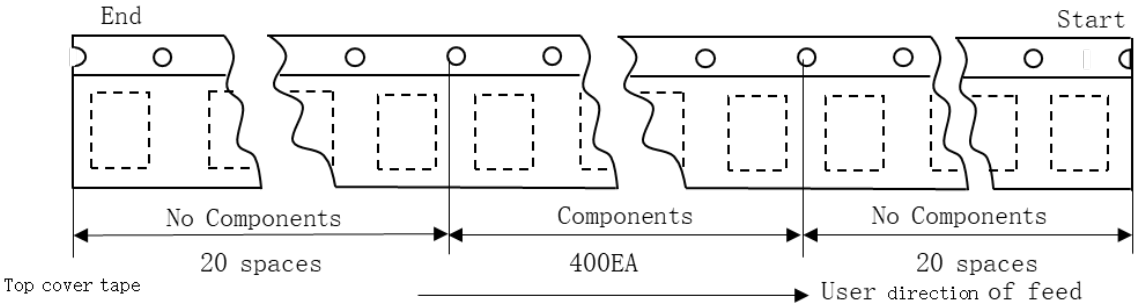
- Raise the temperature of the soldering tip between 260 °C and 300 °C and solder within 5 seconds.
- Use a flattened soldering tip when performing rework on the solder bridge.
- Complete rework in one time.

11. Packing Information

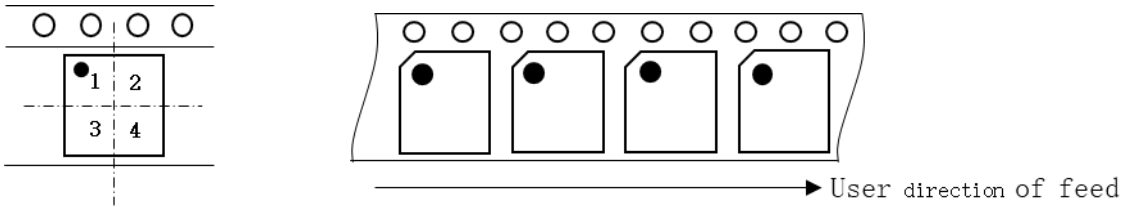


E(mm)	F(mm)	P2(mm)	D0/D1(mm)	P0(mm)	10P0(mm)	W(mm)	P(mm)	A0(mm)	B0(mm)	K0(mm)	T(mm)
1.75±0.10	11.5±0.10	2.0±0.10	1.5+0.1	4.0±0.1	40.0±0.20	24.0±0.30	20.0±0.10	10.80±0.10	10.70±0.10	9.90±0.10	0.50±0.05

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

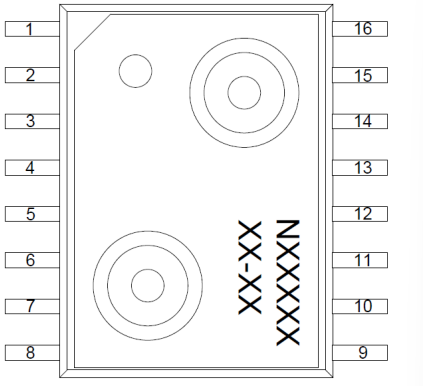


Pin1 is located at the first quadrant, as shown in the following figure.



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

12. Identification Code



Nxxxxx xx-xx: package date code.

13. Revision History

Revision	Description	Date
1.0	Formal release.	2023/09/27
1.1	Update Packing Information and Package Size.	2025/12/26

14. Notes

14.1. I²C routine

```
#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 I2C, 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 I2C, 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 I2C
{
        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 NSPDS5F001DT02_Write_Byte(uchar WriteAddr,uchar WriteData)
{
    IIC_Start();
    IIC_Send(0xFE|0x00);
    IIC_Wait_ACK();
    IIC_Send(WriteAddr);
    IIC_Wait_ACK();
    IIC_Send(WriteData);
    IIC_Wait_ACK();
    IIC_Stop();
}

void NSPDS5F001DT02_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 NSPDS5F001DT02_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(ACK);
    pBuffer[1]=IIC_Receive(ACK);
    pBuffer[2]=IIC_Receive(NACK);
    IIC_Stop();
}

void main()
{
        uchar PData[3]={0,0,0};
        while(1)
        {
                NSPDS5F001DT02_Write_Byte(0x30,0x0A);
                while(1)                                        //Check whether the conversion ends
                {
                        if(number<=50)
                        {
```

```
                    number++;
                    delay_ms(1);
                    NSPDS5F001DT02_Read_Byte(0x30,Reg30);
                    if(0x02==Reg30[0])
                    {
                        number=1;
                        break;
                    }
                }
                if(number>50)
                {
                    number=1;
                    //User can add his own error handler function
                    break;
                }
            }
            NSPDS5F001DT02_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 (1.25*Pdata/8388607-0.625）;          // P=A*PCode/8388607+B
                                                        // A=1.25, B= -0.625
                                                       //PNormalized=PCode/8388607
        }
}
```

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