LDE Series

Digital low differential pressure sensors

FEATURES

- **Pressure ranges from 25 to 500 Pa (0.1 to 2 inH_2O)**
- **Pressure sensor based on thermal micro-flow measurement**
- **Calibrated and temperature compensated**
- **Analog output and digital SPI interface**
- **High flow impedance**
  → very low flow-through leakage
  → high immunity to dust and humidity
  → no loss in sensitivity using long tubing
- **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

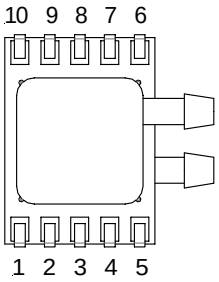
Maximum ratings

Supply voltage V_S	
LDE...3...	2.70 ... 3.30 V_{DC}
LDE...5...	4.75 ... 5.25 V_{DC}
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[1]	20 g
Mechanical shock[2]	500 g

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.

ELECTRICAL CONNECTION



Pin	Connection
1, 10	NC
2	V_S
3	GND
4, 5	V_{out}
6	SCLK
7	MOSI
8	MISO
9	/CS

Note: Pins 1 and 10 are internally connected. They can be externally grounded.

Important: If the LDE sensor is used as a drop-in replacement for the LBA sensor in an existing circuit, pins 6 to 9 have to be connected to ground in order to avoid sensor failure.

PRESSURE SENSOR CHARACTERISTICS

Part no.	Operating pressure	Proof pressure[5]	Burst pressure[5]
LDES025U...	0...25 Pa / 0...0.25 mbar (0.1 inH_2O)	2 bar (30 psi)	2 bar (30 psi)
LDES050U...	0...50 Pa / 0...0.5 mbar (0.2 inH_2O)		
LDES100U...	0...100 Pa / 0...1 mbar (0.4 inH_2O)		
LDES250U...	0...250 Pa / 0...2.5 mbar (1 inH_2O)		
LDES500U...	0...500 Pa / 0...5 mbar (2 inH_2O)		
LDES025B...	0...±25 Pa / 0...±0.25 mbar (±0.1 inH_2O)		
LDES050B...	0...±50 Pa / 0...±0.5 mbar (±0.2 inH_2O)		
LDES100B...	0...±100 Pa / 0...±1 mbar (±0.4 inH_2O)		
LDES250B...	0...±250 Pa / 0...±2.5 mbar (±1 inH_2O)		
LDES500B...	0...±500 Pa / 0...±5 mbar (±2 inH_2O)		

GAS CORRECTION FACTORS[11]

Gas type	Correction factor
Dry air	1.0
Oxygen (O_2)	1.07
Nitrogen (N_2)	0.97
Argon (Ar)	0.98
Carbon dioxide (CO_2)	0.56

Specification notes (cont.):

3. Total accuracy is the combined error from offset and span calibration, linearity, pressure hysteresis and temperature effects.
4. 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:

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

ΔP_{eff} = True differential pressure
ΔP_{sensor} = Differential pressure as indicated by output voltage
P_{abs} = Current absolute common mode pressure

5. The max. common mode pressure is 2 bar.
6. Figure based on accelerated lifetime test corresponding to 1 year of life.
7. The digital output signal is a signed, two's complement integer. Negative pressures will result in a negative output.
8. Please contact First Sensor for low power options.
9. Non-linearity refers to a terminal based FSL (Fitting Straight Line) going through the actual zero pressure reading.
10. Specification is preliminary. Data sheet is based on Pre-Series sample verification.
11. For example with a LDES500... sensor measuring CO_2 gas, at full-scale output the actual pressure will be 500 Pa x 0.56 = 280 Pa.

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

ΔP_{eff} = True differential pressure
ΔP_{sensor} = Differential pressure as indicated by output voltage

PERFORMANCE CHARACTERISTICS[4,10]

LDE...5...

(V_S=5.0 V_{DC}, T_A=20 °C, P_{Abs}=1 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
Non-linearity[9]				±(1 % of reading + 0.5 %FSS)	
Total accuracy[3]	5...55 °C			±(1.5 % of reading + 1.5 %FSS)	
	0...70 °C			±(3.5 % of reading + 1.5 %FSS)	
Noise level			0.03		%FS
Offset warm-up shift				less than noise	
Offset long term stability[6]			±0.05	±0.1	Pa/year
Current consumption (no load)[8]			7	8	mA
Response time (t_{63})			5		ms
Power-on time				25	

Analog output (unidirectional devices)

Characteristics			Min.	Typ.	Max.	Unit
Zero pressure offset			0.49	0.50	0.51	V
Full scale span			3.97	4.00	4.03	
Full scale output				4.50		
Thermal effects	Offset	5...55 °C			±20	mV
		0...70 °C			±40	
	Span	5...55 °C		±1.25	±2	%FSS
		0...70 °C		±1.75	±2.75	

Analog output (bidirectional devices)

Characteristics			Min.	Typ.	Max.	Unit
Zero pressure offset			2.49	2.50	2.51	V
Full scale span			3.97	4.00	4.03	
Output	at max. specified pressure			4.50		
	at min. specified pressure			0.50		
Thermal effects	Offset	5...55 °C			±15	mV
		0...70 °C			±30	
	Span	5...55 °C		±1.25	±2	%FSS
		0...70 °C		±1.75	±2.75	

Digital output

Characteristics			Min.	Typ.	Max.	Unit
Scale factor (digital output)[7]		0...25 / 0...±25 Pa		1200		counts/Pa
		0...50 / 0...±50 Pa		600		
Zero pressure offset tolerance			-0.2		+0.2	% FSS
Full scale span tolerance			-0.75		+0.75	
Thermal effects	Offset	5...55 °C			±60	counts
		0...70 °C			±120	
	Span	5...55 °C		±1	±1.75	%FSS
		0...70 °C		±1.75	±2.75	

PERFORMANCE CHARACTERISTICS[4,10]

LDE...5...

(V_S=5.0 V_{DC}, T_A=20 °C, P_{Abs}=1 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
Non-linearity[9]				±(1 % of reading + 0.5 %FSS)	
Total accuracy[3]	5...55 °C			±(1.5 % of reading + 1.5 %FSS)	
	0...70 °C			±(3.5 % of reading + 1.5 %FSS)	
Noise level			0.03		%FS
Offset warm-up shift				less than noise	
Offset long term stability[6]				±0.1	%FSS/year
Current consumption (no load)[8]			7	8	mA
Response time (t_{63})			5		ms
Power-on time				25	

Analog output (unidirectional devices)

Characteristics			Min.	Typ.	Max.	Unit
Zero pressure offset			0.49	0.50	0.51	V
Full scale span			3.97	4.00	4.03	
Full scale output				4.50		
Thermal effects	Offset	5...55 °C			±10	mV
		0...70 °C			±12	
	Span	5...55 °C		±1	±1.75	%FSS
		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
Full scale span			3.97	4.00	4.03	
Output	at max. specified pressure			4.50		
	at min. specified pressure			0.50		
Thermal effects	Offset	5...55 °C			±10	mV
		0...70 °C			±12	
	Span	5...55 °C		±1	±1.75	%FSS
		0...70 °C		±2	±2.75	

Digital output

Characteristics			Min.	Typ.	Max.	Unit
Scale factor (digital output)[7]		0...100 / 0...±100 Pa		300		counts/Pa
		0...250 / 0...±250 Pa		120		
		0...500 / 0...±500 Pa		60		
Zero pressure offset tolerance			-0.1		+0.1	% FSS
Full scale span tolerance			-0.75		+0.75	
Thermal effects	Offset	5...55 °C			±30	counts
		0...70 °C			±60	
	Span	5...55 °C		±1	±1.75	%FSS
		0...70 °C		±2	±2.75	

PERFORMANCE CHARACTERISTICS[4,10]

LDE...3...

(V_S=3.0 V_{DC}, T_A=20 °C, P_{Abs}=1 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
Non-linearity[9]				±(1 % of reading + 0.5 %FSS)	
Total accuracy[3]	5...55 °C			±(1.5 % of reading + 1.5 %FSS)	
	0...70 °C			±(3.5 % of reading + 1.5 %FSS)	
Noise level			0.03		%FS
Offset warm-up shift				less than noise	
Offset long term stability[6]			±0.05	±0.1	Pa/year
Current consumption (no load)[8]			14	16	mA
Response time (t_{63})			5		ms
Power-on time				25	

Analog output (unidirectional devices)

Characteristics			Min.	Typ.	Max.	Unit
Zero pressure offset			0.29	0.30	0.31	V
Full scale span			2.37	2.40	2.43	
Full scale output				2.70		
Thermal effects	Offset	5...55 °C			±20	mV
		0...70 °C			±40	
	Span	5...55 °C		±1.25	±2	%FSS
		0...70 °C		±1.75	±2.75	

Analog output (bidirectional devices)

Characteristics			Min.	Typ.	Max.	Unit
Zero pressure offset			1.49	1.50	1.51	V
Full scale span			2.37	2.40	2.43	
Output	at max. specified pressure			2.70		
	at min. specified pressure			0.30		
Thermal effects	Offset	5...55 °C			±15	mV
		0...70 °C			±30	
	Span	5...55 °C		±1.25	±2	%FSS
		0...70 °C		±1.75	±2.75	

Digital output

Characteristics			Min.	Typ.	Max.	Unit
Scale factor (digital output)[7]		0...25 / 0...±25 Pa		1200		counts/Pa
		0...50 / 0...±50 Pa		600		
Zero pressure offset tolerance			-0.2		+0.2	% FSS
Full scale span tolerance			-0.75		+0.75	
Thermal effects	Offset	5...55 °C			±60	counts
		0...70 °C			±120	
	Span	5...55 °C		±1	±1.75	%FSS
		0...70 °C		±1.75	±2.75	

PERFORMANCE CHARACTERISTICS[4,10]

LDE...3...

(V_S=3.0 V_{DC}, T_A=20 °C, P_{Abs}=1 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
Non-linearity[9]				±(1 % of reading + 0.5 %FSS)	
Total accuracy[3]	5...55 °C			±(1.5 % of reading + 1.5 %FSS)	
	0...70 °C			±(3.5 % of reading + 1.5 %FSS)	
Noise level			0.03		%FS
Offset warm-up shift				less than noise	
Offset long term stability[6]				±0.1	%FSS/year
Current consumption (no load)[8]			7	8	mA
Response time (t_{63})			5		ms
Power-on time				25	

Analog output (unidirectional devices)

Characteristics			Min.	Typ.	Max.	Unit
Zero pressure offset			0.29	0.30	0.31	V
Full scale span			2.37	2.40	2.43	
Full scale output				2.70		
Thermal effects	Offset	5...55 °C			±10	mV
		0...70 °C			±12	
	Span	5...55 °C		±1	±1.75	%FSS
		0...70 °C		±2	±2.75	

Analog output (bidirectional devices)

Characteristics			Min.	Typ.	Max.	Unit
Zero pressure offset			1.49	1.50	1.51	V
Full scale span			2.37	2.40	2.43	
Output	at max. specified pressure			2.70		
	at min. specified pressure			0.30		
Thermal effects	Offset	5...55 °C			±10	mV
		0...70 °C			±12	
	Span	5...55 °C		±1	±1.75	%FSS
		0...70 °C		±2	±2.75	

Digital output

Characteristics			Min.	Typ.	Max.	Unit
Scale factor (digital output)[7]		0...100 / 0...±100 Pa		300		counts/Pa
		0...250 / 0...±250 Pa		120		
		0...500 / 0...±500 Pa		60		
Zero pressure offset tolerance			-0.1		+0.1	% FSS
Full scale span tolerance			-0.75		+0.75	
Thermal effects	Offset	5...55 °C			±30	counts
		0...70 °C			±60	
	Span	5...55 °C		±1	±1.75	%FSS
		0...70 °C		±2	±2.75	

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 asynchronous data input and output communication port. The serial interface operates in 3-wire SPI mode. In this setup, the MOSI and MISO pins are tied together, forming a bidirectional data line to the master microcontroller. The remaining serial interface connections consist of chip select (/CS) and serial clock (SCLK).

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.

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.

Note: If SPI communication is not required (i.e. only analog output is being used) pins 6 to 9 have to be connected to ground. Failure to do so may result in sensor failure.

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 (as shown in Fig. 1):

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.

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

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

So for a ±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.

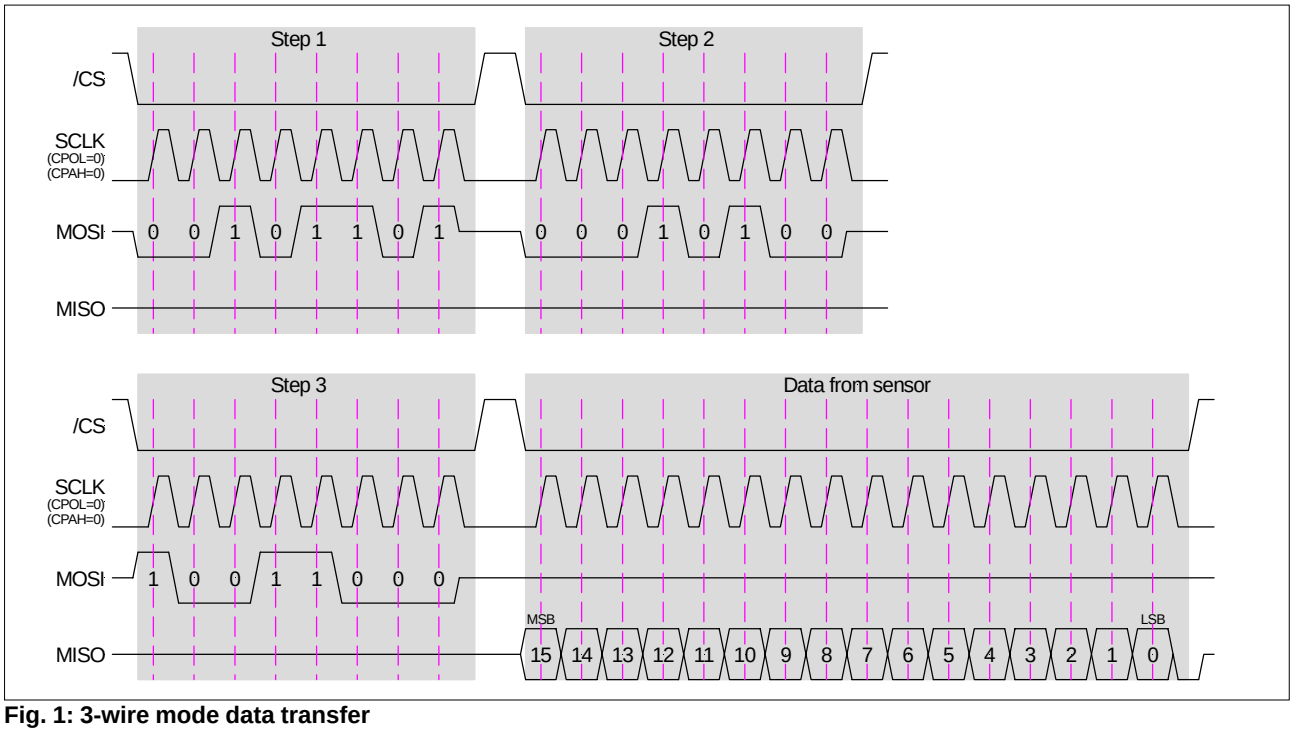


Fig. 1: 3-wire mode data transfer

Serial interface specification

Parameter	Symbol	Conditions		Min.	Typ.	Max.	Unit
Internal oscillator clock frequency	f_{ICLK}	OSC(4:0)=00000		3.3	4.15	5.3	MHz
External clock frequency	f_{ECLK}	V_{CKSEL}=0	Min.		0.2		
			Max.		5		
External master clock input low time	$f_{ECLKIN\ LO}$	$t_{ECLK}=1/f_{ECLK}$		40		60	$\%t_{ECLK}$
External master clock input high time	$f_{ECLKIN\ HI}$	$t_{ECLK}=1/f_{ECLK}$		40		60	
Serial interface							
SCLK setup to falling edge /CS	t_{SC}			30			ns
/CS falling edge to SCLK rising edge setup time	t_{CSS}			30			
/CS idle time	t_{CSI}	f_{CLK}=4 MHz		1.5			µs
SCLK falling edge to data valid delay	t_{DO}	C_{LOAD}=15 pF				80	ns
Data valid to SCLK rising edge setup time	t_{DS}			30			
Data valid to SCLK rising edge hold time	t_{DH}			30			
SCLK high pulse width	t_{CH}			100			
SCLK low pulse width	t_{CL}			100			
/CS rising edge to SCLK rising edge hold time	t_{CSH}			30			
/CS falling edge to output enable	t_{DV}	C_{LOAD}=15 pF				25	
/CS rising edge to output disable	t_{TR}	C_{LOAD}=15 pF				25	

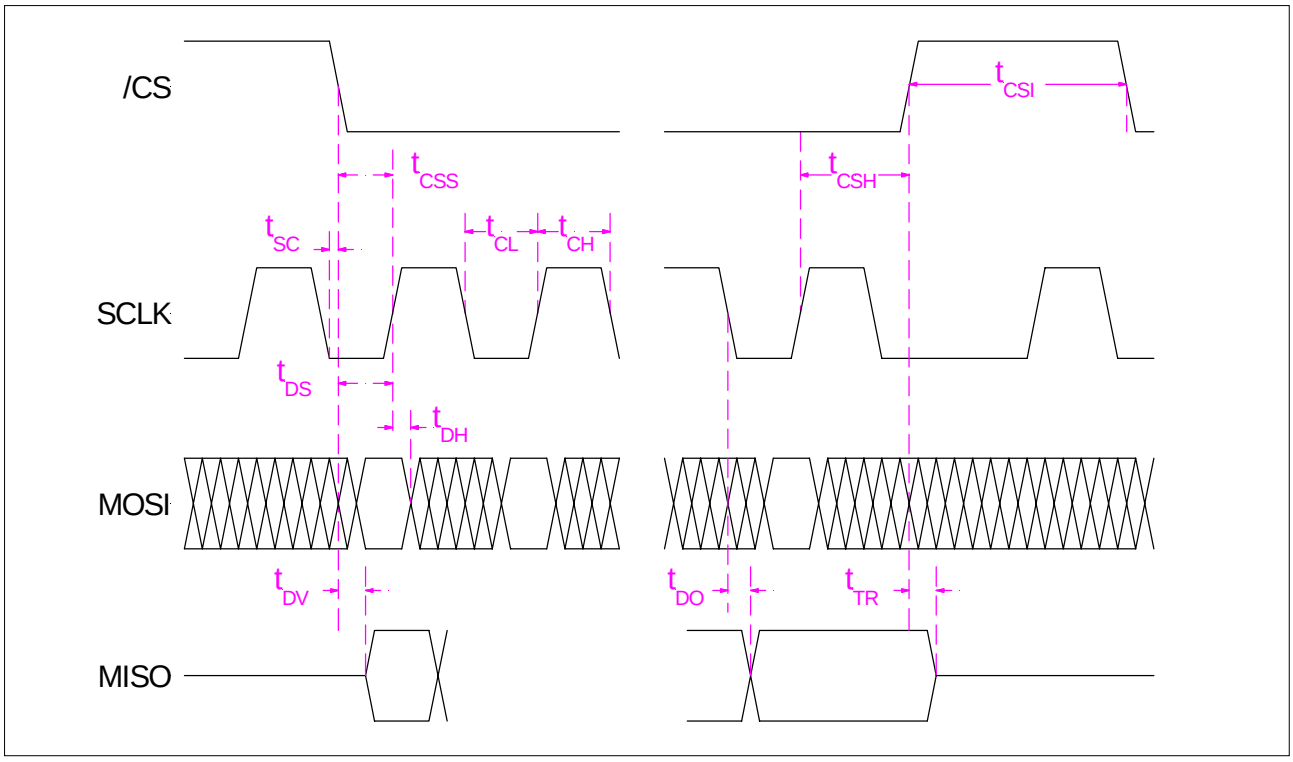
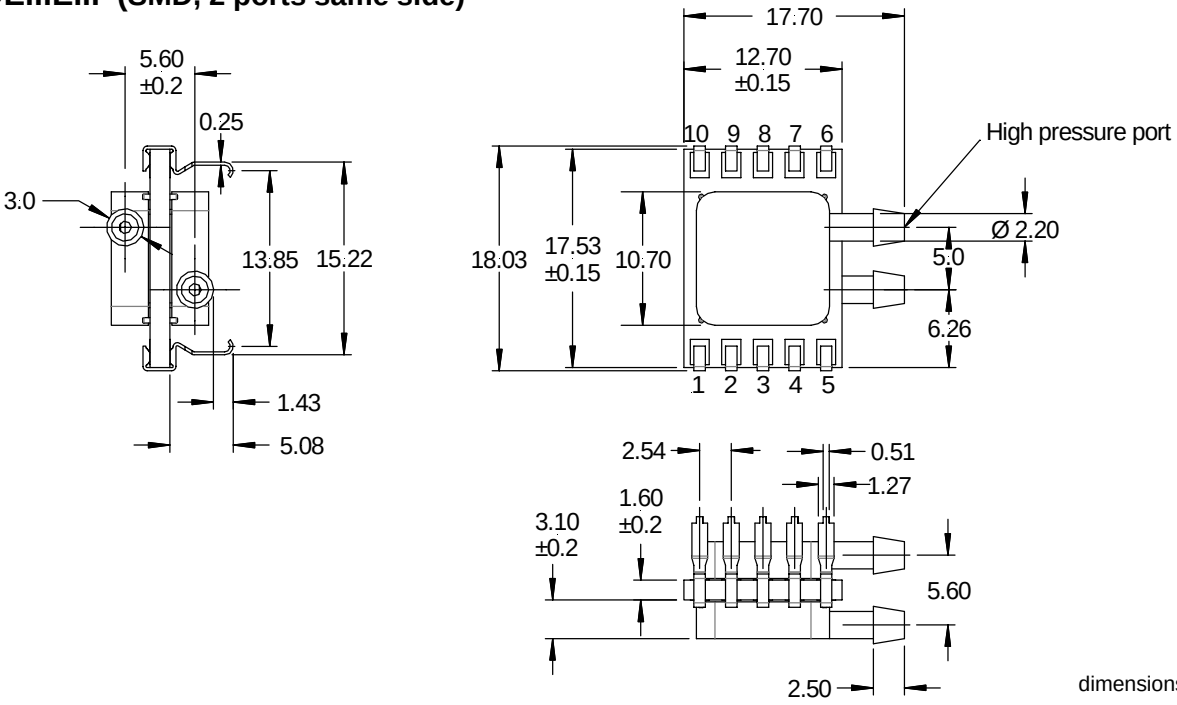


Fig. 2: Timing diagram

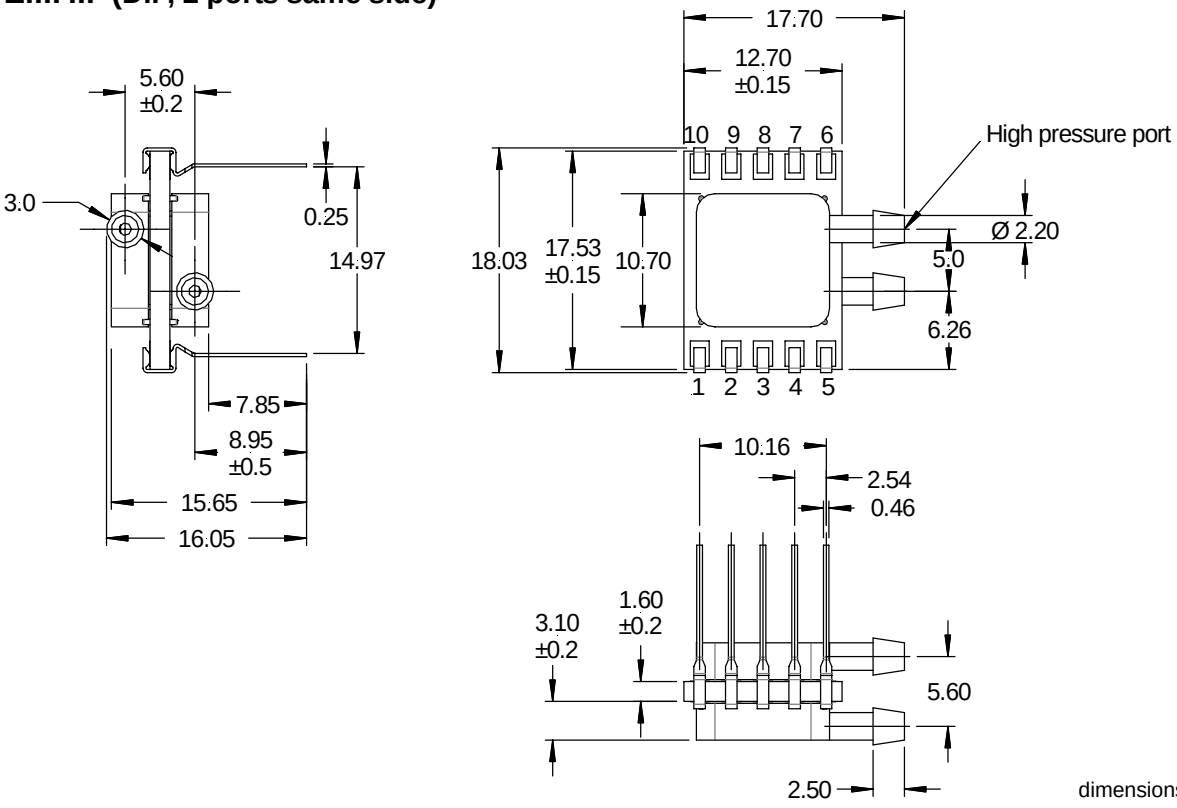
OUTLINE DRAWING

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



dimensions in mm

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



dimensions in mm

ORDERING INFORMATION

	Series	Pressure range		Calibration		Housing		Output		Grade	
Options	**LDE**	**S025**	25 Pa (0.1 inH_2O)	**B**	Bidirectional	**E**	SMT, 2 ports same side	**3**	non-ratiometric, 3 V supply	**S**	High
		S050	50 Pa (0.2 inH_2O)	**U**	Unidirectional	**F**	DIP, 2 ports same side	**6**	non-ratiometric, 5 V supply		
		S100	100 Pa (0.4 inH_2O)								
		S250	250 Pa (1 inH_2O)								
		S500	500 Pa (2 inH_2O)								
Example:	**LDE**	**S250**		**B**		**F**		**6**		**S**	

LGA InterCert
Certified Quality System
EN ISO 13485:2003+AC:2009
DIN EN ISO 9001:2008