

# LDE Series

## Digital low differential pressure sensors

### FEATURES

- Pressure ranges from 25 to 500 Pa (0.1 to 2 inH<sub>2</sub>O)
- Pressure sensor based on thermal micro-flow measurement
- High flow impedance
  - very low flow-through leakage
  - high immunity to dust and humidity
  - no loss in sensitivity using long tubing
- Calibrated and temperature compensated
- Unique offset autozeroing feature ensuring superb long-term stability
- Offset accuracy better than 0.2 %FS
- Total accuracy better than 0.5 %FS typical
- Analog output and digital SPI interface
- RoHS and REACH compliant
- Quality Management System according to EN ISO 13485 and EN ISO 9001



### MEDIA COMPATIBILITY

Air and other non-corrosive gases

### SPECIFICATIONS

#### Maximum ratings

|                      |                               |
|----------------------|-------------------------------|
| Supply voltage $V_s$ |                               |
| LDE...3...           | 2.70 ... 3.60 V <sub>DC</sub> |
| LDE...6...           | 4.75 ... 5.25 V <sub>DC</sub> |

|                |      |
|----------------|------|
| Output current | 1 mA |
|----------------|------|

#### Lead specifications

|                                         |           |
|-----------------------------------------|-----------|
| Average preheating temperature gradient | 2.5 K/s   |
| Soak time                               | ca. 3 min |
| Time above 217 °C                       | 50 s      |
| Time above 230 °C                       | 40 s      |
| Time above 250 °C                       | 15 s      |
| Peak temperature                        | 260 °C    |
| Cooling temperature gradient            | -3.5 K/s  |

#### Temperature ranges

|             |                |
|-------------|----------------|
| Compensated | 0 ... +70 °C   |
| Operating   | -20 ... +80 °C |
| Storage     | -40 ... +80 °C |

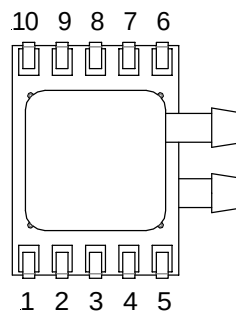
|                                  |        |
|----------------------------------|--------|
| Humidity limits (non-condensing) | 97 %RH |
|----------------------------------|--------|

|                        |      |
|------------------------|------|
| Vibration <sup>1</sup> | 20 g |
|------------------------|------|

|                               |       |
|-------------------------------|-------|
| Mechanical shock <sup>2</sup> | 500 g |
|-------------------------------|-------|

### ELECTRICAL CONNECTION<sup>3</sup>

#### Top-down view



| Pin | Function |
|-----|----------|
| 1   | Reserved |
| 2   | $V_s$    |
| 3   | GND      |
| 4   | Vout     |
| 5   | Vout     |
| 6   | SCLK     |
| 7   | MOSI     |
| 8   | MISO     |
| 9   | /CS      |
| 10  | Reserved |

There are three use cases that will change the manner in which the LDE sensor is connected in-circuit. For detailed pin connections see page 11.

#### Specification notes:

1. Sweep 20 to 2000 Hz, 8 min, 4 cycles per axis, MIL-STD-883, Method 2007.
2. 5 shocks, 3 axes, MIL-STD-883E, Method 2002.4.
3. The maximum voltage applied to pin 1 and pins 6 through 10 should not exceed  $V_s + 0.3$  V.

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### PRESSURE SENSOR CHARACTERISTICS

| Part no.    | Operating pressure                                    | Proof pressure <sup>4</sup> | Burst pressure <sup>4</sup> |
|-------------|-------------------------------------------------------|-----------------------------|-----------------------------|
| LDES025U... | 0...25 Pa / 0...0.25 mbar (0.1 inH <sub>2</sub> O)    | 2 bar<br>(30 psi)           | 5 bar<br>(75 psi)           |
| LDES050U... | 0...50 Pa / 0...0.5 mbar (0.2 inH <sub>2</sub> O)     |                             |                             |
| LDES100U... | 0...100 Pa / 0...1 mbar (0.4 inH <sub>2</sub> O)      |                             |                             |
| LDES250U... | 0...250 Pa / 0...2.5 mbar (1 inH <sub>2</sub> O)      |                             |                             |
| LDES500U... | 0...500 Pa / 0...5 mbar (2 inH <sub>2</sub> O)        |                             |                             |
| LDES025B... | 0...±25 Pa / 0...±0.25 mbar (±0.1 inH <sub>2</sub> O) |                             |                             |
| LDES050B... | 0...±50 Pa / 0...±0.5 mbar (±0.2 inH <sub>2</sub> O)  |                             |                             |
| LDES100B... | 0...±100 Pa / 0...±1 mbar (±0.4 inH <sub>2</sub> O)   |                             |                             |
| LDES250B... | 0...±250 Pa / 0...±2.5 mbar (±1 inH <sub>2</sub> O)   |                             |                             |
| LDES500B... | 0...±500 Pa / 0...±5 mbar (±2 inH <sub>2</sub> O)     |                             |                             |

### GAS CORRECTION FACTORS<sup>5</sup>

| Gas type                          | Correction factor |
|-----------------------------------|-------------------|
| Dry air                           | 1.0               |
| Oxygen (O <sub>2</sub> )          | 1.07              |
| Nitrogen (N <sub>2</sub> )        | 0.97              |
| Argon (Ar)                        | 0.98              |
| Carbon dioxide (CO <sub>2</sub> ) | 0.56              |

#### Specification notes (cont.):

4. The max. common mode pressure is 5 bar.
5. For example with a LDES500... sensor measuring CO<sub>2</sub> gas, at full-scale output the actual pressure will be 500 Pa x 0.56 = 280 Pa.

$$\Delta P_{\text{eff}} = \Delta P_{\text{sensor}} \times \text{gas correction factor}$$

$$\Delta P_{\text{eff}} = \text{True differential pressure}$$

$$\Delta P_{\text{sensor}} = \text{Differential pressure as indicated by output voltage}$$

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### PERFORMANCE CHARACTERISTICS<sup>6</sup>

#### LDE...6...

( $V_S=5.0\text{ V}_{DC}$ ,  $T_A=20\text{ °C}$ ,  $P_{Abs}=1\text{ bara}$ , calibrated in air, output signals analog and digital are **non-ratiometric** to  $V_S$ )

#### all 25 Pa and 50 Pa devices

| Characteristics                            | Min. | Typ.  | Max.            | Unit         |
|--------------------------------------------|------|-------|-----------------|--------------|
| Noise level                                |      | ±0.01 |                 | Pa           |
| Offset warm-up shift                       |      |       | less than noise |              |
| Offset long term stability <sup>7</sup>    |      | ±0.05 | ±0.1            | Pa/year      |
| Offset repeatability                       |      | ±0.01 |                 | Pa           |
| Span repeatability <sup>10, 11</sup>       |      | ±0.25 |                 | % of reading |
| Current consumption (no load) <sup>8</sup> |      | 7     | 8               | mA           |
| Response time ( $t_{63}$ )                 |      | 5     |                 | ms           |
| Power-on time                              |      |       | 25              |              |

#### Digital output

| Characteristics                             |        |                     | Min. | Typ. | Max.  | Unit         |
|---------------------------------------------|--------|---------------------|------|------|-------|--------------|
| Scale factor (digital output) <sup>9</sup>  |        | 0...25 / 0...±25 Pa |      | 1200 |       | counts/Pa    |
|                                             |        | 0...50 / 0...±50 Pa |      | 600  |       |              |
| Zero pressure offset accuracy <sup>10</sup> |        |                     |      | ±0.1 | ±0.2  | %FSS         |
| Span accuracy <sup>10, 11</sup>             |        |                     |      | ±0.4 | ±0.75 | % of reading |
| Thermal effects                             | Offset | 5...55 °C           |      |      | ±0.2  | %FSS         |
|                                             |        | 0...70 °C           |      |      | ±0.4  |              |
|                                             | Span   | 5...55 °C           |      | ±1   | ±1.75 | % of reading |
|                                             |        | 0...70 °C           |      | ±2   | ±2.75 |              |

#### Analog output (unidirectional devices)

| Characteristics                 |        |           | Min. | Typ.  | Max.  | Unit         |
|---------------------------------|--------|-----------|------|-------|-------|--------------|
| Zero pressure offset            |        |           | 0.49 | 0.50  | 0.51  | V            |
| Full scale output               |        |           |      | 4.50  |       |              |
| Span accuracy <sup>10, 11</sup> |        |           |      | ±0.4  | ±0.75 | % of reading |
| Thermal effects                 | Offset | 5...55 °C |      |       | ±15   | mV           |
|                                 |        | 0...70 °C |      |       | ±30   |              |
|                                 | Span   | 5...55 °C |      | ±1.25 | ±2    | % of reading |
|                                 |        | 0...70 °C |      | ±2    | ±2.75 |              |

#### Analog output (bidirectional devices)

| Characteristics                 |                            |           | Min. | Typ.  | Max.  | Unit         |
|---------------------------------|----------------------------|-----------|------|-------|-------|--------------|
| Zero pressure offset            |                            |           | 2.49 | 2.50  | 2.51  | V            |
| Output                          | at max. specified pressure |           |      | 4.50  |       |              |
|                                 | at min. specified pressure |           |      | 0.50  |       |              |
| Span accuracy <sup>10, 11</sup> |                            |           |      | ±0.4  | ±0.75 | % of reading |
| Thermal effects                 | Offset                     | 5...55 °C |      |       | ±15   | mV           |
|                                 |                            | 0...70 °C |      |       | ±30   |              |
|                                 | Span                       | 5...55 °C |      | ±1.25 | ±2    | % of reading |
|                                 |                            | 0...70 °C |      | ±2    | ±2.75 |              |

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### PERFORMANCE CHARACTERISTICS<sup>6</sup>

#### LDE...6...

( $V_S=5.0 V_{DC}$ ,  $T_A=20\text{ °C}$ ,  $P_{Abs}=1\text{ bara}$ , calibrated in air, output signals analog and digital are **non-ratiometric** to  $V_S$ )

#### all 100 Pa, 250 Pa and 500 Pa devices

| Characteristics                            | Min. | Typ.  | Max.            | Unit         |
|--------------------------------------------|------|-------|-----------------|--------------|
| Noise level                                |      | ±0.02 |                 | Pa           |
| Offset warm-up shift                       |      |       | less than noise |              |
| Offset long term stability <sup>7</sup>    |      | ±0.05 | ±0.1            | %FSS/year    |
| Offset repeatability <sup>12</sup>         |      | ±0.02 |                 | Pa           |
| Span repeatability <sup>10, 11</sup>       |      | ±0.25 |                 | % of reading |
| Current consumption (no load) <sup>8</sup> |      | 7     | 8               | mA           |
| Response time ( $t_{63}$ )                 |      | 5     |                 | ms           |
| Power-on time                              |      |       | 25              |              |

#### Digital output

| Characteristics                             | Min.                  | Typ.      | Max.  | Unit         |
|---------------------------------------------|-----------------------|-----------|-------|--------------|
| Scale factor (digital output) <sup>9</sup>  | 0...100 / 0...±100 Pa | 300       |       | counts/Pa    |
|                                             | 0...250 / 0...±250 Pa | 120       |       |              |
|                                             | 0...500 / 0...±500 Pa | 60        |       |              |
| Zero pressure offset accuracy <sup>10</sup> |                       | ±0.05     | ±0.1  | %FSS         |
| Span accuracy <sup>10, 11</sup>             |                       | ±0.4      | ±0.75 | % of reading |
| Thermal effects                             | Offset                | 5...55 °C |       | %FSS         |
|                                             |                       | 0...70 °C |       |              |
|                                             | Span                  | 5...55 °C | ±1    | % of reading |
|                                             |                       | 0...70 °C | ±2    |              |

#### Analog output (unidirectional devices)

| Characteristics                 | Min.   | Typ.      | Max.  | Unit         |
|---------------------------------|--------|-----------|-------|--------------|
| Zero pressure offset            | 0.49   | 0.50      | 0.51  | V            |
| Full scale output               |        | 4.50      |       |              |
| Span accuracy <sup>10, 11</sup> |        | ±0.4      | ±0.75 | % of reading |
| Thermal effects                 | Offset | 5...55 °C |       | mV           |
|                                 |        | 0...70 °C |       |              |
|                                 | Span   | 5...55 °C | ±1    | % of reading |
|                                 |        | 0...70 °C | ±2    |              |

#### Analog output (bidirectional devices)

| Characteristics                 | Min.                       | Typ.      | Max.  | Unit         |
|---------------------------------|----------------------------|-----------|-------|--------------|
| Zero pressure offset            | 2.49                       | 2.50      | 2.51  | V            |
| Output                          | at max. specified pressure | 4.50      |       |              |
|                                 | at min. specified pressure | 0.50      |       |              |
| Span accuracy <sup>10, 11</sup> |                            | ±0.4      | ±0.75 | % of reading |
| Thermal effects                 | Offset                     | 5...55 °C |       | mV           |
|                                 |                            | 0...70 °C |       |              |
|                                 | Span                       | 5...55 °C | ±1    | % of reading |
|                                 |                            | 0...70 °C | ±2    |              |

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( $V_S = 3.0 V_{DC}$ ,  $T_A = 20\text{ °C}$ ,  $P_{Abs} = 1\text{ bara}$ , calibrated in air, output signals analog and digital are **non-ratiometric** to  $V_S$ )

#### all 25 Pa and 50 Pa devices

| Characteristics                            | Min. | Typ.  | Max.            | Unit         |
|--------------------------------------------|------|-------|-----------------|--------------|
| Noise level                                |      | ±0.01 |                 | Pa           |
| Offset warm-up shift                       |      |       | less than noise |              |
| Offset long term stability <sup>7</sup>    |      | ±0.05 | ±0.1            | Pa/year      |
| Offset repeatability                       |      | ±0.01 |                 | Pa           |
| Span repeatability <sup>10, 11</sup>       |      | ±0.25 |                 | % of reading |
| Current consumption (no load) <sup>8</sup> |      | 14    | 16              | mA           |
| Response time ( $t_{63}$ )                 |      | 5     |                 | ms           |
| Power-on time                              |      |       | 25              |              |

#### Digital output

| Characteristics                             | Min.                | Typ.      | Max.  | Unit         |
|---------------------------------------------|---------------------|-----------|-------|--------------|
| Scale factor (digital output) <sup>9</sup>  | 0...25 / 0...±25 Pa | 1200      |       | counts/Pa    |
|                                             | 0...50 / 0...±50 Pa | 600       |       |              |
| Zero pressure offset accuracy <sup>10</sup> |                     | ±0.1      | ±0.2  | %FSS         |
| Span accuracy <sup>10, 11</sup>             |                     | ±0.4      | ±0.75 | % of reading |
| Thermal effects                             | Offset              | 5...55 °C |       | %FSS         |
|                                             |                     | 0...70 °C |       |              |
|                                             | Span                | 5...55 °C | ±1    | % of reading |
|                                             |                     | 0...70 °C | ±2    |              |

#### Analog output (unidirectional devices)

| Characteristics                 | Min.   | Typ.      | Max.  | Unit         |
|---------------------------------|--------|-----------|-------|--------------|
| Zero pressure offset            | 0.29   | 0.30      | 0.31  | V            |
| Full scale output               |        | 2.70      |       |              |
| Span accuracy <sup>10, 11</sup> |        | ±0.4      | ±0.75 | % of reading |
| Thermal effects                 | Offset | 5...55 °C |       | mV           |
|                                 |        | 0...70 °C |       |              |
|                                 | Span   | 5...55 °C | ±1.25 | % of reading |
|                                 |        | 0...70 °C | ±2    |              |

#### Analog output (bidirectional devices)

| Characteristics                 | Min.                       | Typ.      | Max.  | Unit         |
|---------------------------------|----------------------------|-----------|-------|--------------|
| Zero pressure offset            | 1.49                       | 1.50      | 1.51  | V            |
| Output                          | at max. specified pressure | 2.70      |       |              |
|                                 | at min. specified pressure | 0.30      |       |              |
| Span accuracy <sup>10, 11</sup> |                            | ±0.4      | ±0.75 | % of reading |
| Thermal effects                 | Offset                     | 5...55 °C |       | mV           |
|                                 |                            | 0...70 °C |       |              |
|                                 | Span                       | 5...55 °C | ±1.25 | % of reading |
|                                 |                            | 0...70 °C | ±2    |              |

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### PERFORMANCE CHARACTERISTICS<sup>6</sup>

#### LDE...3...

( $V_S = 3.0 V_{DC}$ ,  $T_A = 20\text{ °C}$ ,  $P_{Abs} = 1\text{ bara}$ , calibrated in air, output signals analog and digital are **non-ratiometric** to  $V_S$ )

#### all 100 Pa, 250 Pa and 500 Pa devices

| Characteristics                            | Min. | Typ.  | Max.            | Unit         |
|--------------------------------------------|------|-------|-----------------|--------------|
| Noise level                                |      | ±0.02 |                 | Pa           |
| Offset warm-up shift                       |      |       | less than noise |              |
| Offset long term stability <sup>7</sup>    |      | ±0.05 | ±0.1            | %FSS/year    |
| Offset repeatability <sup>12</sup>         |      | ±0.02 |                 | Pa           |
| Span repeatability <sup>10, 11</sup>       |      | ±0.25 |                 | % of reading |
| Current consumption (no load) <sup>8</sup> |      | 14    | 16              | mA           |
| Response time ( $t_{63}$ )                 |      | 5     |                 | ms           |
| Power-on time                              |      |       | 25              |              |

#### Digital output

| Characteristics                             | Min.                  | Typ.      | Max.  | Unit         |
|---------------------------------------------|-----------------------|-----------|-------|--------------|
| Scale factor (digital output) <sup>9</sup>  | 0...100 / 0...±100 Pa | 300       |       | counts/Pa    |
|                                             | 0...250 / 0...±250 Pa | 120       |       |              |
|                                             | 0...500 / 0...±500 Pa | 60        |       |              |
| Zero pressure offset accuracy <sup>10</sup> |                       | ±0.05     | ±0.1  | %FSS         |
| Span accuracy <sup>10, 11</sup>             |                       | ±0.4      | ±0.75 | % of reading |
| Thermal effects                             | Offset                | 5...55 °C |       | %FSS         |
|                                             |                       | 0...70 °C |       |              |
|                                             | Span                  | 5...55 °C | ±1    | % of reading |
|                                             |                       | 0...70 °C | ±2    |              |

#### Analog output (unidirectional devices)

| Characteristics                 | Min.   | Typ.      | Max.  | Unit         |
|---------------------------------|--------|-----------|-------|--------------|
| Zero pressure offset            | 0.29   | 0.30      | 0.31  | V            |
| Full scale output               |        | 2.70      |       |              |
| Span accuracy <sup>10, 11</sup> |        | ±0.4      | ±0.75 | % of reading |
| Thermal effects                 | Offset | 5...55 °C |       | mV           |
|                                 |        | 0...70 °C |       |              |
|                                 | Span   | 5...55 °C | ±1    | % of reading |
|                                 |        | 0...70 °C | ±2    |              |

#### Analog output (bidirectional devices)

| Characteristics                 | Min.                       | Typ.      | Max.  | Unit         |
|---------------------------------|----------------------------|-----------|-------|--------------|
| Zero pressure offset            | 1.49                       | 1.50      | 1.51  | V            |
| Output                          | at max. specified pressure | 2.70      |       |              |
|                                 | at min. specified pressure | 0.30      |       |              |
| Span accuracy <sup>10, 11</sup> |                            | ±0.4      | ±0.75 | % of reading |
| Thermal effects                 | Offset                     | 5...55 °C |       | mV           |
|                                 |                            | 0...70 °C |       |              |
|                                 | Span                       | 5...55 °C | ±1    | % of reading |
|                                 |                            | 0...70 °C | ±2    |              |

### PERFORMANCE CHARACTERISTICS (cont.)

#### Total accuracy<sup>13</sup>

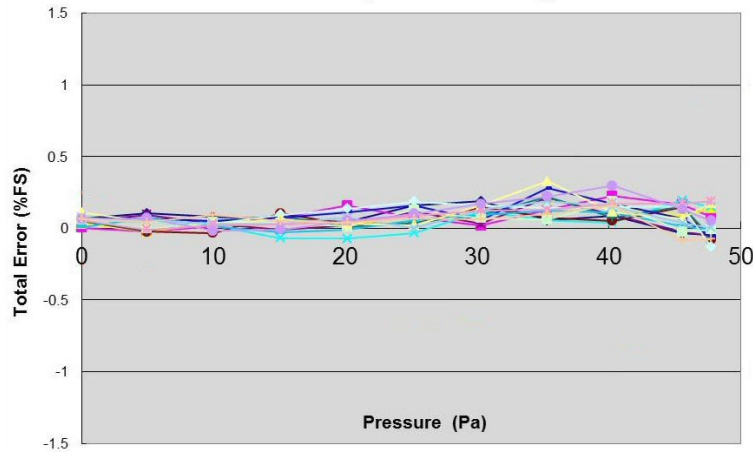


Fig. 1: Typical total accuracy plot of 16 LDE 50 Pa sensors @ 25 °C (typical total accuracy better than 0.5 %FS)

#### Offset long term stability

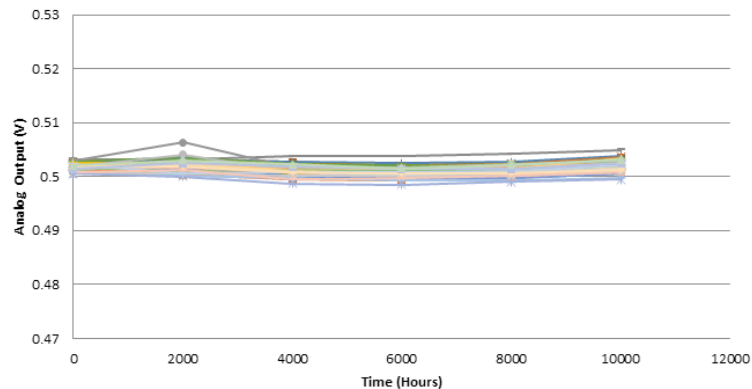


Fig. 2: Offset long term stability for LDE 250 Pa sensors after 10 000 hours @ 85°C powered, equivalent to over 43.5 years @ 25 °C (better than  $\pm 2$  mV /  $\pm 0.125$  Pa)

#### Specification notes (cont.):

6. The sensor is calibrated with a common mode pressure of 1 bar absolute. Due to the mass flow based measuring principle, variations in absolute common mode pressure need to be compensated according to the following formula:

$$\Delta P_{\text{eff}} = \Delta P_{\text{sensor}} \times \frac{1 \text{ bar}}{P_{\text{abs}}}$$

$$\begin{aligned} \Delta P_{\text{eff}} &= \text{True differential pressure} \\ \Delta P_{\text{sensor}} &= \text{Differential pressure as indicated by output voltage} \\ P_{\text{abs}} &= \text{Current absolute common mode pressure} \end{aligned}$$

7. Figure based on accelerated lifetime test of 10 000 hours at 85 °C biased burn-in.
8. Please contact First Sensor for low power options.
9. The digital output signal is a signed, two's complement integer. Negative pressures will result in a negative output.
10. Zero pressure offset accuracy and span accuracy are uncorrelated uncertainties. They can be added according to the principles of error propagation.
11. Span accuracy below 10 % of full scale is limited by the intrinsic noise of the sensor.
12. Typical value for 250 Pa sensors.
13. Total accuracy is the combined error from offset and span calibration, non-linearity, repeatability and pressure hysteresis.

### SPI - SERIAL PERIPHERAL INTERFACE

**Note:** It is important to adhere to the communication protocol in order to avoid damage to the sensor.

#### Introduction

The LDE serial interface is a high-speed synchronous data input and output communication port. The serial interface operates using a standard 4-wire SPI bus. The LDE device runs in SPI mode 0, which requires the clock line SCLK to idle low (CPOL = 0), and for data to be sampled on the leading clock edge (CPHA = 0). Figure 5 illustrates this mode of operation.

Care should be taken to ensure that the sensor is properly connected to the master microcontroller. Refer to the manufacturer's datasheet for more information regarding physical connections.

There are, however, some cases where it may be helpful to use 33Ω series resistors at both ends of the SPI lines, as shown in Figure 3. Signal quality may be further improved by the addition of a buffer as shown in Figure 4. These cases include multiple slave devices on the same bus segment, using a master device with limited driving capability and long SPI bus lines.

If these series resistors are used, they must be physically placed as close as possible to the pins of the master and slave devices.

#### Application circuit

The use of pull-up resistors is generally unnecessary for SPI as most master devices are configured for push-pull mode. If pull-up resistors are required for use with 3 V LDE devices, however, they should be greater than 50 kΩ.

#### Signal control

The serial interface is enabled by asserting /CS low. The serial input clock, SCLK, is gated internally to begin accepting the input data at MOSI, or sending the output data on MISO. When /CS rises, the data clocked into MOSI is loaded into an internal register.

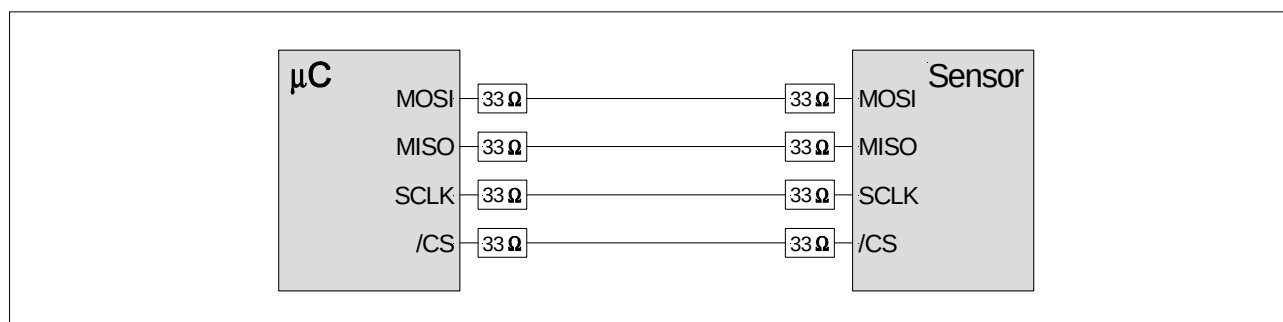


Fig. 3: Resistors at both ends of the SPI lines

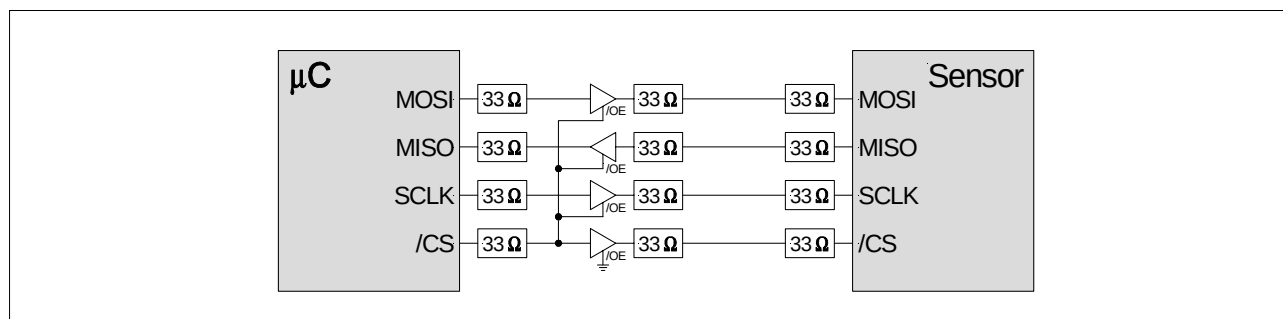


Fig. 4: Addition of a buffer



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## Digital low differential pressure sensors

### SPI - SERIAL PERIPHERAL INTERFACE (cont.)

**Note:** It is important to adhere to the communication protocol in order to avoid damage to the sensor.

#### Data read

When powered on, the sensor begins to continuously measure pressure. To initiate data transfer from the sensor, the following three unique bytes must be written sequentially, MSB first, to the MOSI pin (see Figure 5):

| Step | Hexadecimal | Binary    | Description                       |
|------|-------------|-----------|-----------------------------------|
| 1    | 0x2D        | B00101101 | Poll current pressure measurement |
| 2    | 0x14        | B00010100 | Send result to data register      |
| 3    | 0x98        | B10011000 | Read data register                |

The entire 16 bit content of the LDE register is then read out on the MISO pin, MSB first, by applying 16 successive clock pulses to SCLK with /CS asserted low. Note that the value of the LSB is held at zero for internal signal processing purposes. This is below the noise threshold of the sensor and thus its fixed value does not affect sensor performance and accuracy.

From the digital sensor output the actual pressure value can be calculated as follows:

$$\text{pressure [Pa]} = \frac{\text{digital output [counts]}}{\text{scale factor} \left[ \frac{\text{counts}}{\text{Pa}} \right]}$$

For example, for a  $\pm 250$  Pa sensor (LDES250B...) with a scale factor of 120 a digital output of 30 000 counts (7530'h) calculates to a positive pressure of 250 Pa. Similarly, a digital output of -30 000 counts (8AD0'h) calculates to a negative pressure of -250 Pa.

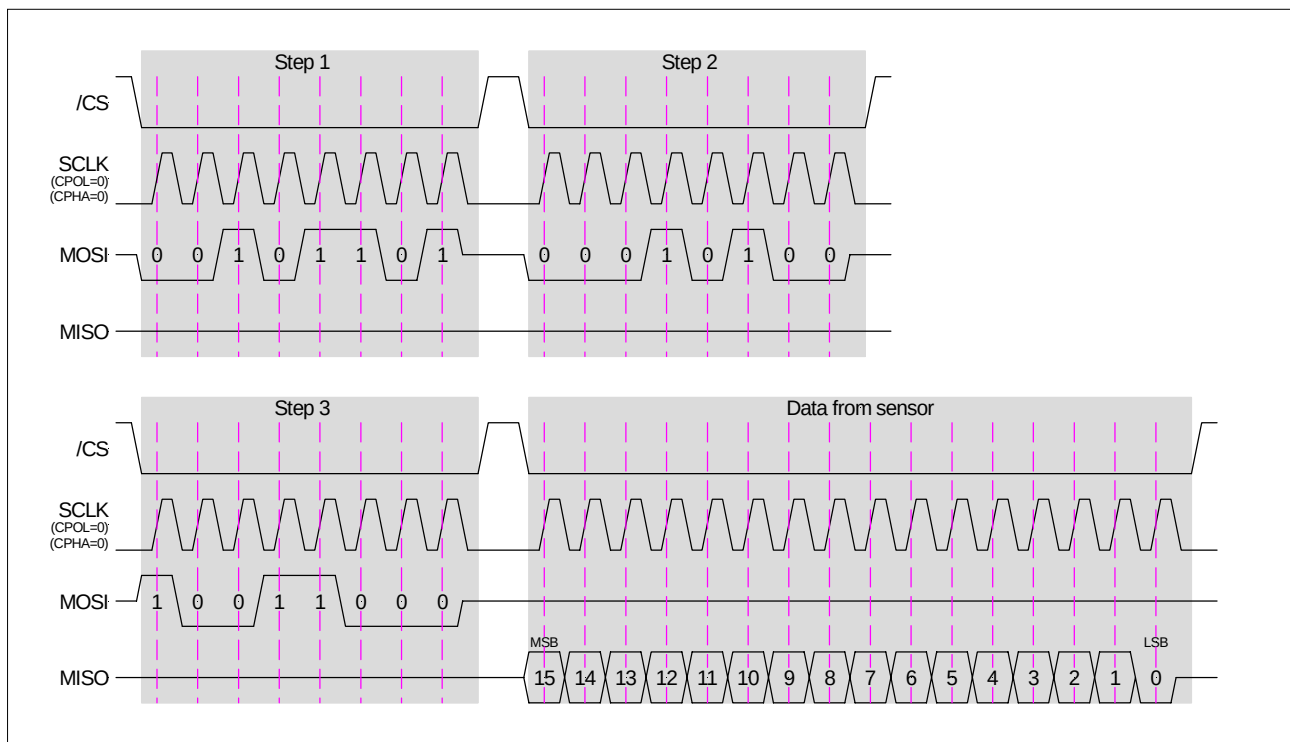


Fig. 5: SPI data transfer

# LDE Series

## Digital low differential pressure sensors

### Interface specification

| Parameter                                       | Symbol                 | Conditions                                      | Min.                                        | Typ.     | Max.                | Unit               |
|-------------------------------------------------|------------------------|-------------------------------------------------|---------------------------------------------|----------|---------------------|--------------------|
| External clock frequency                        | f <sub>ECLK</sub>      | V <sub>CKSEL</sub> =0<br>Min.<br>Max.           |                                             | 0.2<br>5 |                     | MHz                |
| External master clock input low time            | f <sub>ECLKIN LO</sub> | t <sub>ECLK</sub> =1/f <sub>ECLK</sub>          | 40                                          |          | 60                  | %t <sub>ECLK</sub> |
| External master clock input high time           | f <sub>ECLKIN HI</sub> | t <sub>ECLK</sub> =1/f <sub>ECLK</sub>          | 40                                          |          | 60                  |                    |
| SCLK setup to falling edge /CS                  | t <sub>SC</sub>        |                                                 | 30                                          |          |                     | ns                 |
| /CS falling edge to SCLK rising edge setup time | t <sub>CSS</sub>       |                                                 | 30                                          |          |                     |                    |
| /CS idle time                                   | t <sub>CSI</sub>       | f <sub>CLK</sub> =4 MHz                         | 1.5                                         |          |                     | μs                 |
| SCLK falling edge to data valid delay           | t <sub>DO</sub>        | C <sub>LOAD</sub> =15 pF                        |                                             |          | 80                  | ns                 |
| Data valid to SCLK rising edge setup time       | t <sub>DS</sub>        |                                                 | 30                                          |          |                     |                    |
| Data valid to SCLK rising edge hold time        | t <sub>DH</sub>        |                                                 | 30                                          |          |                     |                    |
| SCLK high pulse width                           | t <sub>CH</sub>        |                                                 | 100                                         |          |                     |                    |
| SCLK low pulse width                            | t <sub>CL</sub>        |                                                 | 100                                         |          |                     |                    |
| /CS rising edge to SCLK rising edge hold time   | t <sub>CSH</sub>       |                                                 | 30                                          |          |                     |                    |
| /CS falling edge to output enable               | t <sub>DV</sub>        | C <sub>LOAD</sub> =15 pF                        |                                             |          | 25                  |                    |
| /CS rising edge to output disable               | t <sub>TR</sub>        | C <sub>LOAD</sub> =15 pF                        |                                             |          | 25                  |                    |
| LDE...6... (5 V supply)                         |                        |                                                 |                                             |          |                     |                    |
| Maximum output load capacitance                 | C <sub>LOAD</sub>      | R <sub>LOAD</sub> =∞,<br>phase margin >55°      |                                             | 200      |                     | pF                 |
| Input voltage, logic HIGH                       | V <sub>IH</sub>        |                                                 | 0.8×V <sub>s</sub>                          |          | V <sub>s</sub> +0.3 | V                  |
| Input voltage, logic LOW                        | V <sub>IL</sub>        |                                                 |                                             |          | 0.2×V <sub>s</sub>  |                    |
| Output voltage, logic HIGH                      | V <sub>OH</sub>        | R <sub>LOAD</sub> =∞<br>R <sub>LOAD</sub> =2 kΩ | V <sub>s</sub> -0.1<br>V <sub>s</sub> -0.15 |          |                     |                    |
| Output voltage, logic LOW                       | V <sub>OL</sub>        | R <sub>LOAD</sub> =∞<br>R <sub>LOAD</sub> =2 kΩ |                                             |          | 0.5<br>0.2          |                    |
| LDE...3... (3 V supply) <sup>13</sup>           |                        |                                                 |                                             |          |                     |                    |
| Maximum output load capacitance                 | C <sub>LOAD</sub>      | R <sub>LOAD</sub> =1 kΩ                         |                                             | 15       |                     | pF                 |
| Input voltage, logic HIGH                       | V <sub>IH</sub>        |                                                 | 0.65×V <sub>s</sub>                         |          | V <sub>s</sub> +0.3 | V                  |
| Input voltage, logic LOW                        | V <sub>IL</sub>        |                                                 |                                             |          | 0.35×V <sub>s</sub> |                    |
| Output voltage, logic HIGH                      | V <sub>OH</sub>        | I <sub>o</sub> =-20 μA                          | V <sub>s</sub> -0.4                         |          |                     |                    |
| Output voltage, logic LOW                       | V <sub>OL</sub>        | I <sub>s</sub> =20 μA                           |                                             |          | 0.4                 |                    |

#### Specification notes (cont.):

13. For correct operation of LDE...3... devices, the device driving the SPI bus must have a minimum drive capability of  $\pm 2$  mA.

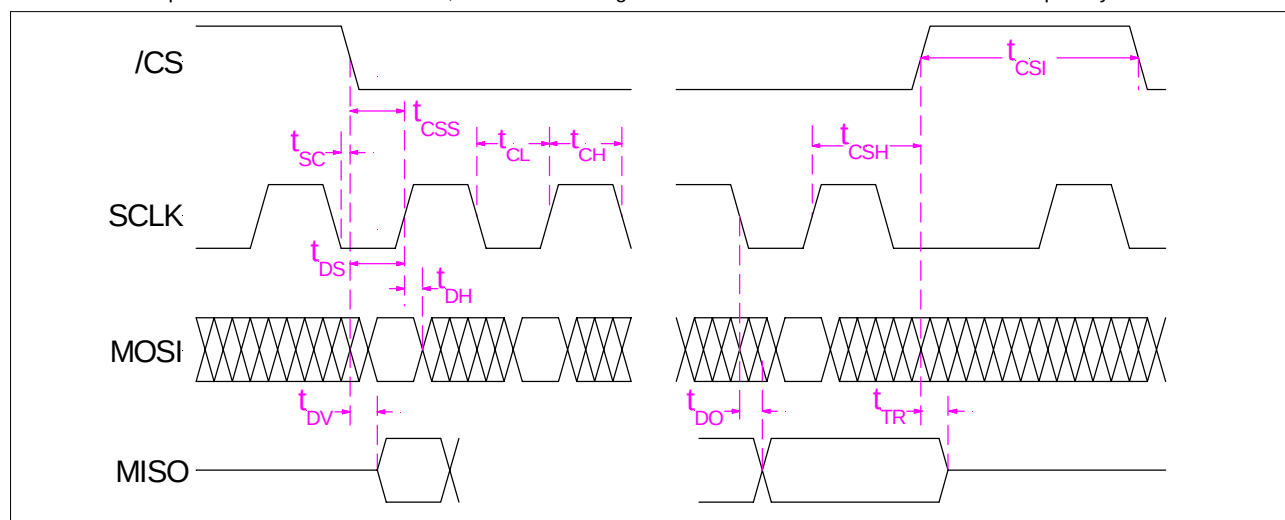


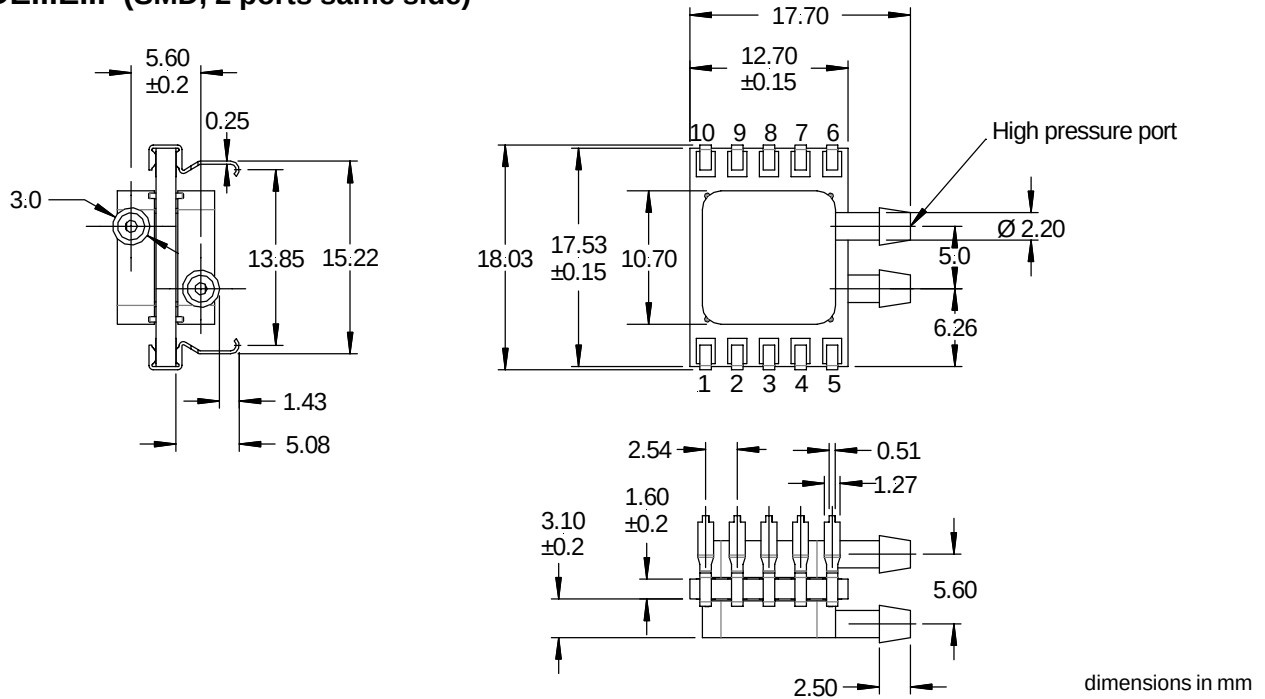
Fig. 5: Timing diagram

# LDE Series

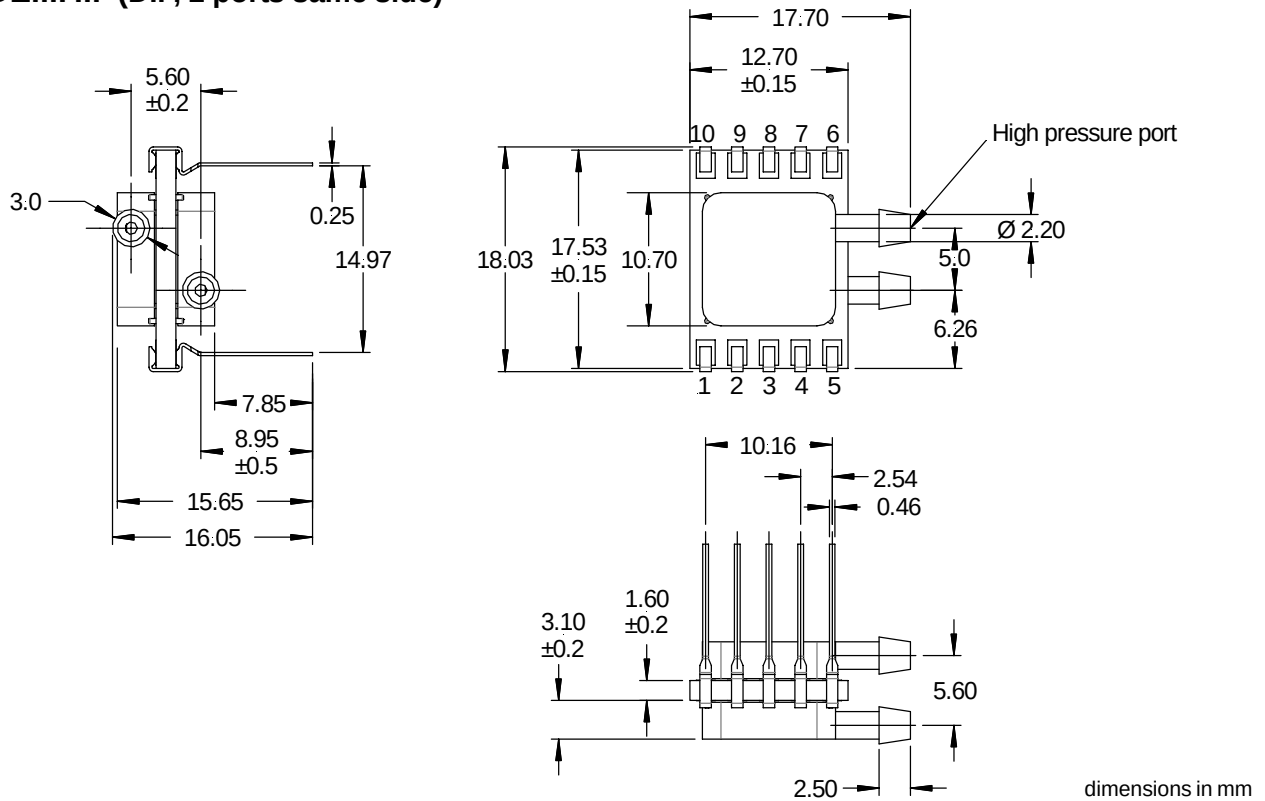
## Digital low differential pressure sensors

### OUTLINE DRAWING

#### LDE...E... (SMD, 2 ports same side)



#### LDE...F... (DIP, 2 ports same side)



# LDE Series

## Digital low differential pressure sensors

### ELECTRICAL CONNECTION (cont.)<sup>3</sup>

There are three use cases that will change the manner in which the LDE series device is connected in-circuit:

- Case 1: Reading of pressure measurement as a digital (SPI) signal;
- Case 2: Reading of pressure measurement as an analog (voltage) signal; and
- Case 3: Pin-to-pin compatible drop-in replacement for LBA series devices (5 V LDE devices only).

The connections for each such use case must be made as indicated below.

| Pin | Function         | Connection                       |                                                   |                                                      |
|-----|------------------|----------------------------------|---------------------------------------------------|------------------------------------------------------|
|     |                  | Case 1:<br>Digital signal output | Case 2:<br>Analog signal output                   | Case 3:<br>LBA drop-in replacement<br>(5 V LDE only) |
| 1   | Reserved         | NC                               | NC                                                | GND                                                  |
| 2   | V <sub>s</sub>   | +5 V / +3 V                      | +5 V / +3 V                                       | +5 V                                                 |
| 3   | GND              | GND                              | GND                                               | GND                                                  |
| 4   | V <sub>out</sub> | NC                               | High-impedance analog input<br>(e.g. op-amp, ADC) | High-impedance analog input<br>(e.g. op-amp, ADC)    |
| 5   | V <sub>out</sub> | NC                               |                                                   |                                                      |
| 6   | SCLK             | Master device SCLK               | GND                                               | GND                                                  |
| 7   | MOSI             | Master device MOSI               | GND                                               | GND                                                  |
| 8   | MISO             | Master device MISO               | GND                                               | GND                                                  |
| 9   | /CS              | Master device (/CS)              | V <sub>s</sub>                                    | GND                                                  |
| 10  | Reserved         | NC                               | NC                                                | GND                                                  |

### ORDERING INFORMATION

| Options                   | Series | Pressure range |                                    | Calibration |                | Housing |                           | Output |                                | Grade |      |
|---------------------------|--------|----------------|------------------------------------|-------------|----------------|---------|---------------------------|--------|--------------------------------|-------|------|
|                           | LDE    | S025           | 25 Pa<br>(0.1 inH <sub>2</sub> O)  | B           | Bidirectional  | E       | SMT, 2 ports<br>same side | 3      | non-ratiometric,<br>3 V supply | S     | High |
|                           |        | S050           | 50 Pa<br>(0.2 inH <sub>2</sub> O)  | U           | Unidirectional | F       | DIP, 2 ports<br>same side | 6      | non-ratiometric,<br>5 V supply |       |      |
|                           |        | S100           | 100 Pa<br>(0.4 inH <sub>2</sub> O) |             |                |         |                           |        |                                |       |      |
|                           |        | S250           | 250 Pa<br>(1 inH <sub>2</sub> O)   |             |                |         |                           |        |                                |       |      |
|                           |        | S500           | 500 Pa<br>(2 inH <sub>2</sub> O)   |             |                |         |                           |        |                                |       |      |
| Example: LDE S250 B F 6 S |        |                |                                    |             |                |         |                           |        |                                |       |      |

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