First Sensor 6

LDE series – digital low differential pressure sensors

The LDE differential low pressure sensors are based on thermal flow measurement of gas through a micro-flow channel integrated within the sensor chip. The innovative LDE technology features superior sensitivity especially for ultra low pressures. The extremely low gas flow through the sensor ensures high immunity to dust contamination, humidity and long tubing compared to other flow-based pressure sensors.



Features

- Ultra-low pressure ranges from 25 to 500 Pa (0.1 to 2 inH₂O)
- Pressure sensor based on thermal microflow 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
- On-chip temperature sensor
- Analog output and digital SPI interface
- No position sensitivity

Certificates

- Quality Management System according to EN ISO 13485 and EN ISO 9001
- RoHS and REACH compliant

Media compatibility

Air and other non-corrosive gases

Applications

Medical

- Ventilators
- Spirometers
- CPAP
- Sleep diagnostic equipment
- Nebulizers
- Oxygen conservers/concentrators
- Insufflators/endoscopy

Industrial

- HVAC
 - VAV
 - Filter monitoring
 - Burner control
- Fuel cells
- Gas leak detection
- Gas metering
- Fume hood
- Instrumentation
- Security systems



Maximum ratings

Parameter		Min.	Max.	Unit
Supply voltage V _s	LDE3	2.70	3.60	
	LDE6	4.75	5.25	V _{DC}
Output current			1	mA
Soldering recommendations				
Reflow soldering (1, 2)				
Average preheating temperature gradient			1.5	K/s
Time above 217 °C			74	
Time above 240 °C			30	s
Peak temperature			245	<u>°C</u>
Cooling temperature gradient			-1.4	K/s
Wave soldering, pot temperature			260	°C
Hand soldering, tip temperature			370	
Temperature ranges				
Compensated		0	+70	
Operating		-20	+80	°C
Storage		-40	+80	
Humidity limits (non-condensing)			97	%RH
Vibration (3)			20	
Mechanical shock ⁽⁴⁾			500	g

Pressure sensor characteristics

Part no.	Operating pressure	Proof pressure (5)	Burst pressure (5)
LDES025U	025 Pa / 00.25 mbar (0.1 inH ₂ O)		
LDES050U	050 Pa / 00.5 mbar (0.2 inH ₂ O)		
LDES100U	0100 Pa / 01 mbar (0.4 inH ₂ O)		
LDES250U	0250 Pa / 02.5 mbar (1 inH ₂ O)		
LDES500U	0500 Pa / 05 mbar (2 inH ₂ O)	2 bar	5 bar
LDES025B	0±25 Pa / 0±0.25 mbar (±0.1 inH ₂ O)	(30 psi)	(75 psi)
LDES050B	0±50 Pa / 0±0.5 mbar (±0.2 inH ₂ O)		
LDES100B	0±100 Pa / 0±1 mbar (±0.4 inH ₂ O)		
LDES250B	0±250 Pa / 0±2.5 mbar (±1 inH ₂ O)		
LDES500B	0±500 Pa / 0±5 mbar (±2 inH ₂ O)		

Gas correction factors (6)

Gas type	Correction factor
Dry air	1.0
Oxygen (O ₂)	1.07
Nitrogen (N₂)	0.97
Argon (Ar)	0.98
Carbon dioxide (CO ₂)	0.56

Specification notes

- (1) Recommendations only. Actually reflow settings depend on many factors, for example, number of oven heating and cooling zones, type of solder paste/flux used, board and component size, as well as component density. It is the responsibility of the customer to fine tune their processes for optimal results.
- (2) Handling instruction: Products are packaged in vacuum sealed moisture barrier bag with a floor life of 168hours (<30C, 60% R.H.). If floor life or environmental conditions have been exceeded prior to reflow assembly, baking is recommended. Recommended bake-out procedure is 72 hours @ 60C.
- (3) Sweep 20 to 2000 Hz, 8 min, 4 cycles per axis, MIL-STD-883, Method 2007.
- (4) 5 shocks, 3 axes, MIL-STD-883E, Method 2002.4.
- (5) The max. common mode pressure is 5 bar.
- (6) For example with a LDES500... sensor measuring ${\rm CO_2}$ gas, at full-scale output the actual pressure will be:

 $\Delta P_{\text{eff}} = \Delta P_{\text{Sensor}} x$ gas correction factor = 500 Pa x 0.56 = 280 Pa

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

 $\Delta P_{Sensor}^{\text{\tiny CIII}}\text{= Differential pressure as indicated by output signal}$



LDE...6... Performance characteristics (7)

 $(V_s = 5.0 V_{DC}, T_A = 20 \, ^{\circ}\text{C}, P_{Abs} = 1 \, \text{bara, calibrated in air, analog and digital output signals are } \underline{\text{non-ratiometric}} \text{ to } V_s V_{DC} = 1.0 \, \text{cm}$

25 Pa and 50 Pa devices

20 T a and 00 T a acvices						
Parameter			Min.	Typ.	Max.	Unit
Noise level (RMS)				±0.01		Pa
Offset warm-up shift					less than noise	
Offset long term stability (8)				±0.05	±0.1	Pa/year
Offset repeatability				±0.01		Pa
Span repeatability (11, 12)				±0.25		% of reading
Current consumption (no load	d) ⁽⁹⁾			7	8	mA
Response time (t ₆₃)				5		ms
Power-on time					25	ms
Digital output						
Parameter			Min.	Typ.	Max.	Unit
Scale factor (digital output) (1	025/0	.±25 Pa		1200		counts/Pa
	050/0	.±50 Pa		600		counts/Pa
Zero pressure offset accuracy	(11)			±0.1	±0.2	%FSS
Span accuracy ^(11, 12)				±0.4	±0.75	% of reading
Thermal effects	Offset	555 °C			±0.2	%FSS
		070 °C			±0.4	%FSS
	Span	555 °C		±1	±1.75	% of reading
		070 °C		±2	±2.75	% of reading
Analog output (unidirect	ional devices)					
• .	ional devices/		Min	Tup	May	Linit
Parameter			Min.	Typ.	Max.	Unit
Zero pressure offset (11)			0.49	0.50	0.51	
Full scale output				4.50		V
Span accuracy (11, 12)				±0.4	±0.75	% of reading
Thermal effects	Offset	555 °C			±15	<u>mV</u>
		070 °C			±30	mV
	Span	555 °C		±1.25	±2	% of reading
		070 °C		±2	±2.75	% of reading
Analog output (bidirection	onal devices)					
Parameter			Min.	Тур.	Max.	Unit
Zero pressure offset (11)			2.49	2.50	2.51	V
Output	at max. specifie	d pressure		4.50		V
	at min. specified	pressure		0.50		V
Span accuracy ^(11, 12)				±0.4	±0.75	% of reading
Thermal effects	Offset	555 °C			±15	mV
		070 °C			±30	mV
	Span	555 °C		±1.25	±2	% of reading
		070 °C		±2	±2.75	% of reading

Specification notes (cont.)

(7) 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:

$$\Delta P_{eff} = \Delta P_{Sensor} \times 1 bara/P_{abs}$$

 ΔP_{eff} = True differential pressure

 $\Delta_{\rm Sensor}^{\rm eff}$ = Differential pressure as indicated by output voltage ${\rm P}_{\rm she}$ = Current absolute common mode pressure

- (8) Figure based on accelerated lifetime test of 10000 hours at 85 °C biased burn-in.
- (9) Please contact First Sensor for low power options.
- (10) The digital output signal is a signed, two complement integer. Negative pressures will result in a negative output
- (11) Zero pressure offset accuracy and span accuracy are uncorrelated uncertainties. They can be added according to the principles of error propagation.
- (12) Span accuracy below 10% of full scale is limited by the intrinsic noise of the sensor.



LDE...6... Performance characteristics (cont.) (7)

 $(V_s = 5.0 V_{DC}, T_A = 20 \, ^{\circ}\text{C}, P_{Abs} = 1 \, \text{bara, calibrated in air, analog and digital output signals are } \underline{\text{non-ratiometric}} \text{ to } V_s V_{DC} = 1.0 \, \text{cm}$

100 Pa, 250 Pa and 500 Pa devices

Notice to the twick (MMS)	Parameter			Min.	Тур.	Max.	Unit
Offset long term stability ⁽¹⁰⁾ ±0.05 ±0.11 %FSS/year Offset repeatability ⁽¹⁰⁾ ±0.25 % of reading Current consumption (no load) ⁽¹⁰⁾ 7 8 mA Response time (t _{re)} 5 ms ms Power-on time 5 ms ms Digital output Win. Typ. Max. Unit Scale factor (digital output) ⁽¹⁰⁾ 0100/0±100 Pa 300 counts/Pa 2cale factor (digital output) ⁽¹⁰⁾ 0100/0±500 Pa 60 counts/Pa 2cale factor (digital output) ⁽¹⁰⁾ 0500/0±500 Pa 60 counts/Pa 2cale factor (digital output) ⁽¹⁰⁾ 0500/0±500 Pa 60 counts/Pa 2cale factor (digital output) ⁽¹⁰⁾ 0500/0±500 Pa 60 counts/Pa 2cale factor (digital output) ⁽¹⁰⁾ 0500/0±500 Pa 60 counts/Pa 2cale factor (digital output) ⁽¹⁰⁾ 0500/0±500 Pa 60 counts/Pa 2cale factor (digital output) ⁽¹⁰⁾ 0500/0±500 Pa 60 counts/Pa 2cale facto	Noise level (RMS)				±0.01		%FSS
Diffect repeatability (**\text{**\t						less than noise	
Diffect repeatability (**\text{**\t	Offset long term stability (8)				±0.05	±0.1	%FSS/year
Current consumption (no load)	Offset repeatability (13)				±0.02		Pa
Power-ontime					±0.25		% of reading
Power-on time Power-on ti	Current consumption (no load	d) ⁽⁹⁾			7	8	mA
Digital output Parameter	Response time (t ₆₃)				5		ms
Parameter	Power-on time					25	ms
Scale factor (digital output) (100)	Digital output						
Description	Parameter			Min.	Тур.	Max.	Unit
Description	Scale factor (digital output) (1	0100/0	±100 Pa		300		counts/Pa
\$\frac{\percentage of fiset accuracy \text{Tit}}{\percentage of fiset accuracy \text{Tit}}{\percentage of fiset \text{Tit}}{					120	 -	counts/Pa
\$\frac{\percentage of fiset accuracy \text{TiT}}{\percentage of fiset accuracy \text{TiT}}{\percentage of fiset \text{TiT}}{		0500/0	±500 Pa		60		counts/Pa
Span accuracy (11, 12) Filt Substituting S	Zero pressure offset accuracy				±0.05	±0.1	
Parameter Par	Span accuracy (11, 12)				±0.4	±0.75	% of reading
Span Simple Span Simple Si		Offset	555 °C			±0.1	
Analog output (unidirectional devices) Parameter			070 °C			±0.2	%FSS
Parameter Min. Typ. Max. Unit		Span	555 °C		±1	±1.75	% of reading
Parameter Min. Typ. Max. Unit			070 °C		±2	±2.75	% of reading
Sero pressure offset (17)	Analog output (unidirect	ional devices)					
Pull scale output Span accuracy (************************************	Parameter			Min.	Тур.	Max.	Unit
Pull scale output Span accuracy (************************************	Zero pressure offset (11)			0.49	0.50	0.51	
Thermal effects	Full scale output				4.50		
Thermal effects	Span accuracy (11, 12)				±0.4	±0.75	% of reading
Span		Offset	555 °C			±10	mV
Analog output (bidirectional devices) Parameter Min. Typ. Max. Unit Zero pressure offset (11) Output at max. specified pressure at min. specified pressure 1			070 °C			±12	mV
Analog output (bidirectional devices) Parameter		Span	555 °C		±1	±1.75	% of reading
Parameter Min. Typ. Max. Unit Zero pressure offset (11) 2.49 2.50 2.51 V Output at max. specified pressure at min. specified pressure at min. specified pressure 0.50 V Span accuracy (11,12) ±0.4 ±0.75 % of reading Thermal effects Offset 555 °C 070 °C ±10 mV Span 555 °C 070 °C 0.			070 °C		±2	±2.75	% of reading
Zero pressure offset (11)	Analog output (bidirection	onal devices)					
Output at max. specified pressure at min. specified pressure 4.50 V Span accuracy (**1, 12) ±0.4 ±0.75 % of reading Thermal effects Offset 555 °C ±10 mV Span 555 °C ±12 mV Span 555 °C ±1 ±1.75 % of reading				Min.	Тур.	Max.	Unit
Output at max. specified pressure at min. specified pressure 4.50 V Span accuracy (**1, 12) ±0.4 ±0.75 % of reading Thermal effects Offset 555 °C ±10 mV Span 555 °C ±12 mV Span 555 °C ±1 ±1.75 % of reading	Zero pressure offset (11)			2.49	2.50	2.51	
at min. specified pressure 0.50 V Span accuracy (*11, 12) ±0.4 ±0.75 % of reading Thermal effects Offset 555 °C ±10 mV Span 555 °C ±1 ±1.75 % of reading		at max. specifie	d pressure			 -	V
Thermal effects $\begin{array}{c ccccccccccccccccccccccccccccccccccc$		at min. specified	pressure		0.50		
Thermal effects $\begin{array}{c ccccccccccccccccccccccccccccccccccc$	Span accuracy (11, 12)				±0.4	±0.75	% of reading
Span 555 °C ±1 ±1.75 % of reading		Offset	555 °C		 -	±10	mV
			070 °C			±12	mV
		Span	555 °C		±1	±1.75	% of reading
			070 °C		±2	±2.75	

Specification notes (cont.)

(7) 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:

$$\Delta P_{\text{eff}} = \Delta P_{\text{Sensor}} \times 1 \text{ bara}/P_{\text{abs}}$$

 ΔP_{eff} = True differential pressure

 $\Delta P_{\text{Sensor}}^{\text{eff}} = \text{Differential pressure as indicated by output voltage } P_{\text{she}} = \text{Current absolute common mode pressure}$

- (8) Figure based on accelerated lifetime test of 10000 hours at 85 °C biased burn-in.
- (9) Please contact First Sensor for low power options.
- (10) The digital output signal is a signed, two complement integer. Negative pressures will result in a negative output
- (11) Zero pressure offset accuracy and span accuracy are uncorrelated uncertainties. They can be added according to the principles of error propagation.
- (12) Span accuracy below 10% of full scale is limited by the intrinsic noise of the sensor.
- (13) Typical value for 250 Pa sensors.



LDE...3... Performance characteristics (7)

 $(V_s=3.0\ V_{DC},\ T_A=20\ ^{\circ}C,\ P_{Abs}=1\ bara,\ calibrated\ in\ air,\ analog\ and\ digital\ output\ signals\ are\ \underline{non-ratiometric}$ to V_sV_{DC}

25 Pa and 50 Pa devices

Parameter			Min.	Typ.	Max.	Unit
Noise level (RMS)				±0.01		Pa
Offset warm-up shift					less than noise	
Offset long term stability (8)				±0.05	±0.1	Pa/year
Offset repeatability				±0.01		Pa
Span repeatability (11, 12)				±0.25		% of reading
Current consumption (no load	d) ⁽⁹⁾			14	16	mA
Response time (t ₆₃)				5		ms
Power-on time					25	ms
Digital output						
Parameter			Min.	Тур.	Max.	Unit
Scale factor (digital output) (1	025/0	.±25 Pa		1200		counts/Pa
	050/0	.±50 Pa		600		counts/Pa
Zero pressure offset accuracy	(11)			±0.1	±0.2	%FSS
Span accuracy ^(11, 12)				±0.4	±0.75	% of reading
Thermal effects	Offset	555 °C			±0.2	%FSS
		070 °C			±0.4	%FSS
						0/ - f
	Span	555 °C		±1	±1.75	% of reading
	Span	555 °C 070 °C		±1 ±2	±1./5 ±2.75	% of reading
Analog output (unidirect						
• •			Min.			
Analog output (unidirect Parameter Zero pressure offset ⁽¹¹⁾			Min. 0.29	±2	±2.75	% of reading
Parameter Zero pressure offset (11)				±2 Typ.	±2.75	% of reading Unit
Parameter Zero pressure offset (11) Full scale output				±2	±2.75	% of reading Unit V
• .				±2 Typ. 0.30 2.70	±2.75 Max. 0.31	% of reading Unit V V
Parameter Zero pressure offset (11) Full scale output Span accuracy (11, 12)	ional devices)	070 °C		±2 Typ. 0.30 2.70	±2.75 Max. 0.31 ±0.75	% of reading Unit V V % of reading
Parameter Zero pressure offset (11) Full scale output Span accuracy (11, 12)	ional devices)	070 °C		±2 Typ. 0.30 2.70	±2.75 Max. 0.31 ±0.75 ±15	% of reading Unit V V % of reading mV
Parameter Zero pressure offset (11) Full scale output Span accuracy (11, 12)	ional devices) Offset	070 °C 555 °C 070 °C		±2 Typ. 0.30 2.70 ±0.4	±2.75 Max. 0.31 ±0.75 ±15 ±30	% of reading Unit V V % of reading mV mV
Parameter Zero pressure offset (11) Full scale output Span accuracy (11, 12)	Offset Span	070 °C 555 °C 070 °C 555 °C		±2 Typ. 0.30 2.70 ±0.4 ±1.25	±2.75 Max. 0.31 ±0.75 ±15 ±30 ±2	% of reading Unit V V % of reading mV mV % of reading
Parameter Zero pressure offset (11) Full scale output Span accuracy (11, 12) Thermal effects	Offset Span	070 °C 555 °C 070 °C 555 °C		±2 Typ. 0.30 2.70 ±0.4 ±1.25	±2.75 Max. 0.31 ±0.75 ±15 ±30 ±2	% of reading Unit V V % of reading mV mV % of reading
Parameter Zero pressure offset (11) Full scale output Span accuracy (11, 12) Thermal effects Analog output (bidirection	Offset Span	070 °C 555 °C 070 °C 555 °C	0.29	±2 Typ. 0.30 2.70 ±0.4 ±1.25 ±2	±2.75 Max. 0.31 ±0.75 ±15 ±30 ±2 ±2.75	% of reading Unit V V % of reading mV mV % of reading % of reading
Parameter Zero pressure offset (11) Full scale output Span accuracy (11, 12) Thermal effects Analog output (bidirection Parameter	Offset Span	555 °C 070 °C 555 °C 070 °C	0.29 Min.	±2 Typ. 0.30 2.70 ±0.4 ±1.25 ±2 Typ.	±2.75 Max. 0.31 ±0.75 ±15 ±30 ±2 ±2.75 Max.	% of reading Unit V V % of reading mV mV % of reading % of reading Unit
Parameter Zero pressure offset (11) Full scale output Span accuracy (11, 12) Thermal effects Analog output (bidirection Parameter Zero pressure offset (11) Output	Offset Span onal devices)	555 °C 070 °C 555 °C 070 °C	0.29 Min.	±2 Typ. 0.30 2.70 ±0.4 ±1.25 ±2 Typ. 1.50	±2.75 Max. 0.31 ±0.75 ±15 ±30 ±2 ±2.75 Max.	% of reading Unit V V % of reading mV mV % of reading % of reading Unit V
Parameter Zero pressure offset (11) Full scale output Span accuracy (11, 12) Thermal effects Analog output (bidirection Parameter Zero pressure offset (11)	Offset Span onal devices) at max. specifie	555 °C 070 °C 555 °C 070 °C	0.29 Min.	±2 Typ. 0.30 2.70 ±0.4 ±1.25 ±2 Typ. 1.50 2.70	±2.75 Max. 0.31 ±0.75 ±15 ±30 ±2 ±2.75 Max.	% of reading Unit V V % of reading mV wo of reading for reading Unit V V
Parameter Zero pressure offset (11) Full scale output Span accuracy (11, 12) Thermal effects Analog output (bidirection Parameter Zero pressure offset (11) Output	Offset Span onal devices) at max. specifie	555 °C 070 °C 555 °C 070 °C	0.29 Min.	±2 Typ. 0.30 2.70 ±0.4 ±1.25 ±2 Typ. 1.50 2.70 0.30	±2.75 Max. 0.31 ±0.75 ±15 ±30 ±2 ±2.75 Max. 1.51	% of reading Unit V V % of reading mV wo of reading for reading Unit V V V
Parameter Zero pressure offset (11) Full scale output Span accuracy (11, 12) Thermal effects Analog output (bidirection Parameter Zero pressure offset (11) Output Span accuracy (11, 12)	Offset Span onal devices) at max. specified at min. specified	555 °C 070 °C 555 °C 070 °C	0.29 Min.	±2 Typ. 0.30 2.70 ±0.4 ±1.25 ±2 Typ. 1.50 2.70 0.30	±2.75 Max. 0.31 ±0.75 ±15 ±30 ±2 ±2.75 Max. 1.51 ±0.75	% of reading Unit V V % of reading mV mV % of reading % of reading Unit V V V V % of reading
Parameter Zero pressure offset (11) Full scale output Span accuracy (11, 12) Thermal effects Analog output (bidirection Parameter Zero pressure offset (11) Output Span accuracy (11, 12)	Offset Span onal devices) at max. specified at min. specified	555 °C 070 °C 555 °C 070 °C d pressure d pressure 555 °C	0.29 Min.	±2 Typ. 0.30 2.70 ±0.4 ±1.25 ±2 Typ. 1.50 2.70 0.30	±2.75 Max. 0.31 ±0.75 ±15 ±30 ±2 ±2.75 Max. 1.51 ±0.75 ±15	% of reading Unit V V % of reading mV wo of reading continue Unit V V V V v % of reading mV

Specification notes (cont.)

(7) 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:

$$\Delta P_{\text{eff}} = \Delta P_{\text{Sensor}} \times 1 \text{ bara}/P_{\text{abs}}$$

 ΔP_{eff} = True differential pressure

 $\Delta P_{\text{Sensor}}^{\text{eff}}$ = Differential pressure as indicated by output voltage $P_{\text{ahe}}^{\text{c}}$ = Current absolute common mode pressure

- (8) Figure based on accelerated lifetime test of 10000 hours at 85 °C biased burn-in.
- (9) Please contact First Sensor for low power options.
- (10) The digital output signal is a signed, two complement integer. Negative pressures will result in a negative output
- (11) Zero pressure offset accuracy and span accuracy are uncorrelated uncertainties. They can be added according to the principles of error propagation.
- (12) Span accuracy below 10% of full scale is limited by the intrinsic noise of the sensor.



LDE...3... Performance characteristics (cont.) (7)

 $(V_s=3.0\ V_{DC},\ T_A=20\ ^{\circ}C,\ P_{Abs}=1\ bara,\ calibrated\ in\ air,\ analog\ and\ digital\ output\ signals\ are\ \underline{non-ratiometric}$ to V_sV_{DC}

100 Pa, 250 Pa and 500 Pa devices

Notice to the twin file	Parameter			Min.	Тур.	Max.	Unit
Offset long term stability (10) ±0.05 ±0.1 %FSS/year Offset repeatability (10) ±0.02 Pa Span repeatability (10) ±0.25 % of reading Current consumption (no load) (10) 14 16 mA Response time (1 _{co}) 5 ms ms Power-on time 5 ms ms Digital output Win. Typ. Max. Unit Scale factor (digital output) (10) 0100/0±100 Pa 300 counts/Pa Scale factor (digital output) (10) 0250/0±250 Pa 60 counts/Pa Scale factor (digital output) (10) 0250/0±50 Pa 60 counts/Pa Zero pressure offset accuracy (11) ±0.05 ±0.1 %FSS Span (10, 25) ±0.0 ±0.05 ±0.1 %FSS Span (10, 25) ±0.0 ±0.0 ±0.0 counts/Pa Thermal effects 0.ffset (1.5.5°) ±0.0 ±0.0 %FSS Span (10, 25) ±0.0 ±0.0 ±0.0 %FSS	Noise level (RMS)				±0.01		%FSS
Span repeatability (**\frac{\text{\$\mathcal{P}}{\$\mathca						less than noise	
Span repeatability (**\frac{\text{\$\mathcal{P}}{\$\mathca	Offset long term stability (8)				±0.05	±0.1	%FSS/year
Segona time (1cg)	Offset repeatability (13)				±0.02		Pa
Power-ontime					±0.25		% of reading
Power-on time Power-on ti	Current consumption (no load	d) ⁽⁹⁾			14	16	mA
Digital output Parameter	Response time (t ₆₃)				5		ms
Parameter	Power-on time					25	ms
Scale factor (digital output) (100)	Digital output						
Description	Parameter			Min.	Тур.	Max.	Unit
Description	Scale factor (digital output) (1	0100/0	±100 Pa		300		counts/Pa
\$\frac{\perp content of the accuracy \text{TID}}{\perp content of \perp content of			±250 Pa		120		counts/Pa
Span accuracy (11, 12) Filt Substituting S			±500 Pa		60		counts/Pa
Span accuracy (11, 12) Filt Substituting S	Zero pressure offset accuracy	(11)			±0.05	±0.1	%FSS
Span	Span accuracy (11, 12)				±0.4	±0.75	% of reading
Span 555 °C ±1 ±1.75 % of reading	Thermal effects	Offset	555 °C			±0.1	%FSS
Analog output (unidirectional devices) Parameter			070 °C			±0.2	%FSS
Parameter Min. Typ. Max. Unit		Span	555 °C		±1	±1.75	% of reading
Parameter Min. Typ. Max. Unit			070 °C		±2	±2.75	% of reading
Sero pressure offset (17)	Analog output (unidirect	ional devices)					
Pull scale output 2.70 V	Parameter			Min.	Typ.	Max.	Unit
Pull scale output 2.70 V	Zero pressure offset (11)			0.29	0.30	0.31	
Thermal effects	Full scale output				2.70		
Thermal effects	Span accuracy (11, 12)				±0.4	±0.75	% of reading
Span		Offset	555 °C			±10	mV
Analog output (bidirectional devices) Parameter Min. Typ. Max. Unit Zero pressure offset (11) 1,49 1,50 1,51 V Output at min. specified pressure at min. specified pressure 40,30 V Span accuracy (11,12) ±0.4 ±0.75 % of reading Thermal effects Offset 555 °C ±0.4 ±10 mV Span 555 °C ±11 ±1.75 % of reading			070 °C			±12	mV
Analog output (bidirectional devices) Parameter		Span	555 °C		±1	±1.75	% of reading
Parameter Min. Typ. Max. Unit Zero pressure offset (11) 1.49 1.50 1.51 V Output at max. specified pressure at min. specified pressure 2.70 V V Span accuracy (11,12) ±0.4 ±0.75 % of reading Thermal effects Offset 555 °C 070 °C ±10 mV Span 555 °C 555 °C 070 °C			070 °C		±2	±2.75	% of reading
Zero pressure offset (11)	Analog output (bidirection	onal devices)					
Output at max. specified pressure at min. specified pressure 2.70 V Span accuracy (**1, 12) ±0.4 ±0.75 % of reading Thermal effects Offset 555 °C ±10 mV Span 555 °C ±12 mV Span 555 °C ±1 ±1.75 % of reading				Min.	Тур.	Max.	Unit
Output at max. specified pressure at min. specified pressure 2.70 V Span accuracy (**1, 12) ±0.4 ±0.75 % of reading Thermal effects Offset 555 °C ±10 mV Span 555 °C ±12 mV Span 555 °C ±1 ±1.75 % of reading	Zero pressure offset (11)			1.49	1.50	1.51	
Span accuracy (*11, 12) ±0.4 ±0.75 % of reading Thermal effects Offset 555 °C ±10 mV 070 °C ±12 mV Span 555 °C ±1 ±1.75 % of reading		at max. specifie	d pressure		2.70		
Thermal effects		at min. specified	pressure	<u> </u>	0.30		V
Thermal effects	Span accuracy (11, 12)			<u> </u>	±0.4	±0.75	% of reading
Span 555 °C ±1 ±1.75 % of reading		Offset	555 °C			±10	mV
			070 °C			±12	mV
070 °C ±2 ±2.75 % of reading		Span	555 °C		±1	±1.75	% of reading
			070 °C		±2	±2.75	% of reading

Specification notes (cont.)

(7) 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:

$$\Delta P_{\text{eff}} = \Delta P_{\text{Sensor}} \times 1 \text{ bara/P}_{\text{abs}}$$

 ΔP_{eff} = True differential pressure

 $\Delta P_{\text{Sensor}}^{\text{mi}}$ = Differential pressure as indicated by output voltage P_{abc} = Current absolute common mode pressure

- (8) Figure based on accelerated lifetime test of 10000 hours at 85 °C biased burn-in.
- (9) Please contact First Sensor for low power options.
- (10) The digital output signal is a signed, two complement integer. Negative pressures will result in a negative output
- (11) Zero pressure offset accuracy and span accuracy are uncorrelated uncertainties. They can be added according to the principles of error propagation.
- (12) Span accuracy below 10% of full scale is limited by the intrinsic noise of the sensor.
- (13) Typical value for 250 Pa sensors.



Performance characteristics

Temperature sensor

Parameter	Min.	Typ.	Max.	Unit
Scale factor (digital output)		95		counts/°C
Non-linearity		±0.5		%FS
Hysteresis		±0.1		% FS

Total accuracy (15)

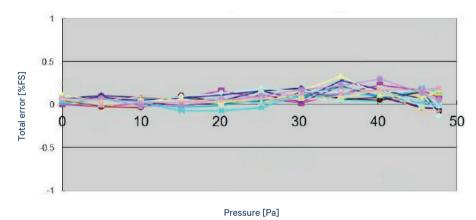


Fig. 1: Typical total accuracy plot of 16 LDE 50 Pa sensors @ 25 °C (typical total accuracy better than 0.5 %FS)

Offset long term stability

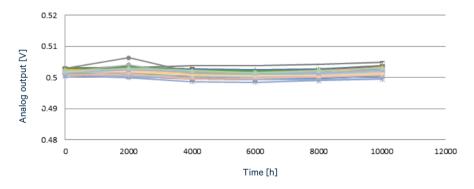


Fig. 2: Offset long term stability for LDE 250 Pa sensors after 10,000 hours @ 85°C powered, equivalent to over 43.5 years @ 25 °C (better than ±2 mV / ±0.125 Pa)

Specification notes (cont.)

(15) 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.

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, howeer, they should be greater than 50 k Ω .

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.

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.

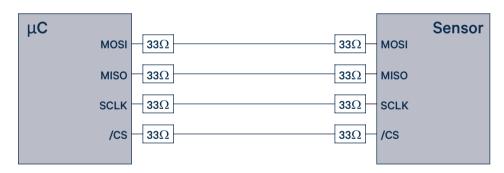


Fig. 3: Application circuit with resistors at both ends of the SPI lines

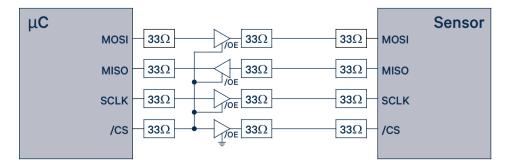


Fig. 4: Application circuit with additional buffer



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 – pressure

When powered on, the sensor begins to continuously measure pressure. calculated as follows: 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):

Pressure [Pa] = 1.5.

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:

For example, 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.

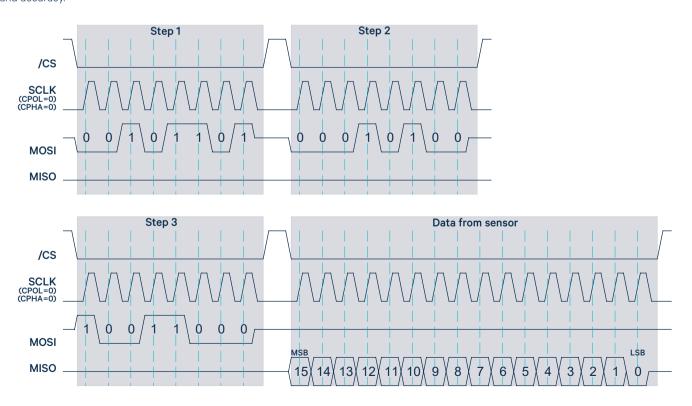


Fig. 5: SPI data transfer



SPI - Serial Peripheral Interface (cont.)

Data read – temperature

The on-chip temperature sensor changes 95 counts/°C over the operating range. The temperature data format is 15-bit plus sign in two's complement format. To read temperature, use the following sequence:

Step	Hexadecimal	Binary	Description
1	0x2A	B00101010	Poll current temperature measurement
2	0x14	B00010100	Send result to data register
3	0x98	B10011000	Read data register

From the digital sensor output, the actual temperature can be calculated as follows:

Temperature [°C] =
$$\frac{\text{TS - TS}_0 \text{ [counts]}}{\text{Scale factor}_{\text{TS}} \left[\frac{\text{counts}}{\text{°C}} \right]} + \text{T}_0 \left[\text{°C} \right]$$

where

TS is the actual sensor readout;

 TS_0 is the sensor readout at known temperature $T_0^{(13)}$;

Scale factor_{TS} = 95 counts/°C

Specification notes (cont.)

(16) To be defined by user. The results show deviation (in $^{\circ}$ C) from the offset calibrated temperature.

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SPI - Serial Peripheral Interface (cont.)

Interface specification

$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
External master clock input low time	External clock frequency	f _{ECLK}	V _{CKSEL} =0 Min.		0.2		
External master clock input high time f_{ECLKINHI} t_{ECLK}			Max.		5		IVITZ
External master clock input high time $f_{ECLKNHI}$ $f_{ECLKNHI}$ $f_{ECLKNHI}$ $f_{ECLKNHI}$ $f_{ECLKNHI}$ f_{ECLK} f_{CLK} f_{C	External master clock input low time	f _{ECLKIN LO}	t _{ECLK} =1/f _{ECLK}	40		60	0/+
/CS falling edge to SCLK rising edge setup time t_{CSS} 30 ns /CS idle time tcsi $f_{CLX}=4$ MHz 1.5 µs SCLK falling edge to data valid delay too $C_{LOAD}=15$ pF 80 Data valid to SCLK rising edge setup time 30 30 30 Data valid to SCLK rising edge hold time toh 30 30 SCLK high pulse width tch 100 30 SCLK rising edge to SCLK rising edge hold time tch 100 25 VCS rising edge to Output enable tov C_LOAD=15 pF 25 25 /CS rising edge to output disable tr C_LOAD=15 pF 25 25 25 LDEG	External master clock input high time	f _{ECLKIN HI}	t _{ECLK} =1/f _{ECLK}	40		60	/oleclk
CS falling edge to SCLK rising edge setup time t_{CSI}	SCLK setup to falling edge /CS	t _{sc}		30			_ no
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	/CS falling edge to SCLK rising edge setup time	t _{css}		30			115
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	/CS idle time	t _{CSI}	f _{CLK} =4 MHz	1.5			μs
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	SCLK falling edge to data valid delay	t _{DO}	C _{LOAD} =15 pF			80	
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	Data valid to SCLK rising edge setup time	t _{DS}		30			
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	Data valid to SCLK rising edge hold time	t _{DH}		30			
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	SCLK high pulse width	t _{CH}		100			
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	SCLK low pulse width	t _{CL}		100			ns
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	/CS rising edge to SCLK rising edge hold time	t _{CSH}		30			_
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	/CS falling edge to output enable	t _{DV}	C _{LOAD} =15 pF			25	
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	/CS rising edge to output disable	t _{TR}	C _{LOAD} =15 pF			25	
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	LDE6 (5 V supply)						
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	Maximum output load capacitance	C _{LOAD}	R _{LOAD} =∞, phase margin >55°		200		pF
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	Input voltage, logic HIGH	V _{IH}		0.8×V _s		V _s +0.3	
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	Input voltage, logic LOW	V _{IL}				0.2×V _s	
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	Output voltage, logic HIGH	V _{OH}	R _{LOAD} =∞	Vs-0.1			
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$			$R_{LOAD} = 2 k\Omega$	V _s -0.15			v
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	Output voltage, logic LOW	V _{OL}	R _{LOAD} =∞			0.5	
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$			$R_{LOAD}=2 k\Omega$			0.2	
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	LDE3 (3 V supply) (17)						
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	Maximum output load capacitance	C _{LOAD}	R _{LOAD} =1 kΩ		15		pF
Output voltage, logic HIGH V_{OH} I_{O} =-20 μA V_{S} =0.4	Input voltage, logic HIGH	V _{IH}		0.65×V _s		V _s +0.3	
Output voltage, logic HIGH V_{OH} I_{O} =-20 μA V_{S} -0.4	Input voltage, logic LOW	V _{IL}				0.35×V _s	
Output voltage, logic LOW V ₀₁ I ₀ =+20 LIA 0.4	Output voltage, logic HIGH	V _{OH}	I _o =-20 μA	V _s -0.4			— v
	Output voltage, logic LOW	V _{OL}	I _o =+20 μA		_	0.4	

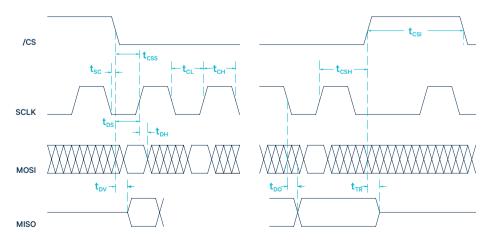


Fig. 6: SPI timing diagram

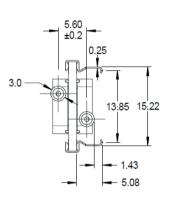
Specification notes (cont.)

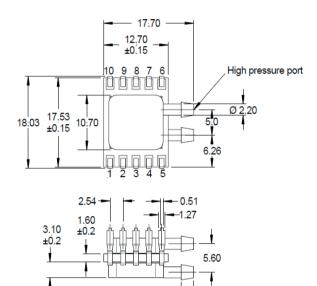
(17) For correct operation of LDE...3... devices, the device driving the SPI bus must have a minimum drive capability of ±2 mA.



Dimensional drawing

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

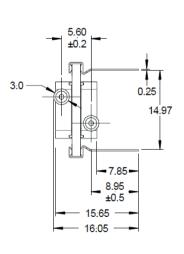


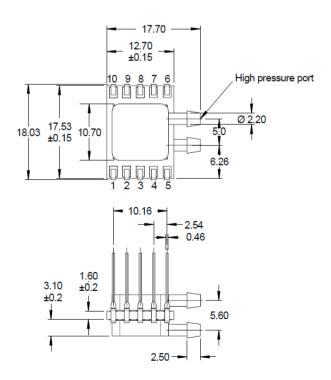


2.50

dimensions in mm, all tolerances ±0.1 mm unless otherwise noted

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

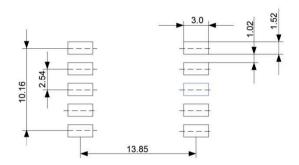




dimensions in mm, all tolerances ±0.1 mm unless otherwise noted



Sensor PCB footprint



dimensions in mm, all tolerances ±0.1 mm unless otherwise noted

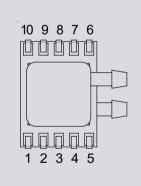
Electrical connection(18)

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;

Case 3: Pin-to-pin compatible drop-in replacement for LBA series devices (5 V LDE devices only).



		Case I:	Case 2:	Case 3:
Pin	Function	Digital signal output	Analog signal output	LBA drop-in replacement (5 V only)
1	Reserved	NC	NC	GND
2	_ V _s	+5V/+3V	+5V/+3V	+5V
3	GND	GND	GND	GND
4	Vout	NC	_ High impedance analog input	High impedance analog input
5	Vout	NC	(e.g. op-amp, ADC)	(e.g. op-amp, ADC)
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_s	GND
10	Reserved	NC	NC	GND

Ordering information

Series	Pressure range		Calibration		Housing	Output	Grade
LDE	S025 S050	25 Pa (0.1 inH ₂ O) 50 Pa (0.2 inH ₂ O)	<u>В</u> U	Bidirectional Unidirectional	E [SMD, 2 ports, same side] F [DIP, 2 ports, same side]	3 [Non-ratiometric, 3 V supply] 6 [Non-ratiometric, 5 V supply]	S [High]
	S100	100 Pa (0.4 inH ₂ O)				, , , , , , , , , , , , , , , , , , , ,	=
	S250	250 Pa (1 inH ₂ O)					
	\$500	500 Pa (2 inH O)	_				

Order code example: LDES250BF6S

Specification notes (cont.)

(18) The maximum voltage applied to pin 1 and pins 6 through 10 should not exceed $\mbox{\sc V}_{\mbox{\scriptsize S}}\mbox{+}0.3\mbox{\sc V}.$

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