NSPDS9 Series

Integrated Differential Ultra-Low Pressure Sensor

Datasheet (EN) 1.1

Product Overview

NSPDS9 is a calibrated differential pressure sensor series product launched by NOVOSENSE for ultra-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 500Pa 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

- Ultra low pressure range
  Pressure range 125Pa to 500Pa
- Operating temperature range -20°C to 70°C
- Initial total error band better than ±1.5%F.S.
- Full life accuracy better than ±2.5%F.S.
- 24bit I²C digital and 12bit analog output
- Vertical port
- RoHS & REACH Compliance

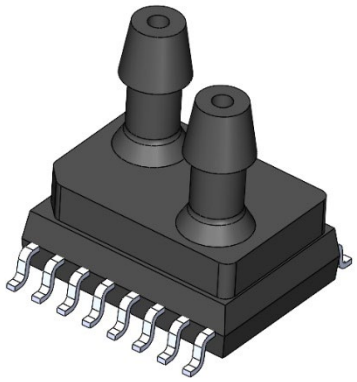
Applications

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

Device Information

Part Number	Package	Body Size
NSPDS9	SOIC16	10.26mm×7.52mm

Outline



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1. Pin Configuration and Functions

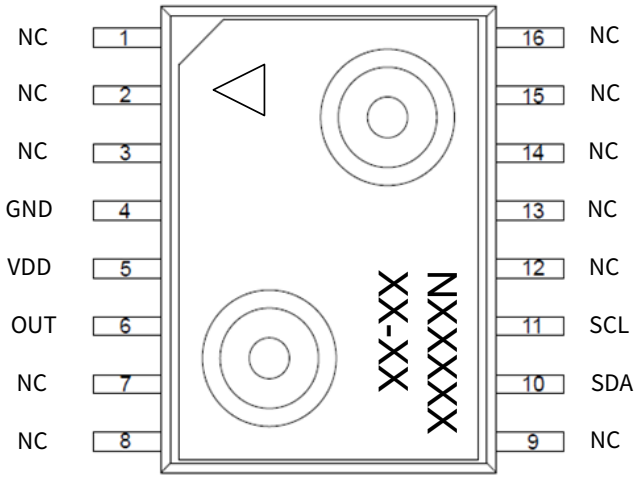


Figure 1.1 NSPDS9 Series Pin Definition (Top view)

Tab 1.1 NSPDS9 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}	7			kPa	
Burst pressure	P_{Burst}	10			kPa	
Storage temperature	T_{stg}	-40		85	°C	

3. ESD Ratings

Ratings		Value	Unit
Electrostatic discharge	Human body model (HBM), per AEC-Q100-002 Rev-E	±2.5	kV
	Charged device model (CDM), per AEC-Q100-011 Rev-D	±500	V
	Latch up (LU), per AEC-Q100-004 REV-D	±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	V	
Operating pressure range	P_{range}	250		1000	Pa	$P_{max} – P_{min}$
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
			0.3	30	uA	Standby mode in digital output
ADC resolution	RES_{RAW}		24		Bits	
PSRR	PSRR	90	120		dB	
DAC resolution			12		Bits	
Accuracy[1,2,3,4]	ACC	-1.5%		1.5%	%FS	Initial accuracy
		-2.5%		2.5%	%FS	Full life accuracy
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 NSPDS9F250DTA2 500 hour HTOL, LTOL, TH (40°C /90%RH) and TCT testing.
3. For pressure accuracy of different part number, please refer to complete part number list at chapter 9. Unless otherwise specified, the accuracy is based on typical operating voltage.
4. The ratiometric analog output also include ±0.5% ratiometric error. The ratiometric error is defined as the difference between the ratio that VDD changed and the ratio that VOUT changed. Ratiometric signal error is not included in the overall accuracy. Absolute analog output and I²C output are not applicable.

5.2. I²C Timing Diagram

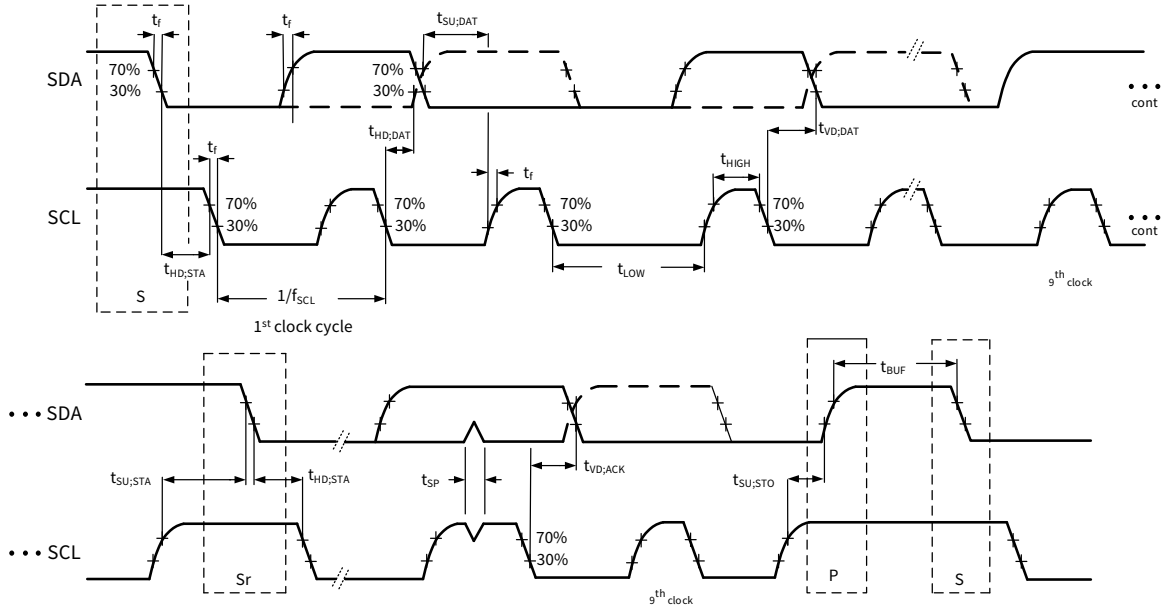


Figure 5.1 I²C Timing Diagram

5.3. 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	

6. Function Description

6.1. Overview

NSPDS9 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.

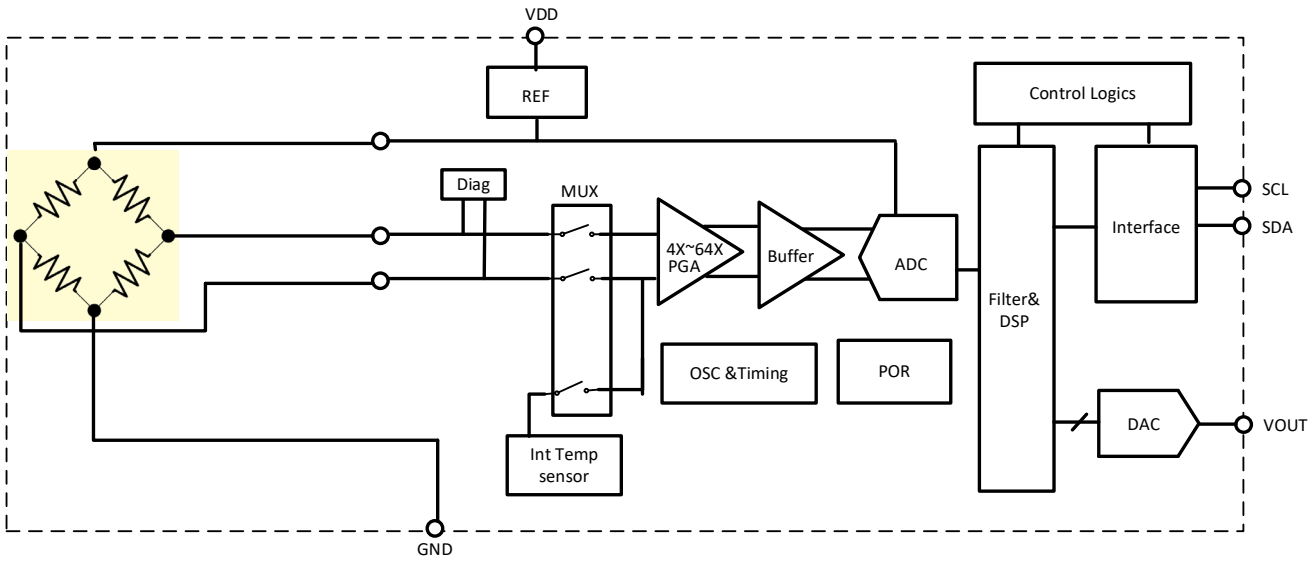


Figure 6.1 Product Function Block Diagram

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 Pa.

Tab6.1 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
NSPDS9F250DTA2	-125Pa	125Pa	838861	7549746	312.5	-156.25

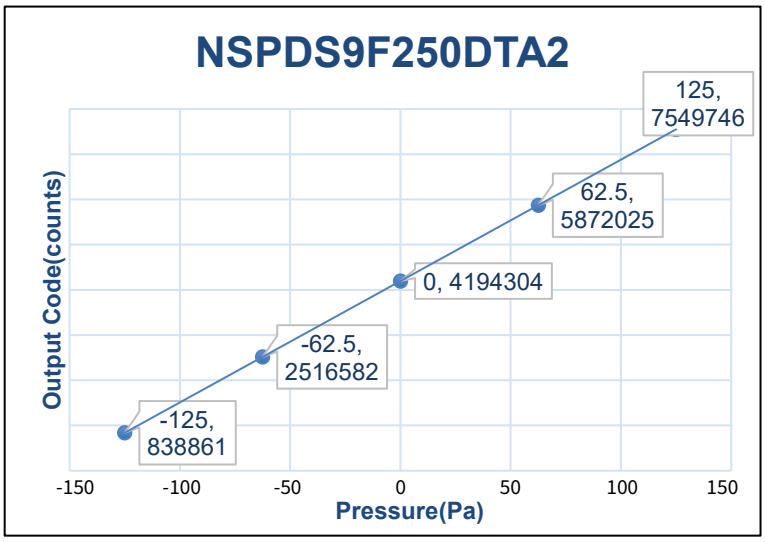


Figure 6.2 Digital Output Transfer Function

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 Pa；

Table 6.2 Analog Output Transfer Function Coefficient

Product NO.	Pressure Range		Analog Output Range		Gain and Offset	
	P_L	O_L	O_L	O_H	A	B
NSPDS9F800RTB5	-400Pa	400Pa	0.1*VDD	0.9*VDD	1000	-500

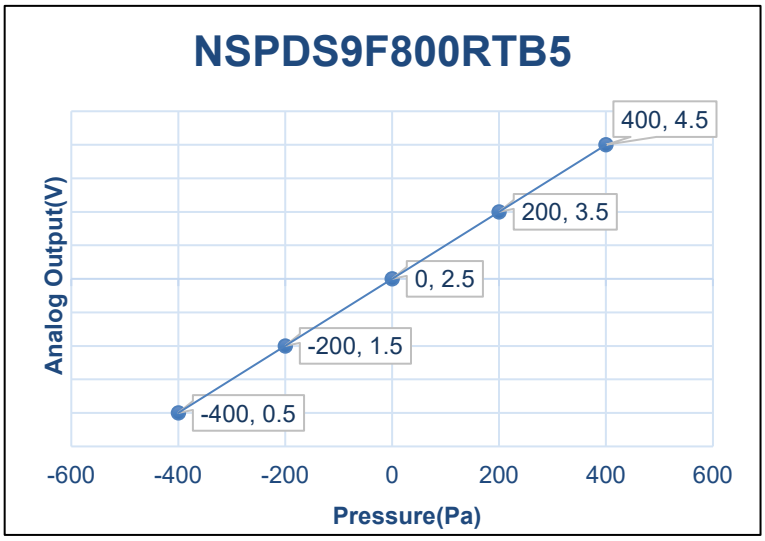


Figure 6.3 Analog Output Transfer Function

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 NSPDS9F250DTA2 transfer function, Code = 4194303, P(Pa) = 4194303/8388607*A+B, and finally get the value of pressure about 0Pa.

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 NSPDS9 is shown below.

Tab 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.

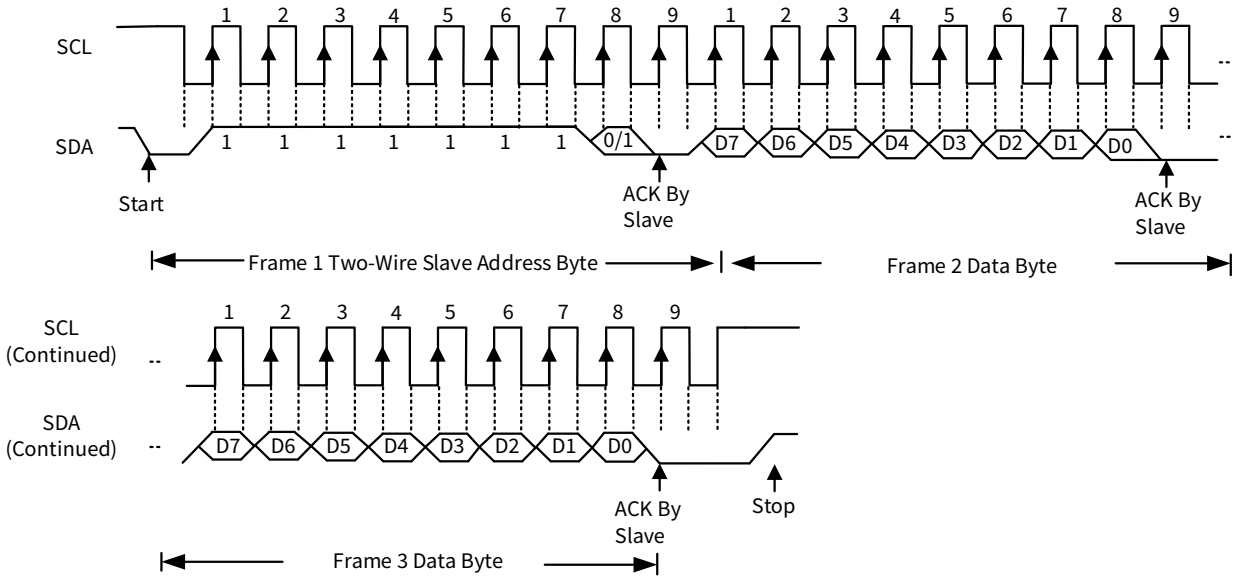


Figure 6.4 I²C Protocol

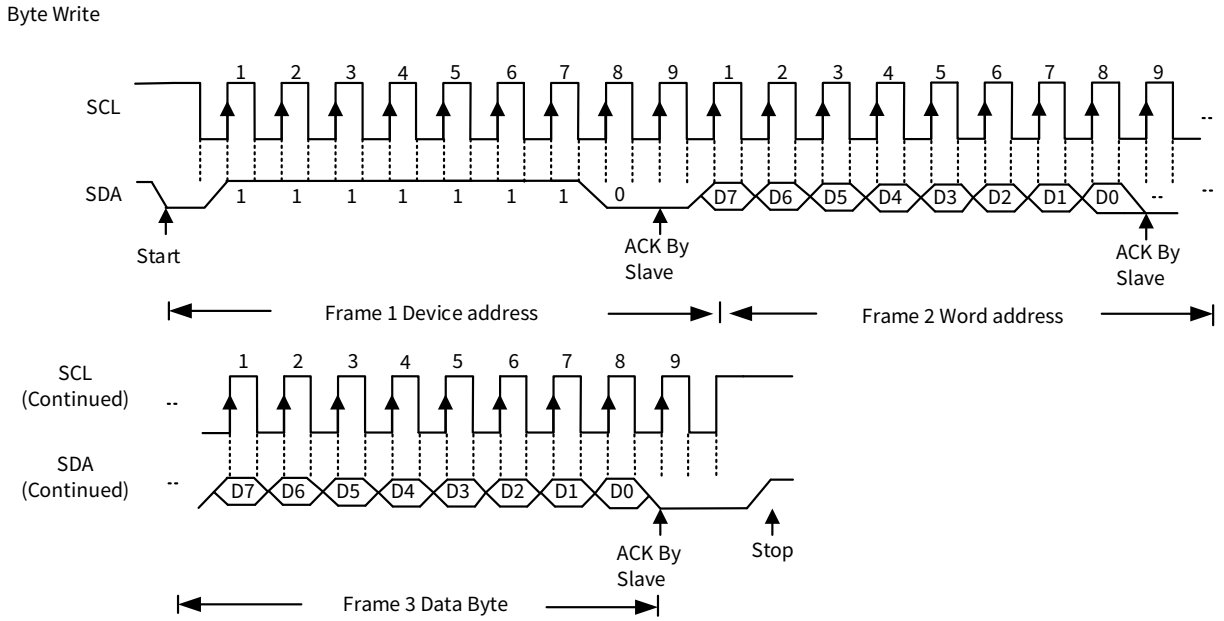


Figure 6.5 I²C Write Byte

Random Read

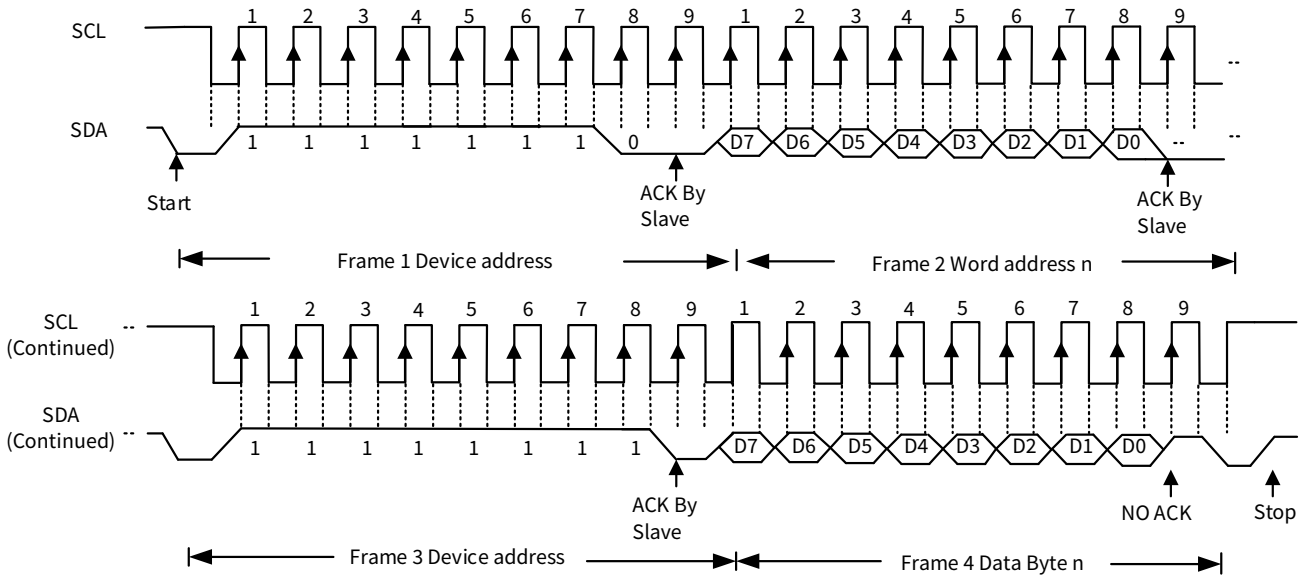


Figure 6.6 I²C Read Byte

7. Typical Application

7.1. Application Circuit

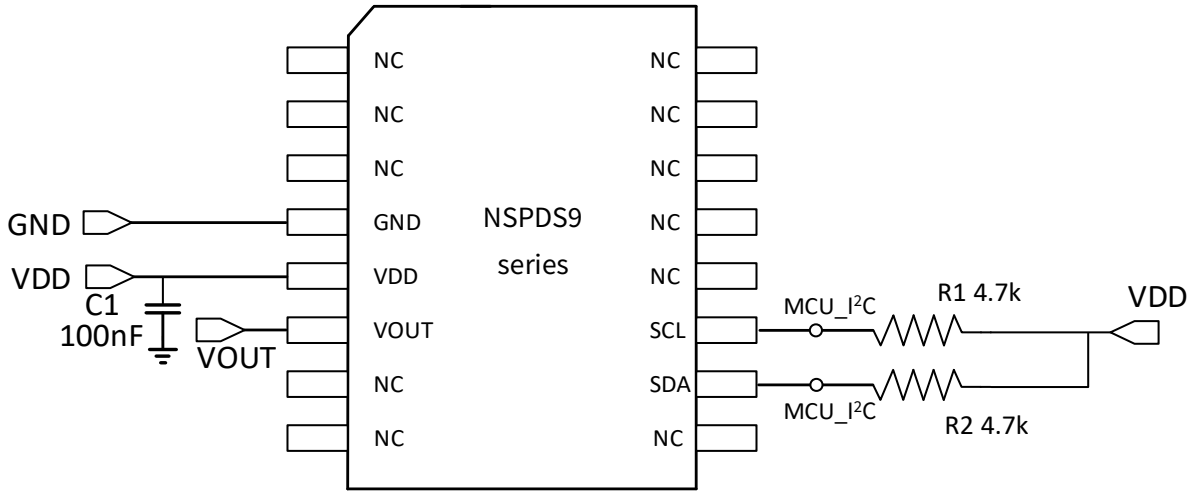


Figure 7.1 Typical Application Circuit

8. Package Information

8.1. Package Size

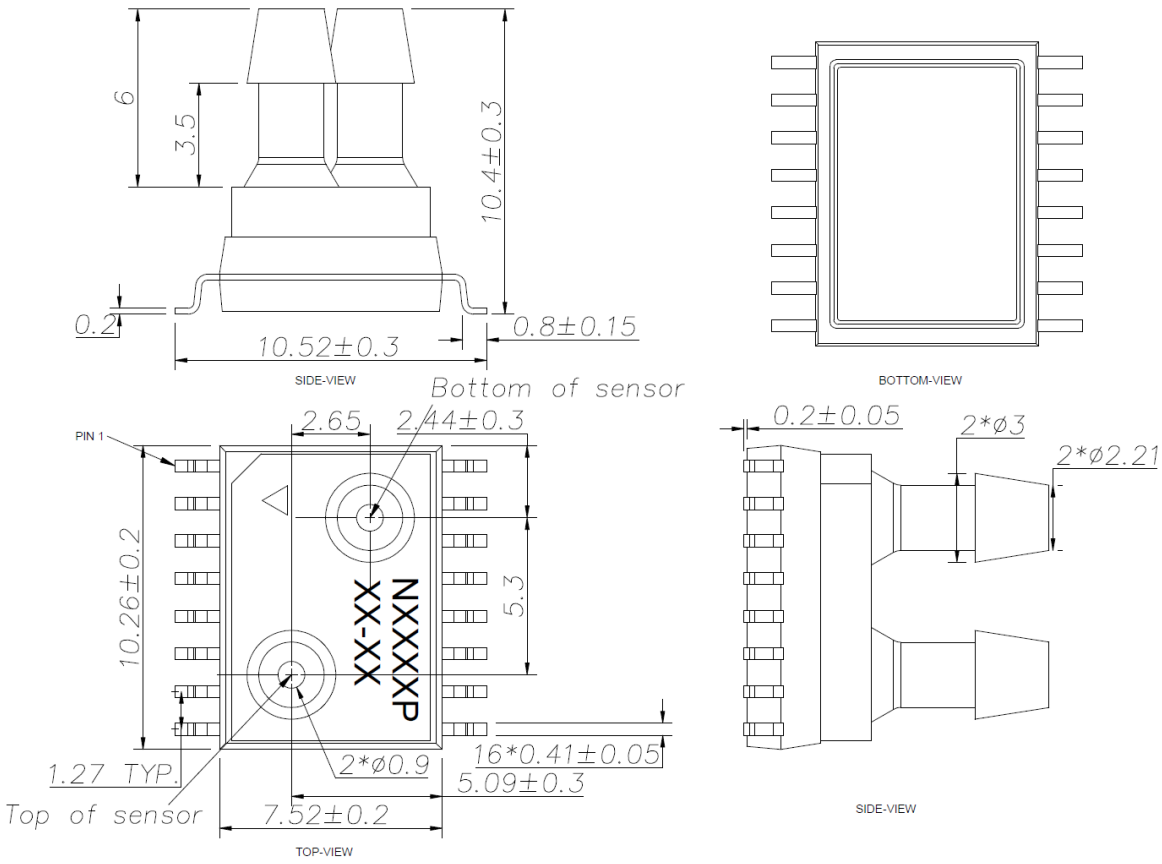


Figure 8.1 SOIC16 Package Outline mm

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

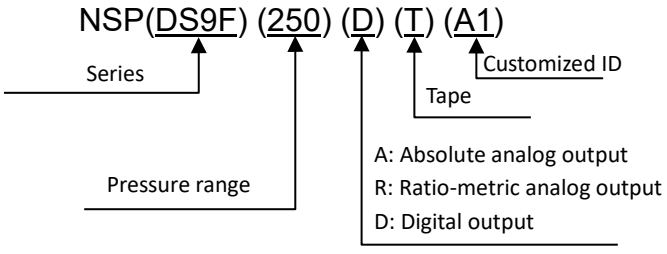
Product No.	Output Type	Pressure Range		Output Range		Gain and Offset		Supply voltage	Accuracy	
		P_L	P_H	O_L	O_H	A	B		Initially	Full Life
NSPDS9F250DTA1	I²C	0.00Pa	250.00Pa	838861	7549746	312.500	-31.250	3.3V	±1.5%	±2.5%
NSPDS9F250DTB1	I²C	0.00Pa	250.00Pa	838861	7549746	312.500	-31.250	5.0V	±1.5%	±2.5%
NSPDS9F250DTA2	I²C	-125.00Pa	125.00Pa	838861	7549746	312.500	-156.250	3.3V	±1.5%	±2.5%
NSPDS9F300DTA5	I²C	0.00Pa	300.00Pa	838861	7549746	375.000	-37.500	3.3V	±1.5%	±2.5%
NSPDS9F300DTB2	I²C	0.00Pa	300.00Pa	838861	7549746	375.000	-37.500	5.0V	±1.5%	±2.5%
NSPDS9F600DTA6	I²C	0.00Pa	600.00Pa	838861	7549746	750.000	-75.000	3.3V	±1.5%	±2.5%
NSPDS9F600DTB3	I²C	0.00Pa	600.00Pa	838861	7549746	750.000	-75.000	5.0V	±1.5%	±2.5%
NSPDS9F500DTA8	I²C	-250.00Pa	250.00Pa	838861	7549746	625.000	-312.500	3.3V	±1.5%	±2.5%
NSPDS9F001DTC3	I²C	-500.00Pa	500.00Pa	838861	7549746	1250.000	-625.000	3.3V	±0.8%	±2%
NSPDS9F800RTB5	Ratiometric	-400.00Pa	400.00Pa	10%VDD	90%VDD	1000.000	-500.000	5.0V	±1.0%	±2.5%
NSPDS9F001DTB6	I²C	-500.00Pa	500.00Pa	838861	7549746	1250.000	-625.000	5.0V	±0.8%	±2%

Please scan the following QR code for complete part number list.

https://www.novosns.com/Public/Uploads/uploadfile4/NSPDS9.pdf

NSPDS9

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

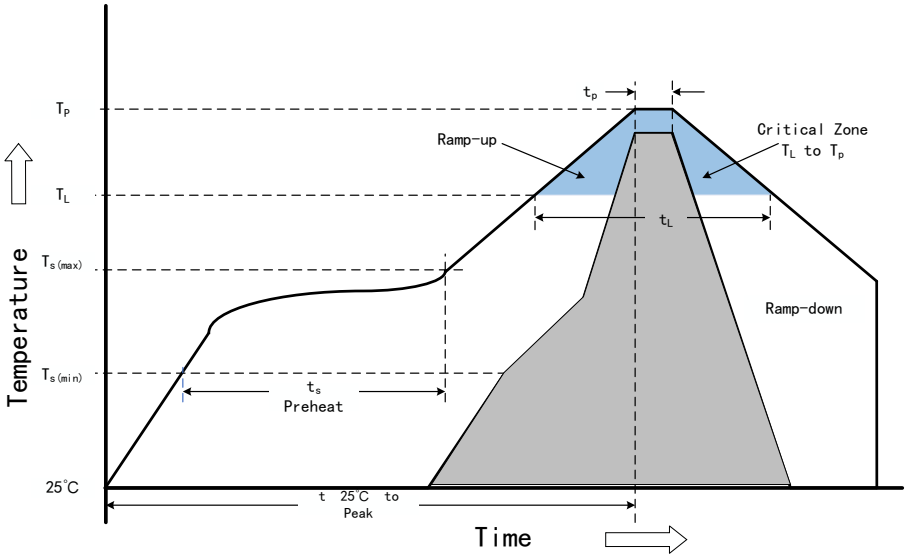
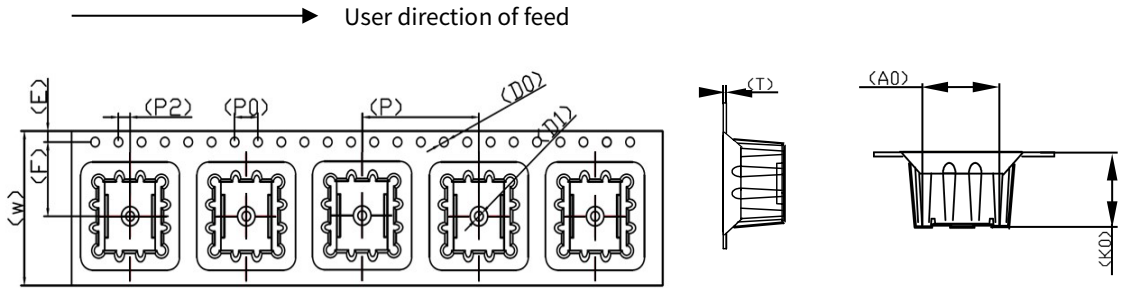


Figure 10.1 Reflow Soldering Curve

10.2. Manual Soldering

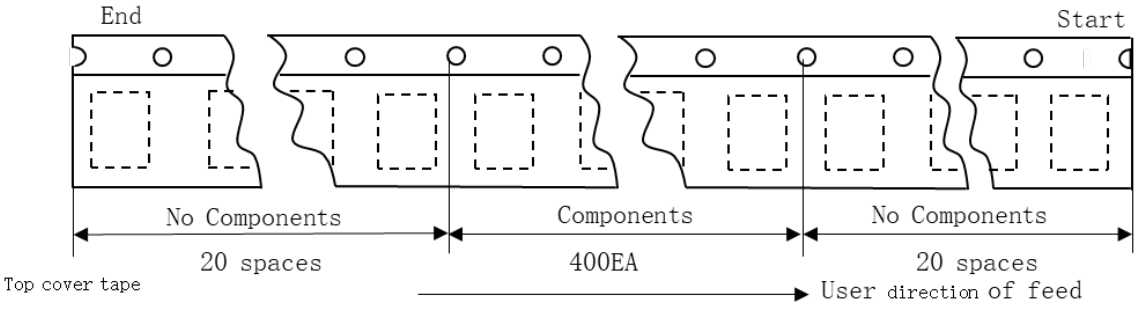
- Raise the temperature of the soldering tip between 260 °C and 300 °C and solder within 5 seconds.
- Use a flattened soldering tip when performing rework on the solder bridge.
- Complete rework in one time.

11. Packing Information

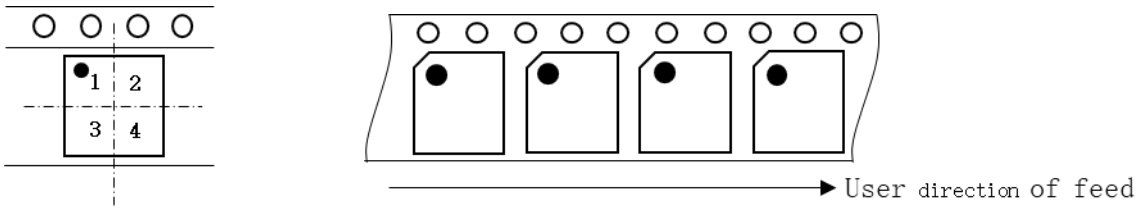


E(mm)	F(mm)	P2(mm)	D0/D1(mm)	P0(mm)	10P0(mm)	W(mm)	P(mm)	A0(mm)	B0(mm)	K0(mm)	T(mm)
1.75±0.10	11.5±0.10	2.0±0.10	1.5+0.1	4.0±0.1	40.0±0.20	24.0±0.30	20.0±0.10	10.80±0.10	10.70±0.10	9.90±0.10	0.50±0.05

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

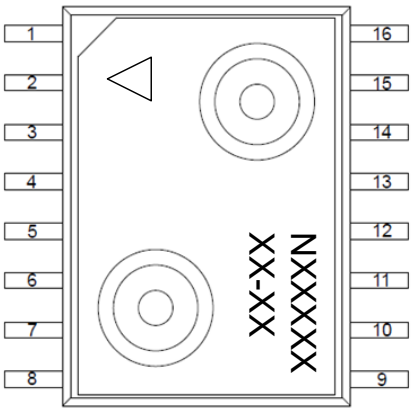


Pin1 is located at the first quadrant, as shown in the following figure.



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.	2023/12/22
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 NSPDS9F250DTA2_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 NSPDS9F250DTA2_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 NSPDS9F250DTA2_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)
        {
                NSPDS9F250DTA2_Write_Byte(0x30,0x0A);
                while(1)                                        //Check whether the conversion ends
                {
                        if(number<=50)
                        {
```

```
                        number++;
                        delay_ms(1);
                        NSPDS9F250DTA2_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;
                }
        }
        NSPDS9F250DTA2_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(312.5*Pdata/8388607-156.25);   //P=A*PCode/8388607+B
                                                        //A=312.5, B= -156.25
                                                        //PNormalized=PCode/8388607
    }
}
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