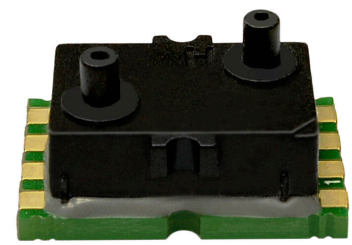
First Sensor

LME 系列 – 数字超低压传感器用于流量测量



LME差压低压传感器基于通过集成在传感器芯片内的微流通道的气体的热流测量。 创新的LME技术具有卓越的灵敏度，特别适用于超低压。 与其他基于流量的压力传感器相比，通过传感器的极低气体流量确保了对灰尘污染，湿度和长管道的高抗扰度。

特点

– 超低压力范围 25 to 2500 Pa (0.1 to 10 inH_2O)
– 基于热质元件的压力传感芯片
– 高抗干扰能力

- 非常低的流通泄漏
- 对灰尘和湿度的高度免疫力
- 使用长管道无灵敏度损失

–卓越的长期稳定性和精度，具有专利的实时偏移补偿和线性化技术
- 长期稳定性优于0.1 Pa /年
- 总精度优于0.5%FS典型
- 芯片上温度传感器
- 线性化数字SPI和模拟输出
- 体积小，薄型，只有9毫米高度和坚固的包装
- 用于直接歧管组件的压力端口
- 适用于特定应用程序的高度通用性安装适配器和歧管
- 最小化内部体积和歧管安装选项允许快速的气体吹扫时间

证书

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

介质兼容性

空气等非腐蚀性气体

应用

医疗
- 呼吸机
- 肺活量计
- CPAP
- 睡眠诊断设备
- 雾化器
- 氧气保存/浓缩器
- 吸入器/内窥镜检查

工业
– HVAC
  – VAV
  – 过滤器检测
  – 工业炉
- 燃料电池
- 气体泄漏检测
- 气体计量
- 通风柜
- 仪器仪表
- 安全系统

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Maximum ratings

Parameter	Min.	Max.	Unit
Supply voltage V_S	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

Pressure sensor characteristics

Part no.	Operating pressure	Proof pressure (3)	Burst pressure (3)
LMES025U...	0...25 Pa / 0...0.25 mbar (0.1 inH_2O)	2 bar (30 psi)	5 bar (75 psi)
LMES050U...	0...50 Pa / 0...0.5 mbar (0.2 inH_2O)		
LMES100U...	0...100 Pa / 0...1 mbar (0.4 inH_2O)		
LMES250U...	0...250 Pa / 0...2.5 mbar (1 inH_2O)		
LMES500U...	0...500 Pa / 0...5 mbar (1 inH_2O)		
LMEM012U...	0...1250 Pa / 0...12.5 mbar (5 inH_2O)		
LMEM025U...	0...2500 Pa / 0...25 mbar (10 inH_2O)		
LMES025B...	0...±25 Pa / 0...±0.25 mbar (0.1 inH_2O)		
LMES050B...	0...±50 Pa / 0...±0.5 mbar (0.2 inH_2O)		
LMES100B...	0...±100 Pa / 0...±1 mbar (0.4 inH_2O)		
LMES250B...	0...±250 Pa / 0...±2.5 mbar (1 inH_2O)		
LMES500B...	0...±500 Pa / 0...±5 mbar (2 inH_2O)		
LMEM012B...	0...±1250 Pa / 0...±12.5 mbar (5 inH_2O)		
LMEM025B...	0...±2500 Pa / 0...±25 mbar (10 inH_2O)		

Gas correction factors (4)

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

(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 max. common mode pressure is 5 bar.

(4) For example with a LMES500... sensor measuring CO_2 gas, at full-scale output the actual pressure will be:

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

ΔP_{eff} = True differential pressure

ΔP_{Sensor} = Differential pressure as indicated by output signal

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Performance characteristics (5)

(V_S=5.0 V_{DC}, T_A=20 °C, P_{Abs}=1 bara, calibrated in air, output signal is non-ratiometric to V_S)

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 (6)		±0.05	±0.1	Pa/year
Offset repeatability		±0.01		Pa
Span repeatability (9, 10)		±0.25		% of reading
Current consumption (no load) (7)		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) (8)	0...25/0...±25 Pa			1200		counts/Pa
	0...50/0...±50 Pa			600		counts/Pa
Zero pressure offset accuracy (9)				±0.1	±0.2	%FSS
Span accuracy (9, 10)				±0.4	±0.75	% of reading
Thermal effects	Offset	5...55 °C			±0.2	%FSS
		0...70 °C			±0.4	%FSS
	Span	5...55 °C		±1	±1.75	% of reading
		0...70 °C		±2	±2.75	% of reading

Analog output (unidirectional devices)

Parameter			Min.	Typ.	Max.	Unit
Zero pressure offset (9)			0.49	0.50	0.51	V
Full scale output				4.50		V
Span accuracy (9, 10)				±0.4	±0.75	% of reading
Thermal effects	Offset	5...55 °C			±15	mV
		0...70 °C			±30	mV
	Span	5...55 °C		±1.25	±2	% of reading
		0...70 °C		±2	±2.75	% of reading

Analog output (bidirectional devices)

Parameter			Min.	Typ.	Max.	Unit
Zero pressure offset (9)			2.49	2.50	2.51	V
Output	at max. specified pressure			4.50		V
	at min. specified pressure			0.50		V
Span accuracy (9, 10)				±0.4	±0.75	% of reading
Thermal effects	Offset	5...55 °C			±15	mV
		0...70 °C			±30	mV
	Span	5...55 °C		±1.25	±2	% of reading
		0...70 °C		±2	±2.75	% of reading

Specification notes (cont.)

(5) 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:

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

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

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

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Performance characteristics (cont.) [5]

(V_S=5.0 V_{DC}, T_A=20 °C, P_{Abs}=1 bara, calibrated in air, output signal is non-ratiometric to V_S)

100 Pa, 250 Pa and 500 Pa devices

Parameter	Min.	Typ.	Max.	Unit
Noise level (RMS)		±0.01		%FSS
Offset warm-up shift			less than noise	
Offset long term stability [6]		±0.05	±0.1	%FSS/year
Offset repeatability [11]		±0.02		Pa
Span repeatability [9, 10]		±0.25		% of reading
Current consumption (no load) [7]		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) [8]	0...100/0...±100 Pa			300		counts/Pa
	0...250/0...±250 Pa			120		counts/Pa
	0...500/0...±500 Pa			60		counts/Pa
Zero pressure offset accuracy [9]				±0.05	±0.1	%FSS
Span accuracy [9, 10]				±0.4	±0.75	% of reading
Thermal effects	Offset	5...55 °C			±0.1	%FSS
		0...70 °C			±0.2	%FSS
	Span	5...55 °C		±1	±1.75	% of reading
		0...70 °C		±2	±2.75	% of reading

Analog output (unidirectional devices)

Parameter			Min.	Typ.	Max.	Unit
Zero pressure offset [9]			0.49	0.50	0.51	V
Full scale output				4.50		V
Span accuracy [9, 10]				±0.4	±0.75	% of reading
Thermal effects	Offset	5...55 °C			±10	mV
		0...70 °C			±12	mV
	Span	5...55 °C		±1	±1.75	% of reading
		0...70 °C		±2	±2.75	% of reading

Analog output (bidirectional devices)

Parameter			Min.	Typ.	Max.	Unit
Zero pressure offset [9]			2.49	2.50	2.51	V
Output	at max. specified pressure			4.50		V
	at min. specified pressure			0.50		V
Span accuracy [9, 10]				±0.4	±0.75	% of reading
Thermal effects	Offset	5...55 °C			±10	mV
		0...70 °C			±12	mV
	Span	5...55 °C		±1	±1.75	% of reading
		0...70 °C		±2	±2.75	% of reading

Specification notes (cont.)

(5) 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:

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

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

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

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Performance characteristics (cont.) (5, 12)

(V_S=5.0 V_{DC}, T_A=20 °C, P_{Abs}=1 bara, calibrated in air, output signal is non-ratiometric to V_S)

1250 Pa and 2500 Pa devices

Parameter	Min.	Typ.	Max.	Unit
Noise level (RMS)		±0.5		Pa
Offset warm-up shift			less than noise	
Offset long term stability (6)		±1.25	±2.5	Pa/year
Offset repeatability		±0.5		Pa
Span repeatability (9, 10)		±0.25		% of reading
Current consumption (no load) (7)		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) (8)	0...1250/0...±1250 Pa			24		counts/Pa
	0...2500/0...±2500 Pa			12		counts/Pa
Zero pressure offset accuracy (9)				±0.1	±0.2	%FSS
Span accuracy (9, 10)				±0.75	±1.5	% of reading
Thermal effects	Offset	5...55 °C			±0.1	%FSS
		0...70 °C			±0.2	%FSS
	Span	5...55 °C		±1	±1.75	% of reading
		0...70 °C		±2	±2.75	% of reading

Analog output (unidirectional devices)

Parameter			Min.	Typ.	Max.	Unit
Zero pressure offset (9)			0.49	0.50	0.51	V
Full scale output				4.50		V
Span accuracy (9, 10)				±0.75	±1.5	% of reading
Thermal effects	Offset	5...55 °C			±10	mV
		0...70 °C			±12	mV
	Span	5...55 °C		±1.25	±2	% of reading
		0...70 °C		±2	±2.75	% of reading

Analog output (bidirectional devices)

Parameter			Min.	Typ.	Max.	Unit
Zero pressure offset (9)			2.49	2.50	2.51	V
Output	at max. specified pressure			4.50		V
	at min. specified pressure			0.50		V
Span accuracy (9, 10)				±0.75	±1.5	% of reading
Thermal effects	Offset	5...55 °C			±10	mV
		0...70 °C			±12	mV
	Span	5...55 °C		±1.25	±2	% of reading
		0...70 °C		±2	±2.75	% of reading

Specification notes (cont.)

(5) 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:

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

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

(6) Figure based on accelerated lifetime test of 10000 hours at 85 °C biased burn-in.

(7) Please contact First Sensor for low power options.

(8) The digital output signal is a signed, two complement integer. Negative pressures will result in a negative output

(9) Zero pressure offset accuracy and span accuracy are uncorrelated uncertainties. They can be added according to the principles of error propagation.

(10) Span accuracy below 10% of full scale is limited by the intrinsic noise of the sensor.

(12) For pressure ranges 1250 Pa and 2500 Pa, more accurate absolute pressure correction procedures than in (5) might be needed. See Application Note "Absolute pressure correction of LME/LMI pressure sensors".

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Performance characteristics (cont.)

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 [13]

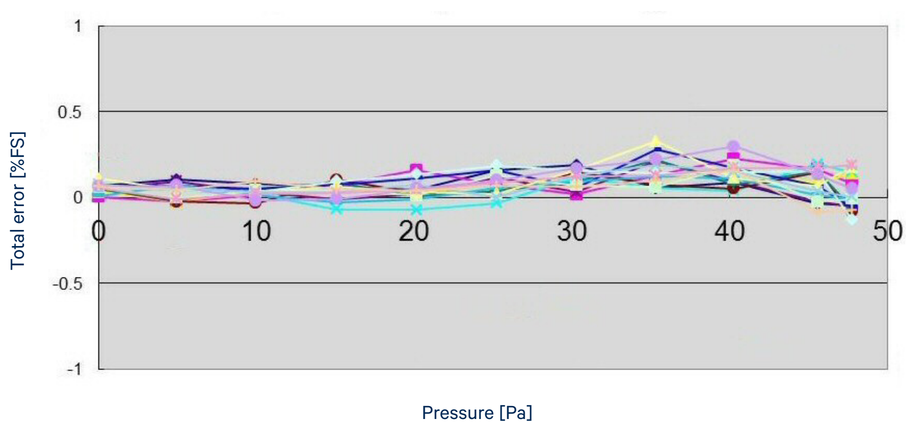

Fig. 1: Typical total accuracy plot of 16 LME 50 Pa sensors @ 25 °C (typical total accuracy better than 0.5 %FS)

Offset long term stability

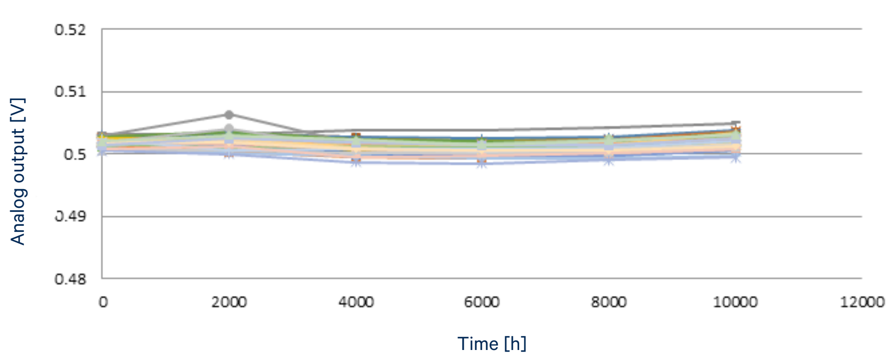

Fig. 2: Offset long term stability for LME 250 Pa sensors after 10,000 hours @ 85°C powered, equivalent to over 43.5 years @ 25 °C (better than ±2 mV / ±0.125 Pa)

Specification notes (cont.)

(13) Total accuracy is the combined error from offset and span calibration, non-linearity, repeatability and pressure hysteresis

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SPI 总线– 串行外设接口（续）

Introduction

LME串行接口是一个高速同步数据输入和输出通信端口。 串行接口使用标准的4线SPI总线进行操作。 LME器件以SPI模式0运行，这要求时钟线SCLK为空闲低电平（CPOL = 0），并且要在前导时钟边沿（CPHA = 0）上采样数据。 图5说明了这种操作模式。

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. 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.

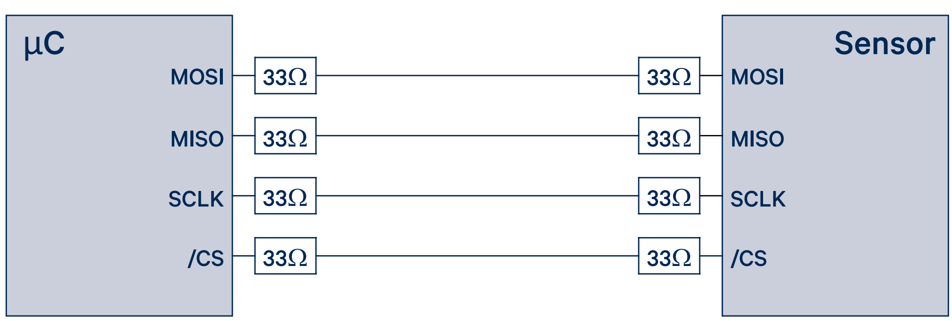

Fig. 3: Application circuit with resistors at both ends of the SPI lines

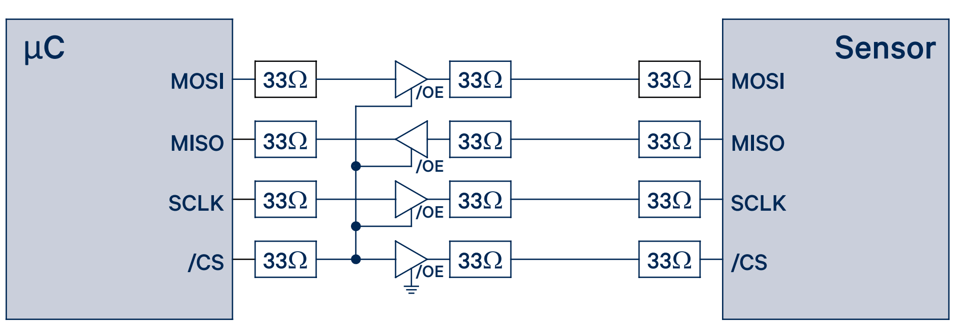

Fig. 4: Application circuit with additional buffer

SPI 总线– 串行外设接口（续）

Data read – pressure

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 LME 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 ±250 Pa sensor (LMES250B...) 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.

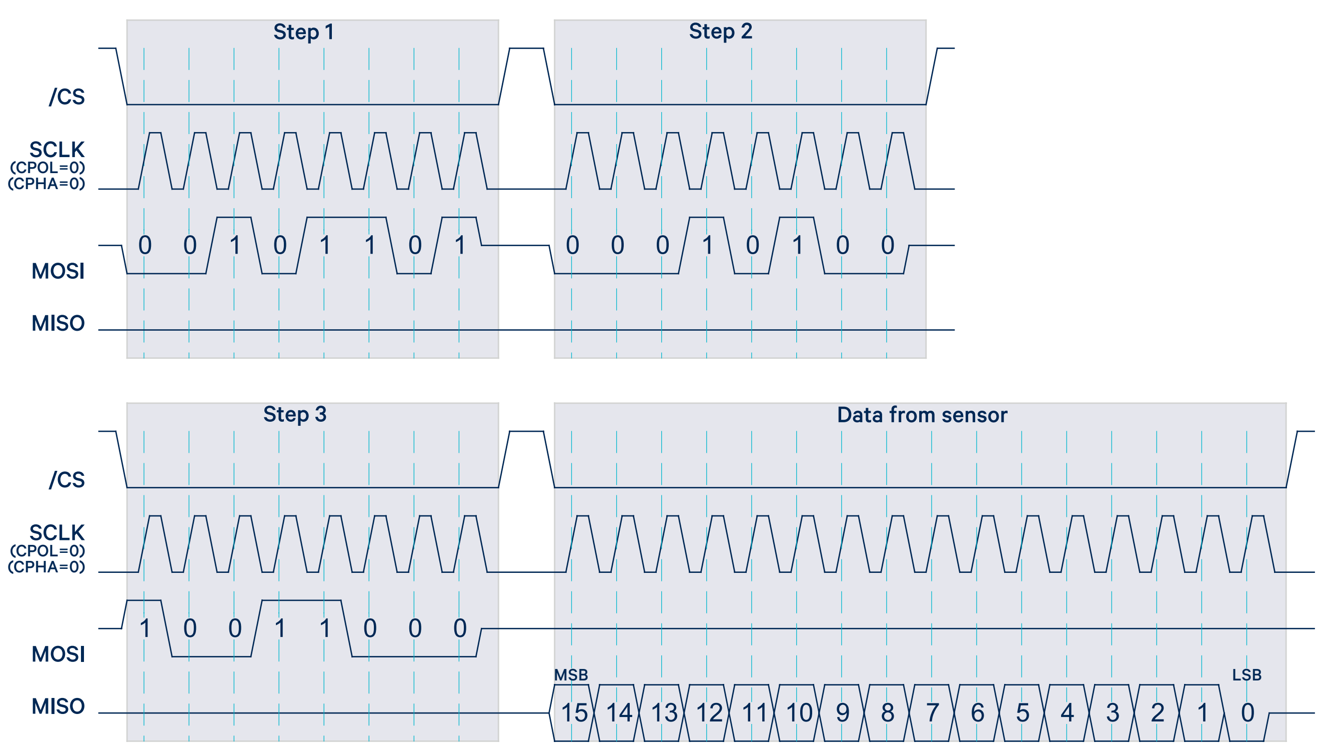

Fig. 5: SPI data transfer

SPI 总线– 串行外设接口（续）

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	0x24	B00100010	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:

$$\text{Temperature [°C]} = \frac{TS - TS_0 \text{ [counts]}}{\text{Scale factor}_{TS} \left[\frac{\text{counts}}{°C}\right]} + T_0 \text{ [°C]}$$

where
TS is the actual sensor readout;
TS_0 is the sensor readout at known temperature T_0 (14);
Scale factor_{TS} = 95 counts/°C

Specification notes (cont.)
(14) To be defined by user. The results show deviation (in °C) from the offset calibrated temperature.

SPI – Serial Peripheral Interface (cont.)

Interface specification

Parameter	Symbol	Conditions		Min.	Typ.	Max.	Unit
External clock frequency	f_{ECLK}	V_{CKSEL}=0	Min.		0.2		MHz
			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	
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	
Maximum output load capacitance	C_{LOAD}	$R_{LOAD}=\infty$, phase margin >55°			200		pF
Input voltage, logic HIGH	V_{IH}			0.8×V_S		V_S+0.3	V
Input voltage, logic LOW	V_{IL}					0.2×V_S	
Output voltage, logic HIGH	V_{OH}	$R_{LOAD}=\infty$		V_S-0.1			
		R_{LOAD}=2 kΩ		V_S-0.15			
Output voltage, logic LOW	V_{OL}	$R_{LOAD}=\infty$				0.5	
		R_{LOAD}=2 kΩ				0.2	

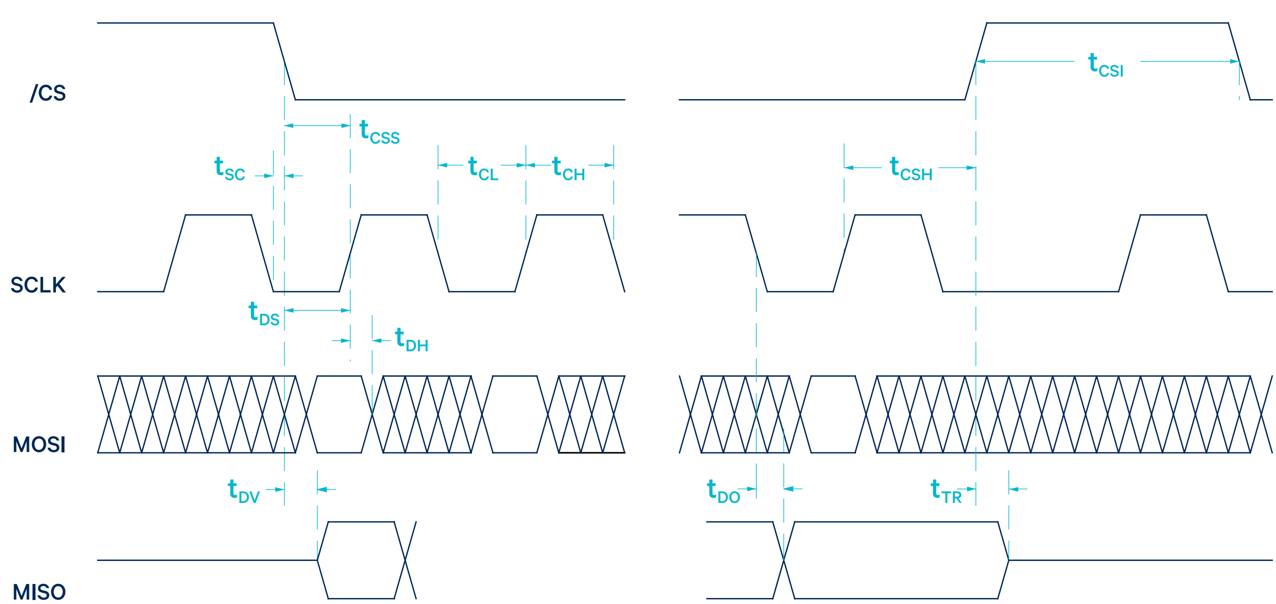

Fig. 6: SPI timing diagram

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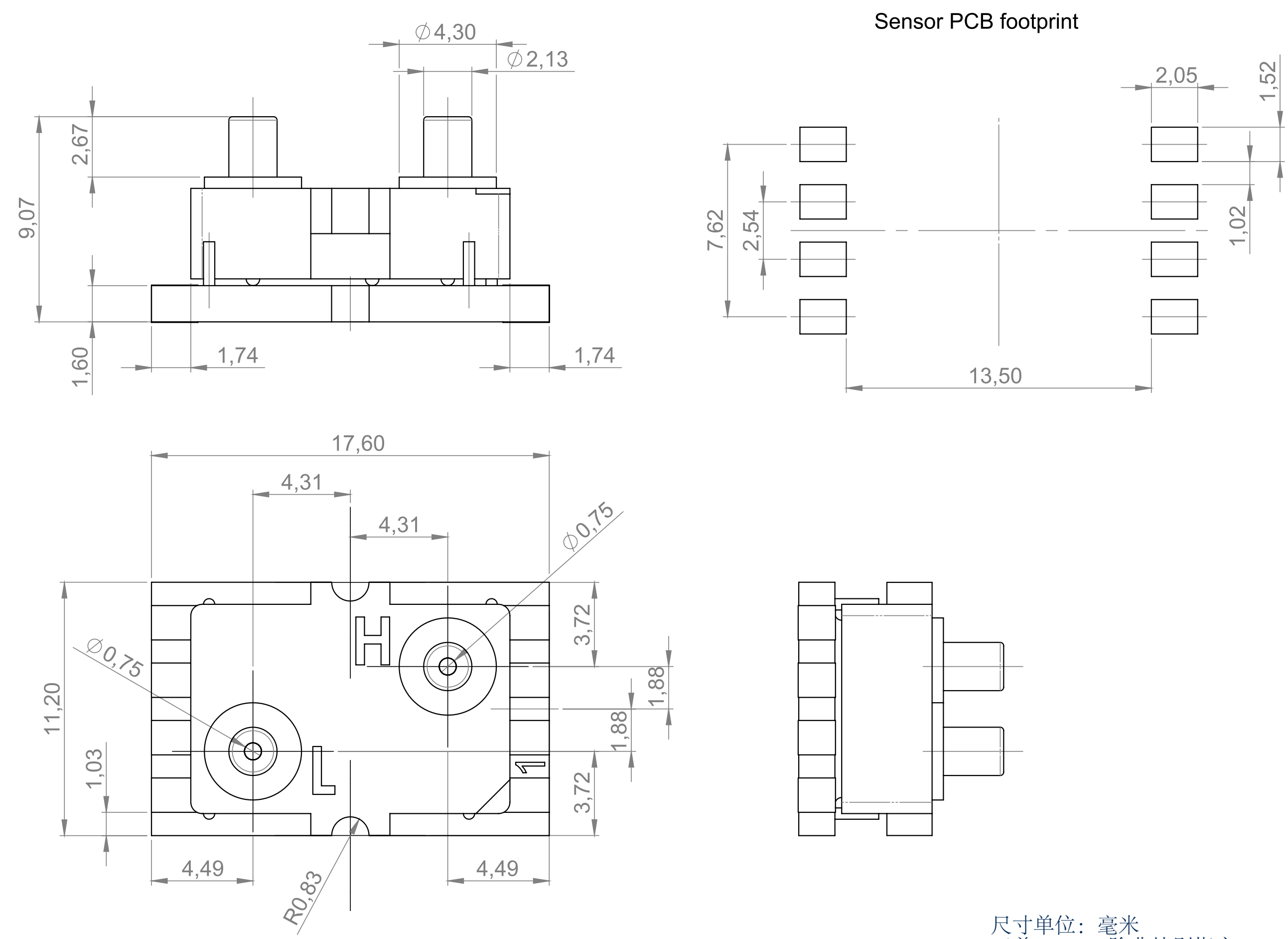
Dimensional drawing

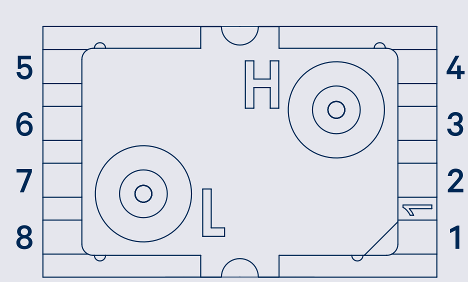


尺寸单位：毫米
工差±0.1 mm 除非特别指定

电气连接

LME系列传感器有2种接口方式

Pin	Function	Case 1: Digital signal output	Case 2: Analog signal output
1	V_s	+5V	+5V
2	GND	GND	GND
3	Vout	NC	High impedance analog input (e.g. op-amp, ADC)
4	Reserved	NC	NC
5	SCLK	Master device SCLK	GND
6	MOSI	Master device MOSI	GND
7	MISO	Master device MISO	GND
8	/CS	Master device (/CS)	V_s



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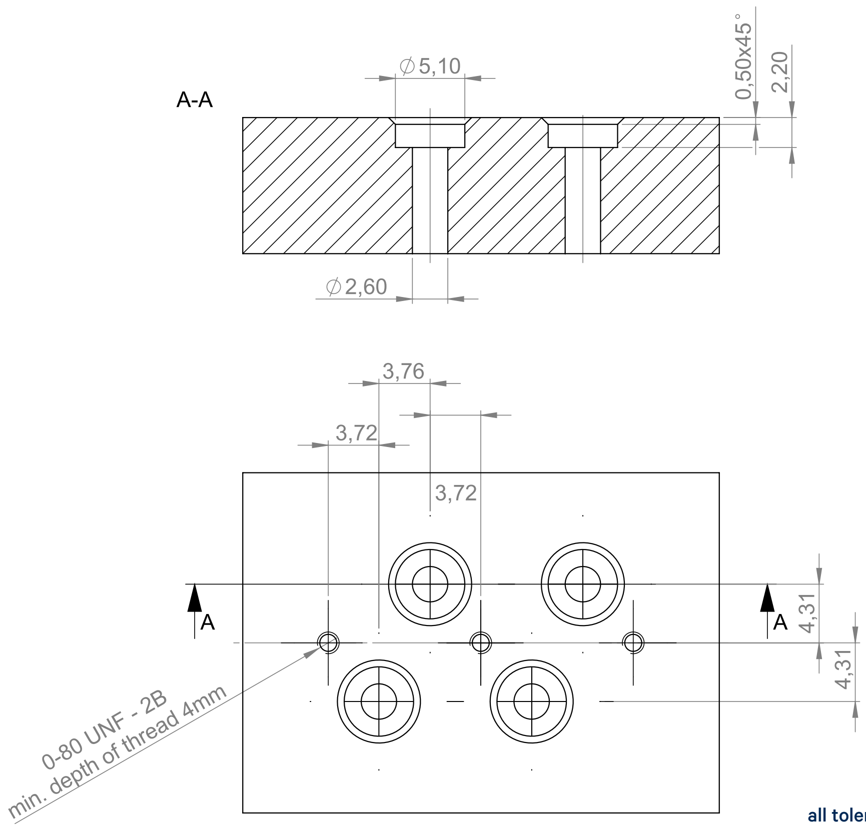
LME 系列 – 数字超低压传感器用于流量测量

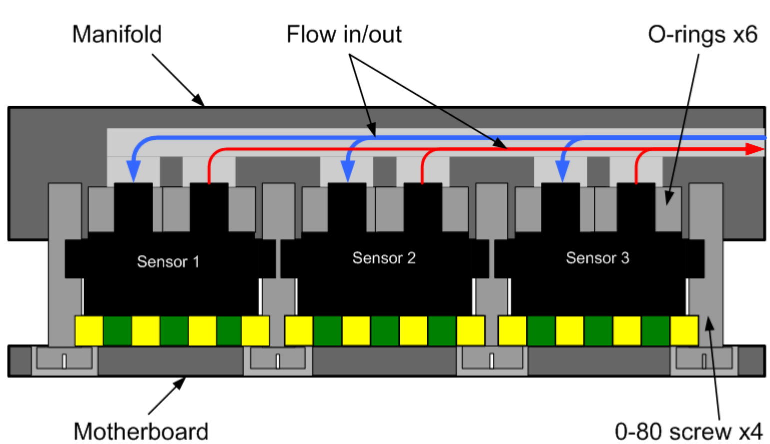
两个并排安装传感器的流形图



推荐的密封圈:
配件号: 90025K119
www.mcmaster.com

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

多个并排安装传感器的歧管图



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Custom adaptor

LME系列压力传感器可以根据应用特定的安装要求，选配配备一个定制适配器。 请联系First Sensor了解更多信息。

Fig. 7: 3D views of a custom adaptor for the LME pressure sensor

气体混合时间 (吹扫时间)

LME系列压力传感器具有最小的内部体积，可同时快速响应气体混合物变化和高气动阻抗。 吹扫时间（TP）可以通过以下公式估算：

$$T_P = \frac{V_{INT}}{F_{Norm}} = \frac{V_{INT}}{P_{Norm}/Z_P}$$

T_P = 吹扫 [s]
V_{INT} = LME 传感器内容量 [ml]
F_{Nom} = 标称流量[ml/s]
P_{Nom} = 标称压力 [Pa]
Z_P = 气动阻抗 [kPa/(ml/s)]

LME传感器（VINT）的典型内部体积为0.04毫升。 使用15 kPa /（ml / s）的气动阻抗（ZP）和250 Pa的额定压力（PNom），估计的净化时间（TP）为2.4秒。

订购信息

Series	压力范围		校正		外壳	输出	等级
LME	S025	25 Pa (0.1 inH$_2$O)	B	Bidirectional	B [SMD, 2 ports, axial, same side]	6 [Non-ratiometric, 5 V supply]	S [High]
	S050	50 Pa (0.2 inH$_2$O)	U	Unidirectional			
	S100	100 Pa (0.4 inH$_2$O)					
	S250	250 Pa (1 inH$_2$O)					
	S500	500 Pa (2 inH$_2$O)					
	M012	1250 Pa (5 inH$_2$O)					
	M025	2500 Pa (10 inH$_2$O)					